

## EFFECT OF DIFFERENT BIOCHARS ON PRODUCTIVITY OF RICE CV. BRRIDHAN100 AND SOIL IMPROVEMENT

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### ABSTRACT

The present experiment was carried out to investigate the effect of biochar application as a soil amendment on rice yield under SAU (AEZ-28), Dhaka region Boro season condition in 2022-23. The rice variety, BRRIDhan100 were used as planting materials with treatment T<sub>0</sub>: without biochar, Treatment T<sub>1</sub>: Rice husk @ 3.0 t ha<sup>-1</sup> + cowdung @ 10 t ha<sup>-1</sup>, and T<sub>2</sub>: Biochar application types included Mango Biochar@ 3.0 t ha<sup>-1</sup> which was applied at time of final land preparations for broadcasting in surface soil followed by base fertilizer application along with row position directly seeding the pre-germinated seeds)Mahogany biochar @ 3.0 t ha<sup>-1</sup>:(at initial stage of seedlings transplanting). The findings of the current study indicated that BRRIDhan100 biochar application treated by Mahogany biochar had significantly the tallest plant (114.78 cm), highest chlorophyll content (40.95) more tillers hill<sup>-1</sup> total (1486.44) and filled grains panicle<sup>-1</sup>, longest panicle (26.72 cm) as well as highest weight of 1000-grain (22.54 g) which could be led to increase the grain yield 8.97 t ha<sup>-1</sup>, straw yield 9.47 t ha<sup>-1</sup> and harvest index 48.66 %. In correlation coefficient, all the selected characters were positively correlated with grain yield means they have direct contribution for create grain yield but length of panicle and number of effective tillers hill<sup>-1</sup> had greater contribution for BRRIDhan100. Further, PC analysis resulted positive and negative response showing such type of contribution for brings about the grain yield. Maximum change in postharvest soil nutrients were also found highest in Mahogany biochar applied plot of BRRIDhan100. Thus, the utilization of biochar might be a sustainable tool to improve plant growth and more yield production across the various agro-climatic zone of Bangladesh also justify the soil health and sustainable crop production.

**Key words:** Biochars, productivity, BRRIDhan100, soil improvement

### Introduction

Different humanoid stimulators can therefore be used to realize this aim, including biochar. Typically, rice husks, plant materials, branches, wood, sawdust, bones, sugarcane by-products, fallen leaves, weeds, straw, and grasses are used in the production of biochar from rice Biochar, which is a “Black Gold” and classified as carbon-dense biomass. The variety of biochar employed may influence the effect of biochar on plant growth performance, and as a result, the biochar is developed in three different types of biomasses: rice husk biochar with cow dung, and wood-based biochar with mango and mahogany. Biochar is a flexible and sustainable tool for many aspects of agricultural and environmental reestablishment due to its unique physicochemical properties related to the fertility of the nutrient and the capacity of the soil for the retention of water. In addition, it is a highly stable carbon-based matter that promotes plant growth and raises crop productivity by stimulating microbial activity and can also be employed as pollutants removal, including heavy metals, organics, and nutrients, from the soil to aquatic bodies as sorbents. So far, no information has been reported in Bangladesh as to which of these biochar is more effective at ameliorating heavy metal in contaminated soil. Selecting a super cultivar is critical is the most competitive crop growth. There was significant progress in the utilization of high yielding varieties which in recent years and a considerable portion of the country more than 93 has reached the level of being self-sufficient in food production The cultivar is, therefore, a genetic trait of the most commercial crop that influences the produce and its components, which are directly to heritable but there is limited information about biochar especially tree or wood-based biochar under field condition likewise over Bangladesh ash and no attempts were made to analyze the biochar application of the rice husk and other wood biomasses. Therefore, current

research aimed to evaluate the biochar application from rice husk and different tree or wood base biomasses for optimizing rice growth and yield for under Bangladesh conditions, in this experiment the objectives are: i) Effect of different biochar in crop growth and surviving potential of the variety; ii) Identifying effect biochar for better rice variety yum and postharvest soil fertility assessment in SAU experiment field.

## Materials and Methods

An experiment was conducted to test the effects of biochars soil amendments on rice yield of SAU (AEZ-28), Dhaka, during the Boro season 2022-23. The experimental was conducted under subtropical climatic conditions, which are characterized by three distinctive seasons: winter throughout November to February, the pre-monsoon or hot season from March to April, and the monsoon season from May to October. The rice used in this experiment was BRRI dhan100, with different biochar forms affecting the planting of rice. Four treatments were applied: those without biochar, rice husk biochar equivalent to 30 tonnes per hectare ( $t\ ha^{-1}$ ) and cow dung equivalent to  $10\ t\ ha^{-1}$  of each rice husk biochar, mango biochar  $3\ t\ ha^{-1}$  and mahogany biochar  $3\ t\ ha^{-1}$ , and plot creation from arrangement to installation with suitable coding. The two biochars were produced in the pyrolysis technique. Data recording was done before harvesting by purposeful and random sampling where 5 hills from each unit plot were chosen, professionally uprooted, and labeled before harvesting. One squared meter area was harvested solely for recording the data for grain yield and hectare. Statistical Analysis: The data obtained from growth, yield characteristics, postharvest soil, and after harvest was systematically tabulated in an appendix box and analyzed using the MSTAT-C software tool. The mean variance differences obtained were further, investigated from a standard error of means and analyzed using the Duncan Multiple range test (Gomez, *et al.* 1984). Soil samples beforehand from diverse depths within the chosen locations. Acquired soil samples were desiccated at ambient temperature, ground, and moved through a 10 mm sieve. Processed soil samples were preserved in tagged polythene bags for laboratory examination: The soil samples were assayed following the routine methodology: soil pH is calculated with a glass electrode pH meter, organic carbon is measured by wet oxidation, total N was assayed by the Kjeldahl method, accessible P is determined by the Bray and Kurtz method available S was quantified by turbidimetric titration, and other supplemented cations were paralleled accordingly. Calcium, potassium, and sodium are assayed by the Ammonium Acetate extraction method. Accessible zinc, copper, iron, and manganese are determined by spectrophotometry.

## Results and Discussion

**Plant height:** Biochar treatment without Mahogany leaf led to a significant increase in plant height, while plant height increase with longer transplanting. Increased plant height could be due to organic amendment by biochars, causing a substantial increase in macro and micronutrients in the soil, increased microbial activity and overall improvement in plant physiological function, resulting in a healthier and taller plant. As shown in Fig. 1, exhibit a significant increase in plant height compared to control at 90 DAT and harvest. It was observed that its tallness increased more with biochar compared with the control at 90 DAT, and harvest. The length increased with the use of Mahogany biochar was the highest at 90 DAT 105.13 cm and 114.78 cm at harvest figure 1.15 followed by Rice husk biochar mixed with cow dung, which measured 103.60 cm at 90 DAT. Kabir *et al.* 2023 added that biochar is a multifaceted tool for the rehabilitation of agriculture and the environment. It is ascribed to the significant physicochemical characteristics of biochar in terms of soil fertility. Biochar is a long-lasting, carbon-rich substance that promotes plant growth and enhances agricultural productivity by increasing microbial activity. Putri *et al.* 2023 had previously carried out research that showed that application of Mahogany leaf biochar administered lower the pH of the soil. It also reduces the pH of macro and microelements in the soil, which supports rapid growth in the seed. Lack of biochar treatment may predispose the plant to pests and diseases due to lack of proper growth.

**Number of total tillers hill<sup>-1</sup>:** The total number of tillers per hill showed a significant difference among different biochar treatments. At 70 days after transplanting 26.26 to 31.06, the lowest rate recorded and at

90 days, it recorded as 27.33 to 32.33, and at harvest 28.77 to 30.33. The highest total tillers per hill were observed in the plot treated by mahogany biochar at 70 31.06, 90 32.33, and harvest 30.33. However, the same value was observed in the plot treated with rice husk and cow dung biochars, which were significantly lower, but not different compared to chi2, treated with the same parametric 30.60; while rice with cow dung and mango exhibited almost similar total tillers per hill were recorded 30.22 and 30.33, respectively. The lowest total tillers per hill were observed on untreated plot at all stages.

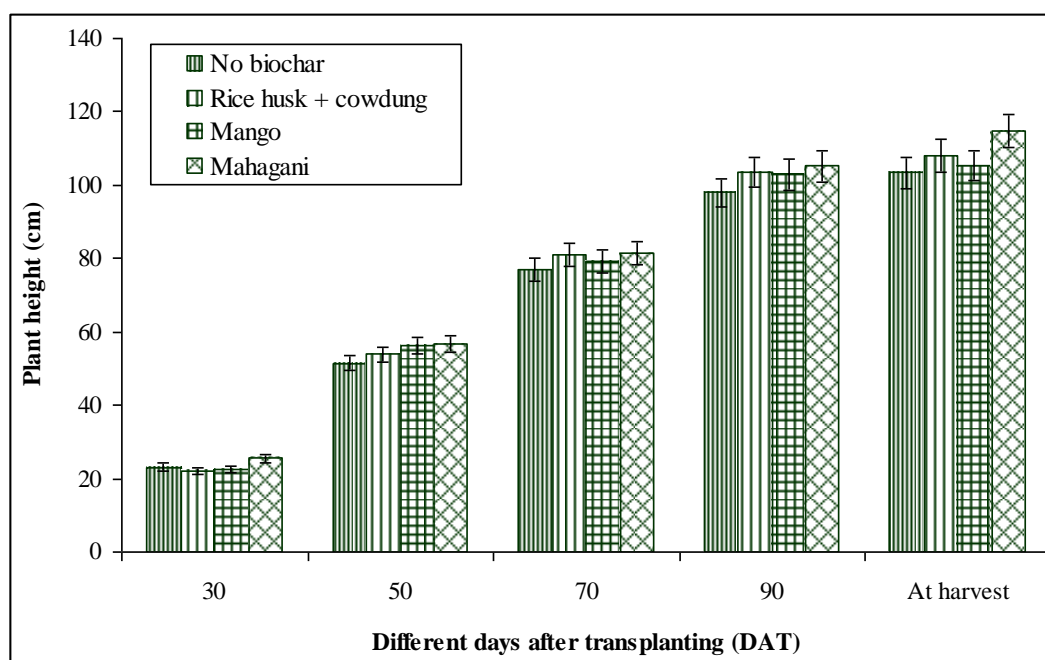


Fig. 1. Effect of different biochars on plant height at different DAT

Table 1. Effect of different biochars on total tillers hill<sup>-1</sup> of rice cv. BRRI dhan100

Biochar treatments	Number of total tillers hill <sup>-1</sup> at different DAT			
	50	70	90	At harvest
No biochar (T <sub>0</sub> )	9.07	26.26 b	27.33 b	28.77 b
Rice husk + cowdung (T <sub>1</sub> )	9.33	27.33 ab	30.60 a	30.22 a
Mango (T <sub>2</sub> )	9.40	21.06 c	28.26 b	30.00 a
Mahagany (T <sub>3</sub> )	10.27	31.06 a	32.33 a	30.33 a
LSD <sub>0.05</sub>	2.44	4.56	2.20	0.85
Level of significance	NS	**	**	**
CV (%)	9.07	6.10	2.63	1.20

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of significance, \*\*= Significant at 1% level of probability and NS= Not significant

**Chlorophyll content:** The higher chlorophyll content was recorded only in the reproductive stage when photosynthetic functions were high. Indeed, the highest chlorophyll content 40.95 was observed in the same plot treated by mahogany biochar and the lowest chlorophyll content 39.57 was recorded in the control treatment plot, while mango biochar also the lowest number of chlorophyll was 39.65. Planted treated by biochar tends to have higher potential to absorb more soil in the form of nutrients and any supply especially the chlorine content may be due to nitrogen levels in the soil increased.

**Yield attributes:** The maximum total 186.44 and effective 148.22 grains panicle<sup>-1</sup> were recorded the highest from number of total and filled grains produced by plant under mahogany biochar treated and without biochar treated plant (Table 2). The rice husk biochar + cow manure and mango biochar yielded the second and third highest total number of grains panicle per decision (171.45 and 167.00, respectively). Both also provide even high with numerically the same maximum filled grain per panicle 144.22 and 137.78, respectively. The longest and shortest Panicle length bring significantly variation 24.62 to 26.72 cm under mahogany biochar treated plant and without biochar biochar treated plant, respectively. Rice husk biochar + cowdung and mango biochar stand for actual numeric same second longest 25.74 and 25.54 cm panicle. Weight of 1000-grain: The significant difference was on the weight of 1000grain among the different biochar treatments where the maximum 22.54 g from mahogany treated plant. The second highest 22.23 g from rice husk biochar + cowdung treated plant. Citing the method of mahogany biochar as a soil modification, it is a healthy way to lose different nutrients easily from the soil so that loss of soil temperature injury can be counted. In numbers and filled grains number panicle<sup>-1</sup>, panicle length, and weight of 1000-grain, Upoma found to be achieved the similar outcome as well as the findings of the present study. Tanzi et al. also found that the tree or tree base green leaf biomass plant of kalo koroï intensified significantly more number of panicles hill<sup>-1</sup>, number of spikelets panicle<sup>-1</sup>, 1000-grain weight and grain yield compared to other green leaf biodcopy or biochar of various trees.

Table 2. Effect of different biochars on yield attributes and grain yield of rice cv. BRR1 dhan100 at harvest during *Boro* season in 2022-23

Biochar treatments	Number of total grains panicle <sup>-1</sup>	Number of filled grains panicle <sup>-1</sup>	Panicle length (cm)	Weight of 1000-grain (gm)	Fresh grain yield (kg plot <sup>-1</sup> )	Grain yield (kg plot <sup>-1</sup> )
No biochar (T <sub>0</sub> )	139.33 c	110.33 b	24.62 c	21.58 c	7.62 d	5.93 d
Rice husk + cowdung (T <sub>1</sub> )	171.45 b	144.22 a	25.74 b	22.23 ab	8.89 c	7.23 c
Mango (T <sub>2</sub> )	167.00 b	137.78 a	25.54 b	21.80 bc	9.59 b	8.04 b
Mahogany (T <sub>3</sub> )	186.44 a	148.22 a	26.72 a	22.54 a	10.08 a	9.04 a
LSD <sub>0.05</sub>	14.19	14.21	0.63	0.45	0.28	0.22
Level of significance	**	**	**	**	**	**
CV(%)	3.02	3.72	0.87	0.72	1.51	1.45

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of significance, \*\*= Significant at 1% level of probability

**Yield related traits and harvest index:** The fresh and dry yield of grain had also statistically significant among the different biochar where mahogany treated plot gave the highest fresh (10.08 kg plot<sup>-1</sup>) and dry (9.04 kg plot<sup>-1</sup>) yield of grain and it was statistically differed from other treatments. Similarly, without biochar treated plot gave the lowest fresh and dry yield of grain i.e 7.62 and 5.93 t of grain. The application of mahogany biochar produced the highest grain yield i.e.8.97 t ha<sup>-1</sup>while it was found statistically lowest yield i.e. 5.92 t ha<sup>-1</sup> under without biochar applied plot. Straw yield also varied significantly from7.69 to 9.47 t ha<sup>-1</sup> where mahogany biochar and rice husk biochar along with cowdung treated plot were produced statistically identical highest straw yield 9.47 and 9.01 t ha<sup>-1</sup>, respectively followed by mango biochar 8.62 t ha<sup>-1</sup>. As a results, without biochar produced the lowest straw yield 7.69 t ha<sup>-1</sup>. The harvest index was also obtained significantly highest (48.66%) with the mahogany treated plot and it was statistically differed from other with or without biochars. In contrast, rice husk biochar + cowdung and mango biochar were statistically identical for obtaining the 2<sup>nd</sup> highest harvest index (46.93 and 45.45%, respectively) while without biochar showed the lowest (43.43%) harvest index (Fig. 4).

The above findings indicate that soil nutrient status is improved by biochar, water retention promoted, carbon sequestration enhanced, cation increases in the exchange content, nitrogen leaching mitigated, and mitigates the effect of toxicity in contaminated soils, all these were leading to the positive contributions to rice yield. Chen *et al.* reported the rice yield with biochar incorporation was 15.53% and 24.43%, which

was more than without biochar incorporation. Moreover, many studies pointed out that the incorporation of biochar increases soil-crop growth rates, promotes the reduction of nutrient leaching, enhances mitigation of soil acidity, improves water retention both decrease the usage of fertilizers Lai *et al.*, 2024; Velu and Seran, 2010. The above study found that increased plant height, increased tiller count, filled grain in panicle, grain weight, and 1000 grain weight, which resulted in the maximum yield of grain and straw when treated with mahogany biochar, which was in agreement with Thavanesan and Seran, 2018, elsewhere found that biochar increased post-harvest nutrients in its application of biochar. Furthermore, the incorporation of biochar in rice improved root development and the rice absorbed more soil nutrients, as reported by Liang *et al.*, 2024, with wood biochar and pig manure; Putri *et al.*, 2023, with mahogany biochar in maize; Islam *et al.*, 2022, with wood baste tree in rice.

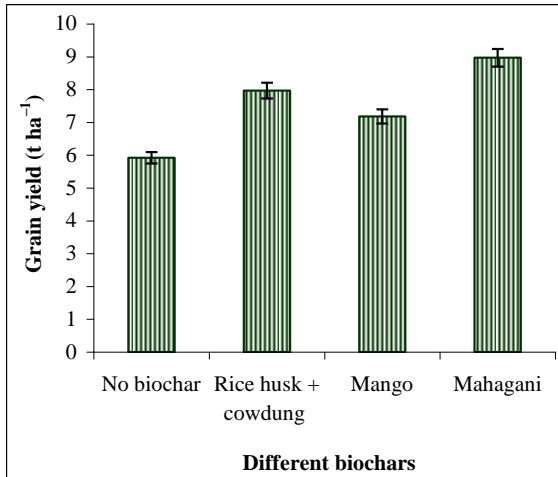


Fig. 2 Effect of different biochars on grain yield (t ha<sup>-1</sup>). Vertical bars represent standard error

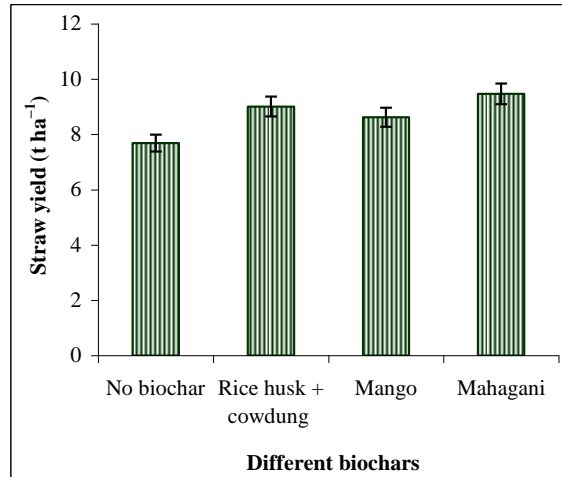


Fig. 3 Effect of different biochars on straw yield (t ha<sup>-1</sup>). Vertical bars represent standard error

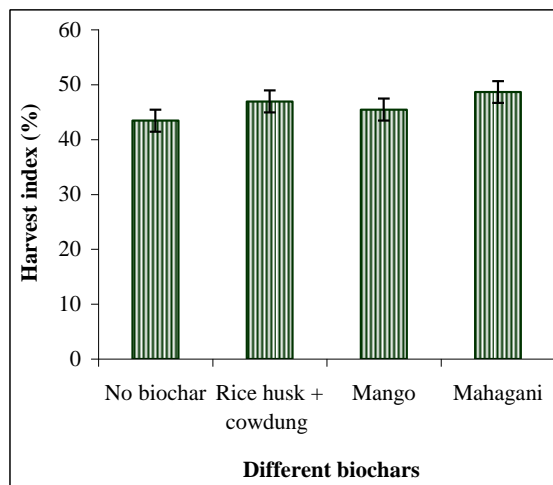


Fig. 4 Effect of different biochars on harvest index (Vertical bars represent standard error)

**Effect of different biochars on postharvest soil properties:** On the other side, postharvest soil properties: The different macro and micro nutrients i.e. pH, organic manure (OM), nitrogen (N), phosphorus (P), potassium (K), sulphur (S), Calcium (Ca), magnesium (Mg), zinc (Zn), boron (B), copper (Cu), iron (Fe), manganese (Mn) and cadmium (Cd) were submitted and analyzed by the Central Laboratory, Soil Resource

Development Institute, Mrittika Bhabon, Krishi Khamar Sarak, Dhaka-1215 from the sample collected from the experimental field after harvest at 0-15 cm depth. It is clearly revealed that all the selected characters had statistically significant except OM, P and S whereas OM, P and S varied from 1.72 to 1.88%, 39.46 to 49.61 mg kg<sup>-1</sup> soil and 35.53 to 41.0 meq 100 g<sup>-1</sup> soil, respectively. The pH was found highest 6.49 while soil was treated by Rice husk, containing cow dung followed by both no biochar and mango biochar treated soil 6.31 and 6.38, respectively where no biochar and mango biochar were statistically identical. As a result, mahogany treated soil had the lowest 6.20 pH in the present study. All the postharvest soil nutrient content, i.e. N, K, Ca, Mg, Zn, B, Cu, Fe, Mn and Cd found maximum 0.11%, 0.099 meq 100 g<sup>-1</sup> soil, 5.57 meq 100 g<sup>-1</sup> soil, 2.19 meq 100 g<sup>-1</sup> soil, 24.14 mg kg<sup>-1</sup> soil, 0.312 mg kg<sup>-1</sup> soil, 7.03 mg kg<sup>-1</sup> soil, 123.00 mg kg<sup>-1</sup> soil, 21.69 and 0.398 mg kg<sup>-1</sup> soil, respectively was accrued while the experimental field treated by mahogany biochar which was statistically differ from other biochar. However, All the above indicating traits were also observed lowest 0.08%, 0.075 meq/100g, 4.92 meq/100g, 1.88 meq/100g, 19.23 mg/kg, 0.118 mg/kg, 4.13 mg/kg, 100.50 mg/kg, 10.89, 0.274 mg/kg.

Table 3. Soil nutrients content of postharvest soil as amendment by different biochars under the *Boro* rice field cv. BRRI dhan100

Treatments	pH	OM	N	P	K	S	Ca
No biochar (T <sub>0</sub> )	6.31 ab	1.75	0.08 b	39.46	0.075 c	35.53	4.92 c
Rice husk + cowdung (T <sub>1</sub> )	6.49 a	1.72	0.08 b	48.83	0.084 bc	39.97	5.21 b
Mango (T <sub>2</sub> )	6.38 ab	1.80	0.10 a	44.80	0.094 ab	40.01	5.33 ab
Mahogany (T <sub>3</sub> )	6.20 b	1.88	0.11 a	49.61	0.099 a	41.00	5.57 a
LSD <sub>0.05</sub>	0.26	0.32	0.01	13.06	0.01	6.20	0.26
Level of significance	*	NS	**	NS	**	NS	**
CV(%)	1.56	6.89	5.55	10.94	4.40	6.06	1.88

Table 3 (Contd.)

Treatments	Mg	Zn	B	Cu	Fe	Mn	Cd
No biochar (T <sub>0</sub> )	1.88 b	19.23 c	0.118 d	4.12 c	100.50 c	10.89 c	0.273 c
Rice husk + cowdung (T <sub>1</sub> )	1.97ab	20.61 bc	0.185 c	4.68 b	110.00 bc	16.81 b	0.330 b
Mango (T <sub>2</sub> )	2.02 ab	22.36 ab	0.254 b	4.90 b	119.50 ab	18.93 b	0.355 ab
Mahogany (T <sub>3</sub> )	2.19 a	24.14 a	0.312 a	7.03 a	123.00 a	21.69 a	0.398 a
LSD <sub>0.05</sub>	0.24	2.03	0.03	0.32	10.08	2.41	0.05
Level of significance	**	**	**	**	**	**	**
CV(%)	4.49	3.61	5.75	2.39	3.41	5.41	5.92

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of significance.

\*\*, \*= Significant at 1 and 5%, respectively level of probability and NS= Not significant

**Note**

OM= Organic matter, N= Nitrogen, P= Phosphorus, K= Potassium, S= Sulphur, Ca= Calcium

Mg= Magnesium, Zn= Zinc, B= Boron, Cu= Copper, Fe= Iron, Mn= Manganese and Cd= Cadmium

Such biochars were used to enhance post-harvest soil properties, potentially supporting sustainable agriculture. The present results will thus contribute to improve the effectiveness of biochar application under rice cropping conditions by improving soil fertility and decreasing soil pH. Results suggested the use of biochar to be beneficial for improvement in soil chemical properties. However, little is known about biochar effects and it has been shown that biochar from *Miscanthus* carries higher amounts of C, N, Ca, Mg, Na, K (however less amounts of P and S) than other soils (de Jesus Duarte *et al.*, 2019). Vijay *et al.* (2021) also support the role of biochar as a fertilizing agent in tropical soils. Results showed that hardwood biochar (WB; Eucalyptus wood) was more ideal for acid soil amelioration and nutrient enrichment than bamboo biochar (BB), as it possessed higher pH value and nutrient levels in the research work.

## Conclusion

It may be noted from the summary of results in present investigation—the Mahogany biochar as compared to other (rice husk biochar + cowdung, mango biochar) or without of the biochar was significant influencing (was superior) biochar which had higher efficiency for increased better production of BRRI dhan100 and its superior definition were well established through their growth and yield performance and improvement post-harvest soil health condition.

## Recommendation

The incorporation of biochar can significantly improve the crop growth and yield containing proper soil environment for a long period. However, biochar based farming system research is still at the early stages in Bangladesh but several research may be conducted before using the biochar at farmers' level in Bangladesh. Many reviews are cited in the present study containing different types of biochars and the obtained findings of the present study must be addressed by future research studies and cultivation status associated with the biochar application at different regions of Bangladesh.

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