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Exploring the possibility of using Agroplus Biodecomposer for boosting up rice productivity under Bangladesh condition

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ABSTRACT

Over dependence on chemical fertilizers is a threat to the sustainability of rice ecosystem. Application of organic and biofertilizers might reduce reliance on chemical fertilizers and thus can play a vital role to boost up rice productivity in an eco-friendly way. An experiment was conducted at Mymensingh , Bangladesh during December 2015 to April 2016 to evaluate the effect of different dosages of Agroplus Biodecomposer, an organic biofertilizer containing *Streptomycetes* bacteria, on the growth and yield performance of some rice varieties. The experiment included four winter rice varieties *viz*. (i) Hybrid rice Hira and (ii) Hybrid rice Tej (iii) BRRI dhan28 and (iv) BRRI dhan29; and four concentrations of Agroplus Biodecomposer *viz*. (i) no Agroplus Biodecomposer (Control), (ii) 2% Agroplus Biodecomposer (iii) 3% Agroplus Biodecomposer, and (iv) 4% Agroplus Biodecomposer. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Agroplus Biodecomposer positively influenced growth and productivity of winter rice. It was evident that both plant height and tillering ability of winter rice were increased gradually with increased concentration of Agroplus Biodecomposer at all the growth stages of rice. All the yield contributing characters of rice were enhanced due to Agroplus Biodecomposer application which resulted in increased grain yield. Compared to control, rice grain yield was increased by 14, 20 and 28%, respectively due to application of Agroplus Biodecomposer at 2, 3 and 4% concentration. Rice variety also differed significantly in terms of growth and yield performance among themselves. Hybrid varieties performed better than inbred ones. Hybrid variety Hira appeared as the best performer followed by another hybrid Tej. Hybrid variety Hira interacted favorably with 4% Agroplus Biodecomposer to produce the highest grain yield of rice (7 t ha^{-1}). Therefore, biofertilizer Agroplus Biodecomposer can be introduced to Bangladesh and foliar spray with 4% Agroplus Biodecomposer at 30, 45 and 60 days after transplanting can be recommended for boosting up winter rice yield in a sustainable way.

Keywords: Boro rice, Agroplus Biodecomposer, biofertilizer, rice growth, rice yield

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1 Introduction

Bangladesh is one of the most important rice growing countries of the world, and rice is her staple food. In respect of area and production, Bangladesh ranks fourth among the rice producing countries of the world following China, India, and Indonesia (FAO, 2016). About 75.61% of cropped area of Bangladesh is used for rice production, with an annual production of 34.55 million tons form 11.8 million hectares of land (BBS, 2016). Rice is usually cultivated in three distinct growing seasons (*viz.* aus or summer rice, aman or rainy season rice and boro or winter rice). The contribution of boro, aman and aus rice production in 2015-16 were 19.23, 13.12 and 2.2 million tons, respectively (BBS, 2016). As yield of winter rice is the highest among the three seasons, farmers are very much interested to grow winter rice. The population of Bangladesh is still growing by two million every year and may increase by another 30 million over the next 20 years. To meet the consequently increasing demand, food production must be increased either by increasing arable land or by increasing yield of crops. However, the arable land in the densely populated countries of South and Southeast Asia like Bangladesh is very limited. Thus, Bangladesh will require about 27.26 million tons of rice for the year 2020. During this time total rice area will also shrink to 10.28 million hectares. Rice yield therefore, needs to be increased from the present 2.74 to 3.74 t ha^{-1} (BRRI, 2014).

To fulfill the ever increasing rice demand it is necessary to develop a less chemical fertilizer and pesticide dependent rice production system to save the agro-ecosystem (Islam et al., 2007). Excessive use of chemical fertilizers are not cost effective and also very detrimental for soil and environment. Its long term residue affects soil fertility, soil microbial population and crop productivity as well (Ahsan et al., 2007; Sultana et al., 2008). Depletion of soil fertility is one of the major constraints for higher crop production in Bangladesh. Most of her cultivated soils have organic matter content of below 1.0% and at the same time addition of organic matter is very low (Khanam et al., 2008). Yadav et al. (2000) reported that degradation of soil organic matter reduced nutrient supplying capacity of soil. According to Chhonkar (2002), up to 30% of nutritional requirements of crops can be met by various organic sources and organic farming is remunerative also (Kalyan, 2005). Yadav et al. (2013) observed that in an organically managed field soil fertility levels increases over time and crop yield gradually increases with the use of organic fertilizers over a period of time. Subbiah and Kumaraswamy (2000) reported that organic farming improved organic matter content and labile status of nutrients and also soil physicochemical properties including C:N ratio. Considering the above fact integration of organic fertilizer with inorganic fertilizer has been tried by many researchers to increase rice productivity in a sustainable way and they reported very encouraging results (Majumdar et al., 2007; Islam et al., 2007; Khanam et al., 2008). Therefore, a suitable combination of organic and inorganic fertilizers is necessary for sustainable rice production.

Bio-fertilizers are considered to be vital to look beyond immediate crop needs for building up soil fertility and conserving soil health, and thus to provide a solid base for increased crop production. They are cost effective, eco-friendly and renewable sources of plant nutrients to supplement chemical fertilizers. Bio-fertilizer is a fertilizer used to improve the fertility of the soil and do not contain any chemicals which are detrimental to the living soil. They are extremely beneficial in enriching the soil with those micro-organisms, which produce organic nutrients for the soil and help to combat disease. Moreover it plays an imperative role in fostering long term soil fertility and sustainability. Kader et al. (2000) revealed that *Azotobacter* application either individually or in combination with organic and chemical fertilizers Increased growth and yield of rice. As reported by Sattar et al. (2008), *Azotobacter*, *Azorpirillum* and blue-green algae were found effective to increase rice yield and to save urea. Potentiality of different biofertilizers in enhancing crop growth and yield and saving chemical fertilizers has been reported by many researchers (Sood and Sharma, 2001; Siavoshi et al., 2011; Roy and Srivastava, 2011).

Organic fertilizer such as Agroplus Biodecomposer, manufactured by a Malaysian company, is an integrated and sustainable solution that is capable of increasing rice yield and soil health. It is specially formulated from mixture of organic matters along with *Streptomycetes* bacteria to assure excellent plant nutrition and thus plant growth and productivity. It is simple and cost effective method. The presence of quality organic substance in it greatly enhances root growth and increases plant resistance toward pathogens (fungus, bacteria, virus and insects). Agroplus Biodecomposer has been successfully using for increased yield and bacterial leaf blight control in rice in Malaysia for the last few years (Hasan et al., 2002). Based on the success of this biofertilizer in Malaysia, it is expected that Agroplus Biodecomposer will also work under Bangladesh condition and, therefore can be a viable option to boost up rice production in a cost-effective and sustainable way.

Therefore, the present study was undertaken to evaluate the potentiality of Agroplus Biodecomposer in increasing rice yield under Bangladesh condition and to identify the proper dose of Agroplus Biodecomposer for its maximum efficacy against hybrid and inbred rice varieties.

Table 1. Chemical composition of Agroplus Biodecomposer

Elements	Content (%)
Nitrogen	3.3
Phosphorus (P_2O_5)	1
Potassium (K_2O)	1.5
Cuprum (Cu)	0.2
Boron (B)	0.1
Zinc (Zn)	0.2
Protein	Trace
Carbohydrate	Trace
Mineral	Trace
Lignin	Trace
Humic Acid	Trace

† Chemical analysis was done at the Crop Science Department, Universiti Putra Malaysia (UPM) following standard methods

2 Materials and Methods

2.1 Experimental site

The experiment was conducted at the Ujan Kashiar Char, Vangabari under Mymensingh district during December 2015 to May 2016. The experiment was conducted in farmer's field. Geographically the experimental field is located at 24°10′0″N, 90°25′0″E, and at 15 m above the sea level. The experimental site belongs to the Old Brahmaputra Floodplain (AEZ-9). The land was medium low and the soil was silt-loam, well drained and its general fertility level was low as per soil test result. The soil was more or less neutral in nature, low in organic matter content. The climate is sub-tropical. Usually there is high temperature, high humidity and heavy rainfall with occasional gusty winds during April to September (kharif season) and scanty rainfall associated with moderately low temperature and low humidity during October to March (rabi season). During the experimental period, monthly average maximum and minimum temperature, relative humidity, and total rainfall and sunshine hours ranged from 23.9 to 33.5 °C, 12.0 to 23.7 °C, and 73.1 to 84.3%, 0.3 to 10.6 mm and 117.9 to 171.3 hrs, respectively.

2.2 Experimental treatments

The experiment comprised two factors. Factor A included four rice varieties namely Hybrid rice Hira, Hybrid rice Tej, BRRI dhan28 and BRRI dhan29. Factor B comprised four different concentration of Agroplus Biodecomposer (AB) *viz.*, control (no AB) , 2% AB, 3% AB and 4% AB. Agroplus Biodecomposer solution were foliar sprayed thrice at 30, 45 and 60 days after transplanting (DAT) as per treatment until rice plants were entirely wet. The experiment was laid out in a Randomized Complete Block Design with 3 replications. Each block was divided into 16 unit plots of size 10 m^2 (4.0 m × 2.5 m). Thus the total number of unit plots was 48.

2.3 Experimental material

Agroplus Biodecomposer was used as the experimental material in this study. Agroplus Biodecomposer is an organic biofertilizer containing *Streptomycetes* bacteria manufactured by DUHC Technologies Sdn. Bhd., Malaysia. It is specially formulated from mixtures of organic materials including fish meal (10%), soya (10%), molasses (40%) and Zeolite (5%) to provide plant nutrition and maintain excellent crop growth by increasing plant resistance against certain diseases. Chemical composition of Agroplus Biodecomposer are presented in Table 1.

2.4 Crop husbandry

The experimental land was first opened with a power tiller and then puddled thoroughly by a country plough and subsequently leveled by laddering. Weeds and stubbles of the previous crop were removed from the field. The treatments were allocated randomly. Transplanting was done with 40 days old seedlings at the rate of 3 seedlings $hill^{-1}$ maintaining the spacing of 25 cm × 15 cm on 10 January 2016. Fertilizers were applied at the rate of 120-80-60-10 kg ha^{-1} of triple super phosphate, muriate of potash, gypsum and Zinc sulphate, respectively at the time of final land preparation as per Bangladesh Rice Research Institute (BRRI) recommendation. Urea at the rate of 220 kg ha^{-1} was top dressed in three equal splits at 15, 45 and 60 DAT. Intercultural operations were done for ensuring and maintaining the normal growth and development of the crops. Weeding was done manually at 30, 45 and 60 DAT. Experimental plots were flood irrigated. Excess water was drained out from the plot before 15 days of harvest to enhance maturity of the crop. Agroplus Biodecomposer was foliar sprayed as per treatment (0, 2 or 3 or 4% solution) at 30, 45 and 60 DAT until rice plants were entirely wet. Different varieties were harvested at full maturity from 24 April to 18 May. Five hills from each plot were randomly selected and uprooted for recording yield parameters. In each plot central 1 m^2 area was harvested to record yield data. The harvested crop of each plot was separately threshed by pedal thresher. Grains were sun dried and cleaned. Straws were also sun dried properly. Finally, grain yield was adjusted to 14% moisture and converted to t ha^{-1}.

2.5 Data collection and statistical analysis

Data were collected on plant height and tillering ability of rice at different growth stages. At maturity, yield contributing characters, grain and straw yield were recorded and biological yield and harvest index were calculated. All the data were tabulated in proper form for the statistical analysis. Analysis of variance was done following the RCBD with the help of computer package MSTAT-C program and the mean differences were adjudged by the Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$.

3 Results and Discussions

3.1 Plant height and tillering ability

Plant height was recorded at 30, 45 and 60 DAT in this study. Plant height was significantly influenced by rice variety at all sampling dates. It was found that Hybrid rice Hira produced the tallest plants of 36.15, 64.33, and 84.22 cm at 30, 45, 60 DAT, respectively. Another hybrid variety Tej closely followed Hira. On the other hand, the lowest plant heights of 31.02, 55.75 and 71.70 cm were observed in BRRI dhan28 at 30, 45 and 60 DAT, respectively (Fig. 1). In our study, hybrid varieties were found taller than inbred ones. Like plant height tillering ability also varied significantly among the rice varieties studied. Here also hybrid varieties produced higher number of tillers compared to inbred ones. The highest number of total tillers $hill^{-1}$ of 4.93, 17.72 and 18.95 were found in Hybrid rice Hira and inbred variety BRRI dhan28, on the other hand, produced lowest values of 4.133, 14.15 and 15.03 at 30, 45, and 60 DAT, respectively (Fig. 1). Plant height in tillering ability are mostly governed by genetic makeup of the variety. Differences in plant height and tillering among rice varieties have been reported by many researchers (Sharker et al., 2008; Anwar et al., 2010).

Effect of Agroplus Biodecomposer on plant height and tillering ability of rice was evident from our study. Both plant height and tillering were increased gradually with the increased concentration of Agroplus Biodecomposer at all observation dates (Fig. 2). The tallest plants and highest number of tillers $hill^{-1}$ were recorded with the highest concentration (4%) of Agroplus Biodecomposer while lowest values were recorded when no Agroplus Biodecomposer was applied (control) at all the growth stages. On an average, the application of 4% Agroplus Biodecomposer resulted in 15% increase in plant height and 2 more tillers $hill^{-1}$ compared to control. Kader et al. (2000) also observed that application of biofertilizer improved the growth of rice. Siavoshi et al. (2011) opined that organic and biofertilizers can play vital role to increase rice growth and yield, and at the same time can contribute to improve soil health wcich is important for sustainable crop production. The effect of interaction between variety and Agroplus Biodecomposer on plant height at different growth stages was not statistically significant (Table 2). Numerically, the highest plant heights were found in hybrid rice Hira treated with 4% of Agroplus Biodecomposer, while the lowest values were recorded with BRRI dhan28 treated with no Agroplus Biodecomposer. Tillering ability, on the other hand was significantly influenced by the interaction between variety and Agroplus Biodecomposer at 45 and 60 DAT. Hybrid varieties Hira and Tej interacted favorably with the highest concentration (4%) of Agroplus Biodecomposer to produce the maximum tillers at both 45 and 60 DATs. Inbred varieties treated with no Agroplus Biodecomposer resulted in the least number of tillers $hill^{-1}$.

3.2 Yield contributing characters and yield

Variety exerted significant influence on all the yield contributing characters and yield of rice (Table 3). Hybrid rice Hira was the best performer in terms of yield (6.07 t ha^{-1}) among the varieties which was the consequence of highest number of effective tillers $hill^{-1}$ (15.31), grains $panicle^{-1}$ (129.5) and 1000-grain weight (24.19 g). Another hybrid variety Tej closely followed Hira variety with the grain yield of 5.39 t ha^{-1}. As expected, hybrid varieties out yielded inbred ones. Inbred variety BRRI dhan28 performed the worst producing grain yield of only 4.41 t ha^{-1} which was 27% lower than the yield of top performer Hira. Lowest effective tillers $hill^{-1}$ (12.64), grains $panicle^{-1}$ (121.5) and 1000-grain weight (20.54 g) contributed resulted in the lowest grain yield of BRRI dhan28. Another inbred variety BRRI dhan29 ranked producing grain yield of 4.88 t ha^{-1}. Like grain yield, straw and biological yield also were found the highest (7.25 and 13.33 t ha^{-1}, respectively) with hybrid variety Hira closely followed by another hybrid Tej. Similarly, inbred variety BRRI dhan28 produced the lowest straw and biological yields (5.43 and 9.85 t

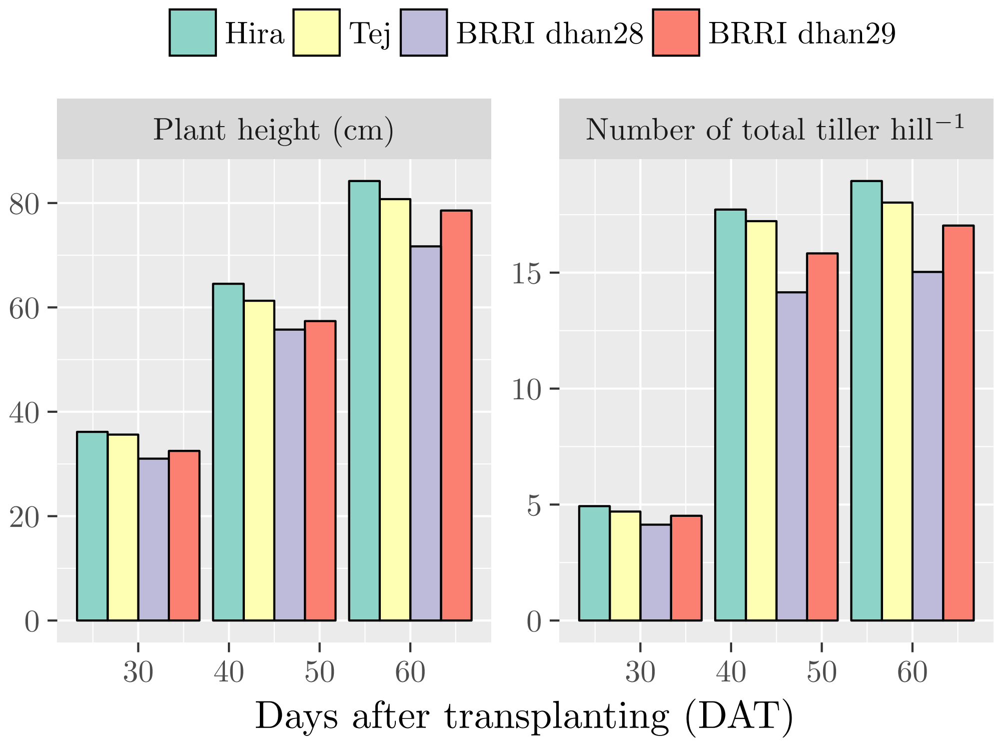

Figure 1. Effect of variety on plant height and total tillers hill^{-1} at different days after transplanting of winter rice

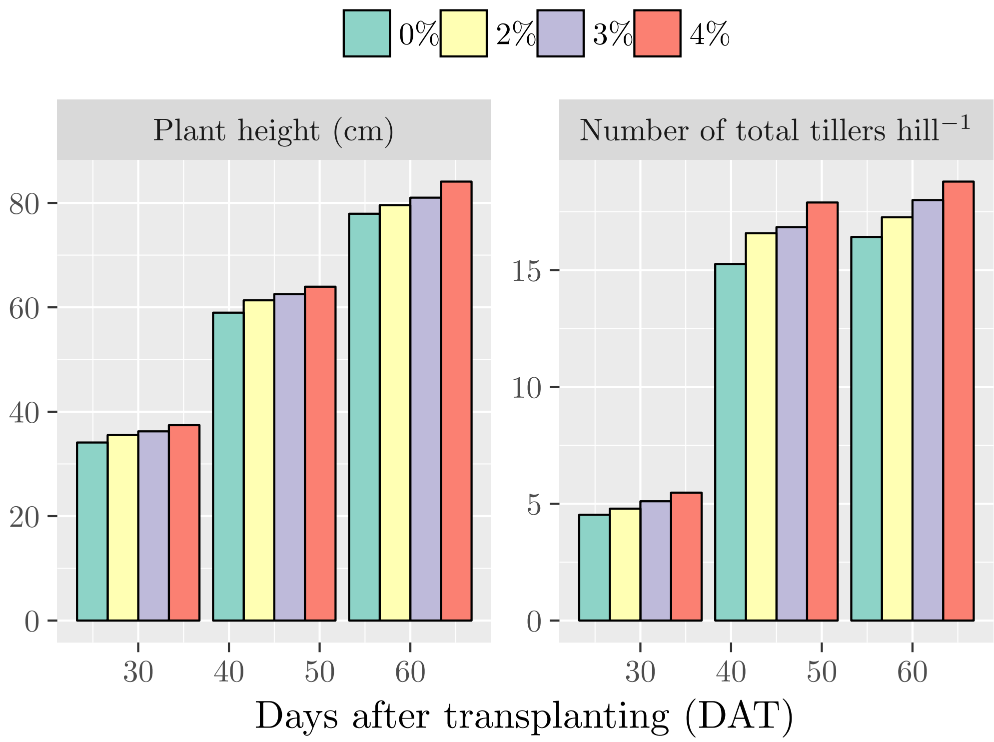

Figure 2. Effect of Agroplus Biodecomposer on plant height and number of total tillers hill^{-1} at different days after transplanting of winter rice

Table 2. Interaction effect of variety and Agroplus Biodecomposer on plant height and number of total tillers hill^{-1} at different days after transplanting of winter rice

Variety × Agro. Bio.	Plant height (cm)			No. of totla tillers hill^{-1} (cm)		
	30	45	60	30	45	60
V1T0	34.6	63.07	82.4	4.66	16.27 c	17.20 def
V1T1	35.53	64.13	83.5	4.73	17.53 b	18.80bc
V1T2	36.87	65.07	84.4	5	18.20 a	19.53 ab
V1T3	37.6	65.87	86.6	5.33	18.87 a	20.27 a
V2T0	34.33	60.33	77.1	4.33	15.93 c	16.53 fgh
V2T1	35.17	61.33	80.5	4.53	17.13 b	17.27def
V2T2	36	61.47	80.9	4.8	17.20 b	18.20 cd
V2T3	37	61.93	84.5	5.13	18.60 a	20.07a
V3T0	28.13	52.47	68.5	3.33	13.60 e	14.40 k
V3T1	30.87	54.67	69.6	3.86	13.93e	14.53jk
V3T2	31.67	55.6	71.3	4.33	14.20 e	15.40ij
V3T3	33.4	60.27	77.4	5	14.87 d	15.80 hi
V4T0	31.53	54.73	76.5	4.13	13.67 e	16.1ghi
V4T1	32.27	57.53	76.9	4.26	15.93 c	16.87 efg
V4T2	32.6	57.93	80	4.6	16.33 c	17.53 def
V4T3	33.6	59.33	80.9	5.06	17.40 b	17.60 de
Standard deviation	1.12	1.63	1.59	0.255	0.229	0.329
Level of significance	NS	NS	NS	NS	**	*
CV (%)	5.71	4.73	3.51	9.67	2.44	3.3

[1] In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT). [2] * and ** signify significant at 5% and 1% level of probability, respectively. NS=not significant. [3] V1 = Hybrid rice Hira, V2 = Hybrid rice Tej, V3 = BRRI dhan28, V4 = BRRI dhan29, T0 = 0%, T1 =2%, T2=3%, T3=4%.

Table 3. Effect of variety on yield contributing characters and yield of winter rice

Variety	No. of effective tillers hill^{-1}	No. of grains panicle^{-1}	No. of sterile spik. panicle^{-1}	Weight of 1000 grains	Grain yield t ha^{-1}	Straw yield t ha^{-1}	Biological yield t ha^{-1}	Harvest index HI (%)
Hybrid rice Hira	15.31a	129.5a	25.18d	24.19a	6.07a	7.25a	13.33a	45.49
Hybrid rice Tej	15.02ab	126.6a	40.76c	23.69a	5.39b	6.54b	11.94b	45.07
BRRI dhan 28	12.64c	121.5b	68.67a	20.54b	4.41d	5.43d	9.85d	44.72
BRRI dhan 29	14.55b	125.1ab	45.88b	20.89b	4.88c	5.99c	10.88c	44.79
Standard deviation	0.213	1.51	0.564	0.327	0.037	0.046	0.108	0.402
Level of significance	**	**	**	**	**	**	**	NS
CV (%)	5.14	4.21	4.34	5.1	2.46	2.51	3.25	3.1

[1] In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT) [2] * and ** signify significant at 5% and 1% level of probability, respectively. NS=not significant.

ha^{-1}, respectively) followed by BRRI dhan29. Harvest index was not differed among varieties. In fact, grain yield of rice is the outcome of different yield contributing characters which is mostly governed by genetic make-up of the variety and also influenced by management practices (Anwar et al., 1999). Each variety has got their potential yield which can only be achieved by providing suitable agro-climatic conditions along with proper agronomic management. In our study, variety differed in their yield attributes and yield, and as expected hybrid varieties out yielded inbred ones because of their hybrid vigor (Ahmed et al., 2000; Anwar et al., 2010; Hasan et al., 2002). Yield variation among rice varieties has been reported by many researchers (Kamal et al., 2007; Hia et al., 2017; Murshida et al., 2017).

Foliar spray of Agroplus Biodecomposer significantly and tremendously improved yield contributing characters and yield of rice (Table 4). Number of effective tillers hill^{-1} and grains panicle^{-1} were increased gradually with the increasing concentration of Agroplus Biodecomposer. Due to spraying with 2, 3 and 4% Agroplus Biodecomposer, number of effective tillers hill^{-1} were enhanced by around 10, 17 and 23% compared to no Agroplus Biodecomposer application. Similarly, number of grains panicle^{-1} also were increased by respectively 9, 17 and 25% while spraying with 2, 3 and 4% Agroplus Biodecomposer when compared with control. Another yield contributing character 1000-grain weight was increased as a result of Agroplus Biodecomposer spraying but found statistically similar for all the concentrations studied. Agroplus Biodecomposer played a significant role in reducing number of sterile spikelets panicle^{-1}, a yield retarding character. The highest number of sterile spikelets panicle^{-1} (54.24) was recorded when Agroplus Biodecomposer was not sprayed but it was reduced gradually with the increase in the concentration of Agroplus Biodecomposer sprayed. Sterile spikelets panicle^{-1} could be reduced by 18, 24 and 28% if rice is foliar sprayed with 2, 3 and 4% Agroplus Biodecomposer, respectively (Table 4). As the consequence of improved yield attributes, grain yield of rice increased gradually as the foliar spray concentration of Agroplus Biodecomposer increased. Present findings show that rice yield could be increased by up to >35% (6.02 t ha^{-1}) by foliar spraying with 4% Agroplus Biodecomposer when compared with control. Spraying with 2 and 3% Agroplus Biodecomposer also increased grain yield by 14 and 26%, respectively. Like grain yield straw yield and biological yield also were increased gradually with the increased concentration of Agroplus Biodecomposer application. It is evident that straw and biological yields of rice were increased by 28 and 32%, respectively when foliar sprayed with the highest concentration (4%) of Agroplus Biodecomposer (Table 4). Harvest index also recorded the highest around 46% with 4% Agroplus Biodecomposer which was statistically similar with that obtained from 3% Agroplus Biodecomposer (45.35%). Control treatment, on the other hand, resulted in 44% harvest index. Interaction between variety and Agroplus Biodecomposer were found significant only for grain and straw yields (Table 5). Hybrid variety Hira interacted favorably with 4% Agroplus Biodecomposer to produce the highest grain and straw yields (7.00 and 8.20 t ha^{-1}, respectively). The same variety sprayed with 3% Agroplus Biodecomposer and another hybrid Tej sprayed with 4% Agroplus Biodecomposer resulted in second highest grain and straw yields. On the other hand, inbred variety BRRI dhan28 sprayed with no Agroplus Biodecomposer resulted in the lowest grain and straw yields (3.6 and 4.63 t ha^{-1}, respectively).

A positive effect of biofertilizers application on the growth and yield of different crops including rice are well documented in world literature (Kader et al., 2000; Singh and Ngachan, 2001; Majumdar et al., 2007; Sattar et al., 2008). The increase in crop growth and yield as the consequence of bio-fertilizer application is not only due to nitrogen fixation or phosphate solubilization, but also due to several other factors such as release of growth promoting substances, control of plant pathogens, and proliferation of beneficial organisms in the rhizosphere (Kundu and Gaur, 1984). Singh and Ngachan (2001), on the other hand, opined that bio-fertilizer works as a supplementary source of nutrients and thus help increase crop yield. Roy and Srivastava (2011) reported that Azotobacter chroococcum substantially increased growth parameters, biomass, leaf area index and yield parameters of rice and at the same time saved 20 kg N ha^{-1}. Similarly, Sattar et al. (2008) revealed that Azotobacter save 20 kg N ha^{-1} with additional yield of 1.24 t ha^{-1}. Hassan et al. (2012) also showed that use of bio-fertilizer increased rice grain yield to some extent. Datta et al. (1982) reported that PSB solubilizes inorganic phosphates in the soil and make them available to the crop which resulted in better yield. In this study, Agroplus Biodecomposer enhanced rice growth and increased yield which might be due to not only Streptomycetes bacteria but also due to presence of different macro and micro nutrients and other organic materials.

4 Conclusion

Findings of the present study confirms that Agroplus Biodecomposer has great potentiality to increase rice yield up to 38% in a sustainable way under Bangladesh condition. In our study, rice yield increased gradually up to the highest concentration (4%) of Agroplus Biodecomposer which does not ventilate any clue regarding its optimum concentration for maximum potentiality. Therefore, further studies are needed considering higher than 4% concentra-

Table 4. Effect of Agroplus Biodecomposer on yield contributing characters and yield of winter rice

Agro. Bio. (%)	No. of effective tillers hill^{-1}	No. of grains panicle^{-1}	No. of sterile spik. panicle^{-1}	Weight of 1000 grains	Grain yield t ha^{-1}	Straw yield t ha^{-1}	Biological yield t ha^{-1}	Harvest index HI (%)
0	12.81d	111.7d	54.24a	21.48b	4.33d	5.51d	9.84d	44.02c
2	14.05c	121.3c	44.38b	22.23ab	4.94c	6.08c	11.03c	44.74bc
3	14.95b	130.3b	41.97c	22.65a	5.45b	6.51b	12.03b	45.35ab
4	15.74a	139.3a	39.91d	22.93a	6.02a	7.07a	13.10a	45.97a
Standard deviation	0.213	1.51	0.564	0.327	0.037	0.046	0.108	0.402
Level of significance	**	**	**	*	**	**	**	**
CV (%)	5.14	4.21	4.34	5.10	2.46	2.51	3.25	3.10

[1] In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT).
[2] * and ** signify significant at 5% and 1% level of probability, respectively.

Table 5. Interaction effects of variety and Agroplus Biodecomposer on yield contributing characters and yield of winter rice

Variety × Agro. Bio.	No. of effective tillers hill^{-1}	No. of grains panicle^{-1}	No. of sterile spik. panicle^{-1}	Weight of 1000 grains	Grain yield t ha^{-1}	Straw yield t ha^{-1}	Biological yield t ha^{-1}	Harvest index HI (%)
V1T0	13.73	112.1	30.26h	23.2	5.10 d	6.53cd	11.63	43.83
V1T1	15.33	127.9	24.73 i	23.81	5.90 c	6.79c	12.69	46.45
V1T2	15.47	134.1	23.13 i	24.87	6.30 b	7.50b	13.8	45.64
V1T3	16.7	144	22.59 i	24.88	7.00a	8.20a	15.2	46.05
V2T0	13.53	112	52.35d	22.9	4.53f	5.78g	10.31	43.97
V2T1	14.6	121.7	38.59f	23.61	5.10 d	6.31de	11.41	44.66
V2T2	15.47	131.6	37.93f	23.96	5.70 c	6.80c	12.5	45.59
V2T3	16.47	141.1	34.19 g	24.29	6.23 b	7.29b	13.52	46.08
V3T0	11.13	110.9	81.19a	19.69	3.63h	4.63i	8.267	43.92
V3T1	11.87	115.5	66.19 b	20.59	4.22g	5.33h	9.553	44.18
V3T2	13.3	125.9	65.59 b	20.79	4.76e	5.76g	10.53	45.27
V3T3	14.27	133.5	61.72c	21.08	5.03d	6.02fg	11.06	45.51
V4T0	12.87	111.9	53.14 d	20.15	4.06g	5.10h	9.167	44.36
V4T1	14.4	120.1	48.00e	20.92	4.56ef	5.89g	10.46	43.66
V4T2	15.4	129.6	41.23f	21	5.07d	6.21ef	11.28	44.9
V4T3	15.53	138.7	41.13f	21.48	5.83c	6.76c	12.6	46.25
S	0.427	3.05	1.12	0.656	0.073	0.091	0.216	0.804
Level of sig.	NS	NS	**	NS	*	*	NS	NS
CV (%)	5.14	4.21	4.34	5.1	2.46	2.51	3.25	3.1

[1] In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT)
[2] * and ** signify significant at 5% and 1% level of probability, respectively. NS=not significant.

tion for optimizing its concentration. However, foliar spray with 4% Agroplus Biodecomposer at 30, 45 and 60 DAT along with hybrid rice variety Hira may be recommended for increased rice yield in boro season.

Conflict of Interst

The authors declare that there is no conflict of interests regarding the publication of this article.

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