ENHANCING CARROT YIELD THROUGH INTEGRATED USE OF ORGANIC AND CHEMICAL FERTILIZERS IN COASTAL ECOSYSTEM

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Abstract

Vegetable production in the south central coastal ecosystem of Bangladesh is exceedingly low; a major reason is farmer's unawareness about proper fertilizer management. The role of organic amendment is very important for crop production, especially vegetable crops. A study was done to evaluate the effect of integrated use of organic and chemical fertilizers on the yield and nutrient concentration of carrot (Daucus carota). The experiment was set up at Patuakhali Science & Technology University (PSTU) research farm during November 2020 to March 2021. The experiment consisted of six treatments such as T_1: 100% poultry manure (PM), T_2: 75% PM + 25% chemical fertilizers (CF), T_3: 50% PM + 50% CF, T_4: 100% CF, T_5: 75% CF and T_6: control (no manure or fertilizer); 100% CF represents 100% recommended dose of nutrients which were 125 kg N, 32 kg P, 95 kg K & 25 kg S per hectare; and 100% PM indicates 4 t ha^{-1} rate. The results reveal that the effect of integrated use of poultry manure and chemical fertilizers on the growth, yield and nutrient concentration of carrot was positive and significant. Application of 50% PM + 50% NPKS fertilizer demonstrated the highest plant height (68.5 cm), root length (12.6 cm), root diameter (4.9 cm), root weight $plant^{-1}$ (43.8 g) and root yield (25.8 t ha^{-1}), and also the highest nutrient concentrations of carrot (0.205% N, 0.035% P, 0.192% K & 0.1% S). Hence, application of poultry manure at 2 t ha^{-1} with chemical fertilizers at 63 kg N, 16 kg P, 48 kg K & 13 kg S per hectare could be the best strategy for maximizing yield and nutrient concentration of carrot in the coastal region of Bangladesh.

Keywords: Coastal ecosystem, NPKS fertilizers, Nutrient content, Poultry manure, Root yield

1. Introduction

Carrot (*Daucus carota* L) is the leading delicious vegetable that grown worldwide. In tropics and subtropics it is grown in winter season, but in temperate region it is cultivated in the spring. Being a yellow colour vegetable, it contains high amount of vitamin-A, carotene,

thiamine and riboflavin (Djoufack *et al.,* 2023). Due to good market price the farmers of Bangladesh are very much interested in cultivating carrot. Unfortunately carrot yield is much below the standard level. Apart from the farmers' unawareness, the widespread varying degrees of soil salinity might be a great cause of reduced yield of various crops in the coastal ecosystem (Jodder *et al.,* 2016; Sikder *et al.,* 2016; Haque, 2018; Kumar *et al.,* 2018). For maximizing the yield of a crop in the saline soil, both macro and micronutrients need to apply to the soil in adequate amount (Khanam *et al.,* 2000; Haque *et al.,* 2000; Haque and Hoque, 2023; Haque *et al.,* 2023a, 2023b; 2024a).

Recently silicon application deemed beneficial for various crops including rice in the coastal delta (Sultana *et al.,* 2021; Sume *et al.,* 2023; Haque *et al.,* 2023c, Mobaswera *et al.,* 2023) and maize (Haque *et al.,* 2024b). However, chemical fertilizer could have a negative impact in terms of creating soil acidity from excessive urea application and causing GHG emissions and leaching. Furthermore, the Bangladesh government is giving subsidy on fertilizers (Urea, TSP, MoP, DAP and gypsum) since it is costly to the farmers.

Instead of using sole chemical fertilizers, the integared use of organic manure with chemical fertilizers could be an effective alternative (Haque *et al.,* 2015a). Manure as a source of organic matter has multiple benefits such as improving soil aggregates, porosity, water holding capacity, chief source of N, P & S, and carbon and energy source of soil microbes (Adeleye *et al.,* 2010; Haque *et al.,* 2015b). Cowdung, poultry manure and composts are available in the rural and crop farming areas; nevertheless poultry manure has higher nutrient content compared to the other kinds of manure (Haque *et al.,* 2018).

In the recent years, huge numbers of poultry farm have grown all over the country which obviously produces a large amount of poultry feces daily. It is reported that in this country there are 2.63 crore poultry birds which expels 10.5 thousand mt feces day^{-1} (Karim *et al.* 2010). Thus, scope exists to utilize poultry manure as a good source of organic manure. Poultry farm holders use concentrates to feed their birds, so the drop out serves as a quality manure. Unlike cattle manure, poultry excreta is not used as an alternate source of fuel, rather those are highly suitable to be used as manure for crop production. Therefore, it is necessary to apply manure and fertilizers in an integrated manner in order to sustain soil health as well as crop productivity.

Neither fertilizer nor manure alone can support soil health with a satisfactory crop yield. (Khan *et al.,* 2008). Thus, integrated application of organic manure and chemical fertilizer might be the best option for improving crop productivity with sustainable soil fertility (Islam *et al.,* 2011). The present study was undertaken to evaluate the benefits of using poultry manure along with reduced amount of chemical fertilizers in carrot production and soil health in the coastal ecosystem.

2. Materials and Methods

2.1 Experimental site and soil

The experiment was conducted at the Patuakhali Science & Technology University (PSTU) research farm during the period from November 2020 to February 2021. Geographically, the research farm situated at $22^0$37' N latitude and $89^0$10' E longitudes. The study area falls under the agro-ecological zone AEZ- 13, Ganges Tidal Floodplain. This area gets affected by tidal water during monsoon. The soil of experimental field belongs to Barisal soil series. Textural class of the soil was silty clay loam. The soil was slightly acidic in reaction (pH 5.8) and non-saline (EC 1.54 dSm^{-1}). The soil contains 1.14 % organic carbon, 0.12 g kg^{-1} total nitrogen, 6.3 mg kg^{-1} available P, 0.251 cmol kg^{-1} exchangeable K, and 33.4 mg kg^{-1} available sulfur.

2.2 Treatments and design

There were six treatments including 100% poultry manure (T_1), 75% poultry manure + 25% NPKS fertilizers (T_2), 50% poultry manure + 50 % NPKS (T_3), 100% NPKS (T_4), 75% NPKS (T_5) and control (T_6). In the experiment 100% NPKS indicates 125 kg N, 32 kg P, 95 kg K and 25 kg S per hectare. The 100% poultry manure refers to 4 t ha^{-1} poultry manure. The design of the experiment was randomized complete block design (RCBD) with three replications, each block represents each replication. The sources of N, P, K, and S were urea, triple superphosphate (TSP), muriate of potash (MoP) and gypsum ($CaSO_4$ $2H_2O$), respectively. Based on the treatments and design the poultry manure, TSP, MoP and Gypsum were applied after preparing the unit plots. The urea fertilizers were devided into two equal portions: one half was applied as basal, and another half was applied at 30 days after seed sowing (DAS). The fertilizers and manures were mixed well with the soils through spading.

2.3 Experiment set up

The carrot variety was 'New Kuruda 35' which was marketed by Lal Teer Seed Company. Befor sowing, carrot seeds were immersed into water for 24 hours for rapid germination. Seeds were sown into 20 cm apart furrows with 5cm seed to seed distance on 01 December 2020. Seedlings were thinned out at 20 days after sowing. Irrigation was done whenever required. Sevin 85 WP @ 0.2 % was applied to every plot with 15 day-intervals to control soil borne insects. The crop was harvested on 05 March 2021, and soils, stubbles and fibrous roots were removed from the main root. The yield and yield component data were recorded plot-wise then coverted to t ha^{-1}. After harvest the root samples from every plot were collected and analyzed for N, P, K & S concentrations following standard procedures.

2.4 Statistical analysis

All the data were statistically analysed using STAR (Statistical Tool for Agricultural Research) software. The significant effects of the treatments were determined by analysis of variance (ANOVA) technique and the mean separation test was done at 5% level of significance by Duncan's Multiple Range Test (DMRT).

3. Results and Discussion

3.1 Plant height

Plant height at harvest was significantly influenced by the manure-fertilizer treatments showing the order: $T_3 > T_2 > T_1 \approx T_4 > T_5 > T_6$ (Table 1). So, T_3 treatment (50% PM + 50% NPKS) showed the tallest plant (68.5 cm) and T6 treatment indicated the shortest plant (25.0 cm). Treatments T_1 (100% PM), T_2 (75% PM + 25 % NPKS) and T_4 (100% NPKS) were statistically similar in plant heght. The lowest plant height of 25 cm was observed with control (T_6) treatment. Similar finding was reported by several researchers (Sudeb *et al.,* 2018; Khede *et al.* 2019; Ghimire *et al.,* 2020).

3.2 Number of leaves plant-1

The number of leaves per plant was significantly influenced by fertilizer- manure management showing a range of 6.18 to 10.5 (Table 1). The maximum number of leaves plant^{-1} was found in T_3 (50% PM + 50% NPKS) treatment which was statistically at par with treatments T_1, T_2 and T_4 treatments. The minimum number of leaves plant^{-1} (6.18) was noted in T_6 i.e. Control treatment. The results conformed to the findings of Subed *et al.* (2018), Ghimire *et al.,* (2020) and Khede *et al.,* (2019).

3.3 Root length

A remarkable difference in root length of carrot plant was noticed as an effect of different treatments (Table 1). Root length ranged from 3.87 to 12.58 cm, the highest root length being noted in T_3 (50% PM + 50% NPKS) treatment and the lowest in T_6 (Control) treatment. Treatment T_3 was not significantly different from T_1 (100% PM) and T_2 (75% PM + 25% NPKS) treatments in respect of root length. Organic manure act as conditioner of soil, and plant root feel comfortable environment when the fields are adequetly supplied with manure and fertilizers, which positively impact to maximize root growth (Haque, 2021).

3.4 Root diameter

Different amount of poultry manure with chemical fertilizers significantly influenced the root diameter of carrot (Table 1). Diameter of carrot root varied from 2.45 cm to 4.90 cm

depending on the treatments. T_3 (50%PM + 50%NPKS) treatment recorded the highest root diameter which was statistically similar to T_2 treatment. The lowest diameter of root (2.45 cm) was measured at T_6 treatment. The results are in good agreement with the findings of Khede *et al.* (2019).

Table 1. Effects of different poultry manure and fertilizer treatments on plant height, root length and root diameter of carrot

Treatments	Plant height (cm)	No. of leaves plant^{-1}	Root length (cm)	Root diameter (cm)
T_1 : 100% PM	60.7 c	10.12 a	11.70 ab	4.45 bc
T_2: 75% PM + 25% CF	63.1 b	10.19 a	11.90 ab	4.82 ab
T_3: 50% PM +50% CF	68.5 a	10.46 a	12.58 a	4.90 a
T_4: 100% CF	60.0 c	10.14 a	10.88 bc	4.18 cd
T_5: 75% CF	57.1 d	8.98 b	9.73 c	3.93 d
T_6 : Control	25.03 e	6.18 e	3.87 d	2.45 e
CV (%)	4.20	3.75	3.05	3.00
Level of significance	**	**	**	**
SE (±)	0.417	0.286	0.4148	0.0862

3.5 Total weight plant^{-1}

The total weight plant^{-1} varied significantly with different treatments (Table 2). Depending on the treatments it varied from 15.8 g to 98.8 g. The highest plant weight was recorded with T_3 (50 % PM + 50 % NPKS) treatment and the lowest plant weight in T_6 (control) treatment. Treatments T_1, T_2 and T_4 were statistically similar to each other in respect of plant weight.

3.6 Root weight plant^{-1}

Root weight plant^{-1} was significantly influenced by the differnt treatments (Table 2) showing a range of 6.84 g to 43.75 g. The maximum root weight of plant^{-1} was observed in T_3 treatment (50 % poultry manure + 50% NPKS) which was statistically similar to T_1 (100 % poultry manure) and T_2 (75 % PM + 25 % NPKS) treatments. Treatment T_1 (100 % poultry manure), T_2 (75 % PM + 25 % NPKS) and T_4 (100 % NPKS) showed statistically similar results. The minimum root weight plant^{-1} was found in control treatment.

3.7 Root yield

Root yield of carrot significantly differed with the different fertilizer and poultry manure treatments (Table 2). The root yield was found to vary from 4.51 to 25.80 t ha^{-1}. The highest yield was seen in T_3 (50 % NPKS + 50% poultry manure) treatment which was statistically similar to T_1 (100 % poultry manure) and T_2 (75 % PM + 25 % NPKS) treatments. The lowest root yield (4.51 t ha^{-1}) was noted in control treatment. Poultry manure probably improved the root yield as an effect of improved soil health which is especially important for vegetable production (Jahiruddin *et al.,* 2012).

3.8 Shoot yield

The fertilizer and manure treatments had a significant effect on shoot yield of carrot (Table 2). The shoot yield was found to vary from 4.18 to 21.72 t ha^{-1}. The highest shoot yield was noticed in T_3 (50 % poultry manure + 50% NPKS) which was statistical similar to T_1 (100 % poultry manure), T_2 (75 % PM + 25 % NPKS) and T_4 (100 % NPKS) treatments. The lowest shoot yield was found in T6 (control).

Table 2. Effects of different poultry manure and fertilizer treatments on yield parameters of carrot

Treatments	Total wt. of plant^{-1} (g)	Root weight plant^{-1} (g)	Root yield (t ha^{-1})	Shoot yield (t ha^{-1})
T_1 : 100% PM	75.1 b	40.35 ab	23.86 ab	19.40 a
T_2: 75% PM + 25% CF	72.6 bc	40.50 ab	24.06 ab	19.41 a
T_3: 50% PM +50% CF	98.8 a	43.75 a	25.80 a	21.72 a
T_4: 100% CF	70.6 bc	38.10 b	21.60 b	19.27 a
T_5: 75% CF	64.6 c	30.02 c	13.50 c	12.02 b
T_6 : Control	15.8 ab	6.84 d	4.51 d	4.18 c
CV (%)	6.17	6.11	11.04	10.93
Level of significance	**	**	**	**
SE (±)	2.30	1.22	1.34	1.10

3.9 Nutrient content in carrot

Nitrogen content in root of carrot was significantly influenced by the poultry manure and chemical fertilizer (CF) treatments (Table 3). The N concentration in carrot ranged from 0.152 % to 0.205 %, the highest N concentration was observed in T_3 (50 % PM + 50 % CF) treatment which was statistically similar to T_1, T_2 and T_4 treatments. The lowest N

concentration was noted in T_6 (control) treatment. The effect of poultry manure and chemical fertilizer showed significant differences on P concentration in carrot root (Table 3). The P concentration in carrot root was found to vary from 0.015 % to 0.036 % showing the highest P concentration in T_4 (100 % CF) and the lowest P concentration in T_6 (control). Statistically T_4 recording the highest result was identical wth T_1, T_2 and T_3 treatments.

Regarding K concentration in carrot T_3 treatment (50 % PM + 50 % CF) exhibited the maximum value of 0192% and the control treatment gave the lowest result of 0.121% (Table 3). The T_3 treatment although gave the highest value, it was not significantly different from T_4 (100 % CF) treatment. Treatments T_1 and T_2 were also statistically similar with respect to K concentration in carrot root. Similar to N, P and K concentration of carrot root, the S concentration was significantly influenced by the different treatments (Table 3) and T_3 treatment ranked the top (0.102 %) and T_6 did the bottom (0.073 %). The T_3 treatment (50 % PM + 50 % CF) in terms of root S concentration was statistically similar to T_4 (100 % CF). Treatments T_1 and T_2 were also statistically similar to one another.

Table 3. Effects of different poultry manure and fertilizer treatments on N, P, K and S concentrations in carrot root

Treatments	Nutrient concentration in carrot root (%)			
	N	P	K	S
T_1 : 100% PM	0.203 a	0.034 a	0.181 b	0.096 b
T_2: 75% PM + 25% CF	0.201 a	0.034 a	0.178 b	0.093 b
T_3: 50% PM +50% CF	0.205 a	0.035 a	0.192 a	0.100 a
T_4: 100% CF	0.204 a	0.035 a	0.191 a	0.102 a
T_5: 75% CF	0.178 b	0.019 b	0.145 c	0.082 c
T_6 : Control	0.152 c	0.015 c	0.121 d	0.073 d
CV (%)	3.91	6.94	2.47	1.94
Level of significance	**	**	**	**
SE (±)	0.0061	0.0016	0.0034	0.0014

4. Conclusions

Coastal ecosystem is far behind of vegetable production as compared to other areas of the country. Organic amendment is very important for production of any vegetable. The combined application of poultry manure with reduced rate of chemical fertilizers enhanced yield, yield attributes and nutrient concentration of carrot. Application of 50% RD of poultry manure i.e. 2 t ha^{-1} together with 50% RD of chemical fertilizers i.e. 63 kg N, 16 kg P, 48 kg K

& 13 kg S per hectare was found to be the most appropriate combination for achieving the maximizing yield and nutrient quality of carrot. Further research needs to initiate in the other parts of coastal saline areas with the same concept but in different vegetable crops.

Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this paper.

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