EFFECT OF SOIL ENHANCER (XXL) ON THE MORPHO-PHYSIOLOGY, YIELD ATTRIBUTES AND YIELD OF BRRI DHAN 28 IN BORO SEASON

A THESIS

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ABSTRACT

The experiment was conducted at the Research field of Sher-e-Bangla Agricultural University, Dhaka during the period from December 2014 to May 2015 to find out the effect of XXL on the morpho-physiological attributes of BRRI dhan 28 (inbreed) in boro season. The experiment comprised of one factor viz. T_1= No fertilizer (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, T_8=100% dose of XXL + 75% recommended dose of fertilizer. Significant variation was recorded for data on growth, yield and yield contributing parameters of experimental materials. The maximum plant height, leaf area, number of tillers hill^{-1}, number of filled grains panicle^{-1} and weight of filled grains plant^{-1}, SPAD value of leaf was found in 100% dose of XXL with 75% recommended dose of fertilizer treatment. The highest 1000 grain weight (22.98 g) was obtain from100% dose of XXL with 75% recommended dose of fertilizer treatment. The highest grain yield (7.65 t ha^{-1}) was obtained from100% dose of XXL with 75% recommended dose of fertilizer treatment. The lowest grain yield (4.03 t ha^{-1}) was obtained from control treatment.

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LIST OF ABBREVIATION AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
HRC	=	Horticulture Research Centre
BBS	=	Bangladesh Bureau of Statistics
FAO	=	Food and Agricultural Organization
N	=	Nitrogen
et al.	=	And others
TSP	=	Triple Super Phosphate
MOP	=	Muriate of Potash
RCBD	=	Randomized Complete Block Design
DAT	=	Days after Transplanting
ha^{-1}	=	Per hectare
g	=	gram (s)
kg	=	Kilogram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
wt	=	Weight
LSD	=	Least Significant Difference
^0C	=	Degree Celsius
NS	=	Not significant
Max	=	Maximum
Min	=	Minimum
%	=	Percent
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of Coefficient of Variance

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa)*is a cereal food plant, of the grass family Poaceae, extensively cultivated in worm climates, especially in East Asia, producing seeds that are cooked and used as food. Rice being one of the most cultivated cereals in all over the world (Golshani *et al.,* 2010) and the demand for rice will increase dramatically because of the steady increase in population (Liu *et al*., 2012). Crop intensification and higher yields are the ways to bridge the increasing gap between food production and consumption in densely populated tropical Asia, because there is little new land available for rice cultivation (Chauhan *et al*., 1985). About 90 percent of the population of Bangladesh is rice eaters. The Food Department of the Government of Bangladesh recommends 410 gms of rice /head/day. Rice is rich in carbohydrates. The protein content is about 8.5 percent. Rice does not have C and A vitamins. The Thiamin and Riboflavin contents are 0.27 and 0.12 micrograms respectively.

In Bangladesh total cultivable land is 9098460 hectare and near about 70 per cent of this land is occupied by Rice cultivation. In the year of 2011, total production of Rice was 33541099 metric ton. Hybrid rice varieties are cultivated in 653000 hectare of land and total production is 2882000 metric ton in the year of 2010-2011. On the other hand, HYV (High Yielding Variety) is cultivated in 4067000 hectare land and the total production of rice is 15632000 metric ton. The average rice production of hybrid varieties was 4.41 metric ton and HYV varieties was 3.84 metric ton in the year of 2010 – 2011(BBS, 2011).

Bangladesh with a population of 140 million in a land area of 147570 Sq km is one of the most densely settled countries in the world (BBS, 2009). Agriculture is the mainstay of Bangladesh economy and it employs nearly 52% of its labor force and contributes one fourth of its gross national product (BER, 2007). The principal crop and the dominant staple food is rice, which occupies nearly 76% of its total cropped area in the country. It contributes 76 percent of the calorie and 66 percent of the protein intake (BNNC, 2008). It is, by far, the largest sectoral source of income, employment, savings and investment in the economy. The fluctuations in the productivity of rice influence the food security and to some extent ensure political stability of the country. However, Bangladesh needs to increase the rice yield further in order to meet the growing demand. The National Commission of Agriculture projected that in order to remain self-sufficient Bangladesh will need to produce 47 million tones of paddy (31.6 million tones of clean rice) by year 2020, implying a required rate of growth of production is 1.7 percent per year. An earlier Agricultural Research Strategy document prepared by the Bangladesh Agricultural Research Council (BARC) projected the required paddy production by 2020 at 52 million tons (34.7 million tons of rice), which would require a production growth of 2.2 percent per year (BARC, 2006).

Plant growth regulators are synthesized indigenously by plants, however, several studies demonstrated that plants can respond to exogenous application of these chemicals. An exogenous application of plant growth regulators affects the endogenous hormonal pattern of the plant, either by supplementation of sub-optimal levels or by interaction with their synthesis, translocation or inactivation of existing hormone levels (Arshad and Frankenberger, 1993). Plant growth regulators are one of the most important factors for increasing higher yield in leafy vegetables. Application of growth regulators has good management effect on growth and yield of field crops. Hormones regulate physiological process and synthetic growth regulators may enhance growth and development of field crops thereby increased total dry mass of a field crop (Das and Das, 1996; Abd-el-Fattah, 1997; Chibu *et al*., 2000; Dakua, 2002; Rahman, 2004; Islam, 2007; Cho *et al*., 2008). Some investigations indicated that naphthalene acetic acid (NAA) is a potential antifungal agent (Nakamura *et al*., 1978; Tomita *et al*., 1984; Michniewicz and Rozej, 1988). The use of plant growth regulators in the field of agriculture has become commercialized in some advanced counties like Europe, USA and Japan. The current uses for plant growth regulators are not only in a high value horticultural crops but it also increase field crop yield directly either by increasing total biological yield or the harvest index. Growth substances can be divided into five classes as Auxin, Gibberellins, Cytokinins, Abcisic acid, and Ethylene. Naphthalene Acetic Acid (NAA) belongs to synthetic forms of Auxins. Auxins play key role in cell elongation, cell division, vascular tissue, differentiation, root initiation, apical dominance, leaf senescence, leaf and fruit abscission, fruit setting and flowering (Davies, 1987). Growth and yield parameters of rice are significantly promoted in response to various Auxin levels (Zahir, et al. 1998). Planofix (Naphthalene Acetic Acid) had a significant effect on plant height, number of fruiting branches, volume of boll and yield in cotton (Abro, *et al*. 2004). PGRs also increase the root growth and also help promoting new roots. Rice spraying with 10 and 100 ppm NAA at tillering stage significantly increased root dry weight (Wang and Deng, 1992). Naphthalene Acetic Acid, a widebroad, somatotrophin-like growth regulator in plants. It produces significant effects in promoting development of pointed ends for the root system, resulting in more, straighter and thicker roots.

XXL bio green energy-soil enhancer is made millions of years ago from a highly compreesed organic humic acid in the tropical rain forests. The original seam of XXL bio green soil enhancer in ancient times was originally buried in the deep crust of the earth, and subsequently excavated by mankind at the surface of the earth, undergoing weathering and microbial action, then processed through grinding, to make it into our present XXL bio green soil enhancer. It is in fact a soil enhancer or soil supplement used for restoration and increase of land fertility, increase and improve the soil organics and nutrients, adjust the soil pH to achieve acid-base balance, improves fertilizer absorption and efficiency, regulate the growth of plant among many other function. The main action of XXL bio green energy-soil enhancer is to improve the soil and provide the best environment to the plant can achieve the best growth rate and potential.

So, it is expected that the XXL will improve the soil condition and the effect of XXL will be reflected on the morpho-physiological attributes of BRRI dhan 28 (inbreed) in boro season. Under the above circumstances, the present experiment was under taken with the following objectives:

OBJECTIVES

1. To observe the effect of XXL powder on the morphophysiological characters,yield and yield attributes of BRRI 28
2. To find out the optimum doses of XXL powder for having maximum grain yield from the rice variety BRRI 28

CHAPTER II

REVIEW OF LITERATURE

Yield and yield contributing characters of rice are considerably depended on manipulation of basic requirements of crop production. The basic requirements include variety, environment and agronomic practices (planting density, fertilizer, irrigation etc.). Among the factors nutrient management plays key role for promotion of the growth and yield of rice. High yielding varieties (HYV) are generally more adaptive to appropriate plant growth regulator application. The available and relevant reviews related to plant growth regulator in the recent past have been presented and discussed under the following headings:

2.1 Effect of plant growth regulators on rice

Manenji *et al.* (2016) conducted experiment to achieve optimum yield of wheat, supplementation of soil and foliar applied fertilizers with plant growth regulators is vital to assure effective assimilation of nutrients by plants. A trial was conducted at Gwebi Agricultural College Farm in Mashonaland West Province of Zimbabwe, during the 2012 winter wheat season (May to August), to evaluate the effects of differing times of application of Tianda 2116 plant growth regulator on the growth and yield of wheat (variety SC Sekuru). The trial was laid out in a Randomized Complete Block Design with three replications. The treatments were: Tianda 2116 applied at the following weeks after planting (WAP): 2 WAP, 3 WAP, 4 WAP, 5 WAP, 6 WAP, 14 WAP and no Tianda 2116 applied (control). No significant differences ($P > 0.05$) were noted among treatments for mean number of tillers per plant and mean number of spikes per plant. Application of Tianda 2116 at 2 and 3 WAP delayed flowering and physiological maturity. Early application of Tianda 2116 increased the number of spikelets per spike, thousand grain weight and grain yield. Conclusively, Tianda 2116 applied 2 or 3 WAP is effective in reducing growth while enhancing yield parameters in wheat production.

Benlioglu *et al*. (2015) conducted in Ankara University, Faculty of Agriculture, Department of Field crops, Biotechnology Laboratory. The objective of the present study was to determine the effects of growth regulators on tissue parameters in rice. In this study, mature embryos of three rice cultivars (Aromatik-1, Baldo and Karadeniz) and different growth regulators (2,4-Dichlorophenoxyacetic acid (2,4-D) and picloram) were used as material. For callus induction, mature embryos were placed with scutellum upwards on three different medium (hormone-free MS-0, MS + 2 mg/l 2,4-D and MS + 2.5 mg/l picloram) in sterile Petri dishes for two weeks at 25±10C in darkness. After incubation; obtained calli were transferred to hormone-free MS-0 medium for regeneration. According to results, the effect of growth regulators and genotypes on callus induction and plant regeneration in rice were found to be statistically significant.

Upadhyaya *et al.* (2015) conducted in vitro callus induction and plant regeneration potentiality were studied from mature embryo of three Indian rice (Oryza sativa L.) varieties. Study was done by using callus induction medium (Murashige and Skoog, 1962) having different concentration of 2, 4-D viz., 1.0, 1.5, 2.0, 2.5 mg/l. All the three varieties exhibit highest frequency of callus induction at 2 mg/l 2,4-D. The callus induction frequency varied from 63.36% to 92.23%. Sita had maximum frequency of callus formation only, while Masuri showed embryogenic organogenesis (shoot formation) followed by the formation of callus and Rupali showed increase in multi root development in the early stages of callusing. Plant regeneration efficiency of in vitro grown plantlets were further observed and successfully transplanted into soil condition.

Plant growth regulators are one of the most important factors for increasing higher yield in leafy vegetables. Application of growth regulators has good management effect on growth and yield of field crops. Hormones regulate physiological process and synthetic growth regulators may enhance growth and development of field crops thereby increased total dry mass of a field crop. Naphthalene Acetic Acid have been used for the enhancement of growth and yield of cereals. Naphthalene Acitic Acid, a wide broad, somatotrophin-like growth regulator in plants. It produces significant effects in promoting development of pointed ends for the root system, resulting in more, straighter and thicker roots. NAA can increase fruit setting ratio, prevent fruit dropping, promote flower sex ratio (Raoofi *et al*. 2014).

In this study five selected Sri Lankan traditional rice varieties (Kaluheenati, Sulaai, Suwadhal, Dostara Heenati) (*Oryza sativa* L.) and five improved rice varieties (At362, Bg94/1, Bg358, Bg357, Bg379) were examined for callus induction, plant regeneration and rooting using *in vitro* techniques. Seeds were cultured in five different hormone concentrations; 1.0, 1.5, 2.0, 2.5, 3.0 mg/l 2, 4- Dichlorophenoxy acitic acid (2, 4-D) and 0.1 mg/l 6 – Benzyl adenine purine (BAP) on Murashige and Skoogs (MS) basal medium for callus induction. Proliferated calli were transferred to five different hormone concentrations; 1.0, 1.5, 2.0, 2.5, 3.0 mg/l BAP with 0.1 mg/l Indole acetic acid (IAA) to regenerate shoots. Regenerated shoots were transferred to three different hormone concentrations; 1.5, 2.0, 3.0 mg/l Indole butric acid (IBA) for rooting. Complete Randomized Design (CRD) was used with ten replicates and data was analyzed by SAS 9.1.3 version. The interaction between plant varieties and different hormone concentrations are highly significant for callus diameter, number of shoots per explants and root length. All tested rice cultivars (100%) were able to produce callus however only 40% of rice varieties were regenerate shoots. The regeneration ability of rice varieties varied from 0% to 100%. All shoots were able to produce 100% roots in tested IBA concentrations. Among all selected rice varieties 2.0 mg/l 2, 4-D+0.1 mg/l BAP is most successful for callus induction while 2.0 mg/l BAP+0.1 mg/l IAA and 2.0 mg/l IBA most effective for shoot regeneration and root induction respectively (Dissanayaka and Dahanayake, 2014).

Vu Tien Khang (2013) carried out in laboratory of Agronomy department, Cuu Long Delta Rice Research Institute during 2012 wet season. Humic acid was extracted from soil compost of rice straw. Solution of humic acid KT was combined with IAA 100ppm.The first experiment was designed with five treatments and three replications. All the treatments were laid out with humic dose ranging in T1: control, T2: 2%, T3: 4%, T4: 5% and T5: 10%. This experiment determined how humic acid enhances rice root development. The second experiment was designed with five treatments and three replications. Humic acid doses were ranged as T1: control, T2: 1%, T3: 2%, T4: 3% and T5: Comcat (recommended dose). This second experiment was compared to Comcat. Comcat, a plant growth regulator is popularly commercialized. Our results showed that number of root and root length were higher than other treatments at 7 and 14 days after sowing in treatment of Humic KT at 2% dose Moreover, humic KT at 2% dose also gave higher number roots and shoot fresh weight as compared to Comcat.

Growth and yield attributes of rice were evaluated with the application of varying doses of Naphthalene Acetic Acid (NAA) and Phosphorus during 2004 and 2005. The experiment was laid out in Randomized Complete Block (RCB) Design with split-plot arrangements and replicated four times. Main plots were assigned to four levels (0, 60, 90 and 120 ml ha^{-1}) of NAA. Results revealed that NAA @ 90 ml ha-1 and phosphorus application up to 100 kg ha-1 boosted up the rice productivity due to maximum value recorded in terms of panicles m-2 (347.5 and 349.5), spikelets panicle-1 (153.3 and 153.8), sterility (22.25 and 19.94 %), normal kernel (77.25 and 78.69 %), paddy yield (7.62 and 7.82 t ha-1) and net income (Rs. 30986 and 32236 ha^{-1}) with BCR of 1.64 and 1.70 indicating the economical yield of rice during 2004 and 2005 (Bakhsh *et al*.2012).

Niknejhad and Pirdashti (2012) designed to evaluate the effect of growth stimulators application on rice ratoon performance in north of Iran conditions during 2009. Accordingly a randomized complete block design in a factorial arrangement with three replicates was used. Treatments were two factors of gibberellic acid and Ecormon at three levels (0.5, 1 and 2 times of the recommended dose rate). Results indicated that using growth stimulators had a significant effect on all studied parameters such as plant height, flag leaf, tiller number, grain number, 1000 grain weight and paddy yield. Both GA3 and Ecormon markedly increased tiller number in ratoon. The grain yield of the ratoon crop was ranged between 1192.1 to 1753 kg ha^{-1} and remarkably increased when GA3 was applied to the ratoon crop before flowering. Orthogonal comparisons indicated that the Ecormon treated plants had nearly 7% greater grain yield than the GA3 treated plants. Application of both GA3 and Ecormon, however, markedly increased grain yield and grain number per panicle (up to 32 and 40 %, respectively) as compared to untreated plants. There were a positive and significant correlations between flag leaf length (r=0.91**), flag leaf area (r=0.76**), grain number (r=0.79**), panicle length (r=0.96**) and 1000 grain weight (r=0.79*) with paddy yield.

Mohammed and Tarpley (2011) conducted to the presence of seasonally high night temperature (HNT) as a result of global warming, occurring during the critical stages of development, could reduce rice yield and quality. To understand how a combination of HNT and plant growth regulators (PGR; a-tocopherol and glycine betaine) affects yield and yield-related parameters of rice plants, we conducted three pot experiments under two levels of night temperature (NT; 27 and 328C) with or without PGR treatments. Plants were subjected to a HNT through the use of continuously controlled infrared heaters, starting 20 d after emergence (DAE), from 2000 until 0600. Plants were treated with a-tocopherol and glycine betaine 20 DAE. The NT had no effect on number of productive tillers, main-stem panicle length or number of primary branches per panicle; however, reduced yield resulted from significant effects on spikelet sterility (SS), and grain length, width, and weight. The grains located at the base of the panicle showed decreased length and width compared with grains located at the tip of the panicle. Application of glycine betaine increased grain yield by predominantly decreasing SS in rice plants, suggesting the potential future use of glycine betaine to help partially prevent HNT damage to rice.

Bakhsh *et al*. (2011) conducted to find out the growth behaviour of transplanted coarse rice (IR-6) as influenced by plant growth regulator (NAA 4.5 % as sodium salt) under the agro climatic conditions of Dera Ismail Khan, Pakistan during 2004 and 2005. The experiment was laid out in randomized complete block design with split plot arrangements, replicated 4 times. Main plot consisted of three growth stages of rice that is tillering (S1), panicle initiation (S2), and grain formation stage (S3), while subplots included four levels of plant growth regulator viz. 0, 60, 90 and 120 ml naphthalene acetic acid (NAA) ha-1. Data on plant height (cm) at maturity, number of panicles m^{-2}, number of spikelets $panicle^{-1}$, 1000-grain weight (g) and paddy yield (Mg ha^{-1}) were recorded. The data revealed that application of growth regulator (NAA) data at the rate of 90 ml ha^{-1} at panicle initiation stage resulted in highest number of 340 and 342 panicles m^{-2}, 182 and 187 spikelets $panicle^{-1}$, 88 and 90 % normal kernel, 23.00 and 23.20 g 1000-grain weight, 9.00 and 9.20 Mg $^{ha-1}$ paddy yield during 2004 and 2005, respectively.

Bakhsh *et al*. (2011**)** conducted to find out the growth behaviour of transplanted coarse rice (IR-6) as influenced by plant growth regulator (NAA) under the agro climatic conditions of Dera Ismail Khan, Pakistan, during 2004 and 2005 using Randomized Complete Block Design with split plot arrangements. Main plot consisted of three critical growth stages of paddy rice, namely S1 (tillering) S2 (panicle initiation) and S3 (grain formation stage), while sub plot contained four levels of 0, 60, 90 and 120 ml ha^{-1} of plant growth regulator (Naphthalene Acetic Acid). The data was recorded on plant height (cm) at maturity, number of panicle (m^{-2}), number of spikelets panicle-1, 1000-grain weight (g) and paddy yield (Mg ha^{-1}). The effect of plant growth regulator levels, growth stages of paddy rice and interactions between them were found highly significant (LSD, $p < 0.01$) in term of enhancement in paddy yield and yield components. The application of plant growth regulator @ 90 ml ha^{-1} at the stage of panicle initiation proved most beneficial in terms of attaining 130.4 cm and 130 cm as maximum plant height, 324.5 m^2 and 328 m^2 as highest number of panicles, 164.3 and

168.5 as maximum number of spikelets panical^{-1}, 78.5% and 80.5% as maximum normal kernels, 20.76g and 21.02g as higher 1000-grain weight, 7.65 Mg ha^{-1} as economical paddy yield during 2004 and 2005 respectively.

Shanthi *et al.* (2010) conducted to study the effect of growth regulators on callus induction in rice embryo culture. In this experiment, caullogenesis was initiated from the matured seeds of seven indica rice varieties viz., TRY 1, TRY 2, Pokkali, CSR 10, W.Ponni, BPT 5204 and IR 29. The medium used for this callus induction was Murashige and Skoog (1962) commonly referred as MS medium with six different combinations of growth regulators viz., MS+2,4-D 25mMl-1, MS+2,4- D 20mMl-1, MS+2,4-D 15mMl-1, MS+2,4-D 10mMl-1, MS+2,4- D 15mMl-1+ KIN 2.5mMl-1, MS+2,4-D 10mMl-1+ KIN 2.5 mMl-1 Among the above combination of the growth regulators, MS + 2 mMl-1 2,4,D + 0.5 Kinetin performed well irrespective of all the genotypes. Analysis of variation showed that the genotype and medium are significantly different from each other and the interaction between Genotype X Medium also highly significant. Among the seven genotypes, Pokkali was significantly at (1%) superior for callus induction (63.57%) followed by W.Ponni (53.96%). The genotypes TRY 2 (51.70 %), TRY 1 (50.87) and CSR (49.22) are significantly at (5%) on par with each other. The well developed callus was transferred to regeneration medium for regeneration. The medium combination of MS +Kin 5mMl-1 + BAP 5mMl-1 + NAA 0.5mMl-1 recorded maximum average regeneration frequency of 57.25 percentage and higher response than the others. Among the varieties, Pokkali showed maximum regeneration frequency of 39.41% and CSR 10 recorded minimum regeneration frequency of 20.23 %.

Mature seeds of four upland rice cultivars namely Kusan, Lamsan, Selasi and Siam were assessed for callus induction and plant regeneration on different concentrations and combinations of plant growth regulators, incorporated into MS (Murashige and Skoog) basal medium. Callus induction frequency was significantly different among the cultivars, as well as among the 2, 4-Dichlorophenoxyacetic acid (2,4-D) levels tested. All tested cultivars exhibited highest callus frequency at 2 mgl-1 2,4-D. The incorporation of _-naphthaleneacetic acid (NAA) and kinetin (Kin) in the callus induction medium supplemented with 2 mgl^{-1} 2, 4-D did not significantly improve the callus induction frequency. After two subcultures, at 24 days interval, the best response to callus induction was from cultivar Selasi, while callus browning became prominent in cultivars Kusan and Siam. Embryogenic callus placed on different regeneration media exhibited the highest regeneration frequency on medium containing 0.5 mgl^{-1} NAA + 2.0 mgl^{-1} Kin + 2.0 mgl^{-1} 6-benzylaminopurine (BAP). The maximum regeneration frequency was achieved in cultivar Selasi followed by Lamsan while Siam and Kusan exhibited poor regeneration response. Among the four upland rice cultivars evaluated, Selasi and Lamsan are two promising cultivars in terms of callus induction frequency and morphology, and regeneration ability of the embryogenic callus (Shahsavari *et al*. 2010).

Chen *et al.* (2010) found that applying 1.5 mM silicon to drought-stressed rice increased transpiration rate from 19% in a drought-susceptible line and 53% in a drought-resistant line.

Agarie *et al.* (1998) report that silicon prevents the structural and functional deterioration of cell membranes when rice plants are exposed to environmental stress and that silicon may also be "involved in the thermal stability in cell membranes." Kaya *et al.* (2006) showed that 2 mM Na_2SiO3 decreased electrolyte leakage by 18.3% in water-stressed corn (50% of FC). According to Gunes *et al.* (2008), silicon applied to the soil prevented membrane damage in shoots via a reduction in H_2O_2.

Gurmani *et al.* (2006) conducted in glass-house to assess the role of Abscisic acid (ABA), Benzyleadenine (BA) and Cycocel (CCC) on growth, yield, ion accumulation and proline production in three rice cultivars viz, Super Basmati, Shaheen Basmati (fine cultivar) and IR-6 (coarse cultivar) differing in yield. Seeds of each cultivar were soaked prior to sowing with ABA and BA each at 10-5 M and CCC 10-6 M for 24h. Salinity of 5dS/m was developed by adding NaCl salt in five equal splits daily to fifteen days old plants of all the cultivars. Plants were harvested two weeks after salt treatment. Shoot and root dry weight decreased at salinity stress as compared to control, however ABA, BA and CCC treatment caused a substantial increase in shoots and root dry weight over that of salt alone. Salt treatment increased the level of Na+ and Cl- but decreased K+ content in flag leaves as well as in roots of three rice cultivars. ABA and CCC treated plants showed significant decrease in Na+ content but increased K+ content in flag leaves of all thecultivars at salt stress. ABA was more effective to increase Ca2+ content in flag leaf as well as in roots of all the cultivars as compared with BA and CCC. The levels of ions (Na+, K+, Ca2+ and Cl-) were relatively higher in roots than in flag leaves, however higher accumulation of K+ and Ca2+ content with lower accumulation of Na+ and Cl- in IR-6. The ranking of growth regulators for their effects on grain yield and 1000-grain weights were ABA>BA>CCC. Higher grain yield and 1000- grain weight was recorded by IR-6. ABA and CCC treatment further augmented the stimulatory effect of salts on proline accumulation. Higher proline accumulation was observed in IR-6 as compared to Shaheen Basmati and Super Basmati. Rice cv. IR-6 performed better. The relatively low accumulation of Na+ and Cl- and less translocation to flag leaf of IR-6 concomitant with high K+ accumulation, better proline content and greater leaf area under salt stress make this variety salt tolerant. These traits are augmented by ABA more effectively than BA.

Gong *et al.* (2003) found that 7.14 mmol Na2SiO3 per 8 kg of soil supplied to the soil resulted in an increase in leaf relative water content of 2.7% and an increase in leaf water potential of 0.4 MPa of wheat in drought conditions. Ma (2004) reports that silicon reduces cuticular transpiration in drought-stressed rice.

The effect of three growth regulators, namely kinetin, 6 benzyl adenine, 2 chloro ethyl trimethyl ammonium chloride at three concentrations (10-6 M, 5 x 10-5 M 10-4 M) was studied on the catalytic activity of nitrate reductase in green and etiolated seedlings. A concentration of 5 x 10-5 M was optimal for all the growth regulators treatments. All the growth regulators stimulated nitrate reductase activity effectively at 5 x 10-5M concentration in both etiolated and green seedlings and had an additive effect when supplemented by NO-3 up to 140% to 160%. The 99.2% and 93.4% inhibition of nitrate reductase activity resulted in development of etiolated and green seedlings, respectively when treated with eukaryotic 80S ribosome protein synthesis inhibitor cycloheximide. Prokaryotic 70S inhibitor chloromphenicol did not have any effect on measured parameters. Actinomycin D, a RNA synthesis inhibitor also inhibited the enzyme activity as 80s inhibitors (Green 80%, etiolated 98%). One may suggest from this that both DNA and protein synthesis are involved in the induction of nitrate reductase activity. The differential effect of aminoacids was observed on enzyme activity in combination with growth regulators (Hemalatha, 2002).

The effect of plant growth regulators and fertility on transplanted rice was studied. Two foliar spray of either cytokinin (120 PPM}/triacontanol (10 ppm) at tillering and panicle initiation stages or spray of cytokinin at tillering and triacontanol at panicle initiation stage significantly improved plants height, tAL, nitrogen concentration in flag leaves at flowering and milking stages and grain and straw yield of rice. Application of 150:100:60 Kg NPK/ha significantly increased growth, N concentration in flag leaves at flowering and milking stage and grain and straw yield of rice (Pandey *et al.* 2001).

CHAPTER 3

MATERIALS AND METHODS

The experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2014 to May 2015 to find out the effect of XXL on the morpho-physiological attributes of BRRI dhan28 (inbreed) in boro season. This chapter deals with a brief description on experimental site, climate, soil, land preparation, experimental design, intercultural operations, data recording and their analysis.

3.1 Site description

The study was conducted at the Sher-e-Bangla Agricultural University farm, Dhaka, under the Agro-ecological zone of Modhupur Tract, AEZ-28. The location of the site is $23^{0}74^{/}$N latitude and $90^{0}36^{/}$E longitude with an elevation of 8.2 meter from sea level (Appendix I).

3.2 Climate and weather

The geographical location of the experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October (Idris *et al*., 1979). Details of the meteorological data of air temperature, relative humidity and rainfall during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e Bangla Nagar and have been presented in Appendix II.

3.3 Soil

The soil belongs to "The Modhupur Tract", AEZ – 28 (FAO, 1988). Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land. The details have been presented in Appendix II.

3.4 Materials

3.4.1 Seed

In this research work, one sample of inbreed rice variety was used as plant materials. The rice variety used in the experiments was BRRI dhan 28. The seeds were collected from the Bangladesh Rice Research Institute (BRRI), Joydebpur.

3.4.2 XXL

XXL bio-green energy-soil enhancer was made millions of years ago from a highly compressed organic humic acid in the tropical rainforests. The original seam of XXL bio-green soil enhancer in ancient times was originally buried in the deep crust of the earth, and subsequently excavated by mankind at the surface of the earth, undergoing weathering and microbial action, then processed through grinding, to make it into our present XXL bio-green soil enhancer. The minerals and trace elements in XXL bio-green energy-soil enhancer can be comprehensively used and absorbed by plants through a natural and complicated chelation process in the soil. XXL bio-green energy-soil enhancer consists of 100% organic matters and it can improve the existing soil CEC value tremendously depending on the existing soil pH and conditions as well as the quantity. Cation-Exchange-Capacity is a measure of the soil's ability or capability to hold cations (positively charged ions or elements). It is also a useful indicator of soil fertility. Decomposed organic matter like humus has the highest CEC levels as it holds a lot of negative charges when in colloids form while sand has very low CEC value (less than 2 meq/100g).

3.5 Experimental details

3.5.1 Treatments

One factor experiment was conducted to evaluate the performance of XXL on rice variety BRRI dhan28 in Boro season.

Treatment combinations:

T_1= No fertilizer (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

T_8=100% dose of XXL + 75% recommended dose of fertilizer

3.5.2 Experimental design

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the variety. There were 24 plots of size 3 m × 2 m in each of 3 replications. The treatments of the experiment were assigned at random into each replication following the experimental design. Seedlings were sown in seed bed and age of transplanted seedlings are 35 days. Line to line distance was 30 cm where hill to hill distance was 15 cm. Two seedlings hill^{-1} were used during transplanting.

3.6 Growing of crops

3.6.1 Raising seedlings

3.6.1.1 Seed sprouting

Healthy seeds were selected by specific gravity method and then immersed in water bucket for 24 hours and then it was kept tightly in gunny bags. The seeds started sprouting after 48 hours and were sown in nursery bed after 72 hours.

3.6.1.2Preparation of nursery bed and seed sowing

As per BRRI recommendation seedbed was prepared with 1 m wide adding nutrients as per the requirements of soil. Seeds were sown in the seed bed @ 70 g m^{-2} on 30 December, 2014 in order to have seedlings of 35 days.

3.6.2 Preparation of the main field

The plot selected for the experiment was opened in 26 December 2014 with a power tiller, and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed, and finally obtained a desirable tilth of soil for transplanting of seedlings.

3.6.3 Fertilizers application

Recommended doses of fertilizers were applied to each plot. The following doses were used for different fertilizers:

(i) Urea (N) : 200 kg ha^{-1}

(ii) TSP (P_2O_5) : 100 kg ha^{-1}

(iii) MP (K_2O) : 120 kg ha^{-1}

(iv) Gypsum (Sulpher) : 75 kg ha^{-1}

(v) Zinc : 15 kg ha^{-1}

Dose of XXL

2gm XXL/2 liter of water/acre

As per different treatment 1st dose of XXL and basal fertilizer was applied in 31st January 2015.2nd dose of XXL and Urea applied after 7 DAT and10 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.

3.6.4 Uprooting of seedlings

The nursery bed was made wet by application of water one day before uprooting the seedlings. The seedlings were uprooted on February 1, 2015 without causing much mechanical injury to the roots.

3.6.5 Transplanting of seedlings in the field

The seedlings were transplanted in the main field on February 02, 2015 and the rice seedlings were transplanted in lines each having a line to line distance of 30 cm and plant to plant distance was 15 cm for all test varieties in the well prepared plot.

3.6.6 Cultural operations

The details of different cultural operations performed during the course of experimentation are given below:

3.6.6.1 Irrigation and drainage

Irrigation was done one day before transplanting and than 7 DAT,10 DAT,14 DAT,21 DAT,30 DAT.

3.6.6.2 Gap filling

Gap filling was done for all of the plots at 7-10 days after transplanting (DAT) by planting same aged seedlings.

3.6.6.3 Weeding

First weeding was done from each plot at 15 DAT and second weeding was done from each plot at 40 DAT. Mainly hand weeding was done from each plot.

3.6.6.4 Plant protection

Furadan 57 EC was applied at the time of final land preparation and Dimecron 50 EC was applied at 30 DAT.

3.7 Harvesting, threshing and cleaning

The rice plant was harvested depending upon the maturity of grains and harvesting was done manually from each plot. Maturity of crop was determined when 80-90% of the grains become golden yellow in colour. Ten pre-selected hills per plot from which different data were collected and 3 m^2 areas from middle portion of each plot was separately harvested and bundled, properly tagged and then brought to the threshing floor. Enough care was taken for harvesting, threshing and also cleaning of rice seed. Fresh weight of grain and straw were recorded plot wise. Finally the weight was adjusted to a moisture content of 14%. The straw was sun dried and the yields of grain and straw plot^{-1} were recorded and converted to t ha^{-1}.

3.8 Data recording

Data were collected on the following characters:

1. Plant height

2. Number of tillers hill^{-1}
3. Leaf area
4. SPAD value of leaf (Chlorophyll content of leaf)
5. 1% Booting Stage
6. 50% Booting Stage
7. 100% Booting Stage
8. 1% Panicle insertion
9. 50% Panicle insertion
10. 100% Panicle insertion
11. Length of panicle
12. Number of filled grains panicle^{-1}
13. Number of unfilled grains panicle^{-1}
14. Weight of filled grains plant^{-1}
15. Weight of unfilled grains plant^{-1}
16. 1000 grains weight
17. Weight of grains
18. Grain yield

3.8.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 40 DAT (days after transplanting) and at harvest. Data were recorded as the average of same 10 hills selected at random from the outer side rows (started after 2 rows from outside) of each plot. The height was measured from the ground level to the tip of the plant.

3.8.2 Tillers hill^{-1}

The number of tillers hill^{-1} was recorded at harvest by counting total tillers as the average of same 5 hills pre selected at random from the inner rows of each plot.

3.8.3 Leaf area

Twenty leaves were collected randomly from the field and the length and breadth of each leaves were measured. Length and breadth were multiplied to get the area of individual leaves. All the area were summed up and divided by

20 to get the average leaves area. Real leaf area was then determined by using the followng formula:

Real leaf area= area of an individual leaves × number of leaves per plant × 0.75

3.8.4 SPAD value of leaf

SPAD meter reading of fresh leaves was recorded at 40, 60, 80, 100 DAT (days after transplanting) to compare relative chlorophyll content of leaves. Ten reading were taken from leaves of each sample plant avoiding the mid-rib region carefully and average value was presented as SPAD value of leaves. Higher SPAD value was considered as higher total chlorophyll (pigments) content of leaf.

3.8.5 Days to 1st, 50% and 100% booting stage

Days to 1st ,50% and 100% booting was considered when 1st ,50% and 100% of the plants showed booting stage. The number of days to 1st ,50% and 100% booting was recorded from the date of transplanting.

3.8.6 Days to 1st, 50% and 100% panicle insertion stage

Days to 1st, 50% and 100% panicle insertion was considered when 1st,50% and 100% of the plants within a pot showed panicle insertion. The number of days to 1st ,50% and 100% panicle insertion was recorded from the date of transplanting**.**

3.8.7 Length of panicle

Measurement of panicle length was taken from basal node of the rachis to apex of each panicle in cm. Each observation was an average of 10 panicles.

3.8.8 Number of filled grains

Average number of filled grain panicle^{-1} was calculated by counting the number of filled grain of 5 panicles hill^{-1}.

3.8.9 Number of unfilled grains

Number of unfilled grain panicle^{-1} was also counted.

3.8.10 Weight of filled grains plant^{-1}

The total number of filled grains was collected from the randomly selected 10 plants in each plot and then average number of filled grains plant^{-1} was weighted.

3.8.11 Weight of unfilled grains plant^{-1}

The total number of unfilled grains was collected from the randomly selected 10 plants in each plot and then average number of unfilled grains plant^{-1} was weighted.

3.8.12 Weight of 1000 grains

One thousand grains were counted randomly from the total cleaned harvested grains of each individual plot and then weighed with an electric balance in grams and was recorded.

3.8.13 Grain weight per m^2

The separated seeds of 1 m^2 area were collected, cleaned, dried and weighed properly. The seed weight per m^2 was then recorded in gram.

3.8.14 Yield

After threshing, cleaning and drying, total seed from harvested area were recorded and was converted to tones per hectare

3.9 Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatments. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatment means were estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER 4

RESULTS AND DISCUSSION

The experimental results regarding the growth yield and yield contributing parameters of transplanted boro rice as influenced by dose of XXL have been presented and discussed in this chapter. The effects of XXL on growth, yield and yield contributing characters have been presented in this chapter.

4.1 Plant height

Doses of XXL affected the plant height of rice significantly at 60 DAT and at 80 DAT (Fig. 1). The tallest plant (26.78 and 48.90 cm at 60 and 80 DAT, respectively) was recorded with 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).

4.2 Number of tillers hill^{-1}

Significantly varied result was observed in case of number of tillers hill^{-1} as influenced by dose of XXL (Table 1). Results showed that the highest number of tillers hill^{-1} was recorded by T_8 (13.40), which were statistically similar with T_2, T_4, T_6 and T_7. The results obtained from T_1 showed the lowest number of tillers hill^{-1} (8.28).

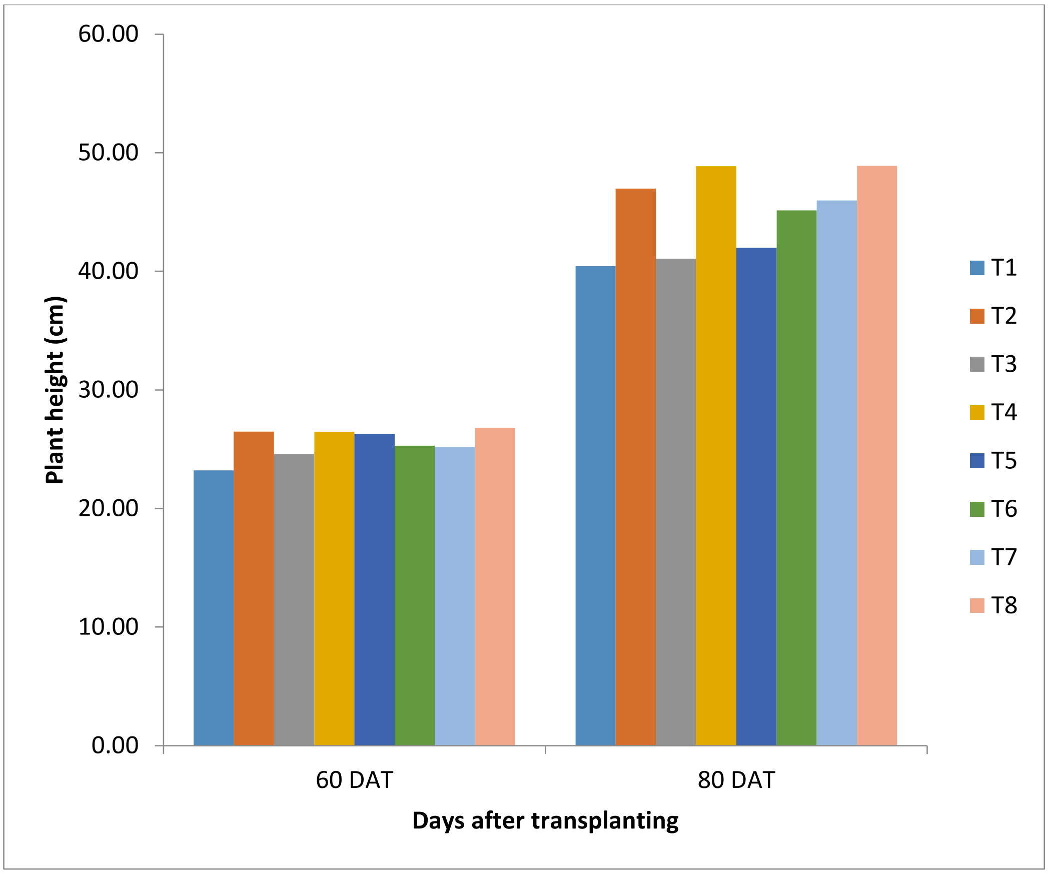

Fig. 1 Effect of different doses of XXL on the plant height of rice.

T_1= No fertilizer (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

T_8=100% dose of XXL + 75% recommended dose of fertilizer

Table 1. Effect of different doses of XXL on the Number of Tiller per plant and Leaf area of rice.

Treatment	Number of Tillers per plant		Leaf area	
T_1	8.28	d	21.35	d
T_2	12.93	a	26.92	ab
T_3	9.53	c	20.74	d
T_4	13.23	a	21.65	d
T_5	11.57	b	24.01	bcd
T_6	12.80	a	22.39	cd
T_7	12.80	a	25.11	bc
T_8	13.40	a	29.54	a
$LSD_{(0.05)}$	0.75		3.121	
CV (%)	6.89		8.87	

In column, means containing same letter indicate significantly similar under DMRT at 5% level of significance. Values are the means of three replications

T_1= No fertilizer (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

T_8=100% dose of XXL + 75% recommended dose of fertilizer

4.3 Leaf area

Significantly varied result was observed in case of leaf area index as influenced by doses of XXL of boro rice (Table 1). Results showed that the highest leaf area index was recorded by T_8 (29.54). The results obtained from T_1 showed the lowest leaf area index (21.34), which was statistically similar to T_3 and T_3.

4.4 SPAD Value of leaf

Analysis of variance indicated that the effect of XXL on rice variey on relative chlorophyll content of leaf was varied significantly during growth period at 60 and 80 DAT (Fig. 2). At 60 DAT the maximum SPAD value (42.59) were found from T_8 treatment. At 80 DAT the maximum SPAD value (32.49) was found from T_8 treatment. The minimum SPAD value (35.39) at 60 DAT was found from T_1 (Control) treatment, which was statistically similar to T_2. At 80 DAT the minimum SPAD value (27.66) was found in T_1 treatment. Salachna and Zawadzińska, (2014) found that medium- and high-molecular-weight chitosan resulted in higher relative chlorophyll content (SPAD).

4.5 1st booting stage

XXL significantly influenced 1% booting stage of rice (Table 2). The numerically highest 1% booting stage (62.67 days) were found in T_1 treatment, which was statistically similar to T_2, T_3, T_4, T_5 and T_7 treatment and the lowest (56.33 days) was found in T_8 treatment.

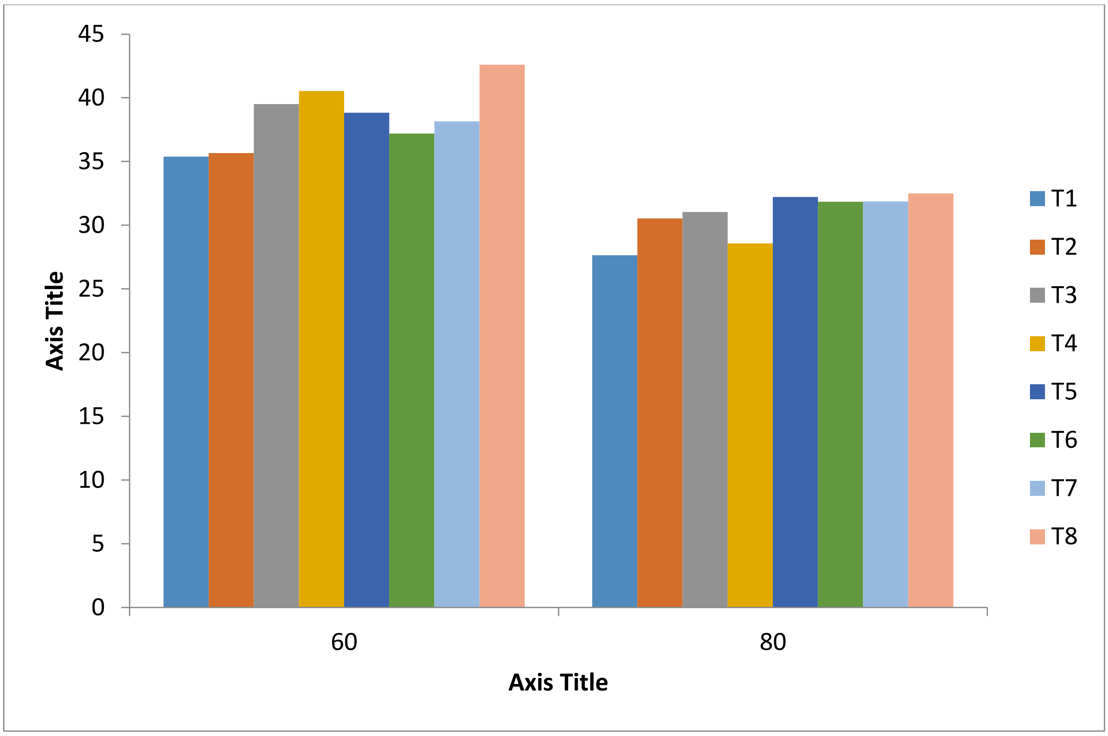

Fig. 2 Effect of treatments on the SPAD value (chlorophyll content) on leaf of rice

at different days after transplanting

T_1= No fertilizer (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

T_8=100% dose of XXL + 75% recommended dose of fertilizer

Table 2. Effect of XXL (soil enhancer) on the days required to booting stages of rice

Treatment	Booting stages (DAT)		
	1st Booting	50% Booting	100% Booting
T_1	62.67 a	64.33 a	65.67 a
T_2	60.00 a	62.00 ab	63.00 ab
T_3	61.00 a	63.68 a	64.00 a
T_4	60.33 a	62.00 ab	63.00 ab
T_5	61.00 a	63.00 a	64.33 a
T_6	59.00 ab	60.33 ab	61.00 ab
T_7	60.00 a	61.00 ab	62.00 ab
T_8	56.33 b	58.33 b	59.33 b
LSD $_{(0.05)}$	3.30	3.83	4.38
CV (%)	6.55	5.89	4.00

In column, means containing same letter indicate significantly similar under DMRT at 5% level of significance. Values are the means of three replications

T_1= No fertilizer (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

T_8=100% dose of XXL + 75% recommended dose of fertilizer

4.6 50% booting stage

XXL significantly influenced 50% booting stage of rice (Table 2). The highest 50% booting stage (64.33 days) was found in T_1 treatment, which was statistically similar to T_3 and T_5. The lowest (58.33 days) was found in T_8 treatment.

4.7 100% booting stage

XXL significantly influenced 100% booting stage of rice (Table 2). The highest 100% booting stage (65.67 days) was found in T_1 treatment which was statistically similar to T_3 and T_5 treatment. On the other hand, the lowest 100% booting stage (59.33 days) was found in T_8 treatment.

4.8 1st panicle insertion stage

First panicle insertion stage was significantly influenced by different concentration level of XXL (Table 3). The control treatment T_1 produced higher 1st panicle insertion (67.33 days), whereas, the lowest (63.67 days) was recorded from T_8 treatment.

4.9 50% panicle insertion stage

50% panicle insertion stage was significantly influenced by different level of XXL (Table 3). The control treatment T_1 produced the highest 50% panicle insertion (70.67days) whereas; the lowest (66.33 days) was recorded from T_8.

Table 3. Effect of XXL (soil enhancer) on the days required to panicle insertion stages of rice

Treatment	Panicle insertion stages (DAT)		
	1st Panicle insertion	**50% Panicle insertion**	**100% Panicle insertion**
T_1	67.33 a	70.67 a	73.33 a
T_2	66.00 ab	68.00 ab	70.00 ab
T_3	65.00 abc	68.00 ab	70.00 ab
T_4	65.00 abc	68.33 ab	69.00 ab
T_5	64.67 bc	67.67 ab	68.67 b
T_6	65.00 abc	69.00 ab	71.33 ab
T_7	64.00 bc	69.00 ab	69.00 ab
T_8	63.67 c	66.33 c	68.00 b
$LSD_{(0.05)}$	2.47	3.14	4.00
CV (%)	4.36	4.51	5.01

In column, means containing same letter indicate significantly similar under DMRT at 5% level of significance. Values are the means of three replications

T_1= No fertilizer (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

T_8=100% dose of XXL + 75% recommended dose of fertilizer

4.10 100% panicle insertion stage

100% panicle insertion stage was significantly influenced by different level of XXL (Table 3). The control treatment T_1 require higher number of days for 100% panicle insertion (73.33 days) whereas; the lowest (68.00 days) was recorded from T_8 treatment, which was statically similar to T_5.

4.11 Panicle length

There were significant difference among the panicle length due to the effect of different doses of XXL(Fig. 3). But the maximum panicle length (20.95 cm) was observed from T_8 treatment. The minimum panicle length (19.32 cm) was observed in T_1 treatment.

4.12 Filled grains panicle^{-1}

Performance of XXL under the present study showed a significant difference in respect of grains panicle^{-1} (Table 4). The highest number of filled grains panicle^{-1} (92.73) was observed in T_8. The treatment T_1 produced the lowest number of filled grains panicle^{-1} (69.25) which was similar to T_3 treatment.

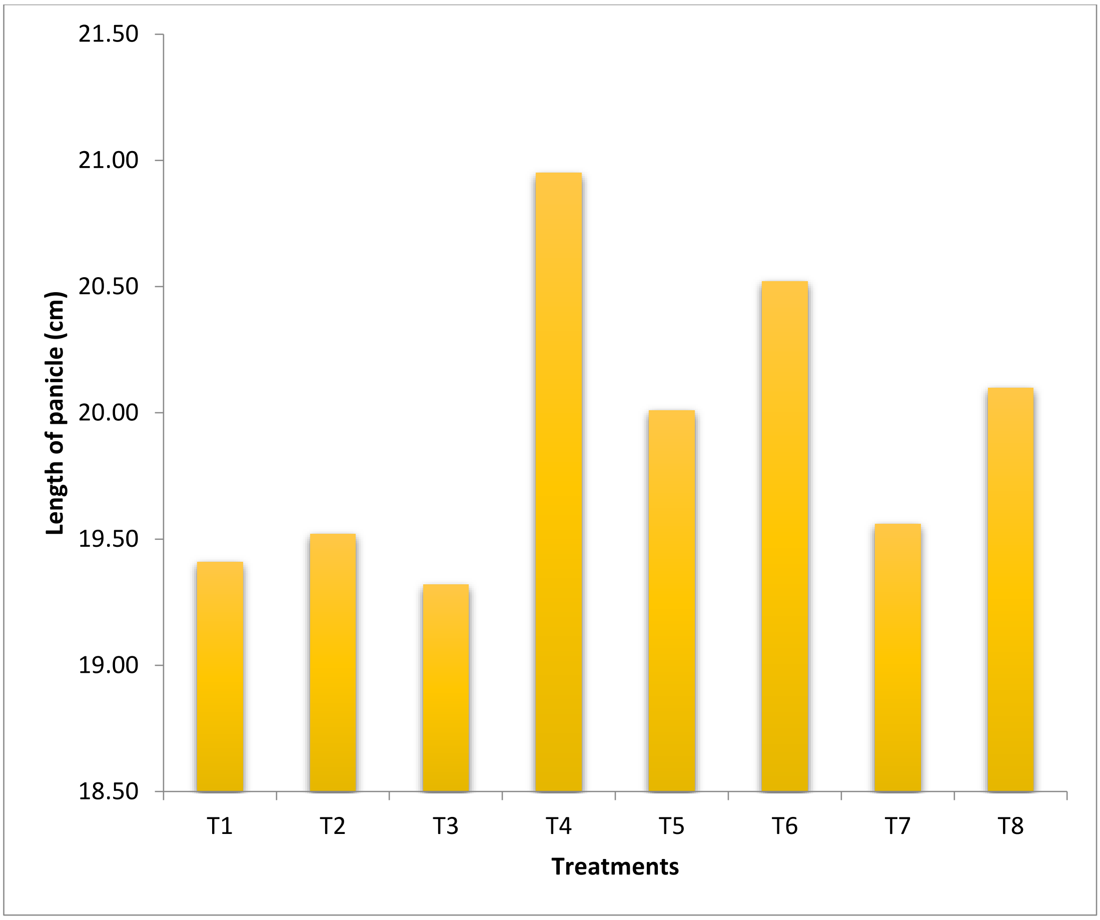

Fig. 3 Effect of XXL on the length of panicle of rice

T_1= No fertilizer (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

T_8=100% dose of XXL + 75% recommended dose of fertilizer

Table 4. Effect of XXL on the number of filled grain per panicle and number of unfilled grain per panicle on rice.

Treatment	Number of filled grains per panicle	Number of unfilled grains per panicle
T_1	69.25 d	7.02 bcd
T_2	80.19 b	6.05 cd
T_3	65.95 d	6.14 cd
T_4	77.81 bc	6.72 cd
T_5	76.49 bc	12.29 a
T_6	79.51 b	8.97 b
T_7	72.10 cd	8.19 bc
T_8	92.73 a	5.57 d
$LSD_{(0.05)}$	6.61	2.01
CV (%)	9.60	5.37

In column, means containing same letter indicate significantly similar under DMRT at 5% level of significance. Values are the means of three replications

T_1= No fertilizer (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

T_8=100% dose of XXL + 75% recommended dose of fertilizer

4.13 Unfilled grains panicle^{-1}

Number of unfilled grains panicle^{-1} was significantly influenced by different doses of XXL (Table 4). Results showed that the highest number of unfilled grains panicle^{-1} (12.29) was observed in T_1. On the other hand, the lowest number of unfilled grains panicle^{-1} (5.57) was achieved from T_8 treatment.

4.14 Weight of filled grains per plant

Significantly different variation was observed in case of weight of filled grain per plant as influenced by different Doses of XXL of boro rice (Table 5). Results showed that the highest weight of filled grain per plant was recorded by T_8 (106.10 g) where the lowest (53.48 g) was obtained from T_1.

4.15 Weight of unfilled grains per plant

Different doses of XXL had significant effect on weight of unfilled grain per plant (Table 5). Results showed that the highest weight of unfilled grain per plant was recorded from T_1 (6.72 g) where as the lowest (2.88 g) was obtained from T_8 and T_7 treatments.

Table 5. Effect of different doses of XXL on the weight of filled grains per panicle, Weight of unfilled grains per panicle and Weight of 1000 grains of rice.

Treatment	Weight of filled grains per panicle (g)	Weight of unfilled grains per panicle (g)	Weight of 1000 grains (g)
T_1	53.48 d	6.72 a	22.51 ab
T_2	60.72 cd	3.19 bc	22.15 b
T_3	70.52 bcd	3.18 bc	22.56 ab
T_4	65.35 bcd	3.53 bc	22.64 ab
T_5	91.77 ab	5.28 ab	22.74 a
T_6	86.00 abc	4.60 bc	22.74 a
T_7	78.12 abcd	2.88 c	22.19 b
T_8	106.10 a	2.88 c	22.98 a
$LSD_{(0.05)}$	26.88	1.99	0.47
CV (%)	10.06	7.48	11.31

In column, means containing same letter indicate significantly similar under DMRT at 5% level of significance. Values are the means of three replications

T_1= No fertilizer (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

T_8=100% dose of XXL + 75% recommended dose of fertilizer

4.16 Weight of 1000 grains

Significant influence of different doses of XXL was observed on 1000 grains weight (Table 5). It is attained that the highest 1000 grain weight (22.98 g) was in T_8 treatment, which was statistically similar to T_6 and T_5. The lowest 1000 seed weight (22.15 g) was observed in T_1 treatment, which was statistically similar to T_6.

4.17 Grain yield per plot

Different doses of XXL had significant effect on grain yield per plot of rice (Table 6). The highest grain yield was recorded from T_8 (764.70 g plot^{-1}) where as the lowest (402.70 g plot^{-1}) was obtained from T_1 treatment.

4.18 Grain yield

Different doses of XXL influenced to produced significantly variable grain yield (Table 6). Among the tested eight doses of XXL T_8 showed the highest grain yield (7.65 t ha^{-1}) and which was followed by T_4 and T_6. On the other hand, the lowest grain yield (4.03 t ha^{-1}) was obtained from T_1 treatment.

Table 6. Effect of different doses of XXL on the yield of rice.

Treatment	Yield/m^2 (g)	Yield (t/ha)
T_1	402.70 c	4.03 c
T_2	739.30 ab	7.39 ab
T_3	537.00 bc	5.37 bc
T_4	735.30 ab	7.35 ab
T_5	562.00 abc	5.62 abc
T_6	734.70 ab	7.35 ab
T_7	599.30 abc	5.99 abc
T_8	764.70 a	7.65 a
LSD $_{(0.05)}$	188.80	1.89
CV (%)	6.99	6.19

In column, means containing same letter indicate significantly similar under DMRT at 5% level of significance. Values are the means of three replications

T_1= No fertilizer (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

T_8=100% dose of XXL + 75% recommended dose of fertilizer

CHAPTER 5

SUMMARY AND CONCLUSION

The experiment was conducted at the Agricultural Botany field of Sher-e-Bangla Agricultural University, Dhaka during the period from December 2014 to May 2015 to find out effect of XXL on the morpho-physiological attributes of BRRI dhan 28 (inbreed) in boro season. The experiment comprised of one factor viz. T_1= No fertilizer (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, T_8=100% dose of XXL + 75% recommended dose of fertilizer. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the doses of XXL. There were 24 plots of size 3 m × 2 m in each of 3 replications. The treatments of the experiment were assigned at random into each replication following the experimental design. Seedlings were sown in seed bed and age of transplanted seedling was 35 days. Line to line distance was 30 cm where hill to hill distance was 15 cm. Two seedlings hill^{-1} were used during transplanting.

Significant variation was recorded for data on growth, yield and yield contributing parameters of experimental materials. Data was collected on plant height (cm), leaf area index,1st,50%,100% booting and panicle insertion, number of tillers hill^{-1}, number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1}, weight of filled grains plant^{-}

^{1}, weight of unfilled grains plant^{-1}, 1000 grain weight (g), grain yield (g plot^{-1}) and grain yield (t ha^{-1}).

Different doses of XXL affected the plant height of rice significantly at 60 DAT and at 80 DAT. 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. Significantly different variation was observed in case of number of tillers hill^{-1} leaf area, SPAD value and length of panicle as influenced by Doses of XXl of boro rice. The highest number of tillers hill^{-1} was recorded from T_8 (13.40). The highest leaf area was recorded from T_8 (29.54). At 60 DAT the maximum SPAD value (42.59) were found from T_8 treatment. At 80 DAT the maximum SPAD value (32.49) was found from T_8 treatment. The numerically highest 1st booting stage (62.67 days) were found in T_1 treatment. The highest 50% booting stage (64.33 days) was found in T_1 treatment. The highest 100% booting stage (65.67 days) was found in T_1 treatment. The control treatment T_1 produced the higher 1st panicle insertion (67.33 days). The control treatment T_1 produced the highest 50% panicle insertion (70.67days). The control treatment T_1 produced the higher 100% panicle insertion (73.33 days). The numerically maximum panicle length (20.95 cm) was observed from T_8 treatment. Doses of XXL had significant effect on number of filled and unfilled grains panicle^{-1} (Table 7). The highest number of filled grains panicle^{-1} (92.73) was observed in T_8. The treatment T_1 produced the lowest number of filled grains panicle^{-1} (69.25). The highest number of unfilled grains panicle^{-1} (12.29) was observed in T_1. The lowest number of unfilled grains panicle^{-1} (5.57) was achieved from T_8 treatment. Significantly different variation was observed in case of weight of filled grain per plant and weight of unfilled grain per plant as influenced by Doses of XXL of boro rice (Table 4). The highest weight of filled grain per plant was recorded by T_8 (106.10 g). The highest weight of unfilled grain per plant was recorded by T_1 (6.72 g). Significant influence of different dose of XXL was observed on 1000 grain weight. It is attained that the highest 1000 grain weight (22.98 g) was in T_8 treatment. Different doses of XXL significantly produced variable grain yield. Among the tested eight doses of XXL T_8 showed the highest grain yield (7.65 t ha^{-1}). The lowest grain yield (4.03 t ha^{-1}) was obtained from T_1 treatment..

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 followed by of 100% dose of XXL + 100% recommended dose of fertilizer. Contol showed lower performance regarding growth, yield and yield contributing characters. So, T_8 with BRRI dhan 28 was the best treatment found in the present study.

Recommendation:

Many other research works can be done using XXL at any other location combination with any other treatments. To justify the result further experiment can be done at Sher E Bangla or any other places with other varieties of rice or other crops.

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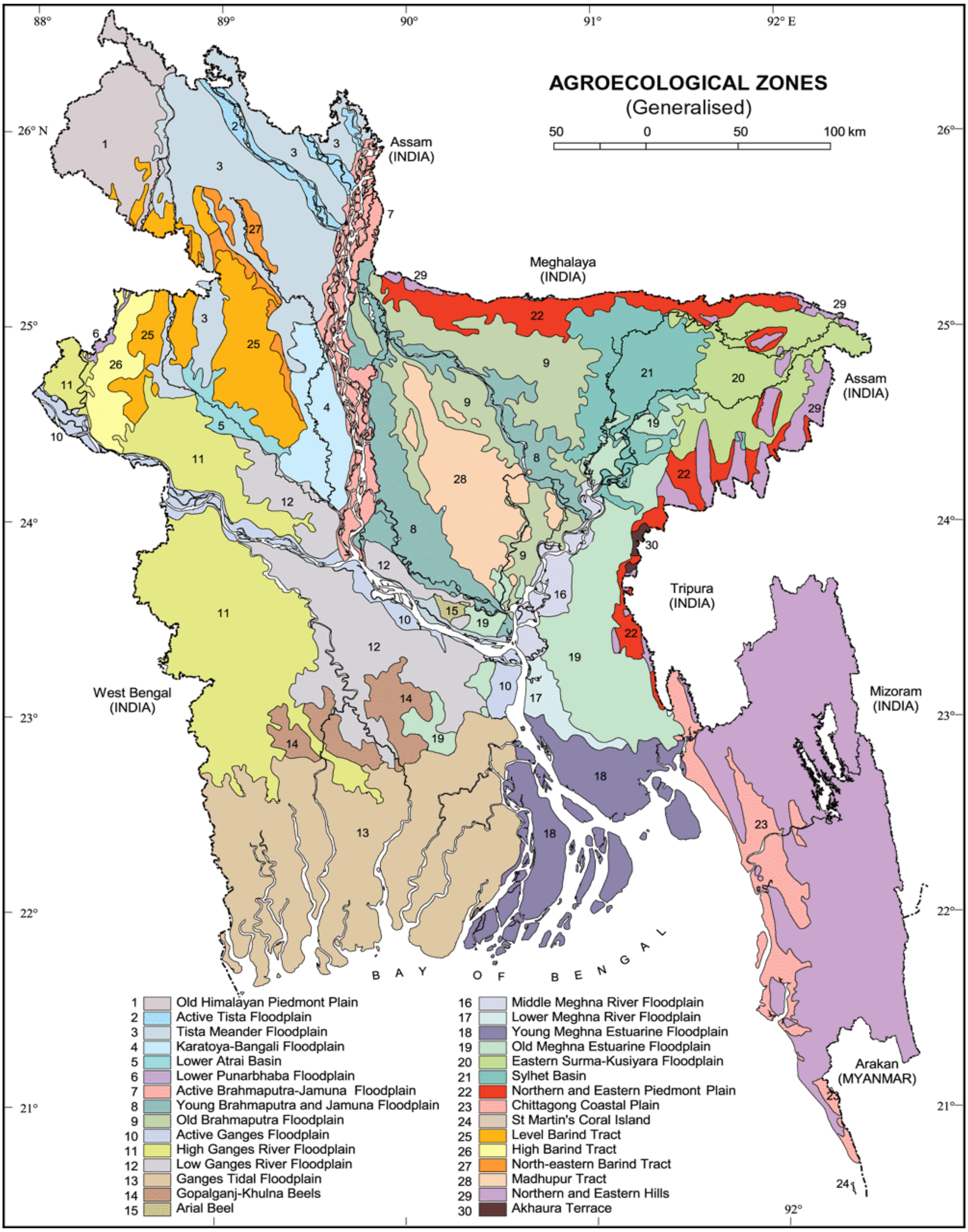
APPENDICES

Appendix I: Experimental location on the map of agro-ecological zones of Bangladesh



Appendix II: **Soil characteristics of Sher-e-Bangla Agricultural University Farm, Dhaka are analyzed by Soil Resources Development Institute (SRDI), Farmgate, Dhaka.**

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy farm, SAU, Dhaka
AEZ	Modhupur tract (28)
General soil type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	**N/A**

Source: Soil Resources Development Institute(SRDI)

B. Physical and Chemical properties of the Initial soil

Characteristics	Value
Practical size analysis	
Sand (%)	16
Silt (%)	56
Clay (%)	28
Silt + Clay (%)	84
Textural class	Silty clay loam
Ph	5.56
Organic matter (%)	0.25
Total N (%)	0.02
Available P (µgm/gm soil)	53.64
Available K (me/100g soil)	0.13
Available S (µgm/gm soil)	9.40
Available B (µgm/gm soil)	0.13
Available Zn (µgm/gm soil)	0.94
Available Cu (µgm/gm soil)	1.93
Available Fe (µgm/gm soil)	240.9
Available Mn (µgm/gm soil)	50.6

Source: Soil Resources Development Institute (SRDI)

Appendix III: Analysis of variance of the data on plant height, Number of tiller per plant of BBRI dhan 28 of rice as influenced by XXL

Sources of Variation	Degrees of freedom	Mean square		
		Plant height		Number of tiller per plant
		60 DAT	80 DAT	
Replication	2	3.287	0.521	21.544
Factor A	7	4.427*	34.477*	10.922*
Error	14	4.607	21.917	3.985

*significant at 5% level of probability,

Appendix IV: Analysis of variance of the data on Leaf area **and SPAD value of BBRI dhan 28 of rice as influenced by XXL**

Sources of Variation	Degrees of freedom	Mean square		
		Leaf area	SPAD value	
			60 DAT	80 DAT
Replication	2	57.291	68.79	9.474
Factor A	7	28.367*	17.807*	9.449*
Error	14	23.176	21.108	4.094

*significant at 5% level of probability,

Appendix V: Analysis of variance of the data on Booting stages (DAT) of BBRI dhan 28 of rice as influenced by XXL

Sources of Variation	Degrees of freedom	Mean square		
		Booting stages (DAT)		
		1st Booting	50% Booting	100% Booting
Replication	2	7.125	6.5	6.125
Factor A	7	9.804*	11.089*	11.089*
Error	14	3.554	4.786	6.268

*significant at 5% level of probability,

Appendix VI: Analysis of variance of the data on Panicle insertion stages (DAT) of BBRI dhan 28 of rice as influenced by XXL

Sources of Variation	Degrees of freedom	Mean square		
		Panicle insertion stages (DAT)		
		1st Panicle insertion	50% Panicle insertion	100% Panicle insertion
Replication	2	6	6.125	6.5
Factor A	7	4.661*	12.661*	8.35*7
Error	14	8	9.982	12.214

*significant at 5% level of probability

Appendix VII: Analysis of variance of the data on number of filled grain and unfilled per panicle of BBRI dhan 28 of rice as influenced by XXL

Sources of Variation	Degrees of freedom	Mean square		
		Length of panicle	Number of filled grain per panicle	Number of unfilled grain per panicle
Replication	2	0.674	77.929	1.744
Factor A	7	1.015*	201.661*	14.569*
Error	14	0.528	54.255	15.317

*significant at 5% level of probability

Appendix VIII: Analysis of variance of the data on weight of filled grain and unfilled grain per plant of BBRI dhan 28 of rice as influenced by XXL

Sources of Variation	Degrees of freedom	Mean square	
		Weight of filled grain per plant	Weight of unfilled grain per plant
Replication	2	144.912	3.298
Factor A	7	918.459*	5.737*
Error	14	235.566	2.285

*significant at 5% level of probability

Appendix IX: Analysis of variance of the data on yield of BBRI dhan 28 of rice as influenced by XXL

Sources of Variation	Degrees of freedom	Mean square		
		weight of 1000 grain	Grain Yield/m^2	Grain yield (t/ha)
Replication	2	0.636	37.875	0.294
Factor A	7	0.237*	19.946*	5.052*
Error	14	0.273	22.161	1.162

*significant at 5% level of probability