# GROWTH AND YIELD OF MODERN RICE VARIETIES AS AFFECTED BY PLANT GROWTH STIMULATOR AND FOLIAR FERTILIZATION IN *BORO* SEASON

**A THESIS**

**BY**

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# *CERTIFICATE*

*This is to certify that the thesis entitled "GROWTH AND YIELD OF MODERN RICE VARIETIES AS AFFECTED BY PLANT GROWTH STIMULATOR AND FOLIAR FERTILIZATION" submitted to the department of Agricultural Botany, faculty of Agriculture, 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 bona fide research work carried out by* ***MD.MOSTAFIZER RAHMAN*** *, registration no.* ***16-07546*** *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 of during the course of this investigation has been duly acknowledged by him.*

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Dedicated to

My

"Be loved Parents"

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# GROWTH AND YIELD OF MODERN RICE VARIETIES AS AFFECTED BY PLANT GROWTH STIMULATOR AND FOLIAR FERTILIZATION IN BORO SEASON

## ABSTRACT

The experiment was carried out at the Research Farm of Sher-e-Bangla Agricultural University, Dhaka-1207 from November, 2016 to May, 2017 to study effect of plant growth stimulator and foliar fertilization on modern rice varieties. The experiment was laid out following Randomized Complete Block Design with three replications. Two Rice varieties (BRRI dhan29 and BRRI dhan45) and five combinations of plant growth stimulator and foliar fertilization management (i) Recommended fertilizer dose; (ii) Recommended fertilizer dose + Akota (iii) Recommended fertilizer dose + Global; (iv) Recommended fertilizer dose + Akota + Global and (v) Recommended fertilizer dose + Akota + Global. Data were recorded on different growth characters and yield contributing parameters. Most of the parameters were showed significant among the treatment means. In case of variety the highest (101.67 cm) plant height at harvest, panicles hill$^{-1}$ (16.71), filled grains panicle$^{-1}$ (192.83), total grains panicle$^{-1}$ (199.26) and grain yield (7.28 t ha$^{-1}$) was recorded from BRRI dhan29. In case of PGS and fertilizer treatment, the highest values were recorded from $T_4$ (Recommended fertilizer dose + Akota +Global ) for all growth and yield attributing characters at different DAT. Due to this $T_4$ treatment effective tillers (95.75 %), Panicles hill$^{-1}$ (17.65), total grains panicle$^{-1}$ (178.0), 1000 grains weight (28.39g), grain yield (7.36 t ha$^{-1}$) was recorded. Due to the interaction the highest value of plant height (103.6 cm), number of tillers hill$^{-1}$ (18.03) was recorded from BRRIdhan29 × $T_4$ (Recommended fertilizer dose + Akota + Global) at harvest. The highest value of all yield attributing characters including grain yield (7.63 t ha$^{-1}$) was recorded from BRRI dhan29 × $T_4$ (Recommended fertilizer dose +Akota + Global). So, BRRI dhan29 and $T_4$ (Recommended fertilizer dose +Akota +Global) treatment together had superiority for growth and yield over the other treatments.

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# LIST OF ACRONYMS

| | | |
|---|---|---|
| % | = | Percent |
| $0_C$ | = | Degree Centigrade |
| AEZ | = | Agro-ecological Zone |
| BARI | = | Bangladesh Agricultural Research Institute |
| BBS | = | Bangladesh Bureau of Statistics |
| BRRI | = | Bangladesh Rice Research Institute |
| BCR | = | Benefit Cost Ratio |
| cm | = | Centimeter |
| DAS | = | Days after sowing |
| DAT | = | Days after sowing |
| *et al.* | = | and others |
| FAO | = | Food and Agricultural Organization of the United Nations |
| g | = | gram (s) |
| Kg | = | Kilogram |
| Kg/ha | = | Kilogram/hectare |
| LER | = | Land Equivalent Ratio |
| LSD | = | Least Significant Difference |
| m | = | Meter |
| MoA | = | Ministry of Agriculture |
| MoP | = | Muriate of potash |
| $p^H$ | = | Hydrogen ion conc. |
| RCBD | = | Randomized Complete Block Design |
| t $ha^{-1}$ | = | ton per hectare |
| TSP | = | Triple Super-phosphate |
| CV% | = | Percentage of coefficient of variance |
| DF | = | Degree of Freedom |

CHAPTER I

# INTRODUCTION

Rice is the most important staple food of about half the world's population, of which more than 90% of the rice consumers inhabit in Asia (FAORAP and APSA, 2014). In Bangladesh it covers about 80% of the total cropped area and contributes about 90% of food grains (BBS, 2016). Therefore, rice plays an important role in ensuring food security, and contributing to poverty alleviation in Asia especially in Bangladesh. It plays a vital role in the economy of Bangladesh providing significant contribution to the GDP, employment generation and food availability. The climatic and edaphic conditions of Bangladesh are favorable for rice cultivation throughout the year. It provides nearly 48% of rural employment, about two thirds of total calorie supply and about one-half of the total protein intakes of an average person in the country. As the population of Bangladesh continues to increase, there will be further increase of rice production to meet additional consumption. Efforts to meet the rice needs can be done in two ways: expanding the rice growing area and increasing productivity, or both. But in the future, expansion will be more difficult and expensive.

Adoption of hybrid rice is one of the major options for improvement of rice yield (Nguyen, 2010). Bangladesh has started adopting hybrid rice technology since 1993 and able to develop her own hybrid rice variety in 2001. Hybrid rice has contributed significantly to food safety in some country like China, India and Thailand etc. Among the rice growing countries, Bangladesh obtained third position in rice area and fourth position in rice production (BRRI, 2012). Our farmers are cultivating hybrid rice varieties extensively. But the yield is not up to the mark.

In Bangladesh rice is cultivated all over the year as *Aus, Aman* and *Boro*. Among these transplanted cropping *Boro* is most important and occupied about 41% of rice cultivated land in 2009-10. The rest 46% is occupied by T. *Aman*, 9% by *Aus* and 4% by broadcast *Aman* (BRRI, 2017). In Bangladesh is the production of total rice is about 31.98 million metric tons where *Boro* rice covers about 18.06 million metric tons, which is the largest part among the total production. In *Boro* season hybrid rice covers about 6.86 lac hectares area with production of 32.2 lac metric tons (BBS, 2010).

The population of Bangladesh is increasing at a high rate and the cultivable land is decreasing day by day due to urbanization and industrialization resulting in in more shortage of food. The population growth rate of Bangladesh two million in every year it may increase by 30 million over the next 20 years. The growth of population demands a continuous increase in rice production in Bangladesh. Production of rice has to be increased by at least 60% to meet up food requirement of the increasing population by the year of 2020 (Masum, 2009).

Rice yield can be increased by various ways like developing new high yielding varieties and by using proper agronomic techniques to the existing varieties to achieve their potential yield. FAO has recognized hybrid rice technology as a key approach for increasing worldwide rice production (Virmani, 1999). Hybrids rice is generally more vigorous and larger in size than their parent stock. The leaves of hybrid rice become long and the leaves becomes broad so that they can take up more nutrients thus they produce more grains.

The effects of humic substances on plant growth depend on the source and concentration, as well as on the molecular fraction weight of humus. Humic acid improves the physical, chemical and biological properties of the soil and influences plant growth by influencing the growth of roots. Initiation of root enhancement and increased root growth may be observed by the application of humic acids and fulvic acids to the soil and by foliar fertilization (Pettit, 2004).

Bangladesh agriculture has experienced multiple nutrient deficiencies over the years. For sustainable agriculture, a soil management strategy must be based on maintaining soil quality, which is only possible by utilization of high-quality manures along with inorganic fertilizer. Humic substances are a major component of aquatic organic colloids and ubiquitous in natural groundwater (Chen *et al*., 2007). Thus, they constitute a large portion of the total organic carbon pool in terrestrial and aquatic environments (Christl *et al*., 2000; Fan *et al.* 2003). More specifically, humic acids are widely spread in nature and occur mainly in heavy degraded peat but also in all natural environments in which organic materials and microorganisms can be found (Jooné and Van Rensburg, 2004). Not only can humic acids be found in soil, natural water, rivers, sea sediments, plants, peat and other chemically and biologically transformed materials but also in lignite, oxidized et bituminous coal, leporine and gyttja (Karaca *et al.*, 2006).

According to Kulikova *et al. (*2005) humic acids comprises 50-90% of the organic matter brans and enhance the uptake of nutrients. It also improved soil nitrogen uptake and encourage the uptake of K, Ca, Mg and $P_2O_5$ making these more mobile and available to plant root system (Pascual *et al.,* 1999).

It has many uses and has become very popular in organic lawn care and organic gardening. Granules are very popular. As it easily absorbs in soil so, humic acid as hamates can be applied to all types of plants. Fulvic acid-Fulmal is the most plant-active of the humic acid compounds. Fulvic acid is a plant growth stimulator that increases plant metabolism and nutrient intake. Fulvic acid is naturally created in soil by composting old plants and can rejuvenate soil.

Humic acid and Fulvic acid is an excellent supplement to fertilizers to improve nutrient absorption. Humic acid can be applied as a foliar spray and to the soil. It increase root vitality, vitality, improved nutrient uptake, increased chlorophyll synthesis, Better seed germination, Increased fertilizer retention, stimulate beneficial microbial activity, healthier plants and improved yields, protects plants from chlorosis, enhance photosynthesis, increase vegetative growth which result in higher yields and healthier crops. It also influence enzyme system, increased root and top growth on a fresh and dry weight basis, enhance plant root uptake of P, K, Fe, Cu, Zn and Ca. humic acid and fulvic acid also stimulates the respiration rates of seeding which lead to quicker germination and uniformity, even under very adverse condition like drought.

Global and Akota are two commercial growth stimulators available in market that imported from China by Akota Agro-product Ltd and Global Agro-vet Ltd. The importer companies claimed that these PGS show positive effect on (i) vegetative growth of seedling, shoot, roots and branches (ii) reproductive growth in number of flower and fruit and. (iii) yield. Our farmers use these growth regulators frequently. But there is no research information on their effectiveness. Therefore, the study has been designed to evaluate the effectiveness of these PGS on growth and yield of hybrid varieties in *Boro* season with the following objectives.

**Objectives**

- To observe the effect of Akota and Global (PGS) on growth parameters and yield of the test modern rice varieties.
- To determine the optimum doses of Akota and Global for modern rice varieties.

## CHAPTER II

# REVIEW OF LITERATURE

Rice (*Oryza sativa* L.) is one of the most labor-intensive crops of the world. Growth and development of rice plants are greatly influenced by the environmental factors i.e. air, day length or photoperiod, temperature, variety and agronomic practices like transplanting time, spacing, number of seedlings, age of seedlings, depth of planting, PGS and fertilizer management etc. Among the factors, which are responsible for the yield of rice, PGS and fertilizer management of *Boro* rice is one of them. Yield and yield contributing characters of rice are considerably influenced by recommended fertilizers doses (NPKSZn), PGS and their combined application. Cultivar plays a momentous role in rice production by affecting the growth, yield and yield components of rice. In this chapter the available relevant reviews related to the research done elsewhere in the world in the recent past have been presented below under the following heads.

Rao *et al.* (1987) Showed that humic acid was very effective in increasing the dry matter yields of root and shoot of sorghum. The dry matter yield of sorghum increased with an increase in the level of humic acid up to 30 kg $ha^{-1}$ and then declined. Addition of humic acid up to 30 kg $ha^{-1}$ resulted in higher root shoot ratio humic acid beyond this level caused adverse effect on the growth and yield of plants. The retardation of IAA oxides activity by higher ortho-dihydroxy phenol would promote the growth of plants resulting in higher dry weight.

Chen and Aviad (1990) observed that the use of humic substances as media amendments or foliar sprays can promote greater root and shoot growth; root branching; leaf chlorophyll content; rates of nutrient uptake, photosynthesis and respiration.

Tattini *et al.* (1991) noted that humic acid promoted the growth of thin (lateral) roots at rates up to 120 mg/pot. N uptake rate increased as humic acid rate increased up to 120 mg $pot^{-1}$ during the first 60 days. It is suggested that humic acid can be used to increase whole plant OW and improve biomass partitioning to the roots.

Fagbenro and Agboola (1993) reported that HA was beneficial to the growth and nutrient uptake of teak seedlings. Plant monthly growth rates, and height and total dry matter yield increased significantly over the controls in the two soils at the three HA application levels. A significant positive correlation was established between rates of HA application and plant height, stem diameter and total dry matter yield. The addition of HA to the two soils increased the uptake by seedlings of N, P, K, Mg, Ca, Zn, Fe, and Cu.

David *et al.* (1994) showed that, the addition of 1280 mg HA liter$^{-1}$ produced significant increase in shoot accumulation of P, K, Ca, Mg, Fe, Mn and Zn as well as increased accumulation of N, Ca, Fe, Zn and Cu in roots. Fresh and dry weights of roots were also increased.

Figliolia *et al.* (1994) stated that, in the presence of humic acids and the Leaf Area Index (LAI) increased in paddy.

Cheng *et al* (1995) suggested that humic acid decreased the loss of soil moisture and enhanced the water retention ability of wheat leaves. The activities of superoxide dismutase and catalase in leaf cells were significantly increased, but the MDA content and leakage rate of electrolyte were significantly decreased, and hence, the chlorophyll decomposition was retarded, the photosynthetic rate and grain filling intensity were increased, the plant senescence was retarded, the drought resistance of wheat was enhanced and its thousand-grain weight was increased.

Ayuso *et al* (1996) noted that the humic substances can also have an indirect effect on the plant by changing the soil structure, increase caution exchange capacity, stimulate microbial activity and has the capacity to solubilize or complex certain soil ion.

Vasudevan *et al.* (1997) showed that, humic acid along with recommended doses of N, P and K. significantly influenced the leaf-area index, seed yield, filled seeds/capitulum, seed filling (%), volume weight, achene and kernel-oil content. The yield increased owing to improvement in yield components, viz. filled seeds head$^{-1}$ (1066), seed filling (86.2%), 1000-seed weight (63.9 g) and leaf-area index (3.81). These treatments also influenced the oil (50.3%) and protein (21.9%) contents compared with the control. The nutrients increased the seedquality parameters such as higher germination after accelerated ageing (61.8%), higher speed of germination (22.2), higher shoot (23.4 cm) and root lengths (20.4 cm), higher vigor index (3947) and seedling-growth rate (25.1 cm) compared with the control.

Rao *et al.* (2002) reported that increased dry matter yields of mustard due to 30 kg humic acid application ha$^{-1}$. Humic acid beyond this level caused adverse effect on the growth and yield of plants.

Kumar saravana *et al.* (2007) noted that, humic acid had no effect on growth percent, significantly. It had significant effects on the growth rate in soybean and caused an increase in the water uptake rate, growth rate, stem and shoot wet and dry weight.

Toledo *et al*. (2011) evaluated that immediately after harvesting by tests for moisture content, seed weight, germination, first count, electrical conductivity, seedling length and seedling dry matter. Soybean plants fertilized with alternative sources of K produced heavier seeds with a lower coat permeability compared to KCl, the physiological quality of soybean seeds and the weight of wheat seeds increase due to higher potassium humate doses.

Valdrighi *et al*. (1996) showed that the biological activity of humic substances encompasses all its activities in regulating plant biochemical and physiological processes, irrespective of their stimulatory or inhibitory effect. In general plant biochemical mechanisms were affected by humic substances. Known affected mechanisms are membrane permeability.

Wang *et al.* (2003) found that potassium could increase the photosynthetic rate after anthesis, the sucrose-phosphate synthetic (SPS) activity and the accumulation of soluble protein content in flag leaf during the period of anthesis Potassium also increased the content of grain protein, wet gluten, and prolonged the dough development time and stability time, improved the grain quality and increased the grain yield.

Patil *et al.* (2010) reported that that potassium humate treated plants showed significantly increased vegetative characters and protein contents of *Glycine max* and *Phaseolus mungo* than control plants.

Masum Mirza zadeh (2011) showed that the effect of potassium humate on different conditions of this investigation was not statistically significant; however, it increased germination percent in the both well watered and after flowering drought stress conditions.

Morard *et al*. (2011) reported that humic substances provoked a better efficiency of plant water uptake and improved the mineral nutrition and grain protein content.

Vaughan and Linehan, (1976) studied that it was generally argued that changes in microbial activity were responsible for the enhanced plant growth.

Suwandi and Nurtika (1987) indicated that the application of humic acid to the soil one week before planting significantly increased marketable yield of cabbage at 7.5 liters /ha.

Bano *et al.* (1988) studied that the sodium humate increased the production of secondary lateral roots, the number of nodules plant$^{-1}$ and their fresh weight and advanced nodule development by 5-7 days. Solutions of 0.075-0.0225% increased shoot and root dry weight. Nitrogenase activity also increased following sodium humate treatment, which appeared to affect the infection process as well as nodule formation and function.

Mandal *et al.* (1989) found that, the applications of energiser 12 PCT (a liquid formulation of KOH extract containing 12% humic acid) produced the highest numbers of fertile tillers (487 $m^2$) and filled grains (93 $panicle^{-1}$) and grain and straw yields (3.1 and 3.6 t $ha^{-1}$, resp.). Root dipping alone produced more fertile tillers (385 $m^{-2}$) and filled grains $Panicle^{-1}$ (76 $panicle^{-1}$) than the control (335 $m^{-2}$ and 67 $panicle^{-1}$).

Chen and Avaid (1990) showed that humic substances have a very pronounced influence on the growth of plant roots and enhance root initiation and increased root growth which known root stimulator.

Tattini *et al*. (1990) reported that HA increased the root/shoot ratio as well as the production of thin lateral roots of olive plants. In addition, HA, prepared from leonardite coal, stimulated both shoot and root growth.

David (1991) showed that the applications of Agro-Lig (dry humate powder containing 80% humic acid) were broadcast on preformed beds and incorporated to a 15 cm depth while Enersol (liquid humate containing 12% humic acid dissolved in 1 N KOH) was applied as a foliar spray. Snap bean (*Phaseolus vulgaris*) plants showed consistent increases in yield with Enersol applications of 1 or 2% and this trend continued for increased nutrient content of foliar N, Ca, Mg, Zn and Fe. Evaluation of crop response to HA under limited nutrient availbiity confirmed that at 1280 mg $liter^{-1}$ plant growth can be stimulated due to increased nutrient accumulation of essential plant nutrients.

Xue (1994) studied that the humic acid (HA) compound fertilizer was applied to maize, wheat, cotton, rape and sesame. HA fertilizer performed better than the equivalent di-amonium phosphate and chemical fertilizers. It increased resistance to drought, cold and diseases, prevented early senescence, increased yield, increased activities of superoxide dismutase and nitrate reductase, and increased plant uptake and trans-location of nutrients.

Chellaiah and Gopal aswamy (1995) found that the on sesame cv. SVPR with the application of 2% DAP + 0.5% humic acid gave the highest seed yield of 625 kg $ha^{-1}$ compared with the control yield of 382 kg and 421 kg with water spray.

Goenadi and Sudharama (1995) reported that the effect of humic acids on shoot development from nodal segments in tissue culture was tested with *Gnetum gnemon*, *Elettaria cardamomum* and *Pogoste moncablin*. The effects of the treatment were evaluated on the basis of the initiation period of shoots and/or roots and the number and height of the shoots. Shoot initiation period was significantly reduced in the presence of humic acids. Root initiation was significantly induced, especially when humic acids were used in liquid medium. In combinations with SA, the addition of humic acids at 400, 40 and 300 mg litte$^{-1}$r yielded the fastest growth of *G. gnemon*, *E. cardamomum* and *P. cablin*, respectively.

Purchase *et al*. (1995) stated that humic substances are stimulating plant growth under certain conditions. Some of these stimulatory effects are increases in the length of roots and shoots. There have also been reports of increases in wheat grain yield

Shang *et al.* (1995) suggested that, the humic acid did not affect seed germination rate at 25 degrees C, but seed treatment with 0.1 or 0.3 g humic acid liter$^{-1}$ increased seedling growth. Adding 0.1 g humic acid liter$^{-1}$ to leaves with 0.1 % $Na_2HPO_4$ increased uptake and translocation of P.

Solaiappan, *et al.* (1995) expressed that seed soaking in 1% humic acid gave the highest seed cotton yield of 1.10 t ha$^{-1}$ foliar application of 0.25% humic acid (1.02 t) or foliar spray of water at flowering and squaring stages (1.02 t).

Ayuso *et al.* (1996) showed that the humic fractions from urban wastes had a more irregular effect on seed germination than those from more humidify organic materials. Humic substances had a more positive effect on germination than humic acids, with the effect depending on the nature of the original organic material.

Yang *et al.* (1999) studied that the foliar application or root injection of HA-K [humic acid-K] to cotton increased lint yields. The increase was greater with foliar application than with root injection. To produce a lint yield of 1.8 t ha$^{-1}$ foliar application of 415-1085 mg kg$^{-1}$ HAK or root injection of 747 mg kg$^{-1}$ HA-K are recommended.

Mac Carthy *et al.* (2001) concluded that humate enhance nutrient uptake, improve soil structure, and increase the yield and quality of various oilseed crops.

Salt *et al*. (2001) found that lower dose of humic acid equally effective to their higher levels in increasing plant growth and enhancing the nutrient uptake.

David and Samuel (2002) reported that, the application of humic acid alone or in combination with other fertilizers has significant beneficial effect on the growth and yield of mustard.

Khan and Mir (2002). Observed that the, humic acid is considered to increase the permeability of plant membranes and enhance the uptake of nutrients yield and yield components of wheat.

Nardi *et al.* (2002) evaluated that humic substances can have a direct effect through absorption of compounds by the plant and thus affecting the enzyme activities and membrane permeability.

Wang *et al.* (2002) studied that effects of potassium humate (2000) and 1250 mg $kg^{-1}$ foliar application on soybean, the average yield increased by 14.06% (3699.9 kg $ha^{-1}$) compared to the control

Yang *et al.* (2004) reported that, the humic materials can affect direct and indirect physiological processes of plant growth. Their direct effects including increase in cell membrane permeability, respiration, nucleic acid bio-synthesis, ion uptake, enzyme activity and sub-enzyme activity. Humic acid reduces the amount of fertilizer consumption, and makes plant tolerant against heat stress, drought stress, cold, diseases, insects and other environmental and agricultural pressures. Also, production of total plant weight and increases yield.

Baskar and Sankaran (2005) evaluated that the application of 100% NPK with HA applied to soil (at 10 kg $ha^{-1}$) and as FS (at 0.1%) + RD (at 0.1%) significantly enhanced the growth and yield attributes, fresh and cured rhizome yields of turmeric.

Delfine *et al.* (2005) reported that more specifically humic acids was also used as growth regulators to regulate hormones, improve plant growth and enhance stress tolerance.

Moser *et al*. (2006) emphasized that drought before pollination reduced the number of rows per ear, seed number per row and seed weight. In this experiment, water stress led to increasing harvest index also.

Ulukan (2008) observed that treated plant with humic acid showed more plant height, spike number, grain number and 100 grain weight as compared to untreated plant.

Venturoso *et al.* (2009) observed a positive response for the yield components, weight of 100 grains and number of green beans per plant, with the increase of levels potassium humate.

Zaghloul *et al.* (2009) showed that potassium humate led to increase of nitrogen, phosphorus and potassium in the plant due to increasing absorption and transfer of nutrients in plants by enhancing metabolism. So humate with its positive effects on physiological processes including photosynthesis and facilitating the transfer of materials within the plant can improve the grain growth.

Balakumbahan and Rajamani (2010) reported that foliar application of humic acid gave better yield in sienna (*Cassia angustifolia* cv. kmi).

Haroon *et al* (2010) showed that seed cotton yield (seed +cotton fiber) significantly responded to both HA and NPK levels at both sites. When averaged across levels of NPK, application of 0.5, 1.0 and 2.0 kg $ha^{-1}$ HA increased seed cotton yield by 10.5, 15.6 and 13.5 at site 1 and 12.2, 17.7 and 21.2 % at site 2 as compared to control.

Molla Sadeghi (2010) observed that the optimal effect of humic materials with natural origin has been observed in biotic and abiotic stresses conditions. Humic acids have important properties that contribute to increasing rooting and shoot germination.

Patil *et al*. (2010) indicated that DPJ with potassium humate treated crop plants showed significant increase on seed germination and seedling growth of wheat and jowar than either potassium humate (1.0%), DPJ or control.

Mollasa deghi (2011) reported that the impact of potassium humate on drought stress decreased and difference between yields under stress and no stress condition decreased from 1 to 0.1 t $ha^{-1}$ in wheat cultivars.

Patil (2011) observed that potassium humate treated plant showed significant increase on growth and yield characters of soybean and black-gram than control plant.

Prakash *et al.* (2011) reported that humic acid influences the growth of sorghum plants.

Patil *et al*. (2011) reported that, Potassium humate (1.0%) treated crop plants showed significantly increased on nutrients uptake of *Glycine max*, *Phaseolus mungo* and *Triticum aestivum* than control plants.

Humin tech (2012) observed that beneficial effects of humic substances on plant growth, mineral nutrition, seed germination, seedling growth, root initiation, root growth, shoot development.

Moraditochaee (2012) reported that humic acid foliar spraying and nitrogen management on all traits were significant at 1% probability level. Interaction effect of humic acid and nitrogen management on seed yield, straw yield and harvest index showed significant differences at 5% probability level. Also on biological yield was non-significant.

Miyauchi *et al*. (2012) obtained that the humic substance had no significant effect on stem length, node number and branch number, but improved seed yields by 6 to 32%. It increased pod number per plant by increasing pod setting, although there was no significant effect on cumulated flower number. The humic substance did not affect the mean leaf area in dices, crop growth rates and net assimilation rates, but increased pod growth rates during the later pod filling period. It also did not affect the $CO_2$ assimilation rate, quantum yield of photo-system II or chlorophyll content. Thus, increasing pod number by plant hormone-like substances in the humic substance was considered to stimulate the trans-location of assimilate toward pods, leading to an increase in seed yield.

Rafat *et al.* (2012) studied that drought reduced seed number in row, seed number per ear, seed weight per ear, seed length, seed weight, grain yield and harvest index. Potassium humate application increased drought tolerance. Grain yield under water deficit situation was higher than in control, but reduction by using potassium humate was lower. The highest grain yield (1539 g $m^{-2}$) was obtained under irrigation after 100 mm evaporation and 2% potassium humate application and the least grain yield (1186 g $m^{-2}$) was obtained without application of potassium humate.

Ajalli *et al*. (2013) revealed that significant effect of potassium Humate, variety and interaction of potassium humate and variety on the studied traits. Savalan and Agra produced the most stem numbers per plant when 300 ml $ha^{-1}$ Potassium humate was used.

Kaizer and Agria (2014) also produced higher plants, whereas the shortest ones were observed in Markiz. Application of 250 and 300 ml $ha^{-1}$ Potassium Humate increased plant height significantly.

## CHAPTER III

# MATERIALS AND METHODS

The experiment was conducted to find out the growth, development and yield of modern rice varieties in aerobic condition. The details of the materials and methods i.e. experimental period, location, soil and climatic condition of the experimental area, materials used treatment and design of the experiment, growing of crops, data collection and data analysis procedure that followed in this experiment has been presented under the following headings:

### 3.1 Experimental period

The field experiments were conducted during the period of November, 2017 to May, 2018.

### 3.2 Description of the experimental site

#### 3.2.1 Location of the experimental field

The experiment was carried out on the farm of Sher-e-Bangla Agricultural University, Dhaka. The location of the site is $23^{0}74^{/}$ N latitude and $90^{0}35^{/}$ E longitude with an elevation of 8.2 meter from sea level.

#### 3.2 2 Characteristics of the soil

belonging to the ago-ecological zone of Madhapur Tract (AEZ-28). The soil belongs to "The Madhapur Tract; AEZ–28 (FAO, 1988). Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish-brown mottles. Soil pH was 5.6 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land.

#### 3.2.3 Climate

The geographical location of the experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October (Edris *et al*., 1979). Details of the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e Bangla Nagar, presented in Appendix 2.

### 3.3 Plant material

In this research, two high yielding rice varieties were used as a plant material. BRRI dhan29 and BRRI dhan45 was used for the experiment as test crop. The seeds were collected from the Bangladesh Rice Research Institution (BRRI) Joydapur, Gazipur.

**3.4 Experimental design**

The experimental was laid out in a randomized complete block Design (RCBD) with three replications having 10 treatment combinations. There were 30 plots of size 3 m × 1.5 m in each of 3 replications. The treatments of the experiment were assigned at random into each replication. The layout of the experiment was shown in Fig.1.

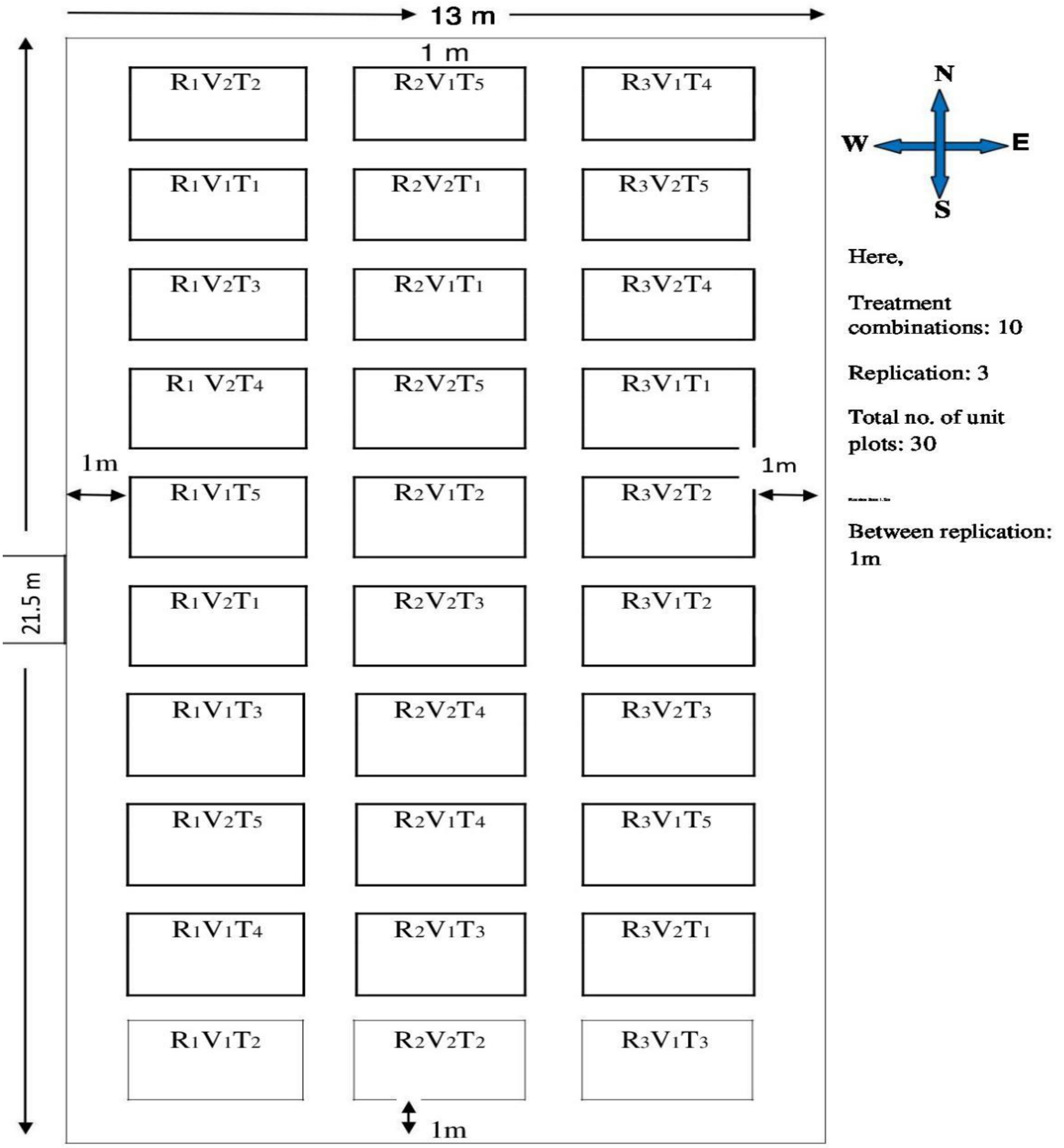


**Figure 1: Layout of experimental field**

### 3.5 Treatments

The experiment was conducted to justify the performance of two hybrid rice varieties in *Boro* season. The experiment consisted of two factors as mentioned below:

**Factor A:** Variety (2)

(i) BRRI dhan29 ($V_1$)
(ii)BRRI dhan45 ($V_2$)

**Factor B:** PGR and fertilizer management:

| | |
|---|---|
| $T_1$: Recommended fertilizer dose (control) | $T_4$: Recommended fertilizer dose+Akota + Global |
| $T_2$: Recommended fertilizer dose+Akota | $T_5$: Recommended fertilizer dose+Akota + Akota |
| $T_3$: Recommended fertilizer dose+Global | |

**Treatment Combinations**

| | |
|---|---|
| $T_1V_1$: Recommended fertilizer dose(control) | $T_1V_2$: Recommended fertilizer dose(control) |
| $T_2V_1$: Recommended fertilizer dose+Akota | $T_2V_2$: Recommended fertilizer dose+ Akota |
| $T_3V_1$: Recommended fertilizer dose+Global | $T_3V_2$: Recommended fertilizer dose+Global |
| $T_4V_1$: Recommended fertilizer dose+Akota + Global | $T_4V_2$: Recommended fertilizer + Akota + Global |
| $T_5V_1$: Recommended fertilizer dose+ Akota + Akota | $T_5V_2$: Recommended fertilizer dose+Akota + Akota |

### 3.6. Method of PGS application

PGR was dispensed @ 200 ml humic acid or Fulvic acid per 20-liter water for 1 hectare every time. It was applied 4 times during the entire crop cycle. Before seed sowing in seed bed, seed were soaked with PGR for 1-2 minutes @ 200 ml per 20 litter water. In main field, it was applied before transplanting and 30 DAT in concern plot with same rate. Finally, it was applied before and after Panicle initiation.

### 3.7 Procedure of experiment

#### 3.7.1 Raising seedling

##### 3.7.1.1 Seed collection

Vigorous and healthy seeds of BRRI dhan29 and BRRI dhan45 were collected from BRRI (Bangladesh Rice Research Institute), Gazipur, Bangladesh.

### 3.7 .1.2 Seed sprouting

Healthy seeds were kept 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 after 72 hours.

### 3.7.1. 2 Preparation of nursery bed and seed sowing

As per BRRI recommendation seedbed was prepared with 1 m wide adding nutrients as per the requirements of soil. Seeds were sown in the seed bed on 20 December, 2016 in order to transplant the seedlings in the main field.

### 3.7.2 Preparation of the main field

The plot selected for the experiment was opened in the first week of 24 January 2017 with a power tiller, and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilt. Weeds and stubble were removed, and finally obtained a desirable tilt of soil for transplanting of seedlings.

### 3.7.3 Fertilizers and manure application

The fertilizers N, P, K, S and B in the form of urea, TSP, MoP, Gypsum and borax, respectively were applied. The entire amount of TSP, MoP, Gypsum, Zinc sulphate and borax were applied during the final preparation of land. Urea was applied in three equal installments at post recovery, tillering and before Panicle initiation stage. The dose and method of application are shown in Table 1.

**Table 1.** Dose and method of application of fertilizers in rice field

| Fertilizers | Dose(kg $ha^{-1}$) | | Application (%) | | |
|---|---|---|---|---|---|
| | | Balas | 1st installment | 2nd installment | 3rd installment |
| Urea | 220 | 0 | 33.33 | 33.33 | 33.33 |
| TSP | 150 | 100 | -- | -- | -- |
| MoP | 180 | 100 | -- | -- | -- |
| Gypsum | 70 | 100 | -- | -- | -- |

### 3.7.4 Uprooting of seedlings

The nursery bed was made wet by application of water one day before uprooting the seedlings. The seedlings were uprooted on January 25, 2017 without causing much mechanical injury to the roots.

### 3.7.5 Transplanting of seedlings in the field

The seedlings were transplanted in the main field on 25 the January, 2017 with a spacing 15 cm from hill to hill and 20 cm from row to row.

### 3.7.6 Intercultural operations:

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of the rice seedlings.

#### 3.7.6.1 Irrigation and drainage

Flood irrigation was given to maintain a constant level of standing water up to 3 cm in the early stages to enhance tillering and 4-5cm in the later stage to discourage late tillering. The field was finally dried out at 15 days before harvesting.

#### 3.7.6.1 Gap filling

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

#### 3.7.6.2 Weeding

The crop was infested with some common weeds, which were controlled by uprooting and remove them three times from the field during the period of experiment. Weeding was done after 15, 32 and 52 days of transplanting.

#### 3.7.6.3 Top dressing

The urea fertilizer was top-dressed in 3 equal installments at 10 days after transplanting at tillering stage and before Panicle initiation stage.

#### 3.7.6.4 Plant protection

There was some incidence in insects specially grasshopper, stem borer, rice ear cutting caterpillar, trips and rice bug which was controlled by spraying Curator 5 G and Smithton. Brown spot of rice was controlled by spraying Tilt.

### 3.9 Harvesting, threshing and cleaning

The rice plant was harvested depending upon the maturity of plant and harvesting was done manually from each plot. The BRRI dhan34 was harvested on 24 November 2014. The harvested crop of each plot was bundled separately, properly tagged and brought to threshing floor. Enough care was taken for harvesting, threshing and also cleaning of rice seed. Fresh weight of grain and straw were recorded plot wise. The grains were cleaned and finally the weight was adjusted to a moisture content of 12%. The straw was sun dried and the yields of grain and straw plot$^{-1}$ were recorded and converted to t ha$^{-1}$.

### 3.10 Data recording

The following data were collected during the study period:
The data will be collected and recorded:

1. Plant height
2. Total tillers hill$^{-1}$
3. Effective tillers hill$^{-1}$
4. Non-effective tillers hill$^{-1}$
5. Leaf area index
6. Flag leaf chlorophyll content
7. Panicle length
8. Filled grains panicle$^{-1}$
9. Un-filled grains pancle$^{-1}$
10. Total grains panicle$^{-1}$
11. 1000 –grain weight
12. Grain yield ha$^{-1}$
13. Biological yield ha$^{-1}$
14. Straw yield ha$^{-1}$
15. Harvest index

### 3.11 Procedure of recording data

#### 3.11.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of harvest. Data were recorded as the average of same 5 plants pre-selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the plant.

#### 3.11.2 Number of total tillers hill$^{-1}$

Total tillers which had at least one leaf visible were counted. It includes both productive and unproductive tillers.

#### 3.11.3 Number of effective tillers hill$^{-1}$

The total number of effective tillers hill$^{-1}$ was counted as the number of panicles bearing hill plant$^{-1}$. Data on effective tillers hill$^{-1}$ were counted from 5 selected hills at harvest and average value was recorded.

### 3.11.4 Number of non-effective tillers hill$^{-1}$

The total number of non-effective tillers hill$^{-1}$ was counted as the number of Panicle bearing tillers plant$^{-1}$. Data on non-effective tiller hill$^{-1}$ were counted from 5 selected hills at harvest and average value was recorded.

### 3.11.5 Panicle length

The length of Panicle was measured with a meter scale from 10 selected panicles and the average value was recorded.

### 3.11.6 Number of filled grains panicle$^{-1}$

The total number of filled grains was collected randomly from selected 5 plants of a plot and then average number of filled grains panicle$^{-1}$ was recorded.

### 3.11.7 Number of unfilled grains panicle$^{-1}$

The total number of unfilled grains was collected randomly from selected 5 plants of a plot and then average number of unfilled grains panicle$^{-1}$ was recorded.

### 3.11.8 Total grains panicle$^{-1}$

The total number of grains was calculated by adding filled and unfilled grains and then average number of grains panicle$^{-1}$ was recorded.

### 3.11.9 1000 seed weight

One thousand seeds were counted randomly from the total cleaned harvested seeds of each individual plot and then weighed in grams and recorded.

### 3.11.10 Grain weight ha$^{-1}$

Grains obtained from each unit plot were sun-dried and weighed carefully. The central 3 lines from each plot were harvested, threshed, dried, weighed and finally converted to t ha$^{-1}$ basis.

### 3.11.11 Straw weight ha$^{-1}$

Straw obtained from each unit plot were sun-dried and weighed carefully. The dry weight of straw of central 3 lines were harvested, threshed, dried and weighed and finally converted to t ha$^{-1}$ basis.

### 3.11.12 Harvest index

The harvest index was calculated with the following formula:

Harvest index = (Grain yield ÷ Biological yield) x 100
Biological yield = Grain yield + Biological yield

### 3.12 Statistical Analysis

All the data collected on different parameters wear statistically analysed following the analysis of variance (ANOVA) technique using MSTAT-C computer package program and the mean difference were adjudged by least significant difference (LSD) test at 5% level of significance.

CHAPTER IV

# RESULTS AND DISCUSSION

The present investigation entitled “Effect of plant growth stimulator on the growth and yield of hybrid rice varieties.” The findings obtained from the study have been presented, discussed and compared in this chapter through different tables and figures. The analyses of variance (ANOVA) and other table on different parameters have been presented in Appendices III-XIII. 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 Growth performance

### 4.1.1 Plant height

#### 4.1.1.1 Effect of variety

Statistically Significant variation was recorded for plant height between the two rice varieties at 40, 60, 80, 100 days after transplanting and at harvest (Figure 2 and Appendix III). Data revealed that at 40, 60, 80, 100 DAT and at harvest, the tallest plant (33.41, 49.54, 65.16, 94.91 and 101.76 cm respectively) was observed from BRRI dhan29, whereas the shortest plant (28.42, 4610, 63.96, 93.45 and 96.07 respectively) was recorded from BRRIdhan45.

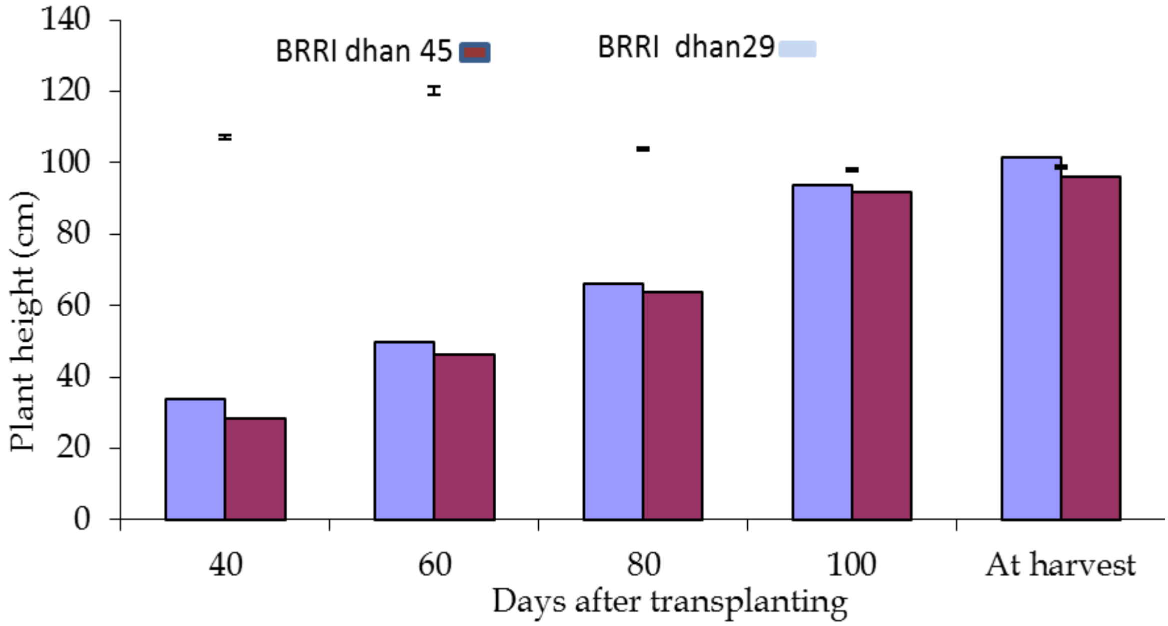


**Figure 2.** Effect of variety on the plant height of modern rice at different days after transplanting. (Vertical bar shows LSD value at % probability level)

#### 4.1.1.2. Effect of different level of PGS and fertilizer management

Significantly different variation was observed in case of different PGS and fertilizer application in terms of plant height of rice at 40, 60, 80, 100 DAT and at harvest (Figure 3 and Appendix III). Among the different treatments the maximum plant height (33.88, 49.45, 66.65, 94.83 and 100 respectively) observed from $T_5$ followed by $T_4$ and $T_3$ as per with $T_2$ whereas the shortest plant height (28.70, 46.70, 63.60, 87.85 and 97.28 respectively) were recorded from $T_1$. The results of the study were supported by the findings of Shayganya *et al.* (2011).

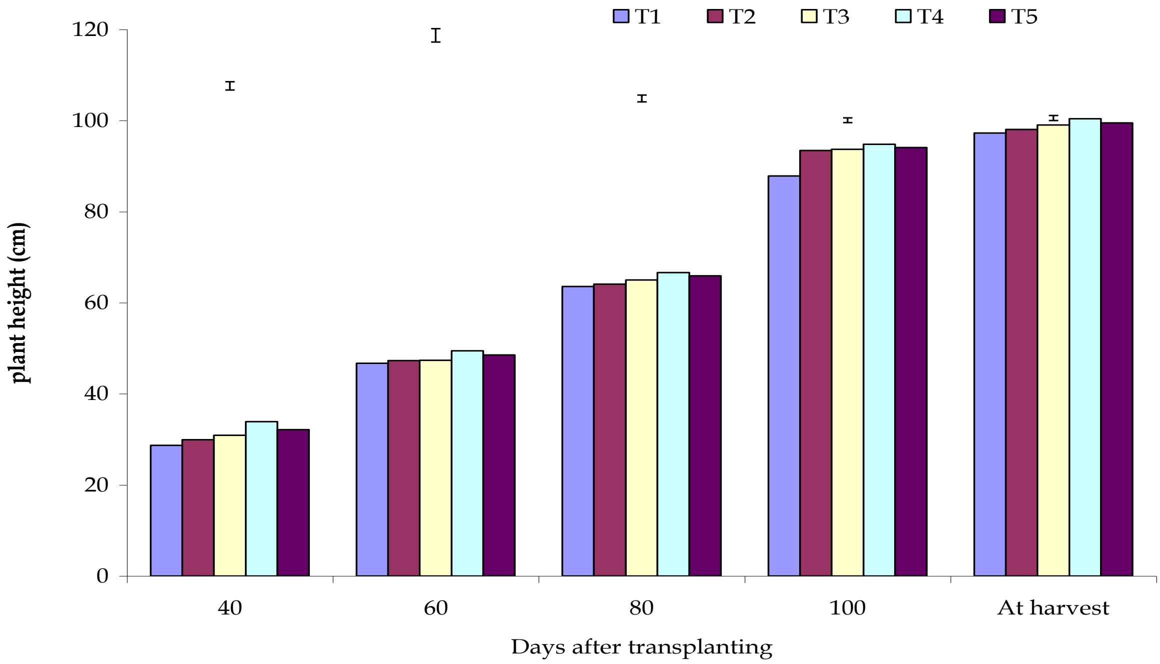


**Figure 3.** Effect of different levels of Akota and Global on plant height of modern rice varieties at DAT. (Vertical bar shows LSD value at 5% probability level)

$T_1$= Recommended fertilizer dose
$T_2$= Recommended fertilizer dose + Akota
$T_3$ = Recommended fertilizer dose + Global
$T_4$= Recommended fertilizer dose + Akota + Global
$T_5$= Recommended fertilizer dose + Akota + Akota

#### 4.1.1.3 Interaction effect of different varieties and levels of PGS and fertilizer management

Different varieties and levels of PGS and fertilizer management expressed significant differences due to their interaction effect on plant height of rice at 40, 60, 80, 100 DAT and at harvest (Table 3 and Appendix III). Significantly the maximum plant height (35.73, 51.20, 68.39, 96.60 and 103.10 cm) at 40, 60, 80, 100 DAT and at harvest, respectively from the treatment of BRRI *dhan29* × $T_4$ (Recommended fertilizer dose + Akota + Global) which was identical to the treatment interaction of BRRI *dhan29* × $T_5$ (Recommended fertilizer dose + Akota + Akota) While, the shortest plant (25.27, 45.03, 62.77, 90.50 and 94.47 cm) at 40, 60, 80, 100 DAT and at harvest respectively was obtained from the combined treatment of BRRI *dhan45* × $T_1$ (Recommended fertilizer dose).

**Table 2:** Effect of variety and doses of Akota and Global on plant height of modern rice at DAT

| Treatment combination | | Plant height (cm) (DAT) | | | | |
|---|---|---|---|---|---|---|
| | | 40 | 60 | 80 | 100 | At harvest |
| BRRI dhan29 | $T_1$ | 32.13 c | 48.37 bc | 64.43 | 81.2 e | 100.10 |
| | $T_2$ | 32.57 bc | 48.80 abc | 65.00 | 95.83 a | 101.43 |
| | $T_3$ | 33.57 b | 48.90 abc | 65.63 | 95.83 a | 101.53 |
| | $T_4$ | 35.73 a | 51.20 a | 68.39 | 96.60 a | 103.10 |
| | $T_5$ | 35.07 a | 50.93 b | 67.33 | 96.10 a | 102.17 |
| BRRI dhan45 | $T_1$ | 25.27 f | 45.03 f | 62.77 | 90.50 e | 94.47 |
| | $T_2$ | 27.30 e | 45.77 ef | 63.20 | 91.13 de | 94.77 |
| | $T_3$ | 28.25 de | 45.90 ef | 64.43 | 93.07 b | 96.57 |
| | $T_4$ | 32.03 d | 47.70 cde | 64.92 | 92.1o c | 97.67 |
| | $T_5$ | 29.23 e | 46.10 def | 64.50 | 94.3 b | 96.87 |
| $LSD_{0.05}$ | | 1.43 | 2.31 | - | .833 | - |
| Level of significance | | * | * | NS | ** | NS |
| CV (%) | | 2.67 | 2.81 | 1.08 | o.52 | 0.51 |

Values in column having different letter are significantly different and sameletter are not significantly different at 0.05 level of probability.

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

$T_1$ = Recommended fertilizer dose
$T_2$= Recommended fertilizer dose + Akota
$T_3$= Recommended fertilizer dose + Global
$T_4$= Recommended fertilizer dose + Akota + Global
$T_5$= Recommended fertilizer dose + Akota+ Akota
CV = Coefficient of variation, LSD0.05 = Least Significant Difference

### 4.1.2. Total tillers hill$^{-1}$

#### 4.1.2.1. Effect of variety

Statistically Significant variation was recorded for number of tillers hill$^{-1}$ between the two rice varieties at 40, 60, 80, 100 days after transplanting and at harvest (Figure 2 and Appendix IV). Data revealed that at 40, 60, 80, 100 DAT and at harvest the maximum number of tillers hill$^{-1}$ (12.17, 18.23, 20.06, 18.80 and 18.03 respectively) was observed from BRRI dhan29, whereas the minimum number of tillers hill$^{-1}$ (11.97, 16.70, 18.74, 17.17 and 16.01 respectively) was recorded from BRRI dhan45.

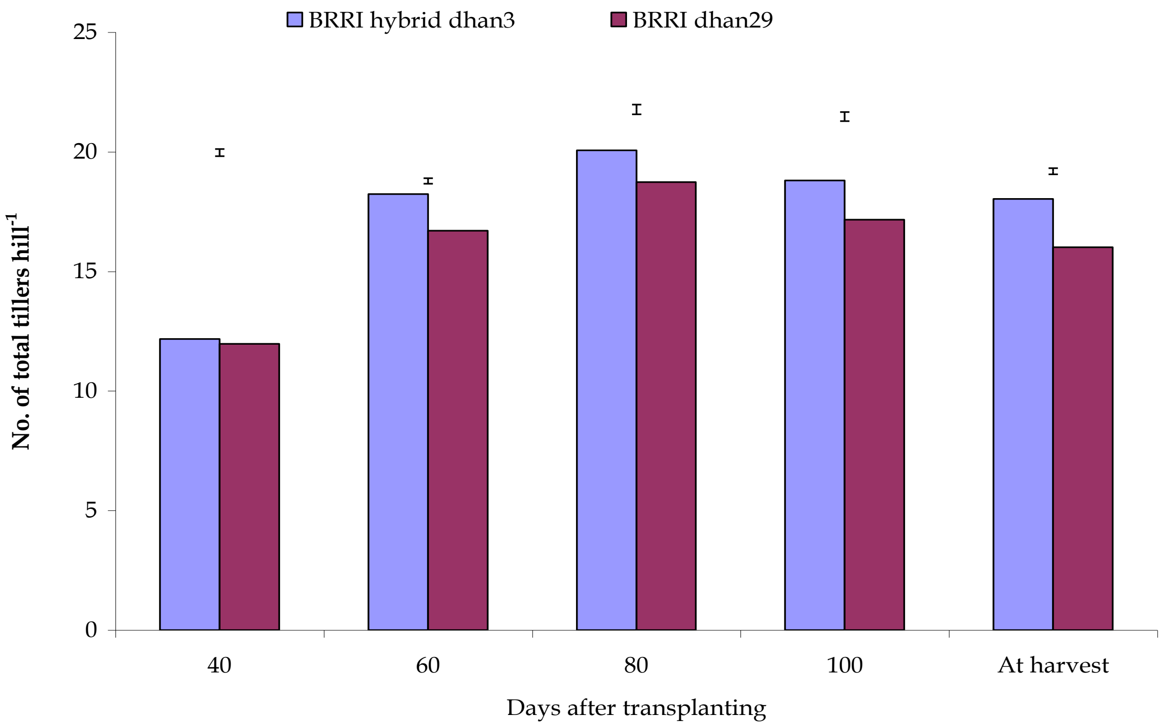


**Figure 4**. Effect of variety on the total number of tiller hill$^{-1}$ of modern rice at DAT in *Boro* season (Vertical bar shows LSD value at % probability level)

#### 4.1.2.2. Effect of PGS and fertilizer management

Significantly different variation was observed in case of different PGS and fertilizer application in terms of total tillers number hill$^{-1}$ of rice at 40, 60, 80, 100 DAT and at harvest (Figure 4 and Appendix IV). Among the different treatments the maximum number of tillers hill$^{-1}$ 13.57, 18.30, 21.55, 19.47 and 18.62, respectively) observed from $T_4$ followed by $T_5$ and $T_3$ at par with $T_2$ whereas the minimum number of tillers hill$^{-1}$ (10.5, 16.50, 17.92, 16.57 and 15.30 respectively) were recorded from $T_1$. The results were supported by the findings of Shayganya *et al*. (2011).

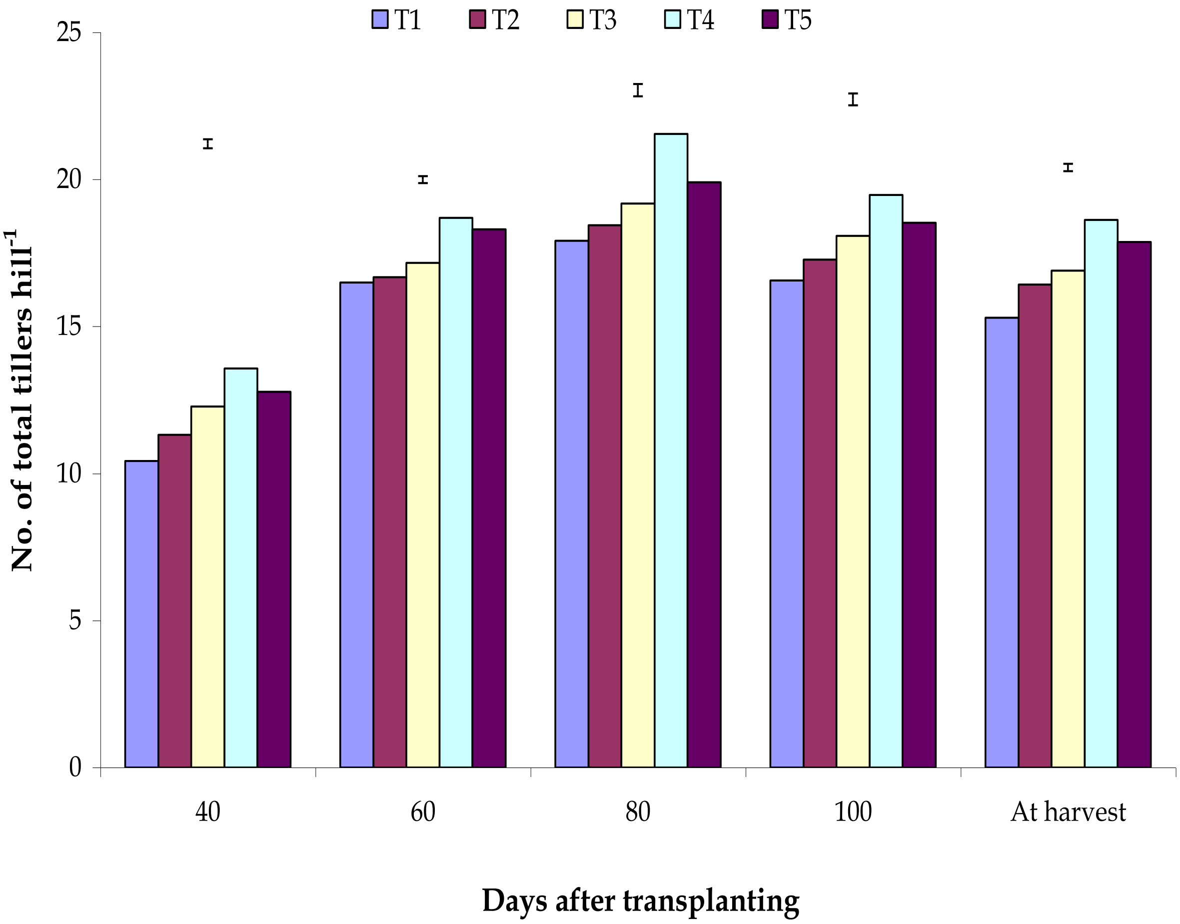


**Figure 5.** Effect of different doses of Akota and Global on number of tillers hill$^{-1}$ at DAT. Vertical bar shows LSD value at 5% probability level).

### 4.1.2.3. Interaction effect of variety and PGS and fertilizer management

Different varieties and levels of PGS and fertilizer management expressed significant differences due to their interaction effect on total number of tillers hill$^{-1}$ at 40, 60, 80, 100 DAT and at harvest (Table 3 and Appendix IV). Significantly the maximum number of tillers hill$^{-1}$ (13.60, 19.50, 20.80, 19.67 and 19.53) at 40, 60, 80, 100 DAT and at harvest respectively from the combination treatment of BRRI *dhan29* × $T_4$ (Recommended fertilizer dose + Akota + Global) which was identical to the treatment interaction of BRRI *dhan29* × $T_5$ (Recommended fertilizer dose + Akota + Akota) While the minimum number of tiller hill$^{-1}$ (10.33, 15.87, 17.23, 15.83, and 14.47) at 40, 60, 80, 100 DAT and at harvest respectively was obtained from the combination treatment of BRRI *dhan45* × $T_1$ (Recommended fertilizer dose).

**Table 3.** Interaction effect of variety and doses of PGS on number of total tillers hill$^{-1}$ of modern rice at DAT in *Boro* season

| Treatment combination | | No. of total tillers hill$^{-1}$ at different days after transplanting (DAT) | | | | |
|---|---|---|---|---|---|---|
| | | 40 | 60 | 80 | 100 | At harvest |
| BRRI dhan29 | $T_1$ | 10.50 f | 17.13 | 18.60 cd | 17.30 cd | 16.13 |
| | $T_2$ | 11.50 de | 17.27 | 19.20 c | 18.03 bc | 17.47 |
| | $T_3$ | 12.37 cd | 18.17 | 20.07b | 19.00 ab | 17.93 |
| | $T_4$ | 13.60 a | 19.50 | 21.63a | 20.00 a | 19.53 |
| | $T_5$ | 12.90 abc | 19.10 | 20.80 ab | 19.67 ab | 19.10 |
| BRRI dhan45 | $T_1$ | 10.33 f | 15.87 | 17.23 e | 15.83 e | 14.47 |
| | $T_2$ | 11.13 ef | 16.07 | 17.70 de | 16.50 de | 15.37 |
| | $T_3$ | 12.20 cd | 16.17 | 18.30 cde | 17.17cd | 15.87 |
| | $T_4$ | 13.53 ab | 17.90 | 21.47 a | 18.93 ab | 17.70 |
| | $T_5$ | 12.67 bc | 17.50 | 19.00 c | 17.40 cd | 16.63 |
| $LSD_{0.05}$ | | 0.891 | 0.677 | 1.21 | 1.16 | 0.750 |
| Level of significance | | ** | NS | ** | ** | NS |
| CV (%) | | 4.30 | 2.26 | 3.64 | 3.75 | 2.57 |

Values in column having different letter are significantly different and same letter are not significantly different at 0.05 level of probability.

** = Significant at 1% level of probability, NS = Not significant
$T_1$= Recommended fertilizer dose
$T_2$ = Recommended fertilizer dose + Akota
$T_3$ =Recommended fertilizer dose + Global
$T_4$ = Recommended fertilizer dose + Akota + Global
$T_5$ = Recommended fertilizer dose + Akota+ Akota
CV = Coefficient of variation     $LSD_{0.05}$ = Least Significant Difference

### 4.1.3. Leaf area index

#### 4.1.3.1. Effect of variety

Leaf area index of two rice varieties varied insignificantly (Figure 6 and Appendix V). The leaf area index ranges from 6.76 to 6.56. The maximum leaf area index was obtained from BRRI dhan29 and the minimum in BRRIdhan45.

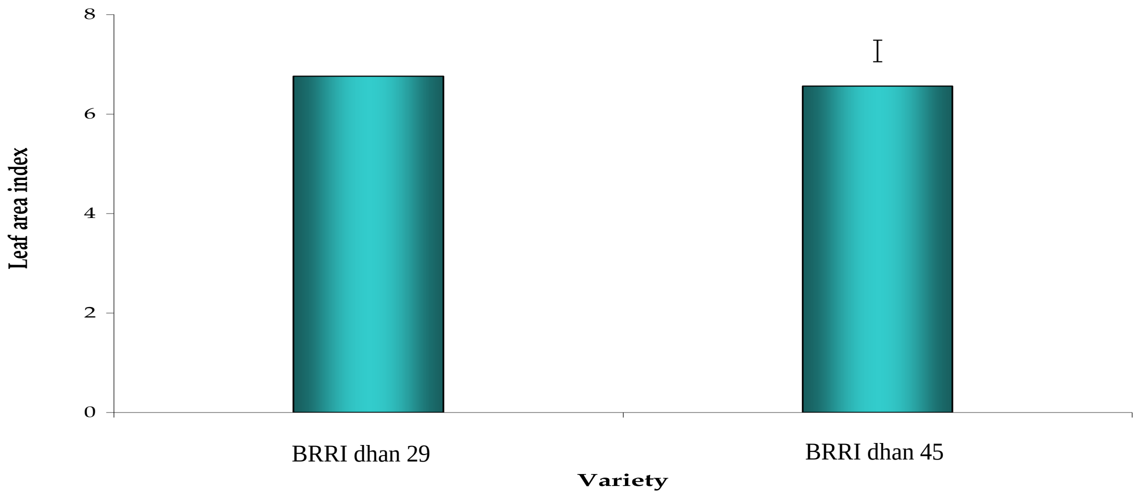


**Figure 6:** Effect of variety on the leaf area index of modern rice at DAT. (Vertical bar shows LSD value at 5% probability level)

**4.1.3.2. Effect of different levels of PGS and fertilizer management**

Statistically significantly variation was recorded for Leaf area index of rice due to different levels of PGS and fertilizer application at 40, 60, 80, 100 days after transplanting (DAT) and at harvest (Figure 7 and Appendix V). The significantly maximum LAI was noted in $T_{\mathbf{4}}$ (Recommended fertilizer dose + Akota + Global) (7.42) at per with $T_5$ (7.17) followed by $T_3$ (6.79) whereas the minimum leaf area index (5.68) was found in $T_1$ (Recommended fertilizer dose).

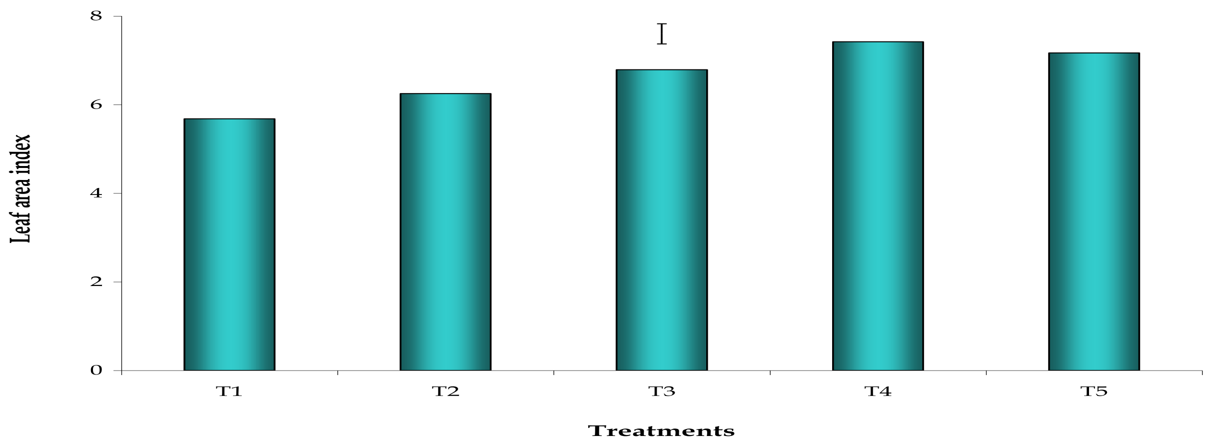


**Figure 7.** Effect of different doses of Akota and Global on the leaf area index of modern rice at DAT (Vertical bar shows LSD value at % probability level)

** = Significant at 1% level of probability, NS = Not significant
$T_1$= Recommended fertilizer dose
$T_2$= Recommended fertilizer dose + Akota
$T_3$ = Recommended fertilizer dose + Global
$T_4$= Recommended fertilizer dose + Akota + Global
$T_5$= Recommended fertilizer dose + Akota + Akota

#### 4.1.3.3. Interaction effect of different variety and levels of PGS and fertilizer management

Interaction effect of different varieties and levels of PGS and fertilizer management showed non-significant variation of leaf area index (LAI) of *Boro* rice at 80 DAT (Table 4). At 80 DAT the maximum (7.33) leaf area index was observed from the interaction of BRRI dhan29 × $T_4$ (Recommended fertilizer dose + Akota + Global) followed by the interaction of BRRI dhan45 × $T_4$ (Recommended fertilizer dose + Akota + Global). The minimum (5.55) leaf area index was noted from the combination effect of BRRI dhan45 × $T_1$ (Recommended fertilizer dose).

### 4.1.4 Chlorophyll content

#### 4.1.4.1. Effects of variety

Chlorophyll content varied significantly due to varieties of rice (Appendix V). The optimum chlorophyll content was observed on the BRRI *dhan*29 whereas the minimum chlorophyll was noted in BRRI dhan 45.

#### 4.1.4.2 Effects of PGR and fertilizer management

This investigation showed that chlorophyll content of rice showed significant variation at different levels of PGS and fertilizer applications (Table 4 and Appendix V). The optimum value of chlorophyll (1.285), was found in $T_4$ (Recommended fertilizer dose + Akota + Global) followed by $T_5$ (Recommended fertilizer dose + Akota +Akota) whereas the lowest value in $T_1$ (Recommended fertilizer dose).

#### 4.1.4.3. Interaction effect of variety and PGS and fertilizer management Chlorophyll content of rice varieties.

Statistically significant variation was found for chlorophyll content due to different levels of PGS and fertilizer application and varieties (Table 5 and Appendix V). The highest value of chlorophyll (1.34) was obtained in the interaction of BRRI dhan29 × $T_4$ (Recommended fertilizer dose + Akota + Global) followed by the interaction of BRRI dhan29 × $T_5$ (Recommended fertilizer dose + Akota + Akota) (1.30) on the other hand the lowest value was observed in the interaction of BRRI dhan45 × $T_1$ (Recommended fertilizer dose).

**Table 4.** Effect of variety and level of fertilizer on leaf area index of modern rice.

| Treatments | LAI | Chlorophyll content |
|---|---|---|
| **Effect of variety** | | |
| BRRI dhan29 | 6.76 | 1.275 a |
| BRRI dhan45 | 6.56 | 1.230 b |
| Level of significance | NS | ** |
| $LSD_{0.05}$ | 0.109 | 0.024 |
| **Effect of different levels of PGS management** | | |
| | | |
| $T_1$ | 5.68 | 1.180 d |
| $T_2$ | 6.25 | 1.252 bc |
| $T_3$ | 6.79 | 1.320 a |
| $T_4$ | 7.42 | 1.225 c |
| $T_5$ | 7.17 | 1.28 ab |
| $LSD_{0.05}$ | 0.171 | 0.038 |
| Level of significance | ** | ** |
| CV (%) | 2.15 | 2.98 |

Value in column having different letter are significantly different and same letter are not significantly different at 0.05 level of probability by DMRT

**Table 5.** Interaction effect of variety and levels of PGS on leaf area index (LAI) and chlorophyll content of modern rice

| Treatment combination | | LAI | Chlorophyll content |
|---|---|---|---|
| BRRI dhan29 | $T_1$ | 5.80 gh | 1.21 |
| | $T_2$ | 6.35 ef | 1.25 |
| | $T_3$ | 6.90 cd | 1.27 |
| | $T_4$ | 7.50 a | 1.34 |
| | $T_5$ | 7.23 abc | 1.30 |
| BRRI dhan45 | $T_1$ | 5.55 h | 1.15 |
| | $T_2$ | 6.15 fg | 1.20 |
| | $T_3$ | 6.67 de | 1.23 |
| | $T_4$ | 7.33 a | 1.30 |
| | $T_5$ | 7.10 ab | 1.27 |
| LSD0.05 | | 0.41 | 0.054 |
| Level of significance | | NS | NS |
| CV (%) | | 5.15 | 2.98 |

Values in column having different letter are significantly different and same letter are not significantly different at 0.05 level of probability by DMRT.

NS = Not significant
$T_1$= Recommended fertilizer dose
$T_2$ = Recommended fertilizer dose + Akota
$T_3$= Recommended fertilizer dose + Global
$T_4$ = Recommended fertilizer dose + Akota + Global
$T_5$ = Recommended fertilizer dose + Akota+ Akota
CV = Coefficient of variation
LSD0.05 = Least Significant Difference

### 4.2. Yield component

### 4.2.1 Panicle length

#### 4.2.1.1. Effect of variety

Significantly variation was recorded for Panicle length due to varieties of rice (Table 6 and Appendix VI). Significantly the longest (25.83cm) Panicle was observed in BRRI dhan29, whereas the shortest (23.72 cm) Panicle length was obtained from BRRIdhan29.

#### 4.2.1.2. Effect of PGS and fertilizer management

Panicle length of rice variation were found significantly due to different levels of PGS and fertilizer applications (Table 6 and Appendix VI) statistically the longest (25.32 cm) Panicle was found in $T_4$ (Recommended fertilizer dose +Akota + Global) followed by (23.73 cm) with $T_5$ (Recommended fertilizer dose +Akota +Akota) other hand the shortest (22.73cm) Panicle length was obtained from $T_1$ (Recommended fertilizer dose)

#### *4.2.1.3.* Interaction effect of variety and PGS and fertilizer management

Significant interaction between PGS and fertilizer levels and variety were observed on Panicle length of rice (Table 6 and Appendix VI). The interaction result showed that the interaction of BRRI dhan29 × $T_4$ (Recommended fertilizer dose + Akota + Global) produced the longest (27.57 cm) Panicle length followed by the combination of BRRI dhan29 × $T_4$ (Recommended fertilizer dose + Akota + Global) and the shortest (22.73cm) Panicle length was counted in the interaction of BRRI dhan45 × $T_1$ (Recommended fertilizer dose).

### 4.2.2. Effective panicles hill$^{-1}$

#### 4.2.2.1. Effect of variety

Significantly variation was recorded for the number of effective panicles hill$^{-1}$ due to rice varieties (Table 7 and Appendix VI). The maximum number of effective tillers hill$^{-1}$ (16.71) was noted from BRRI dhan29 whereas the minimum number of effective panicles hill$^{-1}$ (15.24) was obtained from BRRI dhan45.

#### 4.2.2.2. Effect of PGS and fertilizer management

Number of effective tillers significantly varied due to different levels of PGS and fertilizer application (Table 6 and Appendix VI). The optimum value (17.65) of effective tiller was observed from $T_4$ (Recommended fertilizer dose + Akota + Global) whereas the minimum value (14.52) was obtained from $T_1$ (Recommended fertilizer dose).

**Table 6.** Effect of variety and levels of fertilizer on yield and yield contributing characters of modern rice

| Treatments | Panicle height (cm) | Number of total effective tillers hill$^{-1}$ | Number of effective tillers hill$^{-1}$ | No of non-effective tillers hill$^{-1}$ | No of filled grains panicle$^{-1}$ | No of unfilled grains panicle$^{-1}$ | 1000 grain weight (g) |
|---|---|---|---|---|---|---|---|
| **Effect of variety** | | | | | | | |
| BRRI dhan29 | 25.83a | 17.77a | 16.71a | 1.06b | 192.83a | 8.84b | 28.39a |
| BRRI dhan45 | 23.72b | 16.62b | 15.24b | 1.38a | 129.57b | 13.55a | 20.37b |
| $LSD_{0.05}$ | 0.449 | 0.300 | 0.266 | 0.073 | 2.56 | 0.547 | 0.216 |
| Level of significance | ** | ** | ** | ** | ** | ** | ** |
| **Effect of different levels of fertilizer** | | | | | | | |
| $T_1$ | 23.73 d | 15.97 d | 14.52e | 1.455 a | 151.5 d | 13.28a | 23.92c |
| $T_2$ | 24.03 cd | 16.66 c | 15.27d | 1.395 a | 157.8 c | 11.89b | 24.27b |
| $T_3$ | 24.58 c | 17.01 c | 15.77c | 1.243 b | 160.1bc | 11.38b | 24.43b |
| $T_4$ | 26.22a | 18.57a | 17.65a | 0.916 d | 172.9 a | 9.218 d | 24.82a |
| $T_5$ | 25.32b | 17.76b | 16.68b | 1.082 c | 163.7 b | 10.20c | 24.47b |
| $LSD_{0.05}$ | 0.710 | 0.475 | 0.420 | 0.115 | 4.05 | 0.865 | 0.341 |
| Level of significance | ** | ** | ** | ** | ** | ** | ** |
| CV (%) | 2.36 | 2.28 | 2.17 | 7.87 | 2.07 | 6.37 | 1.15 |

Values in column having different letter are significantly different and same letter are not significantly different at 0.05 level of probability.

** = Significant at 1% level of probability, NS = Not significant
T1 = Recommended fertilizer dose
T2 = Recommended fertilizer dose + Akota
T3 = Recommended fertilizer dose + Global
T4 = Recommended fertilizer dose + Akota + Global
T5 = Recommended fertilizer dose + Akota+ Akota
CV = Coefficient of variance LSD$_{0.05}$ = Least Significant Difference

#### 4.2.2.3. Interaction effect of variety and PGS and fertilizer management

Significant interaction between PGS and fertilizer levels and variety were found in effective tillers hill$^{-1}$ (Table 7 and Appendix VI). The superior number of effective tiller hill$^{-1}$ (18.07) was noted in the interaction of BRRI dhan29 × $T_4$ (Recommended fertilizer dose + Akota + Global) treatment. The inferior number of effective tillers hill$^{-1}$ was counted from the interaction of BRRI dhan45 × $T_1$ (Recommended fertilizer dose) treatment.

### 4.2.3. Filled grains panicle$^{-1}$

#### 4.2.3.1. Effect of variety

Significantly variation was found for number of filled grains panicle$^{-1}$ due to different varieties exerted (Table 7 and Appendix VI). The maximum number of filled grains pancle$^{-1}$ (192.83) was recorded in case of BRRI dhan29 whereas the minimum number of filled grain panicle$^{-1}$ (129.57) was found in BRRI dhan45.

#### 4.2.3.2. Effect of PGS and fertilizer management

Statistically significant varied was observed for number of filled grains panicle$^{-1}$ due to different combination of treatment (Table 6 and Appendix VI). Statistically the optimum number of filled grains panicle$^{-1}$ (172.9) was recorded from $T_4$ (Recommended fertilizer dose + Akota + Global) treatment on the other hand the minimum number of filled grain panicle$^{-1}$ (151.5) observed in $T_1$ (Recommended fertilizer dose) treatment.

#### 4.2.3.3. Interaction effect of PGS and fertilizer management and variety

The interaction between PGS and fertilizer levels and variety exerted significant effect on number of filled grain panicle$^{-1}$ of rice (Table 7 and Appendix VI). The highest value (205.4) of filled grain panicle$^{-1}$ was recorded in the interaction of BRRI dhan29 × $T_4$ (Recommended fertilizer dose + Akota + Global) treatment which was statistically similar with all the combined treatments BRRI dhan45 + Akota + Global except the combined effect of BRRI dhan45 × $T_4$ (Recommended fertilizer dose). The poorest filled grain panicle$^{-1}$ (123.6) filled grain was observed in the interaction of BRRI dhan29 × $T_1$ (Recommended fertilizer dose).

**Table 7.** Interaction effect of variety and levels of fertilizer on yield and yield contributing characters of modern rice in *Boro* season

| Treatment combination | | Panicle length (cm) | Effective tillers $hill^{-1}$ | Non-effective tillers $hill^{-1}$ | Filled grains $panicle^{-1}$ | Unfilled grains $panicle^{-1}$ | 1000 grain weight (g) |
|---|---|---|---|---|---|---|---|
| BRRI dhan29 | $T_1$ | 24.73 | 16.38 de | 1.210 c | 179.4 d | 11.07 | 27.87 |
| | $T_2$ | 24.97 | 17.29 b-c | 1.157 c | 189.0 c | 9.60 | 28.43 |
| | $T_3$ | 25.60 | 17.60 b | 1.100 c | 192.6 bc | 9.03 | 28.47 |
| | $T_4$ | 27.57 | 18.82 a | 0.750 d | 205.4 a | 6.67 | 28.70 |
| | $T_5$ | 26.30 | 18.77 a | 1.067 c | 197.8 b | 7.83 | 28.50 |
| BRRI dhan45 | $T_1$ | 22.73 | 15.57 f | 1.700 a | 123.6 f | 15.49 | 19.97 |
| | $T_2$ | 23.10 | 16.03 e-f | 1.633 a | 126.5 f | 14.17 | 20.10 |
| | $T_3$ | 23.57 | 16.42d-e | 1.387 b | 127.7 f | 13.73 | 20.40 |
| | $T_4$ | 24.87 | 18.38 a | 1.083 c | 140.4 e | 11.77 | 20.94 |
| | $T_5$ | 24.33 | 16.76 c-d | 1.097 c | 129.6 f | 12.57 | 20.43 |
| $LSD_{0.05}$ | | - | 0.671 | 0.162 | 0.572 | - | - |
| Level of significance | | NS | * | ** | * | NS | NS |
| CV (%) | | 2.36 | 2.28 | 7.87 | 2.07 | 6.37 | 1.15 |

Values in column having different letter are significantly different and same letter are not significantly different at 0.05 level of probability by DMRT.

** = Significant at 1% level of probability
$T_1$ = Recommended fertilizer dose
$T_2$= Recommended fertilizer dose + Akota
$T_3$ = Recommended fertilizer dose + Global
$T_4$= Recommended fertilizer dose + Akota + Global
$T_5$= Recommended fertilizer dose + Akota+ Akota
CV = Coefficient of variation; $LSD_{0.05}$ = Least Significant Difference

### 4.2.4. 1000 grains weight

#### 4.2.4.1. Effect of variety

Statistically significant variation was observed for weight of 1000 grains (Table7 and Appendix VI). Significantly the maximum (28.39 g) weight of 1000 grains was obtained in BRRI dhan29 and the minimum (20.37 g) weight was observed in BRRIdhan29.

#### 4.2.4.2. Effect of different levels PGS and fertilizer management

Statistically significant variation was found for weight of 1000-grains due to different treatments of PGS and fertilizer excreted (Table 7 and Appendix VI). Significantly optimum (24.82 g) 1000 grains weight was obtained from $T_4$ (Recommended fertilizer dose + Akota + Global) at par with $T_5$ (Recommended fertilizer dose + Akota + Akota) (24.47 g) whereas the poorest (23.92 g) 1000 grains weight was recorded from $T_1$ (Recommended fertilizer dose) treatment. Salt *et al.* (2001) reported a significant increase in 1000 grain weight with the foliar application of micro-nutrients. The similar results were shown by Morard *et al.* (2011) and Yang *et al.* (2004).

#### 4.2.4.3. Interaction effect of variety and PGS and fertilizer management

1000 grain weight was not significant varied due to interaction between varieties and levels of PGS and fertilizer management (g) (Table 8 and Appendix VI). The highest (28.70 g) 1000 grains weight was produced by the interaction of BRRI dhan29 × $T_4$ (Recommended fertilizer dose + Akota+ Global) while the lowest (19.57 g) weight of 1000 grains was found in the interaction of BRRI dhan45 × $T_1$ (Recommended fertilizer dose) treatment.

### 4.2.5. Grain yield

#### 4.2.5.1. Effect of variety

Statistically significant variation was observed for grain yield $ha^{-1}$ due to different varieties (Figure 7 and Appendix VII). Among the two varieties BRRI dhan29 showed the highest grain yield which was 7.286 t $ha^{-1}$. The lowest (5.66 t $ha^{-1}$) grain yield was found in BRRI dhan45.

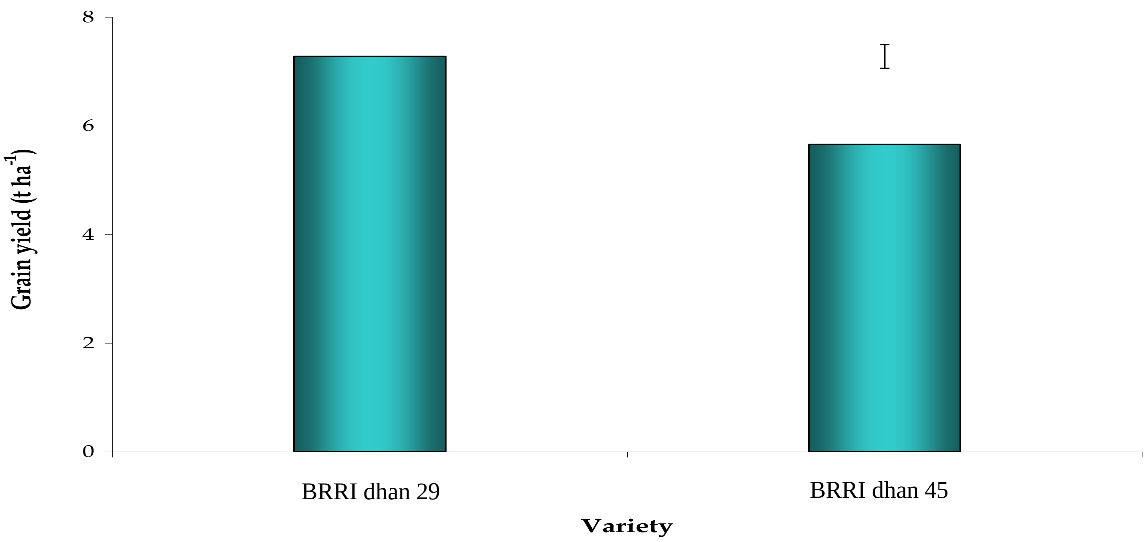


**Figure 8.** Effect of variety on the grain yield of modern rice at DAT. (Vertical bar shows LSD value at 5% probability level)

#### 4.2.5.2. Effects of different levels PGS and fertilizer management

Grain yield was varied significantly due to different PGS and fertilizer management (Figure 8 and Appendix VII). The highest grain yield was produced by $T_4$ (Akota + Global) (6.94 t $ha^{-1}$) followed by $T_5$ (Akota) which was statistically similar (6.68 t $ha^{-1}$) with $T_2$. Whereas the minimum 5.71 t $ha^{-1}$) grain yield was recorded from $T_1$ (Recommended fertilizer dose).

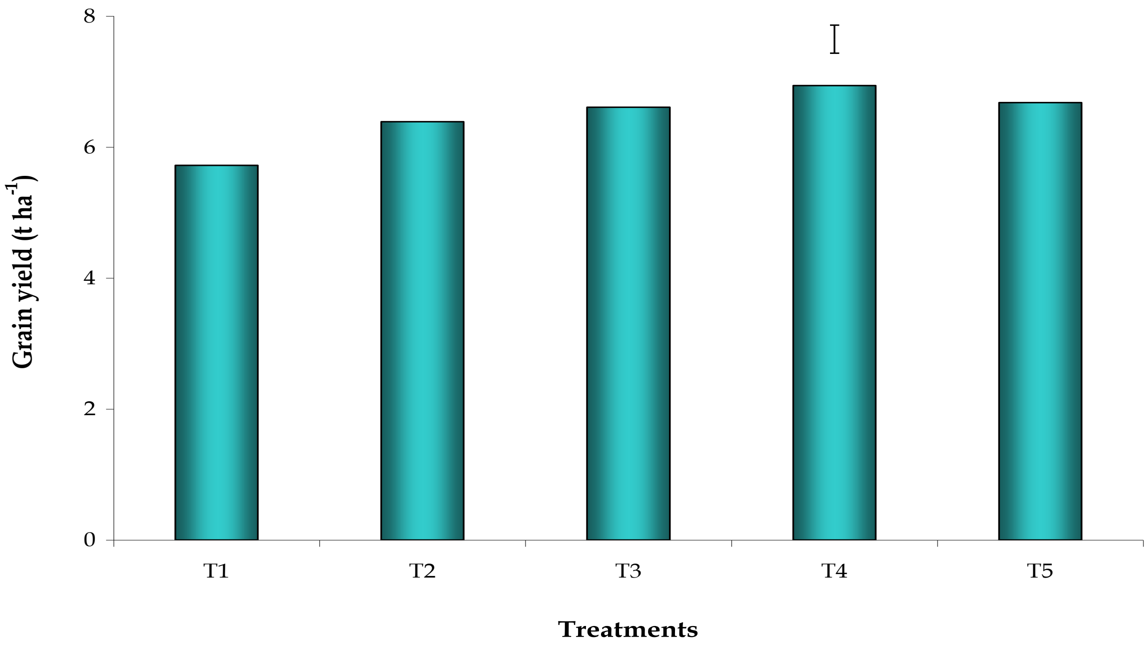


**Figure 9.** Effect of different levels of PGS and fertilizer on the grain yield of modern rice varieties at DAT. (Vertical bar shows LSD value at 5% probability level)

$T_1$ = Recommended fertilizer dose
$T_2$= Recommended fertilizer dose + Akota
$T_3$ = Recommended fertilizer dose + Global
$T_4$= Recommended fertilizer dose + Akota + Global
$T_5$= Recommended fertilizer dose + Akota+ Akota

#### 4.2.5.3. Interaction effect of varieties and levels of PGS and fertilizer management

Grain yield was varied significantly due to the interaction of different levels of PGS and fertilizer management and varieties (Table 8 and Appendix VII). Among the interaction treatments, the highest (7.740 t $ha^{-1}$) grain yield was recorded in the interaction of BRRI dhan29 × $T_4$ (Recommended fertilizer dose + Akota + Global) followed by BRRI hybrid dhan29 × $T_5$ (Recommended fertilizer dose + Akota + Akota). The lowest (4.90 t $ha^{-1}$) grain yield was observed in BRRIdhan45 × $T_1$ (Recommended fertilizer dose).

## 4.2.6 Straw yield

### 4.2.6.1. Effect of variety

Straw yield varied significantly among rice varieties (Figure 10 and AppendixVII). Significantly the highest (8.26 t ha$^{-1}$) straw yield was recorded from BRRI dhan29 whereas the lowest (8.00 t ha$^{-1}$) straw yield was counted in BRRI dhan45.

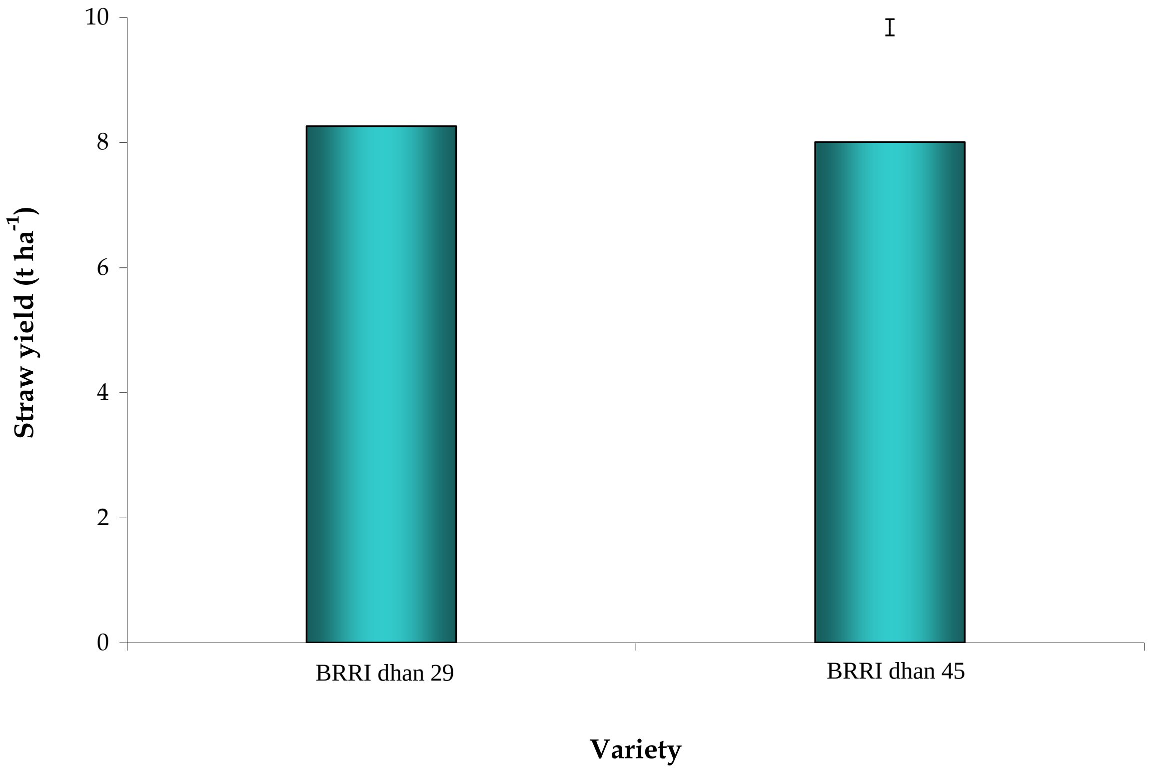


**Figure 10.** Effect of different varieties on the straw yield of rice at DAT. (Vertical bar shows LSD value at 5% probability level)

### 4.2.6.2 Effect of different levels of PGS and fertilizer management

PGS and fertilizer management affected straw yield (t ha$^{-1}$) (Figure 11 and Appendix VII). It was recorded that statistically significant varied of straw yield was found among all the treatments. The investigation found that the optimum (8.932 t ha$^{-1}$) straw yield was obtained from $T_4$ (Recommended fertilizer dose + Akota + Global) followed by $T_5$ (Recommended fertilizer dose + Akota + Akota) as per at $T_3$ (Recommended fertilizer dose + Global) and $T_2$ (Recommended fertilizer dose+ Akota) whereas the lowest (7.76 t ha$^{-1}$) straw yield was recorded from $T_1$ (Recommended fertilizer dose) treatment.

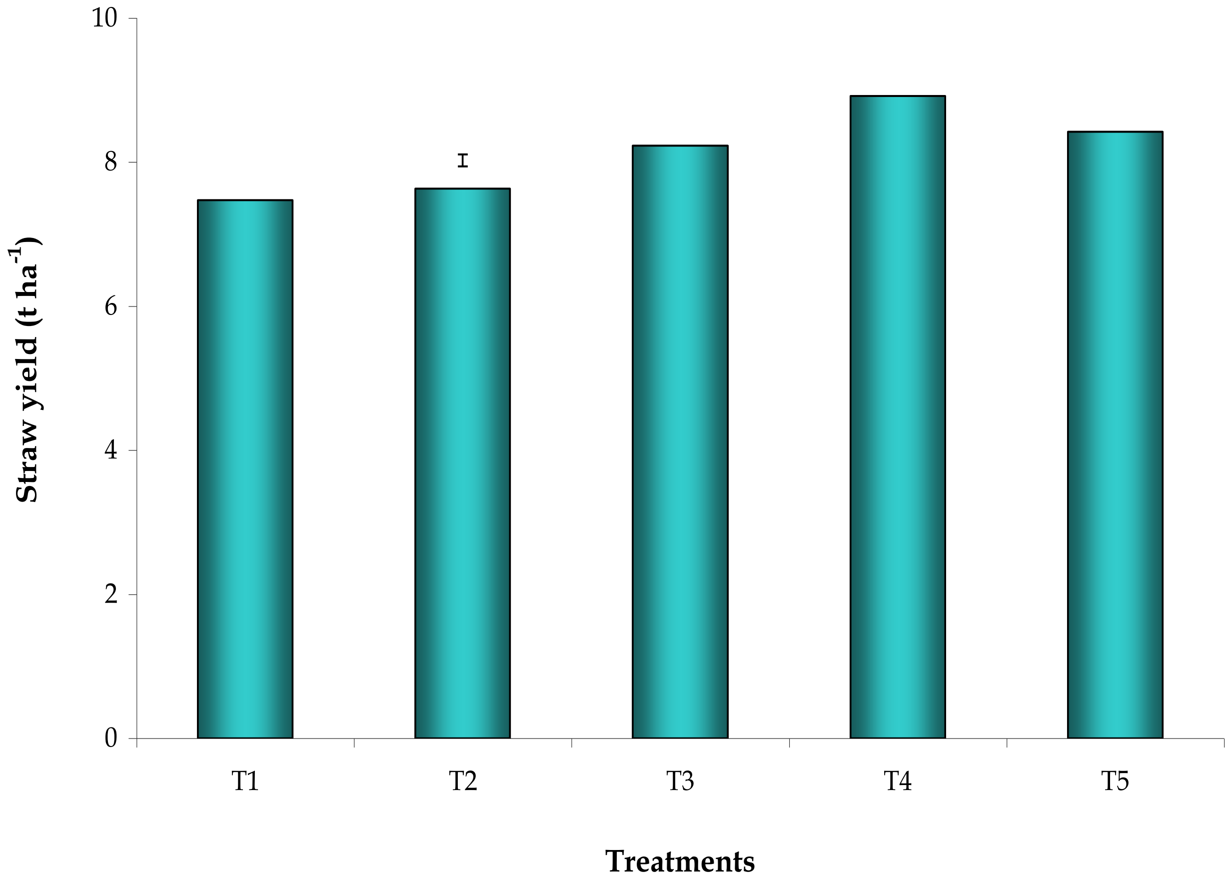


**Figure 11.** Effect of different levels of PGS and fertilizer on the straw yield of modern rice varieties at DAT. (Vertical bar shows LSD value at 5% probability level)

$T_1$= Recommended fertilizer dose
$T_2$= Recommended fertilizer dose + Akota
$T_3$= Recommended fertilizer dose + Global
$T_4$= Recommended fertilizer dose + Akota + Global
$T_5$= Recommended fertilizer dose + Akota+ Akota

#### 4.2.6.3 Interaction effect of variety and PGS and fertilizer management

There were found a significant difference among the interactions of different levels of PGS and fertilizer treatments and varieties in respect of straw yield (t $ha^{-1}$) (Table 8 and Appendix VII). The highest (8.967 t $ha^{-1}$) straw yield was noted from the interaction of BRRI dhan29 × $T_4$ (Recommended fertilizer dose + Akota + Global) which were statistically similar with the interaction of $T_5$ (Recommended fertilizer dose + Akota + Akota) whereas the lowest (7.20 t $ha^{-1}$) straw yield was observed from the interaction of BRRI dhan45 × $T_1$ (Recommended fertilizer dose) treatment.

## 4.2.7. Biological yield

### 4.2.7.1. Effect of variety

Significant variation in biological yield was observed due to varietals difference and it ranges from 13.68 to 15.53 t $ha^{-1}$ (Figure12 and Appendix VII). The maximum biological yield was obtained from BRRI dhan29 and minimum biological yield was obtained from BRRI dhan45 respectively.

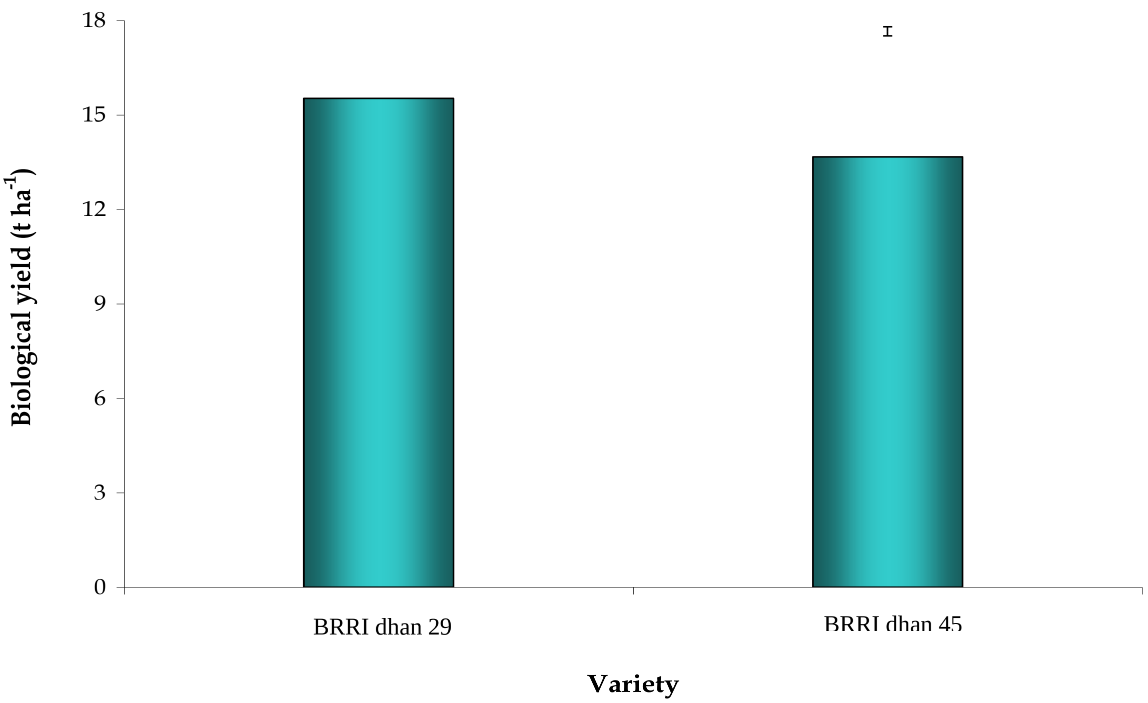


**Figure 12.** Effect of different variety on the biological yield of modern rice at DAT. (Vertical bar shows LSD value at 5% probability level)

### 4.2.7.2 Effect of different levels of PGS and fertilizer management

Biological yield varied significantly due to various treatments of PGS and fertilizer combination (Figure13 and Appendix VII). Significantly maximum (15.86 t $ha^{-1}$) biological yield was observed in $T_4$ (Recommended fertilizer dose +Akota + Global) followed by $T_5$ (Recommended fertilizer dose + Akota +Akota). The lowest (13.18 t $ha^{-1}$) biological yield was recorded at $T_{-1}$ (Recommended fertilizer dose) treatment.

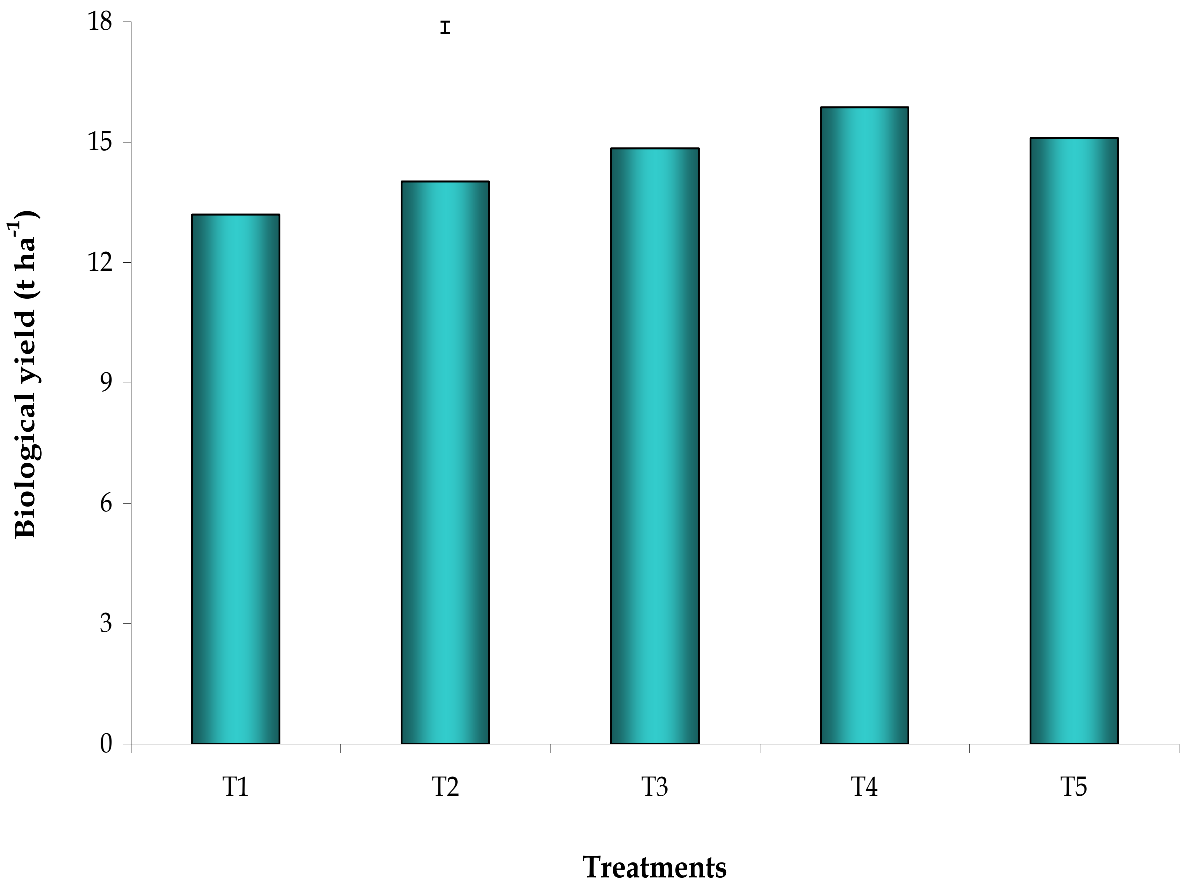


**Figure 13.** Effect of different levels of PGS and fertilizer on the biological yield of modern rice varieties at DAT. (Vertical bar shows LSD value at 5% probability level)

$T_1$ = Recommended fertilizer dose
$T_2$= Recommended fertilizer dose + Akota
$T_3$= Recommended fertilizer dose + Global
$T_4$= Recommended fertilizer dose + Akota + Global
$T_5$ = Recommended fertilizer dose + Akota+ Akota

**4.2.7.3 Interaction effect of variety and PGS and fertilizer management**

Statistically significant variation in biological yield (t $ha^{-1}$) was found due to different interaction of variety and levels of PGS and Fertilizer Management (Table 8 and Appendix VII). The optimum biological yield (16.71 t $ha^{-1}$) was showed by the interaction between BRRI dhan29 × $T_4$ (Recommended fertilizer dose + Akota + Global) that was statistically similar with BRRI dhan29 × $T_5$ (Recommended fertilizer dose + Akota + Akota). The minimum (12.10 t $ha^{-1}$) biological yield was recorded in BRRI dhan45 × $T_1$ (Recommended fertilizer dose) treatment.

**Table 8.** Interaction effect of variety and levels of fertilizer on yield and yield contributing characters of modern rice in *Boro* season

| Treatment combination | | Grain yield (t ha$^{-1}$) | Straw yield (t ha$^{-1}$) | Biological (t ha$^{-1}$) | Harvest index (%) |
|---|---|---|---|---|---|
| BRRI dhan29 | $T_1$ | 6.54 c | 7.73 d | 14.27 e | 45.81 |
| | $T_2$ | 7.34 b | 7.84 d | 15.17 d | 48.35 |
| | $T_3$ | 7.37 b | 8.25 c | 15.62 c | 47.17 |
| | $T_4$ | 7.74 a | 8.96 a | 16.71 a | 46.33 |
| | $T_5$ | 7.40 b | 8.50 b | 15.90 b | 46.54 |
| BRRI dhan45 | $T_1$ | 4.90 g | 7.20 e | 12.10 g | 40.50 |
| | $T_2$ | 5.44 f | 7.42 e | 12.8 f | 42.29 |
| | $T_3$ | 5.85 e | 8.20 c | 14.05 e | 41.64 |
| | $T_4$ | 6.14 d | 8.88 a | 15.02 d | 40.88 |
| | $T_5$ | 5.97 de | 8.33 bc | 14.30 e | 41.74 |
| $LSD_{0.05}$ | | 0.203 | 0.230 | 0.277 | - |
| Level of significance | | * | * | ** | NS |
| CV (%) | | 1.85 | 1.64 | 1.09 | 1.69 |

Values in column having different letter are significantly different and same letter are not significantly different at 0.05 level of probability by DMRT.

* = Significant at 5% level of probability, NS = Not significant
$T_1$= Recommended fertilizer dose
$T_2$= Recommended fertilizer dose + Akota
$T_3$= Recommended fertilizer dose + Global
$T_4$= Recommended fertilizer dose + Akota + Global
$T_5$ = Recommended fertilizer dose + Akota+ Akota
CV = Coefficient of variation; $LSD_{0.05}$ = Least Significant Difference

### 4.2.8. Harvest Index (%)

#### 4.2.8.1 Effect of Variety

Harvest index varied significantly due to varietal differences (Figure 15 and Appendix VII). Significantly highest (46.84%) harvest index was obtained in BRRI dhan29 and the lowest (41.41%) harvest index was observed from BRRI dhan45.

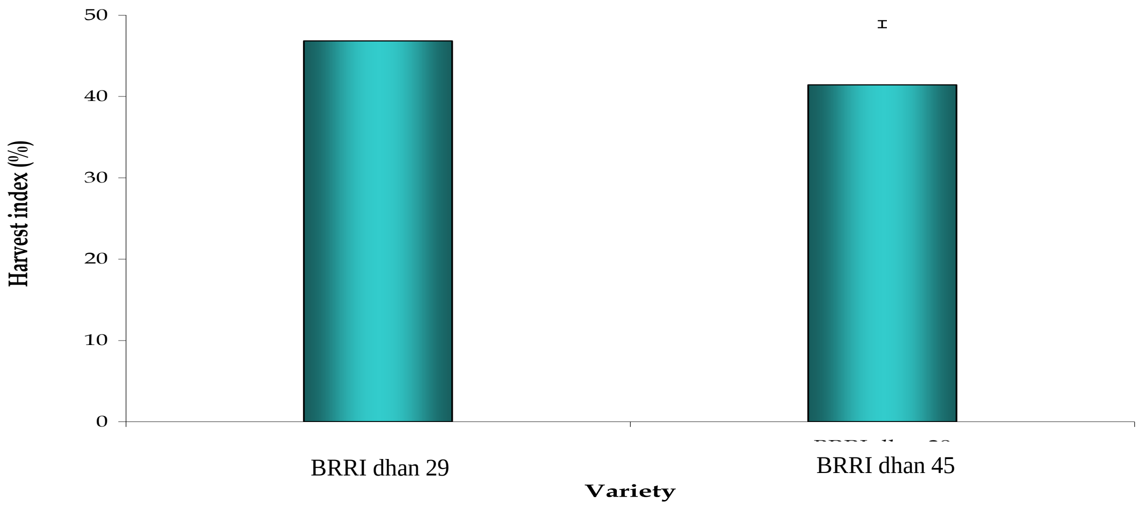


**Figure 14.** Effect of variety on the harvest index of modern rice at DAT in *Boro* season. (Vertical bar shows LSD value at 5% probability level)

### 4.2.8.2 Effect of PGS and fertilizer management

Statistically significant effect of different combination of PGS and fertilizer application variation on harvest index (Figure 15 and Appendix VII). Significantly the maximum (44.14 %) harvest index was noted at $T_4$ (Recommended fertilizer dose + Akota + Global) and the minimum (43.15 %) harvest index was found on $T_1$ (Recommended fertilizer dose) treatment.

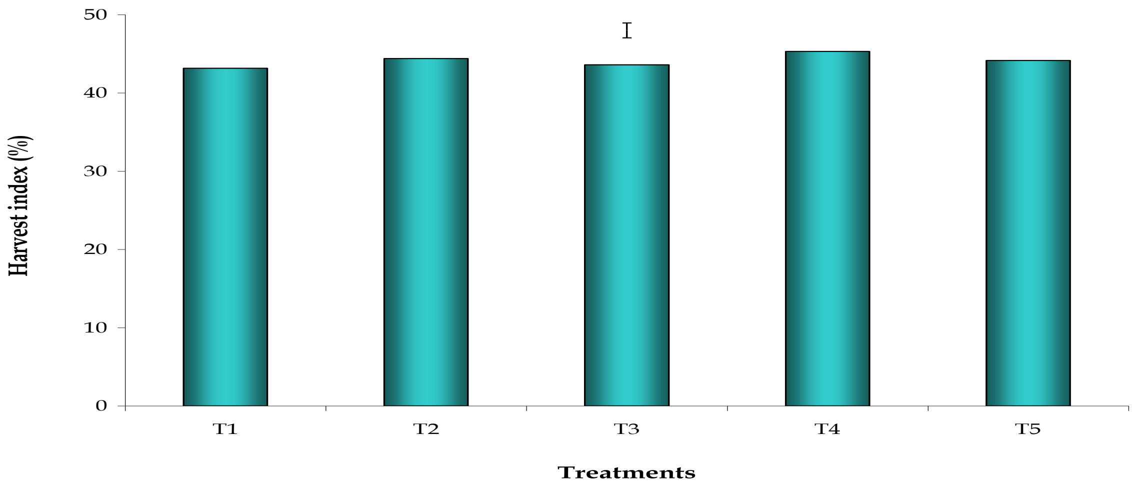


**Figure 15.** Effect of different levels of PGS and fertilizer on the harvest index of modern rice at DAT. (Vertical bar shows LSD value at 5% probability level)

$T_1$ = Recommended fertilizer dose
$T_2$ = Recommended fertilizer dose +Akota
$T_3$ = Recommended fertilizer dose +Global
$T_4$ = Recommended fertilizer dose + Akota+ Global
$T_5$ = Recommended fertilizer dose +Akota + Akota

#### 4.2.8.3 Interaction effect of variety and PGS and fertilizer management

Harvest index significantly was influenced by the interaction of different varieties of rice and levels of PGS and fertilizer management (Table 8 and Appendix VII). The maximum (46.33%) harvest index was observed in the interaction of BRRI dhan29 × $T_4$ (Recommended fertilizer dose + Akota + Global) that was followed by BRRI dhan29 × $T_5$ (Recommended fertilizer dose + Akota + Akota). The minimum (40.50%) harvest index was recorded from the interaction treatment effect of BRRI dhan45 × $T_1$ (Recommended fertilizer dose).

## CHAPTER V

# SUMMARY AND CONCLUSION

The present investigation entitled 'Growth and yield of modern rice varieties as affected by plant growth stimulator and foliar fertilization" was conducted during the period from November, 2016 to May, 2017 at the Agricultural research field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. The experiment comprised of two factors - Factors A: Two rice varieties (BRRI dhan45 and BRRI dhan29) and Factor B: five different treatment of PGS and fertilizer treatment (Recommended fertilizer dose; Recommended fertilizer dose +Akota; Recommended fertilizer dose + Global; Recommended fertilizer dose +Akota +Global and Recommended fertilizer dose +Akota +Akota). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The treatments showed a wide variability in morph physiological structural components of yield and grain yield of rice. Various treatments of humic substances and foliar fertilization significantly affected the growth determinants, yield attributing traits and grain yield as detailed below: -

Results showed that plant height, tillers hill$^{-1}$, effective tillers hill$^{-1}$, Panicles hill$^{-1}$, Panicle length, filled grains panicle$^{-1}$, total grains panicle$^{-1}$, 1000 seeds weight, grain yield, biological yield and harvest index were significantly influenced by rice varieties. Rice varieties, at 40, 60, 80, 100 DAT and at harvest, the tallest plant (33.41, 49.54, 66.16, 94.91 and 101.76 cm, respectively) were shown by BRRI dhan29, while the shortest plant represented by BRRI dhan45.

The maximum (12.17, 18.23, 20.06, 18.80, an 18.03) number of tillers hill$^{-1}$ were found from BRRI dhan29 while minimum (11.97, 16.70, 18.74, 17.17 and 16.01) number of tillers hill$^{-1}$ were obtained from BRRI dhan45. The highest (16.71) effective tillers hill$^{-1}$ was recorded from BRRI dhan29 whereas the lowest (16.62) was recorded from BRRI dhan45. The maximum (16.67) number of panicles hill$^{-1}$ was recorded from BRRI dhan29. The longest (25.83 cm) Panicle was found in BRRI dhan29, while the shortest (23.72 cm) Panicle length was noted from BRRI dhan45. The maximum (192.83) number of filled grains panicle$^{-1}$ was found in BRRI dhan29 variety. The highest (28.70 g) weight of 1000 grains was observed in BRRI dhan29 and the lowest weight (20.10 g) was observed form BRRI dhan 45. The highest (7.74 t ha$^{-1}$) grains yield was recorded in BRRI dhan29 and the lowest (4.90 t ha$^{-1}$) grain yield was found in BRRI dhan45. The highest and lowest biological yield was obtained from BRRI dhan29 and BRRI dhan45 respectively. The maximum (46.84%) harvest index was observed in BRRI dhan29 and the lowest (41.41 %) harvest index was found in BRRIdhan45.

In case of different levels of PGR and fertilizer treatment $T_4$ (Recommended fertilizer dose + Akota + Global) produced the tallest plant (33.88, 49.45, 66.65, 94.83 and 100.7 cm) at 40, 60, 80, 100 DAT and at harvest respectively. At 40, 60, 80, 100 DAT and at harvest, the maximum (13.57, 18.70, 21.55, 19.47 and 18.62) number of tillers hill$^{-1}$ was obtained from $T_4$ (Recommended fertilizer dose + Akota + Global) treatment. At 80 DAT the highest (8.522) leaf area index was observed in treatment $T_4$ (Recommended fertilizer dose + Akota + Global). The highest value of chlorophyll (1.32) was observed in T $_4$ (Recommended fertilizer dose + Akota + Global). The maximum (17.65) number of panicles hill$^{-1}$ was recorded from $T_4$ (Recommended fertilizer dose + Akota + Global). The longest (26.62 cm) Panicle was found in $T_4$ (Recommended fertilizer dose + Akota + Global). The highest (172.9) number of filled grains panicle$^{-1}$ was obtained from $T_4$ (Recommended fertilizer dose + Akota + Global). The highest (24.82 g) 1000 grains weight was achieved from $T_4$ (Recommended fertilizer dose + Akota + Global). The maximum (6.94) t ha$^{-1}$) grain yield was obtained from $T_4$ (Recommended fertilizer dose + Akota +Global). The highest (8.50 t ha$^{-1}$) straw yield was achieved from $T_4$ (Recommended fertilizer dose + Akota). The highest (15.86 t ha$^{-1}$) biological yield was found in $T_4$.

Due to the interaction effect of different PGR and fertilizer and rice was observed at 40, 60, 80, 100 DAT and at harvest respectively from the combination treatment of BRRI dhan29 × $T_4$ (Recommended fertilizer dose + Akota + Global). The maximum (13.60, 19.50, 21.63, 20.00 and 19.53) number of tillers hill$^{-1}$ at 40, 60, 80, 100 DAT and at harvest was recorded respectively from treatment combination of BRRI dhan29 × $T_4$ (Recommended fertilizer dose + Akota + Global). At 80 DAT, the maximum (8.60) leaf area index was recorded from the combined effect of BRRI dhan29 × $T_4$ (Recommended fertilizer dose + Akota + Global). The maximum value of chlorophyll (1.32 mg g$^{-1}$) was found from the interaction of BRRI dhan29 × $T_4$ (Recommended fertilizer dose + Akota + Global). The highest (18.13) number of the Panicles shill$^{-1}$ was counted in the interaction of BRRI dhan29 × $T_4$ (Recommended fertilizer dose + Akota + Global). The interaction of BRRI dhan29 × $T_4$ (Recommended fertilizer dose + Akota + Global) produced the longest (27.57cm) Panicle length. The maximum (197.7) number of filled grains panicle$^{-1}$ was recorded from the combination of BRRI dhan29 × $T_4$.

The maximum (205.5) number of total grains panicle$^{-1}$ was recorded from the interaction of BRRI dhan29 × $T_4$ (Recommended fertilizer dose + Akota + Global). The highest value (93.92%) of filled grains was recorded in $T_4$ (Recommended fertilizer dose + Akota+ Global) treatment. The highest (28.70 g) 1000 grains weight was found from the interaction of BRRI dhan29 × $T_4$ (Recommended fertilizer dose + Akota + Global). The highest (7.740 t ha$^{-1}$) grain yield was recorded in the interaction of (BRRI dhan29 × $T_4$ (Recommended fertilizer dose + Akota + Global). The maximum (8.967 t ha$^{-1}$) straw yield was found from the interaction of BRRI dhan29 × $T_4$ (Recommended fertilizer dose + Akota + Global). The interaction between BRRI dhan29 × $T_4$ (Recommended fertilizer dose + Akota + Global) gave the highest (16.71 t ha$^{-1}$) biological yield. The maximum (46.54 %) harvest index was found in the interaction of BRRI dhan29 × $T_5$ (Recommended fertilizer dose + Akota + Global).

## Conclusion:

- ❖ Due to combined application of Akota and Global ($T_4$ treatment), 18% and 25% higher grain yield from BRRI dhan29 and BRRI dhan45 respectively compared to control attributed by panicles hill$^{-1}$and grains panicle$^{-1}$.
- ❖ $T_4$ treatment also increased 24.5% and 32.0% LAI in BRRI dhan29 and BRRI dhan45 respectively compared to control but flag leaf chlorophyll content remained unaffected.
- ❖ The variety BRRI dhan29 and recommended fertilizer dose with Global Akota signally as well as combination gave the highest grain yield, straw yield and biological yield. Maximum harvest index was also recorded from BRRI dhan29 and recommended fertilizer with Akota + Global.

## Recommendation:

- ❖ For getting higher yield, recommended fertilizer with Akota and Global) should be used according to treatment four.
- ❖ The further research work should be carried out to investigate the effect of various levels of PGS and other micro-nutrients in different Agro-ecological Zone of Bangladesh.

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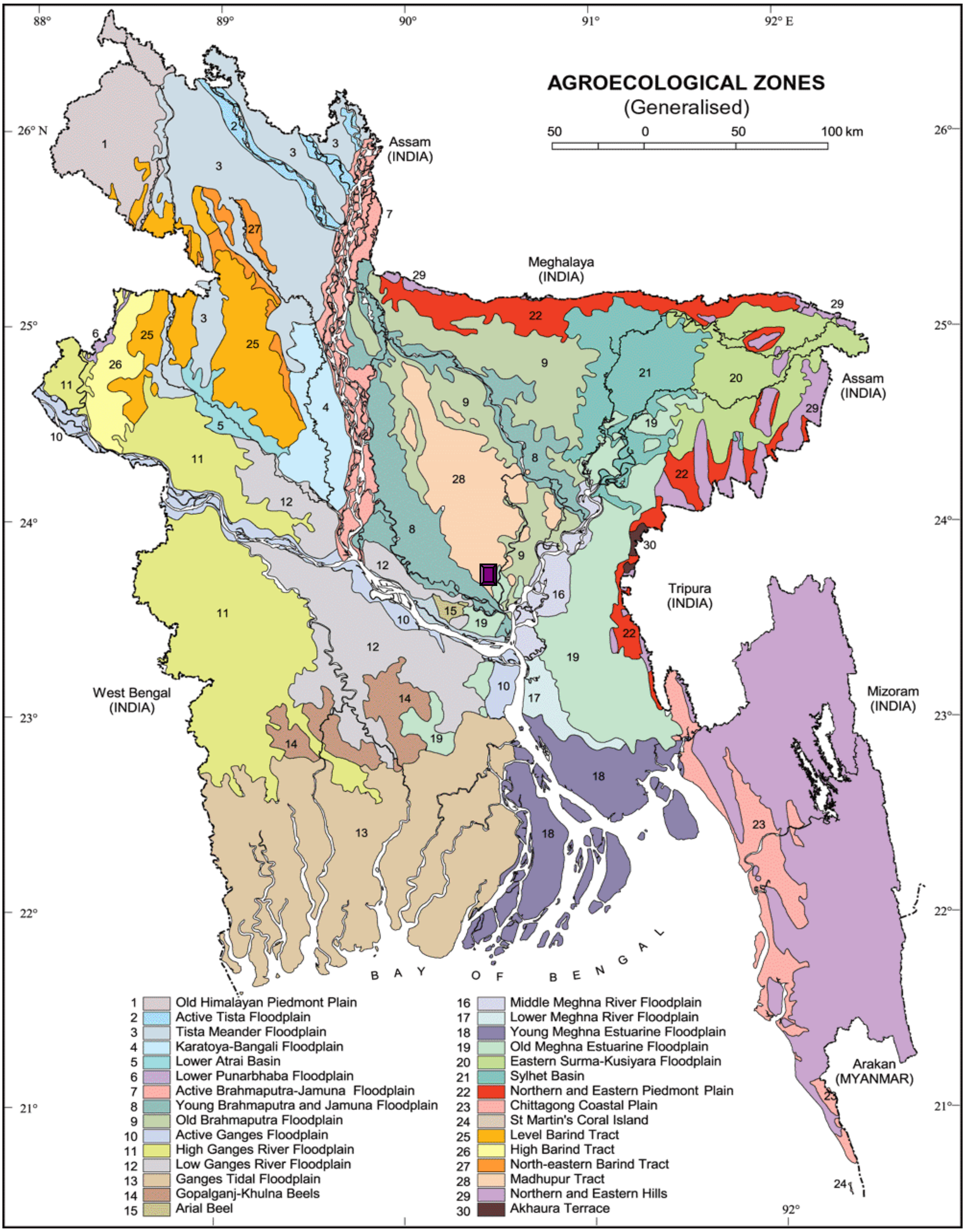
# APPENDICES

**Appendix I:** Map showing the experimental sites under study



**Appendix II:** Characteristics of soil of experimental is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

**A.** Morphological characteristics of the experimental field

| Morphological features | Characteristics |
|---|---|
| Location | Agronomy Field laboratory, SAU, Dhaka |
| AEZ | Modhupur 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 III**. Analysis of variance (mean square) of the data for plant height of rice at different days after transplanting (DAT)

| Source of variation | df | Plant height (cm) at different days after transplanting (DAT) | | | | |
|---|---|---|---|---|---|---|
| | | 40 | 60 | 80 | 100 | At harvest |
| Replication | 2 | 0.193 | 0.129 | 3.585 | 0.142 | 0.485 |
| Variety (A) | 1 | 218.376** | 93.987** | 36.080** | 37.208** | 235.200** |
| Treatment (B) | 4 | 24.008** | 1.809NS | 9.490** | 47.500** | 8.777** |
| A x B | 4 | 1.970* | 6.313* | 1.294NS | 26.826** | 0.622NS |
| Error | 18 | 0.692 | 1.807 | 0.498 | 0.236 | 0.258 |

**Appendix IV**. Analysis of variance (mean square) of the data for total tillers hill$^{-1}$ of rice at different days after transplanting (DAT)

| Source of variation | df | No. of total tillers hill$^{-1}$ at different days after transplanting (DAT) | | | | |
|---|---|---|---|---|---|---|
| | | 40 | 60 | 80 | 100 | At harvest |
| Replication | 2 | 0.060 | 0.597 | 1.204 | 1.089 | 0.019 |
| Variety (A) | 1 | 0.048NS | 17.633** | 11.781** | 20.008** | 30.805** |
| Treatment (B) | 4 | 3.747** | 5.723** | 1.343NS | 0.789NS | 9.905** |
| A x B | 4 | 5.477** | 0.251NS | 11.685** | 7.061** | 0.138NS |
| Error | 18 | 0.270 | 0.156 | 0.500 | 0.455 | 0.191 |

**Appendix V.** Analysis of variance (mean square) of the data for leaf area index (LAI) of rice

| Source of variation | df | **LAI** | **Chlorophyll content** |
|---|---|---|---|
| Replication | 2 | 0.004 | 0.004 |
| Variety (A) | 1 | 0.290** | 0.015** |
| Treatment (B) | 4 | 2.971** | 0.017** |
| A x B | 4 | 0.003NS | 0.000NS |
| Error | 18 | 0.020 | 0.001 |

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

**Appendix VI.** Analysis of variance (mean square) of the data for yield and yield contributing characters of rice

| Source of variation | df | Panicle height (cm) | Total effective tillers hill$^{-1}$ | Effective tillers hill$^{-1}$ | Non-effective tillers hill$^{-1}$ | Filled grains panicle$^{-1}$ | Unfilled grains panicle$^{-1}$ | 1000 seed weight (g) |
|---|---|---|---|---|---|---|---|---|
| Replication | 2 | 0.144 | 0.038 | 0.064 | 0.008 | 13.35 | 0.185 | 0.043 |
| Variety (A) | 1 | 33.49** | 9.92** | 16.28** | 0.784** | 30009.9** | 166.05** | 483.20** |
| Treatment (B) | 4 | 6.066** | 6.032** | 8.969** | 0.296** | 375.50** | 14.623** | 0.643** |
| A x B | 4 | 0.167NS | 0.479* | 0.308NS | 0.052** | 32.69* | 0.098NS | 0.068NS |
| Error | 18 | 0.343 | 0.153 | 0.120 | 0.009 | 11.11 | 0.508 | 0.079 |

**Appendix VII.** Analysis of variance (mean square) of the data for yield and yield contributing characters of rice.

| Source of variation | df | Grain yield (t ha$^{-1}$) | Straw yield (t ha$^{-1}$) | Biological (t ha$^{-1}$) | Harvest index (%) |
|---|---|---|---|---|---|
| Replication | 2 | 0.002 | 0.010 | 0.004 | 0.039 |
| Variety (A) | 1 | 19.602** | 0.474** | 26.171** | 220.920** |
| Treatment (B) | 4 | 1.287** | 2.117** | 6.366** | 4.102** |
| A x B | 4 | 0.047* | 0.068* | 0.183** | 0.305NS |
| Error | 18 | 0.014 | 0.018 | 0.026 | 0.555 |

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

**Plate:** Photo of the experimental field