EFFECT OF FOLIAR FERTILIZATION AND GROWTH STIMULATOR ON THE MORPHO-PHYSIOLOGICAL AND YIELD ATTRIBUTES OF HYBRID RICE (*Oryza sativa* L.)

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CERTIFICATE

*This is to certify that the thesis entitled "**EFFECT OF FOLIAR FERTILIZATION AND GROWTH STIMULATOR ON THE MORPHO-PHYSIOLOGICAL AND YIELD ATTRIBUTES OF HYBRID RICE (Oryza sativa L.)**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University (SAU), Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS)** in **AGRICULTURAL BOTANY**, embodies the results of a piece of bonafide research work carried out by **MST. RIPA KHATUN**, Registration no.: **11-04628** 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 duly been acknowledged.

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Dedicated to

My

"Beloved Parents"

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EFFECT OF FOLIAR FERTILIZATION AND GROWTH STIMULATOR ON THE MORPHO-PHYSIOLOGICAL AND YIELD ATTRIBUTES OF HYBRID RICE (*Oryza sativa* L.)

ABSTRACT

Rice (*Oryza sativa* L.) is one of the important cereal crops and commonly grown all over the world for multiple purposes. The present investigation was undertaken for the improvement of yield of rice (*Oryza sativa* L.) varieties through the manipulation of stem reserve remobilization and filled-grain percentage by plant growth stimulator and foliar fertilization. The experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Dhaka-1207, using Randomized Complete Block Design with three replications during the period from November, 2016 to May, 2017. This experiment was comprised of two factors; Factor A: Rice varieties: (i) BRRI hybrid dhan3 and (ii) BRRI dhan29 and Factor B: PGS and fertilizer management (5) viz. (i) Recommended fertilizer dose (T_1); (ii) Recommended fertilizer dose + Akota + Global (T_2); (iii) Recommended fertilizer dose + Akota + Global + Calsol (T_3); (iv) Recommended fertilizer dose + Akota + Global + Magic Growth (T_4) and (v) Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth (T_5). Data on different growth characters and yield contributing characters were recorded and significant variation was observed among the treatment means. In case of variety the highest (98.98 cm) plant height at harvest, total dry matter after harvest (73.24 g hill^{-1}), shoot dry matter accumulation (43.79 and 33.23 g) at flowering and maturity stage, panicle hill^{-1} (16.67), filled grains panicle^{-1} (180.36), total grains panicle^{-1} (189.26) and grain yield (7.09 t ha^{-1}) was recorded from BRRI hybrid dhan3. In case of PGS and fertilizer treatment, the highest values were recorded from T_3 (Recommended fertilizer dose + Akota + Global + Calsol) for all growth and yield attributing characters at different DAT. Due to this T_3 treatment the highest (81.41 g) total dry matter hill^{-1} at harvest, shoot dry matter accumulation (33.23 g) and its reserve translocation (26.31%), effective tillers (95.75 %), panicle hill^{-1} (17.65), total grains panicle^{-1} (178.0), 1000 grains weight (24.98 g), grain yield (6.99 t ha^{-1}) was recorded. Due to the interaction the highest value of plant height (105.6 cm), number of leaves hill^{-1} (75.33), number of tillers hill^{-1} (19.47) was recorded from BRRI hybrid dhan3 $\times$ T_3 (Recommended fertilizer dose + Akota + Global + Calsol) at harvest. The highest value of total dry matter after harvest (81.41 g hill^{-1}), shoot reserve translocation (15.52 %) and all yield attributing characters including grain yield (7.78 t ha^{-1}) was recorded from BRRI hybrid dhan3 $\times$ T_3 (Recommended fertilizer dose + Akota + Global + Calsol). So, BRRI hybrid dhan3 and T_3 (Recommended fertilizer dose + Akota + Global + Calsol) combinedly had outstanding superiority for growth and yield over the other treatments.

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LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
Annon.	=	Anonymous
BBS	=	Bangladesh Bureau of Statistics
BRRI	=	Bangladesh Rice Research Institute
cm	=	Centimeter
Cont'd	=	Continued
cv.	=	Cultivar
DAT	=	Days after transplanting
^{o}C	=	Degree Centigrade
DF	=	Degree of freedom
et al.	=	And others
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
fed	=	Feddan
g	=	Gram
HI	=	Harvest Index
Hr	=	Hour
Ha^{-1}	=	Aper Hectare
IRRI	=	International Rice Research institute
i.e.	=	That is
J.	=	Journal
Kg	=	Kilogram
K	=	Potassium
LAI	=	Leaf Area Index
LSD	=	Least significant difference
M	=	Meter
m^2	=	Square meter
mg	=	Milligram
viz.	=	Namely
N	=	Nitrogen
ns	=	Non-significant
%	=	Per cent
CV%	=	Percentage of Coefficient of Variation
P	=	Phosphorus
Ppm	=	Parts per million
PGS	=	Plant Growth Stimulator
RCBD	=	Randomized Complete Block Design
SAU	=	Sher-e- Bangla Agricultural University
S	=	Sulphur
Sci.	=	Science
t	=	Ton
Zn	=	Zinc

CHAPTER I
INTRODUCTION

Rice (*Oryza sativa* L.) is our staple food belongs to cereal crops under Poaceae family. Rice is interwoven with Bengali culture. It is the symbol of wealth (Murshed, 2012). It is one of the most labor intensive crop of the world and the most extensively cultivated cereals of the world. It is the prime food crop of Bangladesh and constitutes 95% of food grain production in the country. Rice is the second most widely grown cereal and primary source of food for more than half of the world population, and about 90% of the world rice is grown in Asia which is carrying about 60% of the world population (Haque *et al*., 2015). About 75% of the total cropped area and over 80% of the total irrigated area is planted to rice. It is an excellent source of complex carbohydrates the best source of energy about 70% of direct human calorie intake, making it the most important food crop in Bangladesh (BBS, 2011). Rice production in Bangladesh is a crucial part of the national economy (Bangladesh, 2009). It plays a vital role in the economy of Bangladesh providing significant contribution to the GDP, employment generation and food availability. Rice security is not only an economic issue but also an important parameter for determining social and political stability (Nath, 2015).

Rice is cultivated in Bangladesh throughout the year as Aus, Aman or *Boro*. Among these *Boro* is most important and occupied about 41% of the rice cultivated land in 2009-10. The rest 46, 9 and 4 percent of the land is occupied by Aman, Aus and Sown Aman respectively (BRRI, 2017). According to Annual Report 2016-17 statistics, rice is grown in 114 countries across the world in an area of 161.35 million hectares with a production of 480.13 million metric tons and the productivity is 4.44 t/ha. The production of total rice in Bangladesh is about 31.98 million metric tons where *Boro* covers the largest part of about the production of 18.06 million metric tons. In *Boro* season hybrid rice covers about 6.86 lac hectares area with production of 32.2 lac metric tons, respectively (BBS, 2010). There has been a three-fold increase in rice production in Bangladesh, which jumped from nearly 11 MT in 1971-72 to about 34.86 MT in 2014-15 (AIS, 2016). Among the rice growing countries, Bangladesh occupies third position in rice area and fourth position in rice production (BRRI, 2012).

The population of Bangladesh is increasing at a minacious rate and the cultivable land is decreasing due to urbanization and industrialization resulting in more shortage of food. The population of Bangladesh is increasing by two million every year and may

increase by another 30 million over the next 20 years. Population growth demands a continuous increase in rice production in Bangladesh. Production of rice has to be increased by at least 60% to meet up the food requirement of the increasing population by the year 2020 (Masum, 2009). The current level of annual rice production of around 545 million tons could be increased to about 700 million tons to feed an additional 650 million rice eaters by 2025 using less land, indeed the great challenge in Asia (Dawe, 2003). This can be done in two ways: expanding the rice growing area and increasing productivity, or both (Hasan *et al*., 2015). But there is a little scope to increase rice area (Sarker *et al*., 2008) rather agricultural land is declining @ 0.7% per annum (BBS, 2011). Yearly increment of rice production in Bangladesh needs to meet the current and future food requirements of increasing population and their rising dietary needs to boost up crop yields.

Rice yield can be increased in many ways like developing new high yielding variety and by adopting proper agronomic techniques to the existing varieties to increase yield is important. FAO has considered hybrid rice technology as key approach for increasing global rice production (Virmani, *et al.*, 2004). Hybrid rice has been introduced in Bangladesh through BRRI, IRRI and different seed companies. In Bangladesh it gains positive monument in *Boro* season and a few varieties has been cultivated in *Boro* season (Haque and Biswas, 2011). Hybrids are generally more vigorous and larger in size than the parent stock. The young seedlings produce long roots and broad leaves that enable them to take up more nutrients thus, produce more grains. Hybrid rice has high tillering capacity. During vegetative growth, hybrid rice accumulates more dry matter in the early and middle growth stages which results in more grains panicle^{-1}. They have bigger panicles and more grains panicle^{-1}. Hybrid rice varieties have 15-30% yield advantage over modern inbred one (Julfiquar *et al*., 2009; Abou Khalifa, 2009).

Recently our farmers, several national and international researchers have been reported that higher yield potential of hybrid rice is not frequently translated to the grain yield. The unstable grain yield of hybrids is associated with poor filled grain percent. Poor filled grain percent in hybrid rice is a major problem to get higher grain yield. To overcome this barrier of rice production in Bangladesh needs to boost up crop production by improving yield.

Yield boosting agronomic techniques such as; application of certain plant growth stimulators, foliar feeding etc. need due attention. Higher LAI at grain filling period, strong photosynthetic capability of flag leaf, greater biomass accumulation before heading and higher shoot reserve translocation are the decisive factor of higher yield in hybrids (Chen *et al*., 2008; Wu *et al*., 2008; Lafarge and Bueno 2009; Tang *et al.*,2010; Moinul *et al*., 2015).

Plant stimulators are chemical communicators, or agents, which help regulate a plant's development and its response to its surrounding environment. Remarkable accomplishments of plant stimulators such as manipulating plant growth and crop yield have been actualized in recent years. Plant hormones are considered as yield boosting agronomic technique (Bakhsh *et al*., 2011). Plant growth regulators are becoming popular to ensure efficient growth, production and for other necessary activities of rice plant.

Application of humic substances in agriculture as fertilizer and soil conditioner were tried on limited scale. Significant impact of these humic substances on soil structure and plant growth was reported earlier by Ihsanullah and Bakhashawin (2013); El-Razek *et al*. (2012) and Fong *et al*. (2007). Humic acid improves soil aggregation, aeration, permeability, water holding capacity, hormonal activity, microbial growth, organic matter mineralization, solubilisation, availability of microelements and some macro elements. Humic substances attract positive ions, forms chelates with micronutrients and releases them slowly when required by plants. HA in proper concentration can enhance plant and root growth. It increases the plant's oxygen uptake capacity with an associated increase in chlorophyll production, as a foliar spray and increase the permeability of plant membranes and uptake of nutrients.

Foliar feeding also considered as another yield boosting technique. Foliar feeding is the practice of applying liquid fertilizers to plant leaves (Kovacevic, 2003). Silberbush (2002) reported that foliar fertilization is widely used practice to correct nutritional deficiencies in plants caused by improper supply of nutrients to roots. Camberato *et al.* (2010) reported that if the micronutrient deficiencies occur during growth phage, the most effective method for overcoming micronutrient deficiencies is foliar fertilization. Furthermore, it is an economical way of supplementing the plant's nutrients when they are in short supply or unavailable form in the soils and it has been shown that the

efficiency of foliar application is three to five folds greater than soil-applied fertilizers, and can thus significantly reduce the amount of fertilizer usage (Jamal *et al*., 2006).

However, much research information is available on the development and cultivation technology of hybrid rice varieties. But research work on improving yield of hybrid rice varieties through solving the spikelet sterility / poor grain filling problem is scanty or absent in Bangladesh. At present it is imperative to develop a way for exploiting maximum yield potential of the hybrid rice through maximizing spikelet fertility and solving poor-filled grain problem in hybrid rice. Under these circumstances, the present research proposal has been planned and designed to find out a way of lessening the unfilled-grain problem in hybrid rice varieties through using plant growth regulator and foliar fertilization keeping in mind to achieve the following objectives:

1. To characterize the performance of different hybrid rice varieties in response to varying doses of foliar fertilization and growth stimulator.
2. To assess the effect of foliar fertilization and growth stimulator on stem reserve remobilization for improving grain yield in hybrid rice varieties.

CHAPTER II
REVIEW OF LITERATURE

Rice (*Oryza sativa* L.) is one of the most labor intensive crop 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, liquid fertilizer (Calsol and Magic growth) 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.

2.1. Effect of PGS and fertilizer management on Growth Characters of Rice

2.1.1. Plant height

An experiment was done at the farm of Sher-e-Bangla Agricultural University, Dhaka to find out the influence of foliar application of urea along with magic growth spray on the growth parameters of Aman rice assigning in a RCBD design with three replications. Treatments of the experiment was eight doses of N and application methods with magic growth as foliar spray. Results reported that the highest plant height was observed from the 75% Urea as top dressing and 10% Urea with magic growth as foliar spray (126.4 cm) treatment which was statistically similar with 100% Urea as top dressing and 10% Urea with magic growth as foliar spray (124.0 cm) whereas, the lowest was observed from control (113.9 cm) treatment which was statistically similar with Urea only 10% of the recommended dose (RD) with magic growth as foliar spray (115.9 cm)(Rabin *et al.*, 2016).

A study was set up in a randomized complete block design with three replications to study the effect of different levels of urea and magic growth spray solution on the yield and yield attributes of BRRI dhan29. The experiment consisted of ten treatments. The tallest plant (92.33 cm) was obtained from 126 kg urea ha^{-1} + 5.66 L ha^{-1} magic growth

spray solution treatment while the shortest one (81.40 cm) was from control (Nasrin *et al.*, 2016).

The experiment was carried out using a split plot design with two levels of liquid fertilization viz., no liquid fertilization and liquid fertilization with Magic Growth applied at 30, 45 and 60 DAT and four levels of nitrogen fertilizer viz., no nitrogen fertilizer (N_0), 50% recommended nitrogen fertilizer (N_{50}), 75% recommended nitrogen fertilizer (N_{75}) and 100% recommended fertilizer (N_{100}). The greater plant height (124.81 cm) was recorded when magic growth was applied on leaf compared to that (120.81 cm) recorded in no liquid fertilization treatment in N_{75} nitrogen level compared to other (Alam *et al.*, 2015).

A field experiment was conducted to evaluate the performance of PRH and liquid fertilizer: Calsol and Magic Growth using in Randomized Complete Block (RCB) design with three replications. The plant height reached peak and observed significantly higher in recommended fertilizer dose with recommended PRH treatment at both 50% flowering (98 cm) and harvesting stage (99 cm). On the other hand, at 50% flowering stage recommended fertilizer dose of NPK with Calsol 7 days before panicle initiation (93 cm) treatment showed similar plant height. The lowest plant height recorded in PRH (86 cm) treatment (Karim *et al.*, 2015).

A study was set up in the Kelantan Plains, Malaysia to find out the effect of quality and antioxidant activity of rice grown on alluvial soil amended with Zn, Cu and Mo. The treatments were control (without micronutrient), Zn, Cu and Mo (5, 4, 0.5 kg ha^{-1}), respectively. The respective N, P, K & S fertilizers were applied to all treatments at 120, 30, 60 and 10 kg ha^{-1} respectively. Results showed that significantly the highest plant height was found in the combined Zn, Cu and Mo added treatments (Panhwar *et al.*, 2015).

The experiment was conducted to find out the influence of nitrogen and sulphur on yield of T. Aman rice (BRRI dhan34) in Randomized Complete Block Design (RCBD) with three replications. The experiment comprised of two factors- 4 Levels of Nitrogen (N_0, N_1, N_2, N_3 - control, 80,100, 120 kg N ha^{-1} and 3 Levels of sulphur (S_0: control, S_1: 8 kg and S_2: 12 kg S ha^{-1}) respectively. Data revealed that with the increase of nitrogen and sulpher fertilizer, plant height increased upto a certain level then decreases (Mondal, 2014).

An experiment was conducted with aimed to study the effect of nitrogen fertilizer sources and foliar spray of humic and/or fulvic acids on yield and quality of rice plants. Two nitrogen sources i.e. anhydrous ammonia and urea as well as humic acid at rate of 5 g/L., individually or mixed and non-addition of spray (control treatment) served check which were allocated as a treatment at random. Results of the experiment revealed that plant height wasn't affected by nitrogen form in both seasons. Foliar application of humic and fulvic acids together led to significant increases of plant height under anhydrous ammonia fertilizer form. While, the lowest ones were recorded with control (without foliar application of organic acids) under urea fertilizer in both seasons (Osman *et al.*, 2013).

With a view to finding out the effect of zinc and phosphorus on yield of rice (cv.BR-11) an experiment was carried out assigning 12 treatments comprising 4 levels of Zn (0, 5, 10 and 20 kg Zn ha^{-1} from zinc sulphate) and 3 levels of P (0, 25 and 50 kg P_2O_5 ha^{-1} from TSP) along with basal doses of 100 kg N ha^{-1} from urea, 40 kg K_2O ha^{-1} from muriate of potash and 12 kg S ha^{-1} from gypsum. The tallest plant height was obtained from $Zn_{10}P_{50}$ treatment while the shortest plant height produced in control treatment (Rahman *et al.*, 2011).

2.1.2. Number of leaves $hill^{-1}$

The highest number of leaves $hill^{-1}$ was observed at 75% Urea as top dressing and 10% Urea with magic growth as foliar spray which was identical with 75% Urea as top dressing and 5% Urea with magic growth as foliar spray whereas the lowest was observed 33from control treatment (Rabin *et al*., 2016).

2.1.3. Tillering Pattern

To study the effects of different levels of urea and magic growth spray solution on the yield and yield attributes of BRRI dhan29 a study was set up at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh. The highest number of total tillers $hill^{-1}$ (15.00) was produced at 126 kg urea ha^{-1} + 5.66 L ha^{-1} magic growth spray solution treatment but significantly different from all other treatments and the lowest (9.67) was recorded from control treatment (Nasrin *et al.*, 2016).

An experiment was done to find out the influence of foliar application of urea along with magic growth spray on the growth parameters of Aman rice. Treatments of the experiment were eight doses of N and application methods with magic growth as foliar

spray. The highest number of tillers hill^{-1} was observed from the 75% Urea as top dressing and 10% Urea with magic growth as foliar spray treatment which was statistically similar to 100% Urea as top dressing and 10% Urea with magic growth as foliar spray whereas, the lowest was observed at control treatment (Rabin *et al.*, 2016). The experiment was carried out using a split plot design with two levels of liquid fertilization (no liquid fertilization and liquid fertilization with Magic Growth applied at 30, 45 and 60 DAT and four levels of nitrogen fertilizer (control, 50%, 75% and 100% of the recommended nitrogen fertilizer). Findings reported that higher tillers hill^{-1} (16.44) was recorded at liquid fertilization with Magic Growth compared to that (15.58) recorded in no liquid fertilization (Alam *et al.*, 2015).

A field experiment was conducted to evaluate the performance of PRH and liquid fertilizer: Calsol and Magic Growth. There are 8 treatments. The highest tiller number (433) produced at Recommended fertilizer dose with Calsol at 7 days before panicle initiation treatment among treatments at 50% flowering stage whereas, only PRH ranked the lowest (318) number tiller (Karim *et al.*, 2015).

An experiment was set up to find out the effect of foliar fertilization on BRRI dhan28 to reduce soil application of nitrogenous fertilizer following split plot design with three replications. Treatments consisted of two levels of foliar fertilization of magic growth (No foliar fertilization and foliar fertilization with magic growth and four nitrogen fertilizer levels (control, 50%, 75% and 100% of the recommended nitrogen fertilizer). Number of tillers hill^{-1} was increased considerably due to foliar fertilization compared to control and also increased with the increment of nitrogen level (Pramanik *et al.*, 2015).

To find out the effect of quality and antioxidant activity of rice grown on alluvial soil amended with Zn, Cu and Mo a study was laid out in the Kelantan Plains, Malaysia. The treatments were control; Zn, Cu and Mo (5, 4, 0.5 kg ha^{-1} respectively) with recommended fertilizer dose. The heaviest tiller numbers m^{-2} was found in the combined Zn, Cu and Mo added treatments (Panhwar *et al.*, 2015).

The number of tillers m^{-2} was significantly influenced by foliar application of humic with anhydrous ammonia fertilizer, whereas, the lowest significant ones were obtained when control treatment (without foliar application of organic acids) in both seasons (Osman *et al.*, 2013).

A field experiment was studied by on a non-calcareous dark gray floodplain soil (Sonatola series) of BAU farm, Mymensingh using rice (cv. BRRI dhan29) as a test crop. There are five treatments viz. T_0 (control), T_1 (10 kg S/ha), T_2 (20 kg S/ha), T_3 (40 kg S/ha) and T_4 (60 kg S/ha). All plots received an equal dose of N, P, K and Zn. Data revealed that the maximum number of tillers hill^{-1} (12.15) were recorded in 20 kg S ha^{-1}, which was superior to all other treatments and the lowest in control (7.68) (Rahman *et al.*, 2007).

2.1.4. Leaf area index

Two field experiment was conducted to study the evaluation of some rice varieties (Sakha 106, Sakha 105, GZ 7565, GZ 9075 and GZ 9362) under different nitrogen levels [0, 55, 111, 165 and 220 Kg ha^{-1}] following a split plot design with four replications. Results showed that nitrogen level at 220 kg/N gave the highest value of leaf area index (Khalifa *et al.*, 2012).

2.1.5. Chlorophyll content

An experiment was set up with two levels of foliar fertilization of magic growth (no foliar fertilization and foliar fertilization with magic growth at 7, 30, 45 and 60 DAT) and four nitrogen fertilizer levels (control, 50%, 75% and 100% of the recommended nitrogen fertilizer). The leaf chlorophyll content was increased at different DAT due to foliar fertilization compared to no foliar fertilization. (Pramanik *et al.*, 2015).

A study was set up in the Kelantan Plains, Malaysia to find out the effect of quality and antioxidant activity of rice grown on alluvial soil amended with Zn, Cu and Mo. The treatments were control; Zn, Cu and Mo (5, 4, 0.5 kg ha^{-1} respectively). Recommended fertilizer dose was applied to all treatments respectively. Higher value of chlorophyll content was found with all combined micronutrients compared to those of the other treatments (Panhwar *et al.*, 2015).

A field trials was laid out to study the effect of different micronutrient treatments on Rice (*Oryza sativa* L.) growth and yield under saline soil conditions included the treatments: Zn , Mn, Fe application as soil single treatments or Zn + Mn , Zn + Fe , Mn + Fe and Zn + Mn + Fe as a combined applications through soil as well as a comparative treatment of commercial compound (14% Mn +12% Fe +16% Zn) was applied twice at 20 and 45 days after transplanting (DAT) as foliar spray. The comparative foliar application treatment of Zn + Fe + Mn twice at 20 and 45 days after transplanting

(DAT) gave the highest values of chlorophyll content and panicle length **(**Zayed *et al.*, 2011).

2.1.6. Total dry matter hill^{-1}

The experiments were carried out to study the effect of various soil conditioners, MK doses (0, 1.56, 3.12 and 6.25 tons/ha) and NPK fertilizers (16-8-8 and 16-16-8) on growth and yield of rice grown in acid sulfate soil in Thailand, a Rangsit (Rs) soil series. The use of MK increased shoots dry matter and compared to the control (Rattanapichai *et al*., 2013).

Greenhouse research was conducted to determine the effect of foliar application of humic acid on dry matter and some nutrient element uptake of maize grown under calcareous soil conditions. Agricultural lime ($CaCO_3$) was used to obtain five calcium carbonate ($CaCO_3$) doses (0, 5, 10 20, and 40 %) and three foliar application doses of humic acid (0, 0.1, and 0.2 %) sprayed at 20 and 35 days after emergence. At 20 and 40% of $CaCO_3$ levels, foliar application of humic acid had a statistically significant positive effect on dry weight maize plants. The greatest dry was obtained from the 0.01% humic acid treatment. The interaction of $CaCO_3$ and humic acid was also statistically significant on dry weight (Celik *et al.*, 2010).

With aimed to determine the effect of nitrogen fertilizer effect on tillering, dry matter production and yield of traditional varieties of rice an experiment was conducted with three traditional cultivars (viz. Jharapajam, Lalmota, Bansful Chikon) and a modern cultivar (viz. KK-4) grown as check each at four levels of nitrogen (0, 30, 60 and 90 kg ha^{-1}). The results of the study reported that the total dry matter (TDM) production increased with increasing rate of nitrogen fertilizer varying at different varieties (Amin *et al.*, 2006).

Foliar spray of $Ca(NO_3)_2$, $MnSO_4$ or K_2HPO_4 partially minimized the salt-induced nutrient deficiency, increased photosynthesis and dry matter accumulation. Among the nutrient solutions, $Ca(NO_3)_2$ seemed to be the most effective, followed by $MnSO_4$ and K_2HPO_4. These results suggested that foliar application of nutrient solutions partially alleviates the adverse effects of salinity on photosynthesis and dry matter (Sultana *et al.*, 2001).

2.2. Effect of PGS and fertilizer management on yield and yield contributing characters of rice

2.2.1. Number of effective tillers hill^{-1}

Field experiment was conducted to study the effect of NPK at different levels along with soil and foliar application of organic substitutes on the growth and yield of rice assigning twelve treatments. Results reported that the highest number of productive tillers/m^2 was observed in 100 % NPK + FYM + Humic acid foliar spray treatment when compared to conventional method of 100 per cent NPK and FYM applications (Venkateshprasath *et al.*, 2017).

Highest number of effective tillers hill^{-1} was recorded from the 75% Urea as top dressing and 10% Urea with magic growth as foliar spray which was statistically similar with 100% Urea as top dressing and 10% Urea with magic growth as foliar spray and the lowest was observed from control treatment (Rabin *et al.*, 2016).

Foliar fertilization, nitrogen levels and the combined effect of foliar fertilization and nitrogen levels showed significant influence on the number effective tillers hill^{-1} of BRRI dhan28. Number of effective tillers hill^{-1} was increased with the increment of nitrogen level in no foliar fertilization treatment but in foliar fertilization treatment, the number of effective tillers hill^{-1} was increased with the increment of nitrogen level up to 75% nitrogen and thereafter decreased (Pramanik *et al.*, 2015).

2.2.2. Non- effective tillers hill^{-1}

The number of non-effective tillers hill^{-1} was produced higher amount from control treatment which was statistically similar with Urea only 10% of the recommended dose (RD) with magic growth as foliar spray. In contrast the lowest number of non-effective tillers hill $^{-1}$ was produced from 75 % Urea as top dressing and 10 % Urea with magic growth as foliar spray treatment which was statistically similar with 100 % Urea as top dressing and 10% Urea with magic growth as foliar spray (Rabin *et al.*, 2016).

2.2.3. Panicle length

The experiment was carried out with two levels of liquid fertilization (no liquid fertilization and liquid fertilization with magic growth applied at 30, 45 and 60 DAT) and four levels of nitrogen fertilizer (control, 50%, 75% and 100% of the recommended nitrogen fertilizer). Data reported that greater panicle length (20.94 cm) was recorded

when magic growth was applied on leaf compared to that (20.57 cm) recorded in no liquid fertilization treatment. The shortest panicle (13.22 cm) was recorded in control treatment (Alam *et al.*, 2015).

A study was laid out to find out the effect of quality and antioxidant activity of rice grown on alluvial soil amended with Zn, Cu and Mo in the Kelantan Plains, Malaysia. The treatments were control, Zn, Cu and Mo (5, 4, 0.5 kg ha^{-1} respectively). The respective N, P, K & S fertilizers were applied to all treatments at 120, 30, 60 and 10 kg ha^{-1} respectively. The longest panicle was found in the combined Zn, Cu and Mo added treatments (Panhwar *et al.*, 2015).

An experiment was set up to find out the effect of foliar fertilization on BRRI dhan28 to reduce soil application of nitrogenous fertilizer assigning two levels of foliar fertilization of magic growth (No foliar fertilization and foliar fertilization with magic growth at 7, 30, 45 and 60 DAT) and four nitrogen fertilizer levels (control, 50 %, 75% and 100 % of the recommended nitrogen fertilizer). The longest panicle (24.44 cm) was observed at 100 % nitrogen which was statistically at per with 75% nitrogen (23.69 cm) whereas the shortest panicle was recorded in control (21.83 cm) which was statistically similar with 50 % nitrogen (22.28 cm) (Pramanik *et al.*, 2015).

An experiment was laid out with a view to finding out the effect of zinc and phosphorus on yield of rice (cv.BR-11) assigning 12 treatments comprising 4 levels of Zn (0, 5, 10 and 20 kg Zn ha^{-1}) and 3 levels of P (0, 25 and 50 kg P_2O_5 ha^{-1}) along with basal doses of recommended fertilizer. The highest panicle length (24.30 cm) was produced from 20 kg Zn and 50 kg P_2O_5 ha^{-1} and the lowest was from control (Rahman *et al.*, 2011).

2.2.4. Panicles $hill^{-1}$

The experiment was carried out with two levels of liquid fertilization (no liquid fertilization and liquid fertilization with magic growth applied at 30, 45 and 60 DAT) and four levels of nitrogen fertilizer (control, 50%, 75% and 100% of the recommended nitrogen fertilizer). The highest number of panicle $hill^{-1}$ (14.60) produced at liquid fertilization with magic growth under 75 % N. No fertilization provided the lowest number of panicle $hill^{-1}$ (11.72) (Alam *et al.*, 2015).

2.2.5. Number of grains panicle^{-1}

Field experiment was conducted to study the effect of NPK at different levels along with

with soil and foliar application of organic substitutes on the growth and yield of rice assigning twelve treatments. Results reported that the number of filled grains/ panicle (106) was significantly highest in 100b % NPK + FYM + Humic acid foliar spray compared to 100 % NPK + FYM (Venkateshprasath *et al.*, 2017).

A study was set up to study the effect of different levels of urea and magic growth spray solution on the yield and yield attributes of BRRI dhan29 consisted of ten treatments. Results reported that the highest number of grains panicle^{-1} (100) was found in 26 kg urea ha^{-1} + 5.66 L ha^{-1} magic growth spray solution which was significantly different from other treatments whereas the lowest grains (74.33) was recorded from control treatment (Nasrin *et al.*, 2016).

A field experiment was conducted to evaluate the performance of PRH and liquid fertilizer: Calsol and Magic Growth assigning 8 treatments. Results showed that the total grain panicle^{-1} found maximum in recommended fertilizer dose with Calsol at 7 days before panicle initiation. On the other hand, total grain panicle^{-1} was the lowest in PRH (Karim *et al.*, 2015).

An experiment was laid out to find out the effect of foliar fertilization on BRRI dhan28 to reduce soil application of nitrogenous fertilizer assigning two levels of foliar fertilization of magic growth (no foliar fertilization and foliar fertilization with magic growth at 7, 30, 45 and 60 DAT) and four nitrogen fertilizer levels (control, 50%, 75% and 100% of the recommended nitrogen fertilizer). The number of grains panicle^{-1} was increased with foliar fertilization treatment. On the other hand, the increment of nitrogen level in no foliar fertilization treatment also increased number of grain panicle^{-1} (Pramanik *et al.*, 2015).

Different type of elements (Zinc, Boron and Copper) was significant on the number of spikes per plant, grain per spike, Grain in square meter (Moghadam *et al.* 2012).

An experiment was studied by to find out the effect of zinc and phosphorus on yield of rice (cv.BR-11) assigning 12 treatments comprising 4 levels of Zn (0, 5, 10 and 20 kg Zn ha^{-1}) and 3 levels of P (0, 25 and 50 kg P_2O_5 ha^{-1}) along with basal doses of recommended fertilizer. The findings revealed that the highest number of grains

panicle^{-1} was obtained from 20 kg Zn ha^{-1} treatment over control and 50 kg P_2O_5 ha^{-1} where no Zn and P produced the minimum number of grains panicle^{-1} (Rahman *et al.*, 2011).

2.2.6. Thousand grains weight

An experiment was done to find out the effects of foliar fertilization on BRRI dhan28 to reduce soil application of nitrogenous fertilizer assigning two levels of foliar fertilization of magic growth (no foliar fertilization and foliar fertilization with magic growth at 7, 30, 45 and 60 DAT) and four nitrogen fertilizer levels (control, 50%, 75% and 100% of the recommended nitrogen fertilizer). The 1000 grains weight was increased with the increment of nitrogen level in no foliar fertilization treatment but 1000 grains weight was also increased with the increment of nitrogen level up to 75% N in foliar fertilization treatment (Pramanik *et al.*, 2015).

A study was conducted to find out the effect of quality and antioxidant activity of rice grown on alluvial soil amended with Zn, Cu and Mo. Findings revealed that the significantly highest 1000 grains weight was found in the combined treatment, while the highest percentage (25.09 %) of unfilled grains was found in the control treatment (Panhwar *et al.*, 2015).

A field experiment was conducted to find out the effect of nitrogen fertilizer sources and foliar spray of humic and/or fulvic acids on yield and quality of rice plants with two nitrogen sources i.e. anhydrous ammonia and urea as well as humic and fulvic acids at rate of 5 g/L., individually or mixed and non-addition of spray (control treatment). The findings of the study revealed that the highest significant values of 1000 grains weight (g) were obtained by foliar application of humic and fulvic acids together under anhydrous ammonia fertilizer form. While the lowest was recorded with control under urea fertilizer in both seasons (Osman *et al.*, 2013).

To find out the effect of zinc and phosphorus on yield of rice (cv.BR-11), a study was laid out assigning 12 treatments comprising 4 levels of Zn (0, 5, 10 and 20 kg Zn ha^{-1} from zinc sulphate) and 3 levels of P (0, 25 and 50 kg P_2O_5 ha^{-1}) along with basal doses of 100 kg N ha^{-1}, 40 kg K_2O ha^{-1} and 12 kg S ha^{-1}. Findings revealed that 20 Kg Zn ha^{-1} and 50 Kg P ha^{-1} produced significantly the heaviest 1000-grain weight while control of both Zn and P produced the lowest grain weight (Rahman *et al.*, 2011).

A field trial was conducted to study the effect of different micronutrient treatments on rice (*Oryza sativa* L.) growth and yield under saline soil conditions. The treatments included Zn, Mn, Fe application as soil single treatments or Zn + Mn, Zn + Fe, Mn + Fe and Zn +Mn + Fe as a combined application through soil as well as a comparative treatment of commercial compound (14% Mn +12% Fe +16% Zn) was applied twice at 20 and 45 days after transplanting (DAT) as foliar spray. Data revealed that the comparative foliar application treatment of Zn +Fe + Mn gave the highest values of 1000 grains weight (Zayed *et al.,* 2011).

2.2.7. Filled grain (%)

A field experiment was conducted by to evaluate the performance of PRH and liquid fertilizer: Calsol and Magic Growth using in RCB design with three replications included 8 treatments. Data showed that filled grain (%) recorded maximum in Recommended fertilizer dose with Calsol at 7 days before panicle initiation and the remaining treatment showed almost similar trend of filled grain (%) (Karim *et al.*, 2015).

2.2.8. Grain yield

Field experiment was conducted to study the effect of NPK at different levels along with soil and foliar application of organic substitutes on the growth and yield of rice with twelve treatments. Data reported that the highest grain yield was observed in 100 % NPK + FYM + humic foliar spray whereas 100 % NPK and FYM applications produced least (Venkateshprasath *et al.,* 2017).

An experiment was conducted to study the effects of NPKS on yield and nutrition of BRRI dhan49. There are five fertilizer treatments: NPKS (complete), PKS (-N), NKS (-P), NPS (-K) and NPK (-S). NPKS was applied @ 100-7-80-3 kg ha^{-1} respectively. Results showed that the highest grain yield was recorded with complete fertilizer treatment (Ahmad *et al.,* 2017).

A study was set up to study the effect of different levels of urea and magic growth spray solution on the yield and yield attributes of BRRI dhan29 consisted of ten treatments. The highest grain yield (6.16 t ha^{-1}) was obtained from 126 kg urea ha^{-1} + 5.66 L ha^{-1} magic growth spray solution. The lowest grain yield (4.33 t ha^{-1}) was obtained from control treatment (Nasrin *et al.,* 2016).

The experiment was carried out using a split plot design with two levels of liquid fertilization (no liquid fertilization and liquid fertilization with Magic Growth applied at 30, 45 and 60 DAT) and four levels of nitrogen fertilizer (control, 50%, 75% and 100% of the recommended nitrogen fertilizer). The treatment combinations of liquid fertilization with Magic Growth and 75% N provided the highest grain yield (2.58 t ha^{-1}) whereas no liquid fertilization provided statistically the lowest grain yield (1.84 t ha^{-1}) under control of N (Alam *et al.*, 2015).

A field experiment was conducted to evaluate the performance of PRH and liquid fertilizer: Calsol and Magic Growth with 8 treatments. Data revealed that the highest grain yield was found in recommended fertilizer dose of NPKS and Zn (Control) that showed statistically identical with other treatments. While PRH treatment yielded minimum grain yield among all treatment (Karim *et al.*,2015).

An experiment was studied to find out the effect of foliar fertilization on BRRI dhan28 to reduce soil application of nitrogenous consisted of two levels of foliar fertilization of magic growth (no foliar fertilization and foliar fertilization with magic growth at 7, 30, 45 and 60 DAT) and four levels of nitrogen fertilizer (control, 50%, 75% and 100% of the recommended nitrogen fertilizer). In this present study, foliar fertilization application provided greater grain yield compared to no foliar fertilization in all nitrogen levels (Pramanik *et al.*, 2015).

An experiment was set up to find out the effect of quality and antioxidant activity of rice grown on alluvial soil amended with Zn, Cu and Mo. The treatments were control (without micronutrient), Zn, Cu and Mo (5, 4, 0.5 kg ha^{-1}) respectively. The respective N, P, K & S fertilizers were applied to all treatments at 120, 30, 60 and 10 kg ha^{-1} respectively. The combined micronutrient treatment produced significantly higher rice grain than that of the control. About 18% increment in grain yield was recorded by combined micronutrient treatment compared to control (Panhwar *et al.*, 2015).

A long-term (33 years) experiment was carried out to investigate the effect of chemical fertilization on rice yield and yield trends for the double rice cropping systems in subtropical China including six treatments viz. no fertilization (control); full doses of NPK; full doses of NP without K; full doses of NK without P; double dose of NPK. Findings reported that the full doses of N, P and K (NPK) produced highest rice yield whereas the lowest grain yield was obtained in control treatment (Bi *et al*., 2014).

A field experiment was conducted to study the response of fine rice (*Oryza sativa* L.) to time of application of P in combination with Zn under anaerobic conditions. The highest kernel yield (4.38 t ha^{-1}) was recorded in P + Zn application at the time of last puddling followed by 3.90 t ha^{-1} for P application just before transplanting. Minimum kernel yield (2.96 t ha^{-1}) was observed in P application 20 days after transplanting (Nadeem *et al.*, 2013).

A study was carried to find out the effect of nitrogen fertilizer sources and foliar spray of humic and/or fulvic acids on yield and quality of rice plants with two nitrogen sources i.e anhydrous ammonia and urea as well as humic and fulvic acids at rate of 5 g/L., individually or mixed and control treatment served check which were allocated at random. Results found that grain yield and N, P & K content of grain was significantly increased by foliar application of humic and fulvic acids together with anhydrous ammonia fertilizer whereas, the lowest significant ones were obtained when control treatment in both seasons (Osman *et al.*, 2013).

To evaluate the effect of soil and/or foliar Zn fertilizer application on grain yield and grain Zn concentration of rice grown in 17 field trials was conducted in China, India, Lao PDR, Thailand and Turkey. As an average of all trials, Zn application increased grain yield by about 5 %. On average, Zn concentration in brown rice was increased by 25 % and 32 % by foliar and foliar + soil Zn applications, respectively, and only 2.4 % by soil Zn application (Phattaraku *et al.*, 2012).

Grain yield, straw yield, 1000 grains weight and number of grains/Panicle, Fe, Mn and Zn concentration in flag leaves and grains as well as, protein content in grain were significantly increased by application of these elements in wheat (Zeidan *et al*., 2010).

Results of a broad-based study conducted in 815 irrigated wheat growing regions of Iran between 1995 and 1996 showed that addition of each micronutrient (Fe, Zn, Cu, and B) or a combination of Fe + Zn + Cu + B to NPK fertilizer increased grain yield. The highest yield was obtained by adding all the micronutrients to NPK fertilizer. A 22-site study showed that NPK + micronutrients increased significantly protein content of wheat kernel from 11.66 (%) to 12.01(%) (Malakouti *et al*., 2008).

A field experiment was studied on a non-calcareous dark gray floodplain soil of BAU farm, Mymensingh using rice (cv. BRRI dhan29) used RCBD design was followed with five treatments. viz. T_0 (control), T_1 (10 kg S/ha), T_2 (20 kg S/ha), T_3 (40 kg S/ha) and

T_4 (60 kg S/ha). All plots received an equal dose of N, P, K and Zn. Data revealed that the maximum grain and straw yield (5.81 t /ha) in 20 kg S/ha treatment (Rahman *et al.*, 2007).

2.2.9. Straw yield

An experiment was conducted to study the effect of NPKS on yield and nutrition of BRRI dhan49. There are five fertilizer treatments: NPKS (complete), PKS (-N), NKS (-P), NPS (-K) and NPK (-S). NPKS was applied @ 100-7-80-3 kg ha^{-1} respectively. Findings revealed that NPK (-S) produced the highest straw yield which was statistically identical with complete fertilization. PKS(-N) produced the lowest straw yield followed by NPS(-K) (Ahmad *et al.*, 2017).

A study was set up to study the effects of different levels of urea and magic growth spray solution on the yield and yield attributes of BRRI dhan29. The experiment consisted of ten treatments. Results reported that the highest straw yield (9.33 t ha^{-1}) was produced by 126 kg urea ha^{-1} + 5.66 L ha^{-1} magic growth spray solution and 132 kg urea ha^{-1} + 5.66L ha^{-1} magic growth spray solution and the lowest yield (5.33 t ha^{-1}) was obtained from control (Nasrin *et al.*, 2016).

The experiment was carried out with two levels of liquid fertilization (no liquid fertilization and liquid fertilization with magic growth applied at 30, 45 and 60 DAT) and four levels of nitrogen fertilizer (control, 50%, 75% and 100% of the recommended nitrogen fertilizer). Results revealed that the highest straw yield (4.38 t ha^{-1}) was obtained in liquid fertilization treatment compared to that no liquid fertilization treatment (3.84 t ha^{-1}) (Alam *et al.*, 2015).

To evaluate the effect of foliar fertilization on BRRI dhan28 to reduce soil application of nitrogenous fertilizer. Treatment consisted of two levels of foliar fertilization of magic growth (no foliar fertilization and foliar fertilization with magic growth at 7, 30, 45 and 60 DAT) and four nitrogen fertilizer levels (control, 50 %, 75 % and 100 % of the recommended nitrogen fertilizer). The experiment revealed that the highest straw yield was obtained at 100% N which was statistically equal to that recorded in 75 % N whereas the lowest straw yield was recorded in control treatment (Pramanik *et al.*, 2015).

An experiment was done to find out the effect of quality and antioxidant activity of rice grown on alluvial soil amended with Zn, Cu and Mo in the Kelantan Plains, Malaysia.

The treatments: control; Zn, Cu and Mo (5, 4, 0.5 kg ha^{-1}) respectively. The respective N, P, K & S fertilizers were applied to all treatments at 120, 30, 60 and 10 kg ha^{-1} respectively. The findings of the experiment revealed that the combined micronutrient treatment produced significantly higher straw yield than that of the control. Combined micronutrient treatment produced about 18% more straw yield compared to control (Panhwar *et al.*, 2015).

To find out the effect of nitrogen fertilizer sources and foliar spray of humic and/or fulvic acids on yield and quality of rice plants, an experiment carried out with two nitrogen sources i.e anhydrous ammonia and urea as well as humic and fulvic acids at rate of 5 g/L., individually or mixed and non-addition of spray served check which were allocated at random. The results showed that straw yield and N, P & K content of straw yield was increased significantly by anhydrous ammonia. While, the lowest significant values of straw yield and N, P & K content of straw yield were recorded by urea nitrogen fertilizer in both growing seasons (Osman *et al.*, 2013).

A field experiment was carried out to study the response of humic acid (HA) on the yield and nutrient uptake of rice (ADT-39) at the central farm, Agricultural College and Research Institute, Killikulam. The treatments consisted of: M_1, M_2, M_3-Control, 75% NPK, 100% NPK and 8 levels of sulpher (0, 10, 20, 30, 40 Kg ha^{-1} ,10 +0.1% foliar spray, 10+ 0.2% foliar spray, 10+ 0.3% foliar spray). Data revealed that the highest grain yield was recorded at the combined effect of fertilization compared to single effect of both (Sivakumar *et al.*, 2007).

2.2.10. Biological yield

Manganese separate or mixed with zinc without humic acid application produced (6.62 and 6.67 ton /fed) besides zinc or manganese application at 4 kg humic acid /fed gave (6.43 and 6.67 tons/fed.) of biological yield/fed, while the highest biological yield (6.73 ton /fed) resulted from spraying zinc + manganese mixture with 4kg/fed of humic acid (Radwan *et al.* 2015).

2.2.11. Harvest index

A study was set up to study the effect of different levels of urea and magic growth spray solution on the yield and yield attributes of BRRI dhan29. The experiment consisted of ten treatments. The highest harvest index (44.76 %) was recorded in 117 kg urea ha^{-1} + 1.44 L ha^{-1} magic growth spray solution which was statistically similar with other

treatments and the lowest (37.05%) HI was recorded in 132 kg urea ha^{-1} + 5.66 L ha^{-1} magic growth spray solution application (Nasrin *et al.*, 2016).

A study was done to find out the effect of quality and antioxidant activity of rice grown on alluvial soil amended with Zn, Cu and Mo in the Kelantan Plains, Malaysia. Results showed that the highest harvest index was observed with combined micronutrient applications (Panhwar *et al.*, 2015).

As for harvest index, the highest values (46.30 % and 4.24 %) in the first season, resulted from zinc application without humic acid using and manganese with humic acid at 4kg/fed. Conversely, manganese applied with 3 or 4 kg/fed., of humic acid produced the highest harvest index (43.37 % and 43.48%) and that was along with zinc application under at 4 kg humic acid per feddan which produced (44.59%) (Radwan *et al.* 2015).

CHAPTER III
MATERIALS & METHODS

The field experiment was conducted at the central Research Farm of Sher-e-Bangla Agricultural University, Dhaka from November, 2016 to June, 2017 to study the improvement of yield in hybrid rice varieties through the manipulation of stem reserve remobilization and filled-grain percentage by plant growth stimulator and foliar fertilization. This chapter deals with a brief description on experimental period, experimental site, climate, soil, and land preparation, layout of the experimental design, intercultural operations, data recording and their analyses. Details of materials and methods used in this experiment are given below:

3.1. Experimental period

The experiment was conducted at the central Research Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh during the *Boro* season from November, 2016 to June, 2017.

3.2. Description of the experimental site

3.2.1. Geographical location

The experimental area was situated at $23^0 74'$N latitude and $88^0 35'$E longitude at an altitude of 8.6 meter above sea level (Anon., 2004). For better understanding, experimental site has been shown in the Map of AEZ of Bangladesh in Appendix I.

3.2.2. Agro-Ecological region

The experimental field belongs to the Agro-ecological zone of "The Modhupur Tract", AEZ-28 (Anon., 1988a) (Appendix I). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain (Anon., 1988b).

3.2.3. Climate and weather

The geographical location of the experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October (Edris *et al.,* 1979). Information regarding monthly maximum and

minimum temperature, rainfall, relative humidity and sunshine as recorded by Bangladesh Meteorological Department, Agargaon, Dhaka-1207 during the period of study. The weather data of the experimental site have been presented in Appendix II.

3.2.4. Soil

The soil of the experimental field belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon Series (AEZ 28). The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish-brown mottles. The land was located above flood level and sufficient sunshine was available during the experimental period. The soil pH ranged from 5.4-5.6 and had organic carbon content 0.84% and organic matter 1.29%. Soil samples from 0-15 cm depths were collected from the experimental field. The soil analyses were done at the Soil Resource and Development Institute (SRDI), Dhaka. The physicochemical properties of the soil have been presented in Appendix III.

3.3. Plant material

In this research work, two high yielding rice cultivars were used as plant materials. The rice cultivars used in the experiments were BRRI dhan29 and BRRI hybrid dhan3. The seeds were collected from the Bangladesh Rice Research Institute (BRRI), Joydebpur. Gazipur.

3.3.1. Description of rice cultivar: BRRI dhan29

BRRI dhan29 is a high yielding variety of *Boro* season. The origin of this variety is BR 802-118-4-2 which was developed from the cross between BG 90-2 and BR51-46-5 at the Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur, Bangladesh in 1994. Average plant height of the BRRI dhan29 variety is 95-100 cm at the ripening stage and the flag leaf remains green and erect at maturity. It needs about 155-160 days to complete its life cycle with an average grain yield of 6.5-7.5 t ha^{-1}. The grains are medium slender with light golden husks and kernels are white in color. This genotype is known for its bold grains, with a 1000 grains weight of about 29 g, grain length of 5.9 mm, and grain width of 2.5 mm. It is resistant to damping off and moderately resistant to blast (*Pyricularia oryza*), sheath blight (*Rhizoctonia solani*) and bacterial blight (*Xanthomonas oryza*) in terms of yield, this is the best variety so far released by BRRI (Anon., 2003; Anon., 1991).

3.3.2. Description of rice cultivar: BRRI hybrid dhan3

BRRI hybrid dhan3 is an early variety which is recommended for *Boro* Season. This variety was developed by Bangladesh Rice Research Institute and it was approved by National Seed Board in 2009. It is about 110 cm in height with an average grain yield of about 6.5-9.0 t ha^{-1}. It takes 145 days for maturity. It provides medium thick grain, non-glutinous and tasty rice. Disease, insect and pest resistance power of the variety is more or less similar to our modern inbred varieties.

3.4. Liquid fertilizers

Commercially available common liquid fertilizers were collected from local market. It is a blend of more than one macro and micro nutrients.

Composition of liquid fertilizer

Chemical composition of the commercially available common liquid fertilizers

Name	Chemical composition
Calsol	N2- 1.4%, K2O-0.1%, Mg-0.71%, S-1.5%, Zn-0.12%, B-0.34%, Mo- 50 ppm, Mn-200 ppm with Ca and Fe.
Magic Growth	N_2- 10.51%, P_2O_5- 5.58%, K_2O- 6.33%, S- 0.10%, Zn- 0.16%, Cu- 0.04%, Fe- 0.0006%, Mn- 0.006%, B- 0.25%, Ca- 0.07% and Mg- 0.007%, pH - 1.0

3.5. Plant Growth Stimulator

Name	Ingredients
Akota	Humic acid (a.i-1250ppm)
Global	Humic acid 16%

3.6. Details of the experiment

3.6.1. Treatments

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

Factor A: Variety (2)

i) BRRI hybrid dhan3

ii) BRRI dhan29

List of the genotypes used in the experiment with their origin

Varieties	Origin
BRRI hybrid dhan3	Released by BRRI
BRRI dhan29	Released by BRRI

Factor B: PGS and fertilizer management:

T_1 = Recommended fertilizer dose

T_2 = Recommended fertilizer dose + Akota + Global

T_3 = Recommended fertilizer dose + Akota + Global + Calsol

T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth

T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth

Treatment Combinations

There were altogether 10 (2 x 5) treatment combinations used in each replication as follows:

V_1T_1 = BRRI hybrid dhan3 + Recommended fertilizer dose

V_1T_2 = BRRI hybrid dhan3 + Recommended fertilizer dose + Akota + Global

V_1T_3 = BRRI hybrid dhan3 + Recommended fertilizer dose + Akota + Global + Calsol

V_1T_4 = BRRI hybrid dhan3 + Recommended fertilizer dose + Akota + Global + Magic Growth

V_1T_5 = BRRI hybrid dhan3 + Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth

V_2T_1 = BRRI dhan29 + Recommended fertilizer dose

V_2T_2 = BRRI dhan29 + Recommended fertilizer dose + Akota + Global

V_2T_3 = BRRI dhan29 + Recommended fertilizer dose + Akota + Global + Calsol

V_2T_4 = BRRI dhan29 + Recommended fertilizer dose + Akota + Global + Magic Growth

V_2T_5 = BRRI dhan29 + Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth

3.6.2. Preparation and application of treatments

The descriptions of the application method of PGS and fertilizer management treatments is given below:

3.6.2.1. Method of recommended fertilizer application:

Recommended fertilizers were dispensed as per Bangladesh Rice Research Institute (BRRI) recommended dose (Adhunik Dhaner Chas, 2011).

3.6.2.2. Method of PGS application:

PGS was dispensed @ 200 ml per 20 liters water for 0.10 ha^{-1} every time. It was applied 5 times during the entire crop cycle. Before seed sowing in seed bed, seeds were soaked with PGS for 1-2 minutes @ 200 ml per 20 liters 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.

3.6.2.3. Liquid Fertilizer (Calsol) Application Method:

Calsol was applied at 7 days before and after panicle initiation. During each application it was applied @ 48 ml per 15 liters water for 0.04 ha^{-1} of land. A hand garden sprayer was used to spray foliar fertilizer solution. Foliar fertilizers were applied on leaves at evening, because of less sun light, low transpiration and evaporation rate, absorbing more nutrients over night by the plant and beneficial pollinating agents are absent or return to their hive and also save to them from there nutrients.

3.6.2.4. Liquid Fertilizer (Magic Growth) application method:

Magic Growth is a liquid fertilizer invented by Md. Arif Hossain Khan, Joint Director (Seed Marketing), Bangladesh Agricultural Development Corporation (BADC) which is ready for government recognition. It was sprayed at 7 days before and after panicle initiation. During each application it was applied @ 32 ml per 16 liters water for 0.04 ha^{-1} of land.

3.6.3. Experimental design and layout:

The experimental design was a Randomized complete block design (RCBD) with two factors and three replicates for each treatment. The experiment was arranged in a Randomized complete block design (RBCD) having PGS and fertilizer management in the main plots and varieties in the sub-plot. The total numbers of unit plots were 30. The size of unit plot was 3.0 m x 1.5 m. There were 10 treatment combinations. The distances between plot to plot and replication to replication were 0.5 m and 1m respectively. The Layout of the experimental field has been presented in Figure 1.

3.7. Crop management

3.7.1. Raising of seedlings

3.7.1.1. Seed collection

Vigorous and healthy seeds of BRRI dhan29 and BRRI hybrid dhan3 were collected from Genetic Resource and Seed Division, BRRI, Joydebpur, Gazipur, Bangladesh.

3.7.1.2. Seed sprouting

Healthy vigorous seeds were selected by specific gravity method. The seeds were immersed in water bucket for 24 hours. Then the seeds were taken out from water and kept compactly in gunny bags. The seeds started germination after 48 hours which were compatible for sowing in 72 hours.

3.7.1.3. Preparation of seedling nursery

A common procedure was followed in raising seedlings in the seedbed. The seedbed was prepared by puddling with repeated ploughing followed by laddering. Weeds were removed and irrigation was gently provided to the bed as and when necessary. No fertilizer was used in the nursery bed.

3.7.1.4. Seed sowing

Seeds were sown on the seedbed on December 20, 2016 for raising nursery seedlings.

3.7.2. Experimental land preparation

The experimental field was first uncovered with a tractor drawn disc plough 15 days before transplanting and was exposed to the sun. The experimental field was first tilled on January 10, 2017 with the help of a tractor drawn disc plough, later on January 23, 2017 the land was irrigated and made by three successive ploughings and cross ploughings with a tractor drawn plough and subsequently planed by laddering. All weeds and other plant residues of previous crop were taken aside from the field immediately. After final land preparation the field layout was shaped on January 24, 2017 according to experimental scheme. Individual plots were cleaned and finally leveled with the help of wooden plank so that no water pocket could stay in the puddled field.

3.7.3. Fertilizers and Manure Application

The fertilizers N, P, K, S, Zn and B in the form of urea, TSP, MP, gypsum, zinc sulphate and borax were applied respectively. The following doses of manure and fertilizers (BRRI, 2013) were used.

Manure and Fertilizer	Doses
Cow-dung	5 t ha^{-1}
Urea (N_2)	220 kg ha^{-1}
TSP (P_2O_5)	165 kg ha^{-1}
MP (K_2O)	180 kg ha^{-1}
Gypsum	70 kg ha^{-1}
Zinc	10 kg ha^{-1}

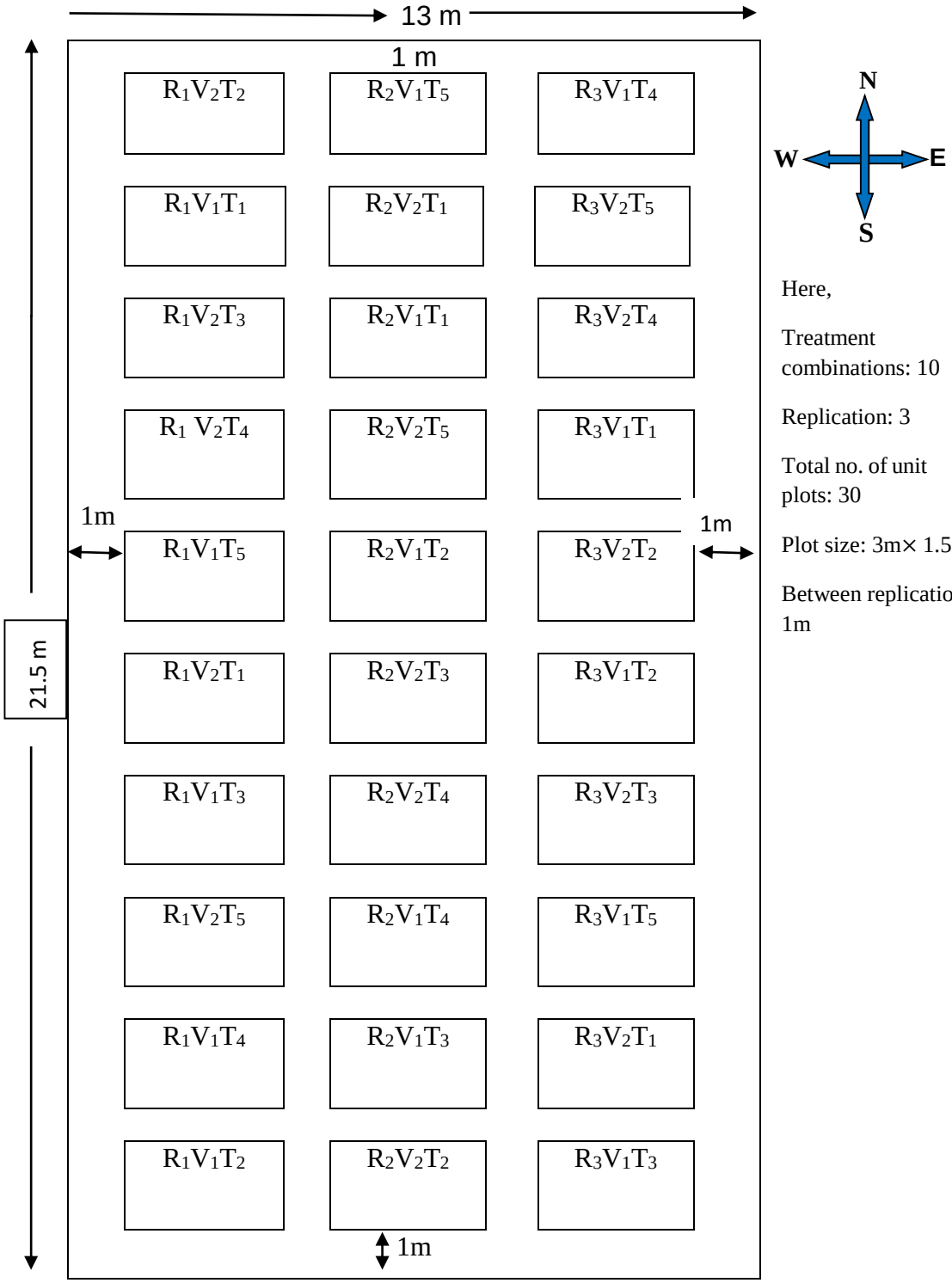
At the time of first ploughing, cow-dung was applied at the rate of 10 t ha^{-1}. Whole amount of triple super phosphate, muriate of potash, gypsum and zinc sulphate were applied at final land preparation through broadcasting method as a basal dose. Urea was top-dressed in three equal installments. One third of urea was applied at the time of final land preparation as a basal dose. Half of the rest two third of urea was applied at 30 DAT and the rest amount of urea was applied at 55 DAT.

3.7.4. Uprooting of seedlings

The seed beds were made wet by water application in previous day before uprooting of the seedlings to lessen mechanical injury of roots. The 35 days old nursery seedlings were uprooted carefully on January 24, 2017 without causing much mechanical injury to the roots and were kept in soft mud in shade. Then the seedlings were transplanted on January 25, 2017.

3.7.5. Transplanting of seedlings in the field

Thirty-five days old seedlings were carefully uprooted from the seedling nursery and transplanted on 25 January, 2017 in well puddle plot. The seedlings were transplanted with 20 cm × 15 cm spacing on the well-puddled plots**.** In each plot, there were 6 rows, each row contains 13 hills of rice seedlings.



Here,

Treatment combinations: 10

Replication: 3

Total no. of unit plots: 30

Plot size: 3m× 1.5m

Between replication: 1m

Figure 1: Layout of experimental field

3.7.6. Intercultural operations

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of the rice seedlings. The details of different cultural operations performed during the course of experimentation have been given below:

3.7.6.1. Thinning and gap filling

No thinning was done for any treatment. To retain immutable plant population, gap filling was done up to 7 days after transplanting. After transplanting the nursery seedlings gap filling was done whenever it was momentous using the seedling from the prior source.

3.7.6.2. Weeding

Weeding was done to keep the plots free from weeds, which ultimately assured better growth and development of plant. To lessen weed infestation, manual weeding through hand pulling was done three times during whole growing season. The first weeding was done at 20 DAT on February 14, 2017. The second and third weeding were done at 35 DAT and 55 DAT followed by second and third top dressing of urea on March 2, 2017 and March 21, 2017 respectively.

3.7.6.3. Irrigation and drainage

Flood irrigation was given to retain a certain level of stable water up to 6 cm in the early stages to promote tillering and 10-12 cm in the later stage to discourage late tillering. Irrigation was given at a regular interval to maintain a thin layer of water (2-3 cm) depth from panicle initiation (PI) to hard dough stage up to hard dough stage of rice. The field was finally dried out 15 days before harvesting.

3.7.6.4. Top dressing

After basal dose, the remaining doses of urea were top-dressed in 2 equal installments. The fertilizers were applied on both sides of seedlings rows with the soil.

3.7.6.5. Plant protection measures

Furadan 57EC was applied at the time of final land preparation and later on other insecticides were applied as and when necessary.

3.7.6.6. General observation of the experimental field

The field was looked into time to time to find out visual difference among the treatments and any kind of infestation by weeds, insects and diseases so that considerable losses by pest could be reduced. The field looked nice with normal green color plants. Incidence of stem borer, green leaf hopper, leaf roller and rice hispa was observed during tillering stage those were controlled properly.

3.7.6.7. Crop harvesting and post-harvest operation

The rice was harvested relying upon the maturity of plant and harvesting was done manually from each plot. Maturity of crop was determined when 80-90% of the grains become golden yellow in color. The harvesting of BRRI hybrid dhan3 was done on May 25, 2017. The harvesting of BRRI dhan29 was done on May 30, 2017. Three pre-selected hills per plot was harvested from which different data were collected. Hills from the central $1m^2$ area of each plot were harvested separately, bundled, properly tagged and then brought to the threshing floor. Threshing was done by using pedal thresher. The grains were cleaned. The grain and straw weights for each plot were recorded at fresh and at dry after proper sun drying. The yields of grain and straw $plot^{-1}$ were converted into t ha^{-1}. The grain yield was adjusted at 12 % moisture level.

3.8. Recording observations

Data were recorded on growth parameters, yield and yield contributing parameters for all the entries on three randomly selected plants from the middle rows in each replication during the study period as follows:

3.8.1. Data on growth parameters

1. Plant height
2. Number of leaves $hill^{-1}$
3. Number of tillers $hill^{-1}$
4. Leaf area index
5. Chlorophyll content
6. Total dry matter $hill^{-1}$
7. Shoot dry matter accumulation and its remobilization to grain

3.8.2. Data on yield and yield contributing parameters

1. Number of effective tillers hill^{-1}
2. Number of non-effective tillers hill^{-1}
3. Effective tiller (%)
5. Panicles hill^{-1}
4. Panicle length
6. Filled grain panicle^{-1}
7. Unfilled grains panicle^{-1}
8. Total grains panicle^{-1}
9. Filled grain (%)
10. 1000 seeds weight
11. Grain yield
12. Straw yield
13. Biological yield
14. Harvest index (%)

3.9. Procedure of Recording Data

A brief outline of the data recording procedure followed during the study is given below:

3.9.1. Growth Parameters

3.9.1.1. Plant height

The first plant height was measured at 40 DAT and continued upto harvest with 20 days interval. The height of the plant was determined by measuring the distance from the soil surface to the tip of the leaf before heading and to the tip of the flag leaf after heading. From each plot, plants of 5 hills were measured and finally averaged.

3.9.1.2. Number of leaves hill^{-1}

The number of leaves hill^{-1} was recorded at 40 DAT and continued up to harvest with 20 days interval. The data was collected from randomly pre-selected plants of three hills from the inner rows of each plot.

3.9.1.3. Number of tillers hill^{-1}

The number of tillers hill^{-1} was counted at first at 40 DAT and continued up to harvest with 20 days interval. Only those tillers having three or more leaves were used for counting.

3.9.1.4. Leaf area index

Leaf area index was estimated manually measuring the length and width of leaf and multiplying by a factor 0.75 as suggested by Yoshida (1981).

3.9.1.5. Chlorophyll content

Flag leaves were sampled at 15 days after flowering and a segment of 20 mg from middle portion of leaf was used for chlorophyll analysis. Chlorophyll content was measured on fresh weight basis extracting with 80 % acetone and used doubled beam spectrophotometer (Model: U-2001, Hitachi, Japan) according to Witham *et al.* (1986). Amount of chlorophyll was calculated using following formulae.

Chlorophyll a (mg g^{-1}) = [12.7 (OD_{663})-2.69 (OD_{645})] $\times \frac{V}{1000\,W}$

Chlorophyll b (mg g^{-1}) = [12.9 (OD_{663})-4.68 (OD_{645})] $\times \frac{V}{1000\,W}$

Where,

OD = Optical density of the chlorophyll extract at the specific wave length.

V = Final volume of the 80% acetone chlorophyll extract (ml)

W = Fresh weight in gram of the tissues extracted.

Chlorophyll (a+b)

The total chlorophyll content (a+b) was calculated with the following formula:

Chlorophyll a+b (mg g^{-1}) =[20.2 (OD_{645})-8.02 (OD_{663})] $\times \frac{V}{1000\,W}$

Chlorophyll a/b Ratio

Chlorophyll a/b ratio was measured with the following formula:

$$\text{Chlorophyll a/b ratio} = \frac{\text{Chlorophyll a (mg g}^{-1})}{\text{Chlorophyll b (mg g}^{-1})}$$

3.9.1.6. Total dry matter hill^{-1}

Total dry matter hill^{-1} was recorded at the time of 40, 60, 80,100 DAT (days after transplanting) and at harvest after drying plant sample by adding stem dry matter and leaves dry matters hill^{-1}.

3.9.1.7. Shoot dry matter accumulation and its remobilization to grain

Plants were sampled from each plot at flowering and maturity stages. The harvesting plant was separated into leaf blade (leaf), culm, sheath (stem) and panicles. Dry matter of each component was determined after drying at 72^0C for 72 hours. The shoot (stem + leaf) translocation was calculated by net loss in dry weight of vegetative organs between flowering and maturity stages (Bonnett and Incoll, 1992).

$$\text{Shoot reserve translocation (\%)} = \frac{A - M}{A} \times 100$$

Where, A = Total shoot dry matter at pre-anthesis, gm^{-2}

M = Total shoot dry matter at maturity, gm^{-2}

3.9.2. Yield and yield contributing parameters

The sample plants of 3 hills were harvested randomly from each plot and tagged them separately. Data on yield components were collected from the sample plants of each plot.

3.9.2.1. Number of effective tillers hill^{-1}

The panicles which had at least one grain was considered as effective tiller. The number of effective tillers of 3 hills was recorded and expressed as effective tillers number hill^{-1}.

3.9.2.2. Number of non-effective tillers hill^{-1}

The tiller having no panicle was regarded as non-effective tiller. The number of non-effective tillers was recorded and was expressed as non–effective tiller number hill^{-1}.

3.9.2.3. Effective Tiller (%)

Effective tiller (%) was calculated by using the formula:

$$\text{Effective tiller (\%)} = \frac{\text{Number of effective tillers hill}^{-1}}{\text{Total number of tillers hill}^{-1}} \times 100$$

3.9.2.4. Panicles hill^{-1}

The total number of panicles hill^{-1} was counted as the number of panicles bearing tiller plant^{-1}. Data on effective tillers hill^{-1} were counted from 3 selected hills at harvest and average value was recorded.

3.9.2.5. Panicle length

Measurement of panicle length was taken from basal node of the rachis to apex of each panicle. Each observation was an average of 5 panicles.

3.9.2.6. Filled grain panicle^{-1}

Grain was considered to be filled if any kernel was present in there. The number of total filled grains present on five panicles were recorded and finally averaged.

3.9.2.7. Unfilled grains panicle^{-1}

Unfilled grain means the absence of any kernel inside it and such grains present on each of five panicles were counted and finally averaged.

3.9.2.8. Total grains panicle^{-1}

The number of filled grains panicle^{-1} plus the number of unfilled grains panicle^{-1} made the total number of grains panicle^{-1}.

3.9.2.9. Filled Grain (%)

Filled grain (%) was computed using the formula:

$$\text{Filled grain (\%)} = \frac{\text{Filled grains panicle}^{-1}}{\text{Total grains panicle}^{-1}} \times 100$$

3.9.2.10. 1000 seeds weight

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

3.9.2.11. Grain yield

Grain yield was determined from the central 1m^2 area of each plot and expressed as t ha^{-1} on about 12% moisture basis. Grain moisture content was measured by using a digital moisture tester.

3.9.2.12. Straw yield

Straw yield was determined from the central $1m^2$ area of each plot. After separating of grains, the sub-samples were oven dried to a constant weight and finally converted to t ha^{-1}.

3.9.2.13. Biological Yield

Grain yield and straw yield were all together regarded as biological yield. Biological yield was calculated with the following formula:

Biological yield (t ha^{-1}) = Grain yield (t ha^{-1}) + Straw yield (t ha^{-1})

3.9.2.14. Harvest Index (%)

Harvest index was calculated from the grain and straw yield of rice for each plot and expressed in percentage.

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (grain weight)}}{\text{Biological yield (Total dry weight)}} \times 100$$

3.10. Statistical Analysis of the Data

All the data collected on different parameters were statistically analyzed following the analysis of variance (ANOVA) technique using MSTAT-C computer package program and the mean differences were adjudged by least significant difference (LSD) test at 5 % level of significance (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The present experiment was conducted to find out the improvement of yield in hybrid rice (*Oryza sativa* L.) varieties through the manipulation of stem reserve remobilization and filled-grain percentage by plant growth regulator and foliar fertilization. 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 I-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

Significant variation was observed in case of plant height between the rice varieties at 40, 60, 80, 100 DAT and at harvest (Figure 2 and Appendix IV). At 40, 60, 80, 100 DAT and at harvest, the tallest plant (33.78, 47.91, 63.70, 92.54 and 98.98 cm respectively) was observed from BRRI hybrid dhan3, while the shortest plant was represented by BRRI dhan29. Two varieties performed different plant height and the basis for this was that of their varietal characters. The varietal traits mainly were genetically inherent but environmental such as different management practices also influence plant height.

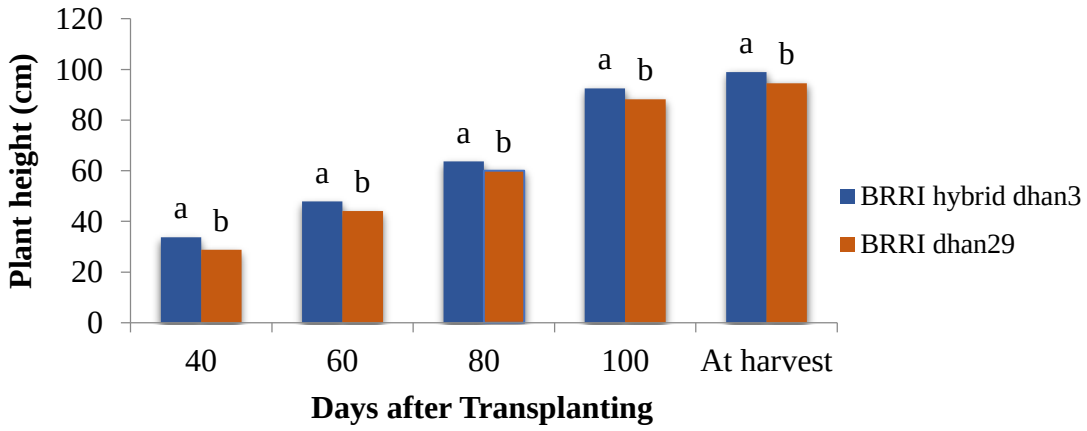


Figure 2. Effect of varieties on the plant height of rice at different days after transplanting (DAT)

4.1.1.2. Effect of PGS and fertilizer management

Plant height of rice exposed to different treatments of PGS and fertilizer management showed significant different results at 40, 60, 80, 100 DAT and at harvest (Figure 3 and Appendix IV). Application of different treatment combinations of PGS and fertilizer management influenced the plant height. Among the different treatments T_3 (Recommended fertilizer dose + Akota + Global + Calsol) produced the tallest plant (34.60, 49.65 67.52, 95.59 and 103.7 cm) at 40, 60, 80, 100 DAT at harvest respectively) and it was statistically identical to the treatment T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth) and T_2 (Recommended fertilizer dose + Akota + Global) for all the different days after transplanting (Appendix VI). While the shortest (28.30, 43.08, 58.06, 85.53 and 90.73 cm) plant height at 40, 60, 80, 100 DAT and at harvest respectively) was recorded from T_1 (Recommended fertilizer dose) which was statistically identical to the treatment T_4 (Recommended fertilizer dose + Akota + Global + Magic Growth) at different days after transplanting. Similar observation was reported by Rawashdeh and Sala (2013).

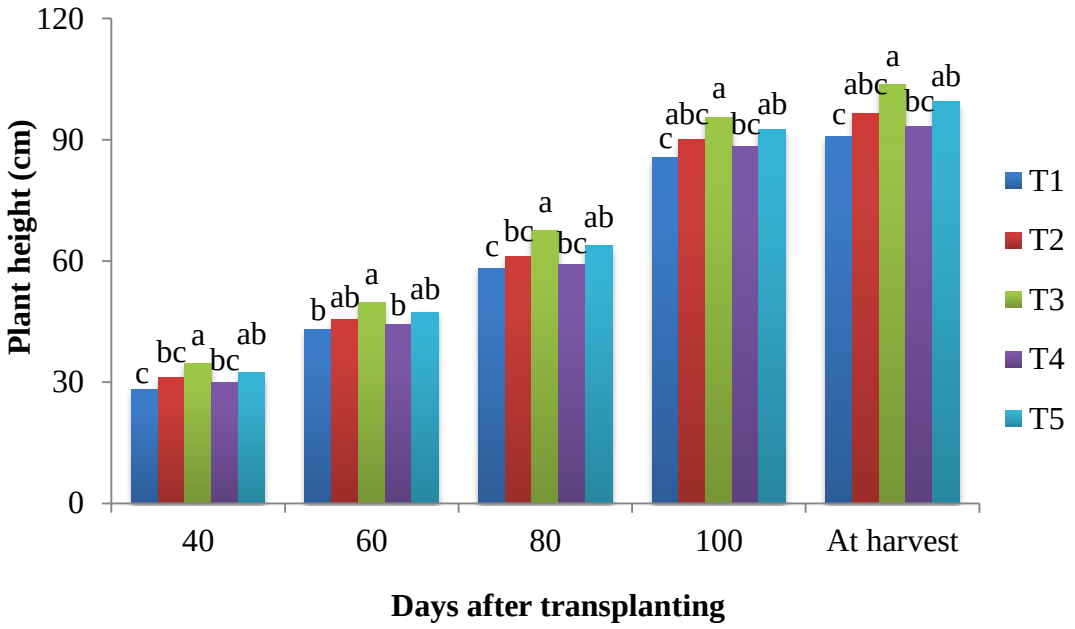


Figure 3. Effect of different levels of PGS and fertilizer on the plant height of rice at different days after transplanting (DAT)

T_1 = Recommended fertilizer dose
T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol
T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth
T_5 = Recommended fertilizer dose + Akota + Global+ Calsol + Magic Growth

4.1.1.3. Interaction effect of variety and PGS and fertilizer management

Interaction effects of PGS and fertilizer management and variety showed significant variation on plant height at 40, 60, 80, 100 DAT and at harvest (Table 1 and Appendix IV). The tallest (36.43, 51.77, 68.43,97.85 and 105.6 cm) plant height was observed at 40, 60, 80, 100 DAT and at harvest respectively from the combined treatment of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol) which was identical to the treatment combination of BRRI hybrid dhan3 × T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth) and BRRI dhan29× T_3 (Recommended fertilizer dose + Akota + Global + Calsol) for all the specific days were observed after transplanting. Whereas, the shortest plant (25.27, 41.20, 55.84, 83.14 and 88.35 cm at 40, 60, 80, 100 DAT and at harvest respectively) was recorded from the combined treatment of BRRI dhan29 × T_1 (Recommended fertilizer dose).

Table 1. Interaction effect of different varieties and levels of PGS and fertilizer on the plant height of rice at different days after transplanting (DAT)

Treatment combinations	Plant height (cm) at different days after transplanting (DAT)				
	40	60	80	100	At Harvest
BRRI hybrid dhan3×					
T_1	31.33 b-e	44.95 b-d	60.28 b-d	87.91 bc	93.10 bc
T_2	33.63 a-c	47.62 a-c	63.25 a-d	92.22 a-c	98.98 a-c
T_3	36.43 a	51.77 a	68.43 a	97.85 a	105.6 a
T_4	32.47 a-d	46.28 a-d	61.45 a-d	90.15 a-c	95.09 a-c
T_5	35.03 ab	48.91 ab	65.07 a-c	94.57 ab	102.1 ab
BRRI dhan29 ×					
T_1	25.27 f	41.20 d	55.84 d	83.14 c	88.35 c
T_2	28.55 d-f	43.38 b-d	58.77 cd	88.01 bc	94.19 a-c
T_3	32.77 a-d	47.53 a-c	66.60 ab	93.33 ab	101.9 ab
T_4	27.29 ef	42.38 cd	56.51 d	86.28 bc	91.62 bc
T_5	29.89 c-e	45.90 a-d	62.50 a-d	90.36 a-c	96.80 a-c
LSD (0.05)	4.46	6.17	7.58	9.29	11.50
CV (%)	8.32	7.82	7.15	5.99	6.92

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

T_1 = Recommended fertilizer dose
T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol
T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth
T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth
CV = Coefficient of Variation LSD (0.05) = Least significant difference

4.1.2. Number of leaves hill^{-1}

4.1.2.1. Effect of variety

Number of leaves hill^{-1} of rice varied significantly between the rice varieties except at 40 DAT under the present trial (Figure 4 and Appendix V). At 40, 60, 60, 80, 100 DAT and at harvest, the maximum (43.07, 70.08, 78.29, 74.45 and 70.73) number of leaves hill^{-1} were found from BRRI hybrid dhan3 while minimum (41.59, 59.63, 70.98, 68.58 and 65.04) number of leaves hill^{-1} were obtained from BRRI dhan29.

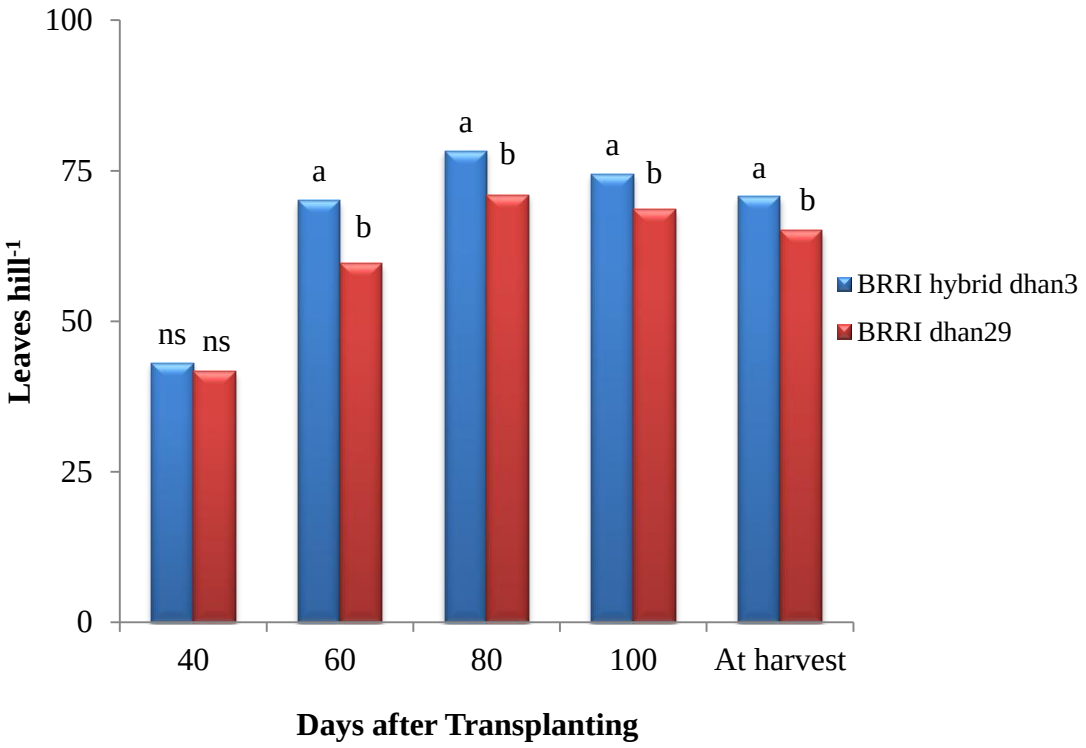


Figure 4. Effect of varieties on the number of leaves hill^{-1} of rice at different days after transplanting (DAT)

4.1.2.2. Effect of PGS and fertilizer management

Number of leaves hill^{-1} of rice showed significant variation when the different treatments of PGS and fertilizer management were applied at 40, 60, 80, 100 DAT and at harvest respectively under the present trial (Figure 5 and Appendix V). The maximum (47.90, 69.22, 80.37, 76.10 and 72.83) number of leaves hill^{-1} was attained from T_3 (Recommended fertilizer dose + Akota + Global + Calsol) which was similar with T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth). While the minimum (37.28, 59.46, 69.35, 66.50 and 62.47) number of leaves hill^{-1} was

found from T_1 (Recommended fertilizer dose) which was similar with T_4 (Recommended fertilizer dose + Akota + Global + Magic Growth). Similar observation was reported by Rawashdeh and Sala (2013); Rabin *et al*., (2016).

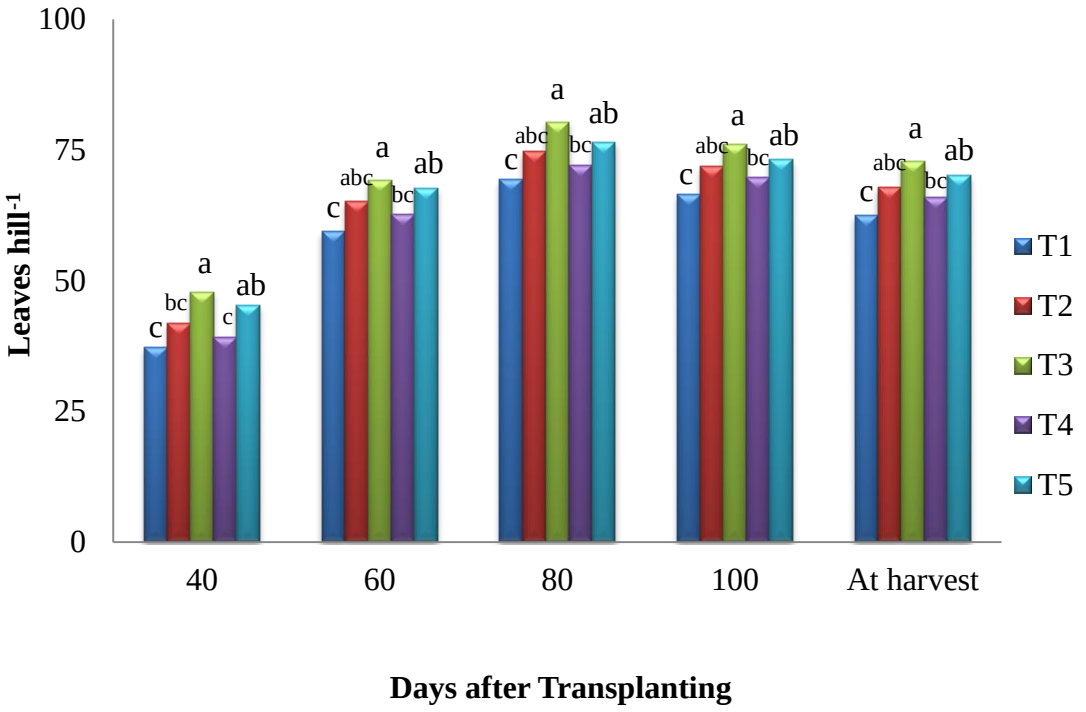


Figure 5. Effect of levels of fertilizer on the number of leaves hill^{-1} of rice at different days after transplanting (DAT)

T_1 = Recommended fertilizer dose
T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol
T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth
T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth

4.1.2.3. Interaction effect of variety and PGS and fertilizer management

Interaction effect of variety and PGS and fertilizer management had significant variation on the number of leaves hill^{-1} of rice (Table 2 and Appendix V). Maximum (48.50, 74.27, 82.77, 78.97 and 75.33) number of leaves at 40, 60, 60, 80, 100 DAT and at harvest was counted in the interaction of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol) treated plants which was statistically identical with the interaction of BRRI hybrid dhan3× T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth) whereas minimum in the interaction of BRRI hybrid dhan3 × T_1 (Recommended fertilizer dose and the interaction of BRRI dhan29× T_1 (Recommended fertilizer dose) at 40 DAT.

Table 2. Interaction effect of different varieties and levels of PGS and fertilizer on the number of leaves hill^{-1} of rice at different days after transplanting

Treatment combinations	Number of leaves hill^{-1} at different days after transplanting (DAT)				
	40	60	80	100	At Harvest
BRRI hybrid dhan3 ×					
T_1	38.07 e	64.43 bc	74.20 a-d	68.90 b-d	63.57 cd
T_2	43.23 a-e	70.77 ab	78.12 ab	75.00 ab	71.33 a-c
T_3	48.50 a	74.27 a	82.77 a	78.97 a	75.33 a
T_4	39.87 c-e	68.13 ab	76.67 a-c	73.10 a-c	69.77 a-d
T_5	45.69 a-c	72.80 a	79.70 ab	76.30 ab	73.66 ab
BRRI dhan29 ×					
T_1	36.50 e	54.49 d	64.50 d	64.10 d	61.37 d
T_2	40.48 b-e	59.52 cd	71.30 b-d	68.90 b-d	64.47 b-d
T_3	47.30 ab	64.17 bc	77.97 ab	73.23 a-c	70.33 a-d
T_4	38.62 de	57.18 cd	67.71 cd	66.47 cd	62.27 cd
T_5	45.03 a-d	62.80 bc	73.40 a-d	70.20 b-d	66.77 a-d
LSD (0.05)	6.83	8.12	9.86	7.86	9.49
CV (%)	9.41	7.30	7.70	6.41	8.15

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

T_1 = Recommended fertilizer dose
T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol
T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth
T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth
CV = Coefficient of Variation LSD (0.05) = Least significant difference

4.1.3. Number of tillers hill^{-1}

4.1.3.1. Effect of variety

Number of tillers hill^{-1} of rice varied significantly variation between the test rice varieties at 60, 100 DAT and at harvest and insignificantly variation at 40 and 80 DAT under the present trial (Figure 6 and Appendix VI). At 40, 60, 80, 100 DAT and at harvest, the maximum (11.72, 17.73, 19.15, 18.38 and 17.61) number of tillers hill^{-1}

were found from BRRI hybrid dhan3 while minimum (11.10, 16.58, 17.90, 17.22 and 16.24) number of tillers hill^{-1} were obtained from BRRI dhan29.

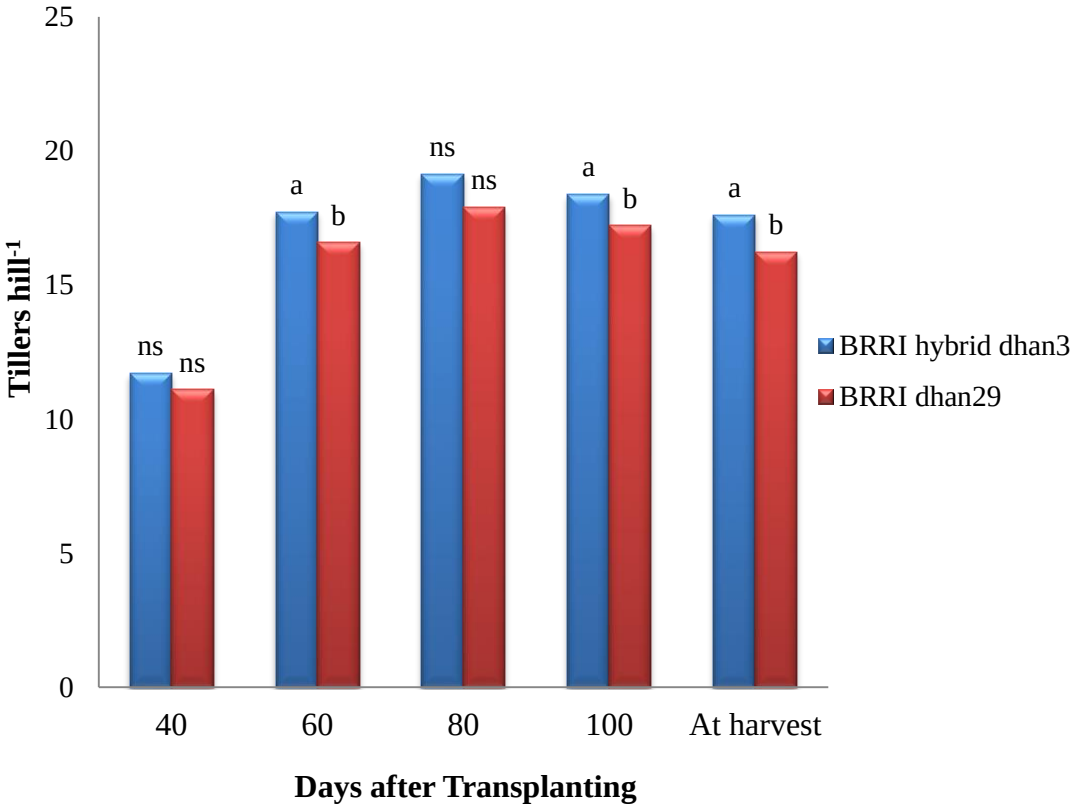


Figure 6. Effect of different varieties on the number of tillers hill^{-1} of rice at different days after transplanting (DAT)

4.1.3.2. Effect of PGS and fertilizer management

Significant variation was recorded due to different PGS and fertilizer management in terms of number of tillers per hill of rice at 40, 60, 80, 100 DAT and at harvest (Figure 7 and Appendix VI). At 40, 60, 80, 100 DAT and at harvest, the maximum (13.20, 18.98, 21.22, 19.42 and 18.62) number of tillers hill^{-1} was attained from T_3 (Recommended fertilizer dose + Akota + Global + Calsol) which was statistically similar (11.95, 18.15, 20.22, 18.45 and 17.93) with T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth). While the minimum (15.27, 16.15 and 16.34) number of tillers hill^{-1} at 60 and 80 DAT was shown by treatment T_1 (Recommended fertilizer dose). The results were supported by the findings of Shayganya *et al*. (2011), who reported that foliar application of different nutrients increased tiller number of direct-seed rice plants.

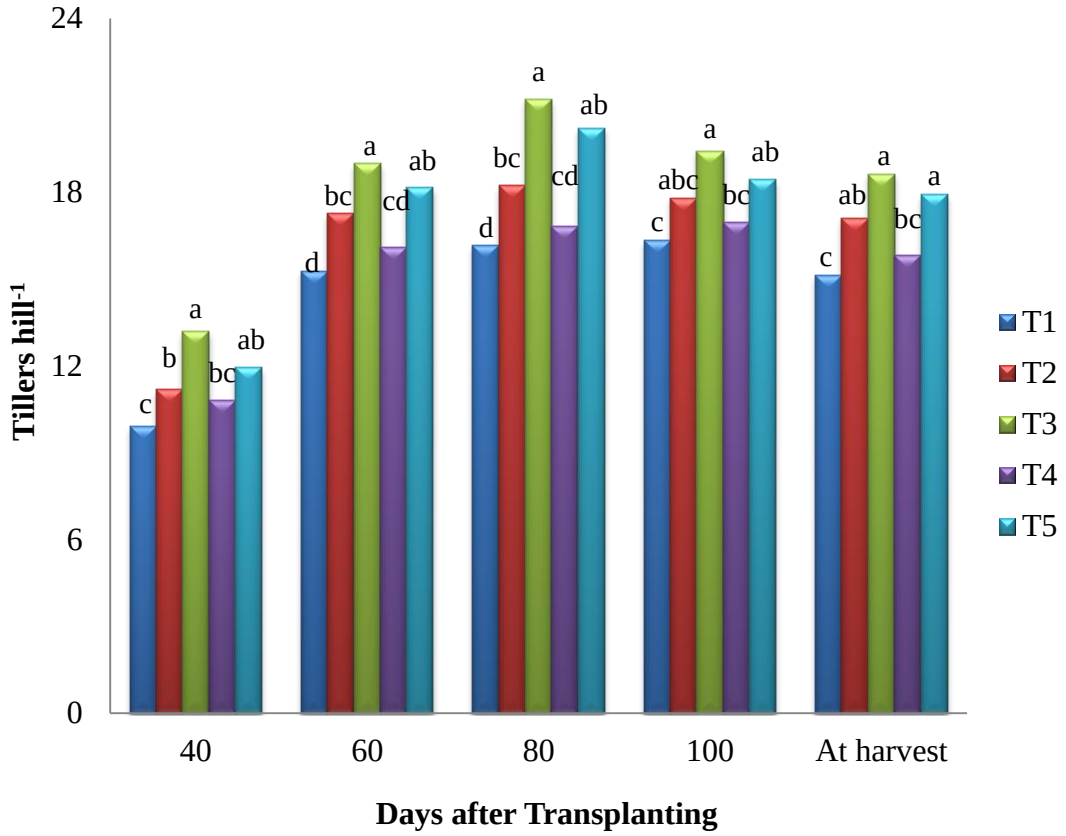


Figure 7. Effect of different levels of PGS and fertilizer on the number of tillers hill^{-1} of rice at different days after transplanting (DAT)

T_1 = Recommended fertilizer dose
T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol
T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth
T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth

4.1.3.3. Interaction effect of variety and PGS and fertilizer management

Different varieties and PGS and fertilizer management showed significant differences due to their interaction effect on number of tillers hill^{-1} of rice at 40, 60, 80, 100 DAT and at harvest (Table 3 and Appendix VI). The maximum (13.63, 19.70, 1.63, 19.97 and 9.47) number of tillers hill^{-1} at 40, 60, 80, 100 DAT and at harvest was recorded respectively from treatment combination of BRRI hybrid dhan3 ×T_3 (Recommended fertilizer dose + Akota + Global + Calsol) which was statistically similar with the interaction of BRRI hybrid dhan3 × T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth) and BRRI dhan29 ×T_3 (Recommended fertilizer dose + Akota + Global + Calsol) while the minimum number of tillers hill^{-1} at 80 DAT was 15.20 from the interaction of BRRI dhan29 × T_1 (Recommended fertilizer dose).

Table 3. Interaction effect of different varieties and levels of PGS and fertilizer on the number of tillers hill^{-1} of rice at different days after transplanting

Treatment combinations	Number of tillers hill^{-1} at different days after transplanting (DAT)				
	40	60	80	100	At Harvest
BRRI hybrid dhan3 ×					
T_1	10.07 de	16.00 c-e	17.10 d-f	17.10 bc	15.90 c-e
T_2	11.48 b-e	17.50 bc	18.47 b-e	18.37 ab	17.80 a-c
T_3	13.63 a	19.70 a	21.63 a	19.97 a	19.47 a
T_4	11.08 b-e	16.90 b-d	17.67 d-f	17.44 a-c	16.13 c-e
T_5	12.33 a-c	18.57 ab	20.86 ab	19.00 ab	18.77 ab
BRRI dhan29 ×					
T_1	9.73 e	14.55 e	15.20 f	15.59 c	14.37 e
T_2	10.89 c-e	17.02 b-d	17.98 c-f	17.23 bc	16.43 c-e
T_3	12.77 ab	18.27 ab	20.80 a-c	18.87 ab	17.77 a-c
T_4	10.55 c-e	15.33 de	15.97 ef	16.50 bc	15.53 de
T_5	11.56 b-d	17.73 bc	19.57 a-d	17.91 a-c	17.10 b-d
LSD (0.05)	1.79	1.80	2.83	2.54	2.15
CV (%)	9.13	6.12	8.91	8.33	7.39

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

T_1 = Recommended fertilizer dose
T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol
T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth
T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth
CV = Coefficient of Variation LSD (0.05) = Least significant difference

4.1.4. Leaf area index

4.1.4.1. Effect of variety

In terms of leaf area index rice varieties varied insignificantly at 80 DAT (Figure 8 and Appendix VII). The leaf area index ranges from 7.18 to 7.27. The highest leaf area index was found in BRRI hybrid dhan3 and the lowest in BRRI dhan29.

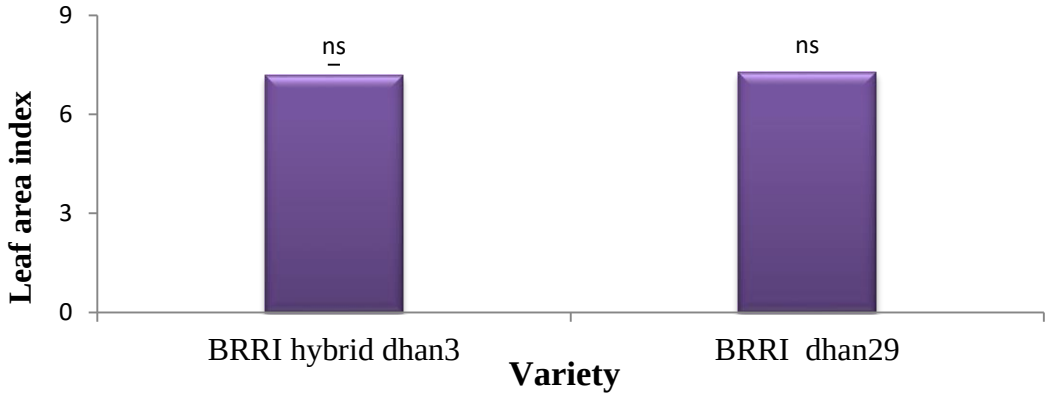


Figure 8. Effect of different varieties on the leaf area index of rice

4.1.4.2. Effect of PGS and fertilizer management

Leaf area index of rice varied significantly variation when the different treatments of PGS and fertilizer were applied under the present trial (Figure 9 and Appendix VII). The leaf area index ranges from 6.09 to 8.52. At 80 DAT, the highest leaf area index (8.52) was observed in T_3 (Recommended fertilizer dose + Akota + Global + Calsol) whereas the lowest leaf area index (6.09) was found in T_1 (Recommended fertilizer dose). Soleymani *et al.* (2012) showed that Fe, Zn and Mn had positive effect on yield and quality of forage sorghum. The highest plant height, LAI, Fresh forage yield, dry leaf and stem yield, total dry yield and dry leaf weight/dry stem weight was obtained in Zn+Fe+Mn application.

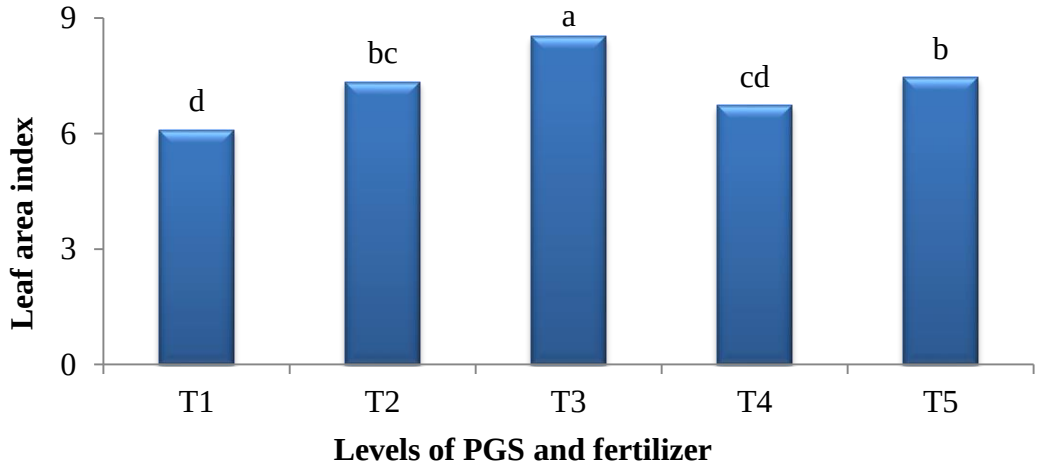


Figure 9. Effect of different levels of PGS and fertilizer on the leaf area index of rice

T_1 = Recommended fertilizer dose
T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol
T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth
T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth

4.1.4.3. Interaction effect of variety and PGS and fertilizer management

Interaction effect of PGS and fertilizer management and variety significantly influenced leaf area index (LAI) of *Boro* rice at 80 DAT (Table 4 and Appendix VII). At 80 DAT, the maximum (8.60) leaf area index was recorded from the combined effect of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol) which was statistically similar with the interaction of BRRI dhan 29 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol). While the minimum (5.79) leaf area index was recorded from the combined effect of BRRI hybrid dhan3 × T_1 (Recommended fertilizer dose).

Table 4. Interaction effect of variety and different levels of PGS and fertilizer on the leaf area index of rice

Treatment combinations	Leaf area index
BRRI hybrid dhan3 ×	
T_1	5.79 e
T_2	7.39 c
T_3	8.60 a
T_4	6.60 c-e
T_5	7.53 bc
BRRI dhan29 ×	
T_1	6.39 de
T_2	7.28 cd
T_3	8.44 ab
T_4	6.85 cd
T_5	7.38 c
LSD $_{(0.05)}$	0.97
CV (%)	4.45

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

T_1 = Recommended fertilizer dose
T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol
T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth
T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth
CV = Coefficient of Variation LSD (0.05) = Least significant difference

4.1.5. Chlorophyll content

4.1.5.1. Effects of variety

Effect of rice varieties varied insignificantly in terms of chlorophyll a, chlorophyll b, chlorophyll ratio (a/b) and total chlorophyll (a+b) (Table 5 and Appendix VIII).

4.1.5.2. Effects of PGS and fertilizer management

This study showed that chlorophyll content of rice showed significant variation at different PGS and fertilizer applications (Table 5 and Appendix VIII). The highest value of chlorophyll a (1.32), chlorophyll b (0.41), chlorophyll raio (a/b) (3.28) and total chlorophyll (a+b) (1.73) was observed in T_3 (Recommended fertilizer dose + Akota + Global + Calsol) followed by T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth) whereas the lowest in T_1 (Recommended fertilizer dose). Tejada and Gonzalez (2004) also reported similar positive effect of foliar fertilization on chlorophyll a and b, and carotenoids content of rice plant, which presumably favored photosynthesis.

Table 5. Effect of different varieties and levels of PGS and fertilizer on the chlorophyll content of rice

Treatments	Chlorophyll content (mg g^{-1})			
	a	**b**	**(a/b) ratio**	**(a+b)**
Effect of variety				
BRRI hybrid dhan3 **BRRI dhan29**	1.28 1.28	0.39 0.40	3.25 3.24	1.77 1.78
LSD (0.05)	NS	NS	NS	NS
CV (%)	3.91	4.67	1.40	4.00
Effect of different levels of PGS and fertilizer				
T_1 **T_2** **T_3** **T_4** **T_5**	1.25 b 1.27 ab 1.32 a 1.26 b 1.30 ab	0.39 b 0.39 b 0.41 a 0.39 b 0.41 a	3.20 b 3.24 ab 3.28 a 3.23 ab 3.25 ab	1.73 b 1.76 ab 1.83 a 1.74 b 1.81 ab
LSD (0.05)	0.05	0.01	0.05	0.08
CV (%)	3.91	4.67	1.40	4.00

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

T_1 = Recommended fertilizer dose
T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol
T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth
T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth
CV = Coefficient of Variation LSD (0.05) = Least significant difference

4.1.5.3. Interaction effect of variety and PGS and fertilizer management

Chlorophyll content of rice varied significantly variation due to different PGS and fertilizer application (Table 6 and Appendix VIII).The maximum value of chlorophyll a (1.32), chlorophyll b (0.42), chlorophyll ratio (a/b) (3.28) and total chlorophyll (a+b) (1.73) was found from the interaction of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol) followed by the interaction of BRRI hybrid dhan3 × T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth) and the interaction of BRRI dhan29 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol). The minimum value of chlorophyll a (1.23), chlorophyll b (0.38) and total chlorophyll (a+b) (1.61) was observed at the interaction of BRRI hybrid dhan3 × T_1 (Recommended fertilizer dose) and chlorophyll ratio (a/b) (3.17) was lowest in BRRI dhan29 × T_1 (Recommended fertilizer dose).

Table 6. Interaction effect of different varieties and levels of PGS and fertilizer on the chlorophyll and nitrogen content of rice

Treatment combinations	Chlorophyll content (mg g^{-1})			
	a	b	(a/b) ratio	(a+b)
BRRI hybrid dhan3 ×				
T_1	1.23 b	0.38 d	3.22 ab	1.65 b
T_2	1.26 ab	0.39 cd	3.24 ab	1.74 ab
T_3	1.32 a	0.42 a	3.28 a	1.93 a
T_4	1.25 ab	0.38 d	3.23 ab	1.74 ab
T_5	1.31 ab	0.41 ab	3.25 ab	1.80 ab
BRRI dhan29 ×				
T_1	1.26 ab	0.39 b-d	3.17 b	1.75 ab
T_2	1.28 ab	0.39 b-d	3.24 ab	1.77 ab
T_3	1.31 ab	0.41 ab	3.28 a	1.79 ab
T_4	1.26 ab	0.39 b-d	3.23 ab	1.75 ab
T_5	1.29 ab	0.40 a-c	3.25 ab	1.80 ab
LSD (0.05)	0.08	0.02	0.08	0.11
CV (%)	3.91	4.67	1.40	4.00

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

T_1 = Recommended fertilizer dose
T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol
T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth
T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth
CV = Coefficient of Variation LSD (0.05) = Least significant difference

4.1.6. Total dry matter hill^{-1}

4.1.6.1. Effect of variety

Total dry matter hill^{-1} varied significantly between rice varieties at different growth stages (Figure 10 and Appendix IX). The highest (27.27, 50.34 and 73.24 g) total dry matter hill^{-1} was obtained from BRRI hybrid dhan3 at different growth stages. On the other hand, the lowest (23.97, 38.14 and 54.27 g) was found from BRRI dhan29.

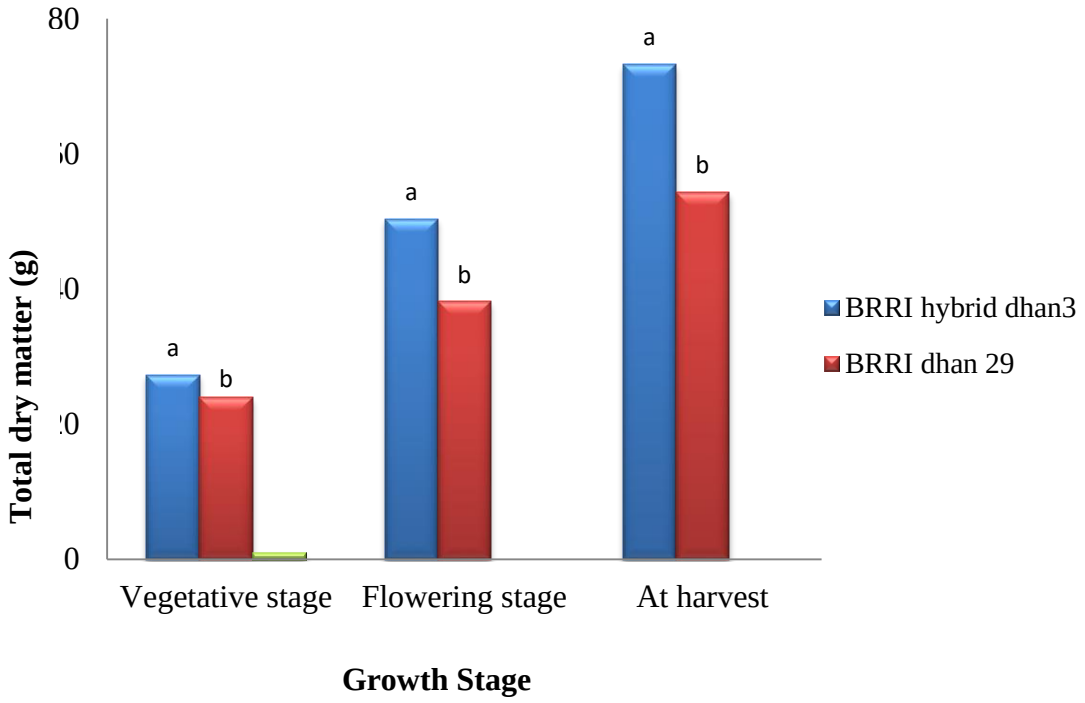


Figure 10. Effect of different varieties on the total dry matter hill^{-1} of rice at different growth stages

4.1.6.2. Effect of PGS and fertilizer management

Total dry matter hill^{-1} was varied due to different PGS and fertilizer treatment (Figure 11 and Appendix IX). The highest (31.47, 51.74 and 70.34 g) total dry matter hill^{-1} was found at different growth stages from T_3 (Recommended fertilizer dose + Akota + Global + Calsol), whereas the lowest (19.30, 34.87 and 55.98 g) was recorded from T_1 (Recommended fertilizer dose). Foliar spray of Ca $(NO_3)_2$, $MnSO_4$ or K_2HPO_4 partially minimized the salt-induced nutrient deficiecy, increased photosynthesis and dry matter accumulation was reported by Sultana *et al.*, (2001). This result also similar to Celik *et al.*, (2010). The results also agreed with Torun *et al.*, (2001) who reported increased dry matter production for application of micronutrients over control.

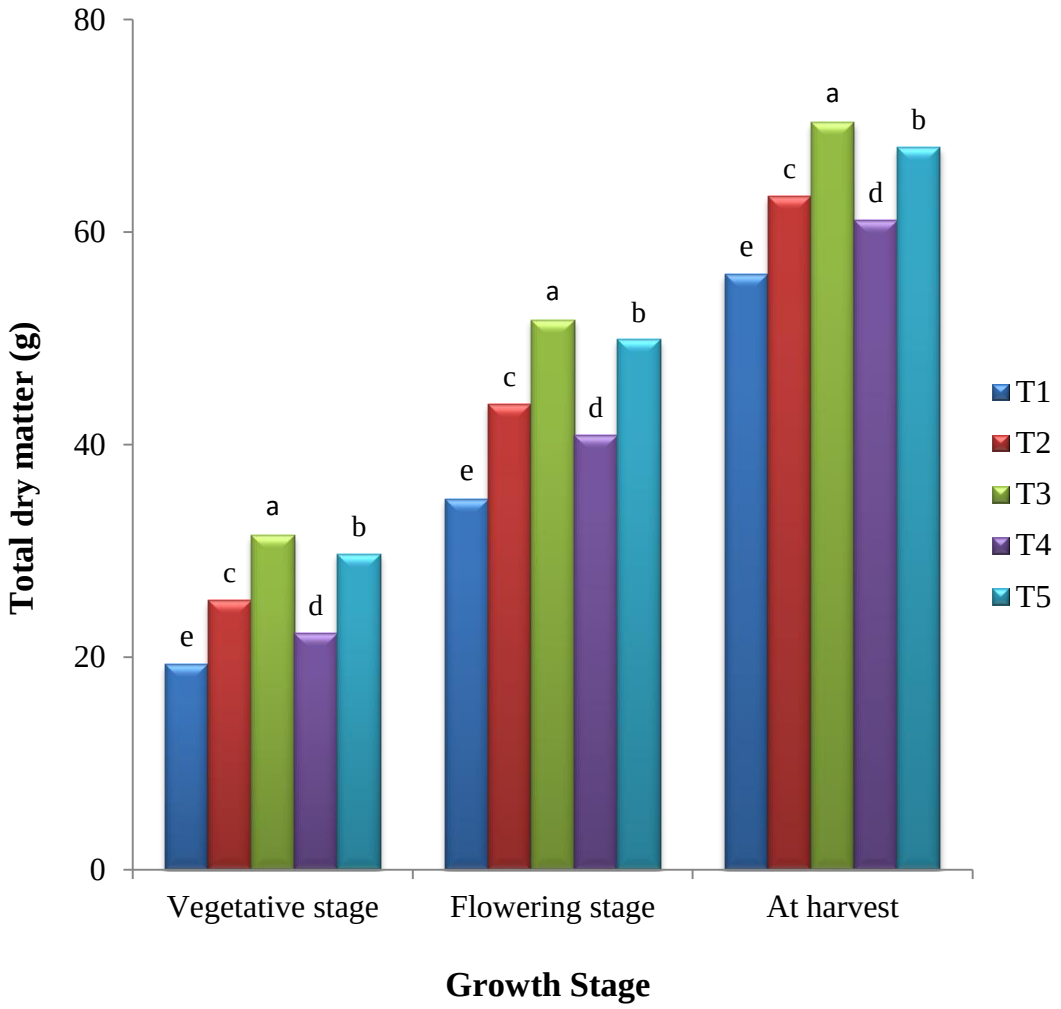


Figure 11. Effect of different levels of fertilizer on the total dry matter hill^{-1} of rice at different growth stages

T_1 = Recommended fertilizer dose
T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol
T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth
T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth

4.1.6.3. Interaction effect of variety and PGS and fertilizer management

Interaction effect of different PGS and fertilizer treatment and rice varieties showed significant variation on total dry matter hill^{-1} (Table 7 and Appendix IX). The highest (33.81, 59.70 and 81.41 g) total dry matter hill^{-1} was found from treatment combination of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol) and the lowest (18.62, 28.58 and 47.75 g) was observed from treatment combination of BRRI dhan29 × T_1 (Recommended fertilizer dose).

Table 7. Interaction effect of different varieties and levels of PGS and fertilizer on the total dry matter hill^{-1} of rice at different growth stages

Treatment combinations	Total dry matter at vegetative stage (g)	Total dry matter at flowering stage (g)	Total dry matter at harvesting stage (g)
BRRI hybrid dhan3×			
T_1	19.99 f	41.16 ef	84.20 c
T_2	26.88 cd	48.19 b	71.24 b
T_3	33.81 a	59.70 a	81.41 a
T_4	23.97 e	45.48 c	70.52 b
T_5	32.70 ab	58.18 ab	78.82 ab
BRRI dhan29 ×			
T_1	18.62 g	28.58 i	47.75 g
T_2	23.83 e	39.52 g	55.48 e
T_3	29.13 b	43.77 d	59.27 d
T_4	20.52 f	36.27 h	51.76 f
T_5	27.73 c	42.54 e	57.08 de
LSD (0.05)	0.94	1.01	2.62
CV (%)	2.14	1.33	2.39

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

T_1 = Recommended fertilizer dose
T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol
T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth
T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth
CV = Coefficient of Variation LSD (0.05) = Least significant difference

4.1.7. Shoot dry matter accumulation and its remobilization to grain

4.1.7.1. Effect of variety

The shoot dry matter accumulation and its remobilization to grain was significantly varied due to varietal differences (Table 8 and Appendix X). The highest (43.79 and 33.23 g) shoot dry matter accumulation at flowering and maturity stage was obtained from BRRI hybrid dhan3. On the other hand, the lowest (31.23 and 24.57 g) was obtained from BRRI dhan29 at both stages.

The shoot reserve translocation was the highest (23.20 %) from BRRI hybrid dhan3 variety. On the other hand, the lowest (19.53 %) was recorded from BRRI dhan29.

4.1.7.2. Effect of PGS and fertilizer management

Significantly varied results were observed in terms of shoot dry matter accumulation and its remobilization to grain as influenced by different fertilizer treatment in *Boro* rice at flowering and maturity stages (Table 8 and Appendix X). Results showed that at flowering stage the highest (45.42 g) shoot dry matter accumulation was recorded by T_3 (Recommended fertilizer dose + Akota + Global + Calsol) and the lowest value (33.99 g) was found in T_4 (Recommended fertilizer dose + Akota + Global + Magic Growth). Similar observation was found by Haldar *et al.* (1981) application of phosphorus and zinc significantly increased the dry matter yield of shoots, grains and roots.

Table 8. Effect of different varieties and levels of PGS and fertilizer on shoot dry matter accumulation and its translocation to the grain

Treatments	Shoot dry mater at flowering stage (g)	Shoot dry mater at maturity stage (g)	Changes in shoot dry mater (g)	Shoot reserve translocation (%)
Effect of variety				
BRRI hybrid dhan3	43.79 a	33.23 a	10.55 a	23.20 a
BRRI dhan29	31.23 b	24.57 b	6.27 b	19.53 b
LSD (0.05)	0.54	1.09	3.39	0.87
CV (%)	1.88	4.91	3.39	5.31
Effect of different levels of PGS and fertilizer				
T_1	36.58 c	23.66 c	15.47 d	4.35 e
T_2	36.58 c	27.68 b	21.37 b	7.89 c
T_3	45.42 a	33.23 a	26.31 a	12.18 a
T_4	33.99 d	27.54 b	18.52 c	6.45 d
T_5	43.55 b	32.38 ab	25.14 a	11.17 b
LSD (0.05)	0.86	1.72	1.38	0.35
CV (%)	1.88	4.91	3.39	5.31

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

T_1 = Recommended fertilizer dose
T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol
T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth
T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth
CV = Coefficient of Variation LSD (0.05) = Least significant difference

At maturity stage, the highest (33.23 and 32.38 g) shoot dry matter accumulation was recorded by T_3 (Recommended fertilizer dose + Akota + Global + Calsol) which was statistically similar with T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth) whereas the lowest value (23.66 g) was observed in T_1 (Recommended fertilizer dose).

The reserve translocation was the highest (26.31 and 25.14 %) from T_3 and T_5 treatment and the lowest (4.35 %) shoot reserve translocation was found in T_1 (Recommended fertilizer dose) treatment.

4.1.7.3. Interaction effect of variety and PGS and fertilizer management

Interaction effect of different PGS and fertilizer levels and variety significantly influenced shoot dry matter accumulation and its translocation to the grain at flowering and maturity stage (Table 9 and Appendix X). The highest (52.81 g) shoot dry matter accumulation at flowering stage was obtained in the interaction of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol) treatment. On the other hand, the lowest (21.63 g) was observed in the interaction of BRRI dhan29 × T_1 (Recommended fertilizer dose).

At maturity stage, the highest (37.26 and 36.91 g) shoot dry matter accumulation was recorded from in the interaction of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol) and BRRI hybrid dhan3 × T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth) treatment. The lowest (18.33 g) shoot dry matter accumulation was observed in the interaction of BRRI dhan29 × T_1 (Recommended fertilizer dose).

The highest (29.39 and 27.95 g) change in shoot dry matter was found in the interaction of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol) and BRRI hybrid dhan3 × T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth) treatment whereas the lowest (15.24 and 15.70 g) was recorded in the interaction of BRRI dhan29 × T_1 (Recommended fertilizer dose) and the interaction of BRRI hybrid dhan3 × T_1 (Recommended fertilizer dose).

The reserve translocation was the highest (15.52 %) in the interaction of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol) and the lowest (3.29 %) results was found in the interaction of BRRI dhan29 × T_1 (Recommended fertilizer dose).

Table 9. Interaction effects of different varieties and levels of PGS and fertilizer on shoot dry matter accumulation and its translocation to the grain

Treatment combinations	Shoot dry mater at flowering stage (g)	Shoot dry mater at maturity stage (g)	Changes in shoot dry mater (g)	Shoot reserve translocation (%)
BRRI hybrid dhan3 ×				
T1	34.38 g	28.98 c	15.70 d	5.40 g
T2	41.16 c	31.44 b	23.77 b	9.72 c
T3	52.81 a	37.26 a	29.39 a	15.52 a
T4	39.35 d	31.56 b	19.18 c	7.787 e
T5	51.23 b	36.91 a	27.95 a	14.32 b
BRRI dhan29 ×				
T1	21.63 j	18.33 e	15.24 d	3.29 h
T2	31.99 h	23.92 d	18.97 c	6.07 f
T3	38.04 e	29.20 bc	23.22 b	8.83 d
T4	28.63 i	23.52 d	17.86 c	5.11 g
T5	35.86 f	27.85 c	22.34 b	8.017 e
LSD (0.05)	.094	1.01		2.62
CV (%)	2.14	1.33		2.39

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

T_1 = Recommended fertilizer dose
T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol
T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth
T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth
CV = Coefficient of Variation LSD (0.05) = Least significant difference

4.2. Yield components

4.2.1. Effective tiller (%) hill^{-1}

4.2.1.1. Effect of variety

Effective tillers (%) hill^{-1} varied significantly variation among rice varieties (Table 10 and Appendix XI). The highest (94.03 %) effective tiller was recorded from BRRI hybrid dhan3 whereas the lowest (91.77 %) was recorded from BRRI dhan29.

4.2.1.2. Effect of PGS and fertilizer management

Effective tillers (%) hill^{-1} was significantly affected due to different PGS and fertilizer application at 5 % level of probability (Table 10 and Appendix XI). The highest value (95.75 %) of effective tiller was recorded in T_3 (Recommended fertilizer dose + Akota + Global + Calsol) whereas the lowest value (90.10) was found in T_1 (Recommended fertilizer dose). These results are in good accordance with those reported by Shafiee *et al.*, (2013).

4.2.1.3. 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 11 and Appendix XI). The highest percentage (97.00 %) of effective tiller hill^{-1} was counted in the interaction of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol) treatment. The lowest percentage (87.86 %) of effective tillers hill^{-1} was counted from the interaction of BRRI dhan29 × T_1 (Recommended fertilizer dose) treatment.

4.2.2. Panicles hill^{-1}

4.2.2.1. Effect of variety

Statistically significant variation was observed in terms of the number of panicles hill^{-1} among rice varieties (Table 10 and Appendix XI). The maximum (16.67) number of panicles hill^{-1} was recorded from BRRI hybrid dhan3 and the minimum (15.45) number was recorded from BRRI dhan29.

4.2.2.2. Effect of PGS and fertilizer management

Statistically significant variation was recorded in case of the number of panicles hill^{-1} due to different PGS and fertilizer applications (Table 10 and Appendix XI). The

maximum (17.65) number of panicles hill^{-1} was recorded from T_3 (Recommended fertilizer dose + Akota + Global + Calsol) which was similar (17.17) in T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth). On the other hand, the minimum (14.45) number was recorded from T_1 (Recommended fertilizer dose) treatment. Soylu *et al.* (2005) and Kenbaev and Sade (2002) reported that foliar application of different micronutrients individually or in combination significantly increased in number of panicles m^{-2}.

4.2.2.3. Interaction effect of variety and PGS and fertilizer management

Significant interaction effects of PGS and fertilizer management and variety was found in producing panicles hill^{-1} (Table 11 and Appendix XI). The highest (18.13) number of the number of panicles hill^{-1} was counted in the interaction of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol) which was similar (17.90, 16.43, 17.65 and 17.17) with the interaction of BRRI hybrid dhan3 × T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth); BRRI hybrid dhan3 × T_2 (Recommended fertilizer dose + Akota + Global); BRRI dhan29 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol) and BRRI dhan29 × T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth) treatment respectively. The lowest (13.77 and 14.10) number of panicle hill^{-1} was counted in the interaction of BRRI dhan29 × T_1 (Recommended fertilizer dose) and BRRI dhan29 × T_4 (Recommended fertilizer dose + Akota + Global+ Magic Growth) treatment.

4.2.3. Panicle length

4.2.3.1. Effect of variety

Panicle length varied significantly between two varieties of rice (Table 10 and Appendix XI). The longest (25.75 cm) panicle was found in BRRI hybrid dhan3, while the shortest (23.29 cm) panicle length was attained from BRRI dhan29.

4.2.3.2. Effect of PGS and fertilizer management

Panicle length of rice varied significantly due to different PGS and fertilizer applications (Table 10 and Appendix XI). The longest (26.28 cm) panicle was found in T_3 (Recommended fertilizer dose + Akota + Global + Calsol) which was statistically similar (25.12 cm) with T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth), while the shortest (23.00 cm) panicle length was attained from T_1

(Recommended fertilizer dose). Same findings were reported by Zayed *et al.*, (2011) that the comparative foliar application treatment of Zn +Fe + Mn twice at 20 and 45 days after transplanting (DAT) gave the highest values of chlorophyll content and panicle length. Similar findings were found by Alam *et al.*, 2015. Again, Panhwar *et al.*, (2015) reported that the longest panicle was found in the combined Zn, Cu and Mo added treatments.

Table 10. Effect of different varieties and levels of PGS and fertilizer on the yield contributing characters of rice

Treatment	Effective tiller (%)	Panicle hill^{-1}	Panicle length (cm)
Effect of variety			
BRRI hybrid dhan3	94.03	16.67 a	25.75 a
BRRI dhan29	91.77 b	15.45 b	23.29 b
LSD (0.05)	0.58	0.91	1.18
CV (%)	0.82	7.42	6.25
Effect of different levels of PGS and fertilizer			
T_1	90.10 e	14.45 d	23.00 c
T_2	92.94 c	16.12 bc	24.52 a-c
T_3	95.75 a	17.65 a	26.28 a
T_4	91.68 d	14.93 cd	23.67 bc
T_5	94.03 b	17.17 ab	25.12 ab
LSD (0.05)	0.92	1.45	1.86
CV (%)	0.82	7.42	6.25

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

T_1 = Recommended fertilizer dose
T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol
T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth
T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth
CV = Coefficient of Variation LSD (0.05) = Least significant difference

4.2.3.3. Interaction effect of variety and PGS and fertilizer management

A significant interaction between PGS and fertilizer levels and variety was observed on panicle length of rice (Table 11 and Appendix XI). The interaction result showed that the interaction of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota +

Global + Calsol) produced the longest (27.77 cm) panicle length followed by the interaction of BRRI hybrid dhan3 × T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth) and the shortest (21.94 cm) panicle length was counted in the interaction of BRRI dhan29 × T_1 (Recommended fertilizer dose).

Table 11. Interaction effect of different varieties and levels of PGS and fertilizer on the yield contributing characters of rice

Treatment combinations	Effective tiller (%)	Panicle hill^{-1}	Panicle length (cm)
BRRI hybrid dhan3 ×			
T_1	92.35 d	15.13 bc	24.07 b-e
T_2	93.72 bc	16.43 ab	25.70 a-c
T_3	97.00 a	18.13 a	27.77 a
T_4	92.74 cd	15.75 bc	24.83 b-d
T_5	94.34 b	17.90 a	26.37 ab
BRRI dhan29 ×			
T_1	87.86 f	13.77 c	21.94 e
T_2	92.15 d	15.80 bc	23.33 c-e
T_3	94.49 b	17.17 ab	24.80 b-d
T_4	90.61 e	14.10 c	22.52 de
T_5	93.72 bc	16.43 ab	23.87 b-e
LSD (0.05)	1.30	2.05	2.63
CV (%)	0.82	7.42	6.25

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

T_1 = Recommended fertilizer dose
T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol
T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth
T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth
CV = Coefficient of Variation LSD (0.05) = Least significant difference

4.2.4. Filled grains panicle^{-1}

4.2.4.1. Effect of variety

The number of filled grains panicle^{-1} varied significantly variation among rice varieties (Table 12 and Appendix XII). The maximum (180.36) number of filled grains panicle^{-1} was found in BRRI hybrid dhan3 variety and the lowest (127.54) number of filled grains panicle^{-1} was obtained from the inbred variety BRRI dhan29.

4.2.4.2. Effect of PGS and fertilizer management

The different PGS and fertilizer levels showed significant variation in case of the number of filled grains panicle^{-1} (Table 12 and Appendix XII). The highest (168.7) number of filled grains panicle^{-1} was obtained from T_3 (Recommended fertilizer dose + Akota + Global + Calsol) which was identical (159.7) with T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth) and the lowest (141.4) number of filled grains panicle^{-1} was obtained from T_1 (Recommended fertilizer dose). These results showed similarity with (Ali, 2012; Tahir *et al.*, 2009; Ahmad and Irshad, 2011), who reported significant increase in number of grains per spike with foliar application of Fe and B single or shared with other micronutrients.

4.2.4.3. Interaction effect of variety and PGS and fertilizer management

The number of filled grains panicle^{-1} was significantly influenced by the interaction effect of different PGS and fertilizer levels and rice varieties (Table 13 and Appendix XII). The maximum (197.7) number of filled grains panicle^{-1} was recorded from the combination of BRRI hybrid dhan3 $\times$ T_3 (Recommended fertilizer dose + Akota + Global + Calsol) and it was statistically similar (187.3) with the interaction of BRRI hybrid dhan3 $\times$ T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth). On the other hand, the minimum (117.2) number of filled grains panicle^{-1} was recorded from the combination of BRRI dhan29 $\times$ T_1 (Recommended fertilizer dose).

4.2.5. Total grains panicle^{-1}

4.2.5.1. Effect of variety

Varieties were differed significantly in production of the number of total grains panicle^{-1} (Table 12 and Appendix XII). The highest (189.26) number of total grains panicle^{-1} was observed in BRRI hybrid dhan3. The lowest (141.15) number of total grains panicle^{-1} was obtained in BRRI dhan29.

4.2.5.2. Effect of PGS and fertilizer management

Different levels of PGS and fertilizer showed significant variation on production of total grains panicle^{-1} (Table12 and Appendix XII). The table showed that the maximum (178.0) number of total grains panicle^{-1} was obtained from T_3 (Recommended fertilizer dose + Akota + Global + Calsol) which was identical with T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth) treatment whereas the minimum

(154.9) number of total grains panicle^{-1} was obtained from T_1 ((Recommended fertilizer dose) treatment. Same findings were observed by Karim *et al.* (2015) that they showed significant difference ($p < 0.05$) in panicle m^{-2}, unfilled grain panicle^{-1} and total grain panicle^{-1}. Similar results were observed by Pramanik *et al*. (2015).

4.2.5.3. Interaction effect of variety and PGS and fertilizer management

Significant variation was observed for number of total grains panicle^{-1} due to different PGS and fertilizer application (Table 13 and Appendix XII). The maximum (204.5) number of total grains per panicle was recorded from the interaction of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol) which was statistically similar (195.4 and 187.4) with the interaction of BRRI hybrid dhan3 × T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth) and BRRI hybrid dhan3 × T_2 (Recommended fertilizer dose + Akota + Global) treatment. The minimum (133.0, 139.6, 151.5, 137.0 and 144.6) number of total grains panicle^{-1} was recorded from BRRI dhan29 under all the fertilizer treatments.

4.2.6. Filled grain (%)

4.2.6.1. Effect of variety

Variety exerted insignificant variation on filled grain (%) of rice (Table 12 and Appendix XII). BRRI hybrid dhan3 showed the highest (92.56 %) filled grain and the lowest (88.62 %) filled grain was found in BRRI dhan29.

4.2.6.2. Effect of PGS and fertilizer management

PGS and fertilizer levels exerted insignificant variation on filled grain (%) (Table 12 and Appendix XII). Result showed that PGS and fertilizer levels affected the filled grain (%) insignificantly. The statistically numerical highest (93.92 %) value of filled grain was recorded in T_3 (Recommended fertilizer dose + Akota + Global + Calsol) treatment and the lowest (87.61 %) filled grain was observed in T_1 (Recommended fertilizer dose) treatment.

4.2.6.3. Interaction effect of PGS and fertilizer management and variety

The interaction between PGS and fertilizer levels and variety exerted significant effect on filled grain (%) of rice (Table 13 and Appendix XII). The highest (96.23 %) filled grain was observed in the interaction of BRRI hybrid dhan3 × T_3 (Recommended

fertilizer dose + Akota + Global + Calsol) treatment which was statistically similar with all the combined treatments except the combined effect of BRRI dhan29 × T_1 (Recommended fertilizer dose). The lowest (85.62 %) filled grain was observed in the interaction of BRRI dhan29 × T_1 (Recommended fertilizer dose).

Table 12. Effect of different varieties and levels of PGS and fertilizer on the yield components of rice

Treatments	Filled grains panicle^{-1} (No.)	Total grains panicle^{-1} (No.)	Filled grain (%)	1000 grains weight (g)
Effect of variety				
BRRI hybrid dhan3	180.36 a	189.26a	92.56	26.84 a
BRRI dhan29	127.54 b	141.15b	88.62	19.52 b
LSD (0.05)	9.29	9.47	NS	1.32
CV (%)	7.87	7.48	5.76	7.43
Effect of different levels of PGS and fertilizer				
T_1	141.4 c	154.9 c	87.61	21.56 c
T_2	152.3 bc	163.5a-c	90.59	23.16 abc
T_3	168.7 a	178.0 a	93.92	24.98 a
T_4	147.7 bc	159.6 bc	88.50	22.22 bc
T_5	159.7 ab	170.0 ab	92.32	23.97 ab
LSD (0.05)	14.69	14.98	NS	2.09
CV (%)	7.87	7.48	5.76	7.43

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

T_1 = Recommended fertilizer dose
T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol
T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth
T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth
CV = Coefficient of Variation LSD (0.05) = Least significant difference

4.2.7. 1000 grains weight

4.2.7.1. Effect of variety

Variety had significant effect on the weight of 1000-grains (g) (Table 12 and Appendix XII). The highest (26.84 g) weight of 1000-grains was observed in BRRI hybrid dhan3 and the lowest (19.52 g) weight was observed in BRRI dhan29.

4.2.7.2. Effect of PGS and fertilizer management

Different treatments of PGS and fertilizer excreted significant effect on 1000 grains weight (g) (Table 12 and Appendix XII). The findings showed that the highest (24.98 g) 1000 grains weight was achieved from T_3 (Recommended fertilizer dose + Akota + Global + Calsol) followed by T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth) (23.97 g) whereas the lowest (21.56 g) 1000 grains weight was recorded from T_1 (Recommended fertilizer dose) treatment. Soylu *et al.* (2005) reported a significant increase in 1000 grain weight with the foliar application of micronutrients. The similar results were shown by Shafiee *et al.* (2013) and Gueins *et al.* (2003).

4.2.7.3. Interaction effect of variety and PGS and fertilizer management

Interaction effect of different treatments of PGS and fertilizer and rice varieties showed significant variation on 1000 grains weight (g) (Table 13 and Appendix XII). The highest (28.90 g) 1000 grains weight was found from the interaction of BRRI hybrid dhan3 $\times$ T_3 (Recommended fertilizer dose + Akota + Global + Calsol) and it was statistically similar (27.49, 26.50 and 25.98 g) with the interaction of BRRI hybrid dhan3 $\times$ T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth); BRRI hybrid dhan3 $\times$ T_2 (Recommended fertilizer dose + Akota + Global) and BRRI hybrid dhan3 $\times$ T_4 (Recommended fertilizer dose + Akota + Global + Magic Growth). On the other hand, the lowest (17.79 g) weight of 1000 grains was counted in the interaction of BRRI dhan29 $\times$ T_1 (Recommended fertilizer dose) treatment.

Table 13. Interaction effect of different varieties and levels of PGS and fertilizer on the yield components of rice

Treatment combinations	Filled grains panicle^{-1}	Total gains panicle^{-1}	Filled grain (%)	1000 grain weight (g)
BRRI hybrid dhan3×				
T_1	165.7 c	176.8 b	89.60 ab	25.33 b
T_2	178.6 a-c	187.4 ab	92.51 ab	26.50 ab
T_3	197.7 a	204.5 a	96.23 a	28.90 a
T_4	172.5 bc	182.3 b	89.54 ab	25.98 ab
T_5	187.3 ab	195.4 ab	94.91 a	27.49 ab
BRRI dhan29 ×				
T_1	117.2 e	133.0 c	85.62 b	17.79 d
T_2	125.9 de	139.6 c	88.66 ab	19.81 cd
T_3	139.8 d	151.5 c	91.61 ab	21.07 c
T_4	122.9 de	137.0 c	87.47 ab	18.46 cd
T_5	132.0 de	144.6 c	89.74 ab	20.46 cd
LSD (0.05)	20.77	21.18	8.95	2.96
CV (%)	7.87	7.48	5.76	7.43

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

T_1 = Recommended fertilizer dose
T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol
T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth
T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth
CV = Coefficient of Variation LSD (0.05) = Least significant difference

4.2.8. Grain yield

4.2.8.1. Effect of variety

Varieties were differed significantly in producing grain yield (t ha^{-1}) (Figure 12 and Appendix XIII). Among the two varieties BRRI hybrid dhan3 showed its superiority in producing highest grain yield which was 7.09 t ha^{-1}. The lowest (5.42 t ha^{-1}) grain yield was found in BRRI dhan29.

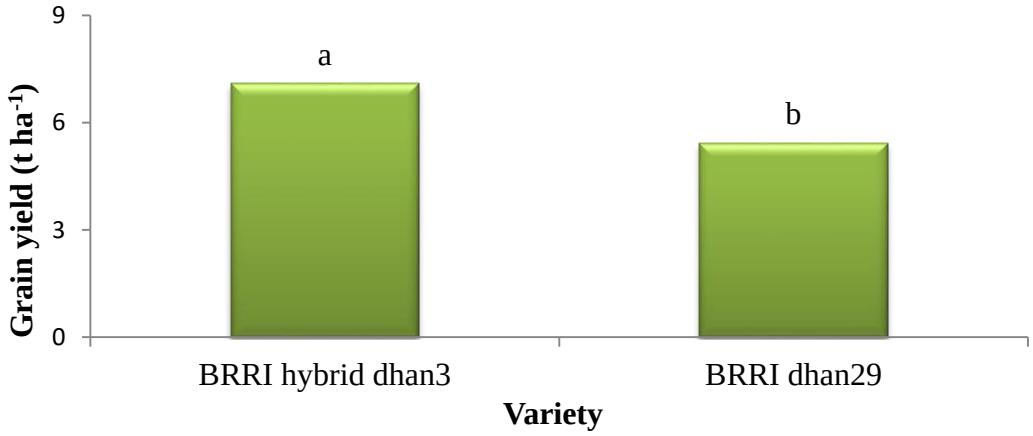


Figure 12. Effect of different varieties on the grain yield of rice

4.2.8.2. Effects of PGS and fertilizer management

Grain yield was significantly influenced by PGS and fertilizer management (Figure13 and Appendix XIII). The maximum (6.99 t ha^{-1}) grain yield was obtained from T_3 (Recommended fertilizer dose + Akota + Global + Calsol) which was statistically similar (6.46 t ha^{-1}) with T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth). Whereas the minimum (5.68 t ha^{-1}) grain yield was recorded from T_1 (Recommended fertilizer dose). Similar findings were reported by Osman *et al.*, (2013), Phattaraku *et al.*, (2012) and Asenjo *et al.*, (2000). Fang *et al.* (2008) reported that foliar application of zinc, selenium and iron fertilizers increased grain yield. Again Panhwar *et al.*, (2015) reported that about 18% increment in grain yield was recorded by combined micronutrient treatment compared to control.

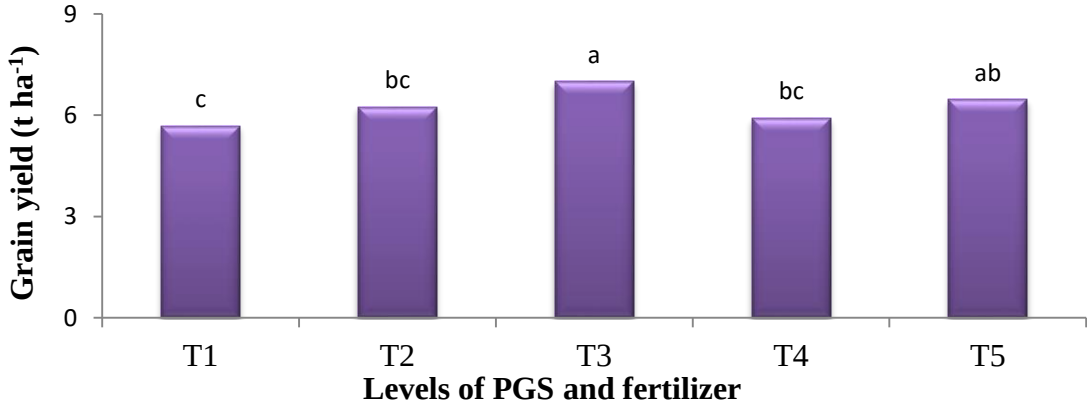


Figure 13. Effect of different levels of PGS and fertilizer on the grain yield of rice

T_1 = Recommended fertilizer dose
T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol
T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth
T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth

4.2.8.3. Interaction effect of variety and PGS and fertilizer management

Grain yield influenced significantly by the interaction of PGS and fertilizer management and varieties (Table 14 and Appendix XIII). Among the interaction treatments, the highest (7.78 t ha^{-1}) grain yield was recorded in the interaction of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol) followed by BRRI hybrid dhan3 × T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth) and BRRI hybrid dhan3 × T_2 (Recommended fertilizer dose + Akota + Global). The lowest (4.88 and 5.02 t ha^{-1}) grain yield was observed in BRRI dhan29 × T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth) and BRRI dhan29 × T_4 (Recommended fertilizer dose + Akota +Global + Magic Growth).

4.2.9. Straw yield

4.2.9.1. Effect of variety

Straw yield varied insignificantly among rice varieties (Figure 14 and Appendix XIII). BRRI hybrid dhan3 gave the highest (8.42 t ha^{-1}) straw yield whereas the lowest (8.11t ha^{-1}) straw yield was found in BRRI dhan29.

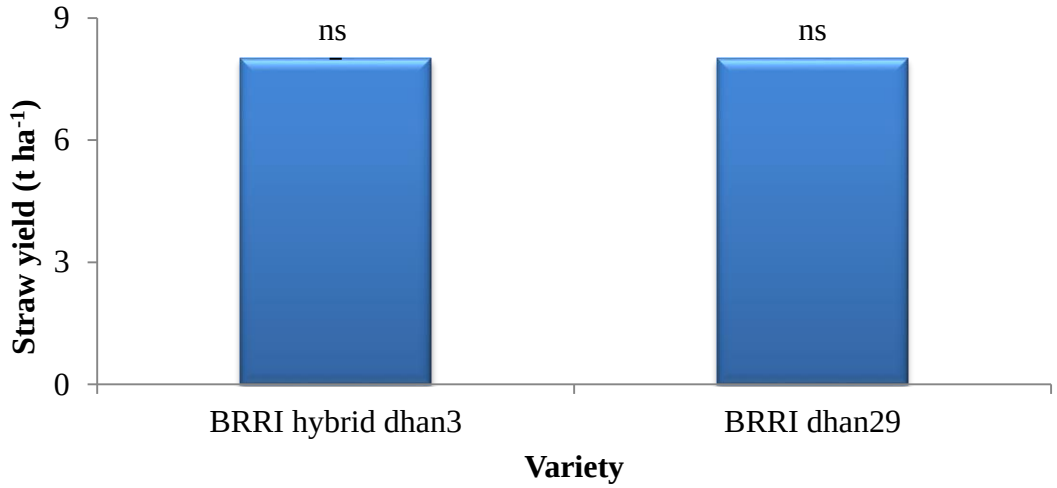


Figure 14. Effect of different varieties on the straw yield of rice

4.2.9.2. Effect of PGS and fertilizer management

In the present study PGS and fertilizer management effect affected straw yield (t ha^{-1}) (Figure 15 and Appendix XIII). It was found that significant variation of straw yield was seen among all the treatments. Results showed that the highest (8.85 t ha^{-1}) straw yield was achieved from T_3 (Recommended fertilizer dose + Akota + Global + Calsol)

followed by T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth), T_2 (Recommended fertilizer dose + Akota + Global) and T_4 (Recommended fertilizer dose + Akota + Global + Magic Growth) whereas the lowest (7.68 t ha^{-1}) straw yield was recorded from T_1 (Recommended fertilizer dose) treatment. Zeidan *et al.* (2010) reported that grain yield, straw yield, 1000 grains weight and number of grains $panicle^{-1}$ were significantly increased by application of these elements in wheat. Similar results were reported by Pramanik *et al.*, 2015; Panhwar *et al.*, 2015 and Osman *et al.*, 2013.

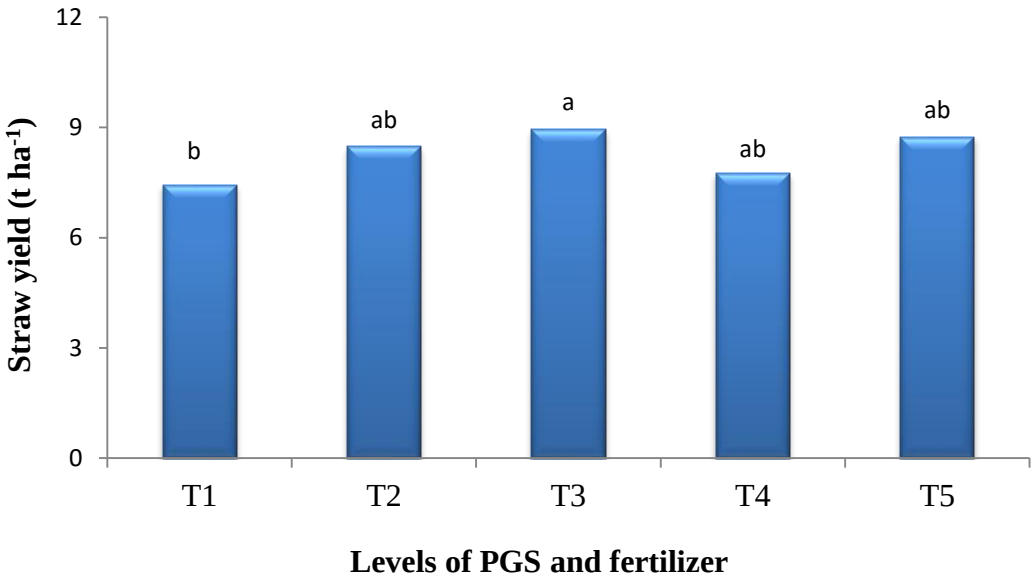


Figure 15. Effect of different levels of PGS and fertilizer on the straw yield of rice

T_1 = Recommended fertilizer dose
T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol
T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth
T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth

4.2.9.3. Interaction effect of variety and PGS and fertilizer management

There were observed a significant difference among the interactions of different PGS and fertilizer treatments and varieties in respect of straw yield (t ha^{-1}) (Table 14 and Appendix XIII). The maximum (8.96 t ha^{-1}) straw yield was found from the interaction of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol) which are statistically similar with the interaction of T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth) and T_2 (Recommended fertilizer dose + Akota + Global) with BRRI hybrid dhan3 and BRRI dhan29 × T_3 (Recommended

fertilizer dose + Akota + Global + Calsol) and BRRI dhan29 × T_5 (Recommended fertilizer dose + Akota + Global +Calsol + Magic Growth) whereas the lowest (7.11 t ha^{-1}) straw yield was recorded from the interaction of BRRI dhan29 × T_1 (Recommended fertilizer dose) treatment.

4.2.10. Biological yield

4.2.10.1. Effect of variety

Significant variation in biological yield was observed due to varietals difference and it ranges from 13.54 to 15.51 t ha^{-1} (Figure 16 and Appendix XIII). The highest and lowest biological yield was obtained from BRRI hybrid dhan3 and BRRI dhan29, respectively.

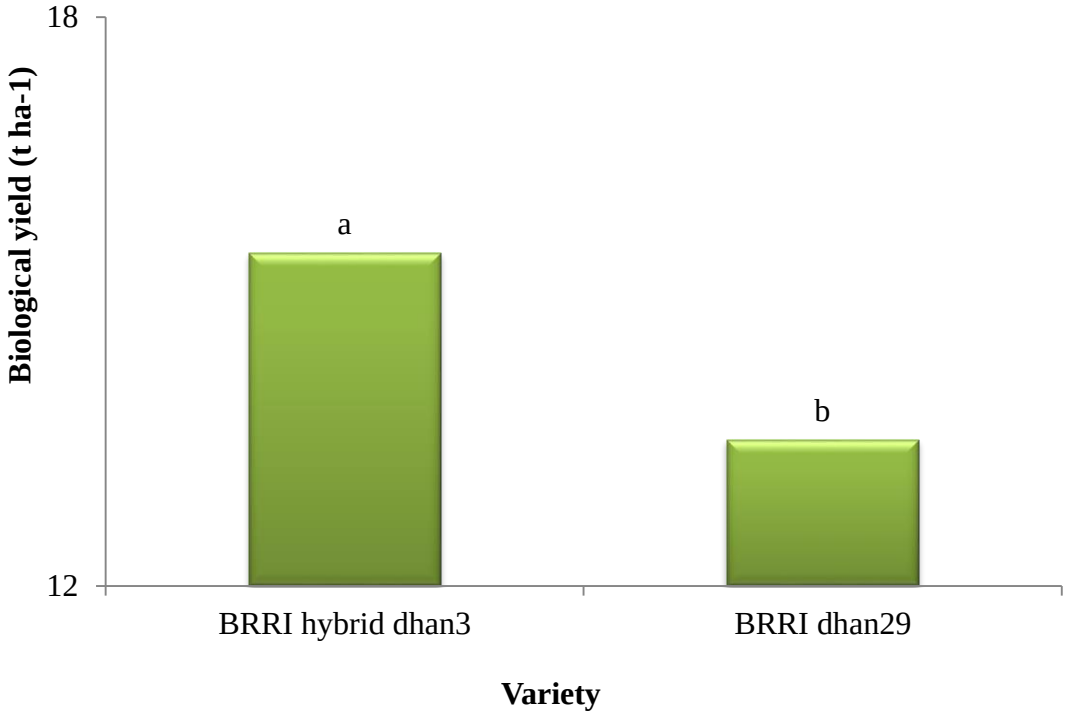


Figure 16. Effect of different varieties on the biological yield of rice

4.2.10.2. Effect of PGS and fertilizer management

Biological yield differed significantly due to the different treatments of PGS and fertilizer (Table 14 and Appendix XIII). The highest (15.94 t ha^{-1}) biological yield was found in T_3 (Recommended fertilizer dose + Akota + Global + Calsol) followed by T_5 (Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth). The lowest (13.12 t ha^{-1}) biological yield was recorded at T_1

(Recommended fertilizer dose) treatment**.** The results were shown similarity with the results of Radwan *et al.* (2015). Also similar to Gueins *et al.* (2003). Soleymani (2012) reported increase in biological yield for foliar application of zinc.

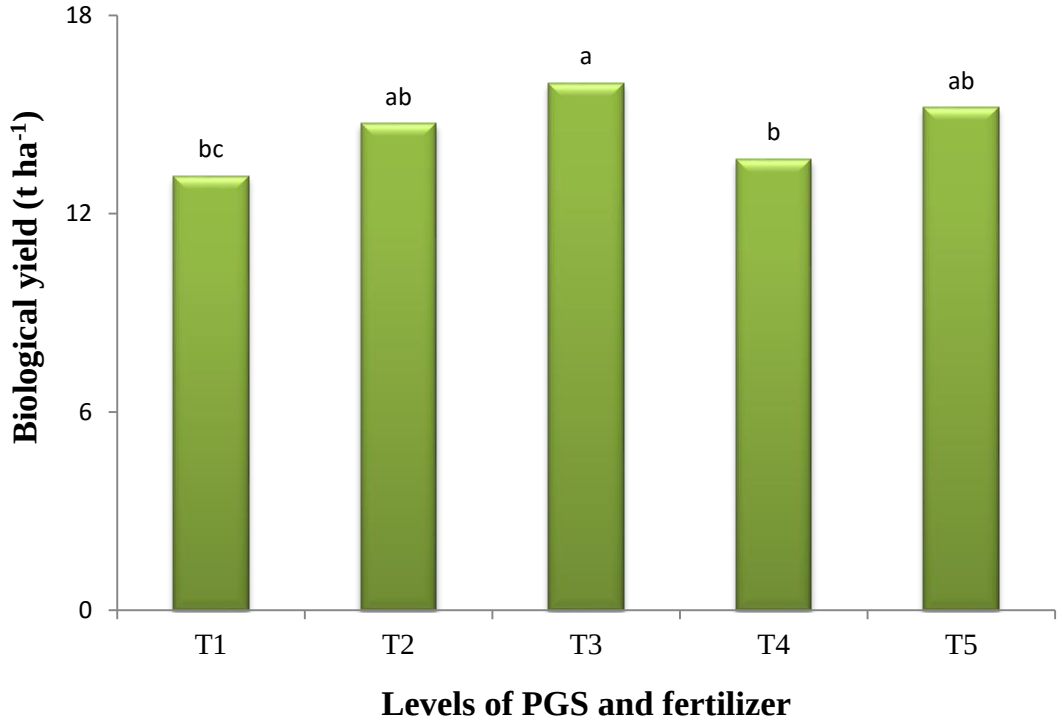


Figure 17. Effect of different levels of PGS and fertilizer on the biological yield of rice

T_1 = Recommended fertilizer dose
T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol
T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth
T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth

4.2.10.3. Interaction effect of variety and PGS and fertilizer management

Significant variation in biological yield (t ha^{-1}) was observed in the interaction effect of PGS and Fertilizer Management and Varieties (Table 14 and Appendix XIII). The results showed that the interaction between BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol) gave the highest (16.74 t ha^{-1}) biological yield that was statistically similar with BRRI hybrid dhan3 × T_5 (Recommended fertilizer dose + Akota + Global + Calsol +Magic Growth). The lowest (11.98 t ha^{-1}) biological yield was found in BRRI dhan29 × T_1 (Recommended fertilizer dose) treatment.

Table 14. Interaction effect of different varieties and levels of PGS and fertilizer on the yield characters of rice

Treatment combinations	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
BRRI hybrid dhan3 ×				
T_1	6.49 b-d	7.77 a-c	14.26 d	45.51 a-c
T_2	7.19 ab	8.63 ab	15.81 a-c	45.50 a-c
T_3	7.78 a	8.96 a	16.74 a	46.44 a
T_4	6.78 bc	7.92 a-c	14.71 b-d	46.11 ab
T_5	7.20 ab	8.83 a	16.03 ab	44.83 a-d
BRRI dhan29 ×				
T_1	4.87 f	7.11 c	11.98 f	40.60 c-e
T_2	5.30 ef	8.32 a-c	13.62 de	39.01 e
T_3	6.20 c-e	8.93 a	15.13 b-d	41.08 b-e
T_4	5.02 f	7.58 bc	12.60 ef	39.86 de
T_5	5.72 d-f	8.66 ab	14.38 cd	39.72 de
LSD (0.05)	0.94	1.21	1.52	5.24
CV (%)	8.78	8.53	6.11	7.12

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

T_1 = Recommended fertilizer dose
T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol
T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth
T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth
CV = Coefficient of Variation LSD (0.05) = Least significant difference

4.2.11. Harvest Index (%)

4.2.11.1. Effect of Variety

Significant difference was observed for harvest index (%) due to varietal differences (Figure 18 and Appendix XIII). The maximum (45.68%) harvest index was showed in BRRI hybrid dhan3 and the lowest (40.05 %) harvest index was found in BRRI dhan29.

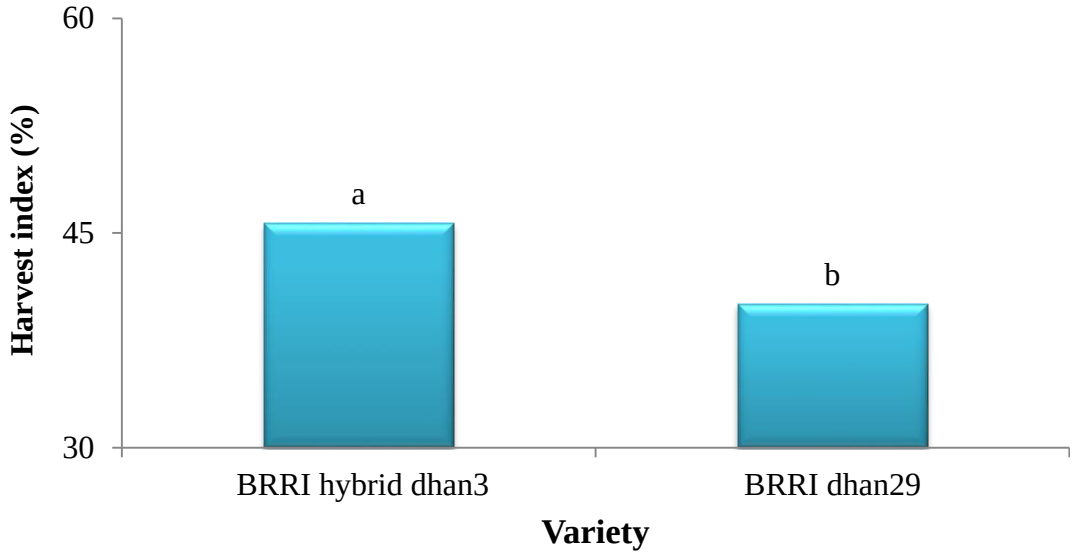


Figure 18. Effect of different varieties on the harvest index of rice

4.2.11.2. Effect of PGS and fertilizer management

Effect of different treatments of PGS and fertilizer exerted insignificant variation on harvest index (Figure 19 and Appendix XIII). The maximum numerical (43.76 %) harvest index was observed at T_3 (Recommended fertilizer dose + Akota + Global + Calsol) and the lowest (43.06 %) harvest index was obtained from T_1 (Recommended fertilizer dose) treatment.

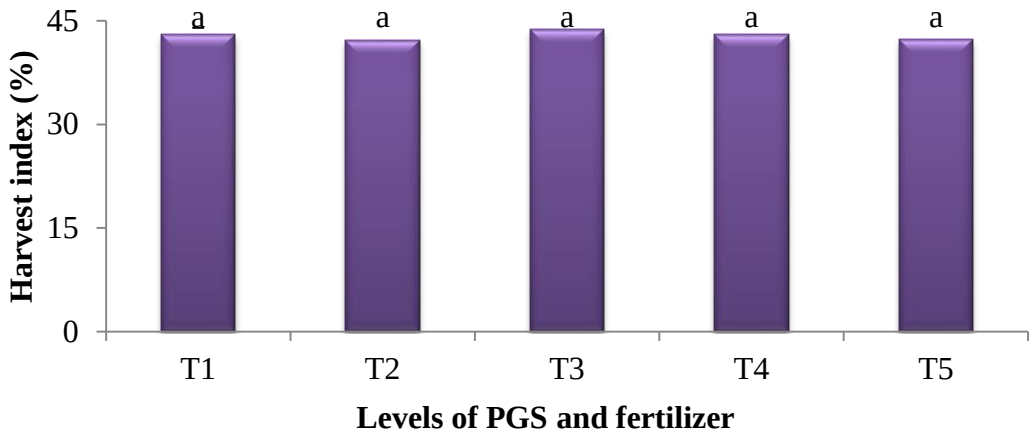


Figure 19. Effect of different levels of PGS and fertilizer on the harvest index of rice

T_1 = Recommended fertilizer dose
T_2 = Recommended fertilizer dose + Akota + Global
T_3 = Recommended fertilizer dose + Akota + Global + Calsol
T_4 = Recommended fertilizer dose + Akota + Global + Magic Growth
T_5 = Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth

4.2.11.3. Interaction effect of variety and PGS and fertilizer management

Harvest index was significantly influenced by the interaction effect of different treatments of PGS and fertilizer and variety (Table 14 and Appendix XIII). The maximum (46.44%) harvest index was observed in the interaction of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol) that followed by BRRI hybrid dhan3 × T_4 (Recommended fertilizer dose + Akota + Global + Magic Growth). The minimum (39.01%) harvest index was found in the interaction treatment effect of BRRI dhan29 × T_2 (Recommended fertilizer dose + Akota + Global).

CHAPTER V

SUMMARY AND CONCLUSIONS

The present experiment was conducted at the Agricultural Botany research field of Sher-e-Bangla Agricultural University, Dhaka-1207, during the period from November, 2016 to May, 2017 to evaluate the improvement of yield in hybrid rice (*Oryza sativa*. L) varieties through the manipulation of stem reserve remobilization and filled-grain percentage by plant growth regulator and foliar fertilization. The experiment consisted of two rice varieties (BRRI hybrid dhan3 and BRRI dhan29) and five different PGS and fertilizer treatment (Recommended fertilizer dose; Recommended fertilizer dose + Akota + Global; Recommended fertilizer dose + Akota + Global + Calsol; Recommended fertilizer dose + Akota +Global + Magic Growth and Recommended fertilizer dose + Akota + Global + Calsol + Magic Growth). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications and the differences between means were separated by Least significant difference (LSD) at 5% level of probability. Data on different growth characters and yield contributing characters were recorded and significant variation was observed.
Results showed that plant height (cm), leaves hill^{-1}, tillers hill^{-1}, total dry matter, shoot dry matter accumulation and its remobilization to grain, effective tiller (%), panicle 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 (33.78, 47.91, 63.70, 92.54 and 98.98 cm respectively) were shown by BRRI hybrid dhan3, while the shortest plant represented by BRRI dhan29. The maximum (43.07, 70.08, 78.29, 74.45 and 70.73) number of leaves hill^{-1} were found from BRRI hybrid dhan3 while minimum (41.59, 59.63, 70.98, 68.58 and 65.04) number of leaves hill^{-1} were obtained from BRRI dhan29. The maximum (11.72, 17.73, 19.15, 18.38 and 17.61) number of tillers hill^{-1} were found from BRRI hybrid dhan3 while minimum (11.10, 16.58, 17.90, 17.22 and 16.24) number of tillers hill^{-1} were obtained from BRRI dhan29. The highest (27.27, 50.34 and 73.24 g) total dry matter hill^{-1} was obtained from BRRI hybrid dhan3 at different growth stages. On the other hand, the lowest (23.97, 38.14 and 54.27 g) was found from BRRI dhan29. The highest (43.79 and 33.23 g) shoot dry matter accumulation at flowering and maturity stage was obtained from BRRI hybrid dhan3.

On the other hand, the lowest (31.23 and 24.57 g) was obtained from BRRI dhan29 at both stages. The shoot reserve translocation was the highest (23.20 %) from BRRI hybrid dhan3 variety. On the other hand, the lowest (19.53 %) was recorded from BRRI dhan29.

The highest (94.03 %) effective tiller (%) was recorded from BRRI hybrid dhan3 whereas the lowest (91.77 %) was recorded from BRRI dhan29. The maximum (16.67) number of panicles hill^{-1} was recorded from BRRI hybrid dhan3. The longest (25.75 cm) panicle was found in BRRI hybrid dhan3, while the shortest (23.29 cm) panicle length was attained from BRRI dhan29. The maximum (180.36) number of filled grains panicle^{-1} was found in BRRI hybrid dhan3 variety. The highest (189.26) number of total grains panicle^{-1} was observed in BRRI hybrid dhan3 while the lowest (141.15) number of total grains panicle^{-1} was obtained in BRRI dhan29. The highest (26.84 g) weight of 1000 grains was observed in BRRI hybrid dhan3 and the lowest weight (19.52 g) was observed in BRRI dhan29. The highest (7.09 t ha^{-1}) grain yield was recorded in BRRI hybrid dhan3 and the lowest (5.42 t ha^{-1}) grain yield was found in BRRI dhan29. The highest and lowest biological yield was obtained from BRRI hybrid dhan3 and BRRI dhan29, respectively. The maximum (45.68%) harvest index was showed in BRRI hybrid dhan3 and the lowest (40.05 %) harvest index was found in BRRI dhan29.

In case of different PGS and fertilizer treatment T_3 (Recommended fertilizer dose + Akota + Global + Calsol) produced the tallest plant (34.60, 49.65 67.52, 95.59 and 103.7 cm) at 40, 60, 80, 100 DAT and at harvest respectively. The maximum (47.90, 69.22, 80.37, 76.10 and 72.83) number of leaves hill^{-1} was attained from T_3 (Recommended fertilizer dose + Akota + Global + Calsol) at 40, 60, 80, 100 DAT and at harvest respectively. At 40, 60, 80, 100 DAT and at harvest, the maximum (13.20, 18.98, 21.22, 19.42 and 18.62) number of tillers hill^{-1} was attained from T_3 (Recommended fertilizer dose + Akota + Global + Calsol) treatment. At 80 DAT, the highest (8.522) leaf area index was observed in treatment T_3 (Recommended fertilizer dose + Akota + Global + Calsol). The highest value of chlorophyll a (1.32), chlorophyll b (0.41), chlorophyll ratio (a/b) (3.28) and total chlorophyll (a+b) (1.73) was observed in T_3 (Recommended fertilizer dose + Akota + Global + Calsol). The highest (31.47, 51.74 and 70.34 g) total dry matter hill^{-1} was found at different growth stages from T_3 (Recommended fertilizer dose + Akota + Global + Calsol). At flowering stage, the highest (45.42 g) shoot dry matter accumulation was recorded by T_3 (Recommended

fertilizer dose + Akota + Global + Calsol). At maturity stage, the highest (33.23 and 32.38g) shoot dry matter accumulation was recorded by T_3 (Recommended fertilizer dose + Akota + Global + Calsol). The shoot reserve translocation was the highest (26.31 and 25.14 %) from T_3 and T_5 treatment. The highest value (95.75%) of effective tiller was recorded in T_3 (Recommended fertilizer dose + Akota + Global + Calsol). The maximum (17.65) number of panicles hill^{-1} was recorded from T_3 (Recommended fertilizer dose + Akota + Global + Calsol). The longest (26.28 cm) panicle was found in T_3 (Recommended fertilizer dose + Akota + Global + Calsol). The highest (168.7) number of filled grains panicle^{-1} was obtained from T_3 (Recommended fertilizer dose + Akota + Global + Calsol). The maximum (178.0) number of total grains panicle^{-1} was obtained from T_3 (Recommended fertilizer dose + Akota + Global + Calsol). The highest value (93.92%) of filled grain was recorded in T_3 (Recommended fertilizer dose + Akota + Global + Calsol) treatment. The highest (24.98 g) 1000 grains weight was achieved from T_3 (Recommended fertilizer dose + Akota + Global + Calsol). The maximum (6.99 t ha^{-1}) grain yield was obtained from T_3 (Recommended fertilizer dose + Akota + Global + Calsol). The highest (8.85 t ha^{-1}) straw yield was achieved from T_3 (Recommended fertilizer dose + Akota + Global + Calsol). The highest (15.94 t ha^{-1}) biological yield was found in T_3 (Recommended fertilizer dose + Akota + Global + Calsol).

Due to the interaction effect of different PGS and fertilizer and rice varieties, the tallest (36.43, 51.77, 68.43,97.85 and 105.6 cm) plant height was observed at 40, 60, 80, 100 DAT and at harvest respectively from the combined treatment of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol). Maximum (48.50, 74.27, 82.77, 78.97 and 75.33) number of leaves at 40, 60, 60, 80, 100 DAT and at harvest was counted in the interaction of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol) treated plants. The maximum (13.63, 19.70, 1.63, 19.97 and 19.47) number of tillers hill^{-1} at 40, 60, 80, 100 DAT and at harvest was recorded respectively from treatment combination of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol). At 80 DAT, the maximum (8.60) leaf area index was recorded from the combined effect of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol). The maximum value of chlorophyll a (1.32), chlorophyll b (0.42), chlorophyll ratio (a/b) (3.28) and total chlorophyll (a+b) (1.73) was found from the interaction of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol). The highest (52.81 g) shoot

dry matter accumulation at flowering stage and (37.26 g) at maturity stage was obtained in the interaction of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol) treatment. The shoot reserve translocation was the highest (15.52 %) in the interaction of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol). The highest value (95.75%) of effective tiller was recorded in T_3 (Recommended fertilizer dose + Akota + Global + Calsol). The highest (18.13) number of the number of panicles $hill^{-1}$ was counted in the interaction of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol). The interaction of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol) produced the longest (27.77 cm) panicle length. The maximum (197.7) number of filled grains $panicle^{-1}$ was recorded from the combination of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol). The maximum (204.5) number of total grains $panicle^{-1}$ was recorded from the interaction of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol). The highest value (93.92%) of filled grains was recorded in T_3 (Recommended fertilizer dose + Akota + Global + Calsol) treatment. The highest (28.90 g) 1000 grains weight was found from the interaction of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol). The highest (7.78 t ha^{-1}) grain yield was recorded in the interaction of (BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol). The maximum (8.96 t ha^{-1}) straw yield was found from the interaction of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol). The interaction between BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol) gave the highest (16.74 t ha^{-1}) biological yield. The maximum (46.44 %) harvest index was observed in the interaction of BRRI hybrid dhan3 × T_3 (Recommended fertilizer dose + Akota + Global + Calsol).

Conclusions and Recommendations

- Combination of BRRI hybrid dhan3 and T_3 (Recommended fertilizer dose + Akota + Global + Calsol) treatment exhibited better growth and provided highest grain yield attributed by panicle hill^{-1}, 1000 grains weight , grain yield etc.
- T_3 (Recommended fertilizer dose + Akota + Global + Calsol) is more effective over the rest combinations.
- For getting higher yield, combination of Recommended fertilizer dose, Akota, Global and Calsol should be used.

Future research

- More experiments should be conducted in different soils with different varieties of rice to have exact doses of fertilizers and stimulator appropriate for particular condition.

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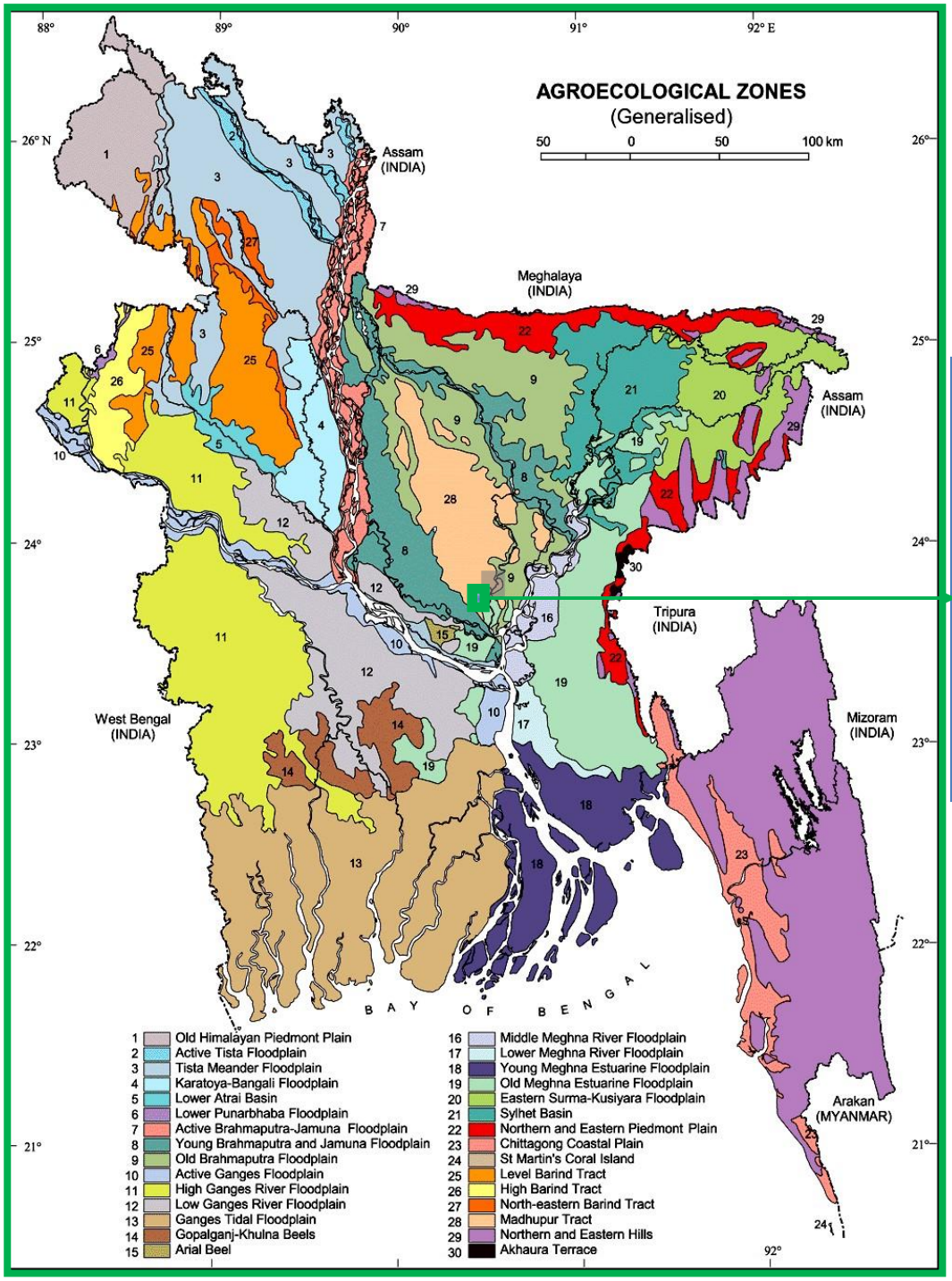
APPENDICES

Appendix I: Map showing the experimental site under study



Appendix II. Monthly recorded the average of air temperature, relative humidity, rainfall and sunshine hour of the experimental site during the period of experiment in the field from November 2016 to June 2017

Month	Air temperature (^{0}C)		Relative humidity (%)	Rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
November, 2016	33.8	19.3	71	11	6.8
December, 2016	30.2	15.2	51	30	5.9
January, 2017	34.1	19.5	59	34	5.7
February, 2017	31.5	15.3	51	65	6.6
March, 2017	31.6	16.8	64	31	8.1
April, 2017	35.4	20.1	72	65	7.2
May, 2017	35.2	21.3	71	80	6.8
June, 2017	39.2	24.1	78	76	6.3

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

Appendix III. Characteristics of the soil of experimental field

A. Morphological characteristics of the soil of experimental field

Morphological features	Characteristics
Location	Expeimental Field, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

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), Khamarbari, armgate, Dhaka

Appendix IV. Mean square values of the plant height of rice at different DAT

Sources of variation	Degrees of freedom	Mean square				
		Plant height (cm)				
		40 DAT	60 DAT	80 DAT	100 DAT	At harvest
Replication	2	2.044	66.933	44.591	14.282	21.505
Variety	1	189.304*	109.672*	100.065*	139.579*	145.684ns
PGS and fertilizer	4	34.963*	40.298*	88.715*	89.698&*	155.601*
Variety × PGS and fertilizer	4	1.116*	0.381*	2.797*	0.177*	0.939*
Error	18	6.768	12.936	19.544	29.310	44.907

*: significant at 0.05 level ns: non-significant

Appendix V. Mean square values of the number of leaves of rice at different DAT

Sources of variation	Degrees of freedom	Mean square				
		Number of leaves per hill				
		40 DAT	60 DAT	80 DAT	100 DAT	At harvest
Replication	2	48.936	60.056	19.443	40.795	23.069
Variety	1	16.532ns	818.601*	401.356*	258.779*	243.048*
PGS and fertilizer	4	113.165*	92.514*	105.649*	78.565*	94.146*
Variety × PGS and fertilizer	4	0.917*	0.551*	5.992*	0.695*	7.040*
Error	18	15.873	22.410	33.052	21.013	30.626

*: significant at 0.05 level ns: non-significant

Appendix VI. Mean square values of the number of tillers of rice at different DAT

Sources of variation	Degrees of freedom	Mean square				
		Number of tillers per hill				
		40 DAT	60 DAT	80 DAT	100 DAT	At harvest
Replication	2	0.639	5.114	0.062	1.113	3.070
Variety	1	2.877^{ns}	10.011*	11.569^{ns}	10.011*	14.145*
PGS and fertilizer	4	9.266*	13.445*	28.117*	8.770*	12.475*
Variety × PGS and fertilizer	4	0.056*	0.336*	0.519*	0.069*	0.306*
Error	18	1.086	1.103	2.727	2.199	1.564

*: significant at 0.05 level ns: non-significant

Appendix VII. Mean square values of the leaf area index of rice at different DAT

Sources of variation	Degrees of freedom	Mean square
		Leaf area index
Replication	2	0.510
Variety	1	0.059^{ns}
PGS and fertilizer	4	4.931*
Variety × PGS and fertilizer	4	0.168*
Error	18	0.321

*: significant at 0.05 level ns: non-significant

Appendix VIII. Mean square values of the Chlorophyll content of rice

Sources of variation	Degrees of freedom	Chlorophyll Content			
		a (mg g^{-1})	b (mg g^{-1})	(a/b)	(a+b) (mg g^{-1})
Replication	2	0.006	0.001	0.003	0.010
Variety	1	0.000^{ns}	0.000 ^{ns}	0.001 ^{ns}	0.000 ^{ns}
PGS and fertilizer	4	0.005*	0.001*	0.006*	0.010*
Variety × PGS and fertilizer	4	0.001*	0.000*	0.001*	0.001*
Error	18	0.002	0.000	0.002	0.004

*: significant at 0.05 level ns: non-significant

Appendix IX. Mean square values of the total dry matter of rice at different growth stages

Sources of variation	Degrees Of freedom	Mean square		
		Total dry matter(g)		
		At vegetative stage	At flowering stage	At harvest
Replication	2	6.996	2.458	4.669
Variety	1	81.807*	1117.764*	2698.198*
PGS and fertilizer	4	153.456*	280.450*	192.657*
Variety × PGS and fertilizer	4	2.317*	15.539*	12.908*
Error	18	0.300	0.346	2.323

*: significant at 0.05 level

Appendix X. Mean square values of the shoot dry matter accumulation and its translocation to the grain

Sources of variation	Degrees of freedom	Mean square			
		Shoot dry matter accumulation and its translocation to the grain			
		Shoot dry mater at flowering stage (g)	Shoot dry mater at maturity stage (g)	Changes in shoot dry mater (g)	Shoot reserve translocation (%)
Replication	2	10.830	3.959	0.596	0.858
Variety	1	1182.273*	563.247*	137.602*	100.980*
PGS and fertilizer	4	304.008*	92.537*	63.600*	122.326*
Variety × PGS and fertilizer	4	10.413*	2.319*	6.601*	10.187*
Error	18	0.498*	2.015	0.081*	1.286*

*: significant at 0.05 level

Appendix XI. Mean square values of the yield components of rice

Sources of variation	Degrees of freedom	Mean square		
		Effective tiller (%)	Panicle hill^{-1}	Panicle length (cm)
Replication	2	0.775	0.729	1.841
Variety	1	38.375*	11.114*	45.240*
PGS and fertilizer	4	28.030*	11.449*	9.727*
Variety × PGS and fertilizer	4	3.086*	0.254*	0.149*
Error	18	0.574	1.421	2.349

*: significant at 0.05 level

Appendix XII. Mean square values of the yield components of rice

Sources of variation	Degrees of freedom	Mean square			
		Filled grains panicle^{-1} (No.)	Total grains panicle^{-1} (No.)	Filled grain (%)	1000 grains weight (g)
Replication	2	61.633	54.527	56.966	1.860
Variety	1	20924.644*	17356.885*	116.427^{ns}	402.088*
PGS and fertilizer	4	675.168*	490.972*	41.003^{ns}	11.125*
Variety × PGS and fertilizer	4	23.010*	21.571*	2.051*	0.310*
Error	18	146.610	152.503	27.214	2.969

*: significant at 0.05 level ns: non-significant

Appendix XIII. Mean square values of the regarding grain yield (t ha^{-1}), straw yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%) of rice

Sources of variation	Degrees of freedom	Mean square			
		Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	1.032	0.548	2.744	5.115
Variety	1	20.817*	0.690^{ns}	29.087*	237.220*
PGS and fertilizer	4	1.559*	2.520*	7.835*	2.360^{ns}
Variety × PGS and fertilizer	4	0.039*	0.082*	0.151*	0.753*
Error	18	0.302	0.498	0.789	9.322

*: significant at 0.05 level ns: non-significant

Plate 1: Collection of data from experimental field

Plate 1: Pictorial view of the experimental field