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Yield and Quality Performance of Carrot under Different Organic and Inorganic Nutrient Sources with Mulching Options

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Authors' contributions

This work was carried out in collaboration between all authors. Author MAR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author MTI managed the analyses of the study. Author MAAM managed the literature searches and improved the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted at the Horticulture Farm, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, Bangladesh to find out the effects of mulch and different manures and fertilizers on the yield components and quality of carrot (*Daucus carota* L.). Twelve treatment combinations were evaluated in two factors Randomized Complete Block Design (RCBD) with three replications. Different doses of manures and fertilizers viz. F_0 = Control, F_1 = Cowdung (CD) @ 10 t ha^{-1}, F_2 = Mustard Oil Cake (MOC) @ 0.25 t ha^{-1}, F_3 = Cowdung (CD) @ 5.0 t ha^{-1} + Mustard Oil Cake (MOC) @ 0.125 t ha^{-1}, F_4 = Urea @ 326.08 kg ha^{-1} + Triple Super Phosphate (TSP) @ 93.75 kg ha^{-1} + Muriate of Potash (MoP) @ 200 kg ha^{-1} and F_5 = Cowdung (CD) @ 5 t ha^{-1}

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+ Urea @ 163.04 kg ha^{-1} + Triple Super Phosphate (TSP) @ 46.87 kg ha^{-1} + Muriate of Potash (MoP) @ 100 kg ha^{-1} were applied under mulched (M_1) and non-mulched (M_0) conditions. Results from our study revealed that maximum fresh weight (3.57 kg $plot^{-1}$), individual root weight (101.90 g), root length (14.64 cm), root diameter (3.27 cm), total yield (23.78 t ha^{-1}), marketable yield (20.53 t ha^{-1}) and beta-carotene content (8.78 mg 100^{-1} g) were recorded from F_5 treatment. The mulching also had a significantly positive effect on maximizing the root yield components as well as beta-carotene contents over non-mulched treatment. On the other hand, the interaction effect of M_1F_5 performed superior in producing yield components and beta-carotene content of root compared to other combinations. The highest marketable yield (25.10 t ha^{-1}) along with best economic gross return (TK. 2,47,167 ha^{-1}) and the benefit-cost ratio (2.91) were also noted from M_1F_5. It was concluded that organic and inorganic sources of nutrients along with mulch effectively increase the carrot yield than the sole application of higher doses of manures and fertilizers.

Keywords: Manures; fertilizers; beta-carotene; Daucus carota L.; benefit-cost ratio etc.

1. INTRODUCTION

Carrot (*Daucus carota* L.) is a cool season crop grown all over the world [1]. The edible part of this crop is characterized by its high beta-carotene content, a precursor of vitamin A [2] and acts as an excellent source of iron, calcium, phosphorus, vitamin B, sugar and folic acid. It is extensively used as salad and cooked vegetable in soups, curries, preparation of jams, pickles, and sweet dishes [3]. Carrot cultivation is now gaining popularity among farmers in Bangladesh but the yield is low due to lack of high yielding varieties as well as use of a low standard of agro-technologies [3]. In 2009-2010, the area under carrot cultivation was 1,215 hectares with the total production of 14,000 metric tons in Bangladesh [4]. However, the average yield is relatively low and not pleasing one compared to other carrot producing countries [5]. This root crop is highly responsive to soil moisture with a typically heavy feeder of nutrients and required recommended application of 70 – 100 kg N, 30 – 50 kg P and 0 – 55 kg K ha^{-1} for higher yield [6]. The available nutrients from chemical fertilizers give the initial boost of crop growth required by the young plants. But the continuous high input of nutrients from the inorganic fertilizers under intensive cropping system pose environmental burden and enhance the toxic bioavailability of nutrients to living beings. The balanced fertilization by managing soil organic matter and reducing the indiscriminate use of chemical fertilizers has now become a vital issue in dealing with the problem of soil fertility and crop productivity in Bangladesh. Also, for sustainable agriculture, a soil management strategy must be based on maintaining soil quality. It is well-established the fact that combination of high-quality manures along with inorganic fertilizers shown to be a useful alternative for maintaining soil quality. Moreover, organic farming of crops recently gained popularity to the consumers due to having the better variety of the produce. Carrot is generally cultivated in Bangladesh during the rabi season when the rainfall and moisture holding a capacity of a soil is scanty. The water requirement by using irrigation for improved carrot yield remained unclear [7]. Mulching can be an alternate option to cultivate carrot in such situation. Mulching is usually an age-old practice that can efficiently control the weeds and also conserve the soil moisture by regulating the soil temperature. The available organic mulches are straw, leaves, grass, bark, compost, sawdust, or peat moss and can be efficiently utilized for improving soil tilth, aeration, and drainage, and finally increase the yield of carrot. Similarly, organic manures provide nutrients slowly but maintain uniformity of supplying available nutrients throughout the season and at the same time improving soil fertility [2]. It was well recognized that inorganic fertilizer in combination with organic manures increases the yield of carrot [8,9]. Several reports have been conducted to find the effects of inorganic nitrogenous fertilizer on growth and yield of carrot. But studies on the effect of mulch practice and use of organic and inorganic nutrient supplementation on growth and yield of carrot are very few. Therefore, the present study was undertaken to study the effect of inorganic fertilizers and organic manures with mulched and non-mulched condition on root yield of carrot. It was also considered the changes in the content of beta-carotene due to the influence of mulching and manuring.

2. MATERIALS AND METHODS

2.1 Experimental Site, Treatments and Design

The experiment was set up at the central research farm and laboratory of Horticulture, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh during the period of November 2014 to March 2015. The soil of the experimental area was Non-Calcareous Brown Floodplain with very low organic matter content (OM: 0.70%) and slightly acidic soil condition (pH: 6.3). The macronutrients in the experimental soil were very low to low in condition (total N: 0.04%, available P: 12.32 ppm, exchangeable K: 0.10 me 100^{-1} g soil, exchangeable Ca: 1.02 me 100^{-1} g soil, exchangeable Mg: 0.59 me 100^{-1} g soil, available S: 30.88 ppm); whereas the micronutrients and cation exchange capacity were low to medium in condition (available Zn: 0.80 ppm, available B: 0.28 ppm, and CEC: 4.1 me 100^{-1} g soil). Twelve treatments were performed under a two factors Randomized Complete Block Design with three replications. Mulch of rice straw (M_1) was compared without mulch or control (M_0) and different manures and fertilizers (6 levels) viz., F_0 = Control, F_1 = CD @ 10 t ha^{-1}, F_2 = MOC @ 0.25 t ha^{-1}, F_3 = CD @ 5 t ha^{-1} + MOC @ 0.125 t ha^{-1}, F_4 = Urea @ 326.08 kg ha^{-1} + TSP @ 93.75 kg ha^{-1} + MoP @ 200 kg ha^{-1} and F_5 = CD @ 5 t ha^{-1} + Urea @ 163.04 kg ha^{-1} + TSP @ 46.87 kg ha^{-1} + MoP @ 100 kg ha^{-1} without manure and fertilizer (F_0). The treatment wise required amounts of manures were applied during the final land preparation. The fertilizers (TSP and MoP) were applied at sowing time. Urea was applied in two equal splits; one after seedling emergence and another after 30 days after sowing. The nutrient contents and supplying capacity of the organic manures and mulch used in this study were shown in Table 1 [10]. New Kuroda, a Japanese variety of carrot was used as a test crop. The size of the unit plot was 150 cm x 100 cm with a distance of 50 cm between blocks and each plot. The mulch of rice straw was provided immediately after emergence of seedling maintaining thickness of 10 cm (3 kg $plot^{-1}$). The intercultural operations, as well as pest management, were done whenever necessary without any irrigation from seedling emergence to harvesting (only flood irrigation was applied before sowing). The crop was harvested depending upon the attaining good size of the root.

2.2 Data Collection

The data were collected from the 10 randomly selected plants. The percent dry matter content of root was calculated by using following formulae:

$$\%\ \text{Dry matter} = \frac{\text{Dry weight of root}}{\text{Fresh weight of root}} \times 100$$

The length of root was measured in centimeter (cm) with a meter scale. The diameter of roots was measured in centimeter after harvest following the middle portion of the root. The number of cracked, rotten and branched roots were counted separately during harvest. Then, the percentage were calculated from the number of total roots. The concentration of β-carotene of root was determined by spectrophotometer using the following equations:

Cβ carotene = 0.216A663 - 1.22A645 - 0.304A505 + 0.452A453

Where 'C' is the concentration of carotenoid expressed in μg ml^{-1}, and A663, A645, A505 and A453 represent the absorbance [11].

2.3 Economic Analysis

The equal cost was considered in the study which was analyzed in order to find out the most economic treatment of mulch and fertilizers. All input costs include the cost for lease of land and interests on running capital were considered in computing the cost of production. The interests were calculated @ 13% for six months. The

Table 1. Nutrient composition and supplying capacity of rice straw, cow dung and mustard oil cake

Manures	Nutrient content (%)			Nutrient supplying capacity (kg t^{-1})		
	N	P	K	N	P	K
Rice straw	0.4±0.04	0.1±0.01	1.5±0.15	2.0	0.5	6.5
Cowdung (well decomposed)	1.0±0.1	0.3±0.01	0.46±0.05	5.0	1.5	2.3
Mustard oil cake	5.0±0.5	1.8±0.18	1.2±0.12	25.5	4.0	5.0

market price of carrot was considered for estimating the cost and return. Analyses were done details according to the procedure of [12]. The benefit-cost ratio (BCR) was calculated as follows:

$$\text{BCR} = \frac{\text{Gross return (Tk. ha}^{-1})}{\text{Total cost of production (Tk. ha}^{-1})} \times 100$$

2.4 Statistical Analysis

The data obtained for different characters were statistically analyzed by "MSTAT-C" program to find out the significance by evaluating analysis of variance. The significance of the difference among the treatment combinations means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability [13].

3. RESULTS AND DISCUSSION

3.1 Fresh Weight of Root

A statistically significant variation was recorded regarding fresh weight of root due to mulching and application of manures and fertilizers. A mulch of rice straw (M_1) showed the maximum (3.41 kg plot^{-1}) fresh weight of root while non-mulch plot produced the minimum (3.25 kg plot^{-1}). On the other hand, the treatment F_5 produced the maximum (3.57 kg plot^{-1}) fresh weight of root (Table 2). In case of an interaction effect, the highest fresh weight of root (4.23 kg plot^{-1}) was noted in M_1F_5 and lowest (2.94 kg plot^{-1}) was in M_0F_0 treatment (Table 3). The results suggested that the utilization of balanced nutrition through organic and inorganic fertilizers as well as with mulched condition enhanced the root growth. The sole application of higher doses of manures or fertilizers was not effective in increasing root growth either under mulched or non-mulched condition. This happening aligned with the slow release of nutrients from manures during crop growth. However, the combined application of fertilizers might be accelerated by the mineralization of organic ones and made the availability of nutrients to plants. These results were in agreement with the other researches [7,14].

3.2 Individual Root Weight

Individual root weight of carrot was statistically different due to the effects of different treatments. From Table 2, it was noted that the treatment of M_1 and F_5 showed the highest individual root weight with the value of 101.10 g and 101.90 g plant^{-1}, respectively. The interaction effect of M_1F_5 performed better in producing individual fresh weight of root which was closely followed by M_1F_4 treatment (Table 3). The results of the current study revealed that the lesser amount of mineral nutrients combined with cowdung influenced increasing the root weights of carrots under mulch conditions within the crop growth period. This result was in accordance with the result of other crops like carrots, aroids and muskmelon [14,15,16].

3.3 Dry Matter Content of Roots

Significant variation was observed due to mulching and fertilizers application on dry matter content of roots. The treatment M_1 and F_5 had the highest performance in increasing dry matter content of root over the control (Table 2). The highest (11.60%) dry matter content of root was recorded from the combination of M_1F_5 while M_0F_0 (non-mulch with no fertilizers) gave the minimum (8.20%) (Table 3). [13] obtained the similar result of dry matter content of roots from the treatments receiving cowdung with black polythene mulch on a carrot. [17] indicated that root dry matter percentages were higher with the treatment containing higher doses of potassium along with mulching.

3.4 Root Length and Diameter

Root length and diameter showed significant differences among the different treatments. A mulch of rice straw (M_1) gave the highest root length (14.41 cm) and diameter (3.10 cm). The longest length of root was also recorded from F_5 while the shortest was recorded from F_0 which was statistically identical to F_2 (Table 2). The combination of M_1F_5 produced the longest root (15.08 cm) while the shortest one (13.24 cm) recorded from M_0F_0 (Table 3). Significantly highest root length was also obtained from the study [18]. The maximum root diameter (3.48 cm) was recorded from the combination of M_1F_5 (Table 3). This result was in agreement with the results of [19] who reported that application of organic matter with NPK increased the diameter of root.

3.5 Percentage of Cracked, Rotten and Branched Root

The percentage of cracked, rotten and branched roots of carrot was significantly influenced by the

application of mulching and fertilizer trials. The maximum cracking percentage of the root (4.54%) was found from the non-mulched plot (M_0) and the minimum (3.49 %) was found from the mulched plot (M_1) (Table 2). On the other hand, rotting and branching percentage of root was highest in the mulched plot (M_1) and lowest in the non-mulched plot (M_0). Significantly highest percentage of cracked (4.67 %), rotten (3.14 %) and branched (7.58 %) root production was recorded from F_0, F_4 and F_1 treatments, respectively. The interaction effect of mulching and different sources of fertilizers showed significant variation in respect of the said parameter of roots. The highest (4.97 %) cracked root was recorded from the M_0F_2 which was closely followed by M_0F_5 and M_0F_0. The combination of M_1F_0 produced the lowest (2.70 %) cracked root of carrot (Table 3). This result of cracked root was also supported by the findings of [14] who reported that percentage of cracked root increased due to the low moisture and higher nitrogen levels. In case of rotting root, the highest (3.47 %) and lowest (0.94 %) was recorded from M_1F_1 and M_0F_0, respectively. This result indicated that the rotting percentage of root was increased in mulch treatments might be the effect of soil moisture with lack of readily available nutrients. It was considered that organic manure addition usually enhanced the soil biological activities and could be a reason for triggering higher rotten root production. Mulch of rice straw with cowdung (M_1F_1) showed the maximum (8.31 %) branched root and was statistically parallel to M_1F_2, M_1F_4 and M_1F_5 treatments. The plot treated without mulch and fertilizers (M_0F_0) gave the lowest (5.12 %) branched root of carrot (Table 3). The results of this experiment showed conformity with the findings of [20] who noted that the highest dose of nitrogen (189 kg ha^{-1}) reduced the exportable yield of carrot due to branching of roots.

3.6 Total and Marketable Yield

A statistically significant difference was recorded in terms of total and marketable yield. The mulch of rice straw (M_1) performed highest in producing a total (23.24 t ha^{-1}) and marketable (20.36 t ha^{-1}) yield of carrot. On the other hand, F_5 treatment produced the maximum amount of total yield as well as marketable yield which was dissimilar to all other treatments but closely linked to F_3 and F_4 treatments. [13] reported significantly highest yield by using straw mulch, black polythene and black paper without irrigated condition. The total yield from interaction effect between mulching and fertilizers treatments ranged from 14.11 to 28.22 t ha^{-1}. The performance of M_1F_5 was superior to all other combinations (Table 3). Similarly, the treatment combination of M_1F_5 ranked top (25.10 t ha^{-1}) for producing the marketable yield followed by M_1F_4; while M_0F_0 ranked bottom (Table 3). This might be due to steady and ready available nutrients to the crops in higher quantity as against the slow release of organic manure application. In case of manures, it required substantial time to release available nutrients for the plant. The sole application of manures either through cowdung and/or mustard oil cake or their combination showed lower yield than the combination of manures and fertilizers or sole application of fertilizers. The analogous yield increases due to the amendment of manure and fertilizers application was also reported in many studies [8,13,21] who mentioned significantly yield increase of carrot by the application of manures in addition to NPK fertilizers.

3.7 Beta-carotene Content of the Root

Mulching and the application of manures and fertilizers on carrot existed statistically significant variation of beta-carotene contents under the trial. Roots from rice straw mulch (M_1) showed the highest (7.79 mg 100^{-1} g) beta-carotene content. In case of manures and fertilizers amended treatments, the highest beta-carotene content of roots (8.77 mg 100^{-1} g) was recorded from F_5 that was followed by F_3 (Table 2). Interaction of M_1F_5 had a superior effect in respect of beta-carotene content of roots with the values of 9.87 mg 100^{-1} g. The second highest beta-carotene content of roots was noted from M_1F_3 while M_0F_0 contributed the lowest (6.72 mg/100g) beta-carotene content (Table 3). [22] suggested that the beta-carotene content of carrot root kept adequately with the organic culture. It was also apparent from the results that the incorporation of NPK in association with cowdung showed the positive effect on beta-carotene content.

3.8 Economic Analysis

Input costs for land preparation, seeds, rice straw as mulch, manures, fertilizers, and manpower required for all the operations including harvesting of carrot were recorded for unit plot and converted into cost per hectare. Prices of the carrot root were considered in market rate basis. The economic analysis was done to find out the gross and net return and the benefit-cost ratio in

Table 2. Main effects of mulching and different manures and fertilizers on yield and quality related characters of root

Treatment	Fresh wt. of root plot^{-1} (kg)	Individual root wt. plant^{-1} (g)	Dry matter content of root (%)	Root length (cm)	Root diameter (cm)	Cracked root (%)	Rotten root (%)	Branched root (%)	Total yield (t ha^{-1})	Marketable yield (t ha^{-1})	Beta-carotene content of root (mg 100^{-1} g)
Mulch											
M_0	3.25b	91.10b	9.46b	13.86b	3.08b	7.08b	4.54a	1.66b	12.36b	10.70b	7.08b
M_1	3.41a	101.10a	9.73a	14.41a	3.10a	7.79a	3.49b	2.31a	23.24a	20.36a	7.79a
CV (%)	1.20	0.42	1.21	0.51	1.84	2.33	2.10	1.39	1.12	1.28	1.95
Different manures and fertilizers											
F_0	3.09e	89.51e	9.01e	14.01c	3.00d	7.39d	4.67a	1.81f	20.77d	17.81e	7.39d
F_1	3.19d	90.00d	9.16d	14.57a	3.08c	8.11b	3.63f	2.47d	21.09d	18.89d	8.11b
F_2	3.28c	91.94c	9.76c	14.32c	3.18b	7.44c	4.45c	3.05b	21.97c	19.11c	7.44c
F_3	3.35bc	95.00b	9.71c	14.34b	3.21ab	8.78a	3.85e	2.68c	22.91b	19.60b	8.18b
F_4	3.40b	95.02b	9.98b	14.42b	3.23ab	7.62c	4.53b	3.15a	22.75b	19.89b	7.62c
F_5	3.57a	101.90a	11.30a	14.64a	3.27a	8.18b	4.29d	2.09e	23.78a	20.53a	8.78a
CV (%)	2.22	0.42	1.21	0.51	1.84	1.41	2.12	3.21	1.12	1.28	1.95

In a column having dissimilar letter(s) differ significantly as per 0.05 level of probability by DMRT (P = .05).

Table 3. Interaction effect of mulching and different manures and fertilizers on yield and quality related characters of root

Treatment combination	Fresh weight of root (kg plot^{-1})	Individual root wt. (g)	Dry matter content of root (%)	Root length (cm)	Root diameter (cm)	Cracked root (%)	Rotten root (%)	Branched root (%)	Total yield (t ha^{-1})	Marketable yield (t ha^{-1})	Beta-carotene content of root (mg 100^{-1} g)
M_0F_0	2.94g	75.00j	8.20g	13.24g	2.99f	4.44d	0.94h	5.12e	14.11g	11.18h	6.72f
M_0F_1	3.04e	81.67i	9.13f	13.61f	3.15de	4.68bc	2.50c	6.37d	20.20g	18.68e	7.19e
M_0F_2	3.20f	88.33h	9.27f	14.04e	3.06ef	4.97a	2.83b	7.14bcd	21.30f	17.92g	7.33de
M_0F_3	3.33def	100.00d	9.53e	14.32d	3.36bc	4.50d	1.64f	7.07bcd	21.08f	18.51f	7.32de
M_0F_4	3.36de	100.00d	10.00d	14.35d	3.33c	4.64c	1.88e	7.21bcd	23.68c	20.53c	7.68c
M_0F_5	3.96b	101.70c	10.73c	14.52bc	3.46ab	4.78b	1.13g	7.22bcd	23.63c	20.56c	7.63c
M_1F_0	3.26ef	90.00g	9.17f	13.70f	3.12de	2.74h	1.14g	6.99bcd	21.66e	17.98g	7.56cd
M_1F_1	3.25ef	98.33e	9.73e	14.53bc	3.20d	3.02g	2.86b	8.31a	21.76e	18.12f	7.59cd
M_1F_2	3.46d	95.00f	9.07f	14.48c	3.09def	4.10e	3.47a	7.49abc	22.63d	19.65d	7.71c
M_1F_3	3.80c	101.70c	10.73c	14.64b	3.17de	4.08e	2.55c	6.65cd	23.84c	20.60c	7.65c
M_1F_4	4.00b	106.70b	11.00b	14.97a	3.19d	3.76f	2.36d	7.77ab	26.42b	23.78b	8.73b
M_1F_5	4.23a	125.00a	11.60a	15.08a	3.48a	4.07e	2.45cd	8.25a	28.22a	25.11a	9.87a
CV%	2.22	0.42	1.21	0.51	1.84	3.11	2.77	2.99	1.12	1.28	1.95

In a column having dissimilar letter(s) differ significantly as per 0.05 level of probability by DMRT (P = .05).

Table 4. Total cost of production and net return of carrot cultivation as influenced by mulching and fertilizers treatments

Treatment	Cost of production (Tk ha^{-1})	Marketable yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Net return (Tk. ha^{-1})	Benefit cost ratio
M_0F_0	96640	11.18	167700	161060	1.74
M_0F_1	111390	18.68	280200	168810	2.52
M_0F_2	108440	17.92	268800	160360	2.48
M_0F_3	109915	18.51	277650	167735	2.53
M_0F_4	109226	20.53	307950	198724	2.82
M_0F_5	108833	20.56	308400	199567	2.83
M_1F_0	114340	17.98	269700	155360	2.36
M_1F_1	129090	18.12	271800	142710	2.11
M_1F_2	126140	19.65	294750	168610	2.34
M_1F_3	127615	20.6	309000	181385	2.42
M_1F_4	129876	23.78	356700	226824	2.75
M_1F_5	129483	25.11	376650	247167	2.91

Price (Local market): Carrot @ Tk. 15,000 t^{-1}; Rice straw @ Tk. 2 $bundle^{-1}$; CD @ Tk. 1000 t^{-1}; MOC @ Tk. 30 kg^{-1}; Urea @ Tk.16 kg^{-1}; TSP @ Tk. 24 kg^{-1}; MoP @ Tk. 16 kg^{-1}
Gross return = Total yield (t ha^{-1}) x Tk. 15,000
Net return = Gross return - Total cost of production
Benefit Cost Ratio (BCR) = Gross return/Total cost of production

the present experiment. The maximum total return (Tk. 3,76,500) was obtained from M_1F_5 and the second maximum gross return (Tk. 3,56,700) was obtained in M_1F_4 whereas the minimum (Tk. 257,700) was noted in the M_0F_0. Similarly, highest net return and benefit-cost ratio was attained from M_1F_5 (Table 4). From an economic point of view, it was obvious that mulch of rice straw along with reduced doses of manures and fertilizers was the best combination for getting more benefit by carrot cultivation in the present trial.

4. CONCLUSION

The mulch performed comparatively more pronounced in quality and yield parameters compared to non-mulch conditions. So, various mulch materials like water hyacinth, sawdust, green leaves like banana leaves may be used for further comparison. Among the manures and fertilizers amendment in this study, cowdung @ 5 t ha^{-1} along with other inorganic sources of fertilizers like urea @ 163.04 kg ha^{-1}, TSP @ 46.87 kg ha^{-1} and MoP @ 100 kg ha^{-1} under mulched condition showed better in producing total as well as marketable yield of carrot. Considering the overall results, the treatment combination of M_1F_5 was the best option for carrot cultivation profitably in this area. The addition of organic manures may be the successful and sustainable nutrient management for improving soil fertility that will be beneficial for the farmers to cultivate next crop.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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