EFFECT OF NITROGEN AND PHOSPHORUS ON THE GROWTH AND YIELD OF T. AMAN RICE (BRRI dhan71)

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EFFECT OF NITRGEN & PHOSPHORUS ON THE GROWTH AND YIELD OF T.AMAN RICE (BRRI dhan71)

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CERTIFICATE

*This is to certify that the thesis entitled **'Effect of N and P on the growth and yield of T. aman rice BRRI dhan71'** 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 results of a piece of bona fide research work carried out by **FAYSAL AHMED**, Registration No. **18-09309** 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.

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DEDICATED TO

MY BELOVED

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The Author

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ABBREVIATIONS AND ACRONYMS

N : Nitrogen

P: Phosphorus

K : Potassium

S : Sulfur

ANOVA: Analysis of variance

LSD: Least significant difference

d.f. : Degrees of freedom

C.V. %: Percentage of coefficient of variation

t: Ton

ha: Hectare

pH: Potential of hydrogen

ppm: Parts per million

RCBD: Randomized complete block design

CEC: Cation exchange capacity

meq: Mill equivalents

Kg: Kilogram

Ha^{-1}: Per hectare

$Hill^{-1}$: Per Hill

EFFECT OF NITROGEN AND PHOSPHORUS ON THE GROWTH AND YIELD OF T.AMAN RICE (BRRI dhan71)

ABSTRACT

The effect of N and P on the growth and yield of T. Aman Rice (BRRI dhan71) experiment was conducted in the farm area of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period of July to November (Aman season)2019. In this experiment BRRI dhan71 was used as test crop. The experiment comprised of eight treatments as T_1: No fertilizer, T_2: N_{100} P_{15} (from TSP) K_{60} S_{12} $Zn_{1.5}$, T_3: N_{100} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$, T_4: N_{80} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$, T_5: N_{100} P_{12} (from DAP) K_{60} S_{12} $Zn_{1.5}$, T_6: N_{80} P_{12} (from DAP) K_{60} S_{12} $Zn_{1.5}$, T_7: N_{60} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$, T_8: N_{60} P_{12} (from DAP) K_{60} S_{12} $Zn_{1.5}$. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were recorded on different growth and yield contributing characters and characteristics of post-harvest soil. From the experiment, the tallest plant (131.43 cm) on T_3 treatment, maximum number of tillers hill^{-1} (16.63), maximum number of grains panicle^{-1} (140.07), the longest panicle (28.52 cm), highest grain yield (5.81 t ha^{-1}) on T_4 treatment and straw yield (7.45 t ha^{-1}) were recorded from T_3 treatment, while the shortest plant (106.50 cm), minimum number of tillers hill^{-1} (11.00), the shortest panicle (20.13 cm), minimum number of grains panicle^{-1} (112.92), lowest grains yield (3.44 t ha^{-1}) and lowest straw yield (4.52 t ha^{-1}) were found in T_1 treated plot. The highest total N (0.068%) was observed in T_3 treatment. Highest available P (36.45 ppm) and highest available S (18.30 ppm) were recorded in T_4 treatment. Highest exchangeable K (0.132 meq/100 g soil) was found in T_3 treatment. The lowest total N (0.034%), available P (18.26 ppm), exchangeable K (0.110 meq/100 g soil) and available S (12.40 ppm) were found in T_1 treatment. Application of T_4: N_{80} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ gave the highest grain yield (5.81 t ha^{-1}) at Tejgaon series soil of SAU farm

CHAPTER I

INTRODUCTION

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food crop of Bangladesh and it plays a dominant role in the country's agriculture covering 78% of total cropped area with an average yield of 2.55 t ha^{-1} (BBS, 2021). In Bangladesh, there are three distinct rice growing season of cultivation, namely Aus, Aman and Boro those are cultivated during the periods from April to July, August to December and January to May, respectively. Total rice production area is 11, 51, 5985 ha and production are 3, 63, 91, 000 tons (BBS, 2021). Total Aman rice of the country covers an area of 55, 59, 964 hectares 49.12% of the total rice area with a production of 1, 42, 03, 197 tons (BBS, 2021). Rice production has increased by three times since the liberation of Bangla3desh. Bangladesh was 3rd in rice production, India second and China first in the world. A recent World Agricultural Production report of United States Department of Agriculture estimated that Bangladesh will have 36 million metric tons of rice while Indonesia 34.9 million metric tons, India 118 million metric tons and China 149 million metric tons during 2020/21 period (USDA, 2021).

Bangladesh rice research institute has developed 106 number of varieties with large yield potential. The growth process of rice plants under different agro-climatic condition differs due to the specific rice variety (Alam *et al.*, 2012). Compared with conventional cultivars, the high yielding varieties have larger panicles resulting in an average increase of rice grains is 7.27% (Bhuiyan *et al.*, 2014). These high yielding and hybrid rice variety however, needs further evaluation under different adaptive condition to interact with different agro-climatic conditions. Intensive cropping high yielding varieties and with imbalanced use of fertilizers has led to mining out the inherent plant nutrients and thereby fertility status of soils severely declined day by day. Crop yield reductions are directly related to soil productivity or nutrient depletions (Roy *et al.*, 2003). Proper management practices are the most effective means for increasing yield of Aman rice. Efficient fertilizer management gives higher yield of crop and reduces fertilizer cost. Optimum dose of nitrogen fertilization plays a vital role in growth and development of rice plant. Plant growth is hampered when improper dose of nitrogen is applied. On the other hand, excessive nitrogen fertilization encourages excessive vegetative growth which makes the plant susceptible to insect, pest and diseases that ultimately reduces yield. So, it is essential to find out the optimum rate of nitrogen for better growth and yield.

Nitrogen is one of the most important plant nutrients that plays a vital role in plant photosynthesis and biomass production. Increasing panicle numbers in per unit area is the main factor of yield increment as a result of nitrogen application (Bindra *et al*. 2000; Laroo and Shivay 2011). Nitrogen is the most important and yield-limiting nutrient in rice production worldwide (Lin *et al*. 2006). Nitrogen is integral part of structural and functional protein, chlorophyll and nucleic acid (Tilahun, 2019). It has positive influence on tillers development, yield and yield components of rice (Djaman *et al*., 2016). Higher dose of N fertilizer makes plants vulnerable to lodging, insect and diseases (Kumar, 2016).

Phosphorus is a major essential plant nutrient plays a role key for increasing crop yield (Dastan *et al*., 2012; Alinajoati Sisie and Mirshekari, 2011). It is also important for phosphorus accumulation in soils. Phosphorus deficit is a most important restrictive factor in plant growth and recognition of mechanisms that increase plant phosphorus use efficiency is important (Alinajoati Sisie & Mirshekari, 2011). So, the appropriate fertilizer input that is not only for getting high yield but also for attaining maximum profitability (Khuang *et al*, 2008).

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, 2018). 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}. 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).

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 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 play a negative role in recuperating soil fertility. For example, 70% loss of urea-N occurs in wet land rice cultivation (IFDC, 2013).

The efficient fertilizer management can increase crop yield and reduce production cost. Excess amount of nitrogen fertilizer results in lodging of plant, prolonging growing period, delaying maturity and reducing yield (Uddin, 2003). Non-judicious application of nitrogen and phosphorous fertilizer not only increases production cost but also reduces the quality of the product. So, it is necessary to find out the suitable rate of nitrogen and phosphorus fertilizer for efficient management and better yield of fine grains rice.

Therefore, the study will help us to compare the effect of both N and P fertilizer application tactics for searching the best strategy to get maximum output with minimum inputs. Hence the objectives are-

- To evaluate the efficacy of P as a source of TSP and DAP on the yield of T. Aman rice, BRRI dhan71.
- To find out the suitable doses of N and P on the maximum yield of T. Aman rice, BRRI dhan71.

CHAPTER II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The continuous and unbalanced use of the chemical fertilizers under intensive cropping has been considered to be the main cause for declining crop yield and environmental degradation. All essential elements must be present in optimum amounts and in forms usable by plants. Nitrogen and Phosphorous are chemical fertilizers most commonly applied by rice farmers. Nitrogen is a major component of proteins, hormones, chlorophyll, vitamins and enzymes, essential for rice. The recommended doses of other nutrients are also necessary for potential rice yield. Considering the above point, available literatures were reviewed under nitrogen and phosphorus application for hybrid and inbreed rice.

2.1 Effect of Nitrogen on growth and yield of rice

Ferdous *et al.* (2019) carried out a study of four different levels of nitrogen (0, 50, 70 and 90 kg N ha^{-1}). In case of the level containing 70 kg N ha^{-1} produced maximum amount of grain yield (4.53 t ha^{-1}) and straw yield (5.623 t ha^{-1}).

Adhikary *et al.* (2018) conducted an experiment with four fertilizer treatment *viz.* 0 kg (N_0), 40 kg (N_1), 80 kg (N_2), 120 kg (N_3) N ha^{-1} respectively. The tallest plant (113.0 cm), number of total tillers $hill^{-1}$ (8.74), number of effective tillers $hill^{-1}$ (6.18), panicle length (21.98 cm), Grain yield (4.0 t ha^{-1}), Straw yield (5.25 t ha^{-1}) and biological yield (9.25 t ha^{-1}) were recorded in N_2 level (80 kg N ha^{-1}).

Haque *et al.* (2016) carried out an experiment on nitrogen levels 0, 20, 40, 60, 80 and 100 kg N ha^{-1} constituted the treatment variable. Results revealed that growth of the new rice variety favored at higher levels of applied nitrogen although it flattened at 80 and 100 kg N ha^{-1}.

Banerjee and Pal (2012) reported that plant height, dry matter production, leaf area index and crop growth rate of hybrid rice cultivar increased with increasing doses of N, P and K fertilizers and all these growth attributes showed their maximum values with 100% recommended dose of fertilizers (RDF) NPK @ 80-40-40 kg ha^{-1}.

Islam *et al*. (2008) conducted an experiment in 2001-2002, 2002-2003 and 2003-2004 to determine the response and the optimum rate of nutrients (NPK) for Chili- Fallow-T. Aman cropping pattern. He found that grains yield influenced significantly due to application of different rates of nutrients and 60-19-36 kg ha^{-1} NPK maximized the yield of T. aman rice varieties in respect of yield and economics.

Ahmed *et al*. (2005) was carried a field experiment during aman season, 2003 at the experimental field of Agro technology Discipline, Khulna University, Khulna to study the effect of nitrogen on different characteristics of transplanted local aman rice variety, Jatai .The levels of nitrogen used in this study were 0, 20, 40, 60 and 80 kg ha^{-1} . Results of this study revealed that different agronomic characteristics varied significantly among the treatments. Higher N dose produced higher plant height. The highest effective tillers $hill^{-1}$, panicle length, filled grains 18 $panicle^{-1}$, 1000-grains weight and grains yield was obtained with 40 kg N ha^{-1}. The highest and lowest biological yield was produced with 40 kg N ha-1 and 0-kg N ha^{-1} respectively.

Hossain *et al*. (2005) carried out a study to assess the effects of nitrogen (30, 60, 90 and 120 kg ha^{-1} N) and phosphorus (20, 40 and 60 kg ha^{-1} P_2O_5) on the growth and yield of rice/sorghum inter-crop. Application of nitrogen up to 90 kg ha^{-1} enhanced the growth and yield of rice crop.

Saito *et al*. (2005) conducted an experiment with three traditional and three improved cultivars were grown under four fertilizer treatments viz. 0 kg N ha^{-1} , 90 kg N ha^{-1} , 50 kg P_2O_5 ha^{-1} and NP. They reported applying P with N increased grains yield over N application alone.

Singh *et al*. (2003) also reported that crop growth rate and relative growth rate such as total dry matter production was significantly influenced by NPK. The tillers number and total dry matter production are closely correlated with yield depending on the rice cultivar which can be greatly enhanced by applying proper nutrient.

Bayan and Kandasamy (2002) noticed that the application of recommended doses of nitrogen in four splits at 10 days after sowing active tillering, panicle initiation and at heading stages recorded significantly lower dry weight of weeds and increased crop growth viz. effective tillers m^{-2} .

Lawal and Lawal (2002) treated three field experiments during the rainy season of 1996, 1997 and 1998 in Nigeria to evaluate the growth and yield responses of lowland rice with 4 nitrogen levels to evaluate the growth and yield responses of lowland rice with 4 nitrogen levels (0, 40, 80 and 120 kg ha^{-1}) and placement methods. They concluded that grains yield increased significantly up to 80 kg nitrogen ha^{-1}.

Sarker *et al*. (2001) obtained the nitrogen responses of a Japonica (*Yumelvitachi*) and an Indica (*Takanari*) rice variety with different nitrogen levels viz. 0, 40, 80, and 120 kg N ha^{-1}. They observed that application of nitrogen increased grains and straw yields significantly but harvest index was not increased significant.

Munnujan *et al*. (2001) treated 4 levels of N 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 grains 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}).

BRRI (2000) reported that the grains yield was linearly increased with increasing N rates.

Singh *et al*. (2000) stated that N significantly increased Plant height, Panicle length, grains and straw yields of rice.

Pully *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 6 N applied as late as booting, but only when the rice is N limited and not severely N stressed.

2.2 Effect of phosphorus on growth and yield of rice

Amanullah *et al.* (2016) stated that higher rates of P addition reduced the number of days to panicle initiation and days to physiological maturity, produced taller plants with more tillers per hill, more leaves per tillers with higher leaf area per hill and leaf area index at panicle initiation and physiological maturity. Control plots took the longest to reach panicle initiation and physiological maturity, produced smallest plants with fewer tillers per hill, fewer leaves per tillers, lower leaf area per hill and lower leaf area index at both growth stages.

Tang *et al*. (2011) conducted a field experiment on winter wheat (*Triticumaestivum* 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 grains yield irrespective of varieties in T. Aman season while in Boro season P response was observed among the P rates. Application of P @ 10 kg ha^{-1} significantly increased the grains yield. But when P was applied @ 20 and 30 kg P ha^{-1}. The grains 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 (EH1 and EH2) used P more efficiently than inbred varieties. A negative P balance was observed up to 10 kg P ha^{-1}.

Alam *et al*. (2009) found that dry matter partitioning in different part plants varied significantly due to variation of P.

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. The Fe-P treatment significantly decreased plant dry weight, P8 uptake per plant, and P concentration in plant dry matter of all cultivars in comparison with the control plants.

Saleque *et al*. (2005) found a linear relationship between P uptake and total system productivity which supports the concept that TSP depends to some extent on P availability. Phosphorus application increased rice yield in different seasons where the highest response in P was in Aus and Boro than T. Aman.

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_5 ha^{-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 grains and straw were obtained at higher levels of 45 kg P_2O_5 ha^{-1} treatment.

Haq *et al*. (2002) carried out a field experiment with twelve treatments combination of N, P, K, S and Zn with objectives to find out the optimum doses of N, P, K, S, Zn for rice cultivation. They found that all the treatments significantly increased the grain and straw yields of BRRI dhan30 rice over control. 90 kg N + 50 kg P_2O_5 + 40 kg K_2O + 10 kg S + 4 kg Zn ha^{-1} gave the highest grains and straw yields.

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^{-1} as triple super phosphate (TSP). Only once used in 1993 and its residual value in 1994, 1995, 1996 and 1998 stated that grains 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.

Ghosal *et al*. (1998) conducted a field experiment in Bihar on rice cv. Pankaj with 10– 40 kg P/ha as triple super phosphate (TSP), highly reactive Morocco Rock Phosphate (HRMRP), Florida Rock Phosphate (FRP) and stated that yield increased with increasing P rates of four sources. They further proposed that grains yield was the highest with TSP followed by PAPR, HRMRP and FRP.

CHAPTER III

MATERIALS AND METHODS

MATERIALS AND METHODS

This chapter includes the information regarding methodology that was used in execution of the experiment. The object of the study was to evaluate the effect of N and P on the growth and yield of T. Aman rice (BRRI dhan71). The details of the materials and methods i.e. experimental period, location, soil and climatic condition of the experimental area, materials used, treatment and design of the experiment, growing of crops, data collection and data analysis procedure that followed in this experiment has been presented under the following headings:

3.1 Description of the experimental site

3.1.1 Experimental Period

The experiment was conducted at the Research farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the Aman season of July-November 2019.

3.1.2 Experimental Location

The present research work was conducted in the farm area of Sher-e-Bangla Agricultural University, Dhaka. The location of the site is $23^{0}74^{/}$N latitude and $90^{0}35^{/}$E longitude with an elevation of 8.4 meter above from sea level. Experimental location presented in Appendix I.

3.1.3 Climatic Condition

The climate of the experimental site is characterized by high temperature, high humidity and medium rainfall with occasional gusty winds during the kharif season (March-September) and during Rabi season (October-March) scanty rainfall associated with moderately low temperature is observed. The weather information regarding temperature, rainfall, relative humidity and sunshine hours prevailed at the experimental area during the cropping season July-November 2019 have been presented in Appendix II. 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. For better understanding about the experimental site has been shown in the Map of AEZ of Bangladesh in Appendix I.

3.1.4 Soil characteristics

The soil of the experimental field belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon soil series. Top soil was Silty Clay Loam in texture, olive gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 6.03 and had organic matter 1.22%. The experimental area was flat having available irrigation and drainage system and above flood level. The details have been presented in Table 1 and 2.

Table 1. Morphological characteristics of the experimental field

Morphology	Characteristics
Locality	SAU farm, Dhaka
Soil series	Tejgaon
Agro-ecological zone	Madhupur Tract (AEZ 28)
General Soil Type	Shallow Red Brown Terrace Soil
Parent material	Madhupur Terrace
Topography	Fairly level
Drainage	Well drained
Flood level	Above flood level

(FAO and UNDP, 1988)

Table 2. Initial physical and chemical characteristics of the experimental soil (0-15 cm depth)

Characteristics	Value
Mechanical fractions:	
% Sand (2.0-0.02 mm)	19.54
% Silt (0.02-0.002 mm)	45.26
% Clay (<0.002 mm)	35.20
Textural class	Silty Clay Loam
pH (1: 2.5 soil- water)	6.03
Organic carbon (%)	0.712
Organic Matter (%)	1.22
Total N (%)	0.06
Available P (mg kg^{-1})	18.76
Exchangeable K (mol kg^{-1})	0.121
Available S (mg kg^{-1})	14.35

3.2 Experimental details

3.2.1 Planting material

In this experiment BRRI dhan71 was used as the test crop it is developed by the Bangladesh Rice Research Institute through hybridization method. It is released in the year 2014. It is recommended for Aman season. Average plant height of the variety is around 125 cm at the ripening stage. The grains are long, slender and white.

3.2.2 Treatment

The experiment comprised of the following 8 treatment:

T_1: Control (No fertilizer)
T_2: N_{100} P_{15} (from TSP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}
T_3: N_{100} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}
T_4: N_{80} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}
T_5: N_{100} P_{12} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}
T_6: N_{80} P_{12} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}
T_7: N_{60} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}
T_8: N_{60} P_{12} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

3.2.3 Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The experimental plot was 25 m × 12 m and it was divided into 3 blocks. The size of the each unit plot was 3.0 m × 2.5 m. The space between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1

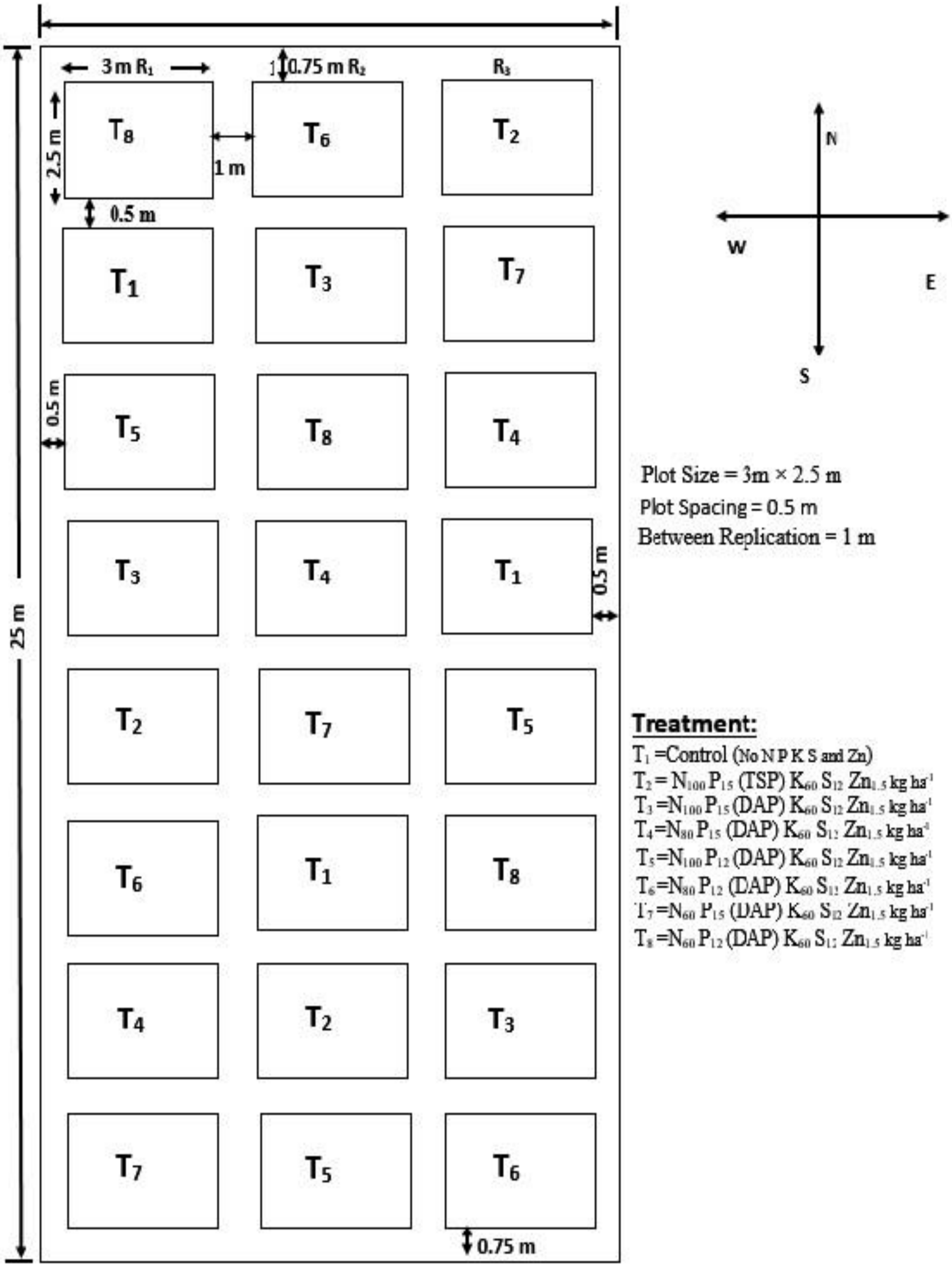

Fig. 1: Layout of Experimental Plot

3.3 Growing of crops

3.3.1 Seed collection and sprouting

Seeds were collected from BRRI, Gazipur just 15 days ahead of sowing seeds in seed bed. Seeds were immersed in water in a bucket for 24 hours. These were then taken out of water and kept in a gunny bags. The seeds started sprouting after 48 hours those were suitable for sowing within 72 hours.

3.3.2 Raising of seedlings

The nursery bed was prepared by puddling with repeated ploughing followed by laddering. Pre germinated seed were sown in wet nursery bed on 21st July, 2019. The sprouted seeds were sown as uniformly as possible. Irrigation was gently provided to the bed as and when needed. No fertilizer was used in the nursery bed.

3.3.3 Land preparation

The land was first opened on 16th August, 2019 by a tractor and prepared thoroughly by ploughing and cross ploughing with a power tillers followed by country plough. Laddering helped breaking the clods and leveling the land followed every ploughing. Before transplanting each unit of plot was cleaned by removing the weeds, stubbles and crop residues. Finally each plot was prepared by puddling.

3.3.4 Fertilizers application

The fertilizers were applied as per treatment and the entire amounts of TSP/DAP, MoP, Gypsum, Zinc Sulphate and 50% of the whole amount of urea were applied during the final preparation of experimental plot.2nd and 3rd split i.e. The remaining 50% of urea was applied in two equal splits on 14th September, 2019 and 06th October, 2019 respectively.

3.3.5 Transplanting of seedling

Thirty days old seedlings were carefully uprooted from the nursery and transplanted on 19th August, 2019. Three seedlings hill^{-1} were used following a spacing of 15 cm × 20 cm.

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 Gap filling

After one week of transplanting, a minor gap filling was done where it was necessary using the seedling from the same source.

3.3.6.2 Weeding

During growing period three hand weeding were done, first weeding was done at 25 DAT (Days after transplanting) followed by second weeding at 35 DAT and final weeding was performed at 45 DAT by sickles.

3.3.6.3 Application of irrigation water

Irrigation water was added to each plot according to the need. Irrigation was done up to 5 cm. The experimental plots were irrigated through irrigation channels. Centimeter marked sticks were installed to measure depth of irrigation water.

3.3.6.4 Plant protection measures

Plants were infested with rice stem borer to some extent which was successfully controlled by applying two times of Diazinon 60 EC on 5th October, 2019. Crop was protected from birds by net during grain filling period.

3.4 Harvesting, threshing and cleaning

The crop was harvested on 23rd November, 2019 when 80-90% of the grains were turned into straw colored. The harvested crop was bundled separately, properly tagged and brought to threshing floor. Enough care was taken during threshing and cleaning. Fresh weight of rice grains and straw were recorded plot wise from 1 m^2 area. The grains were dried, cleaned and weighed for individual plot. The weight was adjusted to a moisture content of 14%. Yields of rice grains and straw m^{-2} were recorded and converted to t ha^{-1}.

3.5 Recording of Data

1. Plant height (cm)
2. Effective tillers $hill^{-1}$
3. Non-effective tillers $hill^{-1}$
4. Total tillers $hill^{-1}$
5. Length of panicle
6. Filled grains $panicle^{-1}$
7. Unfilled grains $panicle^{-1}$
8. Total grains $panicle^{-1}$
9. weight of 1000 grains
10. Grain yield
11. Straw yield
12. Biological yield

3.5.1 Plant Height

The height of plant was recorded in centimeter (cm) at the time of 30, 40, 50, 60, 70 days after transplanting (DAT) and at harvesting stage. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot. The plant height was measured from the ground level to the tip of the panicle with the help of a meter scale.

3.5.2 Effective tillers hill^{-1}

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

3.5.3 Non-effective tillers hill^{-1}

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

3.5.4 Total tillers hill^{-1}

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

3.5.5 Length of Panicle

The length of panicle was measured with a meter scale from 10 randomly selected plants and the average value was recorded as per plant.

3.5.6 Filled Grains Panicle^{-1}

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

3.5.7 Unfilled grains panicle^{-1}

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

3.5.8 Total grains panicle^{-1}

The total numbers of grains was collected randomly from selected 10 plants of a plot by adding filled and unfilled grains and then average numbers of total grains panicle^{-1} was recorded.

3.5.9 weight of 1000 grains

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

3.5.10 Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of central 1 m^2 area and five sample plants were added to the respective unit plot yield to record the final grain yield $plot^{-1}$ and finally converted into t ha^{-1}.

3.5.11 Straw yield

Straw obtained from each unit plot were sun-dried and weighed carefully. The dry weight of straw of central 1 m^2 area and five sample plants were added to the respective unit plot yield to record the final straw yield $plot^{-1}$ and finally converted to t ha^{-1}.

3.5.12 Biological yield

Grain yield and straw yield together were regarded as biological yield. The biological yield was calculated with the following formula:
Biological yield = Grains yield + Straw yield.

3.6 Post Harvest Soil Sampling

After harvesting 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 (10 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, organic carbon, Total N, available P, exchangeable K contents and available S. The soil samples were analyzed by the following standard methods as follows:

3.7.1 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 Organic carbon

Organic carbon in soil sample was determined by wet oxidation method (Page *et al*., 1982). The underlying principle was used to oxidize the organic matter with an excess of 1N $K_2Cr_20_7$ in presence of conc. H_2SO_4 and conc. H_3PO_4 and to titrate the excess $K_2Cr_20_7$ solution with 1N $FeSO_4$. To obtain the content of organic matter was calculated by multiplying the percent organic carbon by 1.73 (Van Bemmelen factor) and the results were expressed in percentage.

3.7.3 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 into micro Kjeldahl flask to which 1.1 g 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 switch 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:

$$\% \, N = (T\text{-}B) \times N \times 0.014 \times 100/S$$

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

3.7.4 Available Phosphorus

Available P was extracted from the soil with 0.5 M $NaHCO_3$ solutions, pH 8.5 (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).

3.7.5 Exchangeable Potassium

Exchangeable K of 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).

3.7.6 Available Sulphur

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

3.8 Statistical Analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference of different treatments on yield and yield contributing characters of BRRI dhan71. The mean values of all the characters were calculated and analysis of variance (ANOVA) was performed by the ‘F’ (variance ratio) test using Statistix 10 computer software. The significance of the difference among the treatment means was compared using the Least Significant Difference (LSD) (Gomez *and* Gomez 1984).

CHAPTER IV

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

The experiment was conducted for comparative study on the effect of N and P on the growth and yield of T. Aman rice (BRRI dhan71). Data on different yield contributing characters and yield as well as characteristics of post-harvest soil were recorded. The finding of the study has been presented and discussed with the help of different Table and Graphs under the following headings and sub-headings:

4.1 Yield attributes and yield of rice

4.1.1 Plant height

Plant height of BRRI dhan71 showed statistically significant differences due to different treatments (Table. 3 and Figure. 2). The highest plant height (131.43 cm) was observed in T_3 {N_{100} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}} which was statistically similar to T_4 (130.57 cm) {N_{80} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}}; whereas the shortest plants (106.50 cm) were found T_1 (control) 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 influences plant height and in suitable environmental condition specific variety produces tallest plant that the adverse situation. These findings corroborated with the results reported by Roy (2019), Howlader *et al*. (2017), Naznin *et al*. (2013) and Masum *et al*. (2008).

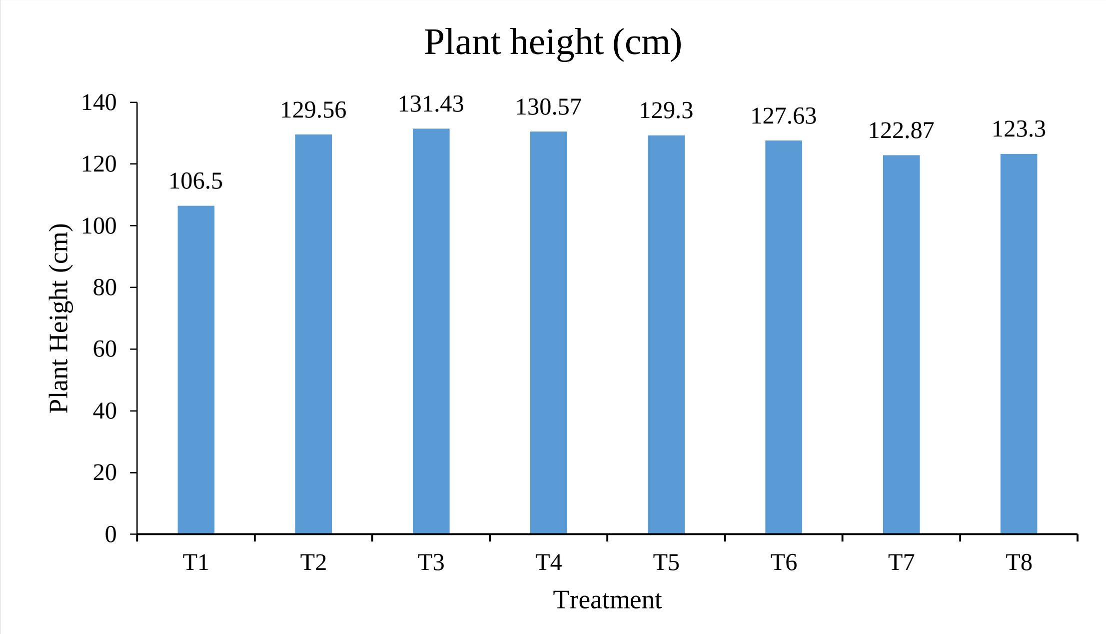

Figure 2: Effect of N and P on plant height of T. Aman Rice (BRRI Dhan71)

4.1.2 Number of effective tillers hill^{-1}

The number of effective tillers hill^{-1} was shown in (Table 3). The maximum number of effective tillers hill^{-1} 15.9 was observed in T_4 treatment. T_6 (15.4) treatment was closely followed by T_5 (14.9) treatment, whereas the lowest number of effective tillers hill^{-1} was found in T_1 which is control. The highest 15.9 (T_4) and the lowest value is 9.6 (T_1). Akter *et al*. (2015), Jisan *et al*. (2014), Tyeb *et al*. (2013) and Mamun *et al*. (2010) are supporting to this result.

4.1.3 Number of non-effective tillers hill^{-1}

Number of non-effective tillers hill^{-1} was varied significantly due to different treatments (Table 3). The minimum number of non-effective tillers hill^{-1} (0.73) was observed in T_4 treatment. T_6 (0.86) was statistically similar with T_7 (0.90), T_8 (0.93) treatments while the maximum number (1.40) was observed in T_1 treatment that was followed by T_3 (1.23) and T_5 (1.13) treatments, respectively. Howlader *et al*. (2017) and Masum, S.M., (2008) also found similar results.

4.1.4 Number of total tillers hill^{-1}

Statistically significant differences was recorded due to different treatments in terms of number of total tillers hill^{-1} of BRRI dhan71 (Table 3). The maximum number of total tillers hill^{-1} (16.63) was observed in T_4 treatment which was statistically similar to T_6 (16.26) treatment. T_5 (16.03) and T_3 (15.56) treatments are closely followed by T_4 treatment. Howlader *et al*. (2017), Rahman *et al*. (2016) and Masum, S.M., (2008) also reported result similar to this.

Table 3. Effect of N and P on plant height, number of effective, non-effective and total tillers hill^{-1} of T. Aman rice (BRRI dhan71)

Treatments	Plant height (cm)	Number of effective tillers hill^{-1}	Number of non-effective tillers hill^{-1}	Total tillers hill^{-1}
T_1	106.50 d	9.6 e	1.40 a	11.00 d
T_2	129.56 ab	13.8 c	1.00 cd	14.80 b
T_3	131.43 a	14.33 bc	1.23 ab	15.56 ab
T_4	130.57 a	15.9 a	0.73 e	16.63 a
T_5	129.30 abc	14.9 abc	1.13 bc	16.03 ab
T_6	127.63 abc	15.4 ab	0.86 de	16.26 a
T_7	122.87 c	12.5 d	0.90 de	13.40 c
T_8	123.30 bc	11.9 d	0.93 cde	12.83 c
LSD(0.05)	4.0912	1.2529	0.1239	1.2306
Significance level	0.05	0.05	0.05	0.05
CV (%)	3.04	5.28	12.04	5.24

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 (No fertilizer)

T_2: N_{100} P_{15} (from TSP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_3: N_{100} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_4: N_{80} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_5: N_{100} P_{12} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_6: N_{80} P_{12} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_7: N_{60} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_8: N_{60} P_{12} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

4.1.5 Length of panicle

Graphical representation of length of panicle of BRRI dhan71 is shown in Figure 3. The longest panicle length (28.52 cm) was observed in T_4 treatment which was statistically similar to the treatment T_6 (27.90 cm) and followed by T_5, T_3, T_2, T_7, T_8 (26.64 cm, 26.36 cm, 25.84 cm, 25.03 cm, 24.65 cm) treatments respectively, while the shortest panicle was found (20.13 cm) from T_1 treatment. Roy, (2019); Paul *et al*. (2017) and Marzia *et al*. (2016) also found similar kind of data.

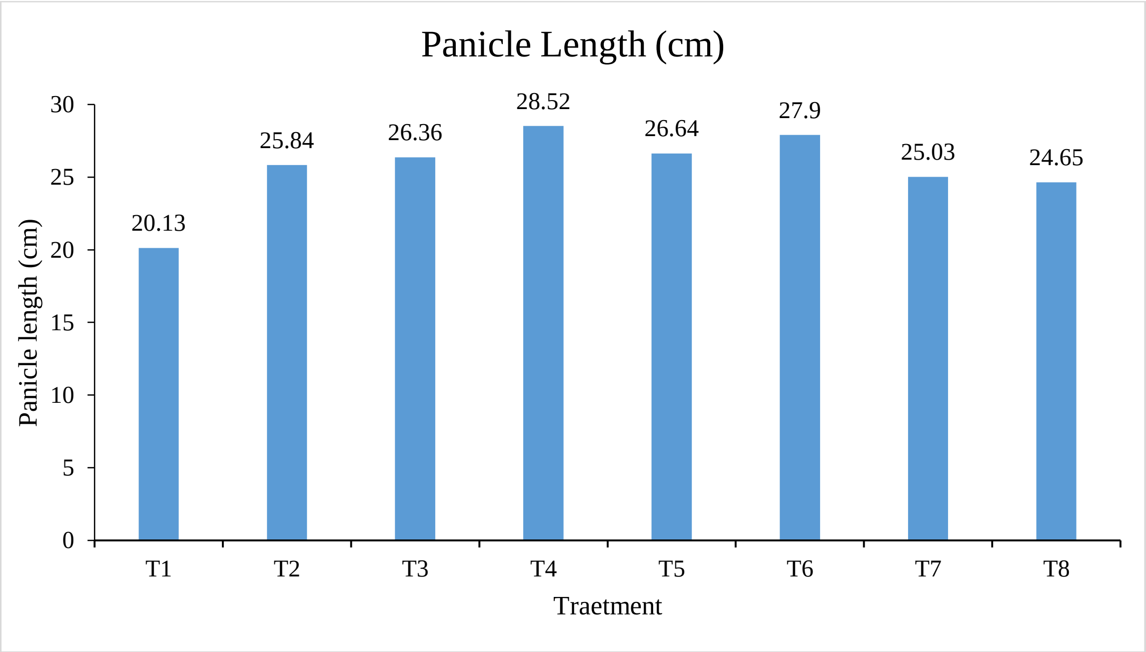

Figure 3: Effect of N and P on panicle length of T. Aman Rice (BRRI Dhan71)

4.1.6 Number of filled grains panicle^{-1}

Statistically significant differences was recorded due to different treatments in terms of number of filled grains panicle^{-1} (Table 4). The maximum number of filled grains panicle^{-1} (124.27) was observed in T_4 treatment which was statistically similar to treatment T_6 (120.41) and closely followed by T_3 (115.74), T_5 (115.25) and T_2 (115.23) treatments. The minimum number of filled grains panicle^{-1} (90.16) was observed in T_1 treatment. Chowdhury *et al*. (2016) and Islam *et al*. (2011) also found this type of result.

4.1.7 Number of unfilled grains panicle^{-1}

Statistically significant difference was observed in the number of unfilled grains panicle^{-1} (Table 4). The minimum number of unfilled grains panicle^{-1} (15.80) was observed in T_4 treatment. Which was closely similar to T_6 (16.24), T_5 (17.8) and T_3 (17.13) treatments, whereas the maximum number of unfilled grains panicle^{-1} (22.76) was observed in T_1 treatment. Similar observation was happened with Rahman *et al.* (2016) and Darade and Bankar (2009).

4.1.8 Number of total grains panicle^{-1}

Number of total grains panicle^{-1} of BRRI dhan71 varied significantly due to different treatments (Table 4). The maximum number of total grains panicle^{-1} (140.07) was observed in T_4 treatment, which was statistically identical with T_6 (136.65), T_2 (134.21), T_3 (132.87), T_5 (132.33) treatments, whereas the minimum number of total grains found in T_1 (112.92) treatment. Similar kind of observation was happened with Howlader *et al*. (2017) and Masum *et al*. (2010 b).

Table 4. Effect of N and P on length of panicle, number of filled, unfilled and total grains panicle^{-1} of T. Aman rice (BRRI dhan71)

Treatments	Length of panicle (cm)	Number of filled grains panicle^{-1}	Number of unfilled grains panicle-1	Total grains panicle^{-1}
T_1	20.13 f	90.16 c	22.76 a	112.92 c
T_2	25.84 cde	115.23 ab	18.98 bc	134.21 ab
T_3	26.36 bcd	115.74 ab	17.13 cd	132.87 ab
T_4	28.52 a	124.27 a	15.80 d	140.07 a
T_5	26.64 bc	115.25 ab	17.08 cd	132.33 ab
T_6	27.90 ab	120.41 a	16.24 cd	136.65 ab
T_7	25.03 de	107.12 b	21.07 ab	128.13 b
T_8	24.65 e	106.43 b	20.17 ab	126.60 b
LSD(0.05)	1.55	11.69	2.77	10.63
Significance level	0.05	0.05	0.05	0.05
CV (%)	3.46	5.97	8.50	4.65

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 (No fertilizer)

T_2: N_{100} P_{15} (from TSP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_3: N_{100} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_4: N_{80} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_5: N_{100} P_{12} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_6: N_{80} P_{12} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_7: N_{60} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_8: N_{60} P_{12} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

4.1.9 Weight of 1000 grains (g)

Weight of 1000 grains varied significantly due to different treatments (Table 5). The highest weight of 1000 grains (28.83 g) was observed in T_4 treatment, while the lowest is (25.29 g) with T_1 treatment. T_6 treatment (28.32) was statistically similar to T_3, T_5 and T_2 treatments. Jisan *et al*. (2014) and Mamun *et al*. (2010 a) and some other researcher also found this similar results.

4.1.10 Grain yield

Grain yield t ha^{-1} have been shown in (Figure 4). The highest grain yield (5.81 t ha^{-1}) was recorded in T_4 treatment which was statistically similar to T_6 (5.67 t ha^{-1}). T_3 treatment (5.17 t ha^{-1}) was closely followed by T_2 and T_5 (4.96 t ha^{-1}, 4.73 t ha^{-1}) treatments, respectively. While the lowest grain yield (3.44 t ha^{-1}) was recorded in T_1 treatment. Hariyano, (2018); Tyeb *et al*. (2013); Bhowmik *et al*. (2012) and Hossain *et al*. (2003) also found similar findings.

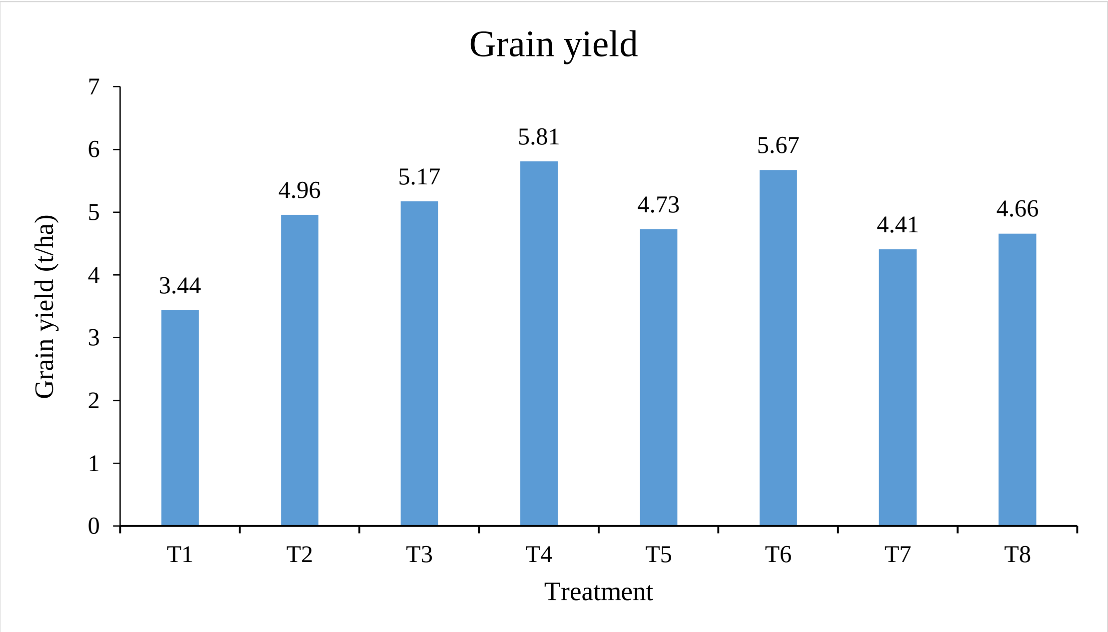

Figure 4: Effect of N and P on grain yield (t/ha) of T. Aman rice (BRRI Dhan71).

4.1.11 Straw yield

Straw yield varied significantly due to different treatments (Table 5). The highest straw yield (7.45 t ha^{-1}) was found in T_3 treatment which was statistically similar to T_4 (7.32 t ha^{-1}). Straw yield of treatment T_5 (6.84) was followed by all other treatments. The lowest straw yield (4.52 t ha^{-1}) was recorded in T_1 treatment. Tapkeer, (2017); Kokare, (2015) and Wining's, (2014) also reported the similar result.

4.1.12 Biological Yield

Statistically significant differences was recorded due to different treatments in terms of biological yield (Table 5). The highest biological yield (13.13 t ha^{-1}) was observed in T_4 treatment. The second highest yield result was found in T_3 (12.62 t ha^{-1}) followed by other treatments like T_6, T_5, T_2, T_8 and T_7 respectively. The lowest biological yield (7.96 t ha^{-1}) was observed in T_1 treatment. It was observed that N and P fertilizer ensured proper growth and development of rice plant and ultimately this treatment produced highest biological yield also. Similar result is found by Roy, (2019); Naznin *et al*., (2013) and Islam *et al*., (2011) and some other.

Table 5. Effect of N and P on weight of 1000 grains, grain, straw and biological yield of T. Aman rice (BRRI dhan71)

Treatments	weight of 1000 grains (g)	Grains yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})
T_1	25.29 c	3.44 e	4.52 e	7.96 e
T_2	27.46 ab	4.96 bc	6.37 c	11.33 c
T_3	27.88 ab	5.17 b	7.45 a	12.62 ab
T_4	28.83 a	5.81 a	7.32 a	13.13 a
T_5	27.82 ab	4.73 bcd	6.84 b	11.57 c
T_6	28.32 ab	5.67 a	6.72 bc	12.39 b
T_7	26.73 bc	4.41 d	5.65 d	10.07 d
T_8	26.53 bc	4.66 cd	5.83 d	10.49 d
LSD(0.05)	2.05	0.4893	0.4451	0.7292
Significance level	0.05	0.05	0.05	0.05
CV (%)	4.29	5.75	4.01	3.72

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 (No fertilizer)

T_2: N_{100} P_{15} (from TSP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_3: N_{100} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_4: N_{80} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_5: N_{100} P_{12} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_6: N_{80} P_{12} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_7: N_{60} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_8: N_{60} P_{12} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

4.2 Post-Harvest Soil

4.2.1 Soil pH

Soil pH of post-harvest soil showed statistically non-significant differences due to different treatments (Table 6). The highest soil pH (6.33) was found from T_3 treatment, whereas the lowest in (6.10) T_1 treatment. Data reveled that soil pH in post-harvest soil was slightly changed but not in significant difference.

4.2.2 Organic carbon

Organic carbon content in post-harvest soil showed statistically non-significant differences among different treatments (Table 6). The highest organic carbon content (1.05%) in soil was recorded in T_4 treatment and it was followed by T_6 (1.01%); and by others treatments (T_5, T_2, T_3, T_7) while the lowest organic carbon was found in T_1 (0.87%) treatment. It was observed that chemical fertilizer have no significant effects on organic carbon contents.

4.2.3 Total N

Total N in post-harvest soil varied significantly due to different treatments (Table 6). The highest total N (0.068%) was recorded in T_3 treatment which was statistically closely similar to T_4 treatment and followed by other like T_6, T_5 and T_2 treatments, while the lowest total N (0.034%) was found in T_1 treatment.

4.2.4 Available P

Available P in post-harvest soil varied significantly due to different treatments (Figure 5). The highest available P (36.45 ppm) was recorded in T_4 treatment. The second highest available P was (34.31 ppm) obtained in T_6 followed by T_5, T_3, T_2, T_7 and T_8 treatments, while the lowest available P (18.26 ppm) was found in T_1 treatment.

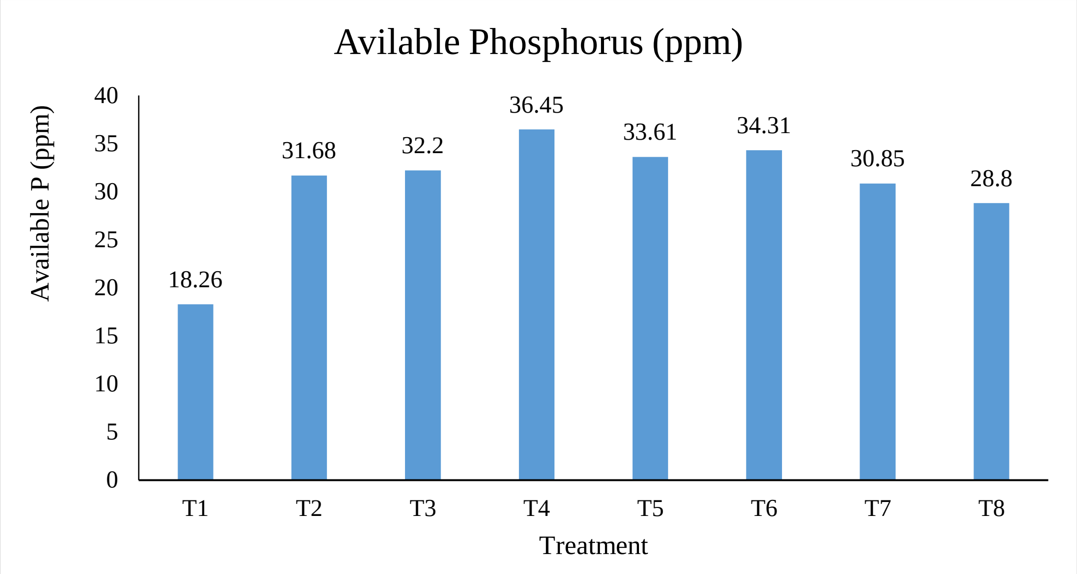

Figure 5: Effect of N and P on the available P (ppm) on post-harvest soil of BRRI dhan71

4.2.5 Exchangeable K

Exchangeable K in post-harvest soil varied significantly due to different treatments (Table 6). The highest exchangeable K (0.132 meq/100 g soil) was obtained from T_3 treatment which was statistically similar to T_6 treatment (0.128 meq/100 g soil). The lowest exchangeable K (0.110 meq/100 g soil) was found in T_1 treatment.

4.2.6 Available S

Available S showed significant variation in post-harvest soil due to different treatments (Table 6). The highest value was found in T_4 (18.30 ppm) which was statistically closely similar to treatment (17.40 ppm) T_6; followed by all other treatments. The minimum Available S was found in T_1 (12.40 ppm) treatment.

Table 6. Effect of N and P on nutrient content of post-harvest soil

Treatments	pH	Organic carbon (%)	Total N (%)	Available P (ppm)	Exchangeable K (meq/100 g soil)	Available S (ppm)
T_1	6.1	0.87	0.034 e	18.26 f	0.110 d	12.40 f
T_2	6.4	0.95	0.061 c	31.68 d	0.122 ab	15.60 cd
T_3	6.33	0.93	0.068 a	32.20 cd	0.132 a	16.20 bcd
T_4	6.3	1.05	0.065 ab	36.45 a	0.115 bc	18.30 a
T_5	6.2	0.98	0.063 bc	33.61 bc	0.124 ab	16.50 bc
T_6	6.16	1.01	0.064 bc	34.31 b	0.128 a	17.40 ab
T_7	6.2	0.91	0.056 d	30.85 d	0.118 bc	13.80 ef
T_8	6.23	0.89	0.054 d	28.80 e	0.121 ab	14.50 de
LSD(0.05)	NS	NS	3.838	1.72	0.015	1.76
Significance level	0.05	0.05	0.05	0.05	0.05	0.05
CV (%)	2.12	5.88	3.77	3.19	5.68	6.45

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 (No fertilizer)

T_2: N_{100} P_{15} (from TSP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_3: N_{100} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_4: N_{80} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_5: N_{100} P_{12} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_6: N_{80} P_{12} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_7: N_{60} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_8: N_{60} P_{12} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

CHAPTER V

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The experiment was conducted at the Research Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the aman season of July-November 2019, with a view to evaluate the effect of N and P on the growth contributing characters and yield of T. Aman rice (BRRI dhan71) and to find out the suitable doses of N and P for yield maximization of T. Aman rice.

The soil of the experiment was silty clay loam in texture having pH 6.03, total N (0.06%) and available P (18.76 ppm). Thirty days old seedling were transplanted on 19 august, 2019 and the crop was harvested on 23rd November, 2019. Data on growth and yield parameters were recorded properly. Nutrient status of the post-harvest soil was also analyzed.

BRRI dhan71 was used as the test crop. There were 8 treatments including the control one. The treatments were-

T_1: Control (No fertilizer)

T_2: N_{100} P_{15} (from TSP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_3: N_{100} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_4: N_{80} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_5: N_{100} P_{12} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_6: N_{80} P_{12} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_7: N_{60} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

T_8: N_{60} P_{12} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}

The experiment was laid out in a randomized complete block design with three replications. In the result we saw, longest plant (131.43 cm) was found with the T_3 {N_{100} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}} treatment and the shortest plant (106.50 cm) was found in T_1 (control) treatment. Maximum number of effective tillers $hill^{-1}$ (15.90) was found with T_4 {N_{80} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}} treatment and the minimum (9.60) was found in T_1 (control). The maximum number of non-effective tillers $hill^{-1}$ (1.40) was recorded from T_1.

On the other hand treatment T_4 {N_{80} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}} produced the minimum number of non-effective tillers $hill^{-1}$ (0.73). The maximum number of total tillers $hill^{-1}$ (16.63) was observed in T_4 {N_{80} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}} treatment, while the minimum number of total tillers $hill^{-1}$ (11.00) observed in T_1 treatment. The longest panicle (28.52 cm) was observed in T_4 {N_{80} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}} treatment and the shortest panicle (20.13 cm) was observed in T_1 (control) treatment.

The maximum number of filled grains $panicle^{-1}$ (124.27) was observed in T_4 {N_{80} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}}, while the minimum number (90.16) was found in T_1 (control) treatment. The minimum number of unfilled grains $panicle^{-1}$ (15.80) was recorded in T_4 {N_{80} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}} treatment, whereas the maximum number (22.76) was noted in T_1 (control) treatment. The maximum number of total grains $panicle^{-1}$ (140.07) was obtained from T_4, while the minimum number (112.92) was in T_1 treatment.

The highest weight of 1000 grains (28.83 g) was found in T_4 {N_{80} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}}, while the lowest weight (25.29 g) was in T_1 treatment. The highest grain yield (5.81 t ha^{-1}) was obtained in T_4 {N_{80} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}} treatment, while the lowest grain yield (3.44 t ha^{-1}) was found in T_1 (control) treatment. Straw yield (7.45 t ha^{-1}) was highest in T_3 {N_{100} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}} treatment, while the lowest straw yield (4.52 t ha^{-1}) was recorded in T_1 treatment. The highest biological yield (13.13 t ha^{-1}) was calculated in T_4 {N_{80} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}} treatment, while the lowest biological yield (7.96 t ha^{-1}) was recorded in T_1.

The highest soil pH (6.33) was found from T_3 {N_{100} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}}, while the lowest soil pH (6.1) was in T_1 treatment. The highest organic carbon (1.05%) was recorded from T_4 {N_{80} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}} treatment and the lowest organic carbon (0.87%) measured in T_1

treatment. The highest total N (0.068%) was recorded in T_3 {N_{100} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}} treatment, while the lowest total N (0.034%) in T_1. The highest available P (36.45 ppm) was recorded in T_4 {N_{80} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}} treatment, while the lowest available P (18.26 ppm) was found in T_1 treatment. The highest exchangeable K (0.132 meq/100 g soil) was recorded in T_3 {N_{100} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}} treatment, while the lowest exchangeable K (0.110 meq/100 g soil) was found in T_1 treatment. The highest value of the available S in post-harvest soil was recorded (18.30 ppm) in T_4 {N_{80} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1}} treatment, while the lowest value of available S recorded (12.40 ppm) in T_1 (control) treatment.

Conclusion:

Applications of N_{80} P_{15} (from DAP) K_{60} S_{12} $Zn_{1.5}$ kg ha^{-1} was optimum for better growth and maximum yield of T. Aman rice (BRRI dhan71).
Considering the results of the present experiment, further studies in the following areas may be suggested:

- Such study is needed to be repeated in different agro-ecological zones (AEZ) of Bangladesh for the evaluation of regional adaptability;
- Organic manures and other management practices may be used for further study.

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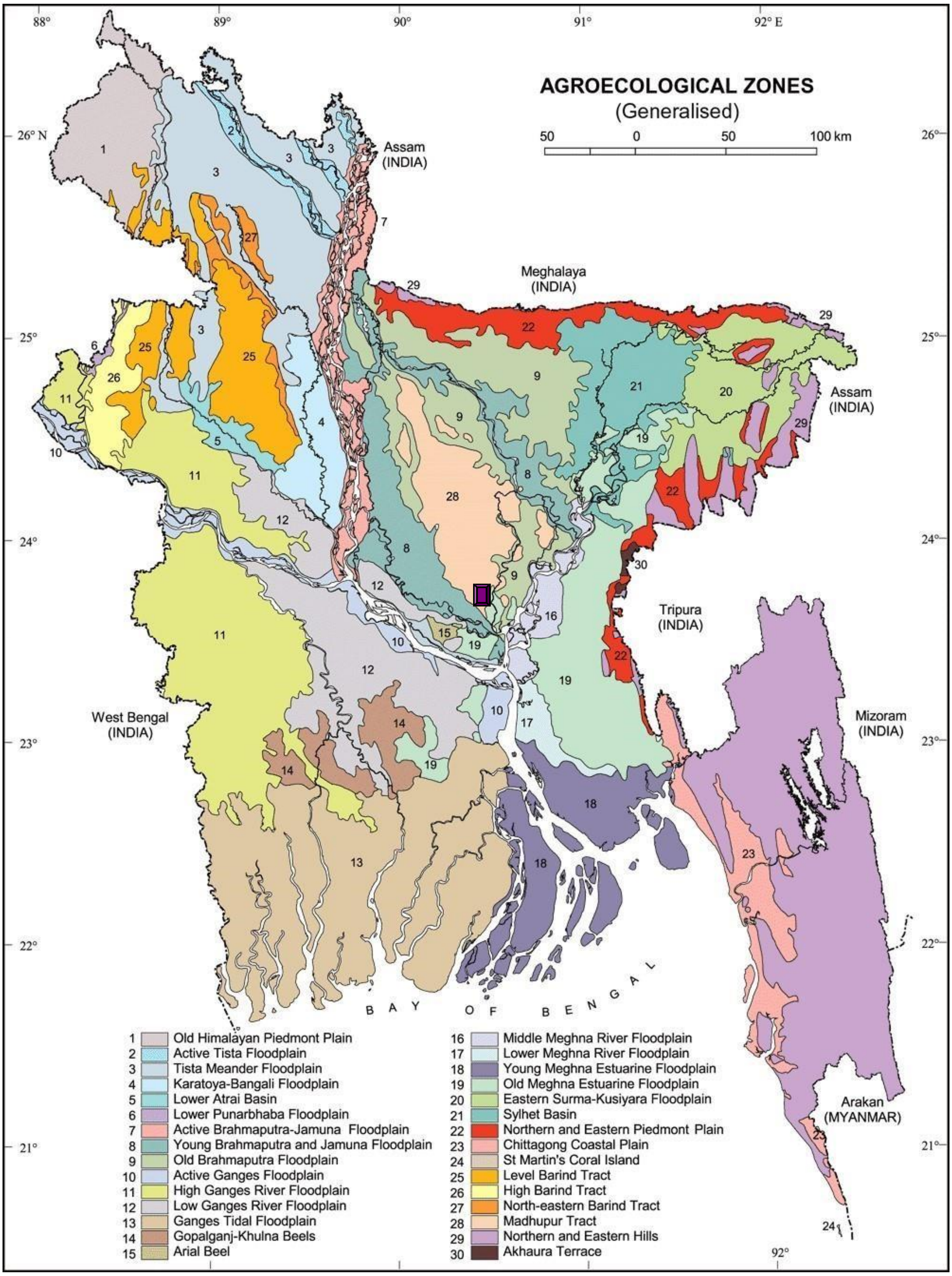
APPENDICES

APPENDICES

Appendix I. The Map of the experimental site



Appendix II. Monthly record of air temperature, relative humidity, rainfall, and sunshine (average) of the experimental site during the period from July to November 2019

Month (2019)	Air temperature (^{0}c)		Relative humidity (%)	Rainfall (mm)	Sunshine (hrs.)
	Maximum	Minimum			
July	37.8	25.0	87	580	5.8
August	35.6	23.5	85	305	6.0
September	32.8	22.5	83	250	6.8
October	26.5	19.2	78	30	6.5
November	24.7	15.8	75	10	6.3

Source: Bangladesh Meteorological Department

Appendix III: ANOVA Table

Mean sum square (MS)									
source	d.f	Pl. H.	Ef. tl.	Non ef. tl.	Tot. tl.	Pa. le.	Fil. Grn.	Unfil. grn.	Tot. grn.
Replication	2	16.74	0.48	0.08	0.17	1.73	44.50	0.97	57.45
Treatment	7	200.89**	13.23**	0.14**	11.76**	20.01**	337.63**	18.67**	206.58**
Error	14	14.50	0.51	0.01	0.58	0.78	44.57	2.51	36.88

Pl. H. = Plant height (cm), Ef. tl. = Effective tiller, Non ef. tl. = Non effective tiller, Tot. tl. = Total tiller, Pa. le. = Panicle length (cm), Fill. Grn. = Filled grain, Unfil. grn. = Unfilled grain, Tot. grn. = Total grain

** indicates significant at 1%

* indicates significant at 5%

NS indicates non-significant

Mean sum square (MS)					
source	d. f.	1000 seed weight	Grain Yield	Straw yield	Biological yield
Replication	2	1.72	0.011	0.109	0.189
Treatment	7	3.84*	1.68**	2.843**	8.395**
Error	14	1.37	0.078	0.064	0.173

** indicates significant at 1%

* indicates significant at 5%

NS indicates non-significant

Mean Sum of Squares (MS)							
source	d.f.	pH	Organic carbon	Total N	Available P	Exchangeable K	Available S
Replication	2	0.01	0.005	9.375	0.146	4.137	0.005
Treatment	7	0.027^{NS}	0.011^{NS}	3.492	92.625^{**}	1.326^{**}	11.309^{**}
Error	14	0.017	0.003	4.804	0.965	7.352	1.009

** indicates significant at 1%

* indicates significant at 5%

^{NS} indicates non-significant

Appendix IV: Images of the Experimental Field

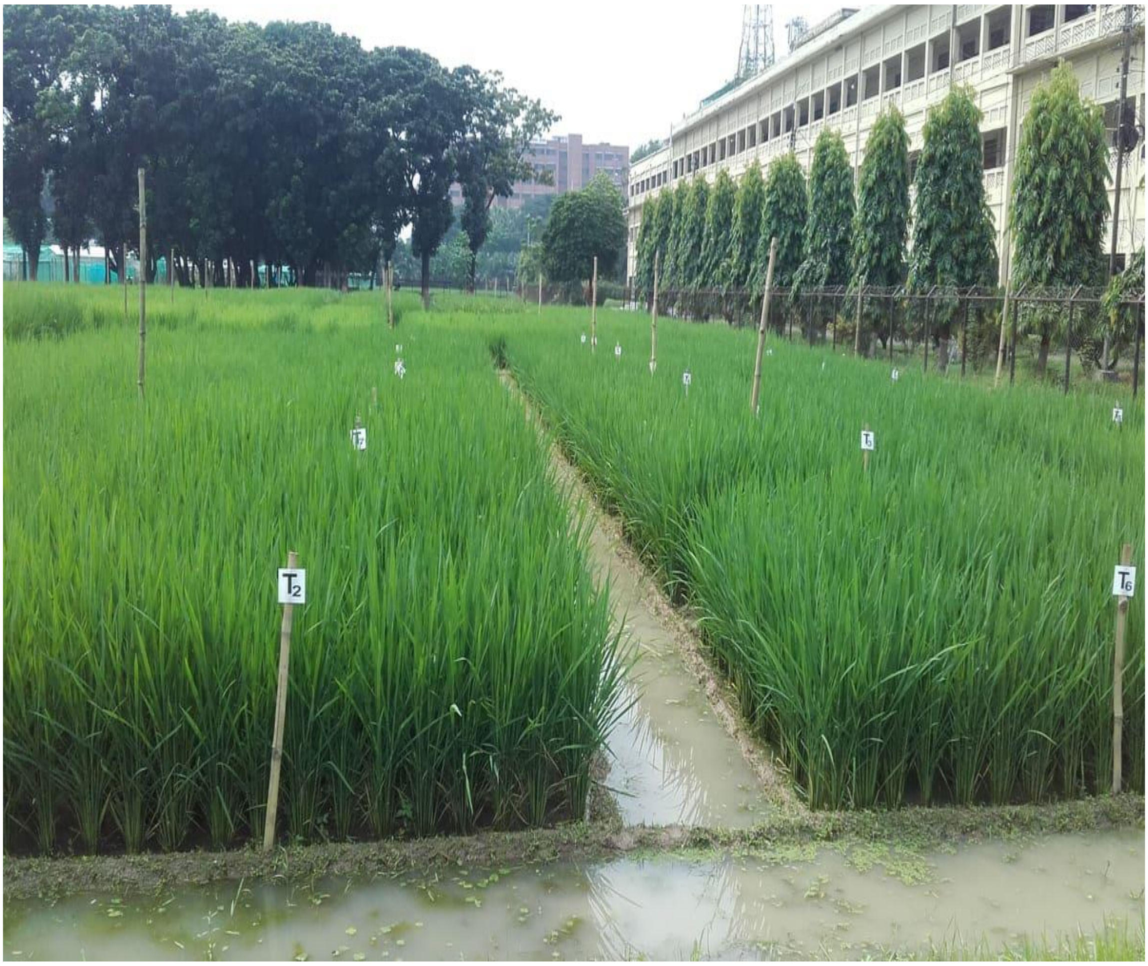


Plate 1: View of experimental plots

Plate 2: Harvesting of rice

Plate 3: Sample Collection of rice