EFFECT OF SOIL ENHANCER (XXL) ON THE GROWTH, DEVELOPMENT AND YIELD ATTRIBUTES OF BRRI DHAN 29 AND HYBRID DHAN TAJ-1 IN *BORO* SEASON

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CERTIFICATE

This is to certify that the thesis entitled ***"EFFECT OF SOIL ENHANCER (XXL) ON THE GROWTH, DEVELOPMENT AND YIELD ATTRIBUTES OF BRRI DHAN 29 AND HYBRID DHAN TAJ-1 IN BORO SEASON"*** *submitted to the Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (MS) in AGRICULTURAL BOTANY****, embodies the result of a piece of bonafide research work carried out by* ***MD. SAIDUR RAHMAN,*** *Registration No.* ***09-03293*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed during the course of this investigation has been duly acknowledged and style of this thesis have been approved and recommended for submission.

Dated: December, 2015
Place: Dhaka, Bangladesh

Prof. Dr. Kamal Uddin Ahamed
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Dedicated to those who

“Working to feed the hungry planet”

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EFFECT OF SOIL ENHANCER (XXL) ON THE GROWTH, DEVELOPMENT AND YIELD ATTRIBUTES OF BRRI DHAN 29 AND HYBRID DHAN TAJ-1 IN *BORO* SEASON

ABSTRACT

The experiment was conducted at the Research Field of Sher-e-Bangla Agricultural University, Dhaka-1207 during November, 2015 to July, 2016 to evaluate the effect of soil enhancer (XXL) on the growth, development and yield attributes of BRRI dhan 29 and Hybrid dhan Taj-1 in *Boro* season. The experiment consisted of two varieties (BRRI dhan 29 and Hybrid dhan Taj-1) and seven different concentrations of XXL {Control, 125% (1.88g/1.5 L), 100% (1.5g/1.5 L), 75% (1.125g/1.5 L), 50% (0.75g/1.5 L), 33% (0.50g/1.5 L) and 25% (0.38g/1.5 L)}. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Significant variation was observed in different growth, development and yield contributing characters with XXL. Among the different XXL concentrations, 75% XXL provided the best result. Irrespective of varieties, the highest SPAD value of leaves (32.04 at 80 DAT), tillers hill^{-1} (15.26 at 80DAT), leaf area (29.26 cm^2), fertile tillers hill^{-1} (11.35), filled grains panicle^{-1} (130.2), shoot dry matter content hill^{-1} (22.72 g) and grain yield (10.58 t ha^{-1}) were achieved. With 75% XXL, BRRI dhan 29 and Hybrid dhan Taj-1 provided their highest grain yield (11.09 t ha^{-1} and 10.07 t ha^{-1}, respectively) contributed by fertile tillers hill^{-1} (13.63 and 9.07) and filled grains panicle^{-1} (127.3 and 133.1). It was 45.16% and 31.81% higher than control, respectively. It meant that BRRI dhan 29 and Hybrid dhan Taj-1 performed well with 75% XXL applied.

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ABBREVIATIONS AND ACRONYMS

AEZ	: Agro-Ecological Zone
ANOVA	: Analysis of Variance
B	: Boron
BARI	: Bangladesh Agriculture Research Institute
BRRI	: Bangladesh Rice Research Institutes
CV%	: Percentage of Coefficient of Variation
CV.	: Cultivars
df	: Degrees of freedom
DM	: Dry matter
FAO	: Food and Agriculture Organization of United Nations
GA_3	: Gibbrellic Acid
IAA	: Indole -3 Acetic Acid
NAA	: Naphthalene Acetic acid
pH	: Potential hydrogen
ppm	: Parts per million
SAU	: Sher-e-Bangla Agricultural University
SAURES	: Sher-e-Bangla Agricultural University Research
TSS	: Total Soluble Solid
USDA	: United States Department of Agriculture
Zn	: Zinc

CHAPTER I
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 (IRRI, 2013). In world, the rice production area, production and yield are 159.16 million hectares, 472.1 million metric tons and 4.42 metric tons per hectare, respectively (USDA, 2016).

Bangladesh is predominantly an agrarian country. Rice is the staple food of about 160 million people of Bangladesh. In Bangladesh, rice covers 75% of the total cropped area (Rekabdar, 2004). It provides nearly 48% of rural employment, about two-third of total calorie supply and about one-half of the total protein intakes of an average person in the country. Rice sector contributes one-half of the agricultural GDP and one-sixth of the national income in Bangladesh (BRRI, 2010). Bangladesh is the 4^{th} ranking position of rice production in the world. The area, production and yield of rice in Bangladesh are 11.77 million hectares, 34.50 million metric tons and 4.40 metric tons rice per hectare, respectively (USDA, 2016).

The trend of *Boro* rice production in Bangladesh is increasing day by day but it still very low in compare to others rice growing countries. There are three growing season of rice in Bangladesh among them *Boro* is the most important and largest crop season in respect of volume of production. It has been persistently contributing to higher rice production in last successive years. The favorable weather condition and long growing season is the main reason for higher production in *Boro* season of Bangladesh. Total area under *Boro* crop has been estimated 4.79 million hectares which covers 42.12% of total rice cropped area. The harvested area has increased by 0.64% in 2014. Average yield rate has been estimated 3.97 metric tons per hectare which is 0.58% higher than that of 2013.

Total *Boro* production has been estimated 19.01 million metric tons which is 1.22% higher than previous year (BBS, 2014). Bangladesh produced around 19.1 million tons of rice from *Boro*, up about 2% from around 18.78 million tons produced from 2013. *Aus*, *Aman* and *Boro* contribute to around 7%, 38% and 55% respectively to the total rice production in Bangladesh (DAE, 2014).

Bangladesh is facing a chronic shortage of food over the year due to high population pressure. About 220 hectares agricultural lands are decreased per year due to urbanization, industrialization, housing and road construction purposes. Fifty lac acres of agricultural land decreased during last 20 years. Moreover, some rice growing area is now being used as ponds for raising fishes to meet increasing protein demand of people. Now it is essential to find out sustainable technology for poverty alleviation and ensuring food security for increasing population.

The production is remarked with different factors such as nutritional management, climatic factors, edaphic factors, biotic and others abiotic factors among them due to the high intensity and severity of insects, pests ,weeds and low quality irrigation water the production of rice facing much problem especially in growth and yield. However, the competition of nutrition and light with weeds and insects the rice cannot perform supremely. As a result, the food security facing an unstable position in the world food demands as a whole of Bangladesh. Bangladesh has been facing persistent challenges in achieving food security. This is mainly due to natural disasters and fluctuations in food prices from the influence of volatile international market for basic food items (Rahman, 2011). So, growth enhancing facilities leads the increasing yield and production performance. So, the researchers have to think how to solve the food problem of the country. That is why continuous efforts are being taken towards the development of new rice cultivars and their management practices to increase the yield per unit area. So, Research has to think in other ways such as by (i) applying biotechnology and (ii) using plant growth regulator or enhancer.

Chitosan is a natural growth regulator which stimulates growth and increases yield of plants (Boonlertnirun *et al*., 2008). PGRs (Plant Growth Regulators) stimulate the growth of plant height, tiller number and yield of rice plant (Nian *et al.,* 1990). Phytohormone influence the translocation of nutrients from individual leaves to grains which leads to yield of rice (Ray and Choudhuri, 1981). Application of Chitosan in agriculture, even without chemical fertilizer can increase the microbial population by large numbers and convert organic nutrient into inorganic nutrient which is easily absorbed by the plant roots (Bolto *et al*., 2004). Exogenous application of Plant Growth Regulators (PGR) that causes dramatic yield of seed production of hybrid rice (Tiwari *et al.,* 2011).

XXL (Soil enhancer) is a complex substance which increase the fertility or productivity of soil that ultimately enhance the growth and yield of plants mainly imported from China where they achieved excellent improved yield by using this substance in rice. 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. Considering the above mentioned facts this XXL has been selected as a soil enhancer or supplementary of growth regulators to study the growth and development along with yield of rice varieties. Therefore, the present study was designed to investigate the effect of various concentrations of soil enhancer (XXL) on growth, development and yield attributing characters of BRRI dhan 29 and Hybrid dhan Taj-1 in SAU campus. The objectives of the experiment were as follows:-

1. To evaluate the effect of soil enhancer (XXL) powder on the morpho-physiological and yield attributes of rice plant.
2. To assess the optimum concentration of XXL in achieving the higher yield of test rice varieties.

CHAPTER II

REVIEW OF LITERATURE

Soil enhancer is the substances that standardize the growth in an incredible form. Many scientists are now studying the pattern of growth and development of plant treated with different plant growth regulators or soil enhancer. XXL is a bio soil enhancer as organic soil conditioner which stimulates growth and increases yield. In Bangladesh, the research on soil enhancer for rice in *Boro* season have not been well recognized or well established. So, some more related review of research information's has discussed in this chapter.

2.1 Morphological and growth characters

2.1.1 Plant height

Surahman *et al.* (2014) showed that GA_3 positively increase plant height, stigma exertion, compared to the control (0 ppm GA_3) of hybrid rice. GA_3 concentration of 200 ppm gave the best results.

Doni *et al.* (2014) reported that *Trichoderma sp*. SL_2 inoculated rice plants exhibited greater plant height (70.47 cm), root length (22.5 cm) compared to the plants treated with other *Trichoderma* isolates tested.

Mondal *et al.* (2012) revealed that most of the morphological such as plant height and leaf number plant^{-1} were increased with increasing concentration of Chitosan until 25 ppm over the control of Okra.

Ahmed (2012) conducted an experiment that revealed that the 50 mg L^{-1} Chitosan produced significantly the tallest plant (99.67 cm) hill^{-1} of *Boro* dhan at harvest.

Nguyen *et al.* (2011) conducted an experiment which involved spraying Chitosan and Chitosan oligomer onto the leaves of coffee in a greenhouse and in the field. The concentration of Chitosan and Chitosan oligomer solution used was 0, 20, 40, 60 and 80 ppm. Spraying Chitosan oligomers with concentration of 60 ppm increased the height of the coffee seedlings up to 33.51%, in the stem diameter up to 30.77%.

Manivannan (2011) observed that three different PGPR traits namely., *Azospirillum*, *Azotobacter* and *Pseudomonas* among them *Azospirillum* showed the best results by means of growth promotion in rice for seedling emergence, increase of shoot length and root length.

Tiwari *et al.* (2011) conducted an experiment to identify a suitable and cost efficient substitute of Gibbrelic acid to enhance hybrid rice seed production. The results indicated that the analysis of variance was significant for all the characters except plant height.

Ashrafuzzaman *et al.* (2009) observed that isolated PGB_4, PGT_1, PGT2, PGT_3, PGG_1 and PGG_2 induced the production of Indole acetic acid (IAA), whereas only PGT_3 isolate was able to solubilize phosphorus. Most of isolates resulted in a significant increase in plant height and root length of rice seedlings.

Guan *et al.* (2009) found that seed priming with Chitosan had no significant effect on germination percentage under low temperature stress, it enhanced germination index, reduced the mean germination time (MGT), and increased shoot height and root length in maize lines. Priming with 0.50% Chitosan for about 60~64 h seemed to have the best effects.

Khatun *et al.* (2008) laid out an experiment and found that application of GABA by spaying at 45 days after transplanting significantly enhanced plant height. The application of 4 mg L^{-1} GABA produced the highest of BR-11 rice compared to lower concentrations as well as control.

Gavino *et al.* (2008) found that GA_3 application was very effective in increasing seed set rate and seed yield of rice through elongation of plant height. 225, 150 and 150 g ha^{-1} of GA_3 dosage were found the most effective and economical seed production.

Sarwar *et al.* (2008) conducted an experiment the result showed that the application of 5 mg L^{-1} Miyodo produced the highest plant height of BR-11 rice compared to other concentrations as well as control.

Emongor (2007) conducted two field experiments and found that exogenous application of GA_3, 7 days after emergence at 30, 60 or 90 mg L^{-1} significantly increased cowpea plant height.

Boonlertnirun *et al.* (2006) showed that application of Chitosan with different molecular weights and different application methods did not affect plant height of rice cultivar Suphan buri 1.

Sarkar *et al.* (2002) investigated that plants of soybean cv. BS-3 were sprayed at three different times with two concentrations (100 and 200 ppm) of gibberellic acid (GA_3) and indole acetic acid (IAA). 100 ppm of IAA produced the highest plant height as compare to other plant growth regulators and control.

Chibu *et al. (*2002) investigated the effect of 0.1% and 0.5% Chitosan application on the shoot growth of rice and soybeans after incorporating it into soil before planting. In non-fertilized soil plant heights of rice increased but in fertilized soil they did not increase by Chitosan application. The effects of Chitosan application on shoot growth improvement were considered to be different by crop.

Ohta *et al.* (2001) reported that Chitosan soil treatment resulted in greater shoot length, stem diameter of *Eustoma grandiflorum* than in the untreated control.

Hoffmann-Benning and Kende (1992) indicated that the growth rate of deep water rice internodes is determined by the ratio of an endogenous growth promoter GA_3 which increase plant height and a growth inhibitor ABA which suppress plant height.

Amzallag *et al*. (1990) found that Treatment of Sorghum *bicolor* (L.) Moench, *cv*. 610, with Abscisic acid (ABA) during the first week of salinization with 150 mol m^{-3} NaCl induced enhancement of growth and accelerated adaptation to high salinity (300 mol m^{-3} NaCl).

Awan and Alizai (1989) observed that solution of 100 ppm Gibberellic acid (GA_3) and 100 ppm Indole acetic acid (IAA) were sprayed at 3 ml $plant^{-1}$ at panicle initiation significantly affected plant height of rice. GA_3 and IAA may be the result of more efficient.

2.1.2 SPAD value /Chlorophyll content

Salachna and Zawadzinska (2014) found that medium- and high-molecular-weight Chitosan resulted in higher plants with higher relative chlorophyll content (SPAD) in potted Freesia.

Manivannan(2011) observed that three different PGPR traits namely *Azospirillum, Azotobacter* and *Pseudomonas* among them *Azospirillum* showed the best results by means of chlorophyll content in paddy.

Nguyen *et al.* (2011) conducted an experiment which involved spraying Chitosan and Chitosan oligomer onto the leaves of coffee in a greenhouse and in the field. The concentration of Chitosan and Chitosan oligomer solution used was 0, 20, 40, 60 and 80 ppm. Obtained results showed that Chitosan oligomer enhanced strongly the content of chlorophylls and carotenoid in the leaves of coffee seedlings up to 46.38–73.51% compared to the greenhouse control.

Limpanavech *et al. (*2008) conducted an experiment with six types of Chitosan molecules, P-70, O-70, P-80, O-80, P-90, and O-90, to determine the effects on *Dendrobium* 'Eiskul' floral production. The chloroplasts in the young leaves of the plants treated with Chitosan O-80 at 10 and 50 ppm were found to be significantly larger than those of the non-Chitosan-treated ones. Enlarged chloroplasts were also detected in the old leaves treated with 50 ppm Chitosan O-80.

Chibu *et al. (*2002) investigated the effect of 0.1% and 0.5% Chitosan application on the shoot growth of rice and soybeans after incorporating it into soil before planting. In non-fertilized soil leaf numbers and SPAD values of rice increased but in fertilized soil they did not increase by Chitosan application.

Hutchison and Kieber (2002) observed that Cytokinins have been implicated in many developmental processes and environmental responses of Arabidopsis plants, including leaf senescence, apical dominance, chloroplast development, anthocyanin production, and the regulation of cell division and sink/source relationships.

Prakash and Prathapasenan (1990) found that treatment of rice plants with Gibberellic acid (GA_3) (10 ppm) increased the leaf growth and chlorophyll content with a concomitant rise in the activity of cellulose under stressed as well as non-stressed conditions.

2.1.3 Number of tillers hill^{-1}

Yeh *et al.* (2015) observed that Cytokinins are plant-specific hormones that affect plant growth and development. Both CX_3 and CX_5transgenic rice plants produce more tillers (27-81%) than the wild type. The increases in grain yield were highly correlated with increased tiller number.

Salachna and Zawadzińska (2014) shown that Chitosan is used as a biostimulator in the cultivation of potted Freesia. Regardless of the molecular weight of the compound, the Chitosan-treated plants flowered earlier, formed more flowers and corms.

Doni *et al.* (2014) reported that *Trichoderma sp*. SL_2 inoculated rice plants exhibited greater net photosynthetic rate (8.66 μmolCO_2 m^{-2} s^{-1}), tiller number (12) compared to the plants treated with other *Trichoderma* isolates tested.

Ahmed (2012) conducted an experiment that revealed that the 50 mg $L^{-1}$of Chitosan had higher number of total tillers per $hill^{-1}$ of *Boro* rice (16.67) at 90 DAT.

Limpanavech *et al. (*2008) conducted an experiment with six types of Chitosan molecules, P-70, O-70, P-80, O-80, P-90, and O-90, to determine the effects on *Dendrobium* 'Eiskul' floral production. Chitosan O-80 at all concentrations tested, 1, 10, 50, and 100 mg L^{-1}could induce early flowering and increase the accumulative inflorescence number during the 68 weeks of the experimental period, when compared to the non-Chitosan treated controls.

Sarwar *et al.* (2008) conducted an experiment and found that application of Miyodo by spraying at 45 days after transplanting of rice seedlings that significantly enhanced number of tillers $plant^{-1}$. Application of 5 mg L^{-1} Miyodo showed the best result.

Khatun *et al.* (2008) laid out an experiment and found that application of GABA by spaying at 45 days after transplanting significantly enhanced number of tillers. The application of 4 mg L^{-1} GABA produced the highest of BR-11 rice compared to lower concentrations as well as control.

Boonlertnirun *et al.* (2006) indicated that application of polymeric Chitosan by seed soaking of rice before planting followed by four foliar sprayings throughout cropping season significantly increased ($P<0.05$) the tillers numbers $plant^{-1}$.

Afroz (2005) conducted an experiment and showed GABA had positive regulatory effect on morphological growth and yield characters of *Boro* rice. GABA @ 2 mg L^{-1} was found the best for number of tillers $hill^{-1}$.

Awan and Alizai (1989) observed that solution of 100 ppm Gibberellic acid (GA_3) and 100 ppm Indole acetic acid (IAA) were sprayed at 3 $mlplant^{-1}$ at panicle initiation of rice significantly affected $tillersplant^{-1}$. GA_3 and IAA may be the result of more efficient.

2.1.4 Leaf area

Ahmed (2012) conducted an experiment that revealed that the 50 mg L^{-1} of Chitosan also had higher number of leaves $plant^{-1}$ (73.00) and LAI (2.83) at 90 DAT of rice plant.

Nguyen *et al.* (2011) conducted an experiment which involved spraying Chitosan and Chitosan oligomer on to the leaves of coffee were conducted in a greenhouse and in the field. The concentration of Chitosan and Chitosan oligomer solution used was 0, 20, 40, 60 and 80 ppm. Spraying Chitosan oligomers with concentration of 60 ppm increased the leaf area by up to 60.53%.

Sarwar *et al.* (2008) conducted an experiment and found that application of Miyodo by spraying at 45 days after transplanting of rice seedlings significantly enhanced number of leaves and leaf area, size of flag leaf of plant. Application of 5 mg L^{-1} Miyodo showed the best result.

Khatun *et al.* (2008) laid out an experiment and found that application of GABA by spaying at 45 days after transplanting significantly enhanced number of leaves and leaf area, size of flag leaf. The application of 4 mg L^{-1} GABA produced the highest of BR-11 rice compared to lower concentrations as well as control.

Kariali and Mohapatra (2007) conducted an experiment to find out the responses of hormone on growth, development, grain yield, senescence patterns, assimilate concentration of the panicle and ethylene production in different classes of rice tillers. The leaf area was higher in the low-tillering cultivar than that of high-tillering cultivar.

Emongor (2007) conducted two field experiments and found that exogenous application of GA_3, 7 days after emergence at 30, 660 or 90 mg L^{-1} significantly increased leaf area and leaf number $plant^{-1}$ of cowpea.

Afroz (2005) conducted an experiment and showed that GABA had positive regulatory effect on morphological growth and yield characters of *Boro* rice. GABA @ 2 mg L^{-1} was found the best for number of leaves $hill^{-1}$ and leaves area $hill^{-1}$.

Sarkar *et al.* (2002) investigated that plants of soybean cv. BS-3 were sprayed at three different times with two concentrations (100 and 200 ppm) of Gibberellic acid (GA_3) and Indole acetic acid (IAA). IAA at 200 ppm increased number of leaves and leaf area $plant^{-1}$ as compare to other plant growth regulators and control.

Chibu *et al.* (2000) reported that the effects of Chitosan applications to soil before planting, on the growth and chitinase activity of several crops were investigated. The early stage of growth of crops was improved and leaf areas were increased by Chitosan application, but effects were different by crop and by the amount of soil-incorporated Chitosan.

2.2 Yield contributing characters

2.2.1 Effective tiller $hill^{-1}$ and panicle length

Surahman *et al.* (2014) showed that GA_3 positively increase panicle exertion, duration of floret opening, angle of floret opening and panicle length of hybrid rice. Concentration of 200 ppm gave the best results.

Ahmed (2012) conducted an experiment that revealed that length of panicle (28.26 cm) was the noticed from the 50 mg L^{-1} Chitosan treated rice plants at harvest.

Khatun *et al.* (2008) laid out an experiment and found that application of GABA by spaying at 45 days after transplanting significantly enhanced effective tillers and panicle length. The application of 4 mg L^{-1} GABA produced the highest of BR-11 rice compared to lower concentrations as well as control.

Gavino *et al.* (2008) found that GA_3 application was very effective in increasing seed set rate and seed yield through promoting panicle and spikelet exertion, enhancing stigma exertion and longevity and receptivity of rice plant. 225, 150 and 150 g ha^{-1} of GA_3 dosage were found the most effective and economical seed production.

Sarwar *et al.* (2008) conducted an experiment and found that application of Miyodo by spraying at 45 days after transplanting significantly enhanced effective tillers and panicle length of T. aman rice. Application of 5 mg L^{-1} Miyodo showed the best result.

Ekamber and Kumar (2007) observed that Indole-3-acetic acid (IAA), kinetin (6-furfuryl amino purine) and Gibberellic acid (GA_3) treatments have been applied at the early tillering stage of two rice cultivars that contrast for tiller number. The leaf area, panicle grain number, fertility percentage and grain yield of tillers were higher in the low-tillering cultivar than that of high-tillering cultivar; the treatment of kinetin was more effective in the latter than in the former.

Kariali and Mohapatra (2007) conducted an experiment to find out the responses of hormone on growth, development, grain yield, and senescence patterns, assimilate concentration of the panicle and ethylene production in different classes of rice tillers. The panicle grain number, fertility percentage and grain yield of tillers were higher in the low-tillering cultivar than that of high-tillering cultivar.

Afroz (2005) conducted an experiment and showed GABA had positive regulatory effect on morphological growth and yield characters of *Boro* rice. GABA @ 2 mg L^{-1} was found the best for number of effective tiller $hill^{-1}$.

Ohta *et al.* (2001) reported that Chitosan soil treatment resulted in greater weight of cut-flowers and increase in number of flowers *(Eustoma grandiflorum)* than in the untreated control. Chemical name used: poly-(1→4)-β-0-glucoseamine (Chitosan).

2.2.2 Number of filled and unfilled grains $panicle^{-1}$

Chen *et al.* (2013) suggested that a potential metabolic interaction between polyamines and ethylene biosynthesis responds to soil drying and mediates the grain filling of inferior spikelet in rice.

Pan *et al.* (2013) found that spraying PBZ with 50 mg L^{-1} or 6-BA with 30 mg L^{-1} at the heading stage could increase the number of spikelets per panicle and seed setting rate in *Peizataifeng* and *Huayou86* in early and late seasons.

Dong *et al.* (2012) indicated that spraying GA_3 after anthesis could significantly improve the panicle weight of rice.

Ahmed (2012) conducted an experiment and revealed that number of rice grains $panicle^{-1}$ (184.67) was the noticed from the 50 mg L^{-1} Chitosan treated plants at harvest.

Zheng *et al.* (2011) indicated that different plant growth regulators affected differently the regulation of the photosynthetic physiology of flag leaf and the grain-filling/seed-setting of rice and the suitable treatment of plant growth regulators(such as NAA-Na, Indole acetic acid, Gibberellic acid or 6-BA) could promote the rate of rice seed-setting and yield of rice.

Zhu *et al.* (2011) investigated that the relatively high concentrations of ethylene and ABA in inferior spikelet's of rice suppress the expression of starch synthesis genes and their enzyme activities and consequently lead to a low grain-filling rate. Alternatively low concentrations of ethylene and ABA lead to a high grain-filling rate.

Bakhsh *et al.* (2011) revealed that application of growth regulator (NAA) 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 spikelet's $panicle^{-1}$, 88 and 90 % normal kernel of paddy during 2004 and 2005, respectively.

An experimental trial was carried out by Ghoname *et al.* (2010) in the two successive seasons of 2008 and 2009 to investigate and compare the enhancing effects of three different biostimulation compounds on growth and production of sweet pepper plants. Three weeks after transplanting, plants were sprayed with any of the individual Chitosan (2, 4 and 6 cm /l). Data showed that individual fruit weight and number of fruits were improved.

Dong *et al.* (2009) observed that solutions with low concentrations of exogenous ABA (75.7 μmol L^{-1}) and GA (57.7 μmol L^{-1}) were sprayed at earlier filling stage. The results indicated that the effects of exogenous hormones at early filling stage on rice quality were great, and varied with exogenous hormone varieties and different grain positions. The exogenous ABA increased the grains weight (KGW) and head milled rice rate (HMRR), and reduced chalkiness degree (CD).

Tang *et al.* (2009) investigated that a higher SUS activity was found in superior grains than in inferior grains in the earlier stage of grain filling, which was significantly and closely related to a higher grain filling rate and starch accumulation in rice. An increase in ABA concentration gave similar results.

Khatun *et al.* (2008) laid out an experiment and found that application of GABA by spraying at 45 days after transplanting significantly enhanced number of total grains and filled grains. The application of 4 mg L^{-1}GABA produced the highest of BR-11 rice compared to lower concentrations as well as control.

Sarwar *et al.* (2008) conducted an experiment and found that application of Miyodo by spraying at 45 days after transplanting significantly enhanced number of total grains and filled grains of rice plant. Application of 5 mg L^{-1} Miyodo showed the best result.

Boonlertnirun*et al.* (2006) found the results which indicated that application of polymeric Chitosan by seed soaking before planting followed by four foliar sprayings throughout cropping season significantly increased ($P<0.05$) the dry matter accumulation but decreased unfilled grains of rice cultivar Suphan buri 1.

Afroz (2005) conducted an experiment and showed that GABA had positive regulatory effect on morphological growth and yield characters of *Boro* rice. GABA @ 2 mg L^{-1} was found the best for number of filled grain $hill^{-1}$.

Ohta *et al.* (2001) also reported that the application of a soil mix of Chitosan 1% w/w at sowing remarkably increased flower numbers of *Eustoma grandiflorum.*

Yang *et al.* (2001) suggested that an altered hormonal balance in rice grains by water stress during grain filling, especially a decrease in GAs and an increase in ABA, enhances the remobilization of prestored carbon to the grains and accelerates the grain filling rate.

Yang *et al.* (2000) suggested that cytokinins in the grains and roots during the early phase of grain development play an important role in regulating grain filling pattern and consequently influence grain filling percentage of rice plant.

Yang *et al.* (1999) observed that low concentration (15mg L^{-1}) ABA treatment raised ADP-glucose pyrophosphorylase and starch synthase activities and starch content, and reduced soluble sugar content in grains at early filling stage, and increased grain filling rate, and shortened the time reaching the maximum filling rate, and promoted matter mobilization from stems and sheaths and raised seed-setting percentage, filled grain percentage and grain yield of rice. The results were reversed for the treatments of high concentration (30mg L^{-1}) ABA as well as both low and high concentration GA (20 and 40mg L^{-1}, respectively).

Nagoshi and Kawashima (1996) investigated that TRIA-treated rice plants showed enhancement of the grain weight increase after heading and the 1,000 grain weight of brown rice and the percentage of ripened grain at harvesting time. The effect of grain weight increase after heading was highest from the middle ripening stage.

Brenner and Cheikh (1995) focused on the involvement of plant hormones as natural regulators of partitioning of photo assimilates especially to developing seeds.

In contrast, the work of Kuznia *et al*. (1993) found that seeds of white lupine treated with Chitosan did not consistently increased yields.

Roy and Choudhuri (1981) observed that when the plants were sprayed with 100 μg ml^{-1} aqueous solutions of the hormones at 100 days, when the rice plants were entering the reproductive stage. GA_3 and IAA increased the grain-filling and ^{32}P mobilization significantly over control but the effects were less marked than those of kinetin.

2.2.3 Total dry matter (TDM)

Ahmed (2012) conducted an experiment that revealed that the 50 mg L^{-1} Chitosan produced significantly the highest TDM (33.46 g) of rice plants $hill^{-1}$ at harvest.

Manivannan (2011) observed that three different PGPR traits namely *Azospirillum, Azotobacter* and *Pseudomonas. Azospirillum* showed the best results by means of dry matter production in paddy.

Guan *et al.* (2009) reported that Chitosan under low temperature increased shoot and root dry weight in maize plants compared to that of the control.

Ashrafuzzaman *et al.* (2009) observed that isolated PGB_4, PGT_1, PGT_2, PGT_3, PGG_1 and PGG_2 induced the production of Indole acetic acid (IAA), whereas only PGT_3 isolate was able to solubilize phosphorus. Most of isolates resulted in a significant increase in plant dry matter production of shoot and root of rice seedlings.

Sarwar *et al.* (2008) conducted an experiment and found that application of Miyodo by spraying at 45 days after transplanting significantly enhanced total dry matter of rice plant. Application of 5 mg L^{-1} Miyodo showed the best result.

Khatun *et al.* (2008) laid out an experiment and found that application of GABA by spaying at 45 days after transplanting significantly enhanced total dry matter. The application of 4 mg L^{-1} GABA produced the highest of BR-11 rice compared to lower concentrations as well as control.

Emongor (2007) conducted two field experiments and found that exogenous application of GA_3, 7 days after emergence at 30, 60 or 90 mg L^{-1} significantly increased plant dry matter accumulation of cowpea.

Gurmani *et al.* (2006) observed that 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 of rice cultivar over that of salt alone.

Boonlertnirun *et al*. (2006) indicated that application of polymeric Chitosan by seed soaking before planting followed by four foliar sprayings throughout cropping season significantly increased ($P<0.05$) the dry matter accumulation in the rice grain.

Afzal *et al*. (2005) investigated that the effects of seed soaking with plant growth regulators (IAA, GA_3, kinetin or prostart) on wheat (*Triticum aestivum* cv. Auqab-2000). Results revealed that fresh and dry weight of seedlings were significantly increased by 25 mg L^{-1} kinetin followed by 1% prostart for 2 h treatments under both normal and saline conditions.

Afroz (2005) conducted an experiment and showed GABA had positive regulatory effect on morphological growth and yield characters of *Boro* rice. GABA @ 2 mg L^{-1} was found the best for dry weight of stem, dry weight of root and total dry matter.

Kang *et al.* (2005) found that post-application in the stressed plants with 30 μM Jasmonic acid (JA) at 24 and 48 h after NaCl treatment, recovered salt inhibition on dry mass production of rice plant more effectively than application of JA at 48 and 24 h before salt stress, and during salt stress simultaneously.

2.2.4 Thousand grains weight

Yeh *et al.* (2015) observed that Cytokinins are plant-specific hormones that affect plant growth and development. Both CX_3 and CX_5 transgenic rice plants produce heavier 1000 grain weight (5-15%) than the wild type.

Ahmed (2012) conducted an experiment and revealed that 1000- grains weight (29.04 g) of BRRI dhan 29 were the noticed from the 50 mg L^{-1} Chitosan treated at harvest.

Bakhsh *et al.* (2011) revealed that application of growth regulator (NAA) at the rate of 90 ml ha^{1} at panicle initiation stage resulted in highest number of 23.00 and 23.20 g 1000-grains weight of paddy yield during 2004 and 2005 respectively.

Du *et al.* (2010) showed that the thousand-grain weight of superior spikelet's was enhanced 5.69%, 4.67% and 8.27% by exogenous application of ABA, GA_3 and PR_1 respectively and the thousand-grain weight of inferior spikelet's was enhanced 12.00%, 7.67% and 13.89% by exogenous application of ABA, GA_3 and PR_1, respectively.

Khatun *et al.* (2008) laid out an experiment and found that application of GABA by spaying at 45 days after transplanting significantly increased 1000 seed weight. The application of 4 mg L^{-1} GABA produced the highest of BR-11 rice compared to lower concentrations as well as control.

Sarwar *et al.* (2008) conducted an experiment and found that application of Miyodo by spraying at 45 days after transplanting significantly enhanced 1000-grain weight of rice plant. Application of 5 mg L^{-1} Miyodo showed the best result.

Emongor (2007) conducted two field experiments and found that exogenous application of GA_3, 7 days after emergence at 30, 60 or 90 mg L^{-1} significantly increased seed number pod^{-1} and 1000 seed weight of cowpea.

Gurmani *et al.* (2006) conducted an experiment 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 and observed thatthe ranking of growth regulators for their effects on 1000-grain weights were ABA>BA>CCC. Higher 1000-grain weight was recorded by IR-6.

2.2.5 Grain yield

Abbasian *et al.* (2016) reported that the foliar application of methanol increased rice plant biomass and yield except cv. Shiroudi of rice.

Known *et al.* (2015) reported that Gibberellic acid (GA_3; or gibberellins) affects the elite *Japonica* cultivar Koshihikari, which has a nonfunctional *el1* allele for early flowering in long days, produce fertile spikelet's and normal grain yields like other elite *Japonica* cultivars.

Yeh *et al.* (2015) observed that Cytokinins are plant-specific hormones that affect plant growth and development. Both CX_3 and CX_5 transgenic rice plants produce more grains (24-67%) per plant than the wild type. The increases in grain yield were highly correlated with increased tiller number.

Doni *et al.* (2014) reported that use of bio-enhancers such as Trichoderma, an aerobic fungus is one of the low input alternatives recognized to increase productivity or yield of rice plant.

Surahman *et al.* (2014) showed that GA_3 positively Increased rice seed production is 0.2 to 1 t/ha compared to the control (0 ppm GA_3). GA_3 concentration of 200 ppm gave the best results as indicated by the highest productivity of seed set and yield in all CMS lines were tested.

Pan *et al.* (2013) found thatspraying PBZ with 50 mg L^{-1} or 6-BA with 30 mg L^{-1} at the heading stage could increase grain yields in *Peizataifeng* and *Huayou86* of super hybrid rice in early and late seasons.

Ahmed (2012) conducted an experiment and revealed that grain yield (7.05 t ha^{-1}), biological yield (17.21 t ha^{-1}) were the noticed from the 50 mg L^{-1} Chitosan treated rice plants at harvest.

Mondal *et al.* (2012) revealed that yield attributes (number of fruits $plant^{-1}$ and fruit size) and the highest fruit yield in okra (27.9% yield increased over the control) by the application of Chitosan.

Bakhsh *et al.* (2011) found that application of growth regulator (NAA) at the rate of 90 ml ha-1 at panicle initiation stage resulted in highest 9.00 and 9.20 Mg ha^{-1} paddy yield during 2004 and 2005, respectively.

Manivannan (2011) observed that three different PGPR traits namely., *Azospirillum, Azotobacter* and *Pseudomonas* among them *Azospirillum* showed the best results by means of yield parameters like increase of grain yield and straw yield of paddy.

Tiwari *et al.* (2011) found that exogenous application of various plant hormones significantly increase rice seed yield with a range of 14.85 g to 23.54 g. Treatment T_{26} (GA_3+C.C.) had highest significant increase in grain yield followed by T_2 (GA_3 45g), T_1 (GA_3 30g), T_5 (NAA 200g), T_3 (NAA 100g), $T2_7$ (Urea 2g+C.C.) and T_{24} (GA_3 45g+K_2PO_4 2g.

Abdel-Mawgoud *et al.* (2010) observed that improved plant yield components (number and weight) or production were increased in strawberry plants by the application of Chitosan.

Uddin *et al.* (2009) studied the effect of four different plant growth regulators viz. Control (No application of PGR), NAA (30 mg L^{-1}), GA (30 mg L^{-1}) and 2, 4-D (30 mg L^{-1}) on tomato plant. The maximum fruits $plant^{-1}$ (42.66), average weight of individual fruit (92.06 g), yield $plant^{-1}$ (2.49 kg) and yield ha^{-1} (93.23 t ha^{-1}) were found in PGR and the minimum for all parameters were found in control (PGR) treatment.

Aziz and Miah (2009) conducted an experiment to determine the performance of “Flora” as PGR on the growth and yield of wetland rice under the different treatment. The treatment T_4 where chemical fertilizer was applied on STB in combination with flora produced the maximum yield but in terms of economic point of view than other treatment.

Boonlertnirun *et al.* (2008) observed that application of Chitosan by seed soaking and soil application four times throughout cropping season significantly increased rice yield over the other treatments whereas application by seed soaking and spraying the foliar four times tended to show an ability on disease control.

Khatun *et al.* (2008) found that the application of 4 mg L^{-1}GABA produced the highest grain yield of BR-11 rice compared to lower concentrations as well as control.

Sarwar *et al.* (2008) conducted an experiment the result showed that the application of 5 mg L^{-1} Miyodo produced the highest grain yield of BR-11 rice compared to other concentrations as well as control.

Emongor (2007) conducted two field experiments and found that exogenous application of GA_3, 7 days after emergence at 30, 60 or 90 mg L^{-1} significantly increased seed yield ha^{-1} of cowpea.

Zhang *et al.* (2007) conducted an experiment and showed that all kinds of external phytohormones could delay leaves senescence, increase the seed setting rate, and increase the yield of rice in which 6-BA did the best.

Gurmani *et al.* (2006) conducted an experiment 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 and observed thatthe ranking of growth regulators for their effects on grain yield were ABA>BA>CCC. Higher grain yield was recorded by IR-6.

Afroz (2005) conducted an experiment and showed that GABA had positive regulatory effect on morphological growth and yield characters of *Boro* rice. GABA @ 2 mg L^{-1} was found the best for gain yield and harvest index.

Sarkar *et al.* (2002) investigated that plants of soybean cv. BS-3 were sprayed at three different times with two concentrations (100 and 200 ppm) of Gibberellic acid (GA_3) and Indole acetic acid (IAA). 100 ppm of IAA produced the highest seed $plant^{-1}$ and seed yield ha^{-1} as compare to other plant growth regulators and control.

Nian *et al.* (1990) conducted a field experiment on effect of 4 plant growth regulators BAS 111, DCiB, EL 500 and Terpal C on growth and yield of paddy rice and found that seed soaking with EL 500, BAS 111 and Terpal C increased grain yield between 10 and 13 % in the first crop.

Awan and Alizai (1989) observed that solution of 100 ppm Gibberellic acid (GA_3) and 100 ppm Indole acetic acid (IAA) were sprayed at 3 ml plant^{-1} at panicle initiation significantly affected grains panicle^{-1}and grain yield, and protein content of rice plant. Higher, better quality yield with GA_3 and IAA may be the result of more efficient.

2.2.6 Harvest index

Ahmed (2012) conducted an experiment and revealed that BRRI dhan 29 showed the highest harvest index (40.98%) which noticed from the 50 mg L^{-1} Chitosan treated plants at harvest.

Sarwar *et al.* (2008) conducted an experiment and found that application of Miyodo by spraying at 45 days after transplanting significantly enhanced harvest index of BR-11 rice. Application of 5 mg L^{-1} Miyodo showed the best result.

Akter *et al*. (2007) showed that the highest harvest index (38.50%) was observed from 50 mg L^{-1} GA_3 which was statistically identical with 25 mg L^{-1} and the lowest harvest index (32.96%) was obtained in control.

Baruah (1990) observed that sprayed with 5 ppm N-triacontanol, 1 ppm Cytozyme crop^{+}, 10 ppm IAA + $ZnSO_4$, 10 ppm GA_3, 4 ppm Increcel, or water. LA_1, NAR, RGR, viable tiller numbers m^{-2}, percentage ripened grain, harvest index and grain yield were highest in crops sprayed with triacontanol.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Research Field of Sher-e-Bangla Agricultural University, Dhaka-1207 during November, 2015 to July, 2016. This chapter consists of materials used and methods followed during the experimental period. A brief description of materials used, treatments, location of the experimental site, characteristic of soil, climate and weather, experimental design, fertilizer application, transplanting of the seedlings, application of soil enhancer, intercultural operations, harvesting, data collection and statistical analysis were described in this chapter.

3.1 Description of the experimental site

3.1.1 Experimental sites

The experiment was conducted at central Research Field of Sher-e-Bangla Agricultural University (SAU), Dhaka-1207, during *Boro* season from (November- July) of 2015-16. Location of the site is 90°33' E longitude and 23°77' N latitude with an elevation of 8 meter from sea level (UNDP-FAO, 1988) in Agro-Ecological Zones of Madhupur Tract (AEZ No. 28) (Appendix I).

3.1.2 Climate

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

3.1.3 Soil

Top soil of experimental area was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 6.7 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 were presented in Appendix III.

3.2 Plant materials

In this research work, two rice varieties were used as plant materials. First one BRRI developed variety namely BRRI dhan 29 and second one exported from China namely Hybrid dhan Taj-1 were used as planting material. Seed of BRRI dhan 29 was collected from Bangladesh Rice Research Institute (BRRI), Gazipur and Hybrid dhan Taj-1 from National Seed Co. Limited, Dhaka.

3.3 Experimental details

3.3.1 Soil Enhancer

XXL (XXL Bio Green Energy - Bio Soil Enhancer) was used as a soil enhancer in the present investigation. XXL consist of organic humic acid, fulvic acid, 40 different trace elements and other plant hormone which made from million years of highly compressed organic humus in the tropical rainforests. XXL has two main functions- i) soil improvement and ii) fertilizer enhancer. By applying XXL bio soil enhancer as organic soil conditioner, damaged soil became productive soil. XXL is a newly formulated organic and biological soil conditioner which is added to soil to improve the soil's physical qualities, especially its ability to provide nutrition for plants. The minerals and trace elements in XXL can be comprehensively used and absorbed by plants through a natural and complicated chelating process in the soil. The application of XXL into soil will restore the natural soil counterbalance which is needed for the maintenance of optimum plant growth. It is suitable to be used with any type of soil to improve soil physical characteristics, soil aggregate structure, and reduce soil compactness.

When plants have larger and longer roots, they grow better and healthier. The XXL was collected from Golden Barn Kingdom (GBK) Office, Panthapath, Dhaka-1205. The experiment consisted of seven different concentrations of XXL, which were applied four doses at every seven days interval (one was basal application and rest three after seedling transplanting).

3.3.2 Treatments

Treatments included in the experiment were as follows:

Factor A: variety

(i) V_1= BRRI dhan 29

(ii) V_2= Hybrid dhan Taj-1

Factor B: Different concentrations of XXL with recommended doses of NPKSZn fertilizer

1. T_1= 0% (Control)
2. T_2= 125% (1.88g/1.5 L)
3. T_3= 100% (1.5g/1.5 L)
4. T_4= 75% (1.13g/1.5 L)
5. T_5= 50% (0.75g/1.5 L)
6. T_6= 33% (0.50g/1.5 L)
7. T_7= 25% (0.38g/1.5 L)

3.3.3 Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the rice variety. There were 42 plotted of size 1m × 3m= $3m^2$ in each of 3 replications. The distance between one replication to another replication was 1m and plot to plot distance was 0.5m.The treatments of the experiment were assigned at random into each replication following the experimental design (Appendix IV).

3.4 Growing of crops

Following cultivation procedures were practiced to grow the crop.

3.4.1 Raising Seedlings

Following steps were taken to raise the seedling

3.4.1.1 Seed collection

The seed of the test crop BRRI dhan 29 was collected from Bangladesh Rice Research Institute (BRRI), Gazipur and Hybrid dhan Taj-1 was collected from National Seed Co. Limited, Dhaka.

3.4.1.2 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.

3.4.1.3 Preparation of nursery bed and seed sowing

As per BRRI recommendation seedbed was prepared with 1m wide adding nutrients as per the requirements of soil (BRRI, 2013). Seeds were sown in the seed bed on the 13th December @ 70 g m^{-2} in order to have healthy seedlings.

3.4.2 Land preparation

Power tiller was used for the preparation of the experimental field. Then it was exposed to the sunshine for 7 days prior to the next ploughing. Thereafter, the land was ploughed and cross ploughed to obtain good tilth. Laddering was done in order to break the soil clods into small pieces followed by each ploughing. All the weeds and stubble were removed from the experimental field. The soil was treated with insecticides at the time of final ploughing. Insecticide Furadan 5G was used @ 8 kgha^{-1} to protect young plants from the attack of mole cricket, ants and cutworms.

3.4.3 Fertilizer application

Recommended doses of fertilizers were applied to each pot. Fertilizers such as Urea, TSP, MoP, Gypsum and Zinc sulphate were used as sources for N, P, K, S and Zn respectively. The full doses of all fertilizers and one third of urea were applied as basal dose to the individual plot during final soil preparation.

The first split of Urea was applied 25 days after transplanting (DAT) and the second split of Urea was applied at 45 DAT, i.e., at maximum tillering stage. The doses of fertilizers with their sources are given below:

Nutrient	Source	Dose (kg ha^{-1})
N (Nitrogen)	Urea	200
P (Phosphorus)	TSP	100
K (Potassium)	MP	120
S (Sulphur)	Gypsum	75
Zn (Zinc)	Zinc sulphate	15

Source: Adhonik dhaner chash, BRRI, 2013

3.4.4 Uprooting of seedlings

The nursery bed was made wet by application of water one day before uprooting the seedlings. The seedlings were uprooted in the morning without causing much mechanical injury to the roots.

3.4.5 Transplanting of seedlings

Twenty one (21) day's old seedlings were transplanted in the experimental plot on the 2nd January, 2016. Healthy seedlings were uprooted carefully from the seedbed and two seedlings were transplanted in each hill with plant to plant distance 15 cm and row to row distance 20 cm.

3.4.6 Application of XXL

XXL was a powder prior to spray. XXL was diluted to get working solution. XXL solution was applied in the form of spray in the soil by hand sprayer and knapsack sprayer. Four sprays were done in the field. 1st one was basal dose before seedling transplanting and rest three were sprayed at 7, 14 and 21 DAT. The sprays were made at early hours to avoid dehydration effect.

3.4.7 Intercultural operation

After transplanting of the seedlings, different intercultural operations were carried out for better growth and development of the plant.

3.4.7.1 Weeding

Few weeds, namely, durba, shama, mutha, azolla etc. were found in each plot after two weeks of transplanting of rice. 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.

3.4.7.2 Irrigation and drainage

During cultivation from November 2015 to July 2016, natural rainfall occurred in the research field. Besides, irrigation was done as per requirement of the field. On the contrary, drainage was done simply by breaking the border ails.

3.4.7.3 Gap filling

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

3.4.7.4 Plant protection

Furadan 5G was applied at the time of final land preparation and Ripcord 400 EC applied at 30 DAT of rice seedlings.

3.5 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 color. Ten pre-selected hills per plot from which different data were collected and 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 grains. Then the plant samples were carried out to the laboratory. Plant height, leaf area, fertile and sterile tillers, length of panicle, filled and unfilled grains and thousand grains were counted.

Fresh weight of grains was recorded plot wise. Then the plant shoot such as leaf, leaf sheath and stem were dried by an electric oven at 70°C for 72 hours. The straw was sun dried and the yields of grain and straw plot^{-1} were recorded and converted to t ha^{-1}.

3.6 Collection of data

Data on the following parameters were recorded during the course of the experiment.

Growth and developmental characters	
1. Plant height	2. Number of tillers hill^{-1}
3. Leaf area	4. SPAD value (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. First Maturity (DAT)	12. Last Maturity (DAT)
Yield contributing characters	
13. Fertile tillers hill^{-1}	14. Sterile tillers hill^{-1}
15. Length of panicle	16. Number of filled grains panicle^{-1}
17. Number of unfilled grains panicle^{-1}	18. Weight of filled grains panicle^{-1}
19. Weight of unfilled grains panicle^{-1}	20. Weight of grains m^{-2}
21. 1000 grains weight	22. Grain yield
23. Dry Weight of -	24. Moisture content (%)
a. Stem b. Leaf	
c. Filled grain d. Unfilled grain	

3.6.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 20, 40, 60, 80 DAT (Days after transplanting) and at harvest. Plant height was measured from the ground level to the tip of the longest leaf/flag leaf. 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.

3.6.2 SPAD value (Chlorophyll content) 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.

3.6.3 Number of tillers hill^{-1}

The Number of tillers hill^{-1} was recorded at the time of 20, 40, 60, 80 DAT by counting total tillers. Data were recorded as the average of 10 hills selected at random from the inner rows of each plot.

3.6.4 Days to 1%, 50% and 100% booting stage

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

3.6.5 Days to 1%, 50% and 100% panicle insertion stage

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

3.6.6 Days to maturity

Days to maturity were recorded by counting the number of days required to mature in each plot. Maturity date was estimated by ken observation of plant and when the plant became brownish in color than the rice plant attained it maturity.

3.6.7 Leaf area

Area of leaf was measured manually. Data were recorded as the average of 10 plants selected at random the inner rows of each plots. The final data were calculated multiplying by a correction factor 0.75 as per Yoshida (1981).

3.6.8 Fertile tillers hill^{-1}

The total number of effective tiller hill^{-1} was counted as the number of panicle bearing tiller hill^{-1}. Data on effective tiller hill^{-1} were counted from 10 selected hills at harvest and average value was recorded.

3.6.9 Sterile tillers hill^{-1}

The total number of non effective tillers hill^{-1} was counted as the number of non panicle bearing tillers plant^{-1}. Data on non effective tiller hill^{-1} were counted from 10 selected hills at harvest and average value was recorded.

3.6.10 Panicle length

Panicle length was measured from the basal node of the rachis to the apex of each panicle.

3.6.11 Filled grains panicle^{-1}

The total number of filled grains was collected randomly from selected 10 plants of a plot on the basis of grain in the spikelet and then average number of filled grains panicle^{-1}was recorded.

3.6.12 Unfilled grains panicle^{-1}

The total number of unfilled grains was collected randomly from selected 10 plants of a plot on the basis of no grain in the spikelet and then average number of unfilled grains panicle^{-1} was recorded.

3.6.13 Weight of grains m^{-2}

The plant of 1 m^2 area was selected from each plot without border plants. The grains were collected and sun dried. Finally, weighted by using an electronic balance.

3.6.14 Shoot dry weight hill^{-1}

Total dry weight of leaf, leaf sheath, stem hill^{-1}, filled grains and unfilled grains was recorded at the time of harvest by drying plant sample for 72 hours in 70°C temperature inside drying oven.

3.6.15 Thousand grains weight

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

3.6.16 Moisture content

Moisture content was taken in fresh grain and sun dried grain by a moisture measuring device.

3.6.17 Grain yield

The grains from each plot were harvested, threshed, dried, weighed and finally converted to t ha^{-1} basis**.**

3.6.18 Straw yield

Straws obtained from each unit plot were oven dried and weighed carefully.

3.7 Statistical analysis

The data recorded on different parameters under the experiment were statistically analyzed to obtain the level of significance difference among the treatment using the MSTAT-C package program developed by Russell (1986). The mean values of all the characters were calculated and analysis of variance was performed. The treatment means were compared by Least Significant Difference (LSD) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to evaluate the effect of soil enhancer (XXL) on the growth, development and yield attributes of BRRI dhan 29 and Hybrid dhan Taj-1 in *Boro* season. The results obtained from the study have been presented, discussed and compared in this chapter through different tables, figures and appendices. The mean square value of data in respect of all the parameters have been shown in Appendix V-XI. The results have been presented and discussed with the help of tables and graphs and possible interpretations have been given under the following headings.

4.1 Plant height

The plant height varied significantly among the test rice varieties at 20, 40, 60, 80 DAT and at harvest (Figure 1 and Appendix V). At 20, 40, 60, 80 DAT and at harvest, the tallest plant (30.13, 56.62, 66.29, 92.37 and 98.58 cm, respectively) were observed from Hybrid dhan Taj-1, while the shortest plant (24.08, 43.99, 61.33, 79.37 and 94.65 cm, respectively) from BRRI dhan 29. Varieties produced different plant height on the basis of their varietal characters and also genetically influences but environmental and different management practices also influences plant height. Khalifa (2009) reported earlier that H_1 hybrid rice variety suppressed other varieties in terms of plant height. Bhuiyan *et al*. (2014) reported earlier significant effects on plant height for different rice variety.

The plant height was significantly influenced due to the effect of different concentrations of XXL in the growth period over control (Figure 2 and Appendix V). Application of XXL as soil enhancer enhanced the plant height.

Among the XXL concentrations, 75% XXL (1.125 g/ 1.5L) produced the tallest plant (29.01, 53.57, 68.72, 92.82 and 104.8 cm) at 20, 40, 60, 80 DAT and at harvest, respectively compare to other concentrations of XXL. XXL level of 50% produced the statistically similar tallest plant (28.48 cm) at 20 DAT and 100% also closely followed (52.40 cm at 40 DAT) by the 75% XXL. On the other hand, control treatment showed the shortest plant (25.19, 46.30, 60.29, 78.46 and 89.83 cm) at 20, 40, 60, 80 DAT and at harvest, respectively. It was also observed that the increasing XXL levels increased the plant height up to 75% after that it was decreased for its high concentration which may destructive for the plant growth at the whole data recording period because 75% XXL with normal dose 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. However, more than 75% XXL with fertilizers is harmful or unsuitable to plants for nutrients uptake that's why growth rate and potential was lower than 75% XXL. This result were support by the work of Chibu *et al.* (2000) in rice who reported that plant height increased in Chitosan applied plants as compared to control plants and similar result was also found by Martinez *et al.* (2007) in tomato.

Interaction effect of different concentrations of XXL and rice varieties showed significant variation on plant height at 20, 40, 60, 80 DAT and at harvest (Table 1 and Appendix V). At 20, 60, 80 DAT and at harvest, the tallest plant (32.47, 71.72, 98.94 and 108.7cm, respectively) were observed from the combination of Hybrid dhan Taj-1 with 75% XXL but Hybrid dhan Taj-1 with 125% XXL showed the highest plant height (61.17cm) at 40 DAT than other combinations, whereas the shortest plant (40.11, 57.27, 74.43 and 87.94 cm, respectively) were recorded from the combination of BRRI dhan 29 with control treatment but BRRI dhan 29 with 125% XXL showed the shortest plant height (22.42 cm) at 20 DAT.

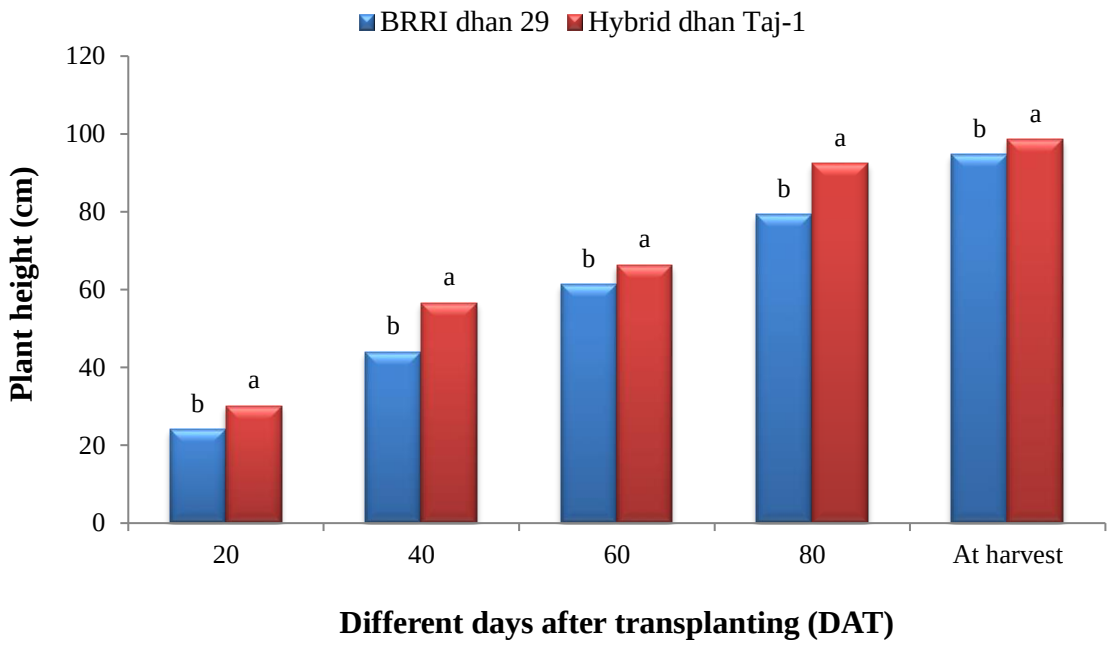

Figure 1. Effect of variety on the plant height of rice at different days after transplanting (LSD $_{(0.05)}$ = 1.34, 2.28, 3.47, 3.64 and 3.89 at 20, 40, 60, 80 DAT and at harvest, respectively)

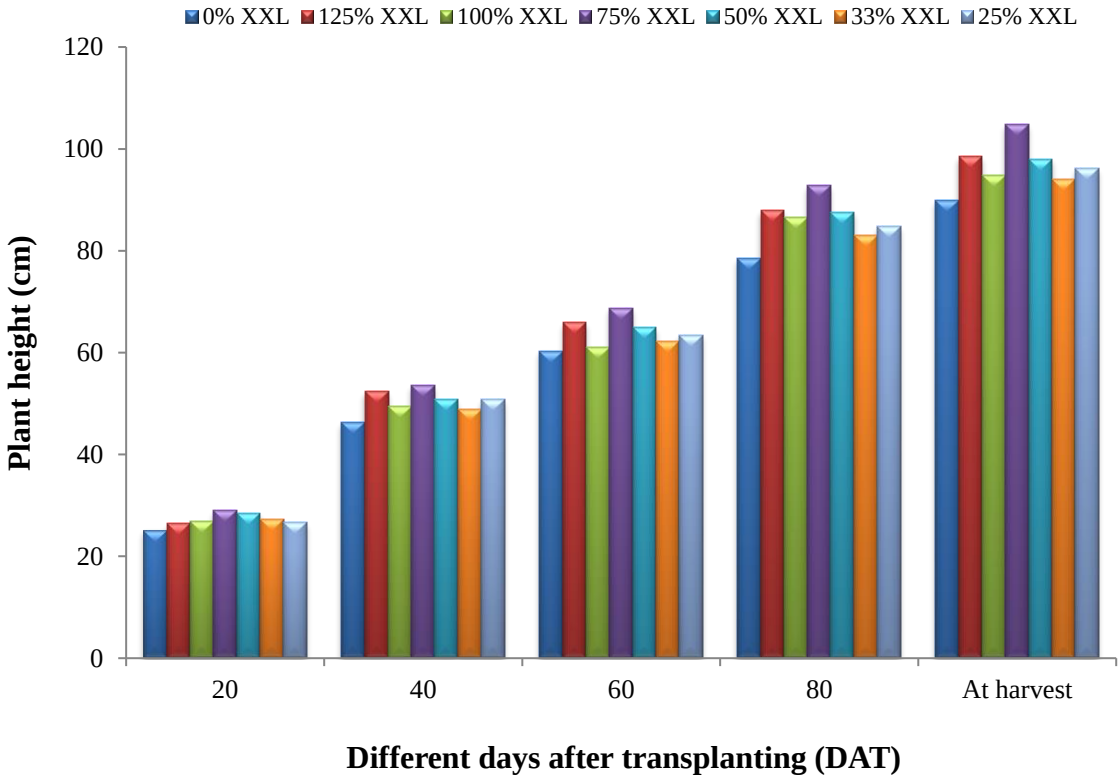

Figure 2. Effect of different concentrations of XXL on the plant height of rice at different days after transplanting (LSD $_{(0.05)}$ = 2.50, 4.27, 6.48, 6.81 and 7.28 at 20, 40, 60, 80 DAT and at harvest, respectively)

Table 1. Interaction effect of variety and XXL on the plant height of rice at different days after transplanting and at harvest

Treatments	Plant height at different days after transplanting (DAT)				
	20	40	60	80	At harvest
BRRI dhan 29 ×					
0% XXL	22.54 f	40.11 e	57.27 c	74.43 e	87.94 d
125% XXL	22.42 f	43.63 de	61.69 bc	78.27 de	95.03 b-d
100% XXL	23.39 f	44.63 de	60.83 c	80.59 de	94.60 b-d
75% XXL	25.55 d-f	46.77 cd	65.72 a-c	86.70 b-d	100.8 a-c
50% XXL	25.53 d-f	44.73 de	63.54 a-c	81.57 c-e	97.42 b-d
33% XXL	24.59 ef	42.30 de	58.60 c	74.87 e	92.10 b-d
25% XXL	24.54 ef	45.77 de	61.68 bc	79.17 de	94.62 b-d
Hybrid dhan Taj-1 ×					
0% XXL	27.84 c-e	52.50 bc	63.32 a-c	82.50 c-e	91.72 cd
125% XXL	30.37 a-c	61.17 a	70.10 ab	97.51 a	102.1 ab
100% XXL	30.22 a-c	54.20 b	61.40 bc	92.56 ab	95.22 b-d
75% XXL	32.47 a	60.37 a	71.72 a	98.94 a	108.7 a
50% XXL	31.43 ab	56.93 ab	66.43 a-c	93.62 ab	98.75 a-c
33% XXL	29.90 a-c	55.37 ab	65.75 a-c	91.00 a-c	96.01 b-d
25% XXL	28.69 b-d	55.80 ab	65.35 a-c	90.46 a-c	97.54 b-d
LSD $_{(0.05)}$	**3.54**	**6.04**	**9.17**	**9.63**	**10.3**
CV (%)	**7.78**	**7.15**	**8.56**	**6.68**	**6.35**

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

4.2 SPAD Value of leaf

SPAD meter reading of leaf was analyzed and presented in order to having an idea about relative leaf chlorophyll content per unit leaf area of the rice varieties. Chlorophyll content was significantly affected by the test rice varieties (Figure 3 and Appendix VI). The highest SPAD value (36.36, 37.87, 32.18 and 31.12) at 40, 60, 80 and 100 DAT, consecutively were obtained from BRRI dhan 29, where the lowest SPAD value (34.11, 33.16, 26.62 and 25.35)at 40, 60, 80 and 100 DAT, consecutively were obtained from Hybrid dhan Taj-1. In non-fertilized soil rice leaf numbers and SPAD values of rice increased but in fertilized soil they did not increase by chitosan application (Chibu *et al.*, 2002). Similar result was found by the Nguyen *et al.* (2011), chitosan oligomer enhanced strongly the content of chlorophylls and carotenoid in the leaves of coffee seedlings up to 46.38–73.51%. Treatment of plants with gibberellic acid (GA_3) (10 ppm) increased the leaf growth and chlorophyll content with a concomitant rise in the activity of cellulose (Prakash and Prathapasenan, 1990).

Analysis of variance indicated that the effect of different concentrations of XXL in rice varieties on relative chlorophyll content of leaf was varied significantly during growth period at 40, 60, 80 DAT except 100 DAT (Figure 4 and Appendix VI). At 40 and 80 DAT the maximum SPAD value (38.92 and 32.04, respectively) were found from 75% XXL. At 60 DAT the maximum SPAD value (37.19) was found from 50% XXL, which was statistically similar to75% XXL (37.05). At 100 DAT the maximum SPAD value (29.16) was found from 125% XXL, which was statistically similar to 33% XXL (28.97) and followed by 25% XXL (28.50) and 75% XXL (28.44), while the minimum SPAD value (33.24, 33.31 and 26.86) at 40, 60 and 100 DAT, respectively were found from control treatment. At 80 DAT the minimum SPAD value (27.64) was found from33% XXL, which was statistically similar to control treatment (27.80). Salachna and Zawadzińska (2014) found that medium and high-molecular-weight chitosan resulted in higher relative chlorophyll content (SPAD) in potted freesia.

Interaction effect of different concentrations of XXL and rice varieties showed significant variation on SPAD value of leaf at 40, 60, 80 and 100 DAT (Table 2 and Appendix VI). The combination of BRRI dhan 29 with 75% XXL showed the maximum SPAD value (39.78, 34.17 and 32.74) at 40, 80 and 100 DAT, respectively but BRRI dhan 29 with 125% XXL showed the highest SPAD value (40.91) at 60 DAT, which was statistically similar to BRRI dhan 29 with 50% XXL(39.68) and followed by 75% XXL (39.03). The minimum SPAD value (32.86, 31.57, 23.87 and 23.43) at 40, 60, 80 and 100 DAT, respectively were obtained from the combination of Hybrid dhan Taj-1 with control treatment.

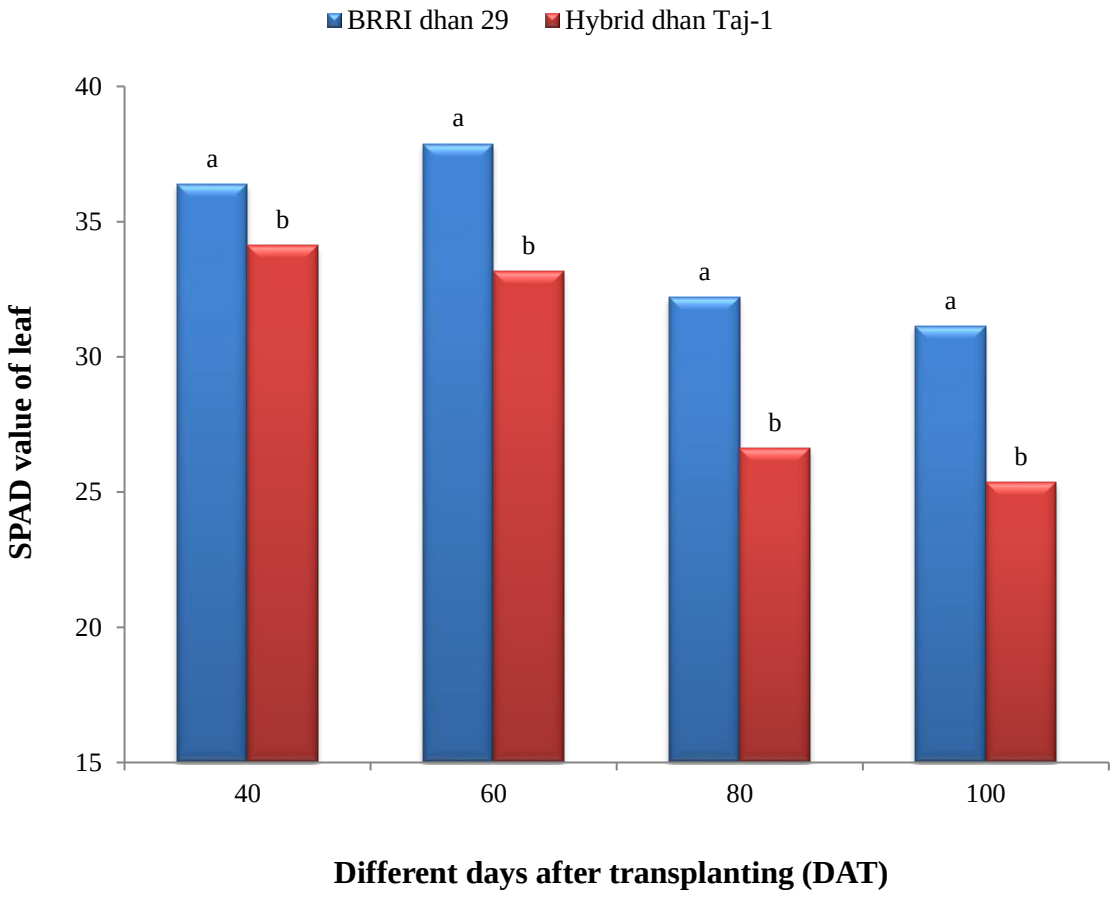

Figure 3. Effect of variety on the SPAD value of rice leaf at different days after transplanting (LSD $_{(0.05)}$ = 1.60, 1.68, 1.46 and 1.39 at 40, 60, 80 and 100 DAT, respectively)

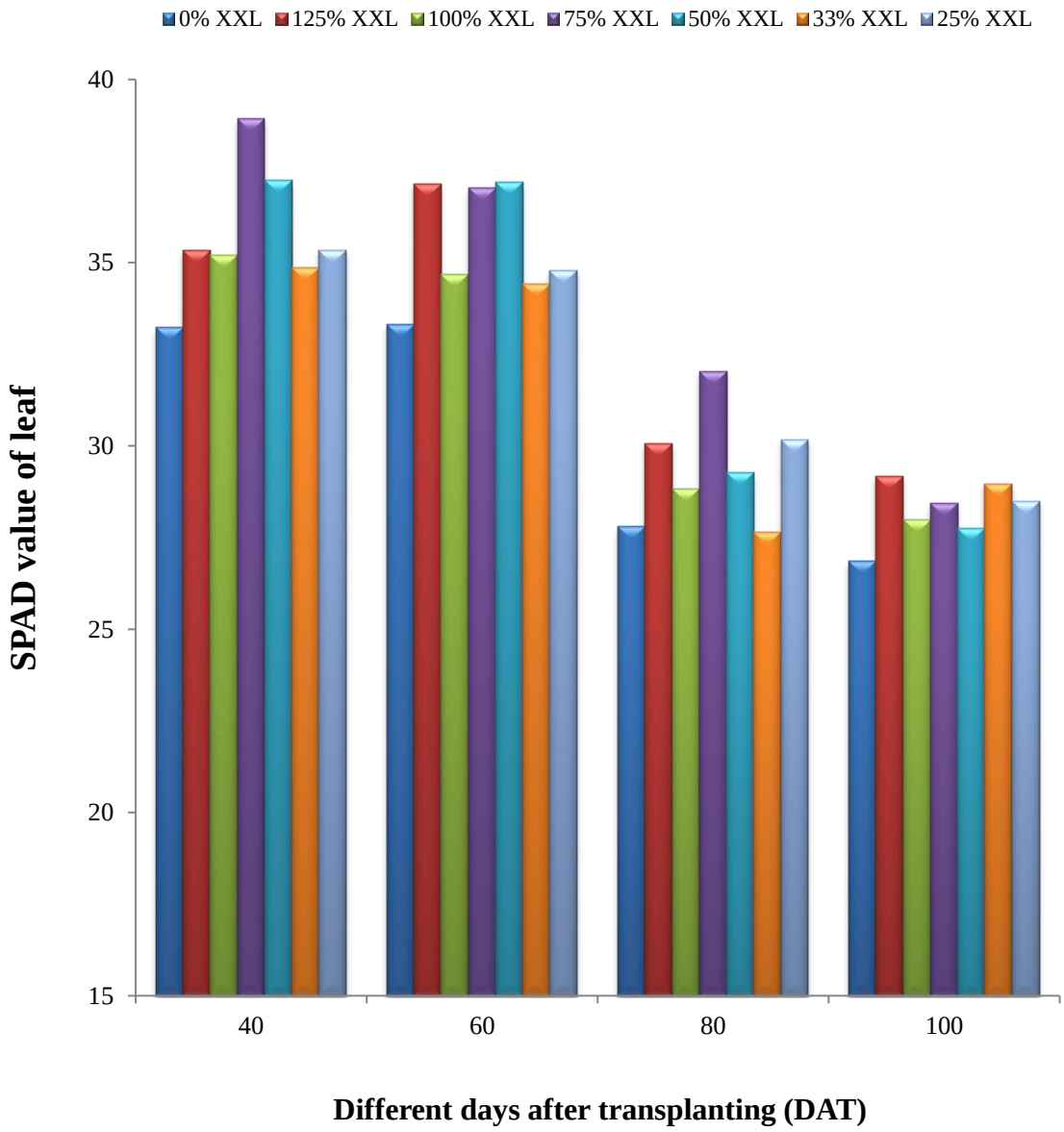

Figure 4. Effect of different concentrations of XXL on the SPAD value of rice leaf at different days after transplanting (LSD $_{(0.05)}$ = 3.03, 3.20, 2.73 and NS at 40, 60, 80 and 100 DAT, respectively)

Table 2. Interaction effect of variety and XXL on the SPAD value of rice leaf at different days after transplanting

Treatments	SPAD value of leaf at different days after transplanting (DAT)			
	40	60	80	100
BRRI dhan 29 ×				
0% XXL	33.61 c	35.05 b-d	31.73 a-d	30.29 ab
125% XXL	36.14 ac	40.91 a	32.01 a-c	32.11 a
100% XXL	35.75 a-c	36.67 a-c	32.96 ab	31.89 ab
75% XXL	39.78 a	39.03 ab	34.17 a	32.74 a
50% XXL	37.92 ab	39.68 a	31.80 a-d	30.66 ab
33% XXL	35.36 bc	36.86 a-c	30.43 a-e	29.59 a-c
25% XXL	35.97 a-c	36.90 a-c	32.16 ab	30.58 ab
Hybrid dhan Taj-1 ×				
0% XXL	32.86 c	31.57 d	23.87 g	23.43 e
125% XXL	34.55 bc	33.42 cd	28.12 d-f	26.22 c-e
100% XXL	34.70 bc	32.68 cd	24.69 fg	24.09 e
75% XXL	38.07 ab	35.06 b-d	29.91 b-e	24.13 e
50% XXL	36.55 a-c	34.71 b-d	26.75 e-g	24.84 de
33% XXL	34.36 bc	32.00 d	24.86 fg	28.34 b-d
25% XXL	34.69 bc	32.68 cd	28.17 c-f	26.42 c-e
LSD $_{(0.05)}$	**4.29**	**4.52**	**3.86**	**3.67**
CV (%)	**7.05**	**7.47**	**7.83**	**7.74**

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

4.3 Number of tillers hill^{-1}

Significant variation was recorded in terms of number of total tillers hill^{-1} for rice varieties at 40, 60 and 80 DAT except 20 DAT (Figure 5 and Appendix VII). At 20, 40, 60 and 80 DAT the maximum number of total tillers hill^{-1} (10.73, 15.33, 13.88 and 11.99, respectively) were recorded from BRRI dhan 29,while the minimum number (10.63, 11.74, 10.9 and 8.92, respectively) were obtained from Hybrid dhan Taj-1. Rice planting in November when the temperature was cool, the vegetative phase was extended by 50 days and the relative tillering rate reached its peak at 40 to 50 days after transplanting. In contrast with planting in July when the temperature was high, the relative tillering rate reached the highest value after transplanting (Kainth and Mehra, 1985). The application of Miyodo by spraying at 45 days after transplanting of rice seedlings that significantly enhanced number of tillers plant^{-1} (Sarwar *et al.*, 2008).

The application of different concentrations of XXL showed statistically significant variations for number of total tillers hill^{-1} at 20, 40, 60 and 80 DAT (Figure 6 and Appendix VII). At 20, 40, 60 and 80 DAT the maximum number of total tillers hill^{-1} (12.93, 12.93, 15.98 and 15.26, respectively) were found from 75% XXL, while the minimum number (8.88, 8.88, 11.25 and 10.05, respectively) were from Control treatment. Awan and Alizai (1989) observed that 100 ppm gibberellic acid (GA_3) and 100 ppm indole acetic acid (IAA) were sprayed at 3 ml plant^{-1} significantly affected tillers plant^{-1}.

The number of total tillers hill^{-1} showed significant variation due to the interaction effect of different concentrations of XXL and rice varietiesat 20, 40, 60 and 80 DAT (Table 3 and Appendix VII). At 20, 40, 60 and 80 DAT the maximum number of total tillers hill^{-1} (13.30, 13.30, 18.20 and 17.42, respectively) were recorded from the combination of BRRI dhan 29 with 75% XXL, which was statistically similar to Hybrid dhan Taj-1 with 75% XXL (12.57 and 12.57) at 20 and 40 DAT, whereas the minimum number of tillers hill^{-1}(8.7, 8.7, 10.03 and 9.27) were recorded at 20, 40, 60 and 80 DAT, respectively from the combination of Hybrid dhan Taj-1 with control treatment.

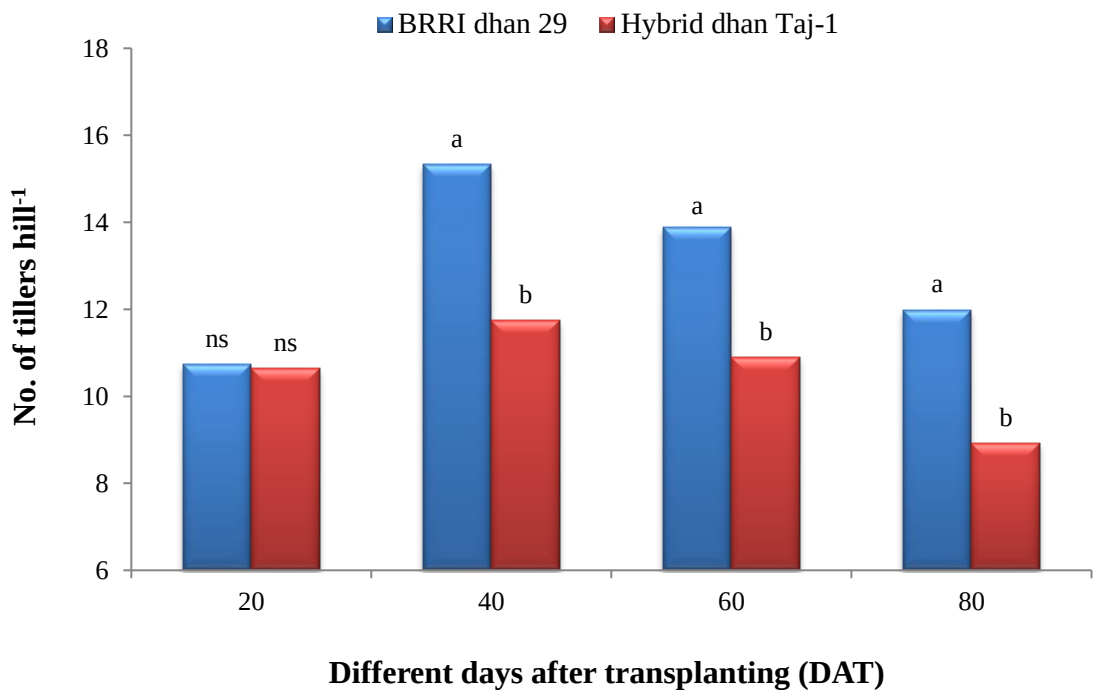

Figure 5. Effect of variety on the number of tillers hill^{-1} of rice at different days after transplanting (LSD (0.05) = NS, 0.63, 0.59 and 0.59 at 20, 40, 60 and 80 DAT, respectively)

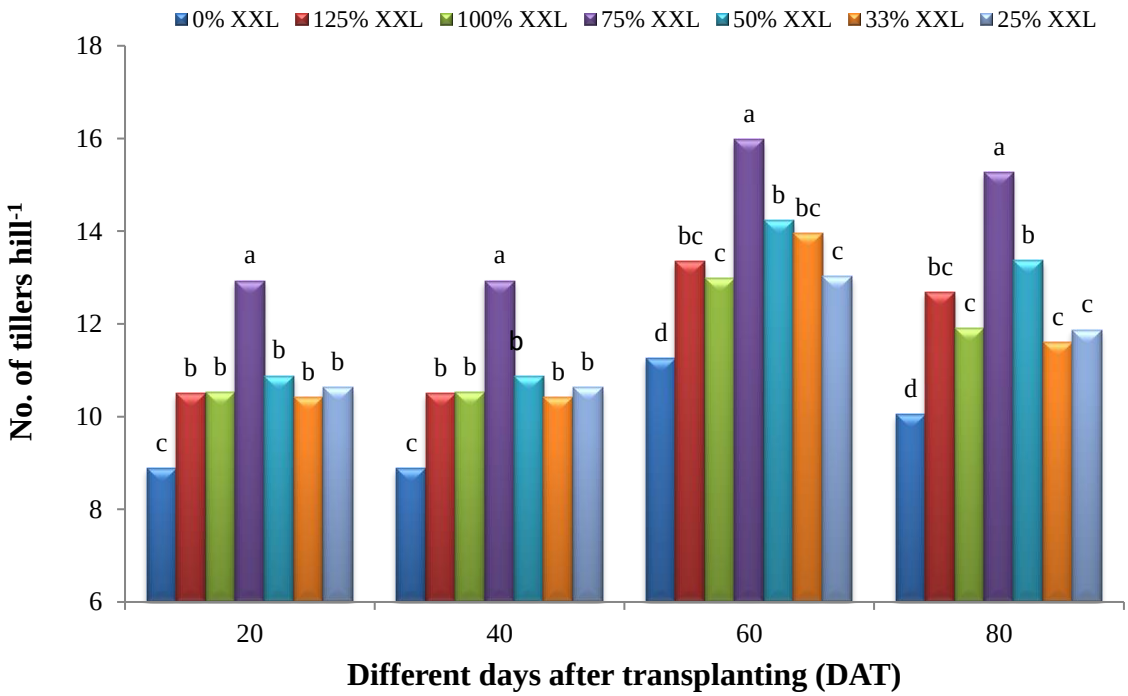

Figure 6. Effect of different concentrations of XXL on the number of tillers hill^{-1} of rice at different days after transplanting (LSD (0.05) = 1.03, 1.17, 1.11 and 1.11 at 20, 40, 60 and 80 DAT, respectively)

Table3. Interaction effect of variety and XXL on the number of tillers hill^{-1} at different days after transplanting of rice

Treatments	No. of tillers at different days after transplanting (DAT)			
	20	40	60	80
BRRI dhan 29 ×				
0% XXL	9.07 ef	9.07 ef	12.47 ef	10.83 de
125% XXL	9.53 d-f	9.53 d-f	14.17 cd	13.23 c
100% XXL	10.33 c-e	10.33 c-f	15.60 bc	13.53 c
75% XXL	13.30 a	13.30 a	18.20 a	17.42 a
50% XXL	11.37 bc	11.37 bc	16.30 b	15.37 b
33% XXL	10.70 cd	10.70 c-e	15.57 bc	13.10 c
25% XXL	10.83 cd	10.83 cd	15.03 b-d	13.67 c
Hybrid dhan Taj-1 ×				
0% XXL	8.700 f	8.70 f	10.03 g	9.267 f
125% XXL	11.47 bc	11.47 bc	12.53 ef	12.13 cd
100% XXL	10.73 cd	10.73 cd	10.37 g	10.27 ef
75% XXL	12.57 ab	12.57 ab	13.77 de	13.10 c
50% XXL	10.40 c-e	10.40 c-e	12.17 f	11.37 de
33% XXL	10.13 c-f	10.13 c-f	12.33 ef	10.10 ef
25% XXL	10.43 c-e	10.43 c-e	11.00 fg	10.07 ef
LSD $_{(0.05)}$	**1.46**	**1.66**	**1.57**	**1.56**
CV (%)	**8.12**	**7.31**	**7.53**	**8.91**

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

4.4 1% booting stage

The varietal effect significantly influenced 1% booting stage of rice (Figure 7 and Appendix VIII). The highest 1% booting stage (67.71 days) was found in the BRRI dhan 29 and the lowest (52.81days) was found in the Hybrid dhan Taj-1. Study referred that the rice variety Hybrid dhan Taj-1 showed best result in terms of 1% booting stage.

Non significant influenced was observed for 1% booting stage of rice due to different concentrations of XXL (Figure 8 and Appendix VIII). The numerically highest 1% booting stage (60.50 days) were found in control, 125%, 50%, 33% and 25% of XXL, respectively while the lowest (59.17 days) was found in 75% XXL.

1% booting stage of rice was significantly influenced by the interaction effect of different concentrations of XXL and rice varieties (Table 4 and Appendix VIII). The highest 1% booting stage (68.67 days) were recorded from the combination of BRRI dhan 29 with 125% XXL, 50% XXL and 33% XXL, respectively which were statistically identical to BRRI dhan 29 with control (67.33 days), 100% XXL (67.33 days) and 25% XXL (67.33 days), whereas the lowest (52.33 days) were recorded from the combination of Hybrid dhan Taj-1 with 125% XXL, 75% XXL, 50% XXL and 33% XXL, respectively which were statistically identical to Hybrid dhan Taj-1 with 100% XXL (53.00 days) and followed by Hybrid dhan Taj-1 with control (53.67 days) and 25% XXL (53.67 days).

4.5 50% booting stage

The varietal effect significantly influenced by 50% booting stage (Figure 7 and Appendix VIII). The highest 50% booting stage (70.19 days) was found in the BRRI dhan 29 and the lowest (55.00 days) was found in the Hybrid dhan Taj-1.Study referred that the rice Hybrid dhan Taj-1 showed best result in terms of 50% booting stage.

Significant variation was observed for 50% booting stage of rice due to different concentrations of XXL (Figure 8 and Appendix VIII). The highest 50% booting stage (63.33 days) was found in control treatment and the lowest (61.33 days) was found in 75% XXL.

50% booting stage of rice significantly influenced by the interaction effect of different concentrations of XXL and rice varieties (Table 4 and Appendix VIII). The highest 50% booting stage (71.33 days) was recorded from the combination of BRRI dhan 29 with control treatment, whereas the lowest (53.33 days) was recorded from the combination of Hybrid dhan Taj-1 with 75% XXL.

4.6 100% booting stage

The varietal effect significantly influenced by 100% booting stage (Figure 7 and Appendix VIII). The highest 100% booting stage (73.95 days) was found in BRRI dhan 29 and the lowest (58.1 days) was found in the variety Hybrid dhan Taj-1.

Significant variation was observed for 100% booting stage of rice due to different concentrations of XXL (Figure 8 and Appendix VIII). The highest 100% booting stage (67.50 days) was found in control treatment, which was statistically identical to 25% XXL (66.83 days) and followed by 33% XXL (66.33 days). On the other hand, the lowest 100% booting stage (64.50 days) was found in 75% XXL.

100% booting stage of rice significantly influenced by the interaction effect of different concentrations of XXL and rice varieties (Table 4 and Appendix VIII). The highest 100% booting stage (76.00 days) was recorded from the combination of BRRI dhan 29 with control treatment, whereas the lowest (56.67 days) was recorded from the combination of Hybrid dhan Taj-1 with 75% XXL.

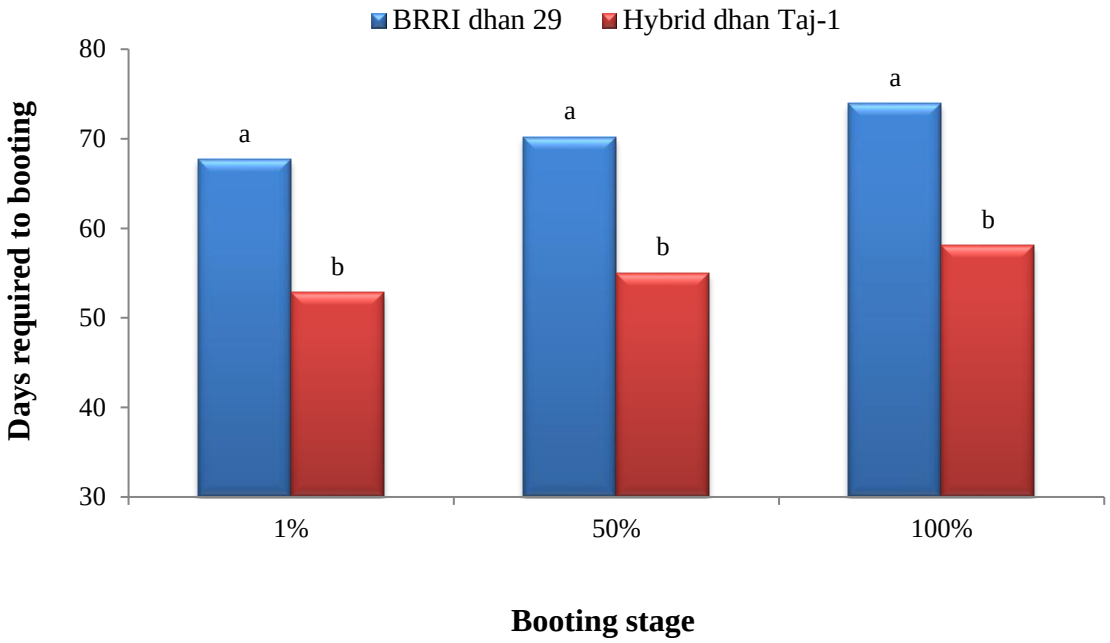

Figure 7. Effect of variety on the days required to booting of rice (LSD $_{(0.05)}$ = 1.24, 0.96 and 1.59 at 1%, 50% and 100% booting, respectively)

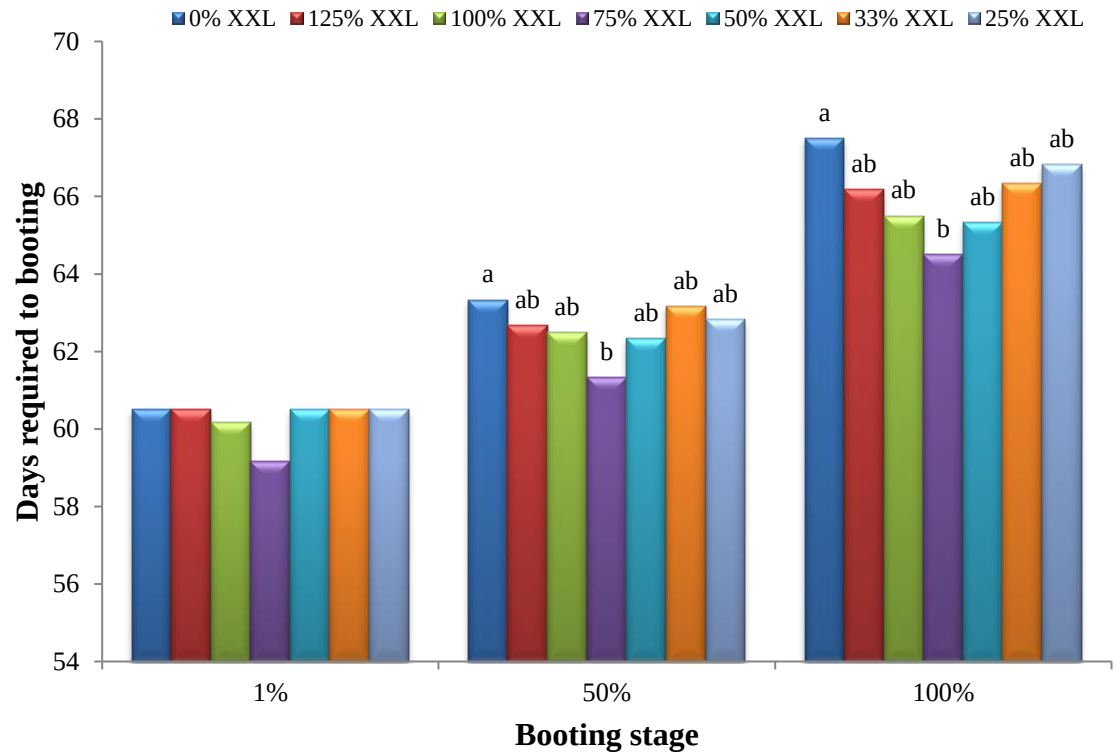

Figure 8. Effect of different concentrations of XXL on the days required to booting of rice (LSD $_{(0.05)}$ = NS, 1.80 and 2.97 at 1%, 50% and 100% booting, respectively)

4.7 1% panicle insertion stage

1% panicle insertion stage significantly influenced by the rice varieties (Figure 9 and Appendix VIII). The highest 1% panicle insertion (75.05 days) was recorded from the BRRI dhan 29, whereas the lowest (59.62 days) was recorded from the Hybrid dhan Taj-1.

1% panicle insertion stage was significantly influenced by the different concentrations of XXL (Figure 10 and Appendix VIII). The control treatment produced highest 1% panicle insertion (70.00 days), which was statistically identical to 33% XXL (67.83 days) and 25% XXL (67.83 days), whereas the lowest (65.17 days) was recorded from 75% XXL, which was statistically identical to 50% XXL (66.33 days).

Interaction effect of different concentrations of XXL and rice varieties significantly influenced the 1% panicle insertion stage (Table 4 and Appendix VIII). It was observed that the highest 1% panicle insertion (78.00 days) was obtained from the combination of BRRI dhan 29 with control treatment, whereas the lowest (57.67 days) was recorded from the combination of Hybrid dhan Taj-1 with 75% XXL.

4.8 50% panicle insertion stage

50% panicle insertion stage significantly influenced by the rice varieties (Figure 9 and Appendix VIII). BRRI dhan 29 produced the highest 50% panicle insertion (82.71 days), whereas the lowest (66.86 days) was recorded from the Hybrid dhan Taj-1.

50% panicle insertion stage significantly influenced by the different concentrations of XXL (Figure 10 and Appendix VIII). The control treatment produced highest 50% panicle insertion (78.67 days), which was statistically identical to 25% XXL (75.17days), whereas the lowest (72.83 days) was recorded from 75% XXL, which was statistically identical to 50% XXL (73.67 days).

Interaction effect of different concentrations of XXL and rice varieties significantly influenced the 50% panicle insertion stage (Table 4 and Appendix VIII). It was observed that the highest 50% panicle insertion (85.67 days) was obtained from the combination of BRRI dhan 29 with control treatment, whereas the lowest (65.00 and 65.00 days) were recorded from the combination of Hybrid dhan Taj-1 with 75% XXL and Hybrid dhan Taj-1 with 125% XXL.

4.9 100% panicle insertion stage

100% panicle insertion stage significantly influenced by the rice varieties (Figure 9 and Appendix VIII). BRRI dhan 29 produced highest 100% panicle insertion (87.24 days), whereas the lowest (77.95 days) was recorded from the Hybrid dhan Taj-1.

100% panicle insertion stage was significantly influenced by the different concentrations of XXL (Figure 10 and Appendix VIII). The control treatment produced the highest 100% panicle insertion (87.50 days), whereas the lowest (77.33 days) was recorded from 75% XXL.

Interaction effect of different concentrations of XXL and rice varieties influenced the 100% panicle insertion stage (Table 4 and Appendix VIII). It was observed that the highest 100% panicle insertion (92.00 days) was obtained from the combination of BRRI dhan 29 with control treatment, whereas the lowest (72.67 days) was recorded from the combination of Hybrid dhan Taj-1 with 75% XXL.

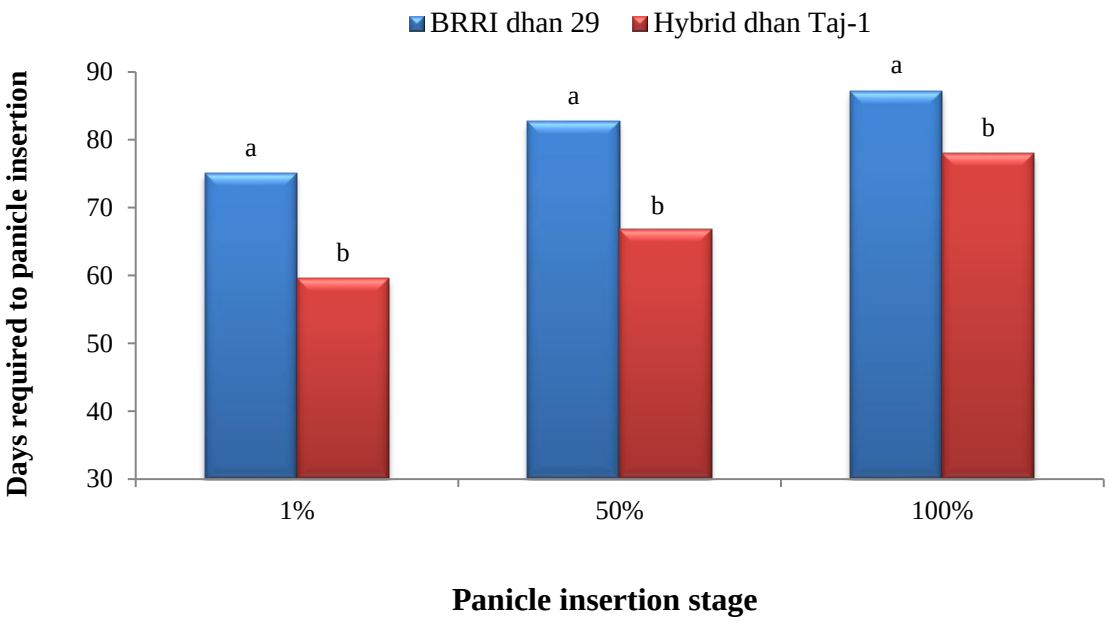

Figure 9. Effect of variety on the days required to panicle insertion of rice (LSD $_{(0.05)}$ = 2.02, 2.26 and 2.29 at 1%, 50% and 100% panicle insertion, respectively)

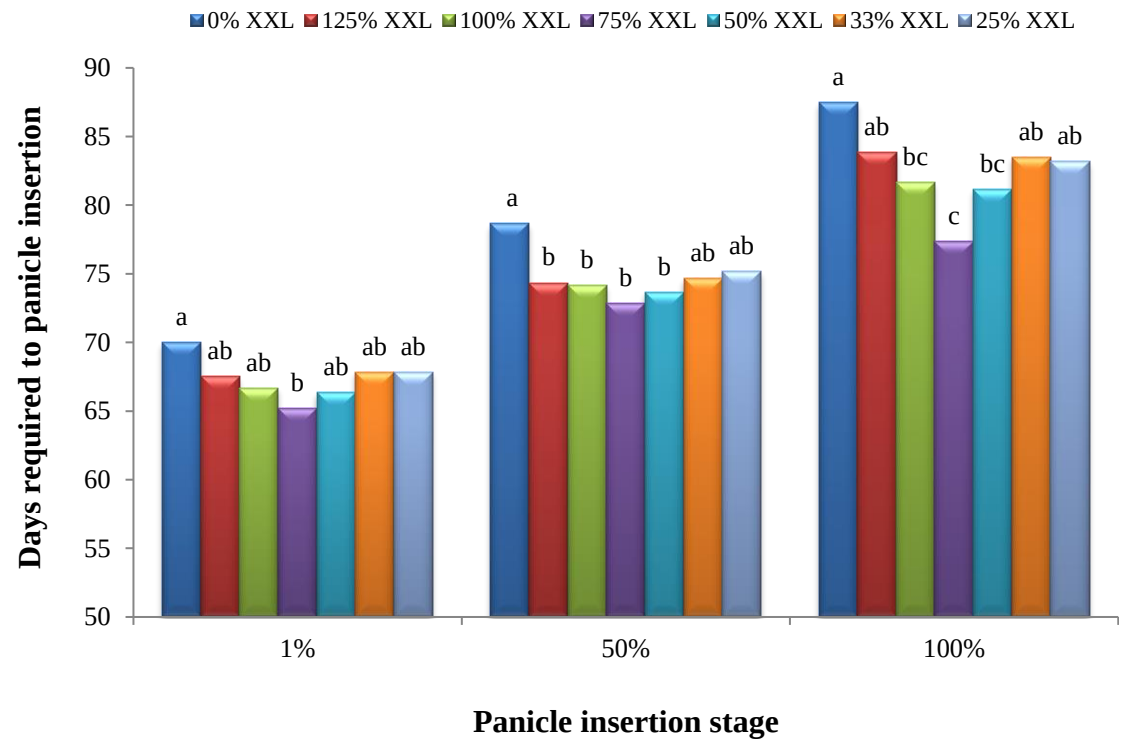

Figure 10. Effect of different concentrations of XXL on the days required to panicle insertion of rice (LSD $_{(0.05)}$ = 3.78, 4.22 and 4.35 at 1%, 50% and 100% panicle insertion, respectively)

Table 4. Interaction effect of variety and XXL on the days required to booting and panicle insertion stages of rice

Treatments	Booting stages (DAT)			Panicle insertion stages (DAT)		
	1% Booting	50% Booting	100% Booting	1% Panicle insertion	50% Panicle insertion	100% Panicle insertion
BRRI dhan 29 ×						
0% XXL	67.33 a	71.33 a	76.00 a	78.00 a	85.67 a	92.00 a
125% XXL	68.67 a	70.67 a	74.67 a	76.00 a	83.67 a	89.67 ab
100% XXL	67.33 a	70.00 a	73.33 a	74.33 a	81.33 a	87.33 a-d
75% XXL	66.00 a	69.33 a	72.33 a	72.67 a	80.67 a	82.00 d-f
50% XXL	68.67 a	69.33 a	72.33 a	73.00 a	81.33 a	85.67 b-d
33% XXL	68.67 a	70.67 a	74.33 a	75.67 a	82.33 a	85.67 b-d
25% XXL	67.33 a	70.00 a	74.67 a	75.67 a	84.00 a	88.33 a-c
Hybrid dhan Taj-1 ×						
0% XXL	53.67 b	55.33 b	59.00 b	62.00 b	71.67 b	83.00 c-e
125% XXL	52.33 b	54.67 b	57.67 b	59.00 b	65.00 c	78.00 e-g
100% XXL	53.00 b	55.00 b	57.67 b	59.00 b	67.00 bc	76.00 fg
75% XXL	52.33 b	53.33 b	56.67 b	57.67 b	65.00 c	72.67 g
50% XXL	52.33 b	55.33 b	58.33 b	59.67 b	66.00 bc	76.67 fg
33% XXL	52.33 b	55.67 b	58.33 b	60.00 b	67.00 bc	81.33 d-f
25% XXL	53.67 b	55.67 b	59.00 b	60.00 b	66.33 bc	78.00 e-g
LSD (0.05)	**3.28**	**2.55**	**4.20**	**5.35**	**5.97**	**6.16**
CV (%)	**3.24**	**2.42**	**3.79**	**4.73**	**4.75**	**4.38**

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

4.10 Leaf area

Leaf area varied significantly for different rice varieties (Figure 11 and Appendix IX). The highest leaf area (27.55 cm^2) was observed from Hybrid dhan Taj-1, while the lowest leaf area (22.58 cm^2) was observed from BRRI dhan 29. Application of Miyodo by spraying at 45 days after transplanting significantly enhanced number of leaves and leaf area, size of flag leaf of plant (Sarwar *et al*., 2008). Similar result was observed by the application of GABA (Khatun *et al*., 2008). Exogenous application of GA_3, 7 days after emergence at 30, 660 or 90 mg L^{-1} significantly increased leaf area and leaf number $plant^{-1}$ (Emongor, 2007).

Statistically significant variation was recorded for leaf area due to the different concentrations of XXL (Figure 12 and Appendix IX). The highest leaf area (29.26 cm^2) was recorded from 75% XXL, which was statistically similar to 50% XXL (27.37 cm^2), while the lowest (19.32 cm^2) was recorded from control treatment. Afroz (2005) reported that GABA had positive regulatory effect on morphological growth and yield characters of *Boro* rice. GABA @ 2 mg L^{-1} was found the best for number of leaves area $hill^{-1}$.

Interaction effect of different concentrations of XXL and rice varieties showed significant variation on leaf area (Table 5 and Appendix IX). The highest leaf area (31.51cm^2) was observed from the combination of Hybrid dhan Taj-1 with 75% XXL, which was statistically similar to Hybrid dhan Taj-1 with 50% XXL (30.57 cm^2), whereas the lowest (17.98 cm^2) was recorded from the combination of BBRI dhan 29 with control treatment.

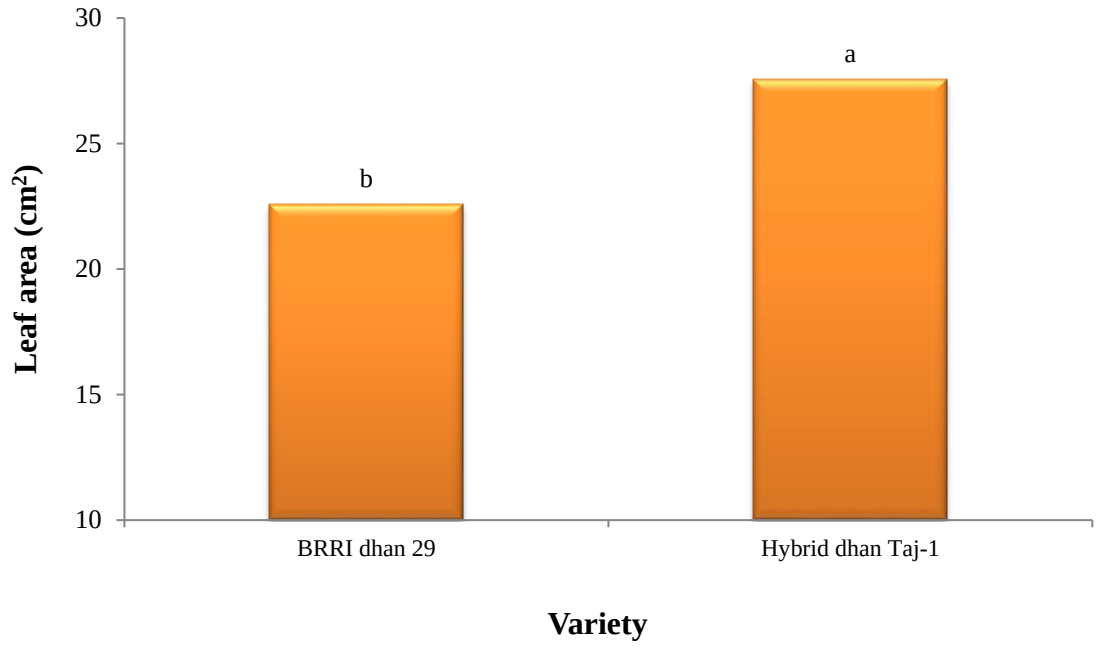

Figure 11. Effect of variety on the leaf area of rice (LSD $_{(0.05)}$ = 1.20)

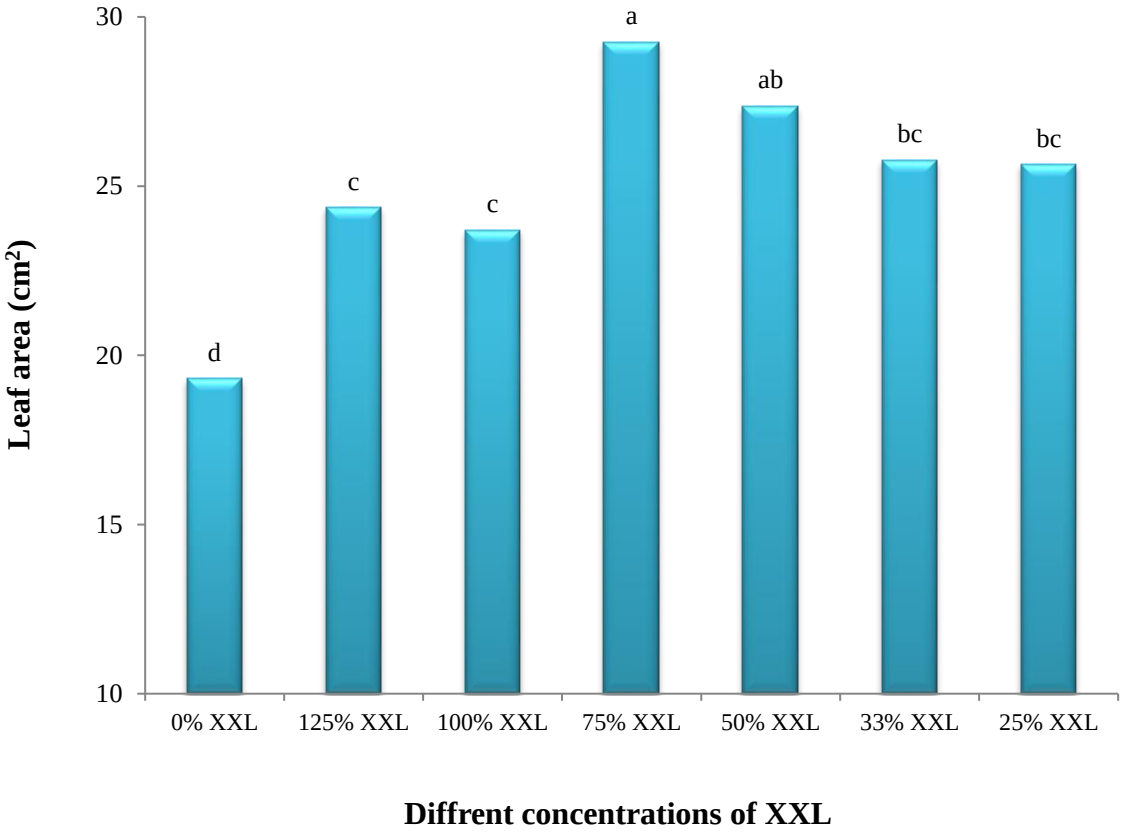

Figure 12. Effect of different concentrations of XXL on leaf area of rice (LSD $_{(0.05)}$ = 2.25)

4.11 1st Days to maturity

1st days to maturity varied significantly for different rice varieties (Figure 13 and Appendix IX). The maximum 1stday to maturity (95.10 days) was recorded from BRRI dhan 29, while the minimum (81.10 days) from Hybrid dhan Taj-1. Similar results also reported by Masum *et al*. (2008); and Chowdhury *et al*. (1993) from their earlier experiment.

Statistically non significant variation was recorded for 1st days to maturity due to different concentrations of XXL (Figure 14 and Appendix IX). The maximum 1st days to maturity (90.17 days) was recorded from control treatment, whereas the minimum (86.33 days) was recorded from 75% XXL.

Interaction effect of different concentrations of XXL and rice varieties showed significant variation on 1st days to maturity (Table 5 and Appendix IX). The maximum 1stdays to maturity (98.00 days) was obtained from the combination of BRRI dhan 29 with control treatment and the minimum (80.00 days) from the combination of Hybrid dhan Taj-1 with 75% XXL.

4.12 Final days to maturity

Final days to maturity varied significantly for different rice varieties (Figure 13 and Appendix IX). The maximum final day to maturity (109.57 days) was found from BRRI dhan 29, while the minimum (96.57 days) from Hybrid dhan Taj-1. Similar results also reported by Masum *et al*. (2008) and Chowdhury *et al*. (1993) from their earlier experiment.

Statistically significant variation was recorded for final days to maturity due to different concentrations of XXL (Figure 14 and Appendix IX). The maximum final days to maturity (105.3 days) was recorded from control treatment, whereas the minimum (100.8 days) was recorded from 75% XXL.

Interaction effect of different concentrations of XXL and rice varieties showed significant variation on final days to maturity (Table 5 and Appendix IX). The maximum final day to maturity (111.7 days) was obtained from the combination of BRRI dhan 29 with control treatment and the minimum (94.33 days) from the combination of Hybrid dhan Taj-1 with 75% XXL.

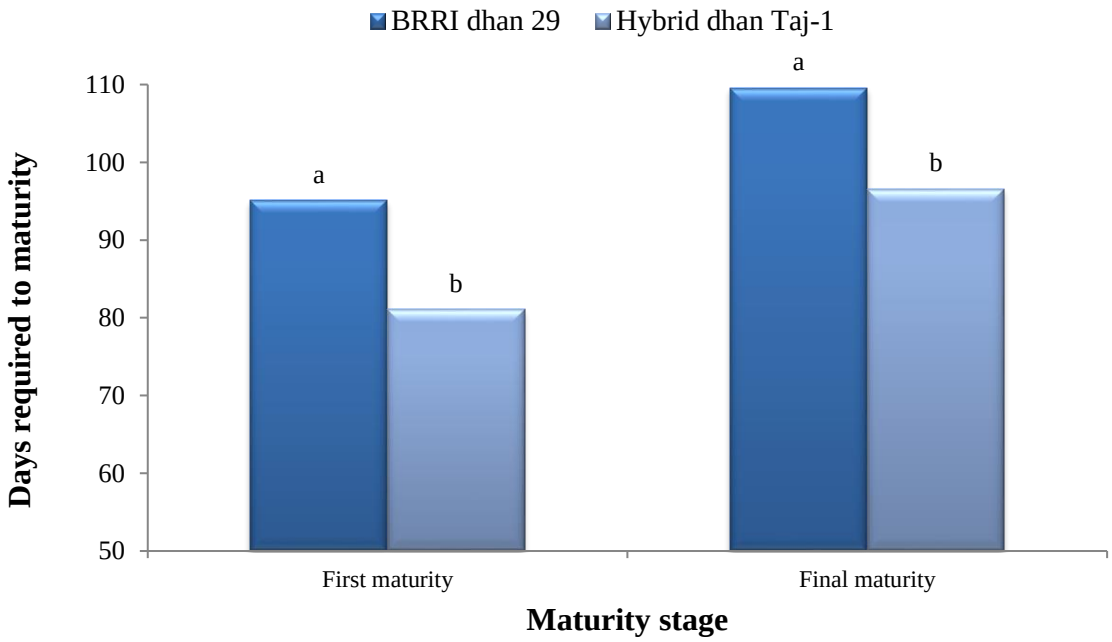

Figure 13. Effect of variety on the days required to maturity of rice (LSD $_{(0.05)}$ = 2.07 and 2.12 at 1st and final maturity, respectively)

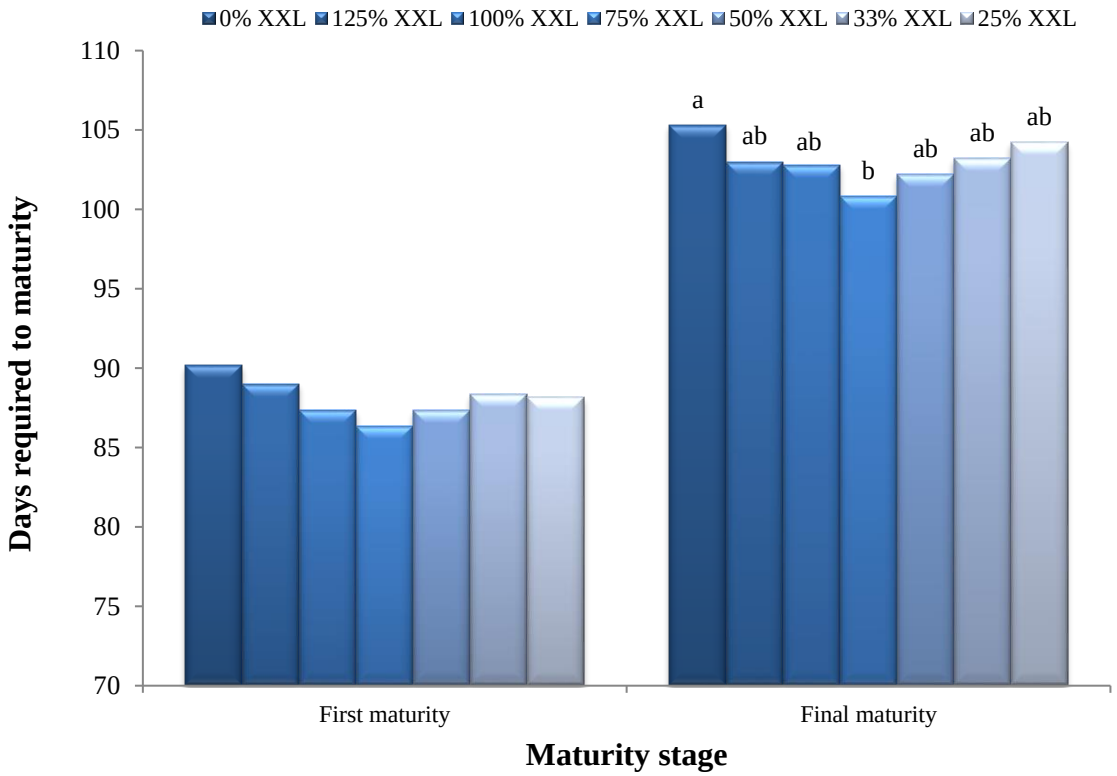

Figure 14. Effect of different concentrations of XXL on the days required to maturity of rice (LSD $_{(0.05)}$ = NS and 3.97 at 1st and final maturity, respectively)

Table 5. Interaction effect of variety and XXL on the leaf area and days required to maturity stages of rice

Treatments	Leaf area (cm^2)	Maturity stages (DAT)	
		First maturity	Finalmaturity
BRRI dhan 29 ×			
0% XXL	17.98 i	98.00 a	111.7 a
125% XXL	19.72 hi	96.67 a	110.3 a
100% XXL	22.52 f-h	94.33 a	109.3 a
75% XXL	27.01 c-e	92.67 a	107.3 a
50% XXL	24.17 ef	93.33 a	108.3 a
33% XXL	23.19 fg	94.67 a	109.3 a
25% XXL	23.49 fg	96.00 a	110.7 a
Hybrid dhan Taj-1 ×			
0% XXL	20.66 g-i	82.33 b	99.00 b
125% XXL	29.04 a-c	81.33 b	95.67 b
100% XXL	24.90 d-f	80.33 b	96.33 b
75% XXL	31.51 a	80.00 b	94.33 b
50% XXL	30.57 ab	81.33 b	96.00 b
33% XXL	28.37 a-c	82.00 b	97.00 b
25% XXL	27.82 b-d	80.33 b	97.67 b
LSD $_{(0.05)}$	**3.18**	**5.47**	**5.62**
CV (%)	**7.57**	**3.70**	**3.25**

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

4.13 Number of fertile tillers hill^{-1}

Significant variation in number of fertile tillers hill^{-1} was observed for both rice varieties (Figure 15 and Appendix X). The BRRI dhan 29 was produced increased number (11.94) of fertile tillers than Hybrid dhan Taj-1 (8.31). Similar report was found by Afroz (2005). GABA had positive regulatory effect on morphological growth and yield characters of *Boro* rice while GABA @ 2 mg L^{-1} was found the best for number of effective tiller hill^{-1}. Khatun *et al.* (2008) found that application of GABA by spaying at 45 days after transplanting significantly enhanced effective tillers.

Significant variation was observed for number of fertile tillers hill $^{-1}$ due to different concentrations of XXL (Figure 16 and Appendix X). The maximum number of fertile tillers hill^{-1} (11.35) was found from 75% XXL, which was statistically similar to 50% XXL (10.85), whereas the minimum number (8.75) was found from control treatment. 75% XXL with normal dose 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. However, more than 75% XXL with fertilizers is harmful or unsuitable to plants for nutrients uptake that's why growth rate and potential was lower than 75% XXL.

Interaction effect of different concentrations of XXL and rice varieties showed significant variation on number of fertile tillers hill^{-1} (Table 6 and Appendix X). The maximum number of fertile tillers hill^{-1} (13.63) was found from the combination of BRRI dhan 29 with 75% XXL, which was statistically similar to BRRI dhan 29 with 50% XXL (12.99), while the minimum number (7.63) was observed from the combination of Hybrid dhan Taj-1 with control treatment.

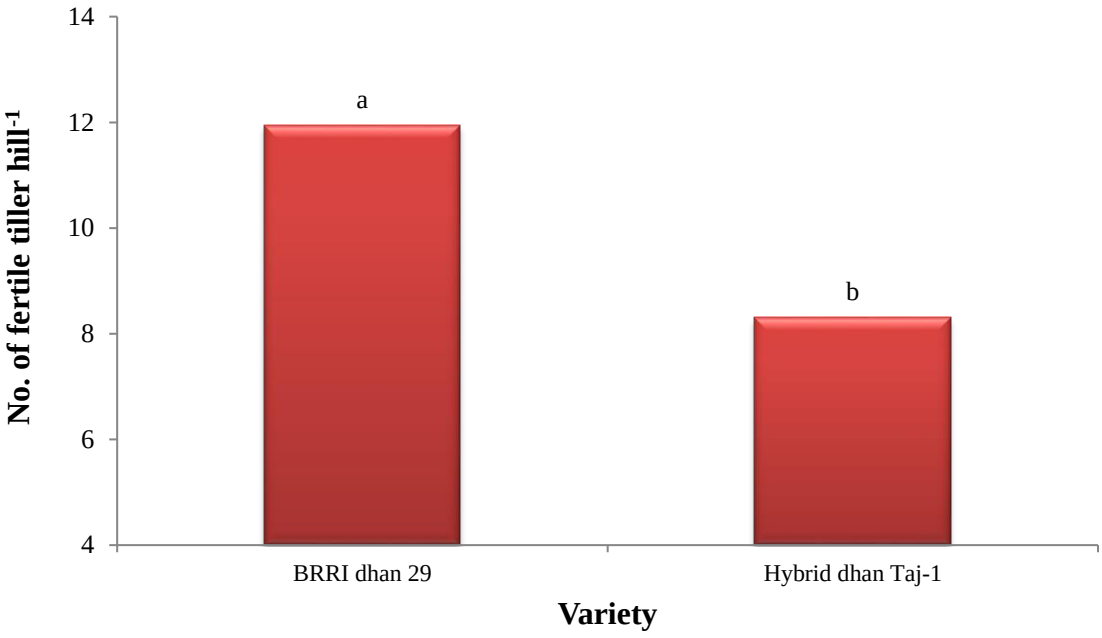

Figure 15. Effect of variety on the number of fertile tillers hill^{-1} of rice (LSD $_{(0.05)}$ = 0.54)

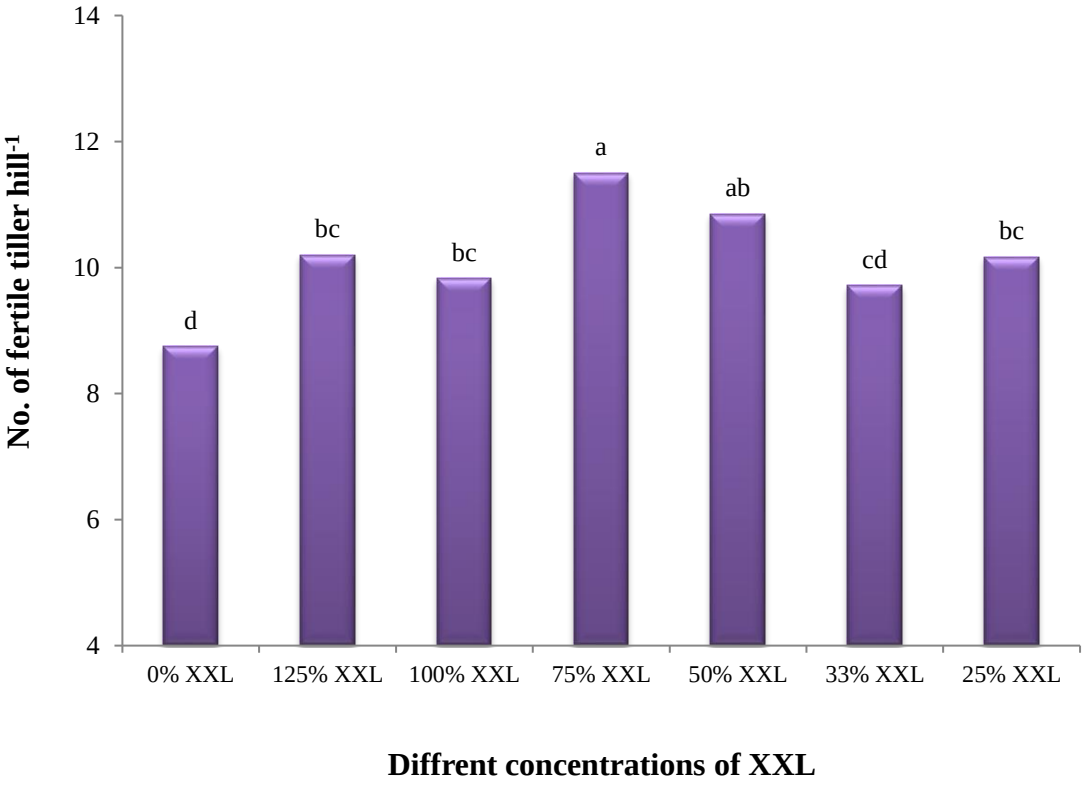

Figure 16. Effect of different concentrations of XXL on the number of fertile tillers hill^{-1} of rice (LSD $_{(0.05)}$ = 1.02)

4.14 Number of sterile tillers hill^{-1}

Number of sterile tillers hill^{-1} varied significantly for different rice varieties (Figure 17 and Appendix X). The minimum number of sterile tillers hill^{-1} (0.53) was found from Hybrid dhan Taj-1, whereas the maximum number (1.02) was obtained from BRRI dhan 29.

Different concentrations of XXL varied significantly for number of sterile tillers hill^{-1} (Figure 18 and Appendix X). The minimum number of sterile tillers hill^{-1} (0.50 and 0.50) was recorded from 75% XXL and 125% XXL, whereas the maximum number (1.42) was from control treatment.

Significant variation was recorded due to interaction effect of different concentrations of XXL and rice varieties in terms of number of sterile tillers hill^{-1} (Table 6 and Appendix X). The minimum number of sterile tillers hill^{-1} (0.37) was found from the combination of Hybrid dhan Taj-1 with 75% XXL, which was statistically similar to Hybrid dhan Taj-1 with 125% XXL(0.43) and 50% XXL(0.43), whereas the maximum number (2.03) was observed from the combination of BRRI dhan 29 with control treatment.

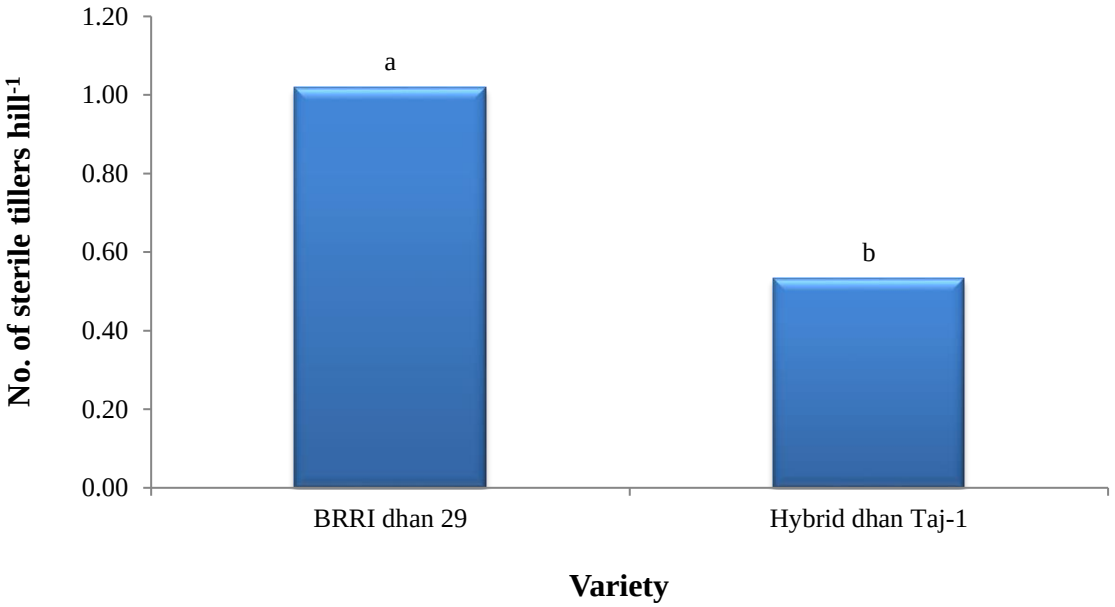

Figure 17. Effect of variety on the number of sterile tillers hill^{-1} of rice (LSD $_{(0.05)}$ = 0.05)

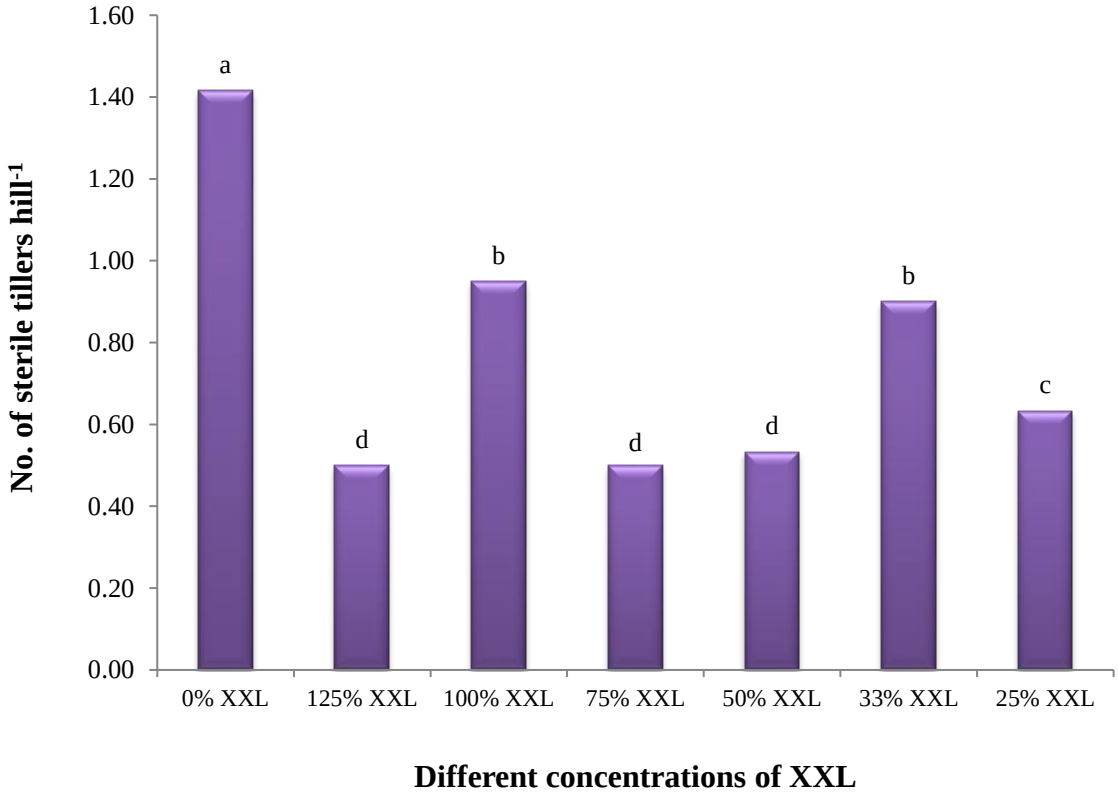

Figure 18. Effect of different concentrations of XXL on the number of sterile tillers hill^{-1} of rice (LSD $_{(0.05)}$ = 0.1)

4.15 Length of panicle

Length of panicle varied significantly for different rice varieties (Figure 19 and Appendix X). The longest panicle (23.95 cm) was observed from BRRI dhan 29, whereas the shortest (23.05 cm) was found from Hybrid dhan Taj-1. Devaraju *et al.* (1998) reported that the increased grain yield of hybrid rice KRH_2 was mainly attributed to the tallest panicle length. Idris and Matin (1990) observed that panicle length differed among varieties and it was greater in IR 20 than in indigenous and high yielding varieties. GA_3 positively increase panicle exertion, duration of floret opening, angle of floret opening and panicle length (Surahman *et al*., 2014).

Statistically significant variation was recorded for length of panicle due to different concentrations of XXL (Figure 20 and Appendix X). The longest panicle (24.26 cm) was found from 75% XXL, which was statistically similar to 125% XXL (23.90 cm) and followed by 50% XXL (23.74 cm), whereas the shortest (22.46 cm) was observed from control treatment. Ahmed (2012) revealed that length of panicle was the noticed from the 50 mg L^{-1} Chitosan treated plants at harvest.

Interaction effect of different concentrations of XXL and rice varieties showed significant variation on length of panicle (Table 6 and Appendix X). The longest panicle (24.62 cm) was observed from the combination of BRRI dhan 29 with 75% XXL, which was statistically similar to BRRI dhan 29 with 50% XXL (24.46 cm), whereas the shortest (22.15 cm) was recorded from the combination of Hybrid dhan Taj-1 with control treatment, which was statistically similar to Hybrid dhan Taj-1 with33% XXL (22.71 cm).

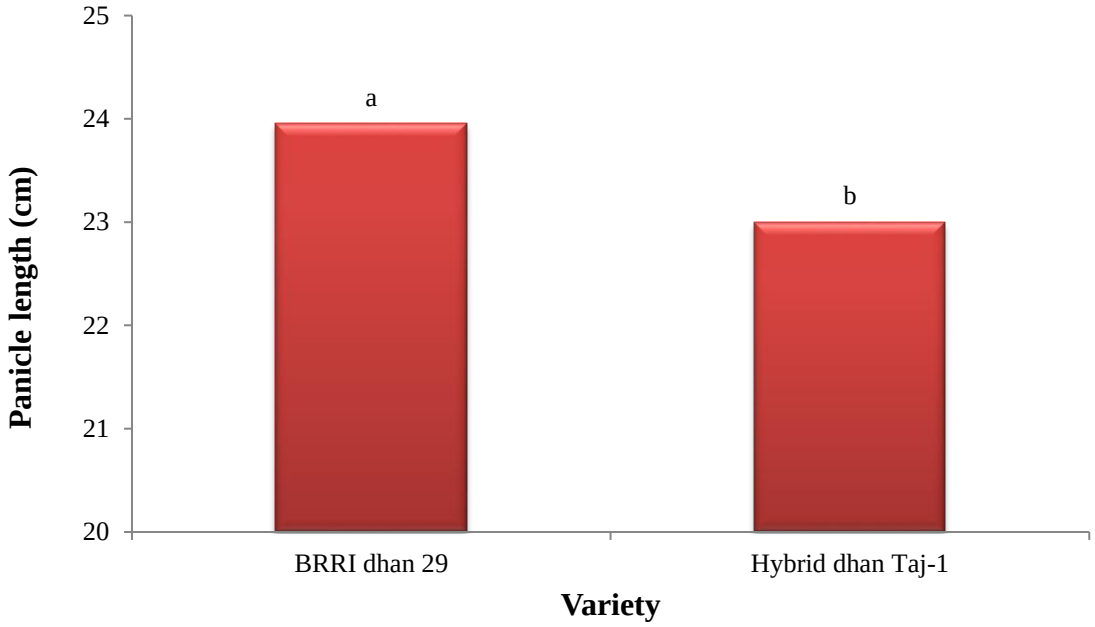

Figure 19. Effect of variety on the panicle length of rice (LSD $_{(0.05)}$ = 0.42)

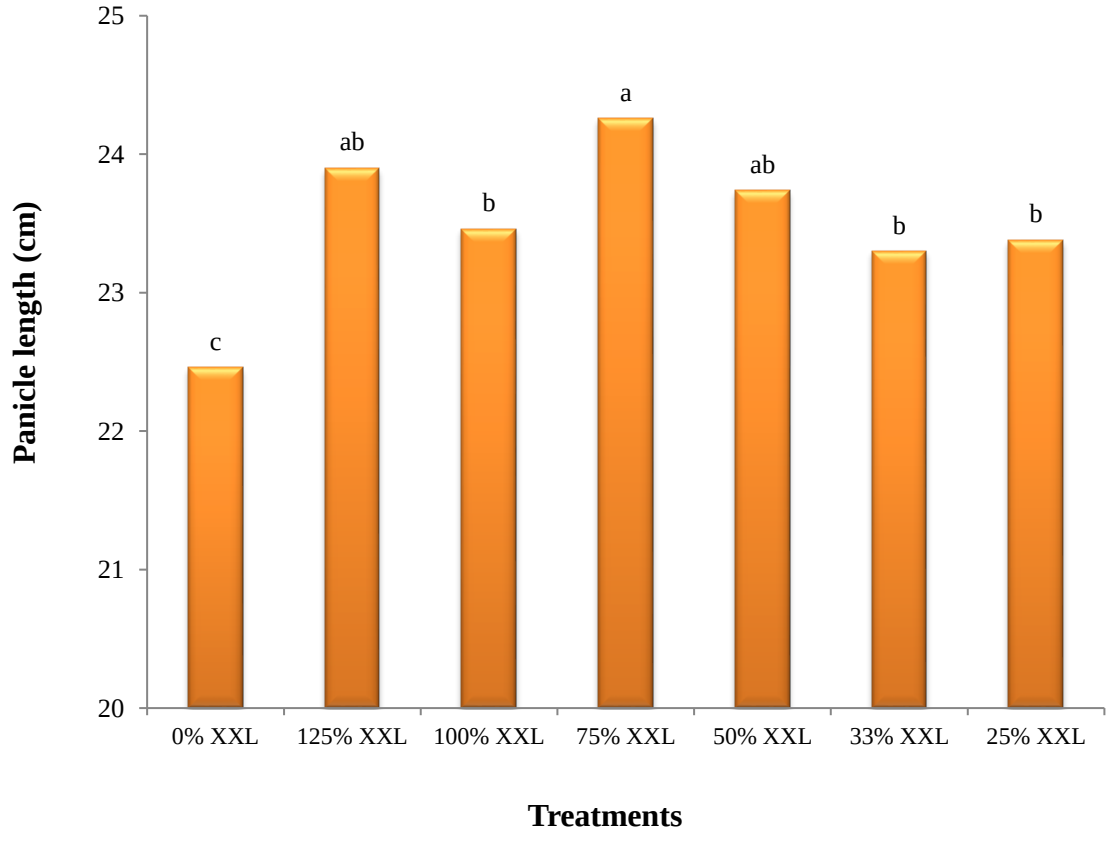

Figure 20. Effect of different concentrations of XXL on the panicle length of rice (LSD $_{(0.05)}$ = 0.79)

4.16 Number of filled grains panicle^{-1}

Filled grains panicle^{-1} varied significantly for different rice varieties (Figure 21 and Appendix X). The highest filled grains panicle^{-1}(125.67) was recorded from Hybrid dhan Taj-1, whereas the lowest (116.06) was found from BRRI dhan 29. Roy and Chudhuri (1981) observed that when the plants were sprayed with 100 μg ml^{-1} aqueous solutions of the hormones at 100 days of GA_3 and IAA increased the grain-filling. Application of Miyodo by spraying after transplanting significantly enhanced number of filled grains (Sarwar *et al.*, 2008).

Statistically significant variation was recorded for filled grains panicle^{-1} due to different concentrations of XXL (Figure 22 and Appendix X). The highest filled grains panicle^{-1} (130.2) was recorded from 75% XXL, whereas the lowest (112.7) was obtained from control treatment.

Interaction effect of different concentrations of XXL and rice varieties showed significant variation on filled grains panicle^{-1} (Table 6 and Appendix X). The highest filled grains panicle^{-1} (133.1) was recorded from the combination of Hybrid dhan Taj-1 with 75% XXL, which was statistically similar to Hybrid dhan Taj-1 with 125% XXL (132.1) and followed by 50% XXL (128.4), while the lowest (108.5) was found from the combination of BRRI dhan 29 with control, which was statistically similar to BRRI dhan 29 with 125% XXL (110.1).

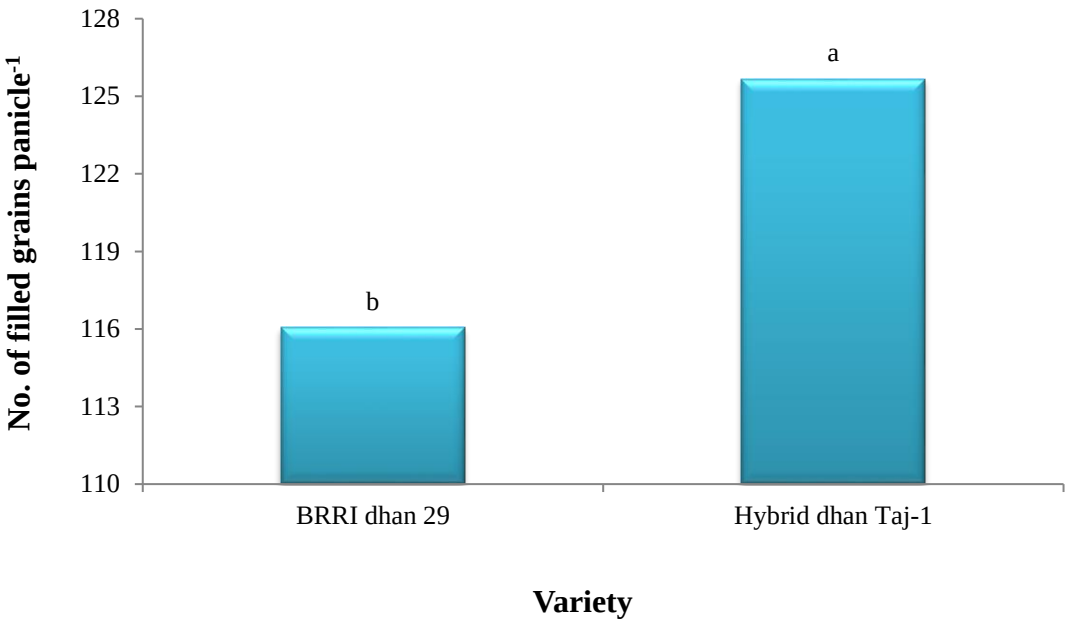

Figure 21. Effect of variety on the number of filled grains panicle^{-1} of rice (LSD $_{(0.05)}$ = 5.73)

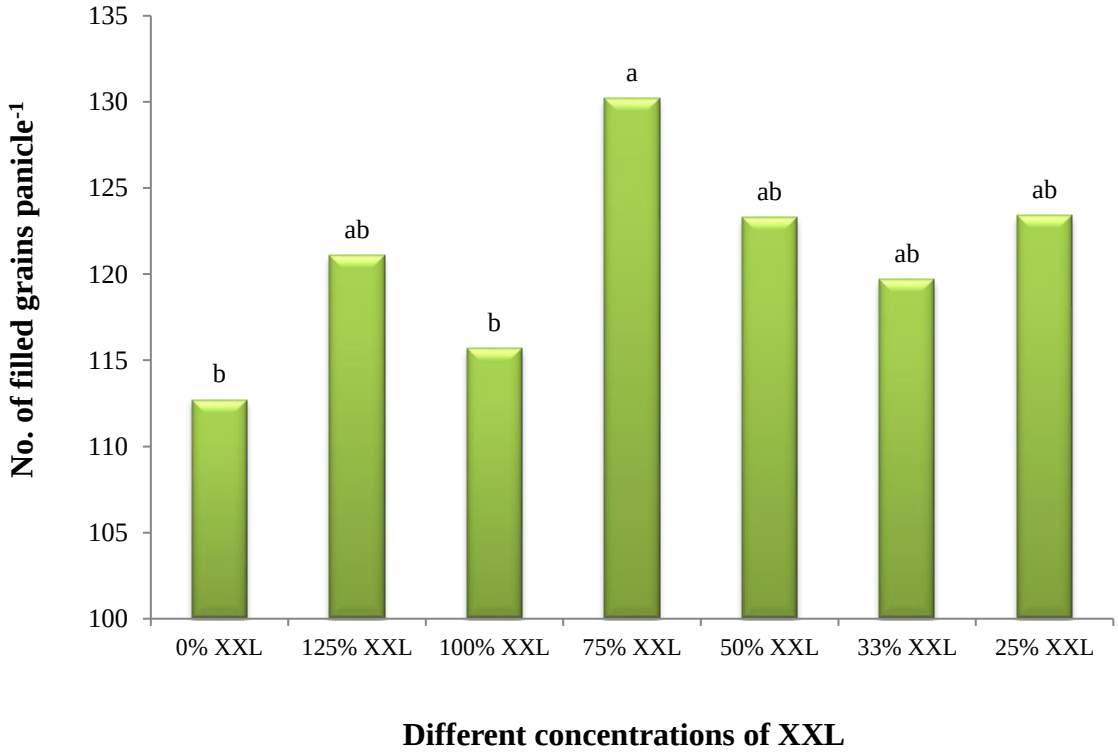

Figure 22. Effect of different concentrations of XXL on the number of filled grains panicle^{-1} of rice (LSD $_{(0.05)}$ = 10.72)

4.17 Number of unfilled grains panicle^{-1}

Unfilled grains panicle^{-1} varied significantly for different rice varieties (Figure 23 and Appendix X). The highest unfilled grains panicle^{-1}(25.16) was recorded from BRRI dhan 29, whereas the lowest (13.50) was found from Hybrid dhan Taj-1. Similar observation was found by the Boonlertnirun *et al*. (2006); application of polymeric chitosan followed by four foliar sprayings throughout cropping season significantly decreased the unfilled grains.

Statistically significant variation was recorded for unfilled grains panicle^{-1} due to different concentrations of XXL (Figure 24 and Appendix X). The highest unfilled grains panicle^{-1} (23.44) was recorded from control treatment, whereas the lowest (15.14) was obtained from 75% XXL.

Interaction effect of different concentrations of XXL and rice varieties showed significant variation on unfilled grains panicle^{-1} (Table 6 and Appendix X). The highest unfilled grains panicle^{-1} (28.55) was recorded from the combination of BRRI dhan 29 with control treatment, which was statistically similar to BRRI dhan 29 with125% XXL(27.59) and followed by 33% XXL (27.46), while the lowest (10.59) was found from the combination of Hybrid dhan Taj-1 with 75% XXL.

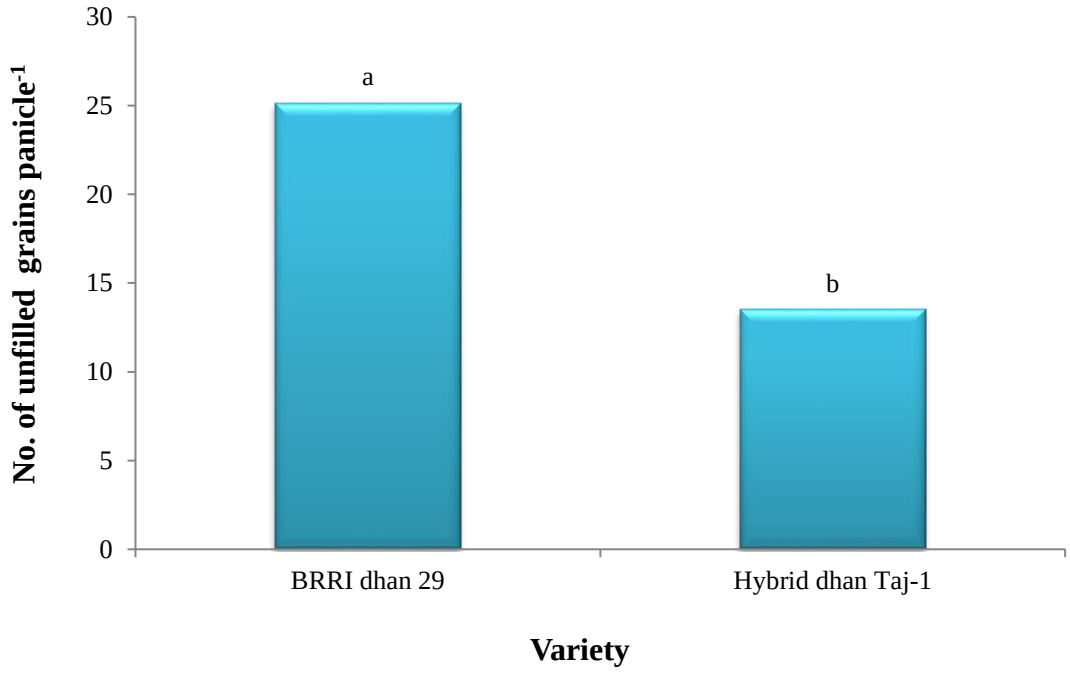

Figure 23. Effect of variety on the number of unfilled grains panicle^{-1} of rice (LSD $_{(0.05)}$ = 1.15)

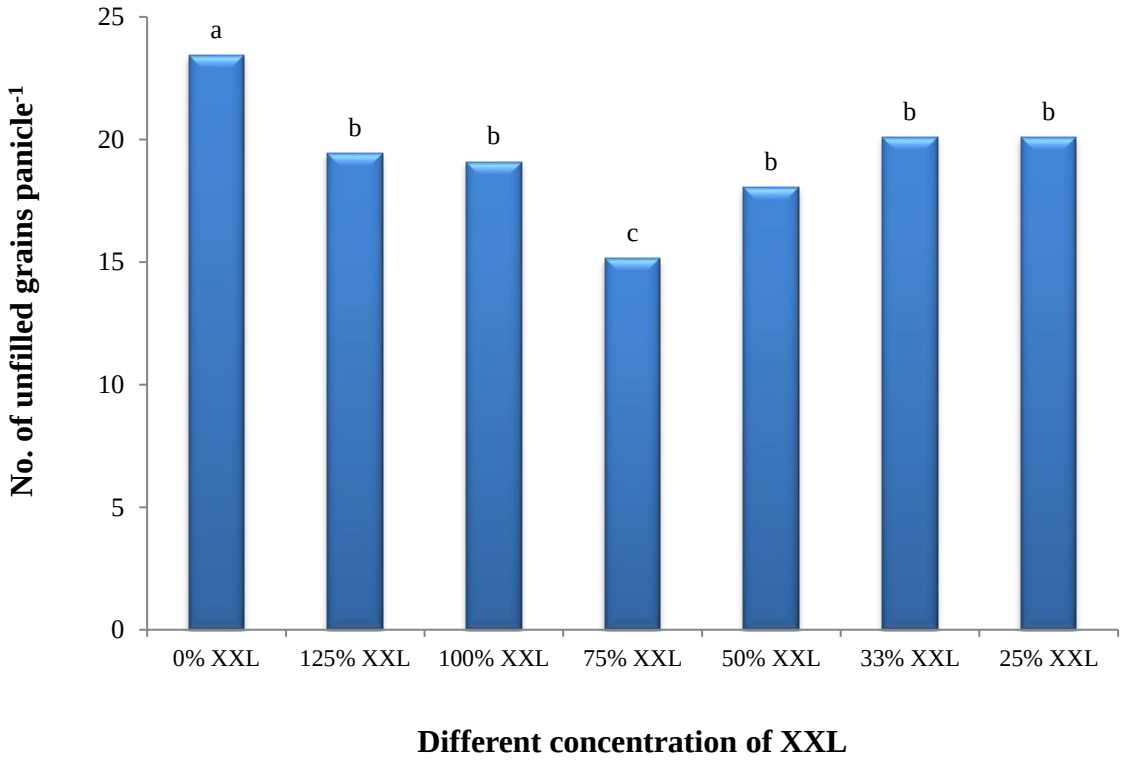

Figure 24. Effect of different concentrations of XXL on the number of unfilled grains panicle^{-1} of rice (LSD $_{(0.05)}$ = 2.16)

Table 6. Interaction effect of variety and XXL on yield contributing characters of rice

Treatments	Fertile tillers hill^{-1} (no.)	Sterile tillers hill^{-1} (no.)	Panicle length (cm)	Filled grains panicle^{-1}(no.)	Unfilled grains panicle^{-1} (no.)
BRRI dhan 29 ×					
0% XXL	9.87 d	2.03 a	22.77 de	108.5 d	28.55 a
125% XXL	11.67 bc	0.57 e-g	24.07 ab	110.1 cd	27.59 a
100% XXL	11.83 bc	1.20 b	23.93 a-c	114.5 b-d	23.67 b
75% XXL	13.63 a	0.63 d-f	24.62 a	127.3 ab	19.70 c
50% XXL	12.99 ab	0.63 d-f	24.46 a	118.1 a-d	23.30 b
33% XXL	11.40 c	1.33 b	23.89 a-c	114.7 b-d	27.46 a
25% XXL	12.20 a-c	0.73 cd	23.91 a-c	119.1 a-d	25.86 ab
Hybrid dhan Taj-1 ×					
0% XXL	7.63 e	0.80 c	22.15 e	116.9 b-d	18.33 c
125% XXL	8.73 de	0.43 gh	23.73 a-d	132.1 a	11.24 e
100% XXL	7.83 e	0.70 c-e	23.00 b-e	116.9 b-d	14.49 d
75% XXL	9.07 de	0.37 h	23.90 a-c	133.1 a	10.59 e
50% XXL	8.70 de	0.43 gh	23.03 b-e	128.4 ab	12.79 de
33% XXL	8.03 e	0.47 gh	22.71 de	124.7 a-c	12.71 de
25% XXL	8.13 e	0.53 fg	22.85 c-e	127.6 ab	14.33 d
LSD $_{(0.05)}$	**1.44**	**0.14**	**1.11**	**15.16**	**3.05**
CV (%)	**8.46**	**11.01**	**2.82**	**7.47**	**9.42**

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

4.18 Moisture content of grains

Moisture content of grains varied significantly for different rice varieties (Appendix IX). The highest moisture content of grains (17.81%) was recorded from Hybrid dhan Taj-1, whereas the lowest (16.27%) was found from BRRI dhan 29.

Statistically non significant variation was recorded for moisture content of grains due to different concentrations of XXL (Appendix IX). The highest moisture content of grains (17.20%) was recorded from 125% XXL, whereas the lowest (16.87%) was obtained from 33% XXL.

Interaction effect of different level of XXL concentration and rice varieties showed significant variation on moisture content of grains (Appendix IX). The highest moisture content of grains (18.00%) was recorded from the combination of Hybrid dhan Taj-1 with 100% XXL, while the lowest (16.10%) was found from the combination of BRRI dhan 29 with 33% XXL.

4.19 Shoot dry matter content hill^{-1}

Shoot dry matter content hill^{-1} varied significantly for different rice varieties (Figure 25 and Appendix XI). The highest shoot dry matter content hill^{-1} (21.59 g) was obtained from BRRI dhan 29. On the other hand, the lowest shoot dry matter content hill^{-1} (19.36 g) was found from Hybrid dhan Taj-1. Similar results also reported by Amin *et al*. (2006) and Son *et al*. (1998) from their earlier experiment in rice. Guan *et al.* (2009) reported that Chitosan application increased shoot dry weight in maize plants. ABA, BA and CCC treatment caused a substantial increase in shoots dry weight (Gurmani *et al.*, 2006).

Statistically significant variation was recorded for shoot dry matter content hill^{-1} due to different concentrations of XXL (Figure 26 and Appendix XI). The highest shoot dry matter content hill^{-1} (22.72 g) was found from 75% XXL, which was statistically similar to 50% XXL (21.30 g), whereas the lowest (18.66 g) was recorded from control treatment, which was statistically similar to 33% XXL (19.57g) and followed by 100% XXL (19.93 g).

Interaction effect of different concentrations of XXL and rice varieties showed significant variation on shoot dry matter content hill^{-1} (Table 7 and Appendix XI). The highest shoot dry matter content hill^{-1} (24.45 g) was found from the combination of BRRI dhan 29 with 75% XXL, which was statistically similar to BRRI dhan 29 with 50% XXL (23.23 g), whereas the lowest (17.35 g) was observed from the combination of Hybrid dhan Taj-1 with control treatment.

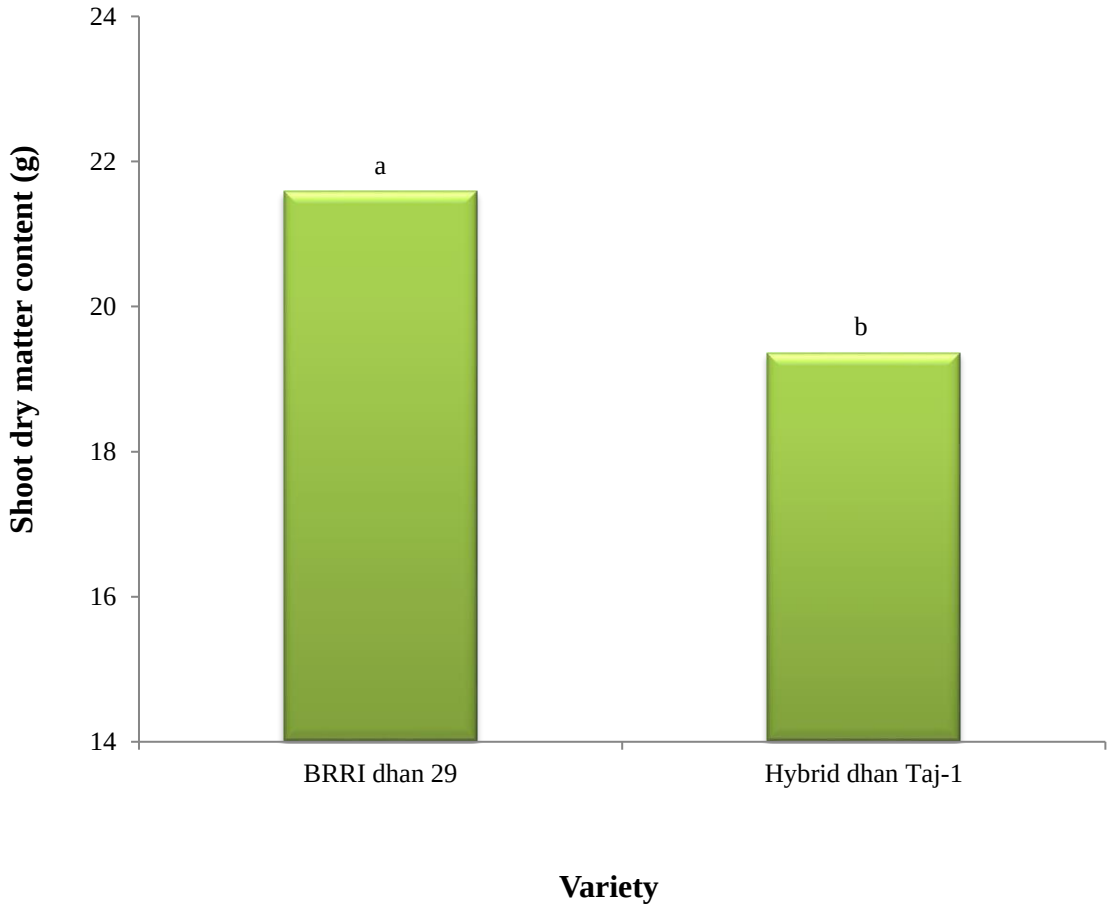

Figure 25. Effect of variety on the shoot dry matter content of rice (LSD $_{(0.05)}$ = 1.12)

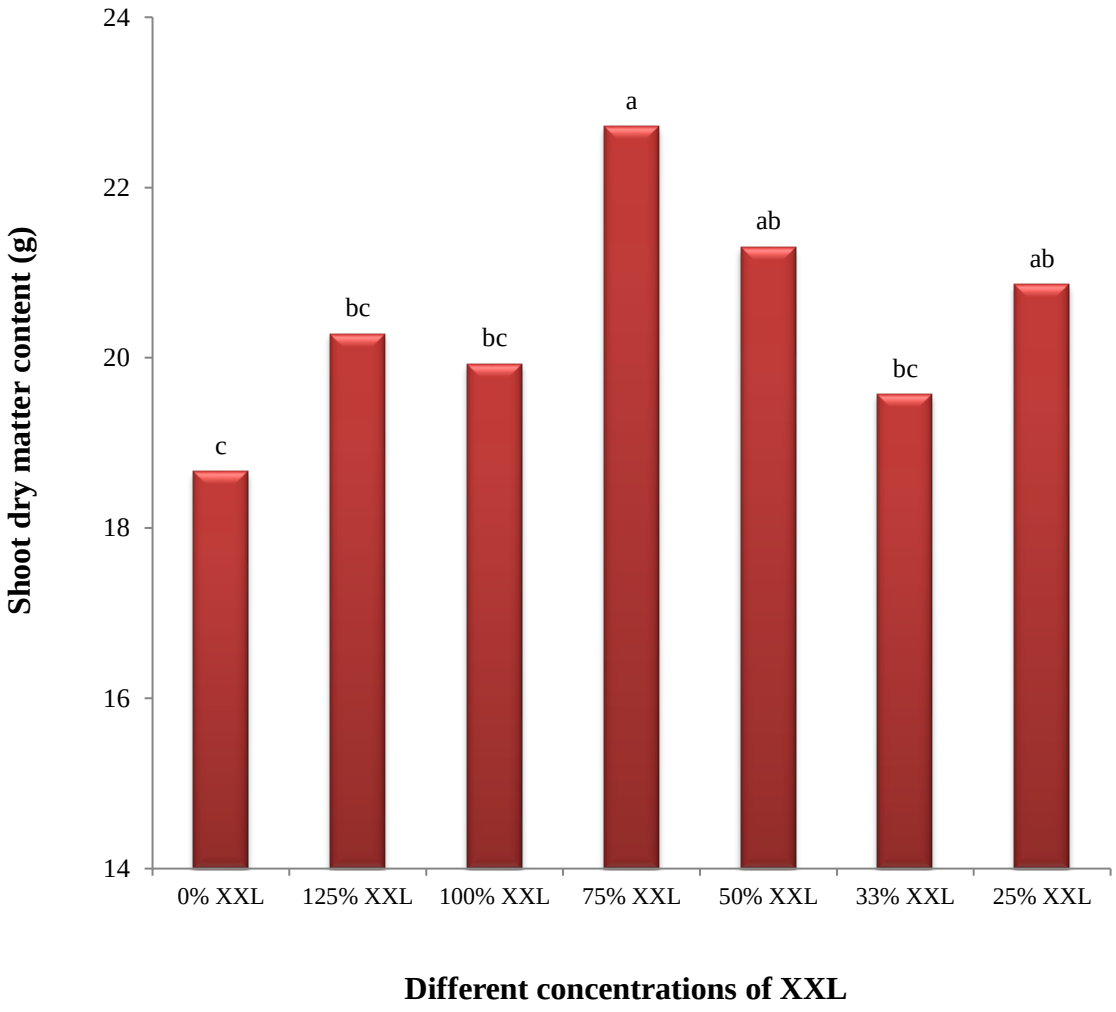

Figure 26. Effect of different concentrations of XXL on the shoot dry matter content of rice (LSD $_{(0.05)}$ = 2.09)

4.20 Thousand grains weight

Varietal effect did not significantly influence 1000 grains weight of rice (Figure 27 and Appendix XI). The maximum 1000 grains weight (23.57 g) was found from the BRRI dhan 29. On the other hand, the minimum 1000 grains weight (23.32 g) was found from the Hybrid dhan Taj-1. The thousand-grain weight of superior spikelet's was enhanced by exogenous application of ABA, GA and PR_1, respectively; the thousand-grain weight of inferior spikelet's was enhanced by exogenous application of ABA, GA and PR_1, respectively (Du*et al.*, 2010).

Different concentrations of XXL non-significantly influenced 1000 grains weight of rice (Figure 28 and Appendix XI). The maximum 1000 grains weight (23.75 g) was found in 50% XXL. On the other hand, the minimum 1000 grains weight (23.23 g) was found in 100% XXL.

1000 grains weight did not significantly influence by the interaction effect of different concentrations of XXL and rice varieties (Table 7 and Appendix XI). The maximum 1000 grains weight (23.89 g) was recorded from the combination of BRRI dhan 29 with 75% XXL. On the other hand, the minimum 1000 grains weight (23.12 g) was recorded from the combination of Hybrid dhan Taj-1 with 25% XXL.

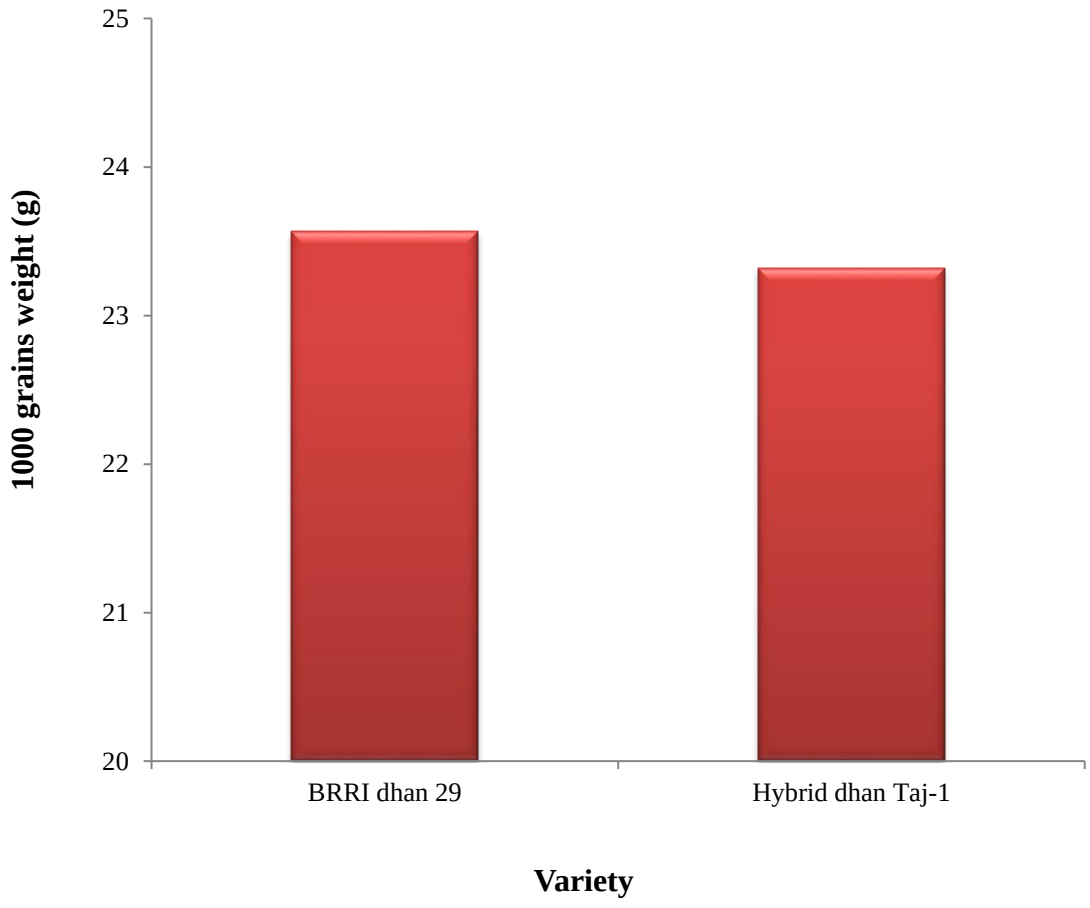

Figure 27. Effect of variety on the 1000 grains weight of rice (LSD $_{(0.05)}$ = Ns)

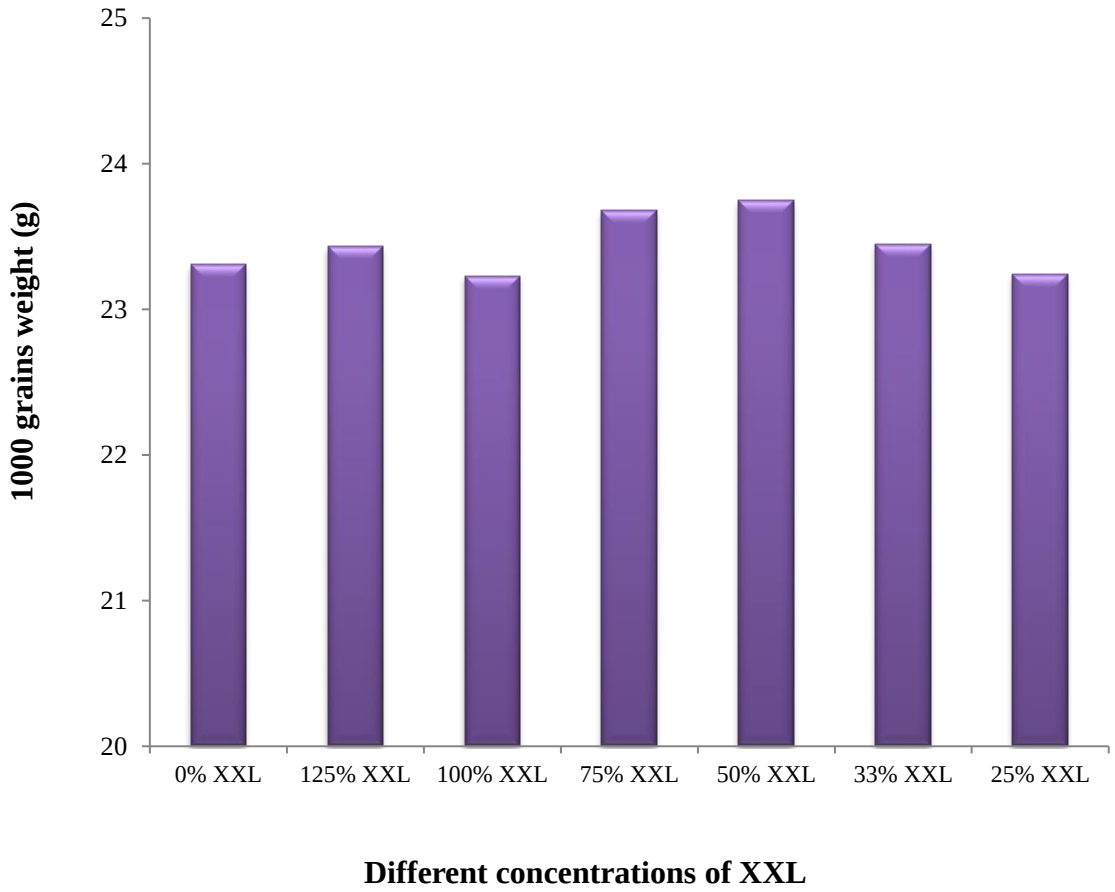

Figure 28. Effect of different concentrations of XXL on the 1000 grains weight of rice ($LSD_{(0.05)}$ = Ns)

4.21 Grain yield (t ha^{-1})

Grain yield varied significantly for different rice varieties (Figure 29 and Appendix XI). The highest grain yield (9.92 t ha^{-1}) was observed from BRRI dhan 29, whereas the lowest (9.09 t ha^{-1}) was observed from Hybrid dhan Taj-1. The exogenous application of various plant growth hormones (GA_3) significantly increased grain yield of rice (Chaubey and Srivastava, 2014). All kinds of external phytohormones could delay leaves senescence, increase the seed setting rate, and increase the grain yield (Zhang *et al.*, 2007). Yeh *et al.* (2015) observed that Cytokinins are plant-specific hormones that affect plant growth and development and produce more grains per plant of rice.

Statistically significant variation was recorded for grain yield due to different concentrations of XXL (Figure 30 and Appendix XI). The highest grain yield (10.58 t ha^{-1}) was observed from 75% XXL, which was statistically similar to 50% XXL (10.15 t ha^{-1}), whereas the lowest (8.23 t ha^{-1}) was recorded from control treatment. 75% XXL with normal dose 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. However, more than 75% XXL with fertilizers is harmful or unsuitable to plants for nutrients uptake that's why growth rate and potential was lower than 75% XXL.

Interaction effect of different concentrations of XXL and rice varieties showed significant variation on grain yield (Table 7 and Appendix XI). The highest grain yield (11.09 t ha^{-1}) was found from the combination of BRRI dhan 29 with 75% XXL, which was statistically similar to BRRI dhan 29 with 50% XXL(10.47 t ha^{-1}). On the other hand, the lowest (7.64 t ha^{-1}) was recorded from the combination of Hybrid dhan Taj-1 with control treatment, which was statistically similar to Hybrid dhan Taj-1 with 100% XXL (8.49 t ha^{-1}).

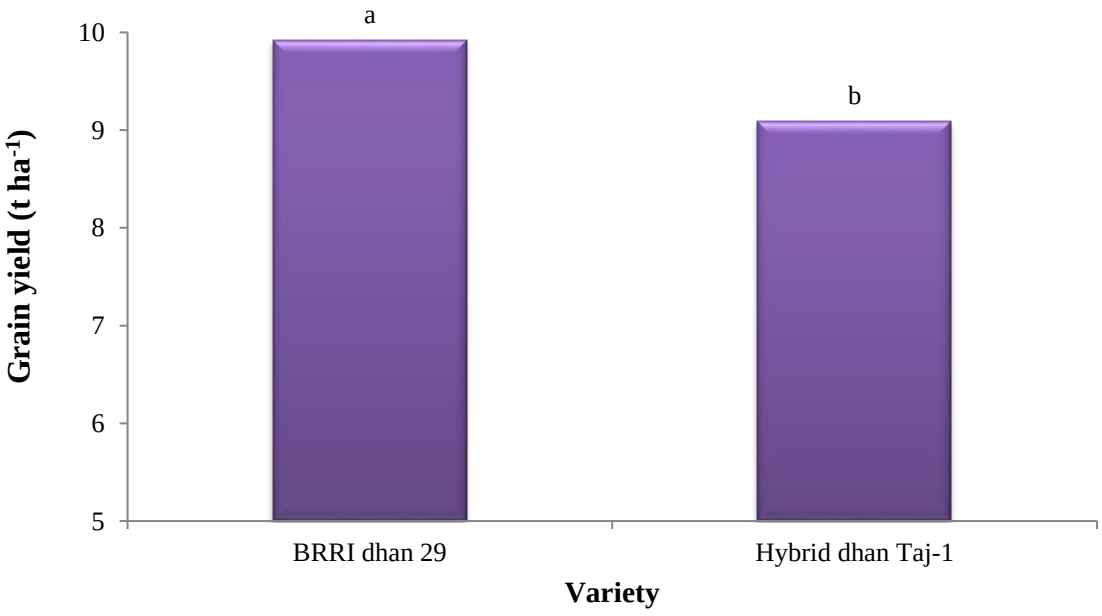

Figure 29. Effect of variety on the grain yield of rice ($LSD_{(0.05)}$ = 0.35)

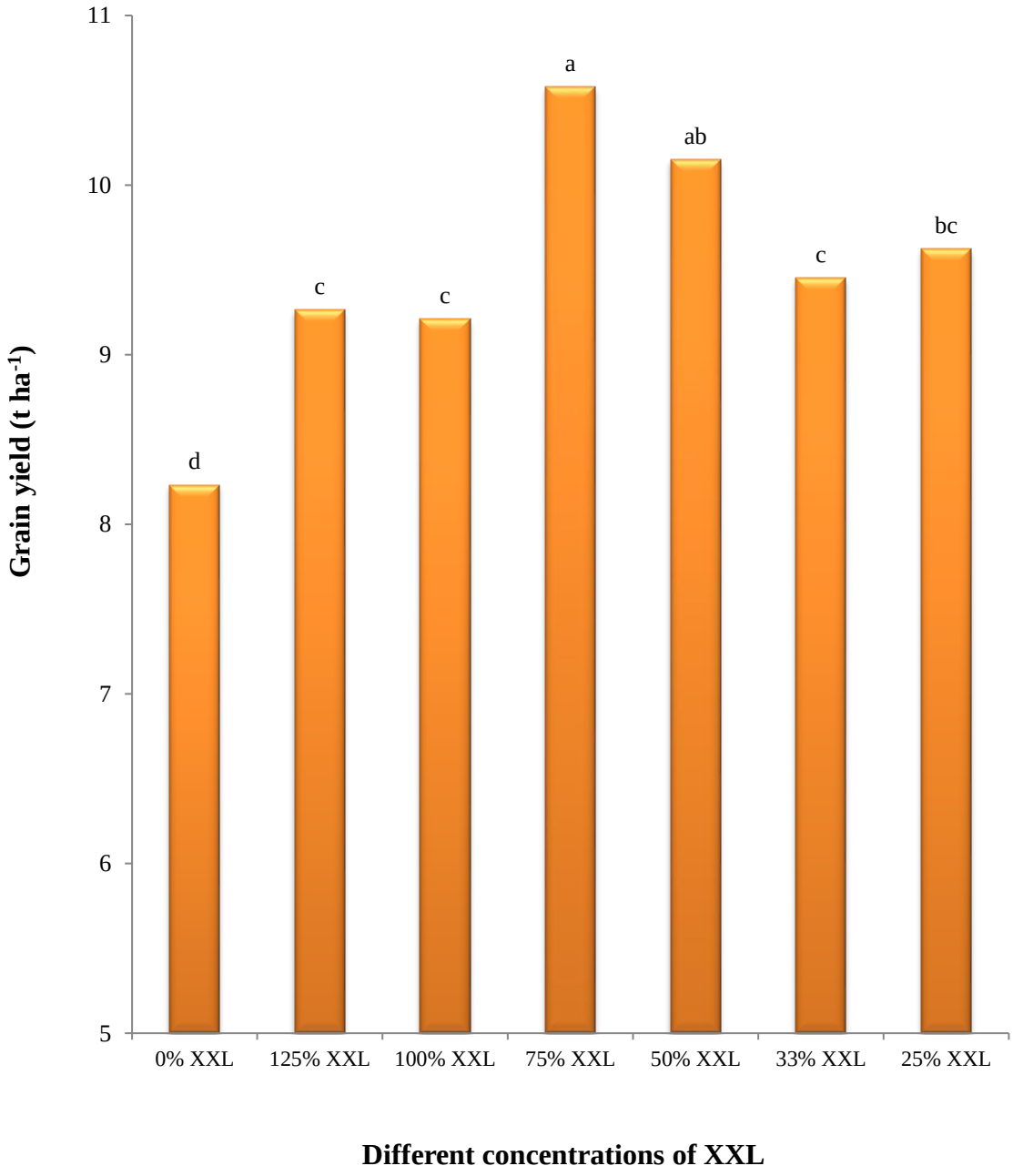

Figure 30. Effect of different concentrations of XXL on the grain yield of rice ($LSD_{(0.05)} = 0.66$)

Table 7. Interaction effect of variety and XXL on shoot dry matter, yield and yield contributing characters of rice

Treatments	Shoot dry matter content hill^{-1} (g)	1000 grains weight (g)	Grain yield (t ha^{-1})
BRRI dhan 29 ×			
0% XXL	19.96 c-e	23.46	8.82 gh
125% XXL	20.21 c-e	2370	9.01 e-h
100% XXL	20.74 b-d	23.33	9.93 b-e
75% XXL	24.45 a	23.89	11.09 a
50% XXL	23.23 ab	23.64	10.47 ab
33% XXL	20.13 c-e	23.56	9.97 b-d
25% XXL	22.40 a-c	23.36	10.13 bc
Hybrid dhan Taj-1 ×			
0% XXL	17.35 e	23.16	7.64 i
125% XXL	20.35 b-d	23.17	9.52 c-g
100% XXL	19.12 de	23.13	8.49 hi
75% XXL	21.00 b-d	23.47	10.07 bc
50% XXL	19.36 de	23.85	9.83 b-f
33% XXL	19.02 de	23.33	8.94 f-h
25% XXL	19.31 de	23.12	9.12 d-h
LSD $_{(0.05)}$	**2.95**	**NS**	**0.93**
CV (%)	**8.59**	**5.88**	**5.84**

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

CHAPTER V
SUMMARY AND CONCLUSION

The experiment was conducted at the Research Field of Sher-e-Bangla Agricultural University, Dhaka-1207, during the period from November, 2015 to July, 2016 to evaluate the effect of soil enhancer (XXL) on the growth, development and yield attributes of BRRI dhan 29 and Hybrid dhan Taj-1 in *Boro* season. The experiment consisted of two varieties (BRRI dhan 29 and Hybrid dhan Taj-1) and seven different concentrations of XXL {Control, 125% (1.875g/1.5 L), 100% (1.5g/1.5 L), 75% (1.125g/1.5 L), 50% (0.75g/1.5 L), 33% (0.50g/1.5 L) and 25% (0.375g/1.5 L)}. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications and the differences between means were evaluated by Least Significant Difference (LSD) at 5% level of probability. Data on different physio-morphological and yield contributing characters were recorded and significant variation was observed.

Results showed that plant height (cm), SPAD value of leaf, number of tiller hill^{-1}, 1%, 50%, 100% booting stage, 1%, 50%, 100% panicle insertion stage, leaf area (cm^2), first days to maturity, final days to maturity, number of fertile tillers hill^{-1}, number of sterile tillers hill^{-1}, panicle length (cm), number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1}, moisture content (%), shoot dry matter content hill^{-1}(g), 1000 grains weight (g), grain yield (t ha^{-1}) were significantly influenced by rice varieties. For rice varieties, at 20, 40, 60, 80 DAT and at harvest, the tallest plant (30.132, 56.62, 66.296, 92.372 and 98.577 cm, respectively) were observed from Hybrid dhan Taj-1, while the shortest plant (24.081, 43.991, 61.332, 79.372 and 94.648 cm, respectively) from BRRI dhan 29. At 40, 60, 80 and 100 DAT, the highest SPAD value (36.362, 37.87, 32.18 and 31.122, respectively) were obtained from BRRI dhan 29, where lowest SPAD value (34.11, 33.159, 26.624 and 25.354, consecutively) were obtained from Hybrid dhan Taj-1.

At 20, 40, 60 and 80 DAT the maximum number of total tillers hill^{-1} (10.73, 15.333, 13.88 and 11.99, respectively) were recorded from BRRI dhan 29 again the minimum number (10.63, 11.743, 10.9 and 8.924 respectively) were obtained from Hybrid dhan Taj-1. The highest 1% booting stage (67.714 days) was found in the BRRI dhan 29 and the lowest (52.81 days) was found in the Hybrid dhan Taj-1. The highest 50% booting stage (70.19 days) was found in the BRRI dhan 29 and the lowest (55.00 days) was found in the Hybrid dhan Taj-1. The highest 100% booting stage (73.952 days) was found in BRRI dhan 29 and the lowest (58.095 days) was found in the Hybrid dhan Taj-1. The highest 1% panicle insertion (75.048 days) was recorded from BRRI dhan 29, whereas the lowest (59.619 days) was recorded from the Hybrid dhan Taj-1. The highest 50% panicle insertion (82.714 days) was recorded from BRRI dhan 29, whereas the lowest (66.857 days) was recorded from the Hybrid dhan Taj-1. The highest 100% panicle insertion (87.238 days) was recorded from BRRI dhan 29, whereas the lowest (77.952 days) was recorded from the Hybrid dhan Taj-1. The highest leaf area (27.551cm^2) was observed from Hybrid dhan Taj-1, where the lowest leaf area (22.584 cm^2) was observed from BRRI dhan 29. The maximum 1stdays to maturity (95.095 days) were found from BRRI dhan 29, while the minimum (81.095 days) from Hybrid dhan Taj-1. The maximum final days to maturity (109.57 days) were found from BRRI dhan 29, while the minimum (96.571 days) from Hybrid dhan Taj-1. The maximum number of fertile tillers (11.941) was produced from BRRI dhan 29, while the minimum number (8.305) from Hybrid dhan Taj-1. The maximum number of sterile tillers (1.019) was produced from BRRI dhan 29, while the minimum number (0.533) from Hybrid dhan Taj-1. The longest panicle (23.951 cm) was observed from BRRI dhan 29, whereas the shortest (23.053 cm) was found from Hybrid dhan Taj-1. The highest filled grains panicle^{-1} (125.673) was recorded from Hybrid dhan Taj-1, whereas the lowest (116.058) was found from BRRI dhan 29.

The highest unfilled grains panicle^{-1} (25.162) was recorded from BRRI dhan 29, whereas the lowest (13.498) was found from Hybrid dhan Taj-1. The highest moisture content of grains (17.814%) was recorded from Hybrid dhan Taj-1, whereas the lowest (16.267%) was found from BRRI dhan 29. The highest shoot dry matter content hill^{-1} (21.588 g) was obtained from BRRI dhan 29, while the lowest shoot dry matter content hill^{-1} (19.36 g) was found from Hybrid dhan Taj-1. The maximum 1000 grains weight (23.57 g) was found in BRRI dhan 29, while the minimum 1000 grains weight (23.32 g) was found in Hybrid dhan Taj-1. The highest grain yield (9.916 t ha^{-1}) was observed from the BRRI dhan 29, whereas the lowest (9.087t ha^{-1}) was observed from the Hybrid dhan Taj-1.

In case of different concentrations of XXL, at 20, 40, 60, 80 DAT and at harvest, the tallest plant (29.01, 53.57, 68.72, 92.82 and 104.8 cm, respectively) were produced from 75% XXL, while the shortest plant (25.19, 46.30, 60.29, 78.46 and 89.83 cm, respectively) from control treatment. At 40 and 80 DAT the maximum SPAD value (38.92 and 32.04, respectively) were found from 75% XXL, at 60 DAT the maximum SPAD value (37.19) was found from 50% XXL and at 100 DAT the maximum SPAD value (28.97) was found from 33% XXL, while the minimum SPAD value (33.24, 33.31 and 26.86) at 40, 60 and 100 DAT, respectively were found from control treatment and at 80 DAT the minimum SPAD value (27.64) was found in 33% XXL. At 20, 40, 60 and 80 DAT the maximum number of total tillers hill^{-1} (12.93, 12.93, 15.98 and 15.26, respectively) were found from 75% XXL, while the minimum number (8.883, 8.883, 11.25 and 10.05 respectively) were from control treatment. The highest 1% booting stage (60.50 days) were found in control, 125% XXL, 50% XXL, 33% XXL and 25% XXL, while the lowest (59.17 days) was found in 75% XXL. The highest 50% booting stage (63.33 days) was found in control treatment and the lowest (61.33 days) was found in 75% XXL. The highest 100% booting stage (67.50 days) was found in control treatment, while the lowest (64.50 days) was found in 75% XXL.

The higher 1% panicle insertion (70.00 days) was recorded from control treatment, while the lowest (65.17 days) was recorded from 75% XXL. The higher 50% panicle insertion (78.67 days) was recorded from control treatment, while the lowest (72.83 days) was recorded from 75% XXL. The highest 100% panicle insertion (87.50 days) was recorded from control treatment, while the lowest (77.33 days) was recorded from 75% XXL. The highest leaf area (29.26 cm^2) was recorded from 75% XXL, while the lowest (19.32 cm^2) was recorded from control treatment. The maximum 1^{st} days to maturity (90.17 days) was recorded from control treatment, whereas the minimum (86.33 days) was recorded from 75% XXL. The maximum final days to maturity (105.3 days) was recorded from control treatment, whereas the minimum (100.8 days) was recorded 75% XXL. The maximum number of fertile tillers $hill^{-1}$ (11.35) was found from 75% XXL, whereas the minimum number (8.75) was found from control treatment. The minimum number of sterile tillers $hill^{-1}$ (0.5000 and 0.5000) was recorded from 75% XXL and 125% XXL, whereas the maximum number (1.417) from control treatment. The longest panicle (24.26 cm) was found from 75% XXL, whereas the shortest (22.46 cm) was observed from control treatment. The highest filled grains $panicle^{-1}$ (130.2) was recorded from 75% XXL, whereas the lowest (112.7) was obtained from control treatment. The highest unfilled grains $panicle^{-1}$ (23.44) was recorded from control treatment, whereas the lowest (15.14) was obtained from 75% XXL. The highest moisture content of grains (17.20%) was recorded from 125% XXL, whereas the lowest (16.87%) was obtained from 33% XXL. The highest shoot dry matter content $hill^{-1}$ (22.72 g) was found from 75% XXL, whereas the lowest (18.66 g) was recorded from control treatment. The maximum 1000 grains weight (23.75 g) was found in 50% XXL, while the minimum 1000 grains weight (23.23 g) was found in 100% XXL. The highest grain yield (10.58 t ha^{-1}) was observed from 75% XXL, whereas the lowest (8.232 t ha^{-1}) was recorded from control treatment.

Due to the interaction effect of different concentrations of XXL and rice varieties, at 20, 60, 80 DAT and at harvest, the tallest plant (32.47, 71.72, 98.94 and 108.7cm, respectively) was observed from the combination of Hybrid dhan Taj-1 with 75% XXL but 125% XXL showed the highest plant height (61.17cm) at 40 DAT, whereas the shortest plant (40.11, 57.27, 74.43 and 87.94 cm) was recorded at 40, 60, 80 DAT and at harvest, respectively from the combination of BRRI dhan 29 with control treatment, but 125% XXL showed the shortest plant height (22.42 cm) at 20 DAT. At 40, 80 and 100 DAT, the the combination of BRRI dhan 29 with 75% XXL showed the maximum SPAD value (39.78, 34.17 and 32.74, respectively) but BRRI dhan 29 with 125% XXL showed the highest SPAD value (40.91) at 60 DAT, while the minimum SPAD value (32.86, 31.57, 23.87 and 23.43) at 40, 60, 80 and 100 DAT, respectively were obtained from the combination of Hybrid dhan Taj-1 with control treatment. At 20, 40, 60 and 80 DAT the maximum number of total tillers hill^{-1} (13.30, 13.30, 18.20 and 17.42, respectively) were found from treatment combination of BRRI dhan 29 with 75% XXL, whereas the minimum number (8.7, 8.7, 10.03 and 9.267, respectively) were recorded from Hybrid dhan Taj-1 with control treatment. The highest 1% booting stage (68.67 days) were recorded from the combination of BRRI dhan 29 with 125% XXL, 50% XXL and 33%, whereas the lowest (52.33 days) were recorded from Hybrid dhan Taj-1 with 125% XXL, 75% XXL, 50% XXL and 33% XXL. The highest 50% booting stage (71.33 days) was recorded from the combination of BRRI dhan 29 with control treatment, whereas the lowest (53.33 days) was recorded from Hybrid dhan Taj-1 with75% XXL. The highest 100% booting stage (76.00 days) was recorded from the combination of BRRI dhan 29 with control treatment, whereas the lowest (56.67 days) was recorded from Hybrid dhan Taj-1 with75% XXL. The highest 1% panicle insertion (78.00 days) was obtained from the combination of BRRI dhan 29 with control treatment, whereas the lowest (57.67 days) was recorded from Hybrid dhan Taj-1 with75% XXL.

The highest 50% panicle insertion (85.67 days) was obtained from the combination of BRRI dhan 29 with control treatment, whereas the lowest (65.00 and 65.00 days) were recorded from Hybrid dhan Taj-1 with75% XXL and 125% XXL. The highest 100% panicle insertion (92.00 days) was obtained from the combination of BRRI dhan 29 with control treatment, whereas the lowest (72.67 days) was recorded from Hybrid dhan Taj-1 with75% XXL. The highest leaf area (31.51cm^2) was observed from the combination of Hybrid dhan Taj-1 with75% XXL, while the lowest (17.98 cm^2) was recorded from BRRI dhan 29 with control treatment. The maximum 1st day to maturity (98.00 days) was obtained from the combination of BRRI dhan 29 with control treatment and the minimum (80.00 days) was found from Hybrid dhan Taj-1 with75% XXL. The maximum final day to maturity (111.7 days) was obtained from the combination of BRRI dhan 29 with control treatment and the minimum (94.33 days) was found from Hybrid dhan Taj-1 with75% XXL. The maximum number of fertile tillers $hill^{-1}$ (13.63) was found from the combination of BRRI dhan 29 with 75% XXL, while the minimum number (7.633) was observed from Hybrid dhan Taj-1 with control treatment. The minimum number of sterile tillers $hill^{-1}$ (0.3667) was found from the combination of Hybrid dhan Taj-1 with75% XXL, whereas the maximum number (2.033) was observed from BRRI dhan 29 with control treatment. The longest panicle (24.62 cm) was observed from the combination of BRRI dhan 29 with 75% XXL, whereas the shortest (22.15 cm) was recorded from Hybrid dhan Taj-1 with control treatment. The highest filled grains $panicle^{-1}$ (133.1) was recorded from the combination of Hybrid dhan Taj-1 with75% XXL, while the lowest (108.5) was found from BRRI dhan 29 with control treatment. The highest unfilled grains $panicle^{-1}$ (28.55) was recorded from the combination of BRRI dhan 29 with control treatment, while the lowest (10.59) was found from Hybrid dhan Taj-1 with75% XXL. The highest moisture content in grains (18.00%) was recorded from the combination of Hybrid dhan Taj-1 with100% XXL, while the lowest (16.10%) was found from BRRI dhan 29 with 33% XXL.

The highest shoot dry matter content hill^{-1} (24.45 g) was found from the combination of BRRI dhan 29 with 75% XXL, while the lowest (17.35 g) was observed from Hybrid dhan Taj-1 with control treatment. The maximum 1000 grains weight (23.89 g) was recorded from the combination of BRRI dhan 29 with 75% XXL, while the minimum 1000 grains weight (23.12 g) was recorded from Hybrid dhan Taj-1 with 25% XXL. The combination of BRRI dhan 29 with 75% XXL exhibited the highest grain yield (11.09 t ha^{-1}) and the Hybrid dhan Taj-1 with control treatment combination performed the worst one (7.64 t ha^{-1}).

Conclusions:

i) Irrespective of varieties and doses, leaf area, fertile tillers hill^{-1}, filled grains panicle^{-1}, shoot dry matter content hill^{-1} and grain yield were increased (34.73%), (18.29%), (5.39%), (8.46%), (11.36%) and (18.00%), respectively with the application of XXL than that of control.

ii) Both BRRI dhan 29 and Hybrid dhan Taj-1 provided their highest grain yield (11.07 t ha^{-1} and 10.07 t ha^{-1}, respectively) with 75% XXL. It was 45.16% and 31.81% higher than control, respectively.

Recommendations:

i) XXL should be applied @ 75% for getting maximum yield from BRRI dhan 29 than Hybrid dhan Taj-1.

ii) However, further study may be needed regarding the effect of XXL on growth and yield of test rice varieties in different Agro-Ecological Zones (AEZ) of Bangladesh to recommend a package of technology for use at farmers' level.

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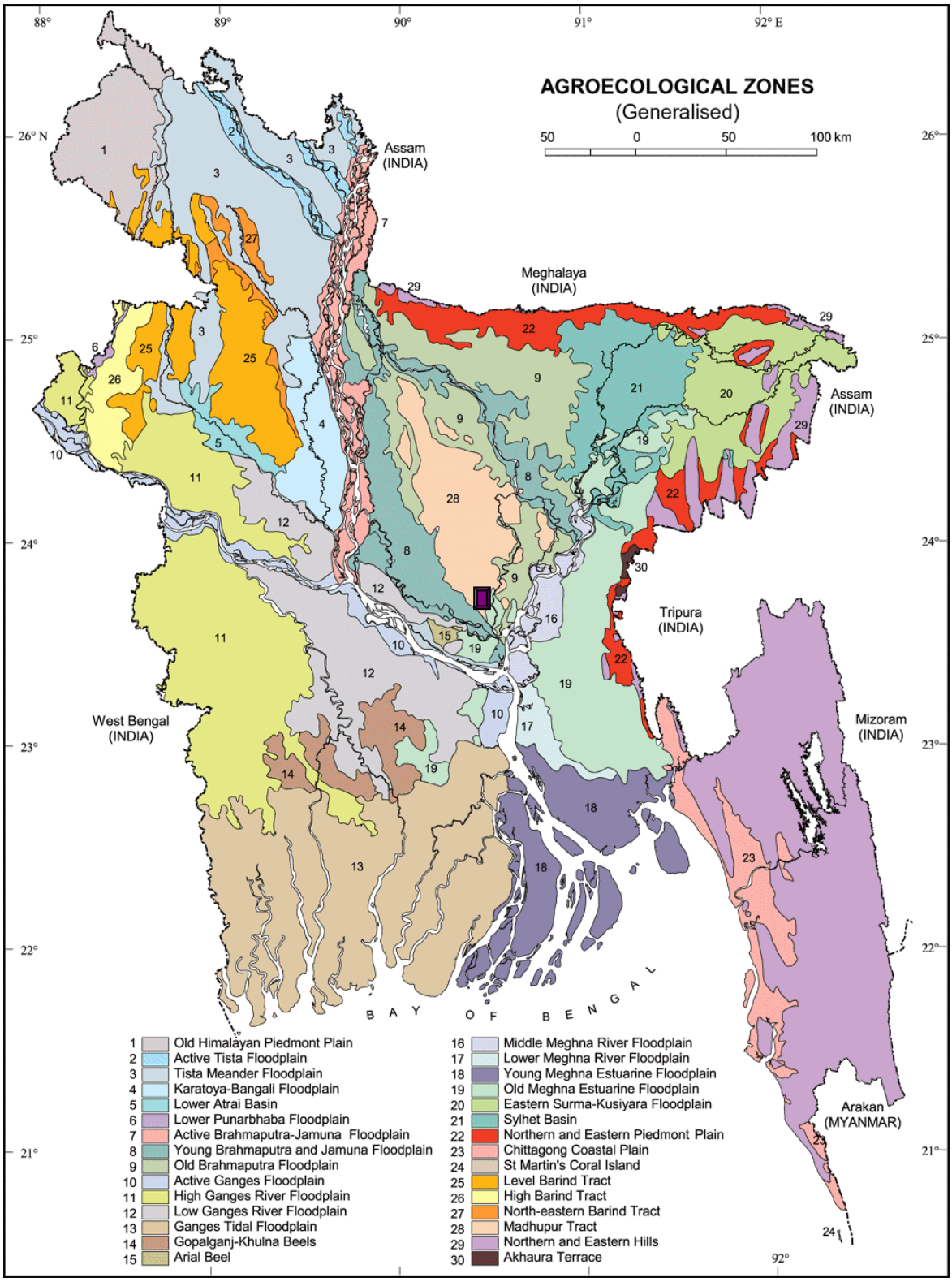
APPENDICES

Appendix I: Map showing the experimental sites under study



The experimental site under study

Appendix II. Monthly record of air temperature, relative humidity, rainfall and sunshine hour at experimental site during the period of experiment in the field

Month	*Air temperature (^{o}c)		*Relative Humidity (%)	Total Rainfall (mm)	*Sunshine
	Maximum	Minimum			
November, 2015	25.8	16.0	78	00	6.8
December, 2015	22.4	13.5	74	00	6.3
January, 2016	24.5	12.4	68	00	5.7
February, 2016	27.1	1.7	67	11	6.7
March, 2016	31.4	19.6	54	30	8.2
April, 2016	33.7	23.8	69	185	7.8
May, 2016	27.0	19.2	63	54	7.2
June, 2016	27.1	16.7	67	147	8.0

*, Monthly average

Source: Bangladesh Meteorological Department (Climate & Weather Division) Agargoan, Dhaka –1212

Appendix III: Characteristics of soil of experimental as analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

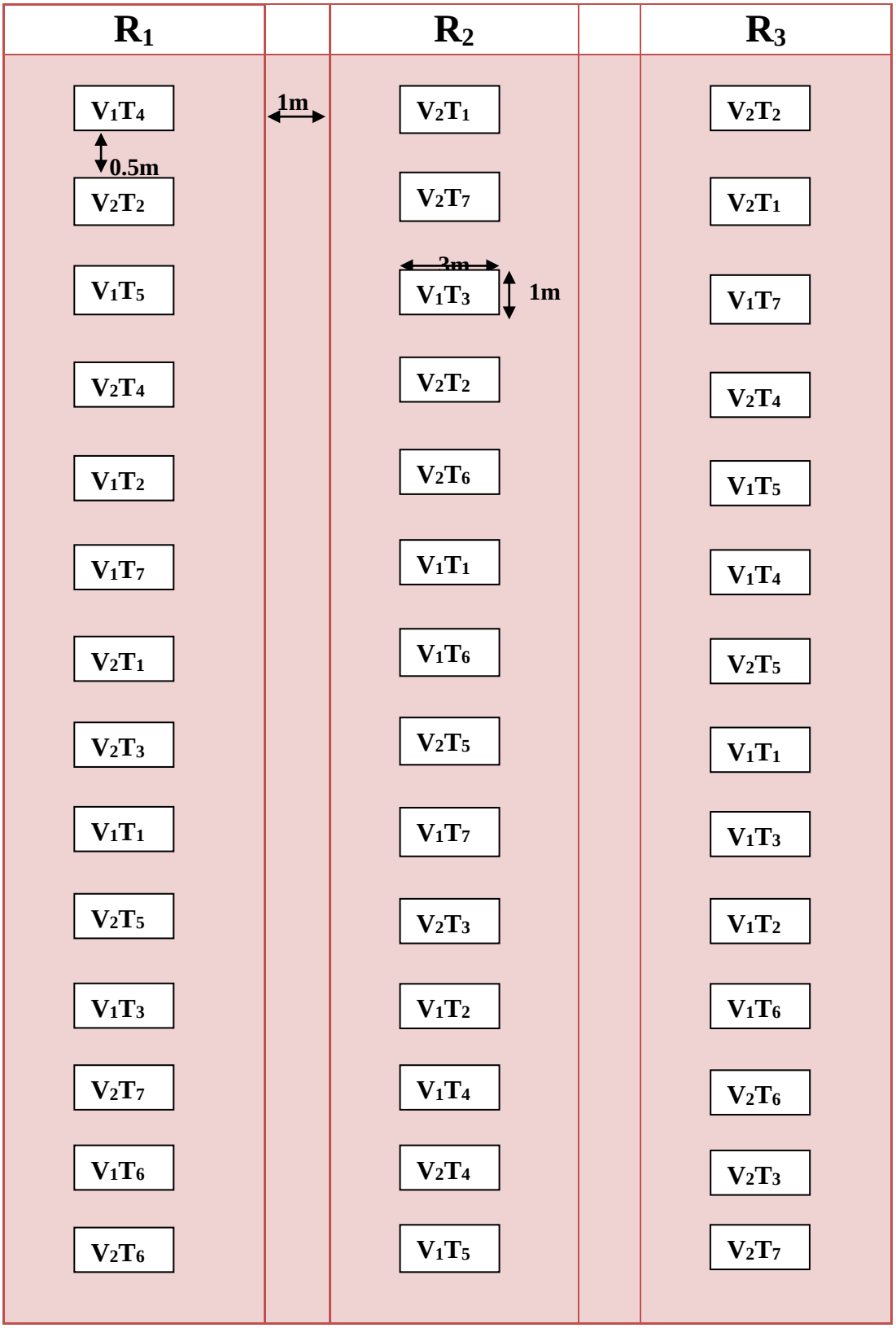
Morphological features	Characteristics
Location	Research field, Sher-e-Bangla Agricultural University, Dhaka-1207
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	Medium High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. 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 (SRDI**)**

Appendix IV. Design and layout of experimental field



Appendix V. Mean square values of plant height at different days after transplanting (DAT) and at harvest as influenced by rice varieties and different concentrations of XXL

Source of variation	Degrees of freedom	Mean square values of plant height (cm)				
		20 DAT	40 DAT	60 DAT	80 DAT	At harvest
Replication	2	6.858	39.359	28.922	73.133	156.434
Rice variety (A)	1	384.508*	1674.549*	258.664*	1774.370*	162.054*
Treatment (B)	6	10.046*	34.525*	52.242*	120.458*	128.479*
Interaction (A x B)	6	2.441*	10.389*	11.047*	19.660*	11.025*
Error	26	4.451	12.938	29.833	32.924	37.637

*****, indicates significant at 0.05 level of probability

Appendix VI. Mean square values of SPAD value of leaf at different days after transplanting (DAT) as influenced by rice varieties and different concentrations of XXL

Source of variation	Degrees of freedom	Mean square value of SPAD value of leaf			
		40 DAT	60 DAT	80 DAT	100 DAT
Replication	2	22.411	6.987	6.227	6.941
Rice variety (A)	1	17.745*****	233.074*****	324.093*****	349.402*****
Treatment (B)	6	19.757*****	15.148*****	13.992*****	3.699ns
Interaction (A x B)	6	0.155*****	2.656*****	4.974*****	9.103*****
Error	26	3.139	4.919	5.300	4.775

*****, indicates significant at 0.05 level of probability and ns= non significant

Appendix VII. Mean square values of number of tillers hill^{-1}at different days after transplanting (DAT) as influenced by rice varieties and different concentrations of XXL

Source of variation	Degrees of freedom	Mean square value of Tillers number hill^{-1}			
		20 DAT	40 DAT	60 DAT	80 DAT
Replication	2	0.365	5.389	1.131	0.331
Rice variety (A)	1	0.105ns	135.361*	93.214*	98.747*
Treatment (B)	6	8.472*	12.483*	15.900*	9.894*
Interaction (A x B)	6	1.479*	2.299*	2.211*	3.176*
Error	26	0.753	0.978	0.870	0.868

*****, indicates significant at 0.05 level of probability and ns= non significant

Appendix VIII. Mean square values of 1%, 50%, 100% booting stage and 1%, 50%, 100% panicle insertion stage as influenced by rice varieties and different concentrations of XXL

Source of variation	Degrees of freedom	Mean square value					
		Booting stage (DAT)			Panicle insertion stage (DAT)		
		1% booting	50% booting	100% booting	1% panicle insertion	50% panicle insertion	100% panicle insertion
Replication	2	6.381	3.738	18.452	24.024	23.357	38.000
Rice variety (A)	1	2332.595*****	2422.881*****	2640.21*****	2499.429*****	2640.214*****	1121.167*****
Treatment (B)	6	1.492ns	2.603*****	6.024*****	13.778*****	20.873*****	9.667*****
Interaction (A x B)	6	2.762*****	1.048*****	1.548*****	1.873*****	4.381*****	18.000*****
Error	26	3.817	2.302	6.247	10.152	12.639	22.897

*****, indicates significant at 0.05 level of probability and ns= non significant

Appendix IX. Mean square values of leaf area, maturity stage and moisture content as influenced by rice varieties and different concentrations of XXL

Source of variation	Degrees of freedom	Mean square value			
		Leaf area (cm^2)	Maturity stages (DAT)		Moisture content (%)
			First maturity	Final maturity	
Replication	2	6.970	41.167	36.857	0.112
Rice variety (A)	1	259.012*	2058.000*	1774.500*	25.149*
Treatment (B)	6	59.134*	9.437ns	12.214*	0.092ns
Interaction (A x B)	6	8.401*	3.722*	0.944*	0.046*
Error	26	3.600	10.628	11.216	0.119

*****, indicates significant at 0.05 level of probability and ns= non significant

Appendix X. Mean square values of yield contributing characters of rice as influenced by rice varieties and different concentrations of XXL

Source of variation	Degrees of freedom	Mean square value				
		Fertile tillers $hill^{-1}$ (no.)	Sterile tillers $hill^{-1}$ (no.)	Panicle length (cm)	Filled grains $panicle^{-1}$ (no.)	Unfilled grains $panicle^{-1}$ (no.)
Replication	2	0.145	0.022	1.889	726.150	3.317
Rice variety (A)	1	138.866*****	2.477*****	8.460*****	970.755*****	1428.467*****
Treatment (B)	6	4.169*****	0.688*****	1.938*****	195.068*****	37.323*****
Interaction (A x B)	6	1.036*****	0.260*****	0.203*****	55.822*****	11.900*****
Error	26	0.733	0.007	0.440	81.560	3.312

*****, indicates significant at 0.05 level of probability

Appendix XI. Mean square values of shoot dry matter, yield and yield contributing characters of rice as influenced by rice varieties and different concentrations of XXL

Source of variation	Degrees of freedom	Mean square value		
		Shoot dry matter content hill^{-1} (g)	1000 grains weight (g)	Grain yield (t ha^{-1})
Replication	**2**	2.437	3.641	1.335
Rice variety (A)	**1**	52.126*****	0.634ns	7.209*****
Treatment (B)	**6**	10.331*****	0.250ns	3.350*****
Interaction (A x B)	**6**	3.086*****	0.080ns	0.615*****
Error	**26**	3.097	1.898	0.308

*****, indicates significant at 0.05 level of probability and ns= non significant

PLATES

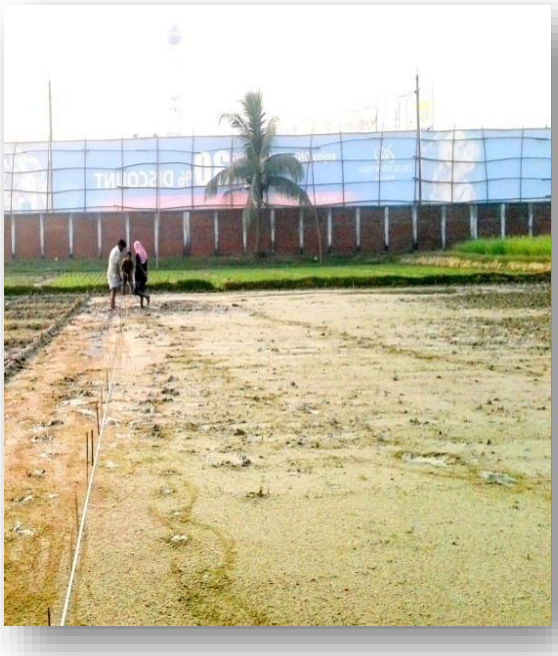


Plate 1. Land preparation according to design and layout

Plate 2. Transplanting of seedling in the allocated plots

A: XXL measurement

B: XXL spraying

Plate 3 (A&B): XXL application in the experimental plots

A: BRRI dhan 29

B: Hybrid dhan Taj-1

Plate 4 (A&B): Growth stage of experimental rice plants

A: BRRI dhan 29

B: Hybrid dhan Taj-1

Plate 5 (A&B): Panicle insertion stage of experimental rice pants

A: BRRI dhan 29

B: Hybrid dhan Taj-1

Plate 6 (A&B): Maturity stage of experimental rice plants