ZIBELINE INTERNATIONAL PUBLISHING

ISSN: 2710-6012 (Online)
CODEN: JWBMAO

Journal of Wastes and Biomass Management (JWBM)

DOI: http://doi.org/10.26480/jwbm.02.2021.53.61

CrossMark

RESEARCH ARTICLE

ASSESSMENT OF FARMERS ADAPTABILITY ON AKHA BIOCHAR FOR WHEAT PRODUCTION IN BANGLADESH

Md. Muktar Hossain[a], Shahjalal[a], Ahmed Khairul Hasan[b], Md Shoriful Islam[a], Md. Mahbubul Islam[c], Md Toufiq Iqbal[a*]

[a] Department of Agronomy and Agricultural Extension, University of Rajshahi, Rajshahi 6205, Bangladesh
[b] Department of Agronomy, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh
[c] Policy Advisor, Bangladesh Biochar Initiative, Dhaka, Bangladesh (www.biochar-bangladesh.org)
[*]Corresponding author email: toufiq_iqbal@yahoo.com

ARTICLE DETAILS

Article History:

Received 03 May 2021
Accepted 08 June 2021
Available online 24 June 2021

ABSTRACT

Akha biochar has the potential to exploit by farmer in Bangladesh. This study was undertaken to assess the perception of Akha biochar to utilize for wheat cultivation in the several farmer's field of Bangladesh. This study aims to assess farmer's adaptability on akha biochar for enhancing wheat production in Bangladesh. The utilization of Akha biochar as a source of nutrients supply for wheat production was investigated in this study. Akha Chula produced biochar was used as a Akha biochar source and the BARI Gom 28 was used as a testing plant. Five treatments like control (nothing was added), BARC (Bangladesh Agricultural Research Council) recommended fertilizer for wheat production, 5 kg/decimal biochar only, BARC recommended fertilizer plus 2.5 kg/decimal biochar and BARC recommended fertilizer plus 5 kg/decimal biochar. Same treatment was applied in three separate farmer's field namely Mansur, Latif and Nayan. Among three farmers, Latif farmer field was highly fertile that resulted highest wheat productivity in several treatments. Result also showed that the BARC recommended dose with 2.5 kg biochar/ decimal produced highest wheat yield among the other treatments in all farmer's field. These findings suggested that optimum level of Akha biochar amendments have potential benefits to improve soil fertility. The use of Akha biochar in addition to the chemical fertilizers in wheat production systems is an economically feasible and practical nutrient management practice. Our findings urged that reduction of chemical fertilizer application is possible with supplementation of Akha biochar. This study concluded that Akha biochar has the potential to improve soil fertility and productivity of wheat in Bangladesh.

KEYWORDS

Nutrient availability, pyrolysis process, incubation, translocation.

1. INTRODUCTION

Biochar is a term synonymously used for charcoal, char and agri-char (Warnock et al., 2007). Biochar is produced subjected to heating under limited or absence of O_2 as it undergoes physical and chemical changes (Lehmann, 2007). The concept of biochar has been developed from ancient historical charcoal added Amazonian soil knows as *Terra Preta soils*. This soil is called the black gold of Amazonian area as it is highly fertile and still sustaining high productivity. Considering the benefits of *Terra Preta Soil*, scientists devoted themselves to incorporate similar type of char (named as biochar) into soil and to harvest similar benefits (Skjimstad et al., 2002).

Biochar as a component of compost can have synergistic benefits in soil-plant system. Biochar can increase microbial activity and reduce nutrient losses during composting. In the soil-plant interaction process, the biochar becomes "charged" with nutrients, covered with microbes and pH balanced, and its mobile matter content is decomposed into plant nutrients (Dias et al., 2010). Soil biological activity is too low in Bangladeshi soil due to frequent or intensive cultivation as well as extensive chemical fertilizer application, resulting in the death of some soil microbes. For sustainable agriculture, utilization of akha biochar would be one of the most efficient techniques for replacing chemical fertilizers to address the nutrient deficiency in Bangladesh soils.

A previous study showed that rice straw biochar plus half BARC (Bangladesh Agricultural Research Council) recommended fertilizer improved growth response and yield of wheat (Iqbal, 2017). Similarly, the supplementation of rice straw biochar can reduce application of chemical fertilizer by fifty percent. Also, rice straw biochar amended soil improves wheat productivity and accumulates phosphorus in grain (Iqbal et al., 2018). Likewise, another farmer's field study found that combined application of BARC with 5 kg per decimal akha biochar enhances soil fertility and productivity of red amaranth plant (Islam et al., 2020). However, no study was conducted to quantify several farmers' adaptability of akha biochar for wheat production. Therefore, this study was undertaken to quantify the farmers acceptability of akha biochar for wheat production. It was hypothesized that combined application inorganic fertilizer with optimum level of akha biochar will improve wheat productivity. Wheat productivity will differ due to treatment effect depending on different farms' field fertility.

Quick Response Code	Access this article online	
	Website: www.jwbm.com.my	**DOI:** 10.26480/jwbm.02.2021.53.61

Cite the Article: Md. Muktar Hossain, Shahjalal, Ahmed Khairul Hasan, Md Shoriful Islam, Md. Mahbubul Islam, Md Toufiq Iqbal (2021). Assessment of Farmers Adaptability on Akha Biochar for Wheat Production in Bangladesh. *Journal of Wastes and Biomass Management, 3(2): 53-61.*

2. Materials and Methods

2.1 Chemical properties of akha biochar used in this study

Biochar is the carbon-rich solid product resulting from the heating of biomass in an oxygen-limited environment. Due to its highly aromatic structure, biochar is chemically and biologically more stable compared to the organic matter from which it was made. Generally, the properties of biochar vary widely, depending on the source of biomass used and the conditions of production of biochar (Lehman and Joseph, 2009). Physiochemical properties of the Akha biochar used in this study are shown in Table 1.

Figure 1: Akah biochar used in this study.

The akha biochar used is shown in Figure 1.

2.2 Description of wheat variety under this study

The recently released Bangladesh Agricultural Research Institute (BARI) wheat variety BARI Gom 28 was used as a testing plant. The yield performance of BARI Gom 28 is best among all recently BARI released wheat varieties in Rajshahi region of Bangladesh and was selected for this reason to use in this study. The pedigree of BARI Gom 28 is shown in Table 2.

2.3 Akha biochar application to the field

Akha biochar was applied in the field according (Dias et al., 2010). Akha biochar was ground properly before mixing with soil and added and mixed to the soil 14 days before seed sowing. Akha biochar was incorporated into the soil in the field by evenly spread the desired amount onto the soil according to treatments, and tilled by hand.

2.4 Soils

These experiments were conducted at the brined tract region of Bangladesh. The experimental soils were located in the Naogaon region which was located at 5th AEZs (Agroecological Zone) of Bangladesh named Lower Atrai Basin. The texture of the soil was clay, clay loam and silty clay. The organic matter status and soil fertility was high and the pH of the soil was in between 8.0 to 8.6 (Bhuiya et al., 2005). The initial soil basic physiochemical properties are shown in Table 3. Initial soil was collected from control (nothing was added) plots before wheat seed sown. Final soil was collected from 5 kg/decimal akha biochar treated plots after wheat plant harvest.

2.5 Experimental design and treatments

The experiment was laid out in randomized completely block design (RCBD) with three replications. The treatments were (T_0) Control (nothing was added), (T_1) BARC recommended fertilizer (T_2) Biochar only (5 kg/decimal) (T_3) BARC recommended fertilizer with biochar (2.5 kg/decimal), (T_4) BARC recommended fertilizer with biochar (5 kg/decimal).

2.6 Fertilizer additions

Several tiny fertilizer doses were added in separate plots according to BARC recommended fertilizer doses for wheat production in Bangladesh. Fertilizer was added according to initial soil basic physical and chemical properties. Magnesium was not added to the soil due its availability to the initial soil as well as availability within akha biochar. The amount of fertilizer mixed within soil is shown in Table 4.

2.7 Experimental procedure

Biochar was mixed at different doses within the field soil and keep 7 days for incubation into the soil. Plot size for each replication was 1m × 1m. Seeds were well germinated before sowing. Wheat plants were harvested at maturity. Maturity of wheat plant was determined of the crops become golden yellow colour and was made crunching sound when wheat grain was pressed under teeth. The harvest of wheat plant from each pot was bundled separately and tagged for yield data collection. Yield and yield components parameters like number of total tiller per plant, number of effective tillers per plant, number of non-effective tillers per plant, spike length, number of grains per spike, 1000-grain weight, grain yield, straw yield, biological yield and harvest index was determined. Grain yields were determined by harvested wheat plant samples. The harvested wheat plant samples was threshed, dried and weighed using an electric balance and values were expressed in gram per plot. After separation of grain from wheat plants, the straw was sun dried and weighed using balance and the value was converted into gram per hectare. Grain yield and straw yield together was regarded as biological yield.

2.8 Initial and bulk soil physiochemical properties measurement

The pH of the bulk soil was determined in deionized water using a soil-to-solution ratio of 1:5. Organic carbon of the bulk soil samples was determined by wet oxidation method (Walkley and Black, 1934). Bulk soil organic matter content was determined by multiplying the percent value of organic carbon with the conventional Van-Bemmelen's factor of 1.724 (Piper, 1966). The nitrogen content of the bulk soil sample was determined by distilling soil with alkaline potassium permanganate solution (Subbiah and Asija, 1956). The distillate was collected in 20 ml of 2% boric acid solution with methylred and bromocresol green indicator and titrated with 0.02 N H_2SO_4 (Podder et al., 2012). Bulk soil available S (ppm) was determined by calcium phosphate extraction method with a spectrophotometer at 535 nm (Petersen et al., 1996). The soil available K was extracted with 1N NH_4OAC and determined by an atomic absorption spectrometer (Biswas et al., 2012). The available P of the bulk soil was determined by spectrophotometer at a wavelength of 890 nm. The bulk soil sample was extracted by Olsen method with 0.5 M $NaHCO_3$ (Huq and Alam, 2005). The Zn in the bulk soil sample was measured by an atomic absorption spectrophotometer (AAS) after extracting with DTPA (Soltanpour and Schwab, 1997).

2.9 Statistical analysis

Results were analyzed by a one-way or two-way analysis of variance (ANOVA) using Genstat 12th ed^{n} for Windows (Lawes Agricultural Trust, UK). The data was analysed for ANOVA and comparison of means of control and akha biochar treatments for determination of significance of farmer's field effect on growth and yield characters of wheat plant. In order to investigate the effect of farmer's adaptability on akha biochar on wheat plant growth response, wheat plant yield, three separate farmer's field and bulk soil physiochemical properties data was analyzed using the Statistical Analysis System (SAS9.1.3). All of the statistical testing were performed based on $P \leq 0.05$ as the critical level for the Tukey test.

3. Results

3.1 Experimental field soil properties

Of the three experimental fields, Mansur farmer field, had the highest fertility, followed by Latif, and Nayan having the lowest fertility (Table 5). Soil pH varied between 8.0 to 8.3 in the three farmer's field, while Arbuscular Mycorrhizae Fungi (AMF) varied between 43 to 51 nos/10 g soil in three farmer's field (Table 5). Soil Organic Matter (SOM) varied from 1.29 to 1.39%, with total nitrogen (TN) content varying between 0.06 to 0.08% in three experimental fields (Table 5).

3.2 Wheat plant growth response

Plant height was measured with 15 days interval. Wheat plant height at 15 DAS for the field at Mansur was 15.38, 16.37, 15.78, 17.67 and 17.53 cm for the control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Wheat plant height at 15 DAS for the farmer of Latif was 14.51, 16.06, 15.41, 17.55 and 16.48 cm under same treatment. Wheat plant height at 15 DAS for the farmer of Nayan was 13.04, 13.63, 14.20, 15.86 and 15.01 cm for control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively (Figure 2a).

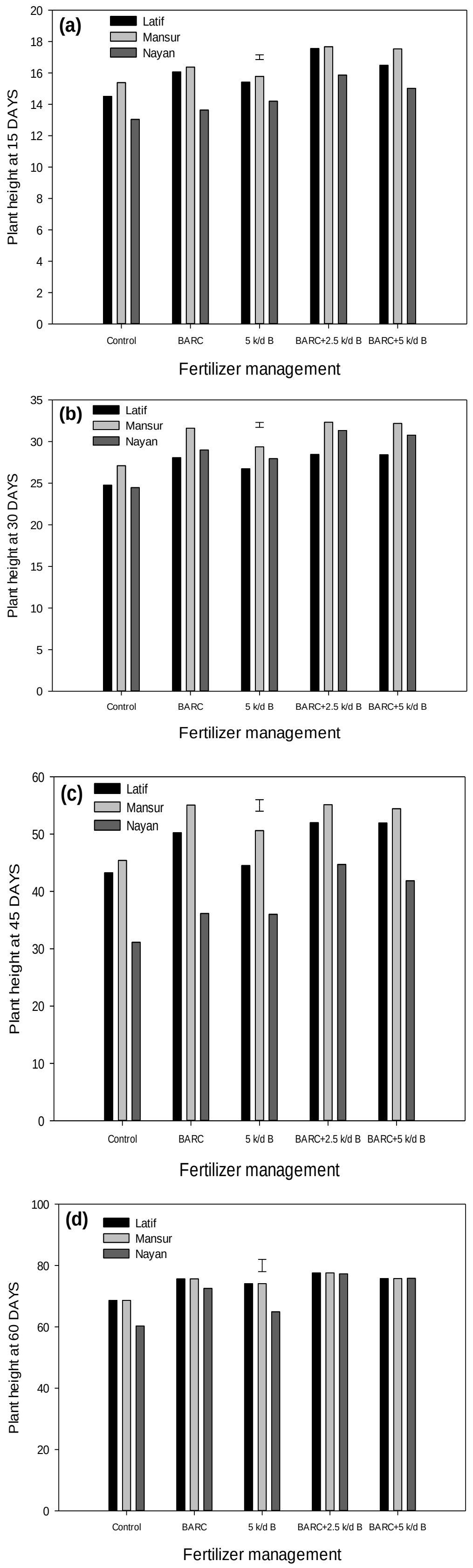


Figure 2: (a-d) Plant height at different days after sowing. Vertical bar represents LSD ($P \geq 0.05$) for fertilizer management× interaction. Where, BARC means Bangladesh Agricultural Research Council recommended fertilizer. k/d B means kg/decimal biochar. Data were means of three replicates.

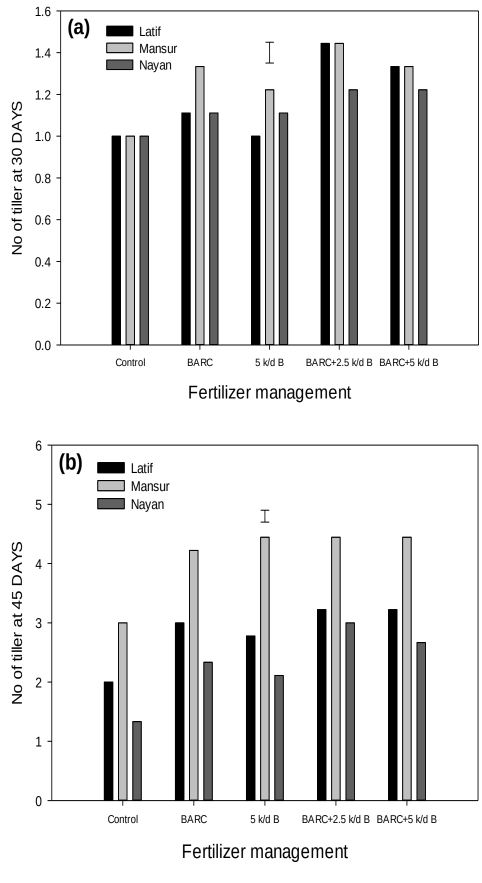
Wheat plant height at 30 DAS for the field at Mansur was 27.09, 31.61, 29.35, 32.31and 32.17 cm for control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Wheat plant height at 30 DAS for the field at Latif was 24.75, 28.05, 26.73, 28.45 and 28.42 cm for the control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Wheat plant height at 30 DAS for the field at Nayan was 24.47, 28.98, 27.94, 31.33 and 30.76 cm for the control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively (Figure 2b).

The wheat plant growth response was highest in the Mansur farmer's field. Plant height at 45 DAS for the farmer of Mansur was 45.41, 55.06, 50.60, 55.11 and 54.41cm for the control, BARC, 5 kg biochar only, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatments, respectively. Wheat plant height at 45 DAS for the field at Latif was 43.23, 50.23, 44.51, 51.99 and 51.92 cm for the control, BARC, 5 kg biochar only, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatments, respectively. Wheat plant height at 45 DAS for the field at Nayan was 31.12, 36.15, 36.01, 44.70 and 41.85 cm for the control, BARC, 5 kg biochar only, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatments, respectively (Figure 2c).

Plant height at 60 DAS was highly ($P \leq 0.001$) for the fertilizer management (Table 6). Plant height at 60 DAS for the field at Mansur was 68.60, 75.63, 74.06, 77.58 and 75.72 cm for the control, BARC, 5 kg biochar only, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Wheat plant height at 60 DAS for the field at Latif was 69.70,76.73, 76.66, 79.78 and 76.92 cm for the control, BARC, 5 kg biochar only, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Wheat plant height at 60 DAS for the field at Nayan was 60.26,72.53, 64.91, 77.27 and 75.80 cm for the control, BARC, 5 kg biochar only, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatments, respectively (Figure 2d).

Number of tillers at 30 days for the field at Mansur was 1.00,1.33,1.22,1.44 and 1.33 for the control, BARC, 5 kg biochar only, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatments, respectively. Number of tillers at 30 DAS for the field at Latif was 1.00,1.11,1.00,1.44 and 1.33 under control, BARC, 5 kg biochar only, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Number of tiller at 30 DAS for the farmer of Nayan was 1.00,1.11, 1.11, 1.22 and 1.22 under control, BARC, 5 kg biochar only, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatments, respectively (Figure 3a).

Number of tiller at 45 days for the farmer of Mansur was 3.00,4.22,4.44,4.44 and 4.44 under control, BARC, 5 kg biochar only, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatments, respectively. Likewise, number of tiller at 45 DAS for the farmer of Latif was 2.00,3.00,2.77,3.22 and 3.22 under control, BARC, 5 kg biochar only, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatments, respectively. Similarly, number of tiller at 45 DAS for the farmer of Nayan was 1.33,2.33, 2.11, 3.00 and 2.66 under control, BARC, 5 kg biochar only, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatments, respectively (Figure 3b).



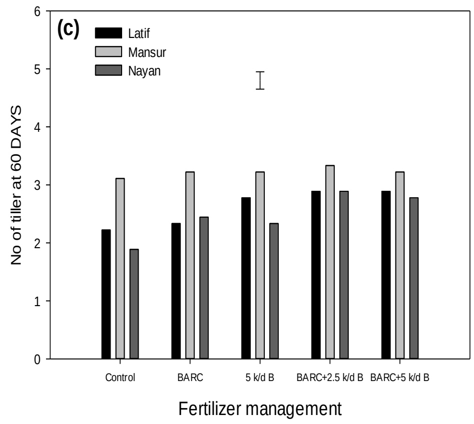
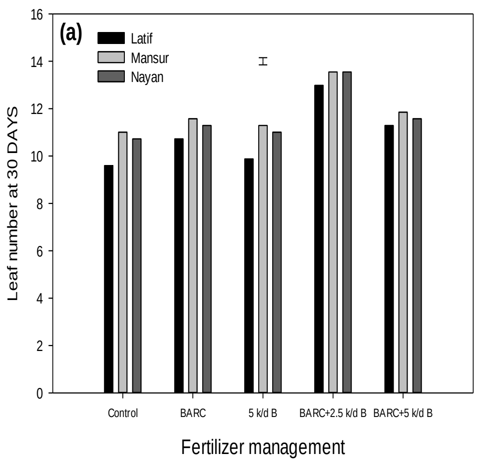
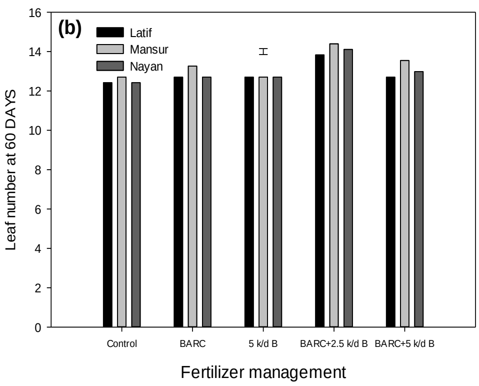


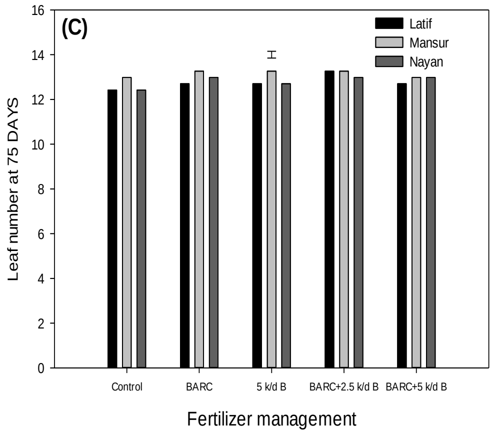
Figure 3: (a-c) No of tiller at different days after sowing. Vertical bar represent LSD ($P≥0.05$) for fertilizer management× interaction. Where, BARC means Bangladesh Agricultural Research Council recommended fertilizer. k/d B means kg/decimal biochar. Data were means of three replicates.

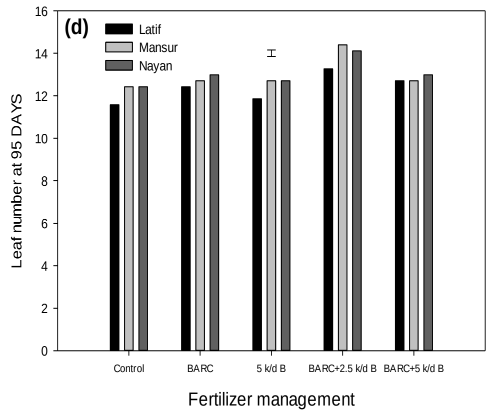
Number of tiller at 60 days for the farmer of Mansur was 3.11,3.22,3.22,3.33 and 3.22 under control, BARC, 5 kg biochar only, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatments, respectively. Likewise, number of tiller at 60 DAS for the farmer of Latif was 2.22,2.33,2.77,2.88 and 2.88 under control, BARC, 5 kg biochar only, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatments, respectively. Similarly, number of tiller at 60 DAS for the farmer of Nayan was 1.88,2.44, 2.33, 2.88 and 2.77 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatments, respectively (Figure 3c).

Leaf number at 30 DAS differ significantly ($P≥0.05$) among fertilizer management, farmers and fertilizer management × farmers interaction (Table 5). Leaf number at 30 Days for the farmer of Mansur was 11.00,11.57,11.28,13.54 and 11.85 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Likewise, number of leaf at 30 DAS for the farmer of Latif was 9.59,10.72,9.87,12.98 and 11.28 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Similarly, number of leaf at 30 DAS for the farmer of Nayan was 10.72,11.28, 11.00, 13.54 and 11.57 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively (Figure 4a).









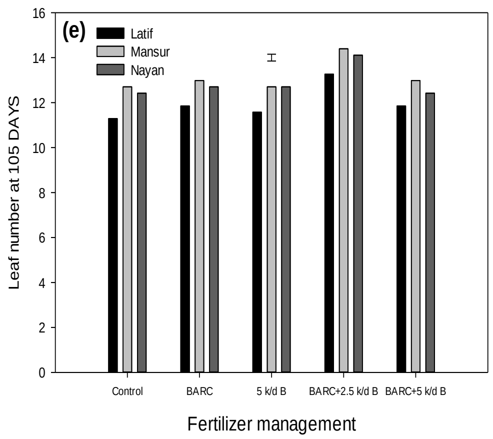


Figure 4: (a-e) Leaf number at different days after sowing. Vertical bar represent LSD ($P≥0.05$) for fertilizer management× interaction. Where, BARC means Bangladesh Agricultural Research Council recommended fertilizer. k/d B means kg/decimal biochar. Data were means of three replicates.

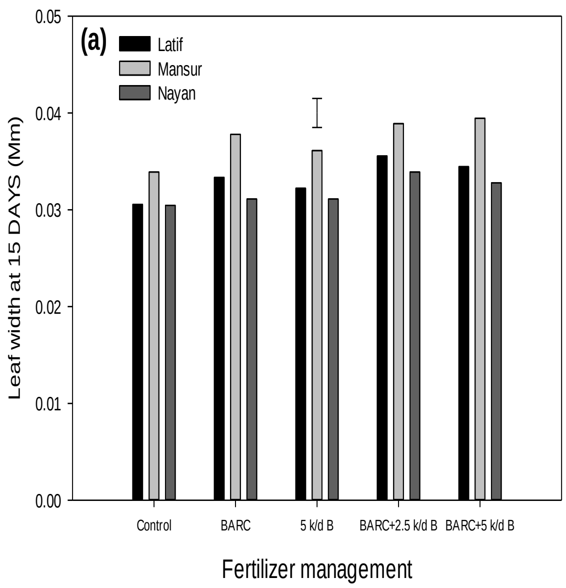
Leaf number at 60 DAS for the farmer of Monsor was 12.70,13.26,12.70,14.39 and 13.54 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Likewise, number of leaf at 60 DAS for the farmer of Latif was 12.41,12.70,12.70,13.82 and 12.70 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Similarly, number of leaf at 60 DAS for the farmer of Nayan was 12.41,12.70,12.70,14.11 and 12.98 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively (Figure 4b).

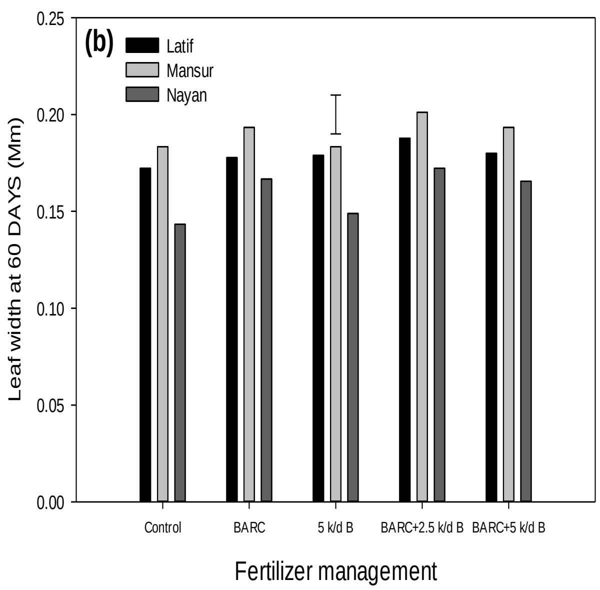
Leaf number at 75 DAS for the farmer of Monsor was 12.98,13.26,13.26,13.26 and 12.98 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Likewise, number of leaf at 75 DAS for the farmer of Latif was 12.41,12.70,12.70,13.26 and 12.70 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Similarly, number of leaf at 75 DAS for the farmer of Nayan was 12.41,12.98,12.70,12.98 and 12.98 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively (Figure 4c).

Leaf number at 90 DAS for the farmer of Monsor was 12.41,12.70,12.70,14.39 and 12.70 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Likewise, number of leaf at 90 DAS for the farmer of Latif was 11.57,12.41,11.85,13.26 and 12.70 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Similarly, number of leaf at 90 DAS for the farmer of Nayan was 12.41,12.98,12.70,14.11and 12.98 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively (Figure 4d).

Leaf number at 105 DAS for the farmer of Monsor was 12.70,12.98,12.70,14.39 and 12.98 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Likewise, number of leaf at 105 DAS for the farmer of Latif was 11.28,11.85,11.57,13.26 and 11.85 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Similarly, number of leaf at 105 DAS for the farmer of Nayan was 12.41,12.70,12.70,14.11 and 12.41 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively (Figure 4e).

Leaf width at 15 DAS differed significantly ($P \geq 0.05$) for the fertilizer management (Table 6). Leaf width at 15 DAS for the farmer of Monsor was 0.04,0.03,0.03,0.03 and 0,04 Mm under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Similarly, wheat leaf width at 15 DAS for the farmer of Latif was 0.03, 0.03, 0.04, 0.04 and 0.04 Mm under same treatment. Likewise, wheat leaf wide at 15 DAS for the farmer of Nayan was 0.03,0.03,0.03,0.03 and 0.03 Mm under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively (Figure 5a).





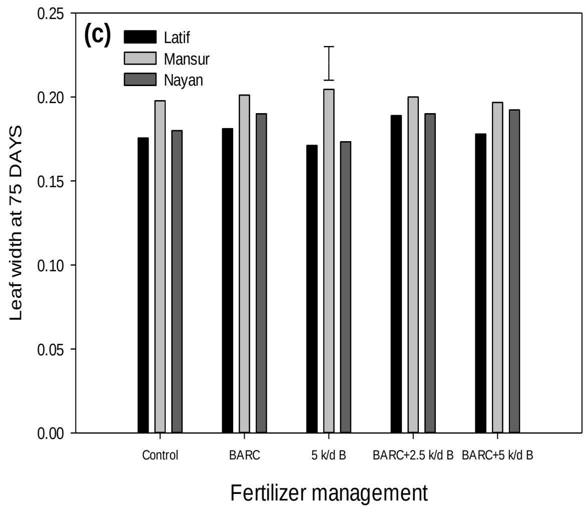
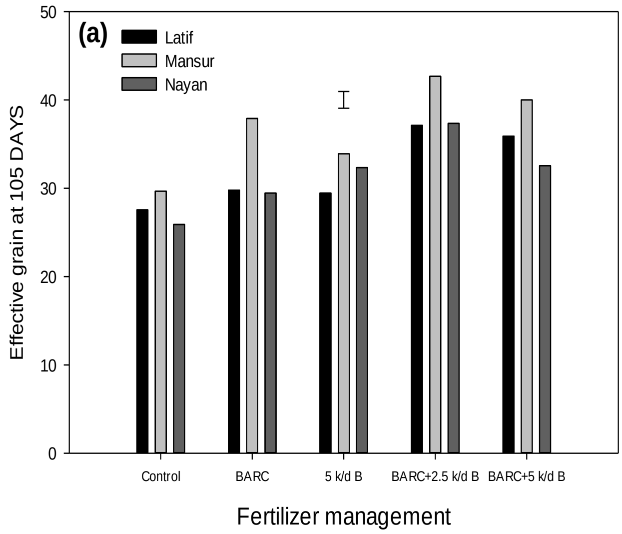


Figure 5: (a-c) Leaf width at different days after sowing. Vertical bar represents LSD ($P \geq 0.05$) for fertilizer management× interaction. Where, BARC means Bangladesh Agricultural Research Council recommended fertilizer. k/d B means kg/decimal biochar. Data were means of three replicates.

Leaf wide at 60 DAS for the farmer of Monsor was 0.18, 0.19, 0.20, 0.18 and 0.19 Mm under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Similarly, wheat leaf wide at 60 DAS for the farmer of Latif was 0.14, 0.17, 0.15, 1.17 and 0.17 Mm under same treatment. Likewise, wheat leaf wide at 60 DAS for the farmer of Nayan was 0.18,0.18,0.17,0.18 and 0.19 Mm under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively (Figure 5b). Leaf width at 75 DAS for the farmer of Monsor was 0.20,0.20,0.20,0.20 and 0.20 Mm under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Similarly, wheat leaf width at 75 DAS for the farmer of Latif was 0.18, 0.18, 0.17, 0.19 and 0.18 Mm under same treatment. Likewise, wheat leaf width at 75 DAS for the farmer of Nayan was 0.18,0.19,0.17,0.19 and 0.19 Mm under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively (Figure 5c).

3.3 Wheat plant yield response

Differences in effective grain at 105 DAS were highly significant ($P \geq 0.001$) among fertilizer treatments (Table 7). Effective grain at 105 DAS for the farmer of Monsor was 29.66, 37.88, 33.88,42.66 and 40.00 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatments, respectively. Likewise, number of effective grain at 105 DAS for the farmer of Latif was 27.55,29.77,29.44,37.11 and 35.88 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Similarly, number of effective grain at 105 DAS for the farmer of Nayan was 25.88, 29.44, 32.33, 37.33 and 32.55 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatments, respectively (Figure 6a).



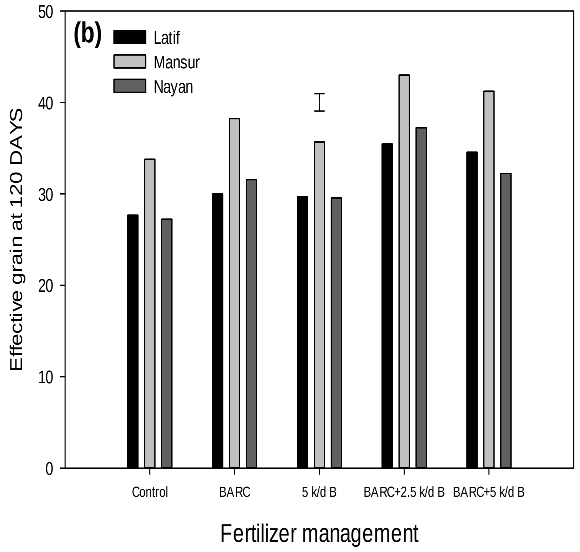
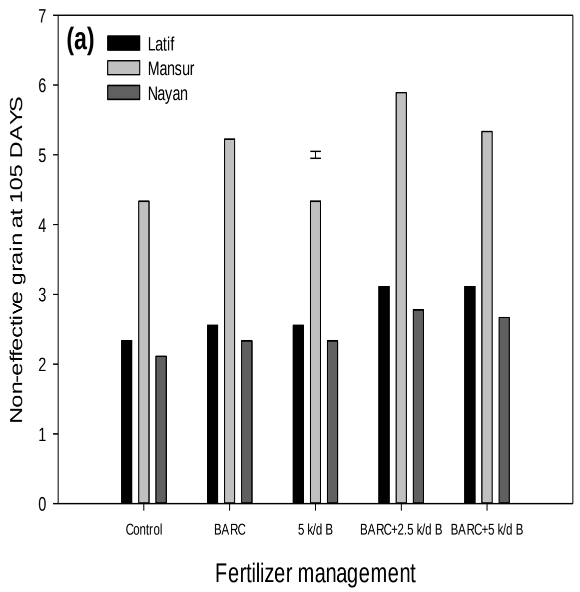


Figure 6: (a-b) Effective grain at different days after sowing. Vertical bar represent LSD (P≥0.05) for fertilizer management× interaction. Where, BARC means Bangladesh Agricultural Research Council recommended fertilizer. k/d B means kg/decimal biochar. Data were means of three replicates.

Effective grain at 120 DAS for the farmer of Mansur was 33.78,38.22,35.67,45.00, and 41.22 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Likewise, number of effective grain at 120 DAS for the farmer of Latif was 27.67,30.00,29.67,35.44 and 34.56 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Similarly, number of effective grain at 120 DAS for the farmer of Nayan was 27.22,31.56,29.56,37.22 and 32.22 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively (Figure 6b).

Non-effective grain at 105 DAS was highly significant (P≤0.001) among fertilizer management, farmers and fertilizer management × farmer's interaction. Non-effective grain at 105 DAS for the farmer of Mansur was 4.333, 5.222, 4.333, 5.889 and 5.333 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Likewise, number of effective grain at 105 DAS for the farmer of Latif was2.332, 2.556, 2.556, 3.111 and 3.111 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Similarly, number of effective grain at 120 DAS for the farmer of Nayan was 2.111, 2.333, 2.333, 2.778 and 2.667 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively (Figure 7a).



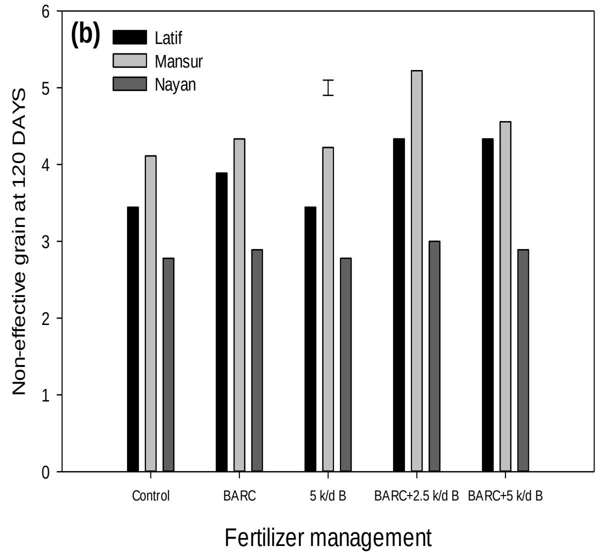


Figure 7: (a-b) non-effective grain at different days after sowing. Vertical bar represents LSD (P≥0.05) for fertilizer management× interaction. Where, BARC means Bangladesh Agricultural Research Council recommended fertilizer. k/d B means kg/decimal biochar. Data were means of three replicates.

Non-effective grain at 120 DAS for the farmer of Mansur was 4.111, 4.333, 4.222, 5.222 and 4.556 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Likewise, number of effective grain at 120 DAS for the farmer of Latif was 3.444, 3.889, 3.444, 4.333 and 4.333 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatments, respectively. Similarly, number of effective grain at 120 DAS for the farmer of Nayan was 2.778, 2.889, 2.778, 3.000 and 2.889 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively (Figure 7b).

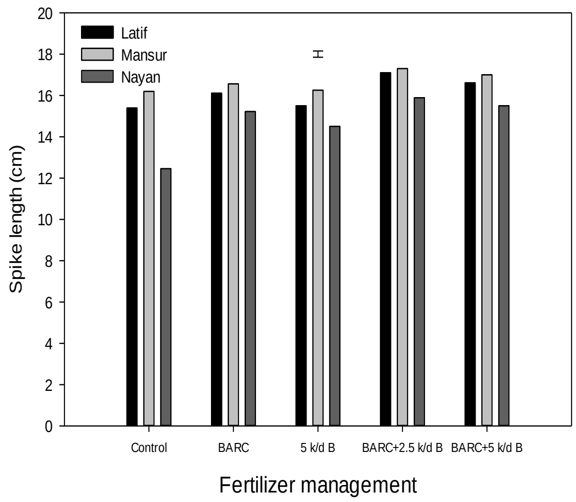


Figure 8: Spike length of wheat plant that grown in three separate farmer's field. Vertical bar represent LSD (P≥0.05) for fertilizer management× interaction. Where, BARC means Bangladesh Agricultural Research Council recommended fertilizer. k/d B means kg/decimal biochar. Data were means of three replicates.

Spike length for the farmer of Mansur was 16.189, 16.556, 16.26, 17.30 and 17.00 cm under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Likewise, spike length for the farmer of Latif was 15.389, 16.111, 15.500, 17.10 and 16.61 cm under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatments, respectively. Similarly, spike length for the farmer of Nayan was 12.456, 15.222, 14.500, 15.889 and 15.50 cm under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively (Figure 8).

Thousand grain weight for the farmer of Mansur was 43.33, 46.73, 47.76, 46.46 and 46.36 g under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatments, respectively. Likewise, thousand grain weight for the farmer of Latif was 42.8, 43.36, 47.36, 47.4 and 46.2 g under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatments, respectively. Similarly, thousand grain weight for the farmer of Nayan was 41.83, 41.13, 41.06, 45.1 and 43.1g under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively (Figure 9).

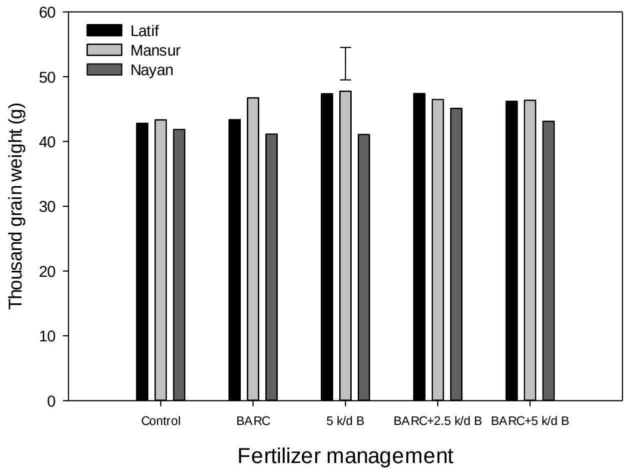


Figure 9: Thousand grain weights of wheat that grown in three separate farmer's field. Vertical bar represents LSD (*P*≥0.05) for fertilizer management × interaction. Where, BARC means Bangladesh Agricultural Research Council recommended fertilizer. k/d B means kg/decimal biochar. Data were means of three replicates.

Grain yield for the farmer of Mansur was 500.00, 521.00, 531.66, 508.33 and 555.00 g/m^2 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively. Likewise, grain yield for the farmer of Latif was 386.66, 460.00, 413.33, 433.33 and 526.66 g/m^2 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatments, respectively. Similarly, grain yield for the farmer of Nayan was 291.66, 375.00, 325.00, 391.67 and 415.00 g/m^2 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively (Figure 10).

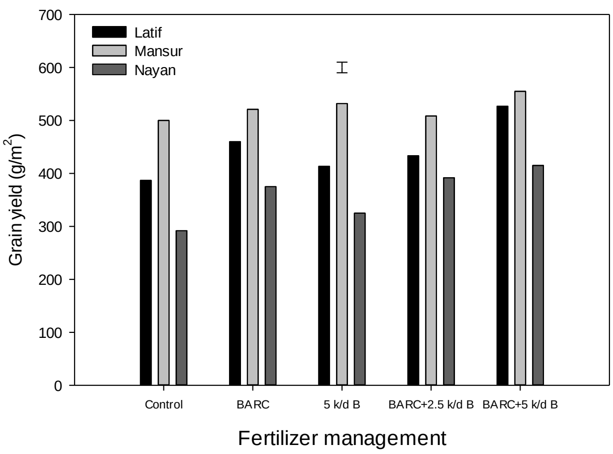


Figure 10: Grain yields of wheat that grown in three separate farmer's field. Vertical bar represent LSD (*P*≥0.05) for fertilizer management × interaction. Where, BARC means Bangladesh Agricultural Research Council recommended fertilizer. k/d B means kg/decimal biochar. Data were means of three replicates.

Straw yield for the farmer of Mansur was 680.00, 758.33, 751.67, 831.67 and 790.00 g/m^2 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatments, respectively. Likewise, straw yield for the farmer of Latif was 524.00, 550.00, 543.33, 624.00 and 584.33 g/m^2 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatments, respectively. Similarly, grain yield for the farmer of Nayan was 360.00, 441.67, 416.67, 464.67 and 451.67 g/m^2 under control, BARC, 5 kg biochar, 2.5 kg biochar + BARC and 5 kg biochar + BARC treatment, respectively (Figure 11).

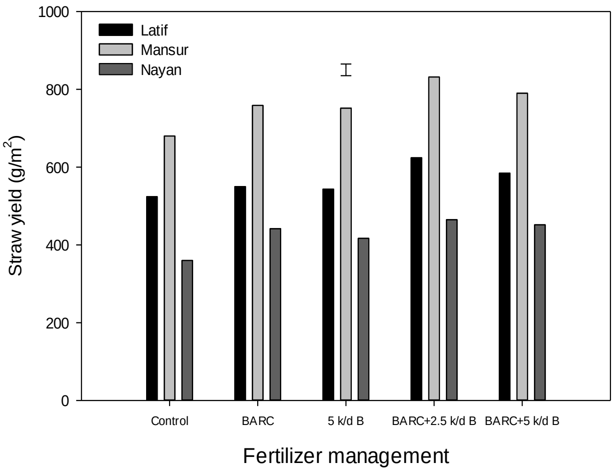


Figure 11: Straw yields of wheat that grown in three separate farmer's field. Vertical bar represent LSD (*P*≥0.05) for fertilizer management × interaction. Where, BARC means Bangladesh Agricultural Research Council recommended fertilizer. k/d B means kg/decimal biochar. Data were means of three replicates.

4. Discussion

4.1 Effect of akha biochar on farmers field soil properties

Akha biochar addition to soil improved soil physical and chemical properties as compared to soil without akha biochar amendment (Table 3 and Table 5). Soil organic matter increased for the 5 kg/decimal Akha biochar application in several farmer's field. Similarly, other study also found that bulk soil organic matter increased 0.54% to 4.09% from control to biochar amended treatment (Masulili et al., 2010). Other study speculated that acidic materials produced by the oxidation of biochar and organic matters may have caused the pH increase in the field (Liu and Zhang, 2012). As plant material were partially decomposed during Akha biochar preparation that resulting in increasing soil organic matter in farmer's field amended soil.

Likewise, soil pH increased 0.04, 0.10 and 0.09 units for Mansur, Latif and Nayan farmers field due to 5 kg/decimal akha biochar application. A study found that soil pH increased 4.8 to 5.4 due to 15 g kg^{-1} biochar mixing into soil (Kamara *et. al.,* 2015). The alkaline soils used for this study have varied initial pH of 7.90 to 8.26, which could have enhanced biochar liming effect. Similarly, increasing trend in initial soil pH was related to lower temperature (300°C). The slow oxidization of biochar in soils could produce carboxylic functional. This might be because of the formation of the acidic functional groups at lower temperature on surface of biochar that can neutralize alkalinity and eventually increase soil pH (Cheng et al., 2008).

The P availability increased 2.53, 0.62 and 0.63 ppm from initial to final measurement for Mansur, Latif and Nayan farmers' field respectively due to 5 kg/decimal akha biochar application. Initial soil available K was found 0.12, 0.13 and 0.12 me/100g soil for Mansur, Latif and Nayan farmers' field respectively (Table 3 and Table 5). Final soil available K was found 0.16, 0.14 and 0.13 me/100g soil for Mansur, Latif and Nayan farmers' field respectively (Table 5). This indicated that 0.04, 0.01 and 0.01 me/100g K increased in soil for Mansur, Latif and Nayan farmers' field respectively due to 5 kg/decimal akha biochar application after wheat plant harvest. Soil available S for initial soil was 12.57, 12.98 and 12.37 ppm for Mansur, Latif and Nayan farmers' field respectively. However, it reaches 14.4, 13 and 12.7 ppm for Mansur, Latif and Nayan farmers' field respectively due to 5 kg/decimal akha biochar application.

Initial soil available K was found 0.12 cmol$^+$kg^{-1} in control treatment. The final soil available K reached to 0.16 cmol$^+$kg^{-1} in the biochar added treatment (Table 5). Other study also found that harvested soil available K was 0.20 cmol$^+$kg^{-1} in control treatment and it reached to 0.51 cmol$^+$kg^{-1} in the biochar amended treatment (Masulili et al., 2010). They speculated that biochar significantly increased the K partial factor productivity only when the highest amounts of N and P fertilizer were mixed. Other study also speculated that biochar also directly adds some macronutrients (P, K, Na, Ca, and Mg) and micronutrients (Cu, Zn, Fe, and Mn) which are needed for sustainable agriculture to the soil (Glaser et al., 2002). Likewise, a study indicated that the combined application of biochar and chemical fertilizer had a better performance than either alone, in terms of soil properties and crop yield (Glaser et al., 2015).

4.2 Effect of akha biochar on wheat productivity

Akha biochar has positive response on growth of wheat. Findings showed that several growth parameters like plant height, number of tiller, leaf number and leaf width was highest for the BARC plus 2.5 kg/decimal akha biochar application treatment as compared to other treatments (Figure 2 to Figure 5). Similarly, yield parameters like effective grain, non-effective grain, spike length, grain yield and straw yield were tended to be higher in BARC plus 2.5 kg/decimal akha biochar application treatment as compared to other treatments (Figure 6 to Figure 9). These findings revealed that akha biochar amended soils increased growth and yield of wheat. It could be due to reason that some inorganic fertilizer can speed up growth and yield performance of the wheat when added with akha biochar (Gebremedhin et al., 2015). They have conducted a pot experiment to evaluate the effect of biochar on wheat productivity and soil properties.

They also have used combination of biochar and chemical fertilizer. They found that plant height at maturity for chemical fertilizer was 64.53 cm and increased to 66.8 cm due to biochar addition with chemical fertilizer. They speculated that biochar retains nutrients and water to improve wheat productivity. Other study also found that compared with chemical fertilizer application, biochar amendment to a typical Ultisol resulted in better crop growth (Peng et al., 2011). We speculated that the effects of akha biochar on wheat production were mainly ascribed to the properties of akha biochar, soil physiochemical properties and wheat variety used in this study. Likewise, speculated that biochar serves as a direct source of nutrients for plant uptake that results increased wheat production (Lehman et al., 2003). Similarly, some researchers found that biochar application increased wheat yield by 30% (Vaccari et al., 2011).

4.3 Farmers management variation

Mansur farmer management was best among the three farmers. This resulted highest growth and yield of wheat in Mansur field. During field experiment period, it was observed that Mansur farmer take proper care in his wheat field as compared to Nayan and Latif. Because, Mansur farmer was trained up about different aspects of crop production especially management of soil and crop. Nayan farmers used to manage proper cultivation of wheat but did not get expected wheat in comparison of Mansur and Latif. This could be due to the reason that Nayan farmer's field fertility and productivity is low. Final bulk soil available total N in Latif field is 0.08 that resulted highest yield in Latif wheat field (Table 5). Likewise, initial soil pH, Ca, Mg, Cu, Fe, B, Mn and AMF spores were highest in Mansur field that resulted highest wheat production of that field. Regardless of that Mansur field got enough sunlight to get maximum wheat yield. Therefore, recycling crop wastes to produce akha biochar is strongly recommended to smallholder farmers for use in agriculture to improve fertility and crop productivity due to their high nutrient content and soil fertility attributes.

5. Conclusion

This study demonstrated that akha biochar amendment increases soil fertility and productivity in wheat fields. This study demonstrated that akha biochar amendments increased soil organic matter in wheat fields at Mansur, Latif and Nayan. This study also demonstrated that highest wheat yield was produced when 2.5 kg/dec plus BARC recommended fertilizer was applied to the field. In contrast, wheat productivity declined due to elevated akha biochar application. Elevated akha biochar application did not have any significant effect on wheat productivity. This study concluded that optimum level of akha biochar should be applied with recommended dose of BARC fertilizer for getting highest wheat production in Bangladesh. However, high akha biochar application (5 kg per decimal) was too high and would be expensive. Elevated biochar application did not have any significant effect on wheat productivity. It indicates that akha biochar could be used as nutrient source to achieve comparable yields to that obtained with inorganic fertilizers. This study recommends that akha biochar be utilized to increase soil fertility status and wheat productivity in Bangladesh.

Acknowledgement

We thank the Christian Commission for Development in Bangladesh (CCDB) for technical and financial support. We also acknowledge Soil Resources Development Institute (SRDI) for measuring the soil basic physiochemical properties in the post-harvest soil.

References

Bhuiyan, S.S., Joadder, M.A.R., Bhuiyan, A.S., 2005. Occurrence of fishes and non-fin fishes of the river Padma near Rajshahi, Bangladesh. Uni. J. of Zoology, Rajshahi University, 27, Pp. 99-100.

Biswas, A., Alamgir, M., Haque, S., Osman, K., 2012. Study on soils under shifting cultivation and other land use categories in Chittagong Hill Tracts, Bangladesh. J. Forest Res., 23, Pp. 261-265.

Cheng, C.H., Lehmann, J., Engelhard, M.H., 2008. Natural oxidation of black carbon in soils: changes in molecular form and surface charge along a climosequence. Geochimica et Cosmochimica Acta, 72, Pp. 1598-1610.

Dias, B.O., Silva, C.A., Higashikawa, F.S., Roig, A., Sanchez-Monedero, M.A., 2010. Use of biochar as bulking agent for the composting of poultry manure: effect of organic matter degradation and humification. Bio. Tech., 101, Pp. 1239-1246.

Gebremedhin, G.H., Haileselassie, B., Berhe, D., Belay, T., 2015. Effect of Biochar on Yield and Yield Components of Wheat and Post-harvest Soil Properties in Tigray. Ethiopian J. of Fert. and Pest., 6, Pp. 158 (doi:10.4172/2471-2728.1000158).

Glaser, B., Lehmann, J., Steiner, C., Nehls, T., Yousaf, M., Zech, W., 2002. Potential of pyrolyzed organic matter in soil amelioration. In: People's Republic of China Ministry of Water Resources (ed) 12th International Soil Conservation Organization Conference, Beijing, China. Ministry of Water Resources, Beijing.

Glaser, B., Wiedner, K., Seelig, S., Schmidt, H.P., Gerber, H., 2015. Biochar organic fertilizers from natural resources as substitute for mineral fertilizers. Agron. for Sust. Dev. 35, Pp. 667-678.

Huq, S.I., Alam, M., 2005. A handbook on analyses of soil, plant and water. BACER-DU, University of Dhaka, Bangladesh, Pp. 246.

Iqbal, M.T., 2017. Utilization of biochar in improving yield of wheat in Bangladesh Bulgarian J. of Soil Sci., 2 (1), Pp. 53-74.

Iqbal, M.T., Ortas, I., Ahmed, M.A.I., Isik, M., Islam, M.S., 2019. Rice straw biochar amended soil improves wheat productivity. J. of Plant Nutr., Pp. 1-19. DOI:10.1080/01904167.2019.162898

Islam, M., Jalal, S., Islam, S., Hossain, M., Işik, M., Iqbal, M.T., 2020 Akha biochar enhances soil fertility and productivity of red amaranth plant. Net J. of Agric. Sci., 8 (1), 1-7.

Kamara, A., Kamara, H.S., Kamara, M.S., 2015. Effect of rice straw biochar on soil quality and the early growth and biomass yield of two rice varieties. Agric. Sci., 6, Pp. 798-781.

Lehman, J., Joseph, S., 2009. Biochar systems. In: Lehman CJ, Joseph S. (Eds.), Biochar for environmental management: science and technology. Earthscan. London, Pp. 20- 222.

Lehmann, J., 2007. Bio-energy in the black. Fron. in Eco. and Env., 5, Pp. 38-41.

Lehmann, J., da Silva Jr, J.P., Steiner, C., Nehls, T., Zech, W., and Glaser, B., 2003. Nutrient availability and leaching in an archaeological Anthrosol and a Ferralsol of the Central Amazon basin: fertilizer, manure and charcoal amendments. Plant Soil, 249, Pp. 343-357.

Liu, X.H., Zhang, X.C., 2012. Effect of biochar on pH of alkaline soils in the loess plateau: results from incubation experiments. International Journal of Agriculture and Biology, 14, Pp. 745–750

Masulili, A., Utomo, W.H., Syechfani, M., 2010. Rice husk biochar for rice based cropping system in acid soil 1. The characteristics of rice husk biochar and its influence on the properties of acid sulfate soils and rice growth in West Kalimantan, Indonesia. J. of Agric Sci., 2, Pp. 39-41.

Peng, X., Ye, L., Wang, C., Zhou, H., Sun, B., 2011. Temperature-and duration-dependent rice straw-derived biochar: Characteristics and its effects on soil properties of an Ultisol in southern China. Soil and Tillage Res., 112, Pp. 159-166.

Petersen, L.W., Moldrup, P., Jacobsen, O.H., Rolston, D., 1996. Relations between specific surface area and soil physical and chemical properties. Soil Sci, 161, Pp. 9-21.

Piper, C., 1950. Soil and plant analysis. Inter. Science Publisher inc., New York.

Podder, M., Akter, M., Saifullah, A., Roy, S., 2012. Impacts of plough pan on physical and chemical properties of soil. J. Environ Sci. Nat. Res., 5, Pp. 289-294.

Raj, P., Das, G., Mal, S., Bhag, S., Jat, S.S., and Gyanendra, S., 2012. Proceedings of the Regional Consultation on Improving Wheat Productivity in Asia, Bangkok, Thailand, Pp. 26-27.

Skjemsted, J.O., Reicosky, D.C., Wills, A.R., McGown, J.A., 2002. Charcoal Carbon in U.S. Agricultural soils. Soil Sci. Soc. of America J., 66, Pp. 1249-1255.

Soltanpour, P.A., Schwab, A., 1977. A new soil test for simultaneous extraction of macro and micro nutrients in alkaline soils 1. Commun Soil Sci Plant Anal, 8, Pp. 195-207.

Subbiah, B., Asija, G., 1956. A rapid method for the estimation of nitrogen in soils. Curr Sci., 26, Pp. 259-260.

Vaccari, F.P., Baronti, S., Lugato, E., Genesio, L., Castaldi, S., Fornasier, F., and Miglietta, F., 2011. Biochar as a strategy to sequester carbon and increase yield in durum wheat. European Journal of Agronomy, 34, Pp. 231-238.

Walkley, A., Black, I.A., 1934. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Sci., 37, Pp. 29-38.

Warnock, D.D., Lehmann, J., Kuyper, T.W. and Rillig, M.C., 2007. Mycorrhizal responses to biochar in soil-concepts and mechanisms. Plant and Soil, 300, Pp. 9-20.

Cite the Article: Md. Muktar Hossain, Shahjalal, Ahmed Khairul Hasan, Md Shoriful Islam, Md. Mahbubul Islam, Md Toufiq Iqbal (2021). Assessment of Farmers Adaptability on Akha Biochar for Wheat Production in Bangladesh. *Journal of Wastes and Biomass Management, 3(2): 53-61*.