

Effects of Organic and Inorganic Fertilizers on Growth and Yield of Different Crops at Charlands in Bangladesh

ABSTRACT

The experiment was conducted at the farmer's fields of three Charlands in Bangladesh during November 2019 to July 2020 for establishing new technologies for enhancement of productivity through innovative soil management practices. The experiments were established in a randomized complete block design using six treatments and three replications. Treatments of the experiments were T_1 = FP (Farmers' Practice) (Control), T_2 = RF (Recommended Fertilizer) + Vermicompost (3t/ha), T_3 = RF (Recommended Fertilizer) + Quick Compost (3t/ha), T_4 = RF (Recommended Fertilizer) + Standard Organic Fertilizers (3t/ha), T_5 = RF (Recommended Fertilizer) + Poultry Manure (3t/ha) and T_6 = RF (Recommended Fertilizer) + Biochar (3t/ha). The soil status in all selected Charlands were very low to optimum. Results of the experiment showed that application of organic fertilizers along with inorganic fertilizers produced significant ($p < 0.05$) variation in growth and yield parameters of the crops. The findings from the study showed that different organic fertilizers showed better performance compared to Farmer's practice. The statistically maximum fruit yield (41.35t/ha) of pumpkin, grain yield (3.24t/ha) of millet and tuber yield (43.69t/ha) of sweet potato was recorded in biochar treated T_6 treatment compared to other treatments. Besides, the statistically highest fresh fruit yield (29.50t/ha) of snake gourd, fresh fruit yield (20.80t/ha) of okra and yield (74.16t/ha) of indian spinach were recorded in poultry manure treated T_5 treatment compared to other treatments. Comparatively higher growth and yield of different crops were obtained from poultry manure along with inorganic fertilizers which was followed by biochar and quick compost application. It is recommended to the farmers to use organic fertilizers along with inorganic fertilizers.

Keywords: Charlands; organic fertilizers; soil status and crops yield.

1. INTRODUCTION

Bangladesh is an agricultural country where limited cultivable land is forced to maximize crop yields per unit area by intensive use of land and soil resources. Organic matter content in Bangladesh soil is alarmingly low around 1% in most and 2% in few soils, where it should be maintained at least 3% [1]. Frequent river erosion occurred and in

drought season, a large number of silted-up bodies are raised up in some parts of Bangladesh. The riverside sand and silt landmasses is known as 'char' in Bengali. The char-lands of the Jamuna-Brahmaputra, Ganges-Padma and Meghna cover 8,450 km² (6% of the total land area) with a population of 6 million in 1992-93 [2] and this char population has increased to 12 million

[3,4,5,6]. The farmers of Bangladesh use chemical fertilizers as an additional source of nutrients but they do not apply in balanced proportion [7]. During the last four decades, indiscriminate use of inorganic fertilizers, pesticides as well as fungicides without any organic manure caused environmental pollution, particularly in soil thereby affecting its fertility on long term basis [8]. Even with balanced use of only chemical fertilizer, high yield level could not be maintained over the years because of deterioration in soil physical and biological environments [9]. The use of household waste, poultry manure, cow dung and other available organic materials contributes in maintaining the long-term fertility of soils by improving its physical and chemical properties [10]. One of the alternatives to economize the use of chemical fertilizer is to incorporate crop residues or farmyard manure in combination with chemical fertilizers [11]. It is well recognized that sustainable production of crops cannot be maintained by using only chemical fertilizer and similarly it is not possible to obtain higher yield by using organic manure alone [12]. Organic manures are essential for healthy development of soil micro-organisms which further carry out biochemical transformations, play active role in decomposing organic matter and help in releasing the essential plant nutrients [13,14]. The application of organic manure had been found to have higher comparative economic advantage over the use of inorganic fertilizer [15]. However, continuous application of inorganic fertilizers helps in crop yield production but cost and availability is too high and does not improve the soil fertility like organic fertilizers [16]. Due to adverse effects of chemical fertilizers, interest has been stimulated for the use of organic manures [17]. Now it is well agreed that depleted soil fertility is a main constraint for higher crop production in Bangladesh and certainly, yield of several crops are declining in some soils [18]. Chemical fertilizers are costly too and are not always affordable to

poor farmers [19]. Poultry manure is a good source of major and minor mineral elements that are capable of enhancing soil fertility [20]. The fertility of soil could be sustained with the addition of poultry manure [21]. Vermicompost enhances soil condition for better crop germination and yield.

However due to continuous and indiscriminate use of inorganic fertilizers, the natural fertility of soil has declined. And this has rapidly leads to contamination of soil, water and food. As a result, has reduced crop yield, increased soil acidity and occurred nutrient imbalance [22,23]. The organic manuring has positive effect on soil texture and water holding capacity [24,25]. The continual productivity of agricultural systems is needed for the level of soil organic matter and the optimization of nutrient cycling to be maintained [26,27]. Nevertheless, of the provision of nutrients available for plants by organic amendments, nutrients transformation during the decomposition of organic matter strongly interacts with nutrients uptake by plants [28]. However, manures are generally very bulky and the cost of transportation is high but are safe sources of nutrition as they are environmentally friendly, release their nutrients in a slow and steady way to crop in the field thus activating soil microbial activities [29]. Constant application of heavy doses of chemical fertilizers without organic manures has led to deterioration of soil health in terms of physical as well as chemical properties of soil, decrease in soil microbial activities, and also reduction in soil humus [30]. Due to the poor soil fertility status of the charlands of Bangladesh, it is crucial to apply available organic materials in combination with synthetic chemical fertilizers for better agricultural production. Therefore, the objective of this study was to determine the effects of different organic fertilizers along with inorganic fertilizers on growth and yield of different crops in charlands of Bangladesh.

2. MATERIALS AND METHODS

The experiment was conducted at the farmer's field in Char Shaluka of Sariakandi upazila in

Bogura district, Naobhangar Char of Jamalpur Sadar upazila in Jamalpur district and Majbari Char of Kazipur upazila in Sirajgonj district

during November 2019 to March 2020 and March 2020 to July 2020 to investigate the effects of different organic fertilizers along with sweet potato, millet) and summer season (snake gourd, indian spinach, okra) crops. Geographically Char Shaluka is located in between 24° 44' to 25° 04' north latitude and 69° 45' to 89° 31' east longitude, Naobhangar Char in between 24°42' and 24°58' north

Before starting the experiment, selected organic fertilizers were collected and prepared for analysis of OC (%), N (%), P (%), S (%), Zn (%) and K (%). Besides, the initial soil samples were also collected from a depth of surface (0-15 cm) and sub-surface (15-30 cm) from the selected experimental plot to assess the nutrient status of the char land soil for pH, organic carbon (%), total N (%), available P (mg/kg), available S (mg/kg), Zn (mg/kg), Fe (mg/kg), Mn (mg/kg), Cu (mg/kg), exchangeable K (cmol (+)/kg), exchangeable Ca (cmol (+)/kg), exchangeable Mg (cmol (+)/kg) and CEC (cmol (+)/kg) by following the standard methods. Organic fertilizers and soil samples were analyzed in the laboratory of the Department of Soil Science of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU). Soil pH was measured potentiometrically using a digital pH meter in the supernatant suspension of soil to water ratio of 1:2.5 [31]. Organic carbon was determined following the wet oxidation method [31]. The percentage total nitrogen was determined using the micro Kjeldahl technique [32]. Available P was determined following Bray and Kurtz method [33]. Available S was determined by turbidity method using BaCl₂ [34]. Available Zn, Fe, Mn and Cu was determined by DTPA method [35]. Exchangeable K, Ca, Mg and CEC was determined by 1N NH₄OAc method [36].

First trials were conducted for location specific validation of these technologies in the selected 54 farmers' fields. Two seasons i.e. winter, and summer were considered for trial. Further illustration of the treatments and cropping pattern for sandbar and usual practice are presented as follows: Treatments, T₁ = FP (Farmers' Practice that means the farmers use fertilizers as their own decision) (Control), T₂ =

inorganic fertilizers application on growth and yield of some winter (pumpkin,

latitudes and in between 89°52' and 90°12' east longitudes, Maijbari Char in between 24°32' and 24°46' north latitudes and in between 89°32' and 89°48' east longitudes above the mean sea level.

RF (Recommended Fertilizer) + Vermicompost (3t/ha), T₃ = RF (Recommended Fertilizer) + Quick Compost (3t/ha), T₄ = RF (Recommended Fertilizer) + Standard Organic Fertilizers (3t/ha), T₅ = RF (Recommended Fertilizer) + Poultry Manure (3t/ha) and T₆ = RF (Recommended Fertilizer) + Biochar (3t/ha).

In all the plots, chemical fertilizer was applied in line with the fertilizer recommendation guide of the Bangladesh Agricultural Research Council [7]. For Pumpkin, the required amount of urea, TSP, MoP, gypsum, zinc sulphate and boric acid were as follows: Recommended Fertilizer (RF): N-P-K-S-Zn-B @ 100-48-80-28-3-2.1 kg/ha. For Millet the required amount of urea, TSP, MoP, gypsum and zinc sulphate were as follows: Recommended Fertilizer (RF): N-P-K-S-Zn @ 80-3-56-12-2.1 kg/ha. For Sweet Potato the required amount of urea, TSP, MoP, gypsum and zinc sulphate were as follows: Recommended Fertilizer (RF): N-P-K-S-Mg-Zn-B @ 140-60-140-20-12-3.0-1.5 kg/ha. For Snake Gourd, the required amount of urea, TSP, MoP, gypsum, zinc sulphate and boric acid were as follows: Recommended Fertilizer (RF): N-P-K-S-Zn-B @ 100-48-80-28-3-2.1 kg/ha. For Okra, the required amount of urea, TSP, MoP, gypsum, zinc sulphate and boric acid were as follows: Recommended Fertilizer (RF): N-P-K-S-Zn-B @ 120-40-80-20-3-2.1 kg/ha. For Indian Spinach the required amount of urea, TSP, MoP and gypsum were as follows: Recommended Fertilizer (RF): N-P-K-S @ 120-24-80-20kg/ha.

Biochar was prepared and supplied to the farmers for application. Being a newly introduced technology biochar is not readily available to the farmers. However, farmers were trained on preparation of biochar. Sandbar cropping is a simple, cost-effective and innovative technology that transforms silted

barren sandy lands created by flooding into arable farmland. During the initial stage of sandbar cropping, pit was dug into sandbar, which was 0.3 meter-deep and 0.5 meter in breadth and width. One jute sack filled with compost was placed into the pit. After a week, four to six seeds were placed into the compost filled sack. The pits were then monitored for the next five months and finally farmers got the results. Vermicompost (VC) was made available to the farmers' condition and applied at the rate of 3t/ha. Poultry manure (PM) was collected from nearby poultry farming house and was kept for sun drying about 1-2 weeks and then applied in the field at the rate of 3t/ha. Quick compost (QC) was prepared by the farmers' in their household condition and applied in the field at the rate of 3t/ha. It was prepared by mixing mustard oil cake, rice husk and cow dung along with required amount of water in the ratio of 5:1:4 by keeping it for

decomposition about 3-4weeks. Standard Organic Fertilizers (SOF) was collected from the nearby fertilizer shop of the selected locations and applied in the field at the rate of 3t/ha.

First and second field trial was conducted at the three selected sites (Char Shaluka, Naobhangar Char and Maijbari Char) under the present study. The test crops under the first trial were pumpkin, sweet potato and millet. The test crops under the second trial were snake gourd, indian spinach and okra.

Experimental crops yield data were collected and analyzed statistically with the help of computer package STATISTIX 10. The mean differences of the treatments were obtained from least significant difference (LSD) test at 5% level of probability for the interpretation of results [37].

3. RESULTS AND DISCUSSION

The nutrient status of the selected organic fertilizers was very high (Table 1). Therefore, organic fertilizers are the key tool to improve

nutrient status, soil health as well as better crop production in Charlands.

Table 1. Chemical characterization of organic fertilizers used in the experiment

Organic fertilizers	OC(%)	N(%)	P(%)	S(%)	Zn(%)	K(%)
Vermicompost	17.62	1.67	1.28	0.93	0.21	0.54
Quick compost	18.64	1.82	1.34	0.57	0.53	0.72
Standard organic fertilizers	17.68	2.41	2.52	0.79	0.46	0.29
Poultry manure	12.21	2.54	2.75	0.68	0.75	0.56
Biochar	41.56	3.52	0.15	0.31	0.27	0.58

All the soils were classified according to the Fertilizer Recommendation Guide [38]. At Char Shaluka, the status of pH (5.95 to 6.22) was slightly acid, OC (0.48 to 0.68%) very low, N (0.05to 0.08%) very low to low, P(13.39 to 15.13mg/kg) medium, S (15.93 to 18.23mg/kg) medium to optimum, Zn (0.52 to 0.73mg/kg)

and Fe (2.18 to 2.43mg/kg) low, Mn (1.61to 1.84mg/kg) and Cu (0.36 to 0.42mg/kg) medium, K (0.17 to 0.19Cmol (+)/kg) medium to optimum, Ca (1.76 to 1.78Cmol (+)/kg) low, Mg (0.17 to 0.18Cmol (+)/kg) very low and CEC (2.87 to 3.41Cmol (+)/kg) very low to low respectively (Table 2).

Table 2. Chemical characteristics of initial soils at 0-15cm and 15-30cm depth in the experimental site of Char Shaluka

Chemical properties	Critical levels	Soil depth (0-15cm)	Soil class	Soil depth (15-30 cm)	Soil class
pH	4.50	6.22	slightly acid	5.95	slightly acid
OC (%)	1.00	0.68	very low	0.48	very low
N (%)	0.10	0.08	low	0.05	very low
P	7.00	15.13	medium	13.39	medium
S	8.00	18.23	optimum	15.93	medium
Zn	0.50	0.73	low	0.52	low
Fe (mg/kg)	3.00	2.43	low	2.18	low
Mn (mg/kg)	1.00	1.84	medium	1.61	medium
Cu (mg/kg)	0.20	0.42	medium	0.36	medium
K (Cmol (+)/kg)	0.08	0.19	optimum	0.17	medium
Ca (Cmol (+)/kg)	2.00	1.78	low	1.76	low
Mg (Cmol (+)/kg)	0.50	0.18	very low	0.17	very low
CEC	3.00	3.41	low	2.87	very low

At Naobhangar Char, the status of pH (5.71 to 6.27) was slightly acid, OC (0.33 to 0.62%) very low, N (0.07 to 0.09%) very low to low, P (16.25 to 20.84mg/kg) and S (20.24 to 21.93mg/kg) were optimum, Zn (0.49 to 0.73mg/kg) low, Fe (2.03 to 3.36mg/kg) very low to low, Mn (1.29

to 1.87mg/k) and Cu (0.18 to 0.37mg/kg) low to medium, K (0.19 to 0.22Cmol (+)/kg) optimum, Ca (1.74 to 1.76Cmol (+)/kg) low, Mg (0.17 to 0.18Cmol (+)/kg) very low and CEC (2.34 to 3.40Cmol (+)/kg) very low to low respectively (Table 3).

Table 3. Chemical characteristics of initial soils at 0-15cm and 15-30cm depth in the experimental site of Naobhangar Char

Chemical properties	Critical levels	Soil depth (0-15cm)	Soil class	Soil depth (15-30 cm)	Soil class
pH	4.50	6.27	slightly acid	5.71	slightly acid
OC (%)	1.00	0.62	very low	0.33	very low
N (%)	0.10	0.09	low	0.07	very low
P	7.00	20.84	optimum	16.25	optimum
S	8.00	21.93	optimum	20.24	optimum
Zn	0.50	0.73	low	0.49	low
Fe (mg/kg)	3.00	3.36	low	2.03	very low
Mn (mg/kg)	1.00	1.87	medium	1.29	low
Cu (mg/kg)	0.20	0.37	medium	0.18	low
K (Cmol (+)/kg)	0.08	0.22	optimum	0.19	optimum
Ca (Cmol (+)/kg)	2.00	1.76	low	1.74	low
Mg (Cmol (+)/kg)	0.50	0.18	very low	0.17	very low
CEC	3.00	3.40	low	2.34	very low

At Maijbari Char, the status of pH (6.74 to 6.88) was neutral, OC (0.25 to 0.49) very low, N (0.08 to 0.09%) low, P (13.19 to 16.66mg/kg) medium, S (18.23 to 21.19mg/kg) optimum, Zn (0.53 to 0.69mg/kg) and Fe (2.29 to 2.35mg/kg) low, Mn (1.25 to 1.55mg/k) low to medium, Cu

(0.44 to 0.53mg/kg) and K (0.17 to 0.19Cmol (+)/kg) medium to optimum, Ca (1.65 to 1.68Cmol (+)/kg) low, Mg (0.17 to 0.18Cmol (+)/kg) very low and CEC (2.87 to 3.77Cmol (+)/kg) very low to low respectively (Table 4).

Table 4. Chemical characteristics of initial soils at 0-15cm and 15-30cm depth in the experimental site of Majibari Char

Chemical properties	Critical levels	Soil depth (0-15cm)	Soil class	Soil depth (15-30 cm)	Soil class
pH	4.50	6.88	neutral	6.74	neutral
OC (%)	1.00	0.49	very low	0.25	very low
N (%)	0.10	0.09	low	0.08	low
P	7.00	16.66	medium	13.19	medium
S	8.00	21.19	optimum	18.23	optimum
Zn (mg/kg)	0.50	0.69	low	0.53	low
Fe (mg/kg)	3.00	2.35	low	2.29	low
Mn (mg/kg)	1.00	1.55	medium	1.25	low
Cu (mg/kg)	0.20	0.53	optimum	0.44	medium
K	0.08	0.19	optimum	0.17	medium
Ca (Cmol (+)/kg)	2.00	1.68	low	1.65	low
Mg (Cmol (+)/kg)	0.50	0.18	very low	0.17	very low
CEC	3.00	3.77	low	2.87	very low

The nutrient status in all selected char lands were very low to optimum. Therefore, organic amendments are the key tool to improve

nutrient status, soil health as well as better crop production in char lands.

3.1 Results of first field trial

3.1.1 Fruit yield per plant (kg) of pumpkin in Char Shaluka, Naobhanga Char and Majibari Char

The pumpkin experiments exhibited a significant variation with regard to fruit yield per plant at Char Shaluka, Naobhangar Char and Majibari Char respectively. In Char Shaluka the fruit yield per plant ranged from 11.56 to 32.05kg and the maximum yield per plant was recorded in T₃ (32.05kg) treatment (RF+ quick compost) which was closely followed by T₆ (31.58kg) treatment but the lowest yield (11.56kg) per plant was obtained from T₁ treatment. In Naobhangar Char the fruit yield per plant ranged from 11.43 to 32.33kg and the maximum yield per plant was recorded in T₆ (32.33kg) treatment (RF+ biochar) which was closely followed by T₃ (23.98kg) and T₄ (27.56kg) treatments while the lowest yield (11.43) per plant was obtained from T₁ treatment. In Majibari Char the fruit yield per plant ranged from 11.65 to 31.09kg and the maximum yield per plant was recorded in T₆ (31.09kg) treatment (RF+ Biochar) which was closely followed by T₃ and T₄ treatments but the lowest yield (11.65kg) per plant was obtained

from T₁ treatment (Table 5). A significant variation was obtained in yield per plant in different Pumpkin genotypes in the range of 5.94 to 36.12 kg [39].

3.1.2 Fruit yield (t/ha) of pumpkin in Char Shaluka, Naobhanga Char and Majibari Char

The pumpkin experiments exhibited a significant variation with regard to fruit yield at Char Shaluka, Naobhangar Char and Majibari Char respectively. In Char Shaluka, the fruit yield ranged from 34.75 to 41.35t/ha and the maximum fruit yield (41.35t/ha) was recorded in T₆ treatment (RF+ biochar) which was closely followed by T₃, T₄ and T₅ treatments whereas the lowest fruit yield (34.75t/ha) was obtained from T₁ treatment. In Naobhangar Char the fruit yield ranged from 34.61 to 40.34t/ha and the maximum fruit yield was recorded in T₆ (40.34t/ha) treatment which was closely followed by T₅ (38.82t/ha) and T₃ (39.18t/ha) treatments while the lowest fruit yield (34.61t/ha) was found in T₁ treatment. In Majibari Char, the fruit yield ranged from 34.19 to 41.17t/ha and the maximum fruit yield was recorded in T₆ (41.17t/ha) treatment which was closely followed by T₂ and T₄ treatments while the lowest fruit yield (34.19t/ha) was found in T₁ treatment (Table 5).

Table 5. Effects of different organic manures for pit experiments with Fruit yield per plant and Fruit yield of pumpkin at the Charlands

Treatments*	Fruit yield per plant (kg)			Fruit yield (t/ha)		
	Char Shaluka	Naobhangar Char	Maijbari Char	Char Shaluka	Naobhangar Char	Maijbari Char
T ₁	11.56d	11.43d	11.65d	34.75c	34.61c	34.19c
T ₂	19.50c	19.66c	19.10c	38.01b	38.01b	39.69ab
T ₃	32.05a	23.98bc	27.98ab	39.04ab	39.18ab	38.28b
T ₄	26.34b	27.56ab	26.18ab	38.79ab	37.83b	40.01ab
T ₅	20.58c	20.15c	24.55b	39.12ab	38.82ab	37.51b
T ₆	31.58a	32.33a	31.09a	41.35a	40.34a	41.17a
CV (%)	9.72	11.74	12.41	3.85	3.33	3.66
SE (±)	1.87	2.15	2.37	1.21	1.03	1.15

*T₁= FP (Control), T₂=RF+ Vermicompost (3t/ha), T₃=RF+ Quick Compost (3t/ha), T₄=RF+ Standard Organic Fertilizer (3t/ha), T₅=RF+ Poultry Manure (3t/ha), T₆=RF+ Biochar (3t/ha), FP= Farmers' practice, RF= Recommended fertilizer, CV= Co-efficient of Variation, SE= Standard Error for Comparison, in a column figures having similar letter (s) do not differ significantly whereas figures with dissimilar letter (s) differ significantly as per LSD at 5% level of significant.

3.1.3 Plant height (cm) of millet in Char Shaluka and Naobhangar Char

The plant height of millet varied significantly (101.67 to 122.29cm) and (97.41 to 122.11cm) because of different organic manures application for field experiments in the study area at both Char Shaluka and Naobhangar Char respectively. In Char Shaluka the highest plant height (122.29cm) was observed in T₅ treatment (RF+ poultry manure) which was statistically similar with all other treatments except T₁ while the lowest plant height (101.67cm) was recorded in T₁ treatment. In Naobhangar Char the highest plant height (122.11cm) was found in T₄ treatment (RF+ standard organic fertilizer) which was statistically similar with T₃, T₆ and T₂ treatments whereas the lowest plant height (97.41cm) was obtained from T₁ treatment (Table 6).

3.1.4 Yield of straw (t/ha) of millet in Char Shaluka and Naobhangar Char

Results of the present study demonstrated that the yield of millet straw varied significantly because of different organic manures treatments that was found (2.87 to 4.32t/ha) and (2.91 to 4.23t/ha) at both Char Shaluka and Naobhangar Char. In Char Shaluka the highest yield of straw (4.32t/ha) was observed in T₆ treatment (RF+ biochar) which was statistically similar with T₅, T₄ and T₂ treatments

while the lowest yield (2.87t/ha) of straw was found in T₁ treatment. In Naobhangar Char the highest yield of straw (4.23t/ha) was found in T₆ treatment which was statistically similar with T₃, T₅ and T₄ treatments while the lowest yield (2.91t/ha) of straw was showed in T₁ treatment which was statistically similar with T₂ (3.47t/ha) treatment (Table 6).

3.1.5 Yield of grain (t/ha) of millet in Char Shaluka and Naobhangar Char

A significance variation was observed among the different treatments of millet grain yield in the study area at both Char Shaluka and Naobhangar Char. In Char Shaluka the yield of grain varied from 1.87 to 3.24t/ha and the maximum yield of grain (3.24t/ha) was found in T₆ treatment (RF+ biochar) which was statistically similar with T₅, T₄ and T₂ treatments while the lowest yield (1.87t/ha) of grain was showed in T₁ treatment. In Naobhangar Char, the yield of grain varied from 1.96 to 3.05t/ha and the highest yield of grain (3.05t/ha) was found in T₆ treatment which was statistically similar with T₅ (2.59t/ha) and T₄ (2.62t/ha) treatments. On the contrary, the lowest yield (1.96t/ha) of grain was observed in T₁ treatment which was statistically similar with T₂ (2.29t/ha) and T₃ (2.41t/ha) treatments (Table 6). Grain yield was found (2.47t/ha) of foxtail millet in their experiment [40].

Table 6. Effects of different organic manures for field experiments with yield and yield contributing characters of millet at the Charlands

Treatments*	Plant height (cm)		Yield of straw (t/ha)		Yield of grain (t/ha)	
	Char Shaluka	Naobhangar Char	Char Shaluka	Naobhangar Char	Char Shaluka	Naobhangar Char
T ₁	101.67b	97.41c	2.87c	2.91c	1.87c	1.96c
T ₂	118.82a	119.68ab	4.23a	3.47bc	3.14ab	2.29bc
T ₃	117.31a	115.05ab	3.82b	3.59ab	2.76b	2.41bc
T ₄	116.62a	122.11a	4.16ab	3.80ab	3.07ab	2.62ab
T ₅	122.29a	112.79b	3.98ab	3.77ab	3.02ab	2.59ab
T ₆	118.50a	118.36ab	4.32a	4.23a	3.24a	3.05a
CV (%)	5.08	4.15	5.46	10.05	7.64	12.37
SE (±)	4.80	3.86	0.17	0.29	0.17	0.25

*T₁= FP (Control), T₂=RF+ Vermicompost (3t/ha), T₃=RF+ Quick Compost (3t/ha), T₄=RF+ Standard Organic Fertilizer (3t/ha), T₅=RF+ Poultry Manure (3t/ha), T₆=RF+ Biochar (3t/ha), FP= Farmers' practice, RF= Recommended fertilizer, CV= Co-efficient of Variation, SE= Standard Error for Comparison, in a column figures having similar letter (s) do not differ significantly whereas figures with dissimilar letter (s) differ significantly as per LSD at 5% level of significant.

3.1.6 Tuber length (cm) of sweet potato in Maijbari Char

Tuber length varied significantly (13.41 to 19.44cm) because of different organic manures for field experiments of sweet potato in the study area of Maijbari Char. The significantly highest tuber length (19.44cm) was found in T₄ treatment (RF+ standard organic fertilizer) which was statistically similar with T₅ treatment. While the lowest tuber length (13.41cm) was showed in T₁ treatment (Table 7). Sweet potato tuber length was obtained 10.80 cm in their experiment [41].

3.1.7 Number of tuberous roots/plant of sweet potato in Maijbari Char

Number of tuberous roots/plant varied significantly (3.33 to 6.33) due to the effect of different organic manures for field experiments of sweet potato in the study area of Maijbari Char. The significantly maximum average number of tubers roots/plant (6.33) was found in T₄ treatment (RF+ standard organic fertilizer) that was statistically similar with all other treatments except T₁. However, the minimum number of tubers roots/plant (3.33) was showed in T₁ treatment (Table 7). The number of tuberous roots/plant was found 6.53 in the study report [41].

3.1.8 Yield of biomass (t/ha) of sweet potato in Maijbari Char

Yield of biomass varied significantly because of different organic manures for field experiments of sweet potato in the study area of Maijbari Char. Results of the present study showed that the yield of biomass due to different organic manures treatments varied from 25.61 to 33.34t/ha. The significantly highest yield of biomass (33.34t/ha) was obtained from T₆ treatment (RF+ biochar) which was statistically similar with all other treatments except T₁. While the lowest yield of biomass (25.61t/ha) was found in T₁ treatment (Table 7).

3.1.9 Yield of tuber (t/ha) of sweet potato in Maijbari Char

Yield of tuber varied significantly (36.08 to 43.69t/ha) because of different organic manures for the field experiments of sweet potato in the study area of Maijbari Char. The significantly highest yield of tuber (43.69t/ha) was found in T₆ treatment (RF+ biochar) which was statistically similar with T₃ and T₄ treatments. While the lowest yield (36.08t/ha) of tuber was found in T₁ treatment (Table 7). It was showed 23.12 ton/ha average production of sweet potato in a study [42]. It was found yield of tuber 22.83 ton/ha of sweet potato [41].

Table 7. Effects of different organic manures for field experiments with yield and yield contributing characters of sweet potato at Majjbari Char

Treatments*	Tuber length (cm)	No. of tuberous roots/plant	Yield of biomass (t/ha)	Yield of tuber (t/ha)
T ₁	13.41e	3.33b	25.61b	36.08d
T ₂	17.35cd	6.00a	31.34a	39.02c
T ₃	16.71d	5.33a	30.56a	42.04ab
T ₄	19.44a	6.33a	32.17a	42.44ab
T ₅	18.79ab	5.66a	32.16a	40.79bc
T ₆	18.02bc	6.00a	33.34a	43.69a
CV (%)	3.99	14.49	5.01	2.64
SE (±)	0.56	0.64	1.26	0.87

*T₁= FP (Control), T₂=RF+ Vermicompost (3t/ha), T₃=RF+ Quick Compost (3t/ha), T₄=RF+ Standard Organic Fertilizer (3t/ha), T₅=RF+ Poultry Manure (3t/ha), T₆=RF+ Biochar (3t/ha), FP= Farmers' practice, RF= Recommended fertilizer, CV= Co-efficient of Variation, SE= Standard Error for Comparison, in a column figures having similar letter (s) do not differ significantly whereas figures with dissimilar letter (s) differ significantly as per LSD at 5% level of significant.

3.2 Results of second field trial

3.2.1 Fruit yield per plant (kg) of snake gourd in Char Shaluka, Naobhanga Char and Majjbari Char

The snake gourd experiments exhibited a significant variation with regard to fruit yield per plant at Char Shaluka, Naobhangar Char and Majjbari Char respectively. In Char Shaluka the fruit yield per plant ranged from 3.45 to 8.70kg and the maximum yield per plant was recorded in T₅(8.70kg) treatment (RF+ poultry manure) which was closely followed by T₂ treatment moreover the lowest yield (3.45kg) per plant was obtained from T₁ treatment. In Naobhangar Char the fruit yield per plant ranged from 3.35 to 8.40kg and the maximum yield per plant was recorded in T₂ (8.40kg) treatment (RF+ vermicompost) which was closely followed by T₅ treatment besides the lowest yield per plant (3.35kg) was obtained from T₁ treatment. In Majjbari Char the fruit yield per plant ranged from 3.03 to 8.37kg and the maximum yield per plant was recorded in T₅ (8.37kg) treatment which was closely followed by T₂ treatment but the lowest yield per plant was obtained from T₁ (3.03kg) treatment (Table 8).

3.2.2 Fresh fruit yield (t/ha) of snake gourd in Char Shaluka, Naobhanga Char and Majjbari Char

The snake gourd experiments showed a remarkable variation of fresh fruit yield at Char Shaluka, Naobhangar Char and Majjbari Char respectively. In Char Shaluka the fresh fruit yield ranged from 17.73 to 28.80t/ha and the maximum fresh fruit yield was recorded in T₂ (28.80t/ha) treatment (RF+ vermicompost) which was closely followed by T₅ treatments while the lowest fruit yield (17.73t/ha) was found in T₁ treatment. In Naobhangar Char the fresh fruit yield ranged from 16.93 to 29.50t/ha and the maximum fresh fruit yield was recorded in T₅ (29.50t/ha) treatment (RF+ poultry manure) which was closely followed by T₂ treatments while the lowest fruit yield (16.93t/ha) was found in T₁ treatment. In Majjbari Char the fresh fruit yield ranged from 20.43 to 29.00t/ha and the maximum fresh fruit yield was recorded in both T₂ and T₅ (29.00t/ha) treatments while the lowest fruit yield (20.43t/ha) was found in T₁ treatment (Table 8). Significantly higher fruit yield (20.15 t/ha) was obtained by application of organic manure mixed with fertilizer over control with no manure treatment [43].

Table 8. Effects of different organic manures for pit experiments with fruit yield per plant and fresh fruit yield of snake gourd at the Charlands

Treatments*	Fruit yield per plant (kg)			Fresh fruit yield (t/ha)		
	Char Shaluka	Naobhangar Char	Maijbari Char	Char Shaluka	Naobhangar Char	Maijbari Char
T ₁	3.45c	3.35c	3.03c	17.73c	16.93c	20.43c
T ₂	8.00a	8.40a	8.10a	28.80a	27.90a	29.00a
T ₃	6.56b	6.23b	6.56b	25.63b	25.63b	26.00b
T ₄	6.26b	6.28b	6.26b	24.66b	24.73b	24.80b
T ₅	8.70a	8.29a	8.37a	28.43a	29.50a	29.00a
T ₆	5.92b	6.23b	6.09b	24.20b	25.66b	25.33b
CV (%)	8.26	7.25	7.53	5.45	4.16	3.78
SE (±)	0.43	0.38	0.39	1.10	0.85	0.79

*T₁= FP (Control), T₂=RF+ Vermicompost (3t/ha), T₃=RF+ Quick Compost (3t/ha), T₄=RF+ Standard Organic Fertilizer (3t/ha), T₅=RF+ Poultry Manure (3t/ha), T₆=RF+ Biochar (3t/ha), FP= Farmers' practice, RF= Recommended fertilizer, CV= Co-efficient of Variation, SE= Standard Error for Comparison, in a column figures having similar letter (s) do not differ significantly whereas figures with dissimilar letter (s) differ significantly as per LSD at 5% level of significant.

3.2.3 Number of fruits per plant of okra in Char Shaluka and Naobhangar Char

The number of fruits per plant varied significantly due to the effect of different organic manures for field experiments of okra in the study area of both Char Shaluka and Naobhangar Char. In Char Shaluka the number of fruits per plant due to different organic manures treatments varied from 24.66 to 42.00 and the maximum number of fruits per plant (42.00) was showed in T₅ treatment (RF+ poultry manure) which was statistically similar with T₂ treatment. While the minimum number of fruits (24.66) per plant was found in T₄ treatment. In Naobhangar Char, the number of fruits per plant due to different organic manures treatments varied from 25.00 to 41.66 and the maximum number of fruits per plant (41.66) was showed in T₅ treatment which was statistically similar with T₂ treatment. Whereas the minimum number of fruits (25.00) per plant was found in T₁ treatment (Table 9). It was reported that maximum fruits per plant (18.65) with chemical fertilizer + organic manure treatment over control [44].

3.2.4 Weight of fruit per plant (g) of okra in Char Shaluka and Naobhangar Char

Significant difference was observed in okra experiments in respect of weight of fruit per plant ranged from 13.20 to 25.26g and 12.00 to 25.96g at Char Shaluka and Naobhangar Char respectively. In Char Shaluka the significantly

maximum weight of fruit (25.26g) per plant was recorded in T₅ treatment (RF+ poultry manure) closely followed by T₂ and T₃ treatments and the minimum weight of fruit (13.20g) per plant was observed in T₁ treatment. In Naobhangar Char the significantly maximum weight of fruit (25.96g) per plant was recorded in T₅ treatment closely followed by T₂ and T₃ treatments and the minimum weight of fruit (12.00g) per plant was observed in T₁ treatment (Table 9).

3.2.5 Fresh fruit yield (t/ha) of okra in Char Shaluka and Naobhangar Char

The okra experiments showed a significant variation with regard to fresh fruit yield at both Char Shaluka and Naobhangar Char. In Char Shaluka the fresh fruit yield ranged from 14.53 to 20.56t/ha and the maximum fresh fruit yield was recorded in T₅ (20.56t/ha) treatment (RF+ poultry manure) which was closely followed by T₂ treatment while the lowest fresh fruit yield (14.53t/ha) was obtained from T₁ treatment which was statistically similar with T₃ and T₄ treatments. In Naobhangar Char the fresh fruit yield ranged from 15.13 to 20.80t/ha and the maximum fresh fruit yield (20.80t/ha) was recorded in T₅ treatment which was closely followed by T₂ treatment whereas the lowest fresh fruit yield (15.13t/ha) was obtained from T₁ treatment (Table 9). reported the highest yield 11.63 t/ha of Okra in the treatment comprising recommended fertilizer dose mixed with organic manure [45].

Table 9. Effects of different organic manures for field experiments with yield and yield contributing characters of okra at the Charlands

Treatments*	Number of fruits per plant		Weight of fruit per plant (g)		Fresh fruit yield (t/ha)	
	Char	Naobhangar	Char	Naobhangar	Char	Naobhangar
	Shaluka	Char	Shaluka	Char	Shaluka	Char
T ₁	29.33b	26.00c	13.20d	12.00c	14.53c	15.13b
T ₂	40.66a	41.00a	24.90ab	25.63a	19.73a	19.53a
T ₃	30.66b	30.00b	23.66abc	23.86ab	16.00bc	16.00b
T ₄	24.66c	25.00c	22.90bc	22.66b	15.93bc	16.06b
T ₅	42.00a	41.66a	25.26a	25.96a	20.56a	20.80a
T ₆	29.66b	30.66b	22.56c	22.20b	17.26b	17.06b
CV (%)	6.27	5.03	5.72	5.63	6.42	6.19
SE (±)	1.67	1.33	1.03	1.01	0.90	0.88

*T₁= FP (Control), T₂=RF+ Vermicompost (3t/ha), T₃=RF+ Quick Compost (3t/ha), T₄=RF+ Standard Organic Fertilizer (3t/ha), T₅=RF+ Poultry Manure (3t/ha), T₆=RF+ Biochar (3t/ha), FP= Farmers' practice, RF= Recommended fertilizer, CV= Co-efficient of Variation, SE= Standard Error for Comparison, in a column figures having similar letter (s) do not differ significantly whereas figures with dissimilar letter (s) differ significantly as per LSD at 5% level of significant.

3.2.6 Plant height (cm) of indian spinach in Maijbari Char

The plant height of indian spinach varied significantly (56.53 to 70.09cm) due to the effect of different organic manures for field experiments in the study area of Maijbari Char. The significantly highest plant height (70.09cm) was found in T₅ treatment (RF+ poultry manure) which was statistically similar with T₂ treatment. Whereas the lowest plant height (56.53cm) was obtained from T₁ treatment (Table 10). It was found that the highest plant height of Indian Spinach was 85.25 cm in their experiment [46].

3.2.7 Fresh yield per plant (g) of indian spinach in Maijbari Char

The indian spinach experiments exhibited a significant variation with regard to fresh yield per plant at Maijbari Char. The fresh yield per plant ranged from 631.67 to 742.97g. The significantly maximum fresh yield (742.97g) per plant was recorded in T₂ treatment (RF+ vermicompost) which was closely followed by

T₄ treatment. But the lowest yield per plant was obtained from T₁ (631.67g) treatment (Table 10).

3.2.8 Yield (t/ha) of indian spinach in Maijbari Char

The indian spinach experiments showed a significant variation of yield at Maijbari Char. The Indian Spinach yield ranged from 51.93 to 74.16t/ha. The significantly maximum indian spinach yield was recorded in T₅ (74.16t/ha) treatment (RF+ poultry manure) which was statistically similar with T₂ treatment. While the lowest Indian Spinach yield (51.93t/ha) was found in T₁ treatment (Table 10). Rahman et al. (1985) studied Indian Spinach and reported that the highest yield (62.89 ton/ha) was obtained in their experiment. The significantly maximum indian spinach yield was recorded (55.01 ton/ha) in their experiment [47]. It was reported that the highest yield of indian spinach (79.34 ton/ha) was obtained in their experiment [46].

Table 10. Effects of different organic manures for field experiments with yield and yield contributing characters of indian spinach at Majbari Char

Treatments*	Plant height (cm)	Fresh yield per plant (g)	Yield (t /ha)
T ₁	56.53c	631.67d	51.93c
T ₂	68.72a	742.97a	73.93a
T ₃	63.16b	671.17c	68.10b
T ₄	64.32b	662.63c	66.86b
T ₅	70.09a	741.87a	74.16a
T ₆	63.77b	689.73b	66.20b
CV (%)	2.38	1.37	1.85
SE (±)	1.25	7.71	1.01

*T₁= FP (Control), T₂=RF+ Vermicompost (3t/ha), T₃=RF+ Quick Compost (3t/ha), T₄=RF+ Standard Organic Fertilizer (3t/ha), T₅=RF+ Poultry Manure (3t/ha), T₆=RF+ Biochar (3t/ha), FP= Farmers' practice, RF= Recommended fertilizer, CV= Co-efficient of Variation, SE= Standard Error for Comparison, in a column figures having similar letter (s) do not differ significantly whereas figures with dissimilar letter (s) differ significantly as per LSD at 5% level of significant.

4. CONCLUSION

The fertility status of the experimental sites for both surface (0-15 cm) and sub-surface (15-30 cm) soil was very low to optimum. Results of the experiment showed that application of organic manures along with inorganic fertilizers produced significant ($p < 0.05$) variation in yield and yield contributing characters of the crops. The findings from the study showed that different organic fertilizers showed better performance compared to Farmer's practice. The maximum fruit yield (41.35t/ha) of

pumpkin, grain yield (3.24t/ha) of millet and tuber yield (43.69t/ha) of sweet potato was recorded in biochar treated T₆ treatment. Besides, the highest fresh fruit yield (29.50t/ha) of snake gourd, fresh fruit yield (20.80t/ha) of okra and yield (74.16t/ha) of Indian spinach were recorded from poultry manure treated T₅ treatment. The use of poultry manure followed by biochar and quick compost along with inorganic fertilizers increased growth and yield of different crops.

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UNDER PEER REVIEW