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Effect of Vermicompost and Biochar on Growth and Yield of Carrot in Red Lateritic Soils of Purulia District of West Bengal

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Authors' contributions

This work was carried out in collaboration among all authors. Author PB designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors BM and DCM managed the analyses of the study. Author FHR edited the whole manuscript. Author CG managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted at Horticultural Farm of Krishi Vigyan Kendra Kalyan, Purulia, West Bengal, India located at Jahajpur during Rabi season of 2019. The main objective was to determine the effectiveness of vermicompost and biochar on growth and yield of carrot. The experimental design applied was randomized block design (RBD) with three replicates for each treatment. The eight treatments comprised of T1- (Control), T2- (100% NPK), T3- (100% Biochar), T4- (50% Biochar + 50% NPK), T5- (75% Biochar + 25% NPK), T6- (100% Vermicompost), T7- (50% Vermicompost + 50% NPK), T8- (75% Vermicompost + 25% NPK). The growth parameters *i.e.* plant height, number of leaves, root length, root diameter and yield parameter fresh weight of root were analyzed during growth period and final harvesting in carrots for each treatment using standard methods. The results showed that vermicompost and biochar had a positive effect on all

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the parameters. T7- 50% Vermicompost + 50% NPK recorded highest yield of 27.67 t/ ha, while the lowest yield (12.24 t/ ha) was recorded in T1- (Control) from the carrots which did not receive any nutrients. However, yield recorded in T4- 50% Biochar + 50% NPK was at par with T8- 75% Vermicompost + 25% NPK. On the basis of the results of this study, 50% Vermicompost + 50% NPK is therefore recommended because it improves the growth parameters resulting to higher yield in carrots.

Keywords: Vermicompost; biochar; carrot; red and lateritic zone.

1. INTRODUCTION

Soil is the basic pool of plant nutrients however; it does not contain adequate reserve to supply sufficient amounts of nutrient elements to meet the increasing requirements for higher production. Carrot production can be a favourite enterprise for most small scale, resource poor farmers, since carrot is a short duration crop and higher yields can be obtained per unit area, hence profitable [1]. The key limiting factors in crop growth, development and yield are the essential nutrients (nitrogen, phosphorous and potassium) and water [2,3]. Carrot (*Daucus carota* L.) is an important vegetable among succulent vegetables consumed across the globe. Apart from its high potential for agricultural products import and export in continental trade, it is one of the exotic vegetables with high nutritive and economic value and of great demand in urban centres of the country [4]. This is cheaply available and is equally consumed by poor and rich people in Pakistan [5]. It is greatly treasured as food mostly because it is the best source of carotene; a precursor of Vitamin A [6]. The crop responds favourably to both organic and inorganic fertilizers [7]. However, excessive amount of inorganic fertilizer results in soil acidification, increased greenhouse gas (GHG) emissions, and increased eutrophication of water bodies [8]. These are detrimental to production and loss of nutritional qualities of most crops. Excessive amounts of soil organic matter also promote forking and reduce market acceptability and profitability [9]. As a way to mitigate the environmental pressure resulting from inorganic fertilizers and simultaneously improve carrot quality and yield, soil amendment using biochar has been recommended [10]. In most cases, carrot growers use synthetic fertilizers as the major supply of nutrients in order to attain higher yields and growth [11,12]. Moreover, the increasing costs of inorganic fertilizers have rendered them unaffordable to most resource-poor small scale growers. Proper use of mineral fertilizers and organic manures is of significant importance for obtaining high yield and quality produce. Organic manure can serve as a substitute to mineral fertilizers. Manures supply the required nutrients, improve soil structure, increase microbial population and at the same time maintain the quality of crop produce. These also play role to prevent adverse effects on soil health and environment [13]. In order to mitigate the negative environmental effects resulting from inorganic fertilizers and simultaneously improve the nutritional quality of carrots, a combination of biochar and inorganic fertilizers were used with a view to improve soil productivity. Vermicompost is regarded ecologically sound bio-fertilizer and also cost–effective and eco-friendly [14]. Vermicompost is a potential source of readily available nutrients, growth enhancing substances and a number of beneficial micro-organisms like N-fixing, P-solubilizing and cellulose decomposing organisms [14,15,16]. It enhances soil fertility as it increases soil porosity, aeration, moisture holding capacity, available plant nutrients, acts as a complex fertilizer granule and accelerates nitrogen mineralization [17].

No such experiment has been so far conducted in this zone on the aspect, keeping this view the experiment was designed to evaluate the effect of vermicompost and biochar in combination with chemical fertilizers on growth and yield of carrot in the red lateritic soils of Purulia district in West Bengal, India.

2. MATERIALS AND METHODS

The field experiment was conducted at Horticultural Farm of Krishi Vigyan Kendra Kalyan, Purulia, West Bengal, India located in Jahajpur during rabi season of 2019. The eight treatments are:

T1- (Control) i.e. without vermicompost, biochar and NPK;

T2- (100% NPK) i.e @ 135:135:150 kg/ ha (RDF),

T3- 100% Biochar i.e. @ 10 ton/ ha

T4- 50% Biochar + 50% NPK i.e. @ 5 ton/ ha + 50% RDF

T5- 75% Biochar + 25% NPK, i.e. @ 7.5 ton/ ha + 25% RDF

T6- 100% Vermicompost i.e. @ 6 ton/ ha

T7- 50% Vermicompost + 50 % NPK i.e. @ 3 ton/ ha + 50% RDF

T8- 75% Vermicompost + 25% NPK i.e. @ 4.5 ton/ ha + 25% RDF.

These treatments were replicated thrice and statistically analyzed in Randomized Block Design (RBD) following the standard methods by Gomez and Gomez [18]. Before planting, beds were prepared to fine tilt by ploughing using tractor. Vermicompost and biochar were incorporated into the experimental plots one week before sowing. It was applied in trenches and thoroughly mixed with the soil and buried. 135 kg N, 135 kg P_2O_5 and 150 kg K_2O which is recommended dose of fertilizer for optimum yield was applied. Out of this 90 kg each of N, P_2O_5 and K_2O was applied at the time of planting. The balance 45 kg of N & P_2O_5 along with 60 kg of K_2O was applied at 45 DAS. Thinning was done at 30 and 40 days after emergence of the plants to maintain the recommended spacing between the plants [19,20]. Other cultural practices were done as and when required. In the present study, growth and yield parameters such as average plant height (cm), number of leaves, root length (cm), root diameter (cm), root fresh weight (g) and yield (t/ ha) were recorded. Chemical properties of Biochar and Vermicompost were tested before application (Table 1). Both initial as well residual soil samples were collected to record the pH, OC, N, P_2O_5 & K_2O status in the soil (Tables 2 & 3) following the standard methods outlined by Jackson [21].

Table 1. Chemical properties of Vermicompost and Biochar

Sl. No.	Properties	Vermicompost	Biochar
1	pH	6.9	8.9
2	N (%)	1.76	0.004
3	P_2O_5 (%)	1.36	0.09
4	K_2O (%)	1.12	0.43

Table 2. Initial Soil Status of the experimental farm at red and lateritic zone of Purulia district of West Bengal

Sl. no.	Properties	Initial values
1.	pH	5.85
2.	OC (%)	0.37
3.	N (kg/ha)	152.21
4.	P_2O_5 (kg/ha)	16.13
5.	K_2O (kg/ha)	162.03

Table 3. Residual status of the soil of the experimental farm at red and lateritic zone of Purulia district of West Bengal

Treatments	pH	O C (%)	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)
T-1 (Control)	5.86	0.31	155.25	14.51	165.89
T-2 (100% NPK)	5.68	0.33	167.51	15.72	171.37
T-3 (100% Biochar)	5.93	0.55	189.68	16.40	196.26
T-4 (50% Biochar + 50% NPK)	5.84	0.43	169.50	15.36	178.37
T-5 (75 % Biochar + 25% NPK)	5.87	0.45	176.43	15.81	185.56
T-6 (100% Vermicompost)	5.99	0.51	203.23	18.33	182.84
T-7 (50% Vermicompost + 50 % NPK)	5.85	0.44	181.42	17.10	172.29
T-8 (75 % Vermicompost + 25 % NPK)	5.91	0.46	186.56	17.67	175.37
CD (0.05)	NS	0.06	6.69	2.21	17.26

3. RESULTS AND DISCUSSION

Application of chemical fertilizers, vermicompost and biochar alone or in combination significantly increased the growth and yield attributing characters of carrot in all the treatments as compared to T1- Control (Table 4). Plant height was recorded highest (26.27 cm) when applied with 50% vermicompost + 50% NPK in T-7. Laird (2010) reported that improvement in soil structure, enhanced nutrient, moisture availability and uptake that may have favoured plant growth. He also opined that due to application of organic manures and beneficial influence of bio-fertilizers releases growth promoting substances that enhances the availability of nitrogen. The data pertaining to number of leaves recorded highest in T-7 (11.78). Minimum (7.72) number of leaves was observed in T-1 (Without biochar, vermicompost & NPK). Application of 50% vermicompost + 50% NPK in T-7 recorded maximum values of all growth and yield attributing characters such as plant height (26.27 cm), number of leaves (11.78), root length (18.86 cm), root diameter (3.84 cm), fresh weight of root (110.66 gm) and yield (27.67 t/ ha). This result indicates positive effects of integrating NPK with vermicompost as well as biochar which is in conformity with the findings of Getaneh and Mezgebu [22]. Integrated application of organic manure and inorganic fertilizer increased the availability of NPK and also improved the fertility status of soil and productivity due to which yield attributing characters might have increased. Sunandarani and Mallareddy [13] in their study reported the effect of different organic manures and inorganic fertilizers on growth, yield and quality of carrot documented that maximum fresh carrot weight was significantly higher with integration of neem cake and half the recommended dose of NPK treatments. Besides NPK, micronutrients might have played an important role in increasing the growth attributing characters of carrot as addition of vermicompost and biochar increased the availability of micronutrients. Also, vermicompost and biochar might have played a vital role in increasing the yield and yield related attributes. Root yield per hectare was recorded highest (27.67 t/ ha) in the treatment combination of 50% vermicompost + 50 % NPK in T-7which was significantly superior over other treatment and minimum root yield (12.24 t/ ha) was recorded in T-1 (Control). The results are in agreement with Hasan et al. [16] who reported that the application of organic matter with NPK increased the diameter of carrot root. In agreement with the study, Yanthan et al. [23] also reported that combined application of pig manure with NPK recorded maximum plant height, number of leaves and root yield. These results are in conformity with the finding of Chumyani et al. [24] in tomato and Vimera et al. [25] in king chilli, they found that maximum growth characters with 50% NPK + 50% FYM + biofertilizers. Sunandarani and Mallareddy [13] also reported the effect of different organic manures and inorganic fertilizers on growth and yield of carrot stating that root weight was maximum in combination with half the recommended dose of NPK. Several other works have also reported the highest plant growth due to the combined application of organic manures and chemical fertilizers in tomato [26,27,28,29]. Sylvestre et al. [30] in their study on effect of poultry manure and NPK (17-17-17) on growth and yield of carrot stated that maximum carrot yield was found by integrating poultry manure with NPK which was in par with sole application of poultry manure. Kanaujia [19] reported that integrated application of chemical fertilizers, organic manures and bio-fertilizers alone or in combination significantly increased the yield and yield attributing characters of carrot compared to control. Sentiyangla et al. [31] observed

Table 4. Influence of vermicompost and biochar on growth and yield attributes of carrot

Treatments	Plant height (cm)	No. of leaves	Root length (cm)	Root diameter (cm)	Root fresh weight (gm)	Yield (t/ha)
T-1 (Control)	18.07	7.72	12.33	2.04	48.97	12.24
T-2 (100% NPK)	22.35	9.24	17.59	2.74	85.51	21.38
T-3 (100% Biochar)	19.16	8.30	14.75	2.34	56.75	14.19
T-4 (50% Biochar + 50% NPK)	23.23	9.66	17.65	2.93	92.37	23.09
T-5 (75 % Biochar + 25% NPK)	22.00	8.75	15.80	2.56	82.62	20.66
T-6 (100% Vermicompost)	21.46	8.56	15.49	2.43	77.45	19.36
T-7 (50% Vermicompost + 50 % NPK)	26.27	11.78	18.86	3.84	110.66	27.67
T-8 (75% Vermicompost + 25 % NPK)	24.25	10.55	18.11	3.17	97.11	24.28
CD (0.05)	1.091	0.572	0.743	0.266	5.221	1.305

maximum yield in radish by combination of NPK, FYM and biofertilizers. Elangovan and Sekaran [32] investigated the effect of biochar on soil properties, growth parameters and crop productivity in cotton and reported that addition of biochar to clay soil not only increased the yield of cotton but also improved the soil physio chemical properties like bulk density, particle density, porosity, hydraulic conductivity, rate of infiltration, pH, EC and organic carbon content in the post-harvest soil enhancing the cotton quality.

4. CONCLUSION

The results of this experiment indicated that application of vermicompost and/ or biochar in combination with chemical fertilizers played an important role on growth, yield and yield contributing characters of carrot. It was found that most of the characters that govern the production of carrot were influenced and increased the yield. It is also very clear from Table 3 that application of vermicompost and/ or Biochar helped the plants to get the nutrients in available form. From production, sustainability and environmental points of view, a combination of 50% vermicompost + 50% NPK may be recommended for sustainable yield of carrot and to nourish the soil fertility. It is found to be optimum for getting maximum productivity of carrot without reducing fertility status of soil. This treatment reduced 50% chemical fertilizers without any compromise on yield of carrot and fertility of soil. Therefore, it may be suggested for maximizing carrot production under red lateritic soil of Purulia District in West Bengal, India. Since the present study was conducted in only one agro ecological zone, further investigations need to be carried out in other agro- ecological zones of India.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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