# PERFORMANCE OF BRRI DHAN72 AS INFLUENCED BY PHOSPHORUS FERTILIZATION

**A Thesis**

**By**


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**DEPARTMENT OF SOIL SCIENCE**

**SHER-E-BANGLA AGRICULURAL UNIVERSITY**

**DHAKA-1207**


**DECEMBER, 2020**

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*A Thesis Submitted to*
*The Department of Soil Science, Faculty of Agriculture*
*Sher-e-Bangla Agricultural University, Dhaka*
*In partial fulfilment of the requirements*
*for the degree*
*of*

**MASTER OF SCIENCE (MS)**

**IN**

**SOIL SCIENCE**

**SEMESTER: JULY-DECEMBER, 2020**

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# *CERTIFICATE*

*This is to certify that the thesis entitled* ***"PERFORMANCE OF BRRI DHAN72 AS INFLUENCED BY PHOSPHORUS FERTILIZATION"*** *submitted to the Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE in SOIL SCIENCE****, embodies the result of a piece of authentic research work carried out by* ***Faija Abedin,*** *Registration No.* ***18-09265*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

*I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.*

Dated: December, 2020
Dhaka, Bangladesh

**Prof. Dr. Alok Kumar Paul**
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DEDICATED TO

MY

BELOVED PARENTS

AND

BROTHER

## *ACKNOWLEDGEMENTS*

*Author is prostrated before The Almighty Allah, most merciful and beneficent, for giving the strength and courage to successfully complete the research work.*

*The author would like to express her deepest sense of gratitude, respect to her research* ***Supervisor Prof. Dr. Alok Kumar Paul****, Department of Soil Science, Sher-e-Bangla Agricultural University (SAU) for his kind and scholastic guidance, untiring effort, valuable suggestions, inspiration, extending generous help and encouragement during the research work and guidance in preparation of manuscript of the thesis.*

*The author sincerely expresses her deepest respect and boundless gratitude to her* ***Co-supervisor, Dr. Biswajit Karmakar,*** *Principal Scientific Officer and Head, Bangladesh Rice Research Institute (BRRI), Regional Station, Sonagazi, Feni for his enthusiastic supervision, valuable advice, scientific guidance, sincerest cooperation, and strong inspiration in carrying out the research work and writing up of the thesis.*

*The author expresses his gratitude to professor A. T. M Shamsuddoha, chairman, Department of Soil Science, Sher-e-Bangla Agricultural University (SAU) for his sincere co-operation, constant inspiration and providing all facilities to carry out the research.*

*The author feels proud to express her sincere appreciation and gratitude to Ministry of Science and Technology, The People's Republic of Bangladesh for providing her National Science and Technology (NST) fellowship.*

*I wish to thank all her fellow for being there in all the hard work and sharing her joys and sorrows.*

*Last but not the least, I express my deepest gratefulness and appreciation to my family for their unflagging love, unconditional support, incredible patience, love and inspirations during the tenure of the study and writing up of the thesis.*

***The Author***

# PERFORMANCE OF BRRI DHAN72 AS INFLUENCED BY PHOSPHORUS FERTILIZATION


## ABSTRACT

The experiment was conducted during the period from July 2019 to November 2019 at Amon season in the research farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh to find out the performance of BRRI dhan72 as influenced by phosphorus fertilization. As planting material BRRI dhan72 was used. The experiment was comprised of $T_1$: Control, $T_2$: $N_{85}$ $P_{15\ (from\ TSP)}$, $T_3$: $N_{85}$ $P_{20\ (from\ DAP)}$, $T_4$: $N_{85}P_{15\ (from\ DAP)}$, $T_5$: $N_{85}P_{10\ (from\ DAP)}$, $T_6$: $N_{75}$ $P_{20\ (from\ DAP)}$, $T_7$: $N_{75}$ $P_{15\ (from\ DAP)}$ and $T_8$: $N_{75}$ $P_{10\ (from\ DAP)}$.The recommended fertilizer doses for K, S, Zn were applied @ 55,12,1 kgha$^{-1}$ respectively. The N fertilizer were used in the form of urea @ 85, 75 kgha$^{-1}$ and P fertilizer were used in the form of DAP (18% N and 20% P) and TSP @ 10, 15, 20 kgha$^{-1}$. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were recorded on different yield contributing characters, yield and characteristics of post-harvest soil and statistically significant variation was recorded for most of the studied characters. Results indicated that the tallest plant (119.73 cm), maximum number of flag leaves (41.98), total tillers hill$^{-1}$ (18.80), effective tillers hill$^{-1}$ (11.67) were recorded from $T_3$ treatment. The highest numbers of filled grains panicle$^{-1}$ (88.84 cm), longest panicle (26.83), 1000 grains weight (0.141 g) were also recorded from $T_3$ treatment. $T_3$ treatment produced the highest grain yield per hectare (5.35 t), while the shortest plant (81.67 cm), minimum number of flag leaves (37.07), total tillers hill$^{-1}$ (8.80), effective tillers hill$^{-1}$ (9.27), filled grains panicle$^{-1}$ (71.13), shortest panicle (24.58), total grains panicle$^{-1}$ (120.47), weight of 1000 grains (0.026 g) and lowest grain yield (3.89 t ha$^{-1}$) were found in $T_1$ treatment. The highest total N (0.119%), available P (20.25 ppm), S (14.67 ppm) and exchangeable K (0.146 meq/100 g soil) was recorded in $T_3$ treatment and lowest from $T_1$ treatment. The overall results indicated that application of $N_{85}$ $P_{20\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg ha$^{-1}$ was more potential in regarding yield contributing characters and yield of BRRI dhan72.

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| | |
|---|---|
| AEZ | Agro-ecological Zone |
| Agric. | Agricultural |
| ANOVA | Analysis of Variance |
| BARI | Bangladesh Agricultural Research Institute |
| Biol. | Biology |
| CV | Coefficient of variance |
| DAT | Days After Transplanting |
| *et al.* | And others |
| Ex. | Experiment |
| USDA | Food and Agriculture Organization of the United Nations |
| g | Gram |
| Hort. | Horticulture |
| i.e. | That is |
| *J.* | Journal |
| Kg | Kilogram |
| LSD | Least Significance difference |
| mm | Millimeter |
| BRRI | Bangladesh Rice Research Institute |
| Res. | Research |
| SAU | Sher-e-Bangla Agricultural University |
| Sci. | Science |
| spp. | Species |
| Technol. | Technology |
| DAP | Di-Ammonium Phosphate |
| Viz. | Namely |
| % | Percent |
| TSP | Triple Super Phosphate |
| IFDC | Relative Growth Rate |
| FRG | Net Assimilation Rate |
| MSTAT | Michigan State University Statistical Package for Data Analysis |
| etc. | Etcetera |
| USG | Urea Super Granule |
| Atm | Atmospheric |
| BBS | Bangladesh Bureau of Statistics |
| No. | Number |
| $m^2$ | Meter squares |
| NS | Non significant |
| SRDI | Soil Resources and Development Institute |
| t $ha^{-1}$ | Ton per hectare |
| $^0C$ | Degree Centigrade |

| | |
|---|---|
| hr | Hour(s) |
| MP | Muriate of Potash |
| Kg | Kilogram (s) |
| NUE | Nitrogen Use Efficiency |
| GM | Green Manures |
| PFP | Partial Factor Productivity |
| AE | Agronomic Efficiency |
| IE | Internal Efficiency |
| PPB | Partial P Balance |
| RE | Recovery Efficiency |
| RS | Rice Straw |
| PM | Pig Manure |
| RCBD | Randomized Complete Block Design |

# CHAPTER I

# INTRODUCTION

Rice (*Oryza sativa* L.), belonging to the family Poaceae, is the principal staple food for more than 50% of the world's population (Jahan *et al.,* 2017). However, the average yield of rice in Bangladesh is 4.35 t/ha which is less than the average yield (4.53 t/ha) (USDA, 2018). The increased rice production has been possible largely due to the adoption of modern rice varieties on around 70.24% which contributes to about 83.39% of the country's total rice production. Bangladesh Rice Research Institute (BRRI) has developed highly productive rice variety suitable for Aman season. BRRI dhan72 is a short duration rice variety developed with the use of modern technology. BRRI dhan72 is a high yielding zinc enriched aman rice variety. Consumption of Zinc enriched rice prevents deficiency of Zinc, Iron and Vitamin-A. Each kilogram of BRRI dhan72 rice contains six milligram of more Zinc per kilogram than other Zinc enriched varieties which meets micro-nutritional demand of the children, woman and common people. BRRI dhan72 rice is more profitable and requires less quantity of urea fertilizer with less pest attacks.

Fertilizer plays an important role in modern agriculture, especially for increased rice production by supplying single or multiple nutrients. Single chemical fertilizers such as N as urea, P as triple super phosphate (TSP) or di-ammonium phosphate (DAP), K as potassium chloride (KCl), S as gypsum and Zn as zinc sulfates or physical mixer of different single fertilizers are used for rice cultivation in Bangladesh. With the development of improved rice varieties as well as better soil and fertilizer management technologies, paddy yield is generally increasing in Bangladesh and other rice growing countries over the years which causes gradual increase of N, P and K nutrient removal (kg $ha^{-1}$) and consequently fertilizer consumption in Bangladesh is generally increasing over the years (Islam and Muttaleb, 2016).

In wet land rice soils, N fertilizer has been applied at higher doses than P and K fertilizers and thus creating nutrients mining from soils. On the other hand modern high-yielding rice varieties remove much higher amount of K than P or even N from the soil (Islam and Muttaleb, 2016; Islam *et al.,* 2016 and Islam *et al.,* 2015). Recent study indicated that about 60% cultivable land of Bangladesh is deficient in N, P and K (Miah *et al.,* 2008). Crop yield reductions are strongly related to soil productivity degradation, particularly nutrient depletions (Rony *et al.,* 2003) which can be attributed to either insufficient or imbalanced use of fertilizers (Tang *et al.,* 2005). The rate and types of fertilizers used depend on a farmer's financial ability and choice often made without considering indigenous supplying capacities of soils under varying agro ecological zones (AEZs) of Bangladesh. Besides, being cheaper and prompt visible response of N than P and K fertilizers, farmers apply more N for rice production (Islam *et al*., 2015; Miah, *et al.,* 2008; Rony *et al.,* 2003; Tang *et al.,* 2005 and Biswas *et al.,* 2004) and thus create nutrients imbalance in many cases. The imbalanced fertilizer use in Bangladesh agriculture is speeding up nutrients depletion (Rijpma and Islam, 2015), which becomes a major problem in rice production. Historically, flood plain soils of Bangladesh was fertile, although fertility varies greatly among different regions even in locations within a region itself. It is reported that the soils are generally content with low organic matter and so do N and S. Total N content of soils is generally very low. Management of soil fertility largely determines the availability of N and P for crop plants. Increased cropping intensity and use of high yielding modern varieties are responsible for luxury consumptions of N, P, K and many others require replenishments; but generally, replenishments of removed nutrients do not happen resulting in mining of nutrients from soil.

Moreover, nutrient losses also have a negative role in recuperating soil fertility. For example, 70% loss of urea-N occurs in wet land rice cultivation (IFDC, 2013). Rice yield in P-deficit soil was less than 50% compared to even moderate levels of P containing soils (Saleque *et al.,* 1998). Although the rice requirement for P is much less than that for N, the continuous removal of P exploits the soil P reserve if the soil is not replenished through fertilizer or manure application (Saleque *et al.,* 2004). Use of inadequate P for growing crops intensively has resulted in P deficiency in most soils of Bangladesh (FRG, 2012). A rice crop depletes about 7-8 kg P $ha^{-1}$ when P fertilizer is not used; while an application of soil test-based doses may cause an accretion of about 9-49 kg P $ha^{-1}$ (Dobermann, 1995). The amount of P application obviously depends upon crop demand and soil-supplying capacity; although a P rich soil can be P deficient within four years in rice-rice cropping sequence (BRRI, 2006). Selection of a fertilizer depends on supplying capability of nutrients to rice plants at right time and optimal amount based on crop demand, capability to increase yield and to reduce nutrient losses to the environment. Therefore, it is necessary to determine an appropriate type of fertilizer for rice cultivation that can help in minimizing environmental pollution.

In many countries, like Vietnam, Cambodia, Philippines farmer use N P compound (NPC) as a slow released N fertilizer for crop production. It was found that use of 80-140 kg N $ha^{-1}$ from NPC fertilizer resulted in about 220-810 kg $ha^{-1}$ more rice yield which saved about 20- 30 kg N $ha^{-1}$ (Granger, 2005.) Moreover, NPC fertilizer is the source of Ca and S for plant nutrition which might be beneficial in Ca and S deficient soil. It can also be stored easily. Its performance with Boro rice at BRRI, Gazipur was comparable with TSP (Hossain and Saha, 2015) but a detailed study with NPC fertilizer has not been conducted in our country. After formal procedures this product has been included in the present investigation to evaluate its performance in terms of N and P supplying capacity for improving rice yield in Bangladesh.

Judicious and proper use of fertilizer can markedly increase the yield and improve the quality of rice. DAP supplies N and also P for plants. Phosphorus fertilizer is a major essential plant nutrient and key input. Much of the P applied to soils as fertilizer become fixed into unavailable forms to plant

(Choudhury *et al.,* 2007). Phosphorus fertilizer management is complex and it requires knowledge of the supply of other nutrients to crop, the overall P balance in soil, the effective P supply from indigenous soil resources, recycling and the processes that govern the ability of P in a particular soil (Dobermann *et al.,* 1996). Many soils of the Indo-gangetic plain, including Bangladesh have P deficient (Ali *et al.,* 1997). So, it is necessary to assess the performance of DAP as a source of P on the growth and yield of BRRI dhan72. From the above discussion the experiment was conducted to study the improving quality of BRRI dhan72 through minimization of phosphorus and supplementation of nitrogen, potassium, Sulphur and zinc with the following objectives-

1. To investigate the effect of P on the growth and yield of BRRI dhan72; and
2. To evaluate the efficiency of P as a source of DAP on the growth and yield of rice.

# CHAPTER II

# REVIEW OF LITERATURE

Rice has remarkable adaptability to different environmental conditions as is evident from its worldwide distribution. Many researchers at home and abroad investigated various aspects of successful rice production. Sole and combined use of inorganic recommended fertilizers in different forms increase plant growth, yield attributes and yield of rice. Experimental evidences that the use of recommended dose of fertilizers (nitrogen, phosphorus, potassium, sulphur and zinc) have an intimate effect on the yield and yield attributes of rice. But research works related to recommended fertilizer doses of fertilizers from different forms of application sources are limited in Bangladesh context. Some related research findings on the performance of Dap fertilizer as a source of P on the growth and yield of BRRI dhan72 as T. aman have been reviewed in this chapter under the following headings-

## 2.1 Effect of nitrogen

Rahman *et al.* (2016) conducted an experiment to evaluate the effect of levels of USG and depth of placement on the growth of T. *aman* rice. USG levels showed non-significant effect on plant height. They also reported that plant height was found highest when USG was applied with BRRI dhan48 and all the characters showed lowest value when absolute control with BRRI dhan55.

Lukman *et al*. (2016) reported that the combined application of cow dung and NPK fertilizer significantly increased most of the results obtained with regards to locations compared to the control plots. The growth and yield parameters of rice considered were significantly affected by the treatments except one thousand grain weight. Application of 8 t $ha^{-1}$ of cowdung in combination with 400 kg $ha^{-1}$ NPK 20:10:10 gave the highest grain yield (5.77 t $ha^{-1}$) at Sokoto anditisrecommendedthatapplicationof12t$ha^{-1}$ofcowdungincombination with 300 kg $ha^{-1}$ NPK 20:10:10 resulted in the best soil nutrient enrichment and yield of rice in Sokoto and Talata Mafara.

Samia (2016) the experiment was conducted during the period from 13th December 2015 to May 2016 at boro season in the research farm of Sher- e- Bangla Agricultural University, Sher- e- Bangla Nagar, Dhaka, Bangladesh to find out the effect of different levels nitrogen and sulphur on the growth and yield of BRRI dhan63. As planting material BRRI dhan63 also known as 'Sorubalam' was used. The experiment was comprised of two factors as Factor A: Levels of N (3 levels) - $N_0$: 0 kg N $ha^{-1}$ (control), $N_1$:100 kg N $ha^{-1}$, $N_2$:140 kg N $ha^{-1}$ and Factor B: Levels of S (3 levels) - $S_0$: 0 kg S $ha^{-1}$ (control), $S_1$: 10 kg S $ha^{-1}$, $S_2$: 15 kg N $ha^{-1}$. The experiment was laid out in a randomized complete block design (RCBD) with three replications. In case of nitrogen, at 30, 50, 70, 90 DAT and harvest, the tallest plant (39.89, 59.45, 77.45, 85.74 and 89.93cm, respectively) was recorded from $N_1$, where as the shortest plant (34.89, 54.64, 72.30, 80.11 and 80.68cm, respectively) was found from $N_0$. The highest grain yield (5.48 t $ha^{-1}$) was found from $N_1$, while the lowest grain yield (4.46 t$ha^{-1}$) was observed from $N_0$. The highest total nitrogen (0.053%) was found from $N_1$, while the lowest (0.013%) was observed from $N_0$. It was revealed that application of 100 kg N $ha^{-1}$ was more potential in regarding yield contributing characters and yield of BRRI dhan63.

Murthy *et al*. (2015) conducted an experiment with an objective to revise the existing fertilizer doses of major nutrients in Krishna Godavari delta regions of Andhra Pradesh. Grain yield was increased by 11.5% and 6.3% due to increase in recommended dose of N from 100% (120 kg $ha^{-1}$) to 125% and 150%.

Naznin *et al*. (2013) investigate the effects of prilled urea (PU), urea super granule (USG) and NPK briquette on $NH_4$-N concentration in field water, yield and nitrogen (N) use efficiency (NUE) of BR22 rice under reduced water conditions and reported that the highest grain yield of 3.93 t $ha^{-1}$ from 104 kg N $ha^{-1}$ as USG and the lowest value of 2.12 t $ha^{-1}$ was obtained from control. The

N use efficiency was increased when the N was applied as USG. The overall results revealed that application of USG and NPK briquette may be practiced for obtainingbetteryieldsinadditiontoincreasingtheefficiencyofNfertilizer.

Duhan and Singh (2002) reported that the rice yield and uptake of nutrients increased significantly with increasing N levels. Moreover, the application along with various green manures (GM) showed additive effect on the yield and uptake of micronutrients. Under all GM treatments, the yield and uptake were always higher with 120 kg $ha^{-1}$ than with lower level of nitrogen.

Angayarkanni and Ravichandran (2001) conducted a field experiment in Tamil Nadu, India from July to October 1997 to determine the best split application of 150 kg N $ha^{-1}$ for rice cv. IR20. They found that applying 16.66% of the recommended N as basal, followed by 33.33% N at 10DAT, 25% N at 20DAT and 25% N at 40 DAT recorded the highest grain (6189.4 kg $ha^{-1}$) and straw (8649.6 kg $ha^{-1}$) yields, response ratio (23.40) and agronomic efficiency (41.26).

Munnujan *et al*. (2001) treated 4 levels of nitrogen fertilizer (0, 40, 80, and 160 kg $ha^{-1}$) application at three levels each planting density (20, 40 and 80 hill $m^{-1}$) and conducted that the highest grain yield (3.8 t $ha^{-1}$) was obtained with 180 kg N $ha^{-1}$, which was similar to the yield obtained at 80 kg N $ha^{-1}$ (3.81 t $ha^{-1}$).

Pulley *et al*. (2000) observed that increased yield associated with application of nitrogen stage, although booting stage nitrogen application had no effect or shoot growth or nitrogen uptake. These preliminary results suggested a single application of nitrogen is sufficient to maintain healthy rice growth, alleviating the need for additional N application after flooding. Rice may be responded to N applied as late as booting, but only when the rice is N limited and not severely N stressed.

BRRI (2000) reported that the grain yield was linearly increased with increasing nitrogen rates. Castro and Sarker (2000) conducted field experiment to see the effects of N applications as basal (80, 60, and 45kg N $ha^{-1}$) and top dressing (10, 30 and 45 kg $ha^{-1}$) on the yield and yield components of Japonica rice and obtained high effective tiller, percentage of ripened grains and high grain yields from 45 kg N $ha^{-1}$ (basal) and 45 kg N $ha^{-1}$ (top dressing). Singh *et al.* (2000) stated that each increment dose of N significantly increased grain and straw yields of rice over its preceding dose. Consequently, the crop fertilized with 100 kg N $ha^{-1}$ gave maximum grain yield (2647 $kgha^{-1}$).

Bellido *et al*. (2000) evaluate a field experiment with 4 levels of nitrogen (0, 50, 100 and 150 kg N $ha^{-1}$) and reported that the amount of total dry matter was significantly greater at the N fertilizer rates of 100 and 150 kg nitrogen $ha^{-1}$.

### 2.2 Effect of phosphorous

Tang *et al*. (2011) conducted a field experiment on winter wheat (*Triticum aestivum* L.) and rice (*Oryza sativa* L.) crop rotations in Southwest China to investigate phosphorus (P) fertilizer utilization efficiency, including the partial factor productivity (PFP), agronomic efficiency (AE), internal efficiency (IE), partial P balance (PPB), recovery efficiency (RE) and the mass (input–output) balance. This study suggests that, in order to achieve higher crop yields, the P fertilizer utilization efficiency should be considered when making P fertilizer recommendations in wheat–rice cropping systems.

Islam *et al*. (2010) conducted a field experiment with five phosphorus rates (0, 5, 10, 20 and 30 kg P $ha^{-1}$) with four rice genotypes in Boro and T. Aman season. Phosphorus rates did not influence grain yield irrespective of varieties in T. aman season while in Boron season P response was observed among the P rates. Application of P @ 10 kg $ha^{-1}$ significantly increased the grain yield. But when P was applied @ 20 and 30 kg P $ha^{-1}$, the grain yield difference was not significant. The optimum and economic rate of P for T. Aman was 20 kg P $ha^{-1}$

but in Boro rice the optimum and economic doses of P were 22 and 30 kg $ha^{-1}$, respectively. Hybrid entries ($EH_1$ and $EH_2$) used P more efficiently than inbred varieties. A negative P balance was observed up to 10 kg $Pha^{-1}$.

Dunn and Stevens (2008) conducted a field experiment to evaluate the effect of polymer coating of phosphate fertilizer on rice yield. Three rates of phosphate fertilizer, including polymer coated and non-coated, were compared to an untreated check. Net return was calculated based on crop price and input costs. At the rate of 25 lb/acre $P_2O_5$rate the polymer coated treatments produced greater yields than equivalent non coated treatments.

Li *et al.* (2007) conducted an experiment to evaluate the contributions of rice root morphology and phosphorus uptake kinetics to P uptake by rice from iron phosphates.TheFe-Ptreatmentsignificantlydecreasedplantdryweight,P uptake per plant, and P concentration in plant dry matter of all cultivars in comparison with the control plants.

Nair and Rajasree (2004) conducted a field experiment to assess comparative efficiency of super phosphate and PR (34/74) at different levels in the yield characters and composition of rice. The treatments were 30 and 45 kg $P_2O_5ha^{-1}$in the form of superphosphate and PR (34/74) with and without organic matter. The results showed that high grade phosphate rock (M, 34/74) with organic manure performed well and were followed by PR (34/74) with iron pyrites and green manure. Thus, PR (34/74) performed well with organic matter, $FeS_2$ and green manure in deciding growth and yield of rice. Higher contents of N, P, K, Ca and Mg of grain and straw were obtained at higher levels of 45 kg $P_2O_5ha^{-1}$treatment.

Sahrawat *et al*. (2001) conducted a field experiment for six years (1993-1998) to determine the response of four promising upland rice cultivars with 0, 45, 90, 135, and 180 kg/ha as triple super phosphate (TSP). Only once used in

1993 and its residual value in 1994, 1995, 1996 and 1998 stated that grain yields of the rice cultivars were significantly increased by fertilizer P in 1993 and by the fertilizer P residues in the subsequent years although the magnitude of response decreased rapidly with time since the fertilizer was not applied.

### 2.3 Effect of potassium

Wang (2011) conducted a field experiment to study the effects of N, P and K fertilizer application on grain yield, grain quality as well as nutrient uptake with four levels of nitrogen (N), phosphorus (P) and potassium (K) fertilizers. The results revealed that the application of N, P and K fertilizer significantly increased grain yield, and the highest yield was found under the combined application of N, P and K fertilizer.

Wan *et al*. (2010) evaluated the effects of application of fertilizer, pig manure (PM), and rice straw (RS) on rice yield, uptake, and usage efficiency of potassium, soil K pools, and the non-exchangeable K release under the rice-rice cropping system. The field treatments included control (no fertilizer applied), NP, NK, NPK, and NK + PM, NP + RS, NPK + RS. The application of K fertilizer (NPK) increased grain yield by 56.7 kg $ha^{-1}$ over that obtained with no K(NP).

Mostofa *et al*. (2009) carried a pot experiment in the net house at the Department of Soil Science, Bangladesh Agricultural University, Mymensingh. Four doses of potassium (0, 100, 200, and 300 kg $ha^{-1}$) were applied. They observed that the yield contributing characters like plant height, tiller number, and dry matter yield were the highest in 100 kg $ha^{-1}$ of K.

Muangsri *et al*. (2008) found that the effect of rice straw and rice hull in combination NPK fertilizer on yield of rice grown on Phimai soil series. The treatments consisted of the control, rice straw at the rate of 0.75, 1.5 and 3.0 g $kg^{-1}$ soil in combination with NPK fertilizers, and rice hull at the rate of 0.75, 1.5, 3.0 and 4.5 g $kg^{-1}$ soil in combination with NPK fertilizer. The results showed that the growth, yield and nutrient uptake of rice plant without fertilizer were the lowest. Yield of rice plant grown on the soil amended with rice straw in combination with NPK fertilizer showed to be higher than that of rice plant grown on the soil amended with only NPK fertilizer.

Krishnappa *et al.* (2006) reported that increasing K rates increased paddy yields. Potassium applied in split dressings were more effective than when applied at transplanting time. Application of potassium fertilizer with organic manure increased soil K availability, K content and the number of grains $panicle^{-1}$.

Sarkar and Singh (2002) conducted a field experiment to determine the effect of potassium and sulphur. They applied 110 kg N: 90 kg P: 70 kg K: 20 Kg S $ha^{-1}$. They observed that the number of tillers $m^{-2}$, 1000-grain weight, paddy and straw yield significantly increased with the application K with other fertilizer.

Natarajan *et al*. (2005) conducted an experiment during 2002-2003 with two rice hybrids, KRH2 and DRRHI in main plots and three levels of potassium (0, 40, and 80 kg $ha^{-1}$) in subplots to study the performance of rice hybrids with different K levels. The results clearly indicated that hybrid KRH2 performed superior with different levels of K.

Hong *et al*. (2004) conducted field experiments to investigate the potassium uptake, distribution and use efficiency of hybrid and conventional rice under different low K stress conditions. The grain yield and total K uptake by rice increased.

Shen *et al*. (2003) studied the effects of N and K fertilizer on the yield and quality of rice. Potassium fertilizer significantly improved all quality parameters and yield at 150 kg N $ha^{-1}$ and equal amounts of K fertilizer applied to rice fields are optimum to obtain high yield.

Singh *et al.* (2000) evaluated the effect of levels of K application on rice at different places. Results indicated that K application significant enhanced the growth and yield of rice over no application. The highest grain and straw yields of rice was obtained at 90 kg $K_2O$ $ha^{-1}$ all the cropping seasons.

## 2.4 Effect of sulphur

Samia (2016) the experiment was conducted during the period from 13th December 2015 to May 2016 at boro season in the research farm of Sher- e- Bangla Agricultural University, Sher- e- Bangla Nagar, Dhaka, Bangladesh to find out the effect of different levels nitrogen and sulphur on the growth and yield of BRRI dhan63. As planting material BRRI dhan63 also known as ‘Soru balam’ was used. The experiment was comprised of two factors as Factor A: Levels of N (3 levels) - $N_0$: 0 kg N $ha^{-1}$(control), $N_1$: 100 kg N $ha^{-1}$, $N_2$: 140 kg N $ha^{-1}$ and Factor B: Levels of S (3 levels) - $S_0$: 0 kg S $ha^{-1}$(control), $S_1$: 10 kg S $ha^{-1}$, $S_2$: 15 kg N $ha^{-1}$. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The highest available S (22.05 ppm) was found from $N_1$, while the lowest (19.57 ppm) was observed from $N_0$. For sulphur, at 30, 50, 70, 90 DAT and harvest, the tallest plant (39.90, 59.62, 76.88, 85.36 and 91.85 cm, respectively) was observed from $S_2$, while the shortest plant (34.88, 54.39, 72.40, 75.26 and 77.35 cm, respectively) was observed from $S_0$. The highest grain yield (5.37 t $ha^{-1}$) was recorded from $S_2$, whereas the lowest grain yield (4.35 t $ha^{-1}$) was observed from $S_0$. The highest straw yield (6.80 t $ha^{-1}$) was recorded from $S_2$, whereas the lowest straw yield (6.01 t $ha^{-1}$) was observed from $S_0$. The highest total nitrogen (0.045%) was recorded from $S_2$, whereas the lowest (0.032%) was found from $S_0$. The highest available S (22.70 ppm) was recorded from $S_2$, whereas the lowest (18.76 ppm) was found from $S_0$. It was revealed that application of 10 kg S $ha^{-1}$ was more potential in regarding yield contributing characters and yield of BRRI dhan63.

A field experiment was carried out by Jawahar and Vaiyapuri (2011) at Experimental Farm, Annamalai University, Annamalai Nagar, Tamil Nadu, India to study the effect of sulphur and silicon fertilization on yield and nutrient uptake. The treatments comprised four levels of sulphur as 0, 15, 30 and 45 kg $ha^{-1}$ and they observed highest yield and nutrient uptake of rice due to application 45 kg $Sha^{-1}$.

An experiment was conducted by Rahman *et al*. (2009) to know the effect of different levels of sulphur on growth and yield of BRRI dhan41 at Soil Science laboratory field of Bangladesh Agricultural University, Mymensingh during T. Aman season. There were eight treatments and they were $T_0$(without S), $T_1$ (50% RFD of S), $T_2$ (75% RFD of S), $T_3$ (100% RFD of S), $T_4$(125% RFD of S), $T_5$ (150%RFDofS), $T_6$ (175% RFD of S) and $T_7$ (200% RFD of S). All yield contributing characters like effective tillers $hill^{-1}$, filled grain $panicle^{-1}$, grain yield, straw yield, biological yield and 1000-grain weight except plant height and panicle length of BRRI dhan41 significantly increased due to different levels of S application.

Alamdari *et al*. (2007) conducted a field experiment to observe the effect of sulphur (S) and sulfate fertilizers on zinc (Zn) and copper (Cu) by rice and reported that both Zn and Cu contents in the grain increased when N, P, K, S and Zn, Cu and Mn sulfate were applied together.

Biswas *et al*. (2004) reported the effect of S in different region of India. The optimum S varied between 30-45 kg $ha^{-1}$. Rice yields increased from 5 to 51%. Across the crops and regions the agronomic efficiency varied from 2 to 27%.

Chandel *et al*. (2003) conducted a field experiment to investigate the effect of sulphur nutrition on the growth and S content of rice and mustard grown in sequence with 4 S levels (0, 15, 30 and 45 kg $ha^{-1}$). They stated that increasing S levels in rice significantly improved yield attributes i.e. tiller number, leaf number, dry matter production and harvest in dexofrice up to 45k $gha^{-1}$.

Singh and Singh (2002) carried out a field experiment to see the effect of different nitrogen levels and S levels (0, 20 and 40 kg $ha^{-1}$) on rice cv. Swarna and PR-108 in Varanasi, Uttar Pradesh. India. They reported that plant height, tillers $m^{-2}$ row length, dry matter production, panicle length and grains panicle $^{-1}$ were significant with increasing levels of S up to 40 kg S $ha^{-1}$. They also found that total N uptake, grain, straw and grain protein yields significantly improved with the increasing level S application being the maximum at 40 kg S $ha^{-1}$ respectively.

Peng *et al*. (2002) carried out a field experiment where the average content of available S in these soil samples was 21.7 mg $kg^{-1}$. The soil with available S content was lower than the critical value of 16 mg $kg^{-1}$ accounted for 57.8%. Field experiments showed that there was a different yield-increasing efficiency by applying S at the doses of 20-60 kg $ha^{-1}$ to rice plant.

**2.5 Effect of zinc**

Kabeya and Shankar (2013) reported that rice (*Oryza sativa*) is the worlds' most important cereal and potentially an important source of zinc (Zn) for people who eat mainly rice. Zinc deficiency being a major constraint to reduce the potential yield of rice. To improve Zn delivery by rice, plant Zn uptake and internal allocation need to be better investigated. The highest effect was observed when treated with 30 kg $ZnSO_4ha^{-1}$ irrespective of zinc groups. However, high zinc groups showed better uptake ability in zinc content and overall performance in growth characteristics.

A field experiment was conducted by Dixit *et al*. (2012) to study the effect of sulphur and zinc on yield, quality and nutrient uptake by hybrid rice grown in sodic soil and that positive response of hybrid rice to zinc application was noticed significantly up to the zinc dose @ 10 $kgha^{-1}$.

An experiment was carried out by Singh *et al.* (2012) at Sari, Mazandaran, Iran and reported that the maximum panicle number $m^{-2}$ and harvest index were observed with 4 kg Zn $ha^{-1}$ and the least of those was obtained in control treatment. The highest zinc content in grain, zinc uptake in grain and straw, and nitrogen uptake in grain were observed with 4 kg Zn $ha^{-1}$, as the most zinc content in straw, nitrogen, potassium, phosphorus and sulphur content in grain and straw, and nitrogen uptake in straw were observed highest with application of 4 and 2 kg $Znha^{-1}$.

Muthukumararaja and Sriramachandrasekhara (2012) reported that zinc deficiency in flooded soil is impediment to obtain higher rice yield. Zinc deficiency is corrected by application of suitable zinc fertilizer. The results revealed that rice responded significantly to graded dose of zinc. The highest grain (37.53 g $pot^{-1}$) and straw yield (48.54 g $pot^{-1}$) was noticed at 5 mg Zn $kg^{-1}$, which was about 100% and 86% greater than control (no zinc) respectively. The highest zinc concentration and uptake in grain and straw and DTPA-Zn at all stages was noticed at 7.5 mg Zn $kg^{-1}$. The agronomic, physiological and agro-physiological apparent recovery and utilization efficiencies was highest at lower level of zinc application and decreased with Zn doses.

The study was conducted by Mustafa *et al*. (2011) at agronomic research area, University of Agriculture, Faisalabad, to evaluate the effect of different methods and timing of zinc application on growth and yield of rice. Experiment was comprised of eight treatments viz., control, rice nursery root dipping in 0.5% Zn solution, $ZnSO_4$ application at the rate of 25 kg $ha^{-1}$ as basal dose, foliar application of 0.5% Zn solution at 15, 30, 45, 60 and 75 days after transplanting. Maximum productive tillers per $m^2$ (249.80) were noted with basal application at the rate 25 kg $ha^{-1}$ of $ZnSO_4$ (21% Zn) and minimum

(220.28) were recorded with foliar application at 60 DAT @ 0.5% Zn solution. Maximum paddy yield (5.21 t $ha^{-1}$) was achieved in treatment $Zn_2$ (Basal application at the rate of 25 kg $ha^{-1}$ of $ZnSO_4.7H_2O$) and minimum paddy yield (4.17 t $ha^{-1}$) was noted in $Zn_7$ (foliar application at 75 DAT @ 0.5% Zn solution).

Naik and Das (2007) reported that rice is mostly transplanted under puddled low land soil conditions in India, where zinc (Zn) deficiency is a common problem. The soil application of Zn at 1.0 kg $ha^{-1}$ as Zn-EDTA ($T_7$) recorded highest grain yield of 5.42 t $ha^{-1}$, filled grain percentage of 90.2%, 1000-grain weight of 25.41 g and number of panicles $m^{-2}$ of 452. The Zn content of grain and straw were also found to be maximum in the treatment $T_7$i.e. 38.19 and 18.27 mg Zn $kg^{-1}$,respectively.

A study was carried out by Cheema *et al*. (2006) to evaluate the effect of four zinc levels on the growth and yield of coarse rice cv. IR-6 at Faisalabad, Pakistan. Four zinc levels viz., 2.5, 5.0, 7.5 and 10.kg $ZnSO_4$ $ha^{-1}$ increased yield and yield component as compared with control. Plant height, number of tillers $hill^{-1}$, panicle bearing tillers, number of primary and secondary spikelets, panicle size, 1000 grain weight, paddy and straw yield and harvest index showed positive correlation with the increase in $ZnSO_4$ levels from 2.5 to 10 $kgha^{-1}$.

A field experiment was conducted by Ullah *et al*. (2001) in Mymensingh, Bangladesh, to study the effect of zinc sulfate (0, 10, and 20 kg $ha^{-1}$) on rice cv. BR30. Plant height; tiller number; 1000-grain weight; grain and straw yields; and grain, straw, and soil Zn contents increased with $ZnSO_4$ application. The tallest plants (75.667 cm) and the highest number of tillers (10.60 $hill^{-1}$), 1000-grain weight (28.700 g), and the concentration of Zn in straw (101.93 ppm) and grain (73.33 ppm) were obtained with 20 kg $ZnSO_4$ $ha^{-1}$.

Yesmin (2017) experiment was conducted during the period of July to November, 2017 in the experimental farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka to assess the effect of NPK briquette fertilization on the growth and yield of aromatic rice variety BRRI dhan70. The experiment comprised of the following 7 treatments as- $T_0$: Control i.e. no fertilizer; $T_1$: 100% RFD; $T_2$: 120% RFD; $T_3$: 80% RFD; $T_4$: 1 NPK briquette in between 4 hills and $T_5$: 2 NPK briquette in between 4 hills and $T_6$: 80% RFD + 1 NPK briquette in between 4 hills. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data were recorded on different yield contributing characters, yield and characteristics of post-harvest soil. Statistically significant variation was recorded for different treatments. During harvest, the longest plant (126.06 cm) was recorded from $T_6$treatment, while the shortest plant (110.68 cm) from $T_0$. The maximum number of effective tillers hill$^{-1}$ (22.80) was observed from $T_6$treatment, whereas the minimum number (15.40) from $T_0$treatment. The longest panicle (26.63 cm) was recorded from $T_6$ treatment, while the shortest panicle (19.50 cm) from $T_0$ treatment. The maximum number of filled grains panicle$^{-1}$ (120.60) was observed from $T_6$ treatment, while the minimum number (101.60) from $T_0$treatment. The highest grain yield (4.72 t ha$^{-1}$) was recorded from $T_6$treatment, while the lowest grain yield (2.04 t ha$^{-1}$) from $T_0$treatment. In post-harvest soil, the highest total N (0.067%) was found from $T_6$treatment, while the lowest soil total N (0.021%) from $T_0$treatment. The highest available P (39.32 ppm) was observed from $T_6$ treatment, whereas the lowest available P (14.40 ppm) from $T_1$ treatment. The highest exchangeable K (0.177 meq/100 g soil) was observed from $T_6$treatment, while the lowest exchangeable K (0.123 meq/100 g soil) from $T_1$ treatment. Applications of $T_6$treatment (80% RFD + 1 briquette NPK) was the superior among the other treatments in consideration of yield contributing characters and yield of aromatic rice variety BRRIdhan70.

## CHAPTER III
## MATERIALS AND METHODS

The experiment was conducted to performance of BRRI dhan72 as influenced by phosphorus fertilization. The details of the materials and methods i.e, experimental period, location, soil and climatic condition of the experimental site, experimental treatment and design, growing of crops, data collection and analysis procedure that was followed for this experiment has been presented below under the following headings:

### 3.1 Description of the experimental site

#### 3.1.1 Experimental period

The experiment was conducted during Aman season from July to November, 2019.

#### 3.1.2 Experimental location

The present experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka. The geographic location of the site is $23^0 74^/$N latitude and $90^0 35^/$E longitude with an elevation of 8.2 meter from sea level. Experimental location presented in Appendix I.

#### 3.1.3 Climatic condition

The geographical location of the experimental site was under the subtropical climate and its climatic conditions is characterized by three distinct seasons, namely winter season from the month of November to February, the pre-monsoon period or hot season from the month of March to April and monsoon period from the month of May to October (FAO, 1988).During the experimental period the maximum temperature ($36.4^0$C), highest relative humidity (88%) and highest rainfall (591 mm) was recorded for the month of July, 2019, whereas the minimum temperature ($16.4^0$C), minimum relative humidity (74%) and rainfall (12 mm) was recorded for the month of

November, 2019. Details of the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during study period are presented in Appendix II.

### 3.1.4 Soil characteristics

The soil of the experimental field belonged to “The Madhupur Tract”, AEZ-28 (FAO, 1988). Top soil was Silty Clay in texture, olive-gray with common fine to medium distinct dark yellowish-brown mottles. The experimental situated above flood level area having available irrigation and drainage system. The soil having a texture of clay loam, organic matter 0.84% and composed of 33.33% sand, 33.02% silt and 33.65% clay. Details morphological, physical and chemical properties of the experimental field soil are presented in Table 1, 2 and 3

**Table 3.1 Morphological characteristics of experimental field**

| Morphological features | Characteristics |
|---|---|
| Location | Sher-e-Bangla Agricultural University |
| AEZ No. and name | AEZ-28, Madhupur Tract |
| General soil type | Shallow Red Brown Terrace Soil |
| Soil series | Tejgaon |
| Topography | Fairly leveled |
| Depth of inundation | Above flood level |
| Drainage condition | Well drained |
| Land type | Medium high land |

**Table 3.2 Physical characteristics of the initial soil of the experimental field**

| | |
|---|---|
| %Sand (2-0.02 mm) | **33.33** |
| %Silt (0.02-0.002 mm) | 33.02 |
| %Clay (<0.002 mm) | 33.65 |
| Textural Class | Clay Loam |
| Particle density | 2.5-2.6 g $cc^{-1}$ |

**Table 3.3 Chemical characteristics of the initial soil of the experimental field**

| **pH** | **6.20** |
|---|---|
| Organic Matter (%) | 0.84 |
| Organic Carbon (%) | 0.48 |
| Total N (%) | 0.065 |
| Available P (ppm) | 16 |
| Exchangeable K (meq) | 0.12 |
| Available S (ppm) | 12.00 |

## 3.2 Experimental details

### 3.2.1 Planting material

The Rice cultivars BRRI dhan72 was used as the test variety in the experiment. BRRI dhan72 is micronutrient Zinc enriched high yielding modern rice variety suitable for Aman season, developed by the Bangladesh Rice Research Institute (BRRI). BRRI dhan72 has breed through a cross between BR7166-4-5-3 and BRRI dhan39. The variety was released in 2015 for cultivation in Aman season. Average grain yield and growth duration of BRRI dhan72 are 6.0 t ha-1 and 125 days, respectively (BRRI, 2020).

### 3.2.2 Treatment of the experiment

The experiment comprised of the following 8 treatments:

$T_1$: Control

$T_2$: $N_{85}$ $P_{15\ (from\ TSP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, Recommended Fertilizer Dose (RFD)

$T_3$: $N_{85}$ $P_{20\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha

$T_4$: $N_{85}P_{15\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha

$T_5$: $N_{85}$ $P_{10\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha

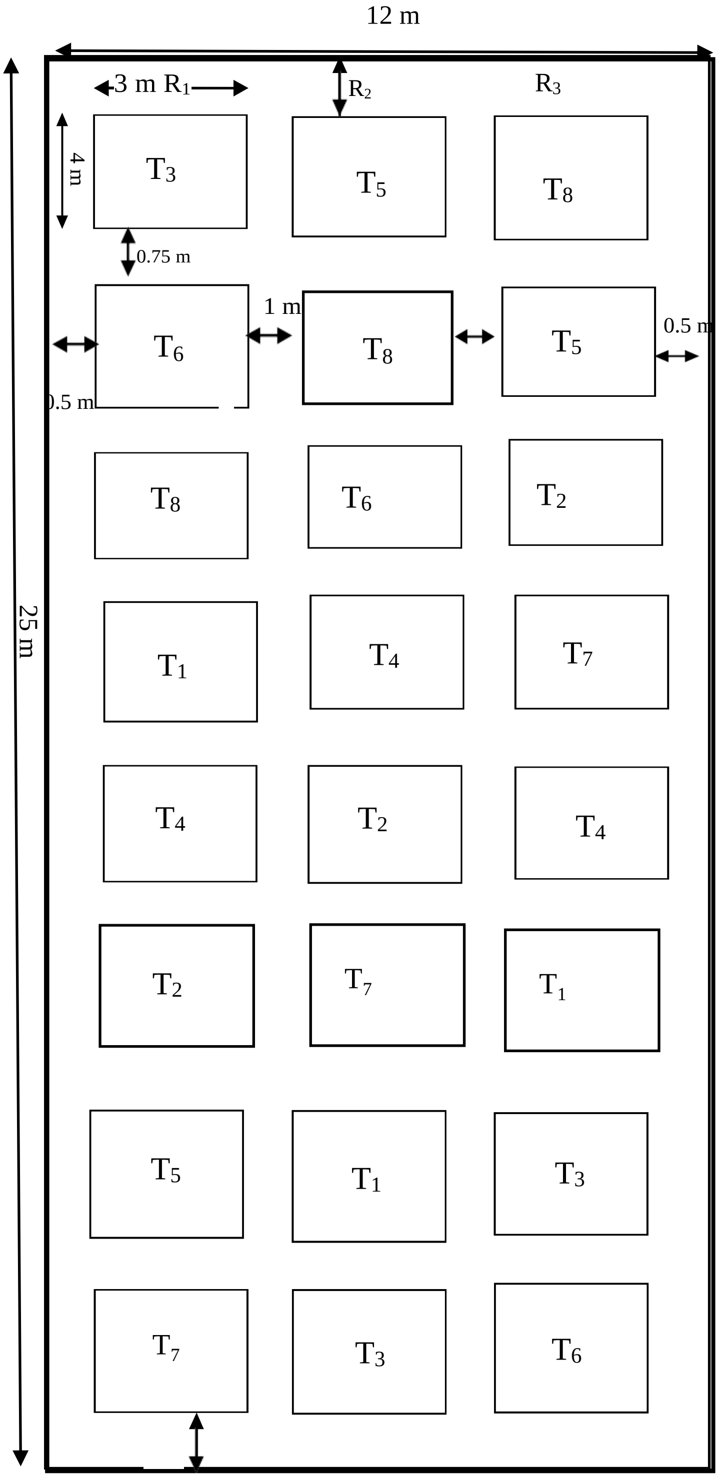
$T_6$: $N_{75}$ $P_{20\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha

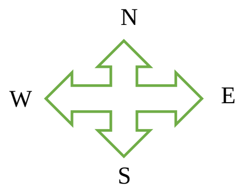
$T_7$: $N_{75}$ $P_{15\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha

$T_8$: $N_{75}$ $P_{10\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha

### 3.2.3 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications and unit plot was 3 m × 4 m. The space between two blocks and two plots were 0.75 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.




Plot size: 3 m × 4 m
Plot spacing: 0.5 m Between replication: 0.75

**<u>Treatment</u>**

$T_1$: Control

$T_2$: $N_{85}$ $P_{15}$ (from TSP) $K_{55}$ $S_{12}$ $Zn_1$ kg/ha

$T_3$: $N_{85}$ $P_{20}$ (from DAP) $K_{55}$ $S_{12}$ $Zn_1$ kg/ha

$T_4$: $N_{85}P_{15}$ (from DAP) $K_{55}$ $S_{12}$ $Zn_1$ kg/ha

$T_5$: $N_{85}P_{10}$ (from DAP) $K_{55}$ $S_{12}$ $Zn_1$ kg/ha

$T_6$: $N_{75}$ $P_{20}$ (from DAP) $K_{55}$ $S_{12}$ $Zn_1$ kg/ha

$T_7$: $N_{75}$ $P_{15}$ (from DAP) $K_{55}$ $S_{12}$ $Zn_1$ kg/ha

$T_8$: $N_{75}$ $P_{10}$ (from DAP) $K_{55}$ $S_{12}$ $Zn_1$ kg/ha

**Figure 1. Layout of the experimental plot**

### 3.3 Growing of crops

#### 3.3.1 Seed collection and sprouting

Grain was collected from BRRI (Bangladesh Rice Research Institute), Gazipur just 20 days ahead of the seed sowing. For seedlings clean grain were immersed in water in a bucket for 24 hours. The imbibed grain were then taken out of water and kept in gunny bags. The grain started sprouting after 48 hours which were suitable for sowing in the seed bed in 72 hours.

#### 3.3.2 Raising of seedlings

The nursery bed was prepared by puddling with repeated ploughing followed by laddering. The sprouted grain were sown on beds as uniformly as possible at $20^{th}$ July, 2019. Irrigation was gently provided to the bed when needed. No fertilizer was used in the nursery bed.

#### 3.3.3 Land preparation

The plot selected for conducting the experiment was opened in the $9^{th}$ July, 2019 with a power tiller, and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good puddle condition. Weeds and stubbles were removed. The experimental plot was partitioned into unit plots in accordance with the experimental design at $20^{th}$ July, 2019. Basal fertilizers as per treatments were applied in respective plots and mixed it in soil.

#### 3.3.4 Fertilizers application

The fertilizers N (from urea) @85,75 $kgha^{-1}$, P (from TSP and DAP) @ 10,15,20 $kgha^{-1}$ and K, S, Zn in the form of MoP, Gypsum, zinc sulphate @55, 12 and 1kg $ha^{-1}$ were applied respectively (BRRI, 2018). Urea and Zn were applied as per treatment. The entire amount of DAP and TSP, MoP, gypsum, zinc sulphate was applied during final land preparation. Urea was applied in three equal installments as top dressing at early and maximum tillering and panicle initiation stages.

### 3.3.5 Transplanting of seedling

Seedlings were carefully uprooted from the nursery bed and transplanted on 3rd August, 2019 in well puddled plot with spacing of 25 × 15 cm. Two seedlings were transplanted in each hill.

### 3.3.6 Intercultural operations

Intercultural operations were done to ensure normal growth of the crop. Plant protection measures were followed as and when necessary. The following intercultural operations were done.

#### 3.3.6.1 Irrigation and drainage

In the early stages to establishment of the seedlings irrigation was provided to maintain a constant level of standing water up to 6 cm and then maintained the amount drying and wetting system throughout the entire vegetative phase. No water stress was encountered in reproductive and ripening phase. The plot was finally dried out at 15 days before harvesting.

#### 3.3.6.2 Weeding

Weeding was done to keep the plots free from weeds, which ultimately ensured better growth and development of the seedlings. The weeds were uprooted carefully at 20 DAT (days after transplanting) and 40 DAT by mechanical means.

#### 3.3.6.3 Insect and pest control

Furadan 5G were applied at 25 DAT in the plot. Leaf roller (*Chaphalocrosis medinalis*) was found and applied Malathion @ 1.12 L $ha^{-1}$ at panicle initiation stage using sprayer.

### 3.4 Harvesting, threshing and cleaning

The crop was harvested at full maturity at 15$^{th}$ November, 2019 when 90% of the grains were turned into straw color. The harvested crop was bundled separately, properly tagged and brought to threshing floor. Fresh weight of rice grain and straw were recorded plot wise from 5 $m^2$ were recorded from each plot and converted to hectare yield and expressed in t $ha^{-1}$. The grains were dried, cleaned and weighed for individual plot. The weight was adjusted to 12% moisture content. Yields of rice grain and straw were recorded from each plot.

### 3.5 Data recording

#### 3.5.1 Plant height

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

#### 3.5.2 Number of flag leaves

The number of flag leaves were counted from selected plants from 20 DAS to 50 DAS at 10) days interval. The total average number of flag leaves was counted.

#### 3.5.3 Number of tillers $hill^{-1}$

Number of tillers $hill^1$ were recorded at harvest as the average of randomly selected 5 plants from the inner rows of each plot.

#### 3.5.4 Effective tillers $hill^{-1}$

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

#### 3.5.5 Non-effective tillers $hill^{-1}$

The total number of non-effective tillers $hill^{-1}$ were counted as the number of non-panicle bearing tillers during harvesting. Data on non-effective tillers $hill^{-1}$ were counted from 5 selected hills and average value was recorded.

### 3.5.6 Panicle length

The length of panicle was measured with a meter scale from 5 selected panicle and the average length was recorded as per panicle in cm.

### 3.5.7 Filled grains panicle$^{-1}$

The total numbers of filled grains were collected randomly from selected 5 panicle of a plot on the basis of grain in the spikelet and then average numbers of filled grains panicle$^{-1}$ was recorded.

### 3.5.8 Unfilled grains panicle$^{-1}$

The total numbers of unfilled grains was collected randomly from selected 5 plants of a plot on the basis of not grain in the spikelet and then average numbers of unfilled grains panicle$^{-1}$ was recorded.

### 3.5.9 Weight of 1000-grains

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

### 3.5.10 Grain yield

Grains obtained from each unit plot were sun-dried (13-14%) and weighed carefully. Dry weight of grains of each plot were taken and converted to ton hectare$^{-1}$ (t ha$^{-1}$) at 14% moisture content.

## 3.6 Post-harvest soil sampling

After harvest of crop soil samples were collected from each plot at a depth of 0 to 15 cm. Soil samples of each plot was air-dried, crushed and passed through a two mm (20 meshes) sieve. The soil samples were kept in plastic container to determine the physical and chemical properties of soil.

### 3.7 Soil analysis

Soil samples were analyzed for both physical and chemical characteristics viz. pH, texture, organic carbon, total N and available P, available S and available K contents. The soil samples were analyzed by the following standard methods as follows:

#### 3.6.1 Soil pH

Soil pH was measured with the help of a glass electrode pH meter, the soil water ratio being maintained at 1: 2.5 as described by (Page *et al.,* 1982).

#### 3.7.2 Total nitrogen

Total N content of soil were determined followed by the Micro Kjeldahl method. One gram of oven dry ground soil sample was taken in to micro kjeldahl flask to which1.1gm catalyst mixture ($K_2SO_4$: $CuSO_4$. $5H_2O$: Se in the ratio of 100:10:1), and 6 ml $H_2SO_4$ were added. The flasks were swirled and heated $200^0C$ and added 3 ml $H_2O_2$and then heating at $360^0C$ was continued until the digest was clear and colorless. After cooling, the content was taken into 100 ml volumetric flask and the volume was made up to the mark with distilled water. A reagent blank was prepared in a similar manner. These digests were used for nitrogen determination (Page *et al.,* 1982).

Then 20 ml digest solution was transferred into the distillation flask, Then 10 ml of $H_3BO_3$indicator solution was taken into a 250 ml conical flask which is marked to indicate a volume of 50 ml and placed the flask under the condenser outlet of the distillation apparatus so that the delivery end dipped in the acid. Add sufficient amount of 10N-NaOH solutions in the container connecting with distillation apparatus. Water runs through the condenser of distillation apparatus was checked. Operating witch of the distillation apparatus collected the distillate. The conical flask was removed by washing the delivery outlet of the distillation apparatus with distilled water. Finally, the distillates were titrated with standard 0.01 N$H_2SO_4$until the color changes from green to pink. The amount of N was calculated using the following

formula:

$$\% N = (T-B) \times N \times 0.014 \times 100/S$$

Where,

T = Sample titration (ml) value of standard $H_2SO_4$

B = Blank titration (ml) value of standard $H_2SO_4$

N = Strength of $H_2SO_4$

S = Sample weight in gram

### 3.7.3 Available phosphorus

Available P was extracted from the soil with 0.5 M $NaHCO_3$ solutions, pH8.5 (Olsen *et al.*, 1954). Phosphorus in the extract was then determined by developing blue color with reduction of phosphomolybdate complex and the color intensity were measured colorimetrically at 660 nm wavelength and readings were calibrated with the standard P curve (Page *et al*., 1982).

### 3.7.4 Available sulphur

Available S content was determined by extracting the soil with $CaCl_2$ (0.15%) solution as described by Page*etal*., 1982. The extractable S was determined by developing turbidity by adding acid solution (20 ppm S as $K_2SO_4$ in 6N HCl) and $BaCl_2$ crystals. The intensity of turbidity was measured by spectrophotometer at 420nm wavelengths.

### 3.7.5 Exchangeable potassium

Exchangeable K in post-harvest soil was determined by 1N $NH_4OAc$ (pH 7) extraction methods and by using flame photometer and calibrated with a standard curve (Page *et al*., 1982).

### 3.8 Statistical analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among different treatments. The analysis of variance of all the recorded parameters performed using Statistix 10 software. The difference of the means value was separated by Least Significant Difference (LSD) at 5% level of probability (Gomez and Gomez, 1984).

# CHAPTER IV
# RESULTS AND DISCUSSION

The experiment was conducted to performance of BRRI dhan72 as influenced by phosphorus fertilization. Data were recorded on different yield contributing characters, yield and characteristics of post-harvest soil. The results have been presented and discussed under the following headings and sub-headings:

## 4.1 Yield attributes and yield of rice

### 4.1.1 Plant height (cm)

Plant height of BRRI dhan72 at harvest showed statistically significant differences due to different treatments (Table 4). At harvest, the highest plant (119.73 cm) was observed in $T_3$ ($N_{85}$ $P_{20\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha) which was statistically similar (119.07 cm and 116.47 cm, respectively) to $T_2$ ($N_{85}$ $P_{15\ (from\ TSP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha), $T_7$ ($N_{75}$ $P_{15\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha) and closely followed (114.33 cm, 111.00 cm and 109.00 cm) by $T_8$ ($N_{75}$ $P_{10\ (from\ TSP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha), $T_6$ ($N_{75}$ $P_{20\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha) and $T_5$ ($N_{85}P_{10\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha) treatment, whereas the shortest plant (81.67 cm) was observed in $T_1$ (Control condition i.e. no fertilizer) treatment. Basically, plant height is a genetical character and it is controlled by the genetic makeup of the specific variety and in normal condition different varieties produced different size of plant but management practices may influence plant height and in suitable environmental condition specific variety produces tallest plant that the adverse situation. Islam *et al.* (2010) observed that plant height was highest when 20kg P $ha^{-1}$were applied and the lowest value of plant height was found in control condition.

**Table 4. Effect of P on plant height and number of flag leaves of BRRIdhan72**

| Treatment | Plant height (cm.) | Number of flag leaves |
|---|---|---|
| $T_1$ | 81.67$^{c}$ | 37.07$^{b}$ |
| $T_2$ | 119.07$^{a}$ | 40.713$^{ab}$ |
| $T_3$ | 119.73$^{a}$ | 41.98$^{a}$ |
| $T_4$ | 91.07$^{bc}$ | 37.27$^{b}$ |
| $T_5$ | 109.00$^{ab}$ | 37.53$^{b}$ |
| $T_6$ | 111.00$^{ab}$ | 37.73$^{b}$ |
| $T_7$ | 116.47$^{a}$ | 40.47$^{ab}$ |
| $T_8$ | 114.33$^{ab}$ | 38.33$^{ab}$ |
| $LSD_{0.05}$ | 24.16 | 4.12 |
| $CV_{(\%)}$ | 12.80 | 23.78 |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$T_1$: Control, $T_2$: $N_{85}$ $P_{15\ (from\ TSP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_3$: $N_{85}$ $P_{20\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_4$: $N_{85}$ $P_{15\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_5$: $N_{85}$ $P_{10\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_6$: $N_{75}$ $P_{20\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_7$: $N_{75}$ $P_{15\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, and $T_8$: $N_{75}$ $P_{10\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha.

### 4.1.2 Number of flag leaves

Statistically significant differences were recorded due to different treatments in terms of number of flag leaves of BRRI dhan72 (Table 4). The maximum number of flag leaves (41.98) was observed in $T_3$ treatment which was statistically similar with other treatments, while the minimum number (37.07) was observed in $T_1$ treatment.

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

Statistically significant differences were recorded due to different treatments in terms of number of total tillers hill$^{-1}$ of BRRI dhan72 (Table 5). The maximum number of total tillers hill$^{-1}$ (18.80) was observed in $T_3$ treatment which was statistically similar (13.47, 12.60 and 12.37 respectively) with $T_2$, $T_7$ and $T_8$ treatment, while the minimum number (9.27) was observed in $T_1$ treatment which was statistically similar (10.77) with $T_4$ treatment. Shah *et al.*(2013)

reported that use of NPK briquette over NPK broadcast and incorporation was very much efficient for the production of number of total tillers $hill^{-1}$. Islam*et al.* (2010) observed that number of total tillers $hill^{-1}$ was highest when 20 kg P $ha^{-1}$ and briquette was applied and the lowest was found in control condition i.e. no fertilizer.

### 4.1.4 Number of effective tillers

Statistically significant differences were recorded due to different treatments in terms of number of effective tillers of BRRI dhan72 (Table 5). The maximum number of effective tillers $hill^{-1}$ (11.67) was observed in $T_3$ treatment which was statistically similar with other treatments except $T_1$ and $T_4$ treatment, while the minimum number (8.80) was observed in $T_1$ treatment. Islam *et al.* (2010) observed that number of effective tillers $hill^{-1}$ was highest when 20 kg P $ha^{-1}$ was applied and the lowest in control condition.

**Table 5. Effect of P on total $tillers^{-1}$, number of effective tiller and ineffective tiller of BRRI dhan72**

| Treatment | Number of total tillers | Number of effective tillers | Number of ineffective tillers |
|---|---|---|---|
| $T_1$ | $9.27^{b}$ | $8.80^{b}$ | $0.80^{b}$ |
| $T_2$ | $13.47^{ab}$ | $11.27^{a}$ | $2.13^{ab}$ |
| $T_3$ | $18.80^{a}$ | $11.67^{a}$ | $2.33^{a}$ |
| $T_4$ | $10.77^{b}$ | $9.56^{b}$ | $0.93^{ab}$ |
| $T_5$ | $11.33^{b}$ | $10.20^{a}$ | $0.95^{ab}$ |
| $T_6$ | $11.40^{ab}$ | $10.40^{ab}$ | $1.13^{ab}$ |
| $T_7$ | $12.60^{ab}$ | $11.20^{a}$ | $1.77^{ab}$ |
| $T_8$ | $12.37^{ab}$ | $10.60^{ab}$ | $1.53^{ab}$ |
| $LSD_{0.05}$ | 7.69 | 1.44 | 17.69 |
| $CV_{(\%)}$ | 13.25 | 34.50 | 16.05 |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$T_1$: Control, $T_2$: $N_{85}$ $P_{15\ (from\ TSP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_3$: $N_{85}$ $P_{20\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_4$: $N_{85}$ $P_{15\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_5$: $N_{85}$ $P_{10\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_6$: $N_{75}$ $P_{20\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_7$: $N_{75}$ $P_{15\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, and $T_8$: $N_{75}$ $P_{10\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha.

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

Number of in-effective tillers hill$^{-1}$ of BRRI dhan72 varied significantly due to different treatments (Table 5). The maximum number of in-effective tillers hill-1 (2.33) was observed in $T_3$ treatment which was statistically similar (2.13, 1.77, 1.53 and 1.13cm respectively) with $T_2$, $T_7$, $T_8$ and $T_6$ treatment respectively, while the minimum number (0.80) was observed in $T_1$ treatment. Naznin *et al.* (2013) reported that application of NPK briquette may be practiced for obtaining lowest number of non-effective tillers hill$^{-1}$.

### 4.1.6 Length of panicle

Statistically significant differences were recorded due to different treatments in terms of length of panicle of BRRI dhan72 (Table 6). The longest panicle (26.83 cm) was observed in $T_2$ treatment which was statistically similar (26.75 cm and 26.40 cm, respectively) with $T_7$ and $T_8$ treatment respectively and closely followed (26.21 cm, 26.19 cm and 26.12 cm, respectively) by $T_6$, $T_5$ and $T_3$treatment, while the shortest panicle (24.58 cm) from $T_1$ treatment which was statistically similar with $T_4$ treatment. Rahman *et al*. (2016) observed that panicle length was highest when USG was and all the characters showed lowest value when absolute control. Shah *et al*. (2013) reported that use of NPK briquette over NPK broadcast and incorporation was very much efficient for the production of longest panicle but the shortest was observed in control condition.

**Table 6. Effect of P on length of panicle, number of filled, unfilled of BRRI dhan72**

| Treatment | Length of panicle (cm.) | Filled grain | Unfiled grain |
|---|---|---|---|
| **$T_1$** | $24.58^{b}$ | $71.13^{c}$ | $26.93^{b}$ |
| **$T_2$** | $26.83^{a}$ | $84.71^{ab}$ | $37.04^{a}$ |
| **$T_3$** | $26.12^{ab}$ | $88.84^{a}$ | $39.46^{a}$ |
| **$T_4$** | $24.98^{b}$ | $71.65^{c}$ | $29.55^{b}$ |
| **$T_5$** | $26.19^{ab}$ | $72.37^{bc}$ | $30.44^{b}$ |
| **$T_6$** | $26.21^{ab}$ | $73.15^{bc}$ | $31.88^{ab}$ |
| **$T_7$** | $26.75^{a}$ | $78.44^{b}$ | $36.93^{a}$ |
| **$T_8$** | $26.40^{a}$ | $76.99^{b}$ | $34.44^{ab}$ |
| **$LSD_{0.05}$** | 1.77 | 6.33 | 7.69 |
| **$CV_{(\%)}$** | 15.14 | 39.98 | 25.54 |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$T_1$: Control, $T_2$: $N_{85}$ $P_{15\ (from\ TSP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_3$: $N_{85}$ $P_{20\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_4$: $N_{85}$ $P_{15\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_5$: $N_{85}$ $P_{10\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_6$: $N_{75}$ $P_{20\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_7$: $N_{75}$ $P_{15\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, and $T_8$: $N_{75}$ $P_{10\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha.

### 4.1.7 Number of filled grainspanicle$^{-1}$

Statistically significant differences were recorded due to different treatments in terms of number of filled grains panicle$^{-1}$ of BRRI dhan72 (Table 6). The maximum number of filled grains panicle$^{-1}$ (88.84) was observed in $T_3$ treatment which was statistically similar with $T_2$ treatment, while the minimum number (71.13) was observed in $T_1$treatment which was statistically similar with $T_4$ treatment. Rahman *et al.* (2016) observed that number of total tillers hill$^{-1}$ was highest when USG and briquette was applied and the lowest was found in control condition i.e. no fertilizer were applied.

### 4.1.8 Number of unfilled grain spanicle$^{-1}$

Statistically significant differences were recorded due to different treatments in terms of number of unfilled grains panicle$^{-1}$ of BRRI dhan72 (Table 6). The maximum number of unfilled grains panicle$^{-1}$ (39.46) was observed in $T_3$which was statistically similar with other treatments except $T_1$, whereas the minimum number (26.93) in $T_1$treatment. Bulbule *et al.* (2008) observed that NPK briquettes reduced the number of unfilled grains panicle$^{-1}$ of rice.

### 4.1.9 Weight of 1000 grains

Weight of 1000 grains of BRRI dhan72 varied non-significantly due to different treatments (Table 7). The highest weight of 1000 grains (0.141 g) were observed in $T_3$ treatment which was statistically similar (0.119 t ha-1) with $T_2$ treatment, while the lowest weight (0.026 g) from $T_1$treatment which was statistically similar (0.027 t ha$^{-1}$) with $T_4$ treatment. Naznin *et al.* (2013) reported that application of USG and NPK briquette may be practiced for obtaining better yields with highest weight of 1000grains.

**Table 7. Effect of P on weight of 1000 grains and grain yield of BRRI dhan72**

| Treatment | 1000-grain weight (g) | Yield (t ha$^{-1}$) |
|---|---|---|
| **$T_1$** | $0.026^{b}$ | $3.89^{b}$ |
| **$T_2$** | $0.119^{a}$ | $5.17^{ab}$ |
| **$T_3$** | $0.141^{a}$ | $5.35^{a}$ |
| **$T_4$** | $0.027^{b}$ | $4.49^{ab}$ |
| **$T_5$** | $0.038^{ab}$ | $4.58^{ab}$ |
| **$T_6$** | $0.059^{ab}$ | $4.61^{ab}$ |
| **$T_7$** | $0.102^{ab}$ | $5.14^{ab}$ |
| **$T_8$** | $0.090^{ab}$ | $4.66^{ab}$ |
| **$LSD_{0.05}$** | 0.08 | 1.4 |
| **$CV_{(\%)}$** | 24.77 | 16.84 |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$T_1$: Control, $T_2$: $N_{85}$ $P_{15\ (from\ TSP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_3$: $N_{85}$ $P_{20\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_4$: $N_{85}$ $P_{15\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_5$: $N_{85}$ $P_{10\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_6$: $N_{75}$ $P_{20\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_7$: $N_{75}$ $P_{15\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, and $T_8$: $N_{75}$ $P_{10\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha.

#### 4.1.10 Grain yield

Statistically significant differences were recorded due to different treatments in terms of grain yield of BRRI dhan72 (Table 7). The highest grain yield (5.35 t $ha^{-1}$) was recorded in $T_3$treatment which was statistically similar (5.17 t $ha^{-1}$) with other treatments except $T_1$, while the lowest grain yield (3.89 t $ha^{-1}$) was observed in $T_1$treatment. Data revealed that application of $N_{85}$ $P_{20\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha within per hills ensured proper growth and development of rice plant and ultimately this treatment produced the highest grain yield also. Shah *et al*. (2013) reported that use of NPK briquette over NPK broadcast and incorporation was very much efficient for rice cultivation in terms of rice yield. Bulbule *et al*. (2008) observed that NPK briquettes influenced on yield attributes, yield and nutrient content of rice. The results showed that grain yield of rice was significantly increased when the crop was fertilized through briquettes (56-30-30 kg NPK $ha^{-1}$) as compared to the application of conventional fertilizers (100-50-50 kg NPK $ha^{-1}$). Naznin *et al*. (2013) reported that application of USG and NPK briquette may be practiced for obtainingbetteryieldsinadditiontoincreasingtheefficiencyofPfertilizer.

## 4.2 Soil pH, total N, available P, available S and available K in post-harvest soil

#### 4.2.1 Soil pH

Soil pH of post-harvest soil showed statistically non-significant differences due to different treatments (Table 8). The highest soil pH (6.46) was found from $T_3$ treatment, whereas the lowest soil pH (6.2) was observed from $T_1$ treatment. Data reveled that different management practices effects soil pH but not significantly.

**Table 8: Effect of P on Soil pH and available P (ppm) of post-harvest soil**

| Treatment | Soil pH | Available P (ppm) |
|---|---|---|
| $T_1$ | 6.2 | $15.19^{d}$ |
| $T_2$ | 6.37 | $18.67^{b}$ |
| $T_3$ | 6.46 | $20.25^{a}$ |
| $T_4$ | 6.27 | $15.89^{cd}$ |
| $T_5$ | 6.40 | $16.67^{c}$ |
| $T_6$ | 6.37 | $16.33^{cd}$ |
| $T_7$ | 6.40 | $17.03^{c}$ |
| $T_8$ | 6.33 | $17.67^{bc}$ |
| $LSD_{0.05}$ | NS | 1.22 |
| CV(%) | 2.55 | 8.82 |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$T_1$: Control, $T_2$: $N_{85}$ $P_{15\ (from\ TSP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_3$: $N_{85}$ $P_{20\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_4$: $N_{85}$ $P_{15\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_5$: $N_{85}$ $P_{10\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_6$: $N_{75}$ $P_{20\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_7$: $N_{75}$ $P_{15\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, and $T_8$: $N_{75}$ $P_{10\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha.

### 4.2.2 Available P

Available P in post-harvest soil varied significantly due to different treatments under the present trail (Table 8). The highest available P (20.25 ppm) was recorded in $T_3$ treatment which was statistically similar (18.67 ppm) with $T_2$ treatment, while the lowest available P (15.19 ppm) was found in $T_1$ treatment which was followed (15.89 and 16.33 ppm) by $T_4$ and $T_6$ treatment.

### 4.2.3 Total N

Total N in post-harvest soil varied significantly due to different treatments under the present trail (Table 9). The highest total N (0.119%) was recorded in $T_3$treatment which was statistically similar with other treatment except $T_{1,}$ $T_4$, and $T_5$ treatment, while the lowest total N (0.110%) was found in $T_1$ treatment.

### 4.2.4 Available S

Available S in post-harvest soil varied significantly due to different treatments under the present trail (Table 9). The highest available S (14.67 ppm) was recorded in $T_3$ treatment which was statistically similar (14.37 ppm) with $T_2$ treatment, while the lowest available S (11.96 ppm) was found in $T_1$ treatment which was followed (12.33 ppm) by $T_4$ treatment.

### 4.2.5 Exchangeable K

Exchangeable K in post-harvest soil varied significantly due to different treatments under the present trail (Table 9). The highest exchangeable K (0.146 meq/100 g soil) was recorded in $T_3$ treatment which was statistically similar (0.136 and 0.134 meq/100 g soil) with $T_2$ and $T_7$ treatment, while the lowest exchangeable K (0.121 ppm) was found in $T_1$ treatment which was followed (0.121, 0.123 and 0.126 meq/100 g soil) by $T_{4,}$ $T_5$ and $T_6$ treatment.

**Table 9: Effect of P on the total N(%), available S(ppm) and exchangeable K (meq) of post-harvest soil**

| Treatment | Total N (%) | Available S (ppm) | Exchangeable K (meq/100 g soil) |
|---|---|---|---|
| $T_1$ | $0.110^{b}$ | $11.99^{e}$ | $0.121^{c}$ |
| $T_2$ | $0.116^{ab}$ | $14.37^{a}$ | $0.136^{b}$ |
| $T_3$ | $0.119^{a}$ | $14.67^{a}$ | $0.146^{a}$ |
| $T_4$ | $0.112^{b}$ | $12.33^{d}$ | $0.121^{c}$ |
| $T_5$ | $0.112^{b}$ | $12.97^{c}$ | $0.123^{c}$ |
| $T_6$ | $0.113^{ab}$ | $13.84^{b}$ | $0.126^{c}$ |
| $T_7$ | $0.116^{ab}$ | $14.02^{b}$ | $0.134^{b}$ |
| $T_8$ | $0.114^{ab}$ | $13.89^{b}$ | $0.129^{bc}$ |
| $LSD_{0.05}$ | 0.006 | 0.330 | 0.008 |
| CV(%) | 3.14 | 9.69 | 4.14 |

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

$T_1$: Control, $T_2$: $N_{85}$ $P_{15\ (from\ TSP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_3$: $N_{85}$ $P_{20\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_4$: $N_{85}$ $P_{15\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_5$: $N_{85}$ $P_{10\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_6$: $N_{75}$ $P_{20\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_7$: $N_{75}$ $P_{15\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, and $T_8$: $N_{75}$ $P_{10\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha.

### 4.3 Relationship between plant height and grain yield t $ha^{-1}$

Correlation study was done to establish the relationship between plant height and grain yield (g) of BRRI dhan72 among different management practices. From the figure 2, it was revealed that positive correlation was observed between the parameters. The regression equation y=2.33x+14.129 gave a good fit to the data and the co-efficient of determination ($R^2$ = 0.9251) had a significant regression coefficient. From the figure it was also observed that the minimum plant height (81.67 cm) gives the yield (3.89 t/ha) and the plant height (119.73) gives the yield (5.35 t/ha) which was found by $T_3$ ($N_{85}$ $P_{20(from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha). So, the increase of plant height (38.06) increased the grain yield (1.46 t/ha). From the figure it may be concluded that plant height strongly as well as positively correlated with grain yield of BRRI dhan72.

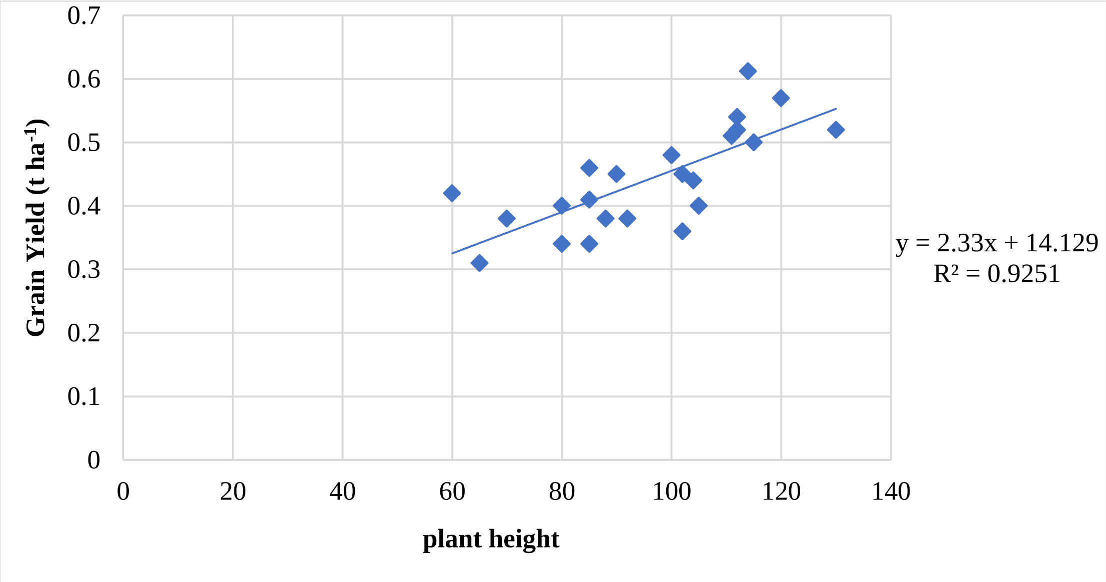



**Figure 2: Linear relationship between plant height and grain yield**

### 4.4 Relationship between filled grain and 1000-grain weight

The data on filled grain were regressed against 1000-grain weight of BRRI dhan72 and a positive linear relationship was obtained between them. The regression equation y = 1.873x + 14.184 gave a good fit to the data and the co-efficient of determination ($R^2$ = 0.94) had a significant regression co- efficient. From the figure 3 it was observed that the lowest filled grain (71.13) gives the 1000-seeds weight (0.026 g) and the highest filled grain (88.84) gives the 1000-

grain weight (0.141 g). So, the increase of filled grain (17.71) increased the 1000-grain weight 0.115 (g) which was found by using treatment $T_3$ ($N_{85}$ $P_{20 \text{ (from DAP)}}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha). From the figure it may be concluded that filled grain strongly as well as positively correlated with 1000-grain weight of BARI dhan72.

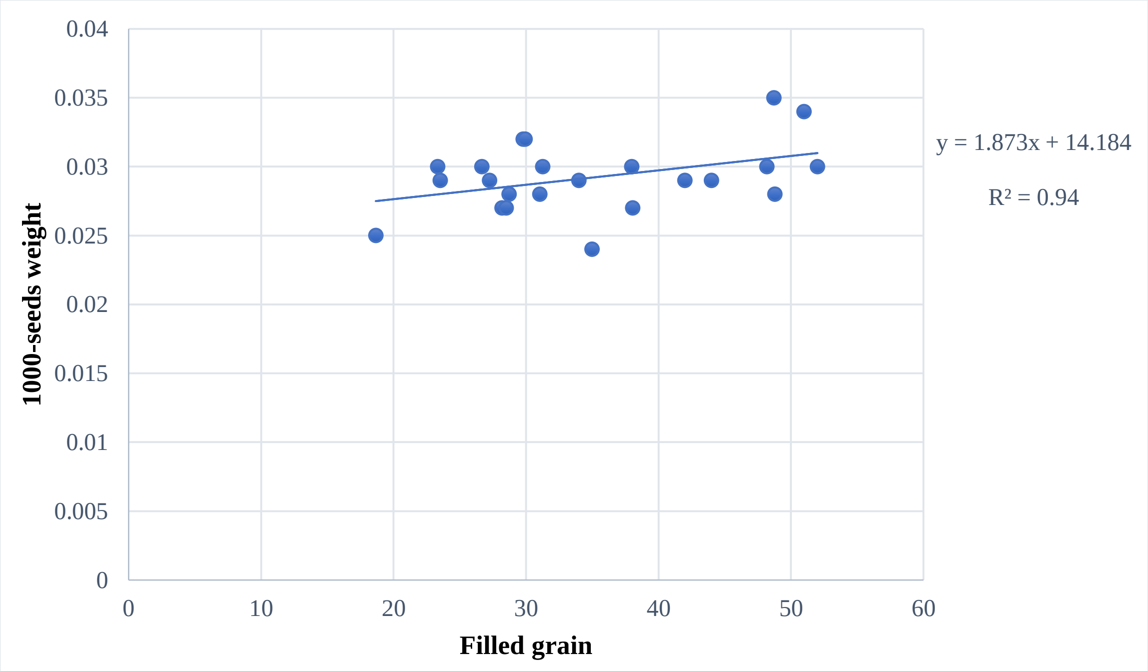



**Figure 3: Linear relationship between filled grain and 1000-grain weight**

### 4.5 Relationship between effective tillers and length of panicles

Correlation study was done to establish the relationship between effective tillers and length of panicles of BRRI dhan72 among different management practices. From the figure 4 it was revealed that positive correlation was observed between the parameters. The regression equation y= 1.302x+10.824 gave a good fit to the data and the co-efficient of determination ($R^2$ = 0.9021) had a significant regression coefficient. From the figure it was also observed that the minimum effective tillers (9.27) give the length of panicles (24.58 cm) and the highest effective tillers (11.67) gives the length of panicles (26.75 cm) which was found by $T_3$ ($N_{85}$ $P_{20 \text{ (from DAP)}}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha). So, the increase of effective tillers (2.70) increased the length of panicles (2.17 cm). From the figure it may be concluded that effective tillers strongly as well as positively correlated with length of panicles of BRRI dhan72.

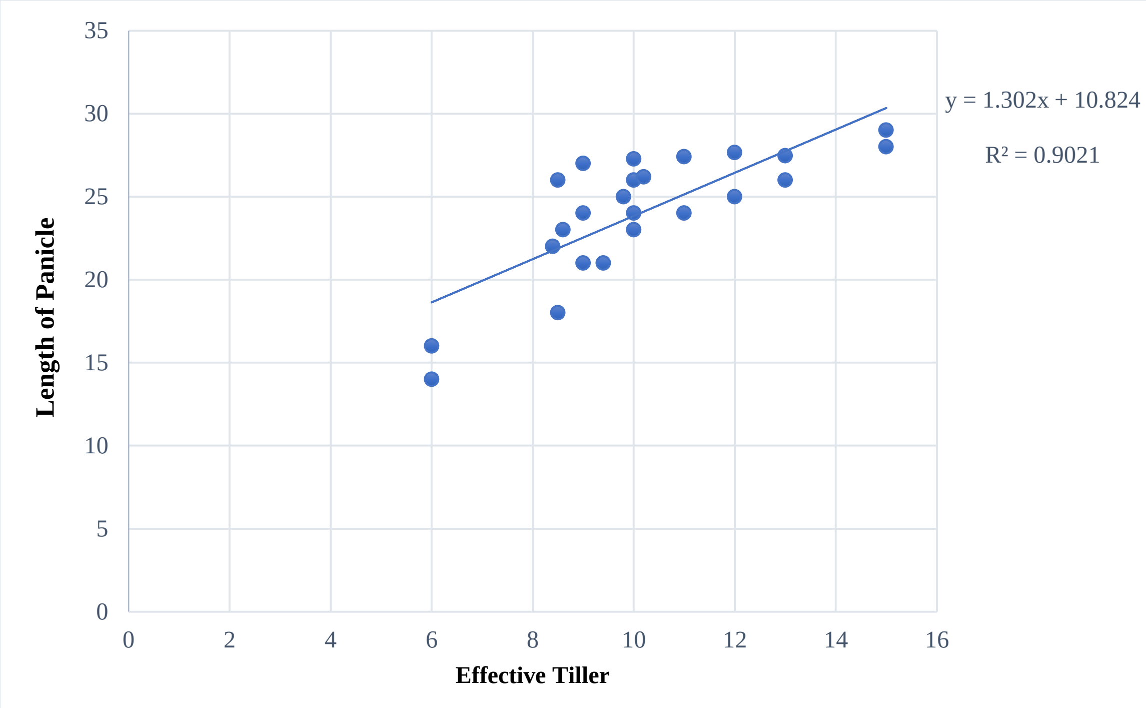



**Figure 4: Linear relationship between effective tillers and length of panicles**

### 4.6 Relationship between yield and soil available P

Correlation study was done to establish the relationship between yield and soil available P of BRRI dhan72 among different management practices. From the figure 5 it was revealed that positive correlation was observed between the parameters. The regression equation y =.831x + 5.667 gave a good fit to the data and the co-efficient of determination ($R^2$ = 0.9699) had a significant regression coefficient. From the figure it was also observed that the minimum yield (3.89 cm) gives the soil available P (15.19 ppm) and the highest yield (5.35 t $ha^{-1}$) gives the soil available P (20.25 ppm) which was found by $T_3$ ($N_{85}$ $P_{20\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha). So, the increase of yield (1.46 t $ha^{-1}$) increased the soil available P (5.06ppm). From the figure it may be concluded that yield strongly as well as positively correlated with soil available P of BRRI dhan72.

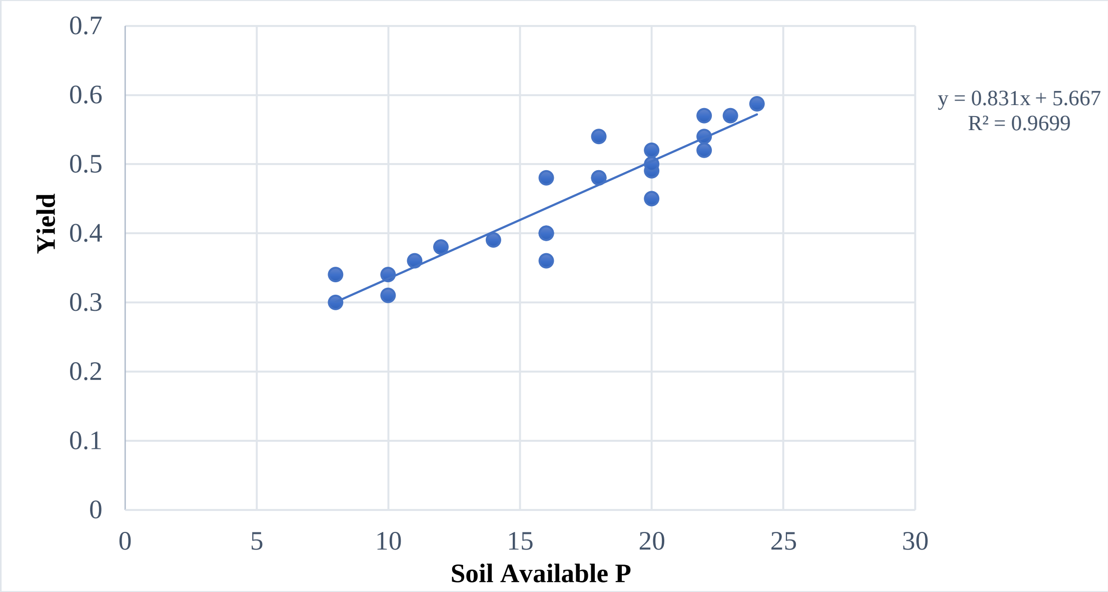



**Figure 5: Linear relationship between yield and soil available P**

### 4.7 Relationship between P and soil available S

Correlation study was done to establish the relationship between P and soil available S of BRRI dhan72 among different management practices. From the figure 6 it was revealed that positive correlation was observed between the parameters. The regression equation y =1.302x + 10.824 gave a good fit to the data and the co-efficient of determination ($R^2$ = 0.9021) had a significant regression coefficient. From the figure it was also observed that the minimum P (15.19 ppm) gives the soil available S (11.99 ppm) and the highest P (20.25 ppm) gives the soil available S (14.67 ppm) which was found by $T_3$ ($N_{85}$ $P_{20}$ $_{\text{(from DAP)}}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha). So, the increase of P (5.06 ppm) increased the soil available S (2.68 ppm). From the figure it may be concluded that P strongly as well as positively correlated with soil available S of BRRI dhan72.

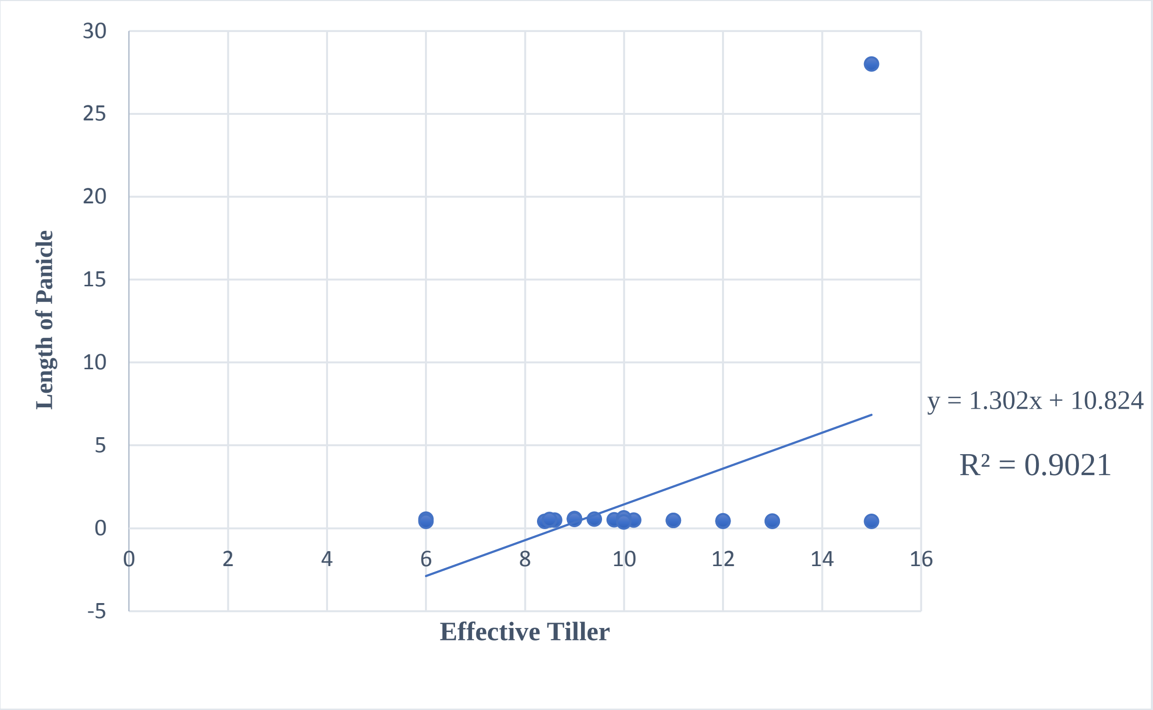



**Figure 6: Linear relationship between P and soil available S**

# CHAPTER V
# SUMMARY AND CONCLUSION

The experiment was conducted during the period from July 2019 to November 2019 at Aman season in the research farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh to investigate the effect of P on the growth and yield of BRRI dhan72 and evaluate the efficiency of P as a source of DAP on the growth and yield of rice. The experiment was comprised of $T_1$: Control, $T_2$: $N_{85}$ $P_{15\ (from\ TSP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_3$: $N_{85}$ $P_{20\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_4$: $N_{85}$ $P_{15\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_5$: $N_{85}$ $P_{10\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_6$: $N_{75}$ $P_{20\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, $T_7$: $N_{75}$ $P_{15\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha, and $T_8$: $N_{75}$ $P_{10\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were recorded on different yield and yield attributes and nutrient status of post-harvest soil and significant variation was observed for different treatment.

Plant height of BRRI dhan72 at harvest, the longest plant (119.73 cm) was observed in $T_3$, while the shortest plant (81.67 cm) was observed from $T_1$. The maximum number of flag leaves (41.98) was found from $T_3$, while the minimum number of flag leaves (37.07) was observed from $T_1$. The maximum number of total tillers hill$^{-1}$ (28.80) was found from $T_3$, while the minimum number (8.80) was observed from $T_1$. The maximum number of effective tillers hill$^{-1}$(11.67) was observed in $T_3$treatment, while the minimum number of effective tillers hill$^{-1}$(9.27) in $T_1$treatment. The maximum number of ineffective tillers hill$^{-1}$ (2.33) was observed in $T_3$treatment, while the minimum number of ineffective tillers hill$^{-1}$(0.80) was observed in $T_1$treatment.The maximum number of filled grains panicle$^{-1}$(88.84) was found from $T_3$, while the minimum number of filled grains panicle$^{-1}$ (71.13) was observed from $T_1$. The maximum number of unfilled grains panicle$^{-1}$(39.46) was found from $T_3$, while the minimum number of unfilled grains panicle$^{-1}$ (26.93) was observed from $T_1$.

The longest panicle (26.83 cm) was found from $T_2$, whereas the shortest panicle (24.58 cm) was observed from $T_1$. The highest weight of 1000 grains (0.141 g) were found from $T_3$, while the lowest weight of 1000 grains (0.026 g) were observed from $T_1$. The highest grain yield (5.35 t $ha^{-1}$) was found from $T_3$, while the lowest grain yield (3.89 t $ha^{-1}$) was observed from $T_1$.

The highest soil pH (6.46) was found from $T_3$, whereas the lowest (6.20) was observed from $T_1$. The highest available P (20.25 ppm) was found from $T_3$, while the lowest (15.19 ppm) was observed from $T_1$. The highest total nitrogen (0.119%) was found from $T_3$, while the lowest (0.110%) was observed from $T_1$. The highest available S (14.67 ppm) was found from $T_3$, while the lowest (11.99 ppm) was observed from $T_1$. The highest exchangeable K (0.146 meq) was found from $T_3$, while the lowest (0.121 meq) was observed from $T_1$.

Therefore, the increase of plant height (38.06) increased the grain yield (1.46 t/ha). So, the increase of filled grain (17.71) increased the 1000-grain weight 0.115 (g) which was found by using treatment $T_3$ ($N_{85}$ $P_{20\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg/ha). So, the increase of effective tillers (2.70) increased the length of panicles (2.17 cm). So, the increase of yield (1.46 t $ha^{-1}$) increased the soil available P (5.06 ppm).

## Conclusion

It was revealed that application of $N_{85}$ $P_{20\ (from\ DAP)}$ $K_{55}$ $S_{12}$ $Zn_1$ kg $ha^{-1}$was more potential in regarding yield contributing characters and yield of BRRI dhan72.

Considering the above results of this experiment, further studies in the following areas may be suggested:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional compliance and other performances.
2. More experiments may be carried out with other organic, inorganic and also macro nutrients.

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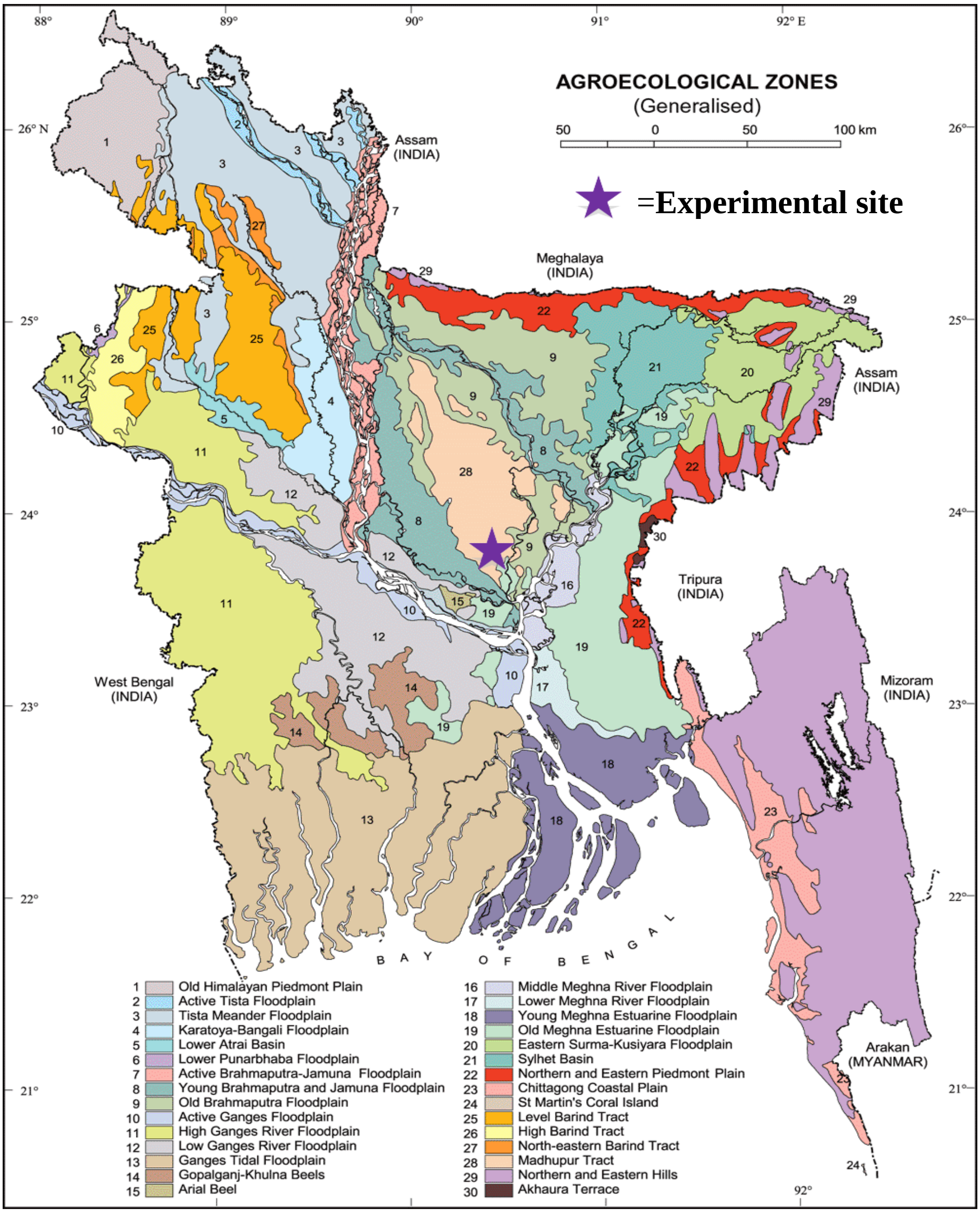
# APPENDICES

**Appendix I. Experimental location on the map of Agro-ecological Zones of Bangladesh**



**Appendix II. Monthly average of air temperature, relative humidity and total rainfall of the experimental site during the period from July, 2019 to November, 2020**

| Month | *Air temperature ($^oC$) | | *Relative humidity (%) | *Rainfall (mm) (total) |
|---|---|---|---|---|
| | Maximum | Minimum | | |
| July, 2019 | 25.8 | 16.0 | 78 | 00 |
| August, 2019 | 22.4 | 13.5 | 74 | 00 |
| September, 2019 | 25.2 | 12.8 | 69 | 00 |
| October, 2019 | 27.3 | 16.9 | 66 | 39 |
| November, 2019 | 31.7 | 19.2 | 57 | 23 |

* Monthly average,
* Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka - 1212

**Appendix III. Analysis of variance of the data on plant height of BRRI dhan72 as influenced by different levels of phosphorus fertilization**

| Source of variation | Degree of freedom | Mean square | | | | |
|---|---|---|---|---|---|---|
| | | Plant height (cm.) | Number of flag leaves | Number of tiller | Number of effective tiller | Number of ineffective tiller |
| Replication (A) | 2 | 80.687 | 20.6218 | 49.052 | 0.7959 | 1.03760 |
| Treatment (B) | 7 | 583.617 | 10.6352 | 117.667 | 2.1298 | 1.02606 |
| Error (A x B) | 14 | 190.399* | 5.5268** | 102.049* | 1.9431** | 0.64570** |
| Total | 23 | | | | | |

*Significant at 5% level of probability ** Significant at 1% level of probability

**Appendix IV. Analysis of variance of the data on yield contributing characters of BRRI dhan72 as influenced by different levels of phosphorus fertilization**

| Source of variation | Degree of freedom | Mean square | | | | |
|---|---|---|---|---|---|---|
| | | Length of panicle (cm.) | Filled grain | Unfiled grain | 1000-seeds weight (g) | Yield (t $ha^{-1}$) |
| Replication (A) | 2 | 7.21115 | 7.816 | 21.866 | 0.01186 | 0.0189 7 |
| Treatment (B) | 7 | 2.49120 | 128.921 | 56.747 | 0.00540 | 0.00670 |
| Error (A x B) | 14 | 2.51855** | 388.507** | 159.047** | 0.00523* | 0.00636 ** |
| Total | 23 | | | | | |

*Significant at 5% level of probability ** Significant at 1% level of probability

**Appendix V. Analysis of variance of the data on plant height of BRRI dhan72 as influenced by different levels of phosphorus fertilization**

| Source of variation | Degree of freedom | Mean square | | | | |
|---|---|---|---|---|---|---|
| | | Soil pH | Available P (ppm) | Total N (%) | Available S (ppm) | Available K (meq) |
| Replication (A) | 2 | 0.03375 | 18.8750 | 0.02089 | 0.04966 | 50.3750 |
| Treatment (B) | 7 | 0.02095 | 13.2798 | 0.02870 | 0.02313 | 25.8988 |
| Error (A x B) | 14 | 0.02613* | 57.0655* | 0.03011* | 0.03250* | 22.4702** |
| Total | 23 | | | | | |

*Significant at 5% level of probability ** Significant at 1% level of probability