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Optimization of organic and inorganic fertilizers on growth and yield of carrot (*Daucus carota* L.)

Md. Amirul Islam BABUL[1], Tatia BISWAS[2*], Sorowardi HOSSAIN[3], Md. Habibur RAHMAN[1] M. Ashraful ISLAM[1*]

[1] Department of Horticulture, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
[2] Department of Horticulture, Khulna Agricultural University, Khulna-9100, Bangladesh
[3] Department of Agricultural Extension, Ministry of Agriculture, Bangladesh

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*CONTACT

tatiabiswas@kau.ac.bd
ashrafulmi@bau.edu.bd

ABSTRACT

Carrot is an important root vegetable cultivated worldwide. The storage root is widely utilized due to its richness in carotenoids, anthocyanins, dietary fiber, vitamins and other nutrients. Carrot extracts, which serve as sources of antioxidants, have important functions in preventing many diseases. The aim of the study was to investigate the combined effect of different levels of organic and inorganic fertilizers on growth and yield attributes of carrot cv. 'T-Summer'. There were 13 treatments in the experiment: T_1= Control, T_2= Inorganic (100%), T_3= Vermicompost (100%), T_4= Cow dung (100%), T_5= Vermicompost (25%) + Inorganic (75%), T_6= Vermicompost (50%) + Inorganic (50%), T_7= Vermicompost (75%) + Inorganic (25%), T_8= Cow dung (25%) + Inorganic (75%), T_9= Cow dung (50%) + Inorganic (50%), T_{10}= Cow dung (75%) + Inorganic (25%), T_{11}= Vermicompost (25%) + Cow dung (25%) + Inorganic (50%), T_{12}= Vermicompost (50%) + Cow dung (25%) + Inorganic (25%), T_{13}= Vermicompost (25%) + Cow dung (50%) + Inorganic (25%). Among these treatments T_{13} (Vermicompost 25%+ Cow dung 50% + Inorganic 25%) gives the maximum plant height (47.03 cm) which is approximately 62.86% higher than the control treatment and maximum number (no.) leaves per plant (8.47) at 75 days after sowing (DAS) which was also considerably distinct from other treatments. In T_{13} treatment, the root weight is increased 108.27% and the leaf weight is increased 171.75% than the control treatment. The highest root diameter (7.72 cm) was obtained from T_{13} treatment, and it is 45.28% higher from control treatment. Application of vermicompost (25%), cow dung (50%) and inorganic fertilizer (50%) produced the highest gross yield. So, difference between the maximum and minimum gross yield is approximately 108.61%. Considering the above findings, the combination of vermicompost (25%), cow dung (50%) and inorganic fertilizer (25%) was found to be best for growth and yield of carrot cv. 'T-Summer' at Horticulture Farm condition of BAU, Mymensingh.

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ORCID> 0009-0000-3286-539X (MAIB), ORCID> 0009-0000-8073-8467 (TB), ORCID> 0009-0007-8672-2344 (SH), ORCID> 0000-0002-0426-050X (MHR), ORCID> 0000-0002-2531-1636 (MAI)

1. Introduction

Carrot (*Daucus carota* L.), a biennial herbaceous species, stands as a versatile and nutrient-rich vegetable renowned for its vibrant color, distinct flavor, and numerous health benefits (Que et al., 2019). It is the most significant crop belonging to the Apiaceae family, *Daucus* genus, and *Daucus carota* species (Singh et al., 2021). In the production year 2022-2023, Bangladesh produced 35270.61 metric tons of carrots from 6488.56 acres of land (BBS, 2023). From a nutritional perspective, carrots are a highly significant root crop.

The succulent and flavorful roots make it highly sought after. Carrots are classified as an annual crop for root growth and a biennial crop for seed production, and they are prized for their rich nutritional profile, offering carotene, thiamin, riboflavin, iron, calcium, and phosphorus, all vital for nutrition and health (Singh and Bahadur, 2015; Sikora et al., 2020). Carrot is a good source of various bioactive compounds, viz. carotenoids, flavonoids, phenolic compounds, vitamins (B1, B2, B6), and minerals, which help to provide biological and medicinal properties such as improving digestion, regulating blood circulation, and improving eye vision. It is a rich source of high antioxidant compounds that show anti-carcinogenic and immune developing properties. Also, it helps to control diabetes, cholesterol, and cardiac disease and has antihypertensive, hepatoprotective, and wound healing properties (Ahmed et al., 2019).

The application of fertilizers, specifically soil management practices, has become a significant aspect of farming aimed at enhancing soil fertility (Zuazo and Pleguezuelo, 2008). There is an increasing global focus on organic agriculture that aims to reduce or eliminate the negative impacts of synthetic fertilizers and pesticides on human health and the environment (Afrin et al., 2019). In 2021, the total agricultural usage of inorganic fertilizers, which includes the combined total of nitrogen (N), phosphorus (as P_2O_5), and potassium (as K_2O), reached 195 million t. Overall, fertilizer consumption in 2021 was 60 million t, representing a 44% increase compared to the year 2000 (FAO, 2023). In recent years, there has been an increase in the use of organic fertilizers, such as farmyard manure (FYM), vermicompost, neem cake, poultry manure, and goat manure, as a means to improve crop yields and maintain soil fertility (Yadav et al., 2023). Farmyard manure, known for its environmentally friendly properties, is crucial for preserving soil health and improving crop yield by enhancing soil fertility (Raj et al., 2014). Inorganic fertilizers, particularly nitrogen, are vital nutrients for plant growth and play an important part in crop development, growth, and yield (Mandal et al., 2023).

Organic application provides nutrients, enhances water holding ability, soil structure and porosity, moisture retention, bulk density, enhance the microbial growth and crop quality (Goel et al., 2021). To achieve high yield and quality product, the proper use of mineral fertilizers and organic manure are of considerable importance. They also display a vital role in avoiding harmful effects on soil and environment as well (Fallah et al., 2020). The effectiveness of the combined application of mineral and organic fertilizers assigned to the increased efficiency of mineral fertilizer and the balanced supply of all the essential nutrients. Therefore, the judicious application of organic manures and fertilizer is very necessary not only for better yield and quality production, but also for the extended preservation of soil health and sustainability.

Vermicompost is produced by earthworms. It is a rich source of macro and micronutrients, vitamins, growth hormones, and enzymes. Vermicompost plays a vital role to improve the physical, chemical and biological properties of soil (Kale, 1998). There is good evidence that vermicompost improves the growth of plants (Rajkhowa et al., 2000). The vermicompost enhance growth from 50-100% than conventional compost and 30-40% than chemical fertilizers (Sinha et al., 2010).

Nowadays, inorganic fertilizer is essential to the crop production system's performance, accounting for approximately 50 percent of Bangladesh's total production (FRG, 2012). Generally, most carrot growers use chemical fertilizers to get higher yields. The rising level of inorganic fertilizers adversely affects the human health (Toor et al., 2020), environment, soil texture and structure. So, the farmers tried the integrated plant nutrients which significantly increased the fertility of soil and crop production (Singh et al., 2020). Carrot yield is increased with the application of various manures, such as compost or mustard oil cake. Additionally, it was discovered that applying one-third inorganic fertilizer in conjunction with two thirds vermicompost increased the yield of other crops, such as tomatoes, cabbage, brinjal, and okra (Islam et al., 2017a,b; Akhter et al., 2019; Farzana et al., 2019).

But organic fertilizers are slowly available to the crops as compared to the inorganic fertilizers. Recently, the researchers focused to practice the combination of chemical fertilizers and organic manures. The combination of both the organic and inorganic fertilizer increase the soil fertility, crop production and decrease the level of soil pollution (Karmakar et al., 2020).. Thus, the goal of the current study is to determine how carrot growth and yield are affected by organic compost manure and inorganic nitrogenous fertilizer. In addition to demonstrating the effects of different manures on carrot productivity, this study aims to suggest the most cost-effective and optimal organic carrot growth practices for regular vegetable growers.

2. Materials and methods

2.1. Location of the experiment

The experiment was conducted at Horticulture Farm during the period from November 2018 to January 2019 at Bangladesh Agricultural University, Mymensingh. The experimental region is about 19 meters above normal sea level and is situated at 24°6" North latitude and 90°5" East longitude.

2.2. Design and treatments of experiment

The experiment is designated at randomized complete block design (RCBD). Organic and inorganic fertilizer application was considered as treatment and there were 13 treatments in this experiment. These are:

T_1 Control
T_2 Inorganic (100%)
T_3 Vermicompost (100%)
T_4 Cow dung (100%)
T_5 Vermicompost (25%) + Inorganic (75%)
T_6 Vermicompost (50%) + Inorganic (50%)
T_7 Vermicompost (75%) + Inorganic (25%)
T_8 Cow dung (25%) + Inorganic (75%)
T_9 Cow dung (50%) + Inorganic (50%)
T_{10} Cow dung (75%) + Inorganic (25%)
T_{11} Vermicompost (25%) + Cow dung (25%) +Inorganic (50%)
T_{12} Vermicompost (50%) + Cow dung (25%) +Inorganic (25%)
T_{13} Vermicompost (25%) + Cow dung (50%) +Inorganic (25%)

2.3. Seed sowing

In Bangladesh, carrots thrive during the season, when temperatures range from 11.17°C to 28.9°C (Alim, 1974). The optimum period to cultivate them is from mid-November to early December, when yields are satisfactory (Rashid, 2004). The 'T-Summer' carrot variety, which originates in Japan, was employed in the study. The seeds were gathered at the neighborhood marketplace. To speed up germination, the seeds were wrapped in a thin piece of cloth after being soaked in water for a whole day before being sown. The seeds for carrots were planted on November 11, 2018. The seeds were planted at a 1.5 cm depth in line. To avoid direct exposure, the seeds were then covered with loose soil. To shield the seed from direct sunshine, banana leaves were placed over the plots after a day. After seven days of seedling emergence, the seedlings were thinned to maintain 25 cm × 10 cm spacing.

2.4. Fertilizer application

Inorganic fertilizers like Urea, Triple Super Phosphate (TSP), Muriate of Potash (MoP) and Gypsum were given as per the guideline of Fertilizer Recommendation Guide (FRG, 2012). Also, different organic fertilizer like cow dung and vermicompost were given. Application of vermicompost, cow dung and inorganic fertilizers were done on the basis of different treatments.

The dose of vermicompost were 0, 3.75, 7.5, 11.25 and 15 (t ha^{-1}), the doses of cow dung were 0, 5, 10, 15, 20 (t ha^{-1}), the doses of urea were 0, 55, 110, 165 and 220 (kg ha^{-1}), doses of TSP were 0, 35, 70, 105, 140 (kg ha^{-1}), doses of MoP were 0, 37.5, 75, 112.5, 150 (kg ha^{-1}) and doses of gypsum were 0, 27.5, 55, 82.5, 110 (kg ha^{-1}). The total amount of TSP, MOP and Gypsum and 1/3rd urea were applied as a basal dose when final preparation of land. After applying vermicompost and cow dung, spading was used to combine it with the soil. 1/3rd of urea according to treatment was applied at 3rd weeks of sowing. Remaining 1/3rd of urea was applied at 5th weeks of seed sowing. All intercultural operations like weeding and irrigation were done when needed.

2.5. Harvesting and data collection

During the crop's growing season, data on growth-contributing traits were collected from the sample plants. The plant height (cm), leaves number, length of root (cm), root diameter (cm), and yield-contributing characteristics (fresh weight of individual root, g) are the criteria. The data was collected by randomly recording the marketable yield and gross yield from the center rows of each unit plot. Ten plants in a plot had their data averaged and treated as a single replication. Thus, there were thirty plants in all for the three replications. The crop was harvested 100 days following seed sowing (DAS).

2.6. Statistical analysis

The mean values for all the parameters were calculated and the analysis of variances (ANOVA) for the characters was accomplished by F variance test. Mean comparisons between treatments were performed by the Duncan's Multiple Range Test (DMRT) at 5% level of probability according to Gomez and Gomez (1984).

3. Result and discussion

3.1. Effect of organic and inorganic fertilizers on growth of carrot

Plant height is one of the most important growth contributing characters in vegetables crops. Plant height was recorded at different stages of growth DAS (45, 60 and 75) and found significant at 5% level with different level of combination of organic and inorganic fertilizer application. It was observed that plant height was higher in T_{13} treatment (Table 1). At 75 DAS the tallest plant (47.03 cm) was obtained from T_{13} treatment, and the shortest plant (28.88 cm) was found from control treatment T_1 which is approximately 62.86% higher than the control treatment. This result is close to the experiment of Kirad et al. (2010) found in carrot. So, plant height depends upon various levels of organic and inorganic fertilizers. The result of the experiment was similar to that of Mamta et al. (2012) who conducted an experiment in Dhaula Kuan, India.

Table 1. Effect of different organic and inorganic fertilizers on plant height at different days after sowing (DAS) of carrot

Treatments	Plant height (cm) at different days after sowing (DAS)		
	45	60	75
T_1	20.36±0.599 c	27.03±2.17 c	28.88±2.16 c
T_2	23.84±0.84 b	31.77±1.66 bc	36.57±0.87 b
T_3	25.03± 0.77 ab	34.36±1.18 ab	39.43±0.73 ab
T_4	25.46±1.62 ab	33.27±4.13 ab	35.73±4.34 bc
T_5	24.63±0.19 ab	34.81±0.69 ab	39.61±3.00 ab
T_6	27.36±0.51 a	34.00±2.72 ab	38.53±2.36 b
T_7	25.98±1.02 ab	37.23±0.56 ab	42.50±0.15 ab
T_8	25.44± 1.06 ab	35.20±1.77 ab	40.33±2.09 ab
T_9	24.90±1.63 ab	38.00± 2.22 ab	42.60±3.07 ab
T_{10}	25.58±0.36 ab	34.60±0.93 ab	42.27±2.97 ab
T_{11}	25.92±0.72 ab	38.83±1.21 a	42.73±0.87 ab
T_{12}	27.11±0.43 a	36.51± 2.70 ab	40.70±2.39 ab
T_{13}	27.23± 0.85 a	38.75±0.95 a	47.03±1.73 a
Level of significance	**	*	**

** = Significant at 1% level of probability, * = Significant at 5% level of probability, T_1= Control, T_2= Inorganic (100%), T_3= Vermicompost (100%), T_4= Cow dung (100%), T_5= Vermicompost (25%) + Inorganic (75%), T_6= Vermicompost (50%) + Inorganic (50%), T_7= Vermicompost (75%) + Inorganic (25%), T_8= Cow dung (25%) + Inorganic (75%), T_9= Cow dung (50%) + Inorganic (50%), T_{10}= Cow dung (75%) + Inorganic (25%), T_{11}= Vermicompost (25%) + Cow dung (25%) +Inorganic (50%), T_{12}= Vermicompost (50%) + Cow dung (25%) +Inorganic (25%), T_{13}= Vermicompost (25%) + Cow dung (50%) +Inorganic (25%)

Rahman (2000) also found highest plant height with the application of compost which was also similar to this experiment (Table 1). Nitrogenous fertilizer is essential for plant height. Organic manures contain nitrogen, and it combined with chemical fertilizer and causes taller plant.

At 45 DAS and 60 DAS no significant effect was found because of the use of both inorganic as well as organic fertilizers (Table 2). But at 75 DAS effect of cow dung, vermicompost and inorganic fertilizers levels on leaf production was significantly affected which was similar to the experiment of Peyvast et al. (2008). Treatment T_{13} dose of produced the maximum number of leaves (8.47) at 75 DAS while the minimum (6.73) number of leaves were produced in T_4 treatment dose of cow dung (100%), which was similar to the experiment of Moniruzzaman et al. (2013) (Table 2). The no. of leaves also increased with the combination of cow dung, vermicompost and inorganic fertilizer treatment and that are very close to the maximum. Mehedi et al. (2012) observed the highest number of leaves from higher amount of nitrogen and cow dung application per hectare land. The obtained results showed that the integrated mineral and organic manure increased the number of leaves by providing macro and micro nutrient to plants. The increase in the number of is attributed to the use of variant nature of the organic manures. The obtained results are in accordance to previously reported literature (Singh et al., 2007). Kirad et al. (2010) also recorded 8.26 and 16.06 leaves per plant.

Table 2. Effect of different organic and inorganic fertilizers on no. of leaves/plant at different days after sowing of carrot

Treatments	No. of leaves/plant at different days after sowing (DAS)		
	45	60	75
T_1	4.73±0.18a	6.33±0.18a	7.000±0.20 bcd
T_2	4.86±0.13a	6.66±0.48a	6.867±0.18 d
T_3	5.00±0.23a	6.80±0.12a	6.933 ±0.47 cd
T_4	5.06±0.291a	6.73±0.71a	6.733 ±0.66 d
T_5	4.86±0.067a	6.53±0.07a	8.067±0.18 abc
T_6	4.93±0.18a	6.66±0.44a	7.133±0.18 bcd
T_7	4.86±0.13a	6.60±0.12a	7.400±0.23 abcd
T_8	4.53±0.07a	6.46±0.07a	7.333±0.29 abcd
T_9	5.26±0.27a	7.53±0.47a	8.133±0.35 ab
T_{10}	4.80±0.00a	6.53±0.58a	7.867 ±0.52 abcd
T_{11}	5.26±0.07a	7.40±0.61a	8.133±0.27ab
T_{12}	5.26±0.18a	7.06±0.47a	7.867 ±0.29 abcd
T_{13}	5.00±0.11a	7.40±0.31a	8.467±0.64 a
Level of significance	NS	NS	**

** = Significant at 1% level of probability, NS = Not significant, T_1= Control, T_2= Inorganic (100%), T_3= Vermicompost (100%), T_4= Cow dung (100%), T_5= Vermicompost (25%) + Inorganic (75%), T_6= Vermicompost (50%) + Inorganic (50%), T_7= Vermicompost (75%) + Inorganic (25%), T_8= Cow dung (25%) + Inorganic (75%), T_9= Cow dung (50%) + Inorganic (50%), T_{10}= Cow dung (75%) + Inorganic (25%), T_{11}= Vermicompost (25%) + Cow dung (25%) +Inorganic (50%), T_{12}= Vermicompost (50%) + Cow dung (25%) +Inorganic (25%), T_{13}= Vermicompost (25%) + Cow dung (50%) +Inorganic (25%)

Leaf weight found non-significant among the treatments (Table 3). However, the maximum weight of fresh leaves (45.06g) was obtained at T_{13} treatment dose of vermicompost (25%), cowdung (50%) and inorganic fertilizer (25%) but in case of organic cultivation the maximum weight of leaves is 26.33 g which was observed in T_4 treatment (Table 3), and the minimum was obtained at control treatment (16.60 g) at the 75 DAS growth stage which was similar to the result of Nihad and Jessykutty (2010) recorded the highest fresh weight of plants with 50% RDN (recommended dose of nitrogen) through FYM and neem cake in *Plumbago rosea*.

3.2. Effect of organic and inorganic fertilizers on yield of carrot

In case of fresh weight of roots has significant difference as a result of using both inorganic and organic fertilizers. However, T_{13} treatment showed the maximum fresh weight of roots (93.93 g plant^{-1}) and control (T_1) showed the lowest fresh weight of roots (45.13 g plant^{-1}) (Table 3). There are no significant variations among the treatments in the means of root length. So, there is no statistical difference, but the maximum root length (15.20 cm) found in T_{13} treatment and lowest found in T_2 treatment (12.33 cm) (Table 3). Kiran et al. (2022) found significant improvements in almost all growth and yield attributes by combined application of NPK and organic manures.

Table 3. Effect of different organic and inorganic fertilizers on weight of leaf, weight of root, root length and root diameter of carrot

Treatments	Leaf weight (g)	Root weight (g)	Root length (cm)	Root diameter (cm)
T_1	16.60±2.91a	45.13±9.77d	12.33±0.72a	5.32±0.47c
T_2	25.20±5.17a	56.67±6.07bcd	12.33±0.55a	6.13±0.33bc
T_3	19.33±4.35a	49.04±13.8cd	14.36±0.50a	6.75±0.25ab
T_4	26.33±6.43a	74.40±9.50abcd	14.93±1.21a	6.82±0.47ab
T_5	32.86±3.18a	57.80±8.66bcd	13.40±0.55a	6.36±0.25bc
T_6	31.00±2.31a	68.27±5.73abcd	13.93±0.75a	6.28±0.15bc
T_7	28.33±0.44a	79.13±8.53ab	13.96±0.48a	7.26±0.27ab
T_8	29.33±3.17a	69.53±9.87abcd	14.00±0.35a	6.81±0.56ab
T_9	31.93±4.43a	78.27±5.57abc	13.96±0.63a	7.26±0.45ab
T_{10}	27.93±0.77a	71.27±3.47abcd	14.06±0.33a	6.88±0.22ab
T_{11}	32.60±3.35a	74.87±7.39abc	13.66±0.26a	6.94±0.46ab
T_{12}	33.86±11.0a	68.07±12.90abcd	14.93±0.94a	7.04±0.42ab
T_{13}	45.06±9.50a	93.93±6.71a	15.20±0.27a	7.72±0.25a
Level of significance	NS	*	NS	**

NS = Not significant, * = Significant at 5% level of probability, ** = Significant at 1% level of probability, T_1= Control, T_2= Inorganic (100%), T_3= Vermicompost (100%), T_4= Cow dung (100%), T_5= Vermicompost (25%) + Inorganic (75%), T_6= Vermicompost (50%) + Inorganic (50%), T_7= Vermicompost (75%) + Inorganic (25%), T_8= Cow dung (25%) + Inorganic (75%), T_9= Cow dung (50%) + Inorganic (50%), T_{10}= Cow dung (75%) + Inorganic (25%), T_{11}= Vermicompost (25%) + Cow dung (25%) +Inorganic (50%), T_{12}= Vermicompost (50%) + Cow dung (25%) +Inorganic (25%), T_{13}= Vermicompost (25%) + Cow dung (50%) +Inorganic (25%)

Statistically significant variation in the root diameter of carrot was found due to application of different levels of vermicompost, cow dung and inorganic fertilizers (Table 3). The highest root diameter of carrot (7.72 cm) was produced by the plants having received treatment T_{13}. The lowest diameter observed in T_1 treatment (5.32 cm) (Table 3). The root diameter of carrot increased with increasing the level of vermicompost, cow dung and inorganic fertilizer. The study showed that the combined use of organic manures together with inorganic fertilizers has substantially positive effect on root diameter of carrot. T_{13} treatment showed the maximum gross yield (3.760 kg plot^{-1}) and control (T_1) showed the minimum gross yield (1.803 kg plot^{-1}) (Table 4). The gross yield is higher in combined treatment of fertilizers due to higher amount of nutrients supplied by organic and inorganic fertilizers. Very similar result found by Biswas et al. (2020) in tomato and Jahan et al. (2022) in sweet pepper, highest yield using combined organic and inorganic fertilizers. Total marketable yield found highest in T_{13} treatment (3.410 kg plot^{-1}) and the lowest found in control treatment (1.703 kg plot^{-1}) (Table 4). The increase in the yield attributing characters by INM treatments might be due to the addition of nitrogen as well as other nutrients and growth-promoting substances through organic manure (Tejalben et al., 2017).

Table 4. Effect of different organic and inorganic fertilizers on gross yield and marketable yield of carrot

Treatments	Gross Yield (kg plot^{-1})	Marketable yield (kg plot^{-1})	Gross yield (ton ha^{-1})	Marketable yield (ton ha^{-1})
T_1	1.803±0.39 d	1.703± 0.36 d	18.03±3.92 d	17.04±3.55d
T_2	2.263 ±0.24 bcd	2.077 ±0.23 bcd	22.63±2.44 bcd	20.77±2.34 bcd
T_3	1.960± 0.55 cd	1.807± 0.49 cd	19.60± 5.49 cd	18.08± 4.86cd
T_4	2.973± 0.37 abc	2.693± 0.33 abc	29.73± 3.79 abc	26.96±3.26abc
T_5	2.310 ±0.35 bcd	2.093 ±0.30 bcd	23.10±3.48 bcd	20.94± 3.02bcd
T_6	2.730±0.23 abcd	2.457± 0.18abcd	27.30±2.29abcd	24.54±1.84abcd
T_7	3.163±0.34 ab	2.840± 0.27 ab	31.63± 3.43 ab	28.39±2.66ab
T_8	2.780 ±0.40 abcd	2.540± 0.34 abcd	27.80±3.96abcd	25.43± 3.41abcd
T_9	3.130± 0.22 ab	2.833±0.15 ab	31.30±2.25 ab	28.36±1.48ab
T_{10}	2.850 ± 0.14abcd	2.590± 0.10 abcd	28.50±1.37abcd	25.87±1.02abcd
T_{11}	3.093± 0.22 abc	2.780± 0.19 abc	30.93± 2.15 abc	27.82±1.85abc
T_{12}	2.720 ± 0.51abcd	2.453± 0.42 abcd	27.20±5.14abcd	24.55±4.17abcd
T_{13}	3.760± 0.27 a	3.410 ±0.22 a	37.60±2.69 a	34.12± 2.21a
Level of significance	*	*	*	*

* = Significant at 5% level of probability, T_1= Control, T_2= Inorganic (100%), T_3= Vermicompost (100%), T_4= Cow dung (100%), T_5= Vermicompost (25%) + Inorganic (75%), T_6= Vermicompost (50%) + Inorganic (50%), T_7= Vermicompost (75%) + Inorganic (25%), T_8= Cow dung (25%) + Inorganic (75%), T_9= Cow dung (50%) + Inorganic (50%), T_{10}= Cow dung (75%) + Inorganic (25%), T_{11}= Vermicompost (25%) + Cow dung (25%) +Inorganic (50%), T_{12}= Vermicompost (50%) + Cow dung (25%) +Inorganic (25%), T_{13}= Vermicompost (25%) + Cow dung (50%) +Inorganic (25%)

It was observed that gross yield was higher (37.60 t ha^{-1}) in T_{13} treatment and the lower yield (18.03 t ha^{-1}) was found from control treatment T_1 (Table 4) (Figure 1) which was close to the experiment of Sah et al. (2024). The gross yield is increased approximately 108.61%. They found the use of organic manures to effectively enhance carrot yield. Abera et al. (2018) found combined fertilizer effective in barley in terms of yield parameters. The highest marketable yield (34.12 t ha^{-1}) obtained from T_{13} and 17.04 t ha^{-1} is lowest marketable yield which is obtained from T_1 treatment (Table 4) (Figure 2). Similarly, application of organic and inorganic fertilizers significantly influenced the plant height, leaf area index and the number of days to maturity, yield attributes of maize (Verma et al., 2012). Plant requires essential nutrients for their growth and development. Combined organic inorganic fertilizers supply essential nutrients properly to plant parts. That is why the defective part is very low in this T_{13} treatment and total marketable yield is so high. Alom (2004) found the treatment with organic and inorganic fertilizers (290 kg urea, 225 kg TSP, 250 kg MP, and 5 t MOC ha^{-1}) produced the maximum gross and marketable yields (67.47 and 60.93 t ha^{-1}).

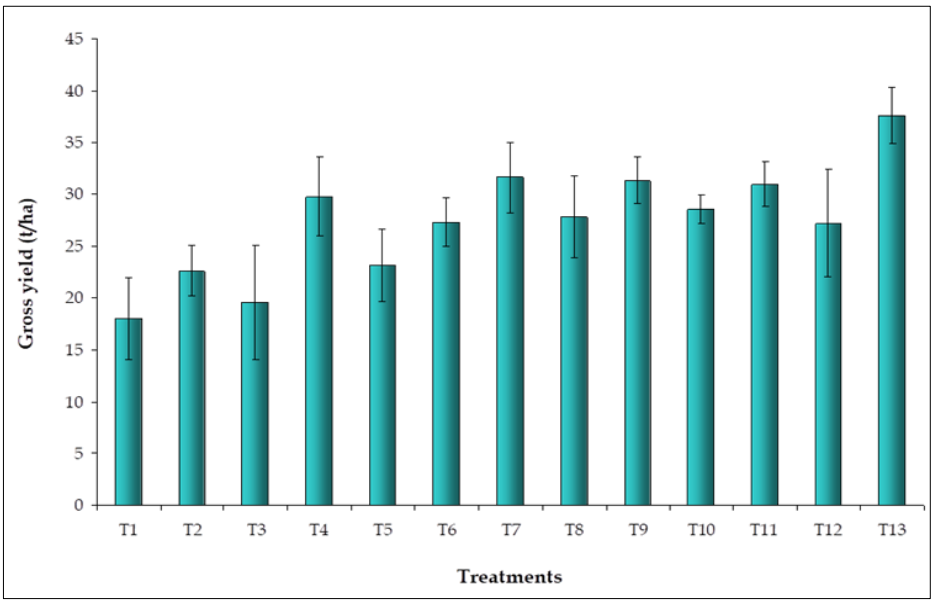

Figure 1. Effect of organic and inorganic fertilizers on gross yield of carrot [Vertical bars represent the ±SE (Standard Errors)]

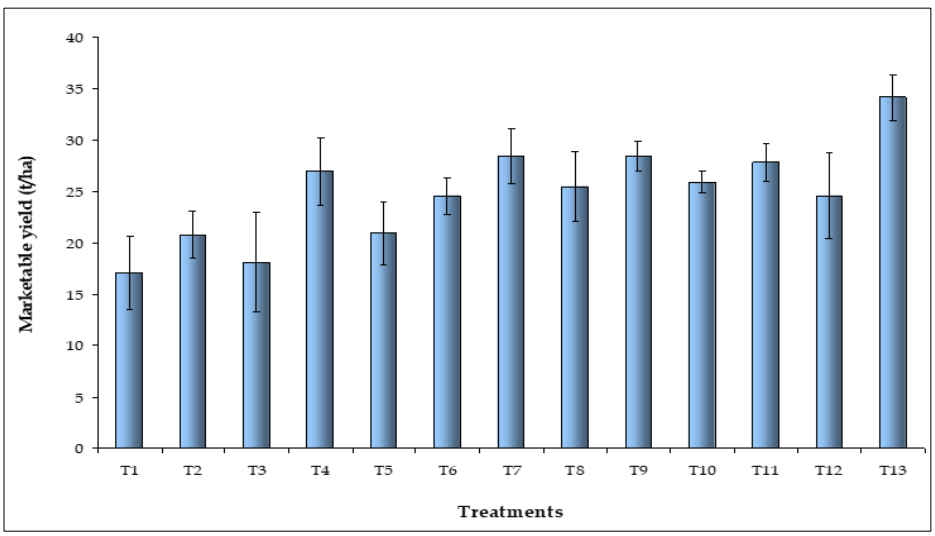

Figure 2. Effect of organic and inorganic fertilizer on marketable yield [Vertical bars represent the ±SE (Standard Errors)]

4. Conclusion

Organic manure helps soil fertility as well as increases organic matter in soil. Proper level of inorganic fertilizers along with vermicompost and cow dung is an important aspect to maximize the crop yield along with maintaining the soil health. In this experiment it was cleared that the growth with highest gross yield of carrot largely depends upon the use of several levels of vermicompost, cow dung and inorganic fertilizers. On the other hand, the lowest yield per hectare was obtained at the control treatment. So combined application of vermicompost, cow dung and inorganic fertilizer may be recommended for the profitable production of carrot along with maintain the soil health and for sustainable crop production.

Compliance with Ethical Standards

Conflict of Interest

No conflicts of interest have been disclosed by the writers.

Authors' Contributions

M. Ashraful ISLAM designed the field experiment. **Tatia BISWAS** prepared the manuscript and assisted with data collection. **Md. Amirul Islam BABUL** collected the field data and helped in manuscript preparation. **Sorowardi HOSSAIN** and **Md. Habibur RAHMAN** assisted with the manuscript evaluation.

Ethical approval

Not applicable.

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Data availability

All necessary data are included in the manuscript. Additional data will be available upon request to the authors.

Consent for publication

All authors have given their consent for the publication of this manuscript.

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