Original Research Article

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 Charlands in Bangladesh during November 2019 to July 2020 to investigate the effects of different organic fertilizers along with inorganic fertilizers on growth and yield of different crops. 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 findings from the study reveal 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 T_6 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 in poultry manure treated T_5 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.

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

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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 is 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 (Nutritional surveillance project, 2003). The char-lands of the Jamuna-Brahmaputra, Ganges-Padma and Meghna cover ~~some~~ 8, 450 km² (6% of the total land area) with a population of 6 million in1992-93 [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

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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]. Yield advantages accruing from the application of inorganic fertilizers but cautioned on the negative influence of their cost and availability results on the popularity of organic materials as means of enhancing native soil fertility in tropical areas [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].

However due to continuous and indiscriminate use of inorganic fertilizers, the natural fertility of soil has ~~been~~ deteriorated and rapidly leads to contamination of soil, water and food and very often associated with reduced crop yield, soil acidity and 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.

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

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 89° 31' to 69° 45' east longitude, Naobhangar Char in between 24°42' and 24°58' north latitudes and in between 89°52' and 90°12' east longitudes, Maijbari Char in between 24°38.5′ north latitudes and 89°39′ east longitudes above the mean sea level.

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 $BaCl_2$ [34]. Available Zn, Fe, Mn and Cu was determined by DTPA method [35]. Exchangeable K, Ca, Mg and CEC was determined by 1N NH_4OAc 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, 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).

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 @ 120-40-80-20-3-2.1 kg/ha.

Biochar was prepared and supplied to the farmers for application. Because, 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

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farmers got the results. Vermicompost (VC) was made available to the farmers' condition and applied at the rate of 3t/ha. Vermicompost enhances soil condition for better crop germination and yield. Poultry manure (PM) was collected from nearby sources and 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.

Experimental data were 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].

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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. Characterization of different organic fertilizers used in the experiments

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

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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).

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

Chemical properties		Soil depth (0-15cm)	Soil class	Soil depth (15-30 cm)	Soil class
pH		6.22	slightly acid	5.95	slightly acid
OC	(%)	0.68	very low	0.48	very low
N		0.08	low	0.05	very low
P		15.13	medium	13.39	medium
S		18.23	optimum	15.93	medium
Zn		0.73	low	0.52	low
Fe	(mg/kg)	2.43	low	2.18	low
Mn		1.84	medium	1.61	medium
Cu		0.42	medium	0.36	medium
K		0.19	optimum	0.17	medium
Ca	(Cmol (+)/kg)	1.78	low	1.76	low
Mg		0.18	very low	0.17	very low
CEC		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 15-3cm depth in the experimental site of Naobhangar Char

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

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Table 4. Chemical characteristics of initial soils at 0-15cm and 15-3cm depth in the experimental site of Maijbari Char

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

First 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 yield data of these crops have been shown in the following Tables.

3.1.1 Fruit yield per plant (kg)

The pumpkin experiments exhibited a significant variation with regard to fruit yield per plant at Char Shaluka, Naobhangar Char and Maijbari 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 T_3 (32.05kg) treatment (RF+ quick compost) which was closely followed by T_6 (31.58kg) treatment but the lowest yield (11.56kg) per plant was obtained from T_1 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 T_6 (32.33kg) treatment (RF+ biochar) which was closely followed by T3 (23.98kg) and T_4 (27.56kg) treatments while the lowest yield (11.43) per plant was obtained from T_1 treatment. In Maijbari Char the fruit yield per plant ranged from 11.65 to 31.09kg and the maximum yield per plant was recorded in T_6 (31.09kg) treatment (RF+ Biochar) which was closely followed by T_3 and T_4 treatments but the lowest yield (11.65kg) per plant was obtained from T_1 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)

The pumpkin experiments exhibited a significant variation with regard to fruit yield at Char Shaluka, Naobhangar Char and Maijbari 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 T_6 treatment (RF+ biochar) which was closely followed by T_3, T_4 and T_5 treatments whereas the lowest fruit yield (34.75t/ha) was obtained from T_1 treatment. In Naobhangar Char the fruit yield ranged from 34.61 to 40.34t/ha and the maximum fruit yield was recorded in T_6 (40.34t/ha) treatment which was closely followed by T_5 (38.82t/ha) and T_3 (39.18t/ha) treatments while the lowest fruit yield (34.61t/ha) was found in T_1 treatment. In Maijbari Char, the fruit yield ranged from 34.19 to 41.17t/ha and the maximum fruit yield was recorded in T_6 (41.17t/ha) treatment which was closely followed by T_2 and T_4 treatments while

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Comment [AS24]: W: This should read: Fruit yield per plant (kg) of pumpkin in Char Shaluka, Naobhanga Char and Maijbari Char. Correct subtitles 3.1.2 – 3.1.9 to reflect the specific crops and locations under discussion.

the lowest fruit yield (34.19t/ha) was found in T_1 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

*T_1= FP (Control), T_2=RF+ Vermicompost (3t/ha), T_3=RF+ Quick Compost (3t/ha), T_4=RF+ Standard Organic Fertilizer (3t/ha), T_5=RF+ Poultry Manure (3t/ha), T_6=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)

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 T_5 treatment (RF+ poultry manure) which was statistically similar with all other treatments except T_1 while the lowest plant height (101.67cm) was recorded in T_1 treatment. In Naobhangar Char the highest plant height (122.11cm) was found in T_4 treatment (RF+ standard organic fertilizer) which was statistically similar with T_3, T_6 and T_2 treatments whereas the lowest plant height (97.41cm) was obtained from T_1 treatment (Table 6).

3.1.4 Yield of straw (t/ha)

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 T_6 treatment (RF+ biochar) which was statistically similar with T_5, T_4 and T_2 treatments while the lowest yield (2.87t/ha) of straw was found in T_1 treatment In Naobhangar Char the highest yield of straw (4.23t/ha) was found in T_6 treatment which was statistically similar with T_3, T_5 and T_4 treatments while the lowest yield (2.91t/ha) of straw was showed in T_1 treatment which was statistically similar with T_2 (3.47t/ha) treatment (Table 6).

3.1.5 Yield of grain (t/ha)

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 T_6 treatment (RF+ biochar) which was statistically similar with T_5, T_4 and T_2 treatments while the lowest yield (1.87t/ha) of grain was showed in T_1 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 T_6 treatment which was statistically similar with T_5 (2.59t/ha) and T_4 (2.62t/ha) treatments. On the contrary, the lowest yield (1.96t/ha) of grain was observed in T_1 treatment which was statistically similar with T_2 (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	Naobhanga r Char	Char Shaluka	Naobhanga r Char	Char Shaluka	Naobhanga r 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

*T_1= FP (Control), T_2=RF+ Vermicompost (3t/ha), T_3=RF+ Quick Compost (3t/ha), T_4=RF+ Standard Organic Fertilizer (3t/ha), T_5=RF+ Poultry Manure (3t/ha), T_6=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)

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 T_4 treatment (RF+ standard organic fertilizer) which was statistically similar with T_5 treatment. While the lowest tuber length (13.41cm) was showed in T_1 treatment (Table 7). Sweet potato tuber length was obtained 10.80 cm in their experiment [41].

3.1.7 Number of tuberous roots/plant

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 T_4 treatment (RF+ standard organic fertilizer) that was statistically similar with all other treatments except T_1. However, the minimum number of tubers roots/plant (3.33) was showed in T_1 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)

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 T_6 treatment (RF+ biochar) which was statistically similar with all other treatments except T_1. While the lowest yield of biomass (25.61t/ha) was found in T_1 treatment (Table 7).

3.1.9 Yield of tuber (t/ha)

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 T_6 treatment (RF+ biochar) which was statistically similar with T_3 and T_4 treatments. While the lowest yield (36.08t/ha) of tuber was found in T_1 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 Maijbari 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

*T_1= FP (Control), T_2=RF+ Vermicompost (3t/ha), T_3=RF+ Quick Compost (3t/ha), T_4=RF+ Standard Organic Fertilizer (3t/ha), T_5=RF+ Poultry Manure (3t/ha), T_6=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

Second field trial was conducted in the three selected sites (Char Shaluka, Naobhangar Char and Maijbari Char) of the projects. The test crops under the second trial were snake gourd, indian spinach and okra. The yield data of these crops have been shown in the following Tables.

3.2.1 Fruit yield per plant (kg)

The snake gourd experiments exhibited a significant variation with regard to fruit yield per plant at Char Shaluka, Naobhangar Char and Maijbari 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 T_5(8.70kg) treatment (RF+ poultry manure) which was closely followed by T_2 treatment moreover the lowest yield (3.45kg) per plant was obtained from T_1 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 T_2 (8.40kg) treatment (RF+ vermicompost) which was closely followed by T_5 treatment besides the lowest yield per plant (3.35kg) was obtained from T_1 treatment. In Maijbari Char the fruit yield per plant ranged from 3.03 to 8.37kg and the maximum yield per plant was recorded in T_5 (8.37kg) treatment which was closely followed by T_2 treatment but the lowest yield per plant was obtained from T_1 (3.03kg) treatment (Table 8).

3.2.2 Fresh fruit yield (t/ha)

The snake gourd experiments showed a remarkable variation of fresh fruit yield at Char Shaluka, Naobhangar Char and Maijbari 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 T_2 (28.80t/ha) treatment (RF+ vermicompost) which was closely followed by T_5 treatments while the lowest fruit yield (17.73t/ha) was found in T_1 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 T_5 (29.50t/ha) treatment (RF+ poultry manure) which was closely followed by T_2 treatments while the lowest fruit yield (16.93t/ha) was found in T_1 treatment. In Maijbari Char the fresh fruit yield ranged from 20.43 to 29.00t/ha and the maximum fresh fruit yield was recorded in both T_2 and T_5 (29.00t/ha) treatments while the lowest fruit yield (20.43t/ha) was found in T_1 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].

Comment [AS25]: X: This should read: Fruit yield per plant (kg) of snake gourd in Char Shaluka, Naobhanga Char and Maijbari Char. Correct subtitles 3.2.2 – 3.2.8 to reflect the specific crops and locations under discussion.

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

*T_1= FP (Control), T_2=RF+ Vermicompost (3t/ha), T_3=RF+ Quick Compost (3t/ha), T_4=RF+ Standard Organic Fertilizer (3t/ha), T_5=RF+ Poultry Manure (3t/ha), T_6=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

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 T_5 treatment (RF+ poultry manure) which was statistically similar with T_2 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 T_5 treatment which was statistically similar with T_2 treatment. Whereas the minimum number of fruits (25.00) per plant was found in T_1 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)

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 T_5 treatment (RF+ poultry manure) closely followed by T_2 and T_3 treatments and the minimum weight of fruit (13.20g) per plant was observed in T_1 treatment. In Naobhangar Char the significantly maximum weight of fruit (25.96g) per plant was recorded in T_5 treatment closely followed by T_2 and T_3 treatments and the minimum weight of fruit (12.00g) per plant was observed in T_1 treatment (Table 9).

3.2.5 Fresh fruit yield (t/ha)

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 T_2 treatment while the lowest fresh fruit yield (14.53t/ha) was obtained from T_1 treatment which was statistically similar with T_3 and T_4 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 T_5 treatment which was closely followed by T_2 treatment whereas the lowest fresh fruit yield (15.13t/ha) was obtained from T_1 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 Shaluka	Naobhangar Char	Char Shaluka	Naobhangar Char	Char Shaluka	Naobhangar 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

*T_1= FP (Control), T_2=RF+ Vermicompost (3t/ha), T_3=RF+ Quick Compost (3t/ha), T_4=RF+ Standard Organic Fertilizer (3t/ha), T_5=RF+ Poultry Manure (3t/ha), T_6=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)

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 T_5 treatment (RF+ poultry manure) which was statistically similar with T_2 treatment. Whereas the lowest plant height (56.53cm) was obtained from T_1 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)

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 T_2 treatment (RF+ vermicompost) which was closely followed by T_4 treatment. But the lowest yield per plant was obtained from T_1 (631.67g) treatment (Table 10).

3.2.8 Yield (t /ha)

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 T_5 (74.16t/ha) treatment (RF+ poultry manure) which was statistically similar with T_2 treatment. While the lowest Indian Spinach yield (51.93t/ha) was found in T_1 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 Maijbari 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

*T_1= FP (Control), T_2=RF+ Vermicompost (3t/ha), T_3=RF+ Quick Compost (3t/ha), T_4=RF+ Standard Organic Fertilizer (3t/ha), T_5=RF+ Poultry Manure (3t/ha), T_6=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 T_6 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 T_5 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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