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Effect of Soil Enhancer (XXL) and Fertilizers on the Morpho-Physiological and Yield Attributes of Brri Dhan28 (*Oryza sativa* L.) In *Boro* Season

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Authors' contributions

This work was carried out in collaboration between all authors. Author KUA designed the study. Author MWF performed the statistical analysis and wrote the protocol. Author MSR wrote the first draft of the manuscript. Author KUA managed the analyses of the study. Authors MSR, MAR and MSR managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The experiment was conducted at the Research Farm of Sher-e-Bangla Agricultural University, Dhaka to find out the effect of soil enhancer (XXL) and fertilizers on the morpho-physiological and yield attributes of BRRI dhan28 in *Boro* season. The experiment comprised one factor viz. T_1= Control, T_2=100% recommended dose of fertilizer, T_3= 100% dose of XXL without fertilizer, T_4=100% dose of XXL + 100% recommended dose of fertilizer, T_5=50% dose of XXL + 50% recommended dose of fertilizer, T_6=50% dose of XXL + 100% recommended dose of fertilizer, T_7=100% dose of XXL + 50% recommended dose of fertilizer and T_8=100% dose of XXL + 75% recommended dose of fertilizer. The experiment was laid out in a Randomized Complete Block

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Design (RCBD) with three replications. Significant variation was observed in different morpho-physiological and yield contributing characters of rice with XXL and fertilizers. Among the different XXL and fertilizers doses, 100% dose of XXL + 75% recommended dose of fertilizer provided the best result of rice with the increased of plant height (20.94%), SPAD value (17.46%), tillers hill^{-1} (61.84%), leaf area (38.43%), panicle length (8.44%), filled grain panicle^{-1} (33.91%) and 1000 grain weight (3.75%) over than control. The highest grain yield (7.65 t ha^{-1}) which was (89.83%) higher than that of control treatment. It meant that BRRI dhan28 performed well with 100% dose of XXL + 75% recommended a dose of fertilizer applied.

Keywords: Rice; XXL; biofertilizer; SPAD value; humic acid and fulvic acid.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food for more than half of the world's population. In Asia, more than 90% of this rice is consumed [1]. In Bangladesh rice are the staple food of about 160 million people and its cover 75% of the total cropped area [2]. It contributes 76 percent of the calorie and 66 percent of the protein intake. The trend of *Boro* rice production in Bangladesh is increasing day by day but it still very low in comparison to others rice growing countries. In Bangladesh, the average yield of rice is about 3.97 t ha^{-1} which very low compared to other rice growing countries of the world, like China (6.30 t ha^{-1}), Japan (6.60 t ha^{-1}) and Korea (6.30 t ha^{-1}) [3]. *Boro* contributes to around 55% of the total rice production in Bangladesh [4]. However, Bangladesh needs to increase the rice yield further to meet the growing demand. Now it is essential to find out sustainable technology for poverty alleviation and ensuring food security for increasing population. So, growth enhancing facilities lead to the increasing yield and production performance [5]. PGRs (Plant Growth Regulators) stimulate the growth of plant height, tiller number and yield of rice plant [6]. Humic acid enhances cell permeability, which in turn made for more rapid entry of minerals into root cells and so resulted in higher uptake of plant nutrients in rice plant [7]. Organic manure or fertilizer significantly increased the soil pH and the concentrations of nitrogen, available phosphorus, exchangeable potassium, calcium, and magnesium [8]. Foliar application of humic and fulvic acids together led to significant increases of grain, straw rice yield and N, P & K content of grain and straw [7]. XXL (Soil enhancer) is a complex substance which made from million years of highly compressed organic humus in the tropical rainforests which consists of organic humic acid, fulvic acid, 40 different trace elements and other plant hormones. Plant morpho-physiological and yield characters are influenced indirectly and directly by humic and fulvic substances which is the main components of XXL [5]. The main action of XXL (soil enhancer) is to improve the soil and provide the best environment to the plant can achieve the best growth rate and potential. Integration of XXL and chemical fertilizers may facilitate the utilization of nutrients for crop growth and productivity and help replenish the organic matter status in soil. Therefore, the present study was designed to investigate the effect of soil enhancer (XXL) and fertilizers on the morpho-physiological and yield attributes of BRRI dhan28 in SAU campus. The experiment was aimed to evaluate the optimum doses of XXL and their effect on the morpho-physiological and yield attributes of BRRI dhan28.

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was conducted at the Research Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka-1207, Bangladesh and it was located in 24.09° N latitude and 90.26° E longitudes.

2.2 Climate and Soil

The climate of the experimental site is sub-tropical, wet and humid. Heavy rainfall occurs in the monsoon (mid-April to mid-August) and scanty during rest of the year. The soil of the experimental area was silty clay in texture. Soil pH was 6.7 and has organic carbon 0.45%.

2.3 Experimental Treatment

The experiment consisted of two different concentrations of XXL [100% doses of XXL (1.5 g/1.5 L) and 50% doses of XXL (0.75 g/1.5 L)], and recommended doses of

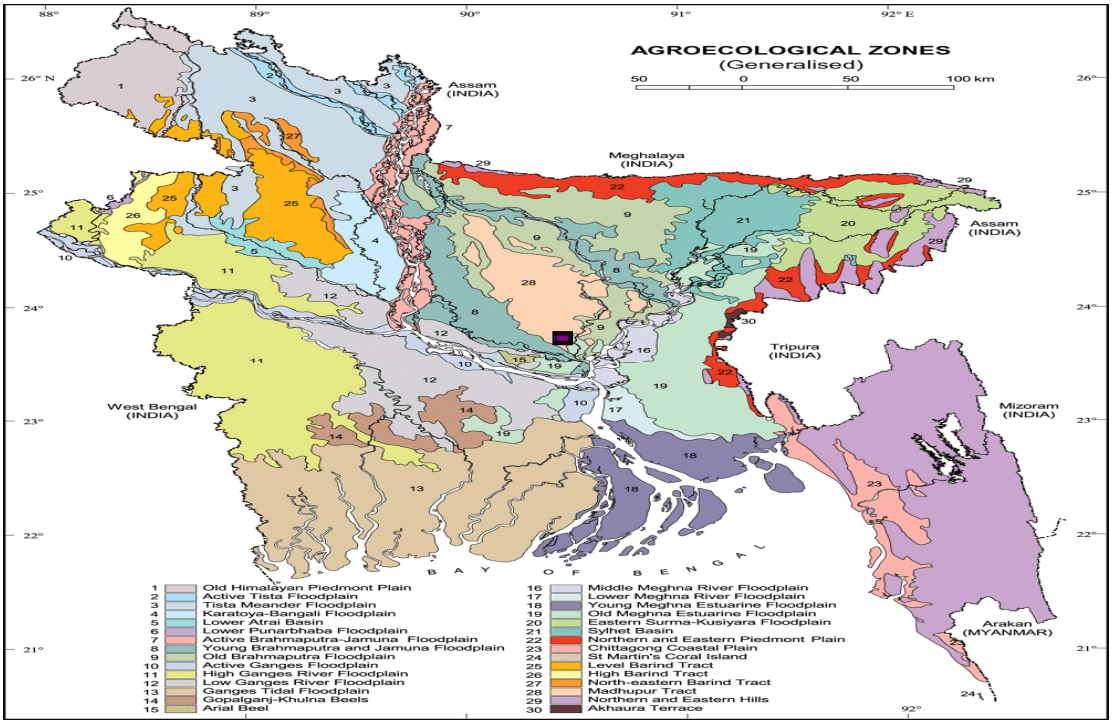

Fig. 1. Map showing the experimental sites (The experimental site)

fertilizers (Urea: 200 kg ha^{-1}, TSP: 100 kg ha^{-1}, MP: 120 kg ha^{-1}, Gypsum: 75 kg ha^{-1}, Zinc: 15 kg ha^{-1}). Treatments included in the single factor experiment were as follows: - T_1 (Control), T_2 (100% recommended dose of fertilizer), T_3 (100% XXL without fertilizer), T_4 (100% XXL + 100% recommended dose of fertilizer), T_5 (50% XXL + 50% recommended dose of fertilizer), T_6 (50% XXL + 100% recommended dose of fertilizer), T_7 (100% XXL + 50% recommended dose of fertilizer), T_8 (100% dose of XXL + 75% recommended dose of fertilizer). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. There were eight plots of 6 m^2 in size in each of 3 replications resulting 24 plots in total. As per different treatment 1st dose of XXL and basal fertilizer was applied in 31st January 2017, 2nd dose of XXL and Urea applied after 7 DAT and 10 DAT, 3rd dose of XXL was applied after 14 DAT and 4th dose after 21 DAT. 3rd dose of Urea was applied in the plots after 30 DAT.

2.4 Description and Justification of the Variety of Rice Used

Rice is the staple food of about 160 million peoples and it is the number one growing cereal crops of Bangladesh. In Bangladesh, rice covers 75% of the total cropped area and its alone constitute 97% of the food grain production. Among the different rice varieties, BRRI dhan28 (mega variety) is the most used by farmers in the whole country due to high yielding characters. As rice is the major cereal grain crop and BRRI dhan28 is the most usable rice variety that's why rice (BRRI dhan28) was used in this experiment to increase the yield for mitigate the food demand for future raising populations.

Table 1. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resources Development Institute [9]

2.5 Crop Husbandry

The seeds were sown in the seedbed @ 70 gm^{-2} to have healthy seedlings. Recommended doses of fertilizers such as Urea, TSP, MoP, Gypsum and Zinc sulphate were applied. Two seedlings (21 days) were transplanted in each hill with the plant to plant distance of 15 cm and row to row distance of 20 cm. XXL was a powder prior to spray. XXL was diluted to get a working solution. XXL solution was applied in the form of a spray in the soil by hand sprayer or knapsack sprayer. The sprays were made at early hours to avoid dehydration effect.

2.6 Data Collection

Ten pre-selected hills per plot from which different data were collected. Data on the following parameters were recorded during the course of the experiment such as - plant height, number of tillers $hill^{-1}$, leaf area, SPAD value of leaf, 1%, 50% and 100% booting stage (DAT), 1%, 50% and 100% panicle insertion stage (DAT), length of panicle (cm), number of filled and unfilled grains $panicle^{-1}$, weight of filled and unfilled grains $plant^{-1}$, 1000 grains weight and grain yield (t ha^{-1}).

2.7 Statistical Package

All the collected data were tabulated and analyzed statistically using analysis of variance technique and subsequently, Least Significance Difference (LSD at 5%) for comparing the treatment means, by MSTAT-C software [10].

3. RESULTS AND DISCUSSION

3.1 Plant Height

The plant height was significantly influenced due to the effect of different doses of XXL and fertilizers in the growth period over control at 60 and 80 DAT (Fig. 2). The tallest plant (26.78 and 48.90 cm at 60 and 80 DAT, respectively) was recorded from T_8 (100% dose of XXL + 75% recommended dose of fertilizer) treatment. In contrast, the shortest plant (23.21 and 40.43 cm at 60 and 80 DAT, respectively) was recorded from T_1 (control). It was also observed that 100% XXL with 75% recommended doses of fertilizers improved the soil condition and provide the best environment to the plant for nutrient uptake, so that plant can achieve the best growth rate and potential. Humic and fluvic acid increased the nitrogen which probably favored the cellular activities during panicle formation and development of rice plant that led to an increase of plant height [7]. Plant height was significantly influenced by different doses of humic acid in rice plant and humic acid produced the longest plant (86.33 cm) by the application of 3 L ha^{-1} [11].

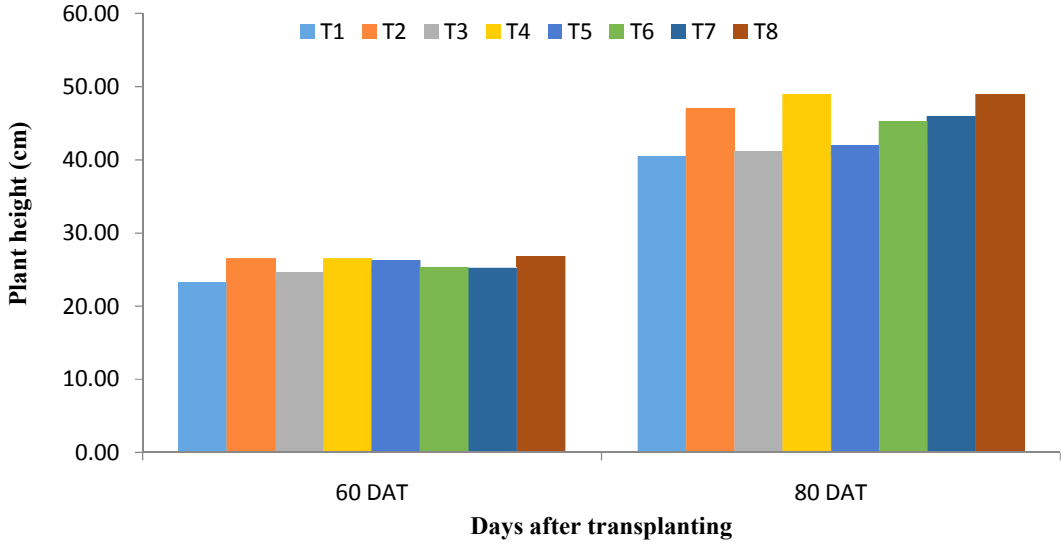

Fig. 2. Effect of different doses of XXL and fertilizers on the plant height of rice

3.2 SPAD Value of Leaf

SPAD meter reading of leaf was analyzed and presented in order to have an idea about relative chlorophyll content per unit leaf area of the rice varieties. SPAD value of rice leaf was significantly affected by the different doses of XXL and fertilizers at 60 and 80 DAT (Fig. 3). At 60 and 80 DAT the maximum SPAD value (42.59 and 32.49, respectively) were found from T_8 (100% dose of XXL + 75% recommended dose of fertilizer) treatment, on the other hand, the minimum SPAD value (35.39 and 27.66) at 60 and 80 DAT, respectively were found from T_1 (control) treatment. Humic acid increased the yield of crops through exerting its positive physiological influences by increasing leaf chlorophyll concentration [12]. Significant effect on leaf chlorophyll content of the test rice varieties with different concentrations of XXL, where 75% XXL gave the best result [5].

3.3 Number of Tillers Hill^{-1}

Significant variation was observed for the number of tillers hill^{-1} as influenced by different doses of XXL and fertilizers (Table 2). Results showed that the highest (13.40) number of tillers hill^{-1} was recorded from T_8 (100% dose of XXL + 75% recommended dose of fertilizer) treatment, whereas the lowest (8.28) was obtained from T_1 (control) treatment. Humic and fluvic acid increased the nitrogen which probably favored the cellular activities that led to an increased number of tillers hill^{-1} of the rice plant [7]. The application of compost (organic matter) together with NPK fertilizers significantly increased the number of tillers per rice plant [13].

3.4 Leaf Area

Statistically, significant variation was recorded for rice leaf area due to the different doses of XXL and fertilizers (Table 2). Results showed that the highest (29.54 cm^2) leaf area was recorded from T_8 (100% dose of XXL + 75% recommended dose of fertilizer) treatment, while the lowest (21.34 cm^2) was obtained from T_1 (control) treatment. Rahman et al. [5] showed the significant effect on leaf area of the test rice varieties with different concentrations of XXL, where 75% XXL gave the best (29.26 cm^2) result and worst (19.32 cm^2) from the control treatment. Humic acid was able to increase leaf area in the common bean leaves. General strong increases in leaf area (cm^2) were observed in almost plants treated with HA and facilitate respiration and photosynthesis processes via modified functioning of mitochondria and chloroplasts [14].

3.5 1%, 50% and 100% Booting Stage

Significant variation was observed from 1%, 50% and 100% booting stage of rice due to different doses of XXL and fertilizers (Table 2). The minimum days to required 1%, 50% and 100% booting stage (56.33, 58.33 and 59.33 days, respectively) were recorded from T_8 (100% dose of XXL + 75% recommended dose of fertilizer) treatment, while the maximum days

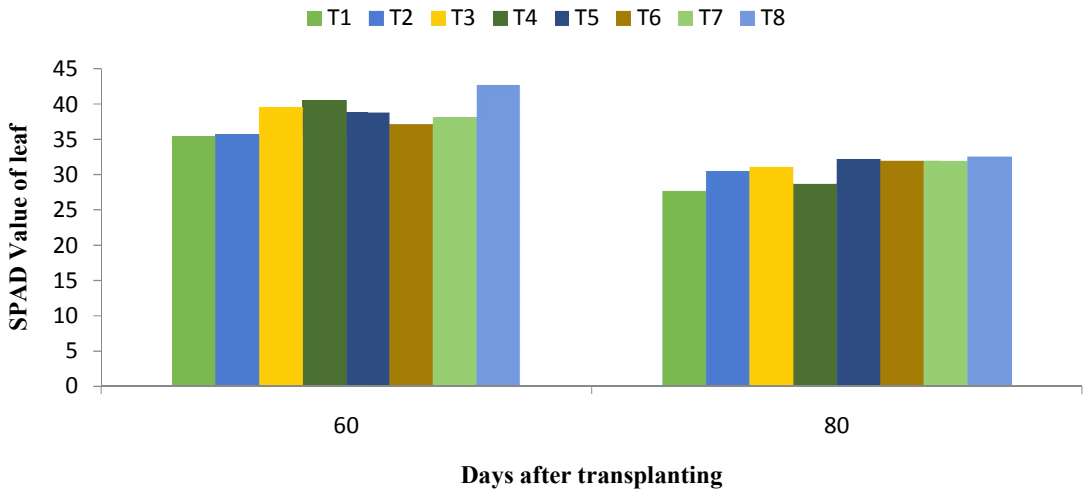

Fig. 3. Effect of different doses of XXL and fertilizers on SPAD value (chlorophyll content) of rice leaf at different days after transplanting

(62.67, 64.33 and 65.67 days, respectively) were found from T_1 (control) treatment. The significant effect on different booting stage of the test rice varieties with different concentrations of XXL, where 75% XXL gave the minimum days for booting [5]. The addition of 100 to 300 ppm of fluvic acid produced highly significant increases in the growth and development of above and below ground cucumber plant parts and in the formation of numbers of flowers per plant [15].

3.6 1%, 50% and 100% Panicle Insertion Stage

Significant variation was observed from 1%, 50% and 100% booting stag panicle insertion stage of rice due to different doses of XXL and fertilizers (Table 2). The minimum days to required 1%, 50% and 100% panicle insertion stage (63.67, 66.33 and 68.00 days, respectively) were recorded from T_8 (100% dose of XXL + 75% recommended dose of fertilizer) treatment , while the maximum days (67.33, 70.67and 70.67days, respectively) were found from T_1 (control) treatment. The significant effect on panicle insertion of the test rice varieties with different concentrations of XXL, where 75% XXL gave the minimum days for panicle insertion [5]. IAA (3-indole acetic acid) treatment increased spikelet growth and development in the distal branches of the rice plant [16].

3.7 Panicle Length

Panicle length was varied significantly due to the effect of different doses of XXL and fertilizers (Fig. 4). The maximum panicle length (20.95 cm) was observed from T_4 (100% dose of XXL + 100% recommended dose of fertilizer) treatment which was followed by T_6 (20.52 cm) and T_8 (20.10 cm) treatment, while the minimum panicle length (19.32 cm) was observed in T_2 (100% XXL) treatment which was statistically similar to T_1 (19.41 cm). The significant difference in panicle length of rice was obtained with the application of humic acid and the longest panicle length (24.78 cm) was obtained with humic acid applied @ 6 L ha-1 and the shortest (23.43 cm) was obtained at control [11]. GA_3 positively increase panicle exertion, duration of floret opening, the angle of floret opening and panicle length of hybrid rice [17].

3.8 Filled Grains Panicle^{-1}

Statistically significant variation was recorded for the number of filled grains panicle^{-1} due to different doses of XXL and fertilizers (Table 3). The highest number of filled grains panicle^{-1} (92.73) was observed in T_8 (100% dose of XXL + 75% recommended dose of fertilizer) treatment, whereas the lowest number of filled grains panicle^{-1} (69.25) was found from T_1 (control) treatment. The number of seeds per panicle of rice significantly increased when the level of humic acid application was raised [18]. The application of biofertilizers significantly increased the number of seeds per row in corn [19].

3.9 Unfilled Grains Panicle^{-1}

The number of unfilled grains panicle^{-1} was significantly influenced by different doses of XXL and fertilizers (Table 3). The lowest number of unfilled grains panicle^{-1} (5.57) was achieved from T_8 (100% dose of XXL + 75% recommended dose of fertilizer) treatment. On the other hand, the highest number of unfilled grains panicle^{-1} (12.29) was observed in T_1 (control) treatment. A similar observation was found where the application of polymeric chitosan followed by four foliar sprayings throughout cropping season significantly decreased the unfilled grains [20].

3.10 Weight of Filled Grain per Plant

Statistically significant variation was recorded for the weight of filled grain plant^{-1} due to different doses of XXL and fertilizers (Table 3). The highest (106.10 g) weight of filled grain plant^{-1} was recorded by T_8 (100% dose of XXL + 75% recommended dose of fertilizer) treatment, whereas the lowest (53.48 g) was obtained from T_1 (control) treatment.

3.11 Weight of Unfilled Grain per Plant

The weight of unfilled grain plant^{-1} was significantly influenced by different doses of XXL and fertilizers (Table 3). The lowest Weight of unfilled grain plant^{-1} (2.88 g and 2.88 g) were obtained from T_8 (100% dose of XXL + 75% recommended dose of fertilizer) and T_7 (100% dose of XXL + 50% recommended dose of fertilizer) treatments, respectively. On the other hand, the highest (6.72 g) weight of unfilled grain plant^{-1} was recorded from T_2 (100% fertilizers) treatment.

3.12 Weight of 1000 Grains

1000 grains weight was significantly influenced by different doses of XXL and fertilizers (Table 3). The highest 1000 grain weight (22.98 g) was attained from T_8 (100% dose of XXL + 75% recommended dose of fertilizer)

Table 2. Effect of different doses of XXL and fertilizers on the number of tiller hill^{-1}, leaf area and days required to booting stage and panicle insertion stages of rice

Treatment	No. of Tillers hill^{-1}	Leaf area (cm^2)	Booting stages (DAT)			Panicle insertion stages (DAT)		
			1% Booting	50% Booting	100% Booting	1% Panicle insertion	50% Panicle insertion	100% Panicle insertion
T_1 (Control)	8.28 d	21.35 d	62.67 a	64.33 a	65.67 a	67.33a	70.67 a	73.33 a
T_2 (100% fertilizers)	12.93 a	26.92 ab	60.00 a	62.00 ab	63.00 ab	66.00 ab	68.00 ab	70.00 ab
T_3 (100% XXL)	9.53 c	20.74 d	61.00 a	63.68 a	64.00 a	65.00 abc	68.00 ab	70.00 ab
T_4 (100% XXL + 100% fertilizers)	13.23 a	21.65 d	60.33 a	62.00 ab	63.00 ab	65.00 abc	68.33 ab	69.00 ab
T_5 (50% XXL + 50% fertilizers)	11.57 b	24.01 bcd	61.00 a	63.00 a	64.33 a	64.67 bc	67.67 ab	68.67 b
T_6 (50% XXL + 100% fertilizers)	12.80 a	22.39 cd	59.00 ab	60.33 ab	61.00 ab	65.00 abc	69.00 ab	71.33 ab
T_7 (100% XXL + 50% fertilizers)	12.80 a	25.11 bc	60.00 a	61.00 ab	62.00 ab	64.00 bc	69.00 ab	69.00 ab
T_8 (100% XXL + 75% fertilizers)	13.40 a	29.54 a	56.33 b	58.33 b	59.33 b	63.67 c	66.33 c	68.00 b
LSD $_{(0.05)}$	**0.75**	**3.121**	**3.30**	**3.83**	**4.38**	**2.47**	**3.14**	**4.00**
CV (%)	**6.89**	**8.87**	**6.55**	**5.89**	**4.00**	**4.36**	**4.51**	**5.01**

In a column means having the similar letter(s) are statistically similar and those having the dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

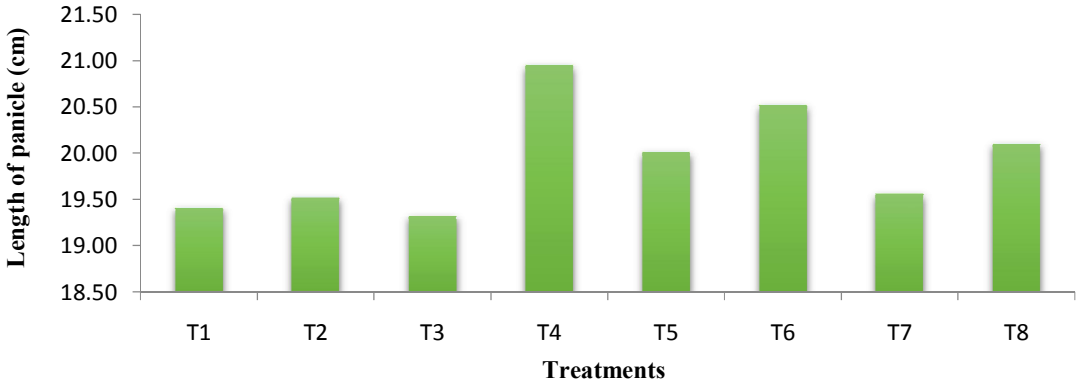

Fig. 4. Effect of different doses of XXL and fertilizers on the length of rice panicle

treatment, while the lowest 1000 seed weight (22.15 g) was observed in T_1 (control) treatment. The foliar application of humic and fulvic acids together led to significant increases of 1000 grains weight (g) and N, P & K content of grain and straw of rice [7]. 1000-grain weight was influenced by the application of humic acid and the highest 1000-grain weight (20.16 g) was obtained when humic acid was applied @ 6 L h ha^{-1} and it was lowest (18.28 g) in control treatment [11].

3.13 Grain Yield (t ha^{-1})

Statistically significant variation was recorded for the grain yield due to different doses of XXL and fertilizers (Table 3). The highest grain yield (7.65 t ha^{-1}) was observed from T_8 (100% dose of XXL + 75% recommended dose of fertilizer) treatment, whereas the lowest grain yield (4.03 t ha^{-1}) was recorded from T_1 (control) treatment. The seed yield of rice improved with increases in the concentration of humic acid in

Table 3. Effect of different doses of XXL and fertilizers on the yield and yield contributing characters of rice

Treatment	Number of filled grain $panicle^{-1}$	Number of unfilled grain $panicle^{-1}$	Weight of filled grain $panicle^{-1}$ (g)	Weight of unfilled grain $panicle^{-1}$ (g)	Weight of 1000 grain (g)	Grain yield (t ha^{-1})
T_1 (Control)	69.25 d	7.02 bcd	53.48 d	6.72 a	22.51 ab	4.03 c
T_2 (100% fertilizers)	80.19 b	6.05 cd	60.72 cd	3.19 bc	22.15 b	7.39 ab
T_3 (100% XXL)	65.95 d	6.14 cd	70.52 bcd	3.18 bc	22.56 ab	5.37 bc
T_4 (100% XXL + 100% fertilizers)	77.81 bc	6.72 cd	65.35 bcd	3.53 bc	22.64 ab	7.35 ab
T_5 (50% XXL + 50% fertilizers)	76.49 bc	12.29 a	91.77 ab	5.28 ab	22.74 a	5.62 abc
T_6 (50% XXL + 100% fertilizers)	79.51 b	8.97 b	86.00 abc	4.60 bc	22.74 a	7.35 ab
T_7 (100% XXL + 50% fertilizers)	72.10 cd	8.19 bc	78.12 abcd	2.88 c	22.19 a	5.99 abc
T_8 (100% XXL + 75% fertilizers)	92.73 a	5.57 d	106.10 a	2.88 c	22.98 a	7.65 a
$LSD_{(0.05)}$	**6.61**	**2.01**	**26.88**	**1.99**	**0.47**	**1.89**
CV (%)	**9.60**	**5.37**	**10.06**	**7.48**	**11.31**	**6.19**

In a column means having the similar letter(s) are statistically similar and those having the dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

the substrate [18]. Humic acid and organic matter application in wheat increased seed yield by 22% [21].

4. CONCLUSION

From the above summary of the study, it can be concluded that among the eight doses of XXL with fertilizer, 100% dose of XXL + 75% recommended dose of fertilizer demonstrated the best performance on morpho-physiological and yield attributes of BRRI dhan28 and increase the yield 89.83% over than control. So, 100% dose of XXL + 75% recommended dose of fertilizer with BRRI dhan28 was the best treatment found in the present experiment than all other. To justify the result further experiment can be done at Sher-e-Bangla Agricultural University or any other places with other varieties of rice or other crops.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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