EFFICACY OF DI-AMMONIUM PHOSPHATE (DAP) FERTILIZER FOR THE GROWTH AND YIELD OF BRRI dhan89 AS BORO RICE

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CERTIFICATE

This is to certify that the thesis entitled **"EFFICACY OF DI-AMMONIUM PHOSPHATE (DAP) FERTILIZER FOR THE GROWTH AND YIELD OF BRRI dhan89 AS BORO RICE"** *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 bona fide research work carried out by* **SUDIPTA DEY,** *Registration No.* ***14-06023*** *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 Parents and

Respected Research Supervisor

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June, 2021 ***The Author***

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SUDIPTA DEY

ABSTRACT

An experiment was conducted at the Research Farm, Sher-e-Bangla Agricultural University, Dhaka during the period from November 2019 to May 2020 in boro season to find out the efficacy of di-ammonium phosphate (DAP) fertilizer for the growth and yield of BRRI dhan89 as boro rice. The experiment consisted of nine treatments viz.T_1 (No fertilizer; Control), T_2 (Recommended Fertilizer Dose, N_{140} $P_{20\ (from\ TSP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha), T_3 (N_{140} $P_{20(from\ DAP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha), T_4 (N_{100} $P_{20(from\ TSP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha), T_5 (N_{100} $P_{20\ (from\ DAP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha), T_6 (N_{140} $P_{15(from\ TSP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha), T_7 (N_{140} $P_{15(from\ DAP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha), T_8 (N_{180} $P_{10(from\ TSP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha) and T_9 (N_{180} $P_{10(from\ DAP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha). BRRI dhan89 was used as a test crop for the experiment. The experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. Results showed that longest plant (108.92 cm), the highest number of effective tillers hill^{-1} (13.54), the maximum number of filled grains panicle^{-1} (166.66), weight of 1000 grains (26.38 g), grain yield (8.48 t ha^{-1}) and straw yield (10.90 t ha^{-1}) were observed from treatment, T_5 (N_{100} $P_{20\ (from\ DAP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha). The lowest results on the respected parameters were found from T_1 (No fertilizer; control). The highest value of the N and K content in post-harvest soil was obtained from treatment $_9$T (N_{180} $P_{10(from\ DAP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha) and T_1 (No fertilizer; control) treated soil showed the lowest.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF PLATES

LIST OF ABBREVIATIONS AND ACRONYMS

BARI	=	Bangladesh Agricultural Research Institute
AEZ	=	Agro-Ecological Zone
BCR	=	Benefit cost ratio
BBS	=	Bangladesh Bureau of Statistics
cm	=	Centimeter
m	=	Meter
DAT	=	Days after sowing
M. S.	=	Master of Science
et al	=	and others (*at elli*)
VC	=	Vermicompost
SAU	=	Sher-e-Bangla Agricultural University
Kg/ha	=	Kilogram/hectare
g	=	Gram
ml/l	=	Milliliter per liter
LER	=	Land Equivalent Ratio
m^2	=	Meter squares
LSD	=	Least Significant Difference
CV%	=	Percent of coefficient of Variation
MoP	=	Muriate of Potash
PGR	=	Plant growth regulator
RCBD	=	Randomized Complete Block Design
TSP	=	Triple Super Phosphate
t/ha	=	ton/hectare
%	=	Per cent

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.) belongs to cereal crops under Poaceae family, is second most widely grown cereal and primary source of food for more than half of the world population. Rice (*Oryza sativa* L.) is the most important food in tropical and subtropical regions (Singh *et al*., 2012). Rice is grown in more than a hundred countries with a total harvested area of nearly 170 million hectares, producing more than 800 million tons every year (FAO, 2020). Rice production and consumption is concentrated in Asia, where more than 90% of all rice is consumed (FAO, 2020). Rice grain is rich in nutrients and contains a number of vitamins and minerals. Rice provides 21% of global human per capita energy and 15% of per capita protein (IRRI, 2010). Rice contributes on an average 20% of apparent calorie intake of the world and also 30% of Asian populations (Hien *et al*., 2006). Among the rice growing countries, Bangladesh occupies third position in rice area and fourth position in rice production (BRRI, 2020). It plays a vital role in the economy of Bangladesh providing significant contribution to the GDP, employment generation and food availability. The climatic and edaphic conditions of Bangldesh are favorable for rice cultivation throughout the year.

Total rice production in Bangladesh was about 10.97 million tons in 1971 when the country's population was only about 70.88 million whereas the country is now producing about 36.60 million tons rice to feed her 162.3 million people as staple food (BBS, 2020). Rice is grown in Bangladesh under diverse ecosystem, irrigated, rainfed and deep water condition in three distinct seasons namely aus, aman and boro. The area and production of total rice in Bangladesh are about 28.21 million hectare and 36.60 million metric tons, respectively where boro covers the largest part of about 11.76 million hectare with the production 19.64 million metric tons (BBS, 2020). The population of Bangladesh is still growing by two million every year and may increase by another 30 million over the next 20 years. It is generally estimated that about 114 million tonnes of additional milled rice will be produce by 2035 which is equivalent to overall increase of 26 percent in the next 25 years (Kumar and Ladha, 2011). Rice production area is decreasing day by day due to high population pressure. The possibility of horizontal expansion of rice production area has come to stand still (Hamid, 1991). As it is not possible to have horizontal expansion of rice area so, rice yield unit^{-1} area should be increased to meet this ever-increasing demand of food. Therefore, increase of boro rice production would be a significant possible way to overcome food deficiency in the country.

Among the production factors affecting crop yield, nutrient is the single most important factor that plays a dominant role in yield increase if other production factors are not limiting. It is reported that chemical fertilizers today hold the key position to enhance crop production (BARC, 1997). Judicious and proper use of fertilizers can markedly increase the yield and improve the quality of rice (Youshida, 1981). There is need to develop appropriate management technique to evaluate the performance and to assess the nutrient requirement for rice cultivation in the country. Phosphorous is the second key plant nutrient (next to nitrogen). TSP (Triple super phosphate) was one of the first high analysis P fertilizer that becomes widely used. It is an excellent P source, but its use has declined as other P fertilizer such as DAP (Diammonium phosphate) has become more popular and is being extensively used in some areas of the country. DAP is a two-nutrient fertilizer. It contains 18% (N) and 20% (P). Thus an understanding of the efficiency of the fertilizer P would provide a basis for consideration of economic response of crops to different P fertilizers.

In Bangladesh soil there is usually deficiency in phosphorus. There are many reasons behind this such as, first, phosphorous does not occur abundantly in soil as N and K. Total content of P in topsoil varies between 0.02% and 0.10% (Tisdale *et al*., 1999). Second, the native P compounds are mostly unavailable for plant uptake. Third, where P fertilizer is added to soils, the element is soon changed to insoluble forms. It is needed greatly by young fast growing tissue of plants and performs a number of functions related to growth, development, photosynthesis and utilization of carbohydrates (Tandon 1987). Brady and Raymond (2017) reported that P makes its contribution through its favorable effect on i) Cell division, fat and albumin formation, ii) flowering and fruiting, including seed formation, iii) crop maturation, thus counteracting effects of excess N application, iv) root development, particularly of the lateral and fibrous rootlets, v) strength of straw in cereal crops, thus help to prevent lodging, vi) crop quality, especially of forages and of vegetables and vii) Resistance to certain diseases. Phosphorus has a marked beneficial impact on seedling establishment, root biomass and days of flowering (Raju *et al*., 1997). Ortega and Rojas (1999) also reported that P application decreased floret sterility. An adequate supply of P is associated with greater strength of cereal straw (Sanches, 1976).

An increase in yield of rice by 70-80% could be obtained by the application of nitrogen. Application of P to rice on P-deficient soil increased rice root growth, number of panicles and grain weight of rice (Fageria and Gheyi 1999). Diammonium phosphate (DAP) is the world's most widely used phosphorus fertilizer. It is an excellent source of P and nitrogen (N) for plant nutrition. It's highly soluble and thus dissolves quickly in soil to release plant-available phosphate and ammonium (Dobermann *et al*., 1998). With balanced fertilization, yield was increased primarily due to an increase in recovery and agronomic efficiency. The rate of fertilizer application is important however, depends on duration and type of crop variety, the season in which the crop is grown, management practices, assimilating capacity of the variety, soils and the expected goal (Islam, 1986). Response of rice to P fertilizer was observed up to 60 kg/ha (E & R project, 1981, Bhargava *et al*., 1985).

Literature indicates that phosphorus deficiency is a major constraint for successful crop production for various reasons: i) it is not always possible to apply the entire P at the time of transplanting of rice as required (Rao *et al*., 1974), ii) basal application of P fertilizer becomes difficult on rainfed rice, if early rains are scanty or surplus and iii) many farmers in this country often ignore P application because P is not manifested usually by a remarkable colour changes as happened in case of N. P-fixation is more in TSP and less in DAP. However, when the farmers fail to apply all inputs at the time of transplanting, usually drop to or use less amount of P and N resulted imbalance fertilizer application and all together produced lower rice yield. Under such circumstances, it is appropriate to know the optimum dose. This research will give a comprehensive idea on this issue.

Based on the above all mentioned situation the present study was conducted for fulfilling the following objectives:

- To evaluate the efficiency of DAP as a source of P and N on the growth and yield of BRRI dhan89.

- To observe the comparative performance of DAP based P and TSP based P with growth and yield of BRRI dhan89.

CHAPTER II

REVIEW OF LITERATURE

Phosphorus is an essential major plant nutrient. It is involved in the supply and transfer of energy for all the biochemical processes in rice plants. It stimulates carly root growth and development, encourages more active tillering, promotes early flowering maturity and good grain development. It is an essential conponent of deoxyribonucleic acid (DNA), the inheritance characteristics of living organisms (Miller and Donahue, 1997). Due to the lack of phosphorus, cell division slows down, the leaf colour changes to dark green, stem becomes more slender, the whole plant becomes dwarfed, heading and ripening is also inhibited (Ishizuka, 1978). An adequate supply of P early in the life of a plant is important in the development of its reproductive parts. Large quantities of P are found in seed and fruit and it is considered essential for seed formation. An adequate supply of P is associated with greater straw strength in cereals (Tisdale *et al*., 1999). Moreover, sufficient P nutrition of riçe is essential for production of optimum grain yields. A good number of research works on rice and its response to different fertilizer treatments have been carried out in different rice growing countries of the world by numerous researchers. They showed that the growth, yield, yield contributing characters and biochemical composition of rice plants are influenced by the nutrient elements applied to soil in the form of fertilizer. But sufficient literature is not available on the efficiency of different phosphatic fertilizers viz. triple super phosphate (TSP), and di-ammonium phosphate (DAP) on growth, yield and yield contributing characters and biochemical composition of rice plants. Scientific results from different studies pertinent to the present research work have been reviewed and discussed in this chapter.

In order to evaluate some growth and yield indicators of rice (cv. Anber 33) towards the various fertilizer treatments (DAP fertilizers and Nano fertilizers), a field experiment was implemented by Al-Khuzai and Al-Juthery (2020). The experiment consisting of two factors, as the first factor represented by DAP fertilizer source consisted of four treatments (Control, M-DAP, O-DAP + micronutrients and O-DAP high K), while the second factor consisting of spraying Nano fertilizers consisted of four treatments (Control, Nano silicon, Nano complete and Nano silicon + Nano complete). The studied indicators on the rice plant included chlorophyll content in leaves

(SPAD unit), plant height (cm), biological yield (ton h^{-1}), grains yield (ton h^{-1}), harvest index (%), fertilization efficiency for production (%). Results showed the superiority of O-DAP + micronutrients fertilizer in achieving the highest chlorophyll content in leaves, biological yield, grains yield and fertilization efficiency for production compared with M-DAP fertilizer which achieved the highest mean of plant height, as well as O-DAP high K fertilizer which achieved the highest mean of harvest index.

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 Boro 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 (EH1 and EH2) used P more efficiently than inbred varieties. A negative P balance was observed up to 10 kg P ha^{-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. The Fe-P treatment significantly decreased plant dry weight, P uptake per plant, and P concentration in plant dry matter of all cultivars in comparison with the control plants.

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.

The Experiment was carried out at Sher-e-Bangla Agricultural University, Dhaka during the period of November, 2010 to May 2011 to study the influence of levels of nitrogen and phosphorus on the growth and yield of hybrid Heera-1. There were six nitrogen fertilizer levels *viz.*, N_0=no nitrogen, N_1=80 kg N ha^{-1}, N_2=urea supergranules (2.7 g) @ 75 kg N ha^{-1}), N_3=120 kg N ha^{-1}, N_4=160 kg N ha^{-1}, N_5=200 kg N $ha^{-1}$and four phosphorus fertilizer levels *viz.*, P0=no phosphorus, P_1=30 kg P_2O_5 ha^{-1}, P_2=50 kg P_2O_5 ha^{-1} and P_3=70 kg P_2O_5 ha^{-1}. Numerically the highest number of grain yield (7.58 t ha-1) was observed with P_2 (50 kg P_2O_5 ha^{-1}), straw yield (9.61 t ha^{-1}) at P_1 (30 kg P_2O_5 ha^{-1}), biological yield (16.92 t ha^{-1}) at P_2 (50 kg P_2O_5 ha^{-1}) followed by P_1 (30 kg P_2O_5 ha^{-1}) (16.72 t ha^{-1}) and harvest index at P_2 (50 kg P_2O_5 ha^{-1}).

A field experiment was conducted by Alam *et al.* (2009a) at the Agronomic field of the Sher-e-Bangla Agricultural University to study the relative performance of inbreed and hybrid rice varieties at different levels of P. Three varieties of inbreed and hybrid (BRRI dhan 48, Aloron and Hira 2) and five levels of P were used as treatment. They reported that plant height, penicle length and growth rate varied significantly due to variation of P.

Fageria and Baligar (1997) carried out an experiment to evaluate on the growth and P use efficiency of 20 upland rice cultivars at low (0 mg P kg^{-1}), medium (75 mg P kg^{-1}) and high (150 mg P kg^{-1}) levels of applied P on an Oxisol. Plant height tillers, shoot and root dry weight, shoot-root ratio were influenced significantly by the application of P.

Alam *et al.* (2009b) carried out an experiment at the Agronomy Field of the Sher-e-Bangla Agricultural University, Dhaka during the period from December, 2006 to June, 2007 to study the relative performance of inbred and hybrid rice varieties at different levels of phosphorus. Three varieties of inbred and hybrid rice (BRRI dhan 29, Aloronand Hira-2) and five levels of phosphorus-(0, 24, 48, 72 and 96 Kg P_2O_5 ha^{-1}) were the treatment variables. They reported that tiller production differed significantly with the application of P fetrilizer and 72 kg P_2O_5 ha^{-1}

showed to produce better tiller production and fertility. Tiller production also differed significantly with the application of phosphorus fertilizer. An application of 72 kg P_2O_5 ha^{-1} showed to produced better tiller production and fertility. Plants grown without added phosphorus gave the lowest tiller production.

A field experiment was conducted by Bhowmick and Nayak (2000) during dry (boro) seasons of 1996-97 and 1997-98 on a lowland alluvial soil (Entisol) in West Bengal, India to study the performance of hybrids (CNHR 2 and CNHR 3) and high-yielding cultivars (IR 36 and IR 64) of rice (*Oryza sativa*) at 5 levels of NPK fertilizer (0:0:0, 120:60:60, 150:75:75, 180:90:90) + 30 $ZnSO_4$ kg/ha. CNHR 2 recorded more panicles (413.4/m^2) and filled grains/panicle (111.0), and higher moderate test weight (21.0 g), grain (7.1 t/ha) and straw (6.95 t/ha) yields. Grain and straw yields increased with increasing level of nutrition for hybrids up to a rate of 180:90:90 + 30 $ZnSO_4$ kg/ha, and for high-yielding cultivars up to 120:60:60. The highest benefit:cost ratio was obtained at 150:75:75 by CNHR 2.

Akinrinde and Gaizer (2006) six rice (*Oryza sativa* L) varieties were evaluated for their P nutrition capability at 0, 50, 100, 150 and 200 mg kg^{-1} levels of P applied in an Alfisol. They found that plant height, number of tillers, as well as dry matter and yields were significantly ($P < 0.01$) influenced by P application rates.

A field experiment was conducted by Fageria and Filho (2007) during two consecutive years to determine dry-matter and grain yield, nutrient uptake, and P-use efficiency of lowland rice (*Oryza sativa* L.). Phosphorus rates used in the experiment were 0, 131, 262, 393, 524, and 655 kg P ha^{-1} applied as broadcast through termophosphate yoorin. Dry-matter yield of shoot and grain yield were significantly ($P<0.01$) and quadratically increased with P fertilization.

Fageria *et al.*, (2011) conducted a field experiment for two years consecutive with the objective to evaluate 12 lowland rice genotypes for P use efficiency. The P rates used were 0, 22, 44, 66, and 88 kg P ha^{-1} (0, 50, 100, 150 and 200 kg P_2O_5 ha^{-1}). There were significant and quadratic responses of genotypes to phosphorus fertilization. Adequate P rates for maximum grain yield varied from genotype to genotype. However, across 12 genotypes, maximum grain yield was obtained with the application of 54 kg P ha^{-1}. Shoot dry weight and panicle number was also increased significantly with increasing P rates in the range of 0 to 88 kg P ha^{-1}. These two plant parameters were positively associated with grain yield. Agronomic efficiency (kg grain produced per kg P applied) was significantly decreased with increasing P rates in the range of 22 to 88 kg P ha^{-1}.

The agronomic efficiency of four phosphate sources (tripol superphate, ordinary Yoorin thermophosp hate, coarse of yoorin thermophosphate and North Carolina phosphate rock) were evaluated by Brasil *et al.* (2002). The soils received three rates of phosphorus (40, 80 and 120 mg P kg^{-1} of soil) plus the control treatment. The results showed the highest dry matter was obtained in soils fertilized with triple superphosphate.

Mahato *et al.*, (2007) conducted a field experiment at farmer fields in dry season, from June to September 2006 with six NPK compound dosages (0, 50, 100, 150, 200 and 250 kg NPK ha^{-1}). Results showed that increasing rate of NPK compound significantly affected the grain number panicle-1, unfilled grain percentages, 1000 grain weight and grain yield. The highest grain yield was found by appling 100 kg Urea + 250 kg NPK compound, following by 82.5 kg N + 37.5 kg P_2O_5 ha^{-1}+ 37.5 kg K_2O ha^{-1}.

Mondal *et al.* (2003) conducted a field experiment to investigate the effect of P application on rice cv. IET-5656- lathyrus cv. The treatments comprised 4 fertilizer management levels, i.e. fertilizer application as per farmers practice (40:20:20 kg N: P_2O_5:K_2O ha-1) to rice and no fertilizer application to lathyrus (T_1); 100% of recommended dose of fertilizer (RDF) both rice and lathyrus (T_2); 100% of RDF to rice + recommended dose of P for lathyrus to rice (T_3) and RDF for lathyrus + recommended dose of P for rice to lathyrus at sowing (T_4). The RDF for rice was 80:40:40: kg N: P_2O_5:K_2O ha^{-1} and that for lathyrus was 10:20:20 kg N: P_2O_5:K_2O ha^{-1}. They reported that highest number of effective tiller m^{-2} (425.0), number grains panicle-1 (92.8) of rice were obtained from T_3 treatment.

In pot trials by Jiang *et al*. (1999) on whitish lacustrine soil, rice was given 0, 2, 4, 6 and 8 kg P_2O_5 mu^{-1}. The total number of panicles and 1 grain number $panicle^{-1}$ increased with up to 6 kg P_2O_5 mu^{-1}.

Shah (2002) examined the P deficiency in control plots caused stunted growth with limited tillers and decreased filled spikelet percentage panicle^{-1}.

A field experiment was conducted by Dwivedi *et al*. (2006) in Uttar Pradesh, India in a silt loam soil to evaluate the effect of nitrogen, phosphorous and potassium levels on growth yield and quality (protein) of hybrid rice (*Oryza sativa*). Optimum nitrogen level was found to be 184.07 kg ha^{-1}. In case of phosphorus and potassium, higher doses each of 80 kg ha^{-1} P_2O_5 and K_2O were found to be better to obtain higher production and good quality (protein) of hybrid rice. The maximum grain yield was recorded with 200 kg N ha^{-1}, 80 kg P_2O_5 ha^{-1}and 80 kg K_2O ha^{-1}.

A field experiment was carried out with rice cv. Jia-9312 by Iqbal (2004) in China, involving P at 0, 40 and 60 kg ha^{-1}under irrigated conditions. He stated that a positive effect on rice biomass and grain yield for P application was observed which varied from 5.8 to 7.8 t ha^{-1}.

Saiti *et al*. (2005) conducted an experiment to evaluate three traditional and three improved cultivars which were grown under four fertilizer treatments: no added fertilizer, nitrogen only (90 kg N ha^{-1}), phosphate only (50 kg P ha^{-1}), and N and P (NP) at three locations. Applying only P gave no effect on grain yield, and applying P with N increased grain yield only by 0.5 t ha^{-1}over N application alone on average over all cultivars at all locations.

Alvi *et al.* (2004) reported that paddy grain and straw yields were influenced significantly by the application of P. Application of 50 kg P_2O_5 gave the higher yield following by 100 kg P_2O_5 ha^{-1}.

Kendaragama *et al.* (2003) conducted an experiment to investigate the seasonal and long- term influence of rice crop on the availability of soil P in relation to five rates of triple super phosphate application (0, 25, 75 and 100 kg P_2O_5 ha^{-1}) in well drained, imperfectly drained and poorly drained soil. This study indicates that practice of correct P supply is needed for sustaining available P status in soil and crop yield although rice does not immediately respond for irregularities phosphate fertilizer application.

Singh (2003) conducted a field experiment under rainfed condition in Jharkhand, India during to establish the relationships between plant P and grain yield of upland rice cv. Kalinga III grown on red upland soils. He reported that rice yield varied significantly due to P fertilizer.

Nadeem and Ibrahim (2002) carried out a study to determine the P requirement of rice crop grown after wheat, under submearsed condition. Rice crop was 100 kg P_2O_5 and 120 kg N ha^{-1} and highest paddy yield was obtained from the treatment where 37.5 kg (50%) P was applied. It showed that when wheat received its recommended dose of P then for rice only 50% of the recommended rate (75%) is enough to achieve the optimum yield of rice.

Zubaida and Munir (2002) conducted an experiment on phosphorus fertilizer on rice. They found that phosphorus application by P-starter (20 kg SP36 ha^{-1}) is more economical and more benefit over phosphorus application of 100 kg SP36 ha^{-1} and reduce fertilizer application 80 kg SP36 ha-1 and gave yield of paddy rice 4.236 and 4.320 t ha-1 respectively.

Lal *et al.* (2002) conducted a field experiment to study the individual and interactive effects of P (0, 11, 22, and 33 kg ha-1) and Zn (0, 6 and 12 kg ha^{-1}) on the yield and P uptake of lowland rice. They reported that maximum grain yield (33.35 q ha^{-1}) and P uptake (10.06 kg ha^{-1}) were observed with the combined application of 33 kg P and 12 kg Zn ha^{-1}. Available P in soil samples after harvest increased considerably with increasing rates of P and Zn application.

Annadurai and Palaniappan (1998) in afield trial India in monsoon season, rice was given 0, 9.5, 19 or 38 kg P_2O_5 ha^{-1} with or without spraying 2% diammonium phosphate (DAP) at 2-3 growth stages. Grain yield increased significantly with up to 19 kg P_2O_5 ha^{-1} and was increased by DAP application with no significantly difference between treatment schedule.

Rao and Shukla (1997) conducted a field trial with rice cv. Sarjoo 52 grown with given 13, 26 or 39 kg P ha^{-1} as ammonium polyphosphate, urea nitric phosphate or diammonium phosphate, in combination with 15, 30 or 45 kg ZnSO4 ha^{-1}. They stated that grain yield in both years increased with increasing P rate also with 30 kg ZnSO4 ha^{-1}. Yield was highest when P was applied as applied as ammonium polyphasphate.

Chen *et al*. (1997) conducted a field experiment at the Rice Research Institute of Yunnan Agricultural University, on soils low in P and Zn and rice cultivers-Xunza 29, hexi 35 and Yungeng 34 were given 0 or 5 kg Zn ha-1 and 60, 150 or 200 kg P ha^{-1}. Application of Zn and P significantly increased yield.

Field experiments were conducted by Sahrawat *et al.,* (1995) for three years to study the response of sorghum to fertilizer P applied at 0, 10, 20 and 40 kg P ha^{-1}, and its residual value in a Vertisol, very low in extractable P (0.4 mg P kg^{-1} soil), at the ICRISAT Center, Patancheru (near Hyderbad), India. The phenology of the sorghum crop and its harvest index were greatly affected by P application. The days to 50% flowering and physiological maturity were significantly reduced by P application as well as by the residues of fertilizer P applied in the previous season. In the first year of the experiment, sorghum grain yield increased from 0.14 t (no P added) to 3.48 t ha^{-1} with P added at the rate of 40 kg P ha^{-1}. Phosphorus applied in the previous year was 58% as effective as fresh P but P applied two years earlier was only 18% as effective as fresh P.

Heenan and Batten (1986) reported that P deficiency symptom occurred in rice when it was grown annually for several years without P fertilizer, They reported that the rice growth and grain yield increased significantly upto application of 20 kg P/ha.

Chaudhury *et al*. (1987) reported that the results of a pot experiment where 0, 20, 40 and 60 mg/kg soil of both P and S were applied to paddy grown under low land conditions, it increased the P and S content in soil, their uptake and yield. The grain: straw and P: S uptake increased up to 40 mg level of each P and S but N. S uptake ratio increased up to 00 and 40 mg level of P and S application, respectively.

Five long-term field trials were conducted at the BRRI Station to determine the appropriate frequency of P fertilizer application. For soils where P availability is marginal (Olsen P just around 10 ppm). P fertilizer application to every alternate crop of Boro-fallow T-aman sequence may be as good as that to each crop. In this case application of P increased grain yield significantly by about 02 to 1.4 t/ha over control. Soils with moderate to high available P contents, Olsen P 15 ppm or more may require even a less frequent P application for optimum rice yield (BRRI, 1988)

Kumar and Sing (2001) reported that the significantly response of rice to P was observed only up to 26.2 kg ha^{-1} and application of P in all seasons recorded maximum rice equivalent yield (79.6 q ha^{-1}) which was at par with treatment receiving P in both year rabi (70.8 q ha^{-1}) and treatment receiving in first year kharif and rabi (70.8 q ha^{-1}).

Saha *et al.* (2004) conducted an experiment to create and compare a suitable fertilizer recommendation model for lowland rice. Five different fertilizer recommendation models were tested and compared with one check plot. Results show that the application of different packages estimated by different fertilizer models significantly influence panicle length, panicle numbers, spikelet number per panicle, total grains panicle^{-1}, number of filled grain and unfilled grain per panicle. The combination of NPK that gives the height result was 120-13-70-20 kg ha^{-1} NPKS.

Awan *et al.* (2003) in an experiment observed that the application of N P and K significantly increased the crop yield and maximum paddy and straw yield were obtained from plot fertilized @ 120-100-75 kg NPK ha Harvest Index was highest at control, N physiological efficiency index and N fertilizer efficiency decreased with increasing N levels. Similarly, P physiological efficiency index decreased while P fertilizer efficiency increased with increasing P levels.

Slaton *et al.* (2002) studied the rice response to P fertilizer applied at different times and they established field studies in six commercial rice fields. Three rates of P (9.8. 19.6, and 39.1 kg P ha^{-1}) were applied at four different times during the growing season including preemergence (PRE), preflood (PF). 5 to 10 post food (POF), or at midseason (MS) and compared with an untreated control. Significant grain yield increase was measured at two of the six locations. Grain yields were maximized by application of 19.6 kg P ha^{-1} at the two highly responsive sites with yield increases of 24 to 41%. Application of P fertilizer PRE, PF, and POF were superior to MS applications, which were not different from the control. Phosphorus concentration in harvested grain was not affected by time or rate of P fertilizer application. The average grain P content represented 56 to 75% of the total P in the above ground portion of rice at physiological maturity. Broadcast applications of p fertilizer-to the soil surface between seeding and active tillering were equally effective at increasing rice yields and optimizing puke on the P delicine soils.

Mehdi *et al.* (2001) indicated that the grain and straw yields, concentration in grain and P uptake by grain and straw increased significantly over control by the application of different sources of phosphorus. All the sources remained at par with each other in all the characteristics studied. However a careful scrutiny of the data showed maximum grain and straw yields. P concentration in grain and straw and P uptake by grain and straw with TSP followed by SSP. NP and DAP. ISP appeared a better source of phosphorus in mildly saline sodic soil.

Tripathi *et al.* (2001) conducted a pot experiment to study the effects of various levels of P on the grain and straw yields and on the uptake of P, S, Mn and Fe by rice. They concluded that increasing levels of P significantly enhanced the yield as well as uptake of P, S and Mn whereas it adversely affected Fe uptake and high P level combined with pudding and submergence significantly increased P uptake.

Asif *et al.* (2000) reported that NPK levels significantly increase the panicle length, number of primary and secondary branches panicle-1 when NPK fertilizer applied in 180-90-90 kg ha-1 this might be attributed to the adequate supply of NPK.

Uddin *et al*. (2001) conducted a field experiment in a silt loam soil to compare the effect of N, P and K fertilizers on the yield and nutrient uptake by rice and post-harvest soil properties. Application of fertilizers significantly increased the grain and straw yields of rice. Panicle length, effective tillers hill' and filled grains panicle' were also increased significantly due to application of fertilizers but the increase of 1000 grain weight was insignificant. Grain yield was highest with (Urea + Triple super phosphate+ Ash) treatment (5.46 t ha^{-1}) which was followed by (Urea + Triple super phosphate + Muriate of potash) treatment (5.30 t ha^{-1}), while the lowest was in control. The grain yields were increased by 47.01 to 68.0% over control due to application of fertilizers. The results on straw yield reflected similar trend as in grain yield. Application of fertilizers caused a significant increase during N, P, K and S uptake by rice. The application of fertilizers had a negligible influence on pH, CEC, organic matter, total N, available P, exchangeable K, and available S content of the post-harvest soils compared to their initial status.

A field experiment was conducted by Kamran *et al*. (2018) to investigated the impact of different P sources (DAP (Diammonium Phosphate), NP (Nitrophos), TSP (Triple Super Phosphate) and SSP (Single super phosphate)) on growth, yield and yield component at two maize varieties (Azam vs. Jalal) at Dargai Malakand during summer. They reported that application of DAP delayed than other P-sources, application of TSP increased plant height, number of grains ear-1, thousand grains weight, biological and grain yields.

Moula (2005) conducted an experiment on T. aman rice. He found that when four treatments (P0, 60 kg ha-1 PR, 60 kg ha^{-1} TSP and 210 kg ha^{-1} PR) were applied. 210 kg PR Showed better performance on yield contributing characters and nutrient content as well as nutrient uptake by rice over other treatments.

Selvi *et al*. (2003a) studied the effects of inorganic P fertilizers (Udaipur phosphate rock or Rajphos. Mussoorie phosphate rock and diammonium phosphate) applied singly or in combination with Pongamia glabrata as green leaf manure (GLM, 6.25 t ha^{-1}) with or without phosphobacteria (2.0 kg ha^{-1}) on the yield of rice cv. ADT 36. Rajphos up to 32.72 kg P ha^{-1} was as effective as diammonium phosphate in increasing rice grain yield but was more effective than Mussoorie phosphate rock, at all levels. Rajphos at 21.82 and 32.73 kg P ha-1 + GLM + phosphobacteria resulted in grain yields which were comparable to those obtained with diammonium phosphate at 21.82 kg P ha.

Selvi *et al*. (2003b) conducted a field experiment to investigate the effect of organic (phosphobacteria and green leaf manure) and inorganic P fertilizers (Diammonium phosphate. Mussoorie phosphate rock and Rajphos) on soil fertility and rice yield in a rice-pulse system. The benefit-cost ratio was highest (2.7) with the application of

Rajphos at 32.73 kg ha^{-1}, followed by DAP at 32.73 kg ha^{-1} green leaf manure phosphobacteria (2.5).

Brasil *et al*. (2002) evaluated the agronomic efficiency of four phosphate sources (triple superphosphate, ordinary yoorin thermophosphate, voorin thermophosphate and north Carolina phosphate rock) in rice production. The results showed that the best dry matter yield and P uptake for rice were obtained from soils fertilizers with triple superphosphate.

Chien (2002) evaluated available P with the use of phosphate rock (PR) for direct application and triple superphosphate (ISP) for crop production. The results showed that the effectiveness of P sources in terms of increasing dry matter Vield and P uptake followed the order of ISP-(PR-ISPPR for rice. P uptake from PR in the presence of TSP was higher than P uptake from PR applied alone. With respect of P. uptake from PR due to ISP influence was 165% for rice.

Alam and Azmi (1989) carried out an experiment with rice variety IR8 and IR6. Phosphorus fertilizers were applied @ 0, 40, 80 and 120 kg ha^{-1}. They stated that dry matter yield, plant height and number of tillers were significantly increased with the increasing rate by P. The further reported that the concentration of N, P, K, Fe, Cu and Mn was increased significantly with P.

Subbian *et al*. (1989) carried out an experiment on rice applying 30, 60 or 90 kg P_2O_5 ha^{-1}, in 3 forms and obtained paddy yields of 4.85-5.12. 5.10-5.27 and 5.23-5.65 t ha^{-1} respectively compared with 3.90-4.06 t ha^{-1} without P. The increasing P rates increased N, P and k uptake. There was no significant difference in vields and nutrient uptake with P applied in three forms.

A field experiment involving different P fertilizer rates (0, 10, 20, 30, 40, 50 and 60 kg P ha^{-1}) was conducted by Hadgu *et al.* (2013) to determine effect of P on maize (*Zea mays* L.) growth, yield, N and P uptakes and P use efficiency. They reported that application of 30 kg P ha^{-1} significantly ($P \leq 0.01$) increased maize grain yield, total above ground N and P uptakes, grain N and P uptakes and P harvest index. At this P level, grain yield increased by 1074 kg ha^{-1} (54.8%) over the control plot. Soil P at harvest has also significantly ($P \leq 0.01$) increased as applied P increased from 0 to 60 kg P ha^{-1}. Significant ($P \leq 0.05$) increments were also observed on plant height, maize ear length and total above ground dry matter weight at 40 kg P ha^{-1} and on shoot P uptake at 30 kg P ha^{-1} over the control. However, no significant ($P > 0.05$) differences were observed on shoot dry matter weight, number of grains per ear, harvest index and shoot N uptake. Phosphorus use efficiencies of maize were also observed to decrease with increasing levels of applied P. At the optimum application rate of 30 kg P ha^{-1}, observed P agronomic and P utilization efficiencies of maize were 28.7 and 32.1 kg kg^{-1}, respectively.

Saleque *et al.* (1998) conducted a field experiment on an Aerie Haplaquept soil to study the effect of phosphorus (P) deficiency in soil on the P nutrition and yield of five modern varieties of rice, viz., Purbachi, BR1, BR3, BR14, and BR29, popular with the rice farmers of Bangladesh. They reported that phosphorus deficiency in soil drastically reduced the grain yield of all the rice varieties. Rice yield increased linearly with an increase in soil P content up to 6 ppm, and the highest grain yield for any variety, obtained at 6–7 ppm of soil-available P leveled off at this point. Soil P deficiency not only decreased rice yield severely but also decreased P content in straw and grain drastically. However, differences among rice varieties were noted in P nutrition, particularly at low soil P levels.

Baskar *et al.* (2000) noted that phosphorus exists mainly as Fe-P in rice soils. They reported that in single super phosphate (SSP) and diammonium phosphate (DAP) treated soils, the applied P converted mainly to Al-P and Fe-P and while in Mussorrie rock phosphate (MRP) treated soils, applied P remained mainly as Ca-P. The response of rice to applied P was observed upto 60 and 90 kg P_20_5 ha^{-1}, but the higher rates showed no beneficial effect. P availability to rice did not differ significantly among different kinds of fertilisers, except on very acidic or very alkaline soils. Split application of phosphorus (basal and top dressing at tillering) was beneficial for Rabi (winter) rice. Foliar spray of DAP 2% at boot leaf, 50% flowering and milky stage increased the rice grain yield during Kharif (rainy) season. They also observed that it is necessary to apply higher doses of P fertilisers during cooler months of the Rabi season.

Yasmin *et al*. (2020) conducted an experiment at Regional Agricultural Research Station (RARS), Jamalpur, Bangladesh during the period of 2018-19 and 2019-2020 to find out suitable phosphorus fertilizer source and application method for higher brinjal production and to increase phosphorus use efficiency. After two years results they revealed that, DAP fertilizer gave superior performance over TSP fertilizer. They observed that the highest average brinjal fruit yield (33.13 t ha^{-1}) was found in DAP application (50 % basal + 50% top dress) compared to TSP (30.05 t ha^{-1}) and the lowest (17.97 t ha^{-1}) came from control treatment. The highest phosphorus use efficiency (433.14 Kg yield/Kg P) and highest phosphorus recovery (28.75%) was also obtained from DAP treatment with highest BCR (3.6) compared to TSP treatment. It was concluded that, splitting application of DAP fertilizer led to an increased of P availability at proper time of demand which effects on growth and yield of brinjal.

This study was conducted by Gökmen and Sencar (1999) to investigate the efficiency of diammonium phosphate (DAP) and triple superphosphate (TSP) as phosphorus (P) sources and the effect of fertilizer application methods on the grain yield, yield components and other characteristics of winter wheat. The research was conducted in the ecological conditions of Tokat–Kazova during the 1990–1991 and 1991–1992 growing seasons. They revealed that DAP produced the higher number of spike, number of seed/ear than TSP. In case of 1000 grain weight and yield DAP was superior to TSP.

Mahadkar *et al.* (1998) carried out a field experiment with rice cultivar Java given 0, 40 and 50 kg P_20_5 ha^{-1} as SSP or DAP. The fertilizer granules were either coated or noncoated. The application of 50 kg P_20_5, as coated DAP produced the highest grain yield of 4.99 t ha^{-1} and highest net return.

Goswami *et al*. (1996) conducted a field experiment during the monsoon and winter seasons at Jorhat, Assam with rice. Culture I was given 30, 60 or 90 kg P_20_5 (ha as single superphosphate (SSP), diammonium phosphate (DAP), mussoorie rock phosphate (MRP) or purulia rock phosphate (PRP). They reported that rice grain yield was highest with 90 kg P_20_5 (2.47 t ha^{-1}). Mean rice grain yields with SSP. DAP, MRP and PRP were 2.33, 2.27.2.14 and 2.09 tha^{-1}, respectively.

Sarkuman *et al.* (1998) carried out a pot experiment to find out the effect of P and S on the yield of rice under flooded condition on a P and S deficient sandy loam soil. The treatments were the combination of 4 levels of P (10, 25, 50 and 100 mg kg^{-1} soil) as ammonium phosphate and 4 levels of S (0, 10, 25 and 50 mg kg^{-1} soil) as ammonium sulphate. Increasing levels of P from 0 to 100 mg kg progressively increased the grain yield 16.90 to 42.50 g pot^{-1}.

Field experiments were carried out by Singh *et al*. (1999) on the effect of sources of phosphorus at three rates of P application (0, 30 and 60 kg ha^{-1}) on growth, grain yield and phosphorus use efficiency of rice and residual effects of the sources and rates of phosphorus on herbage yield of cowpea (dry season). Results revealed that P sources (superphosphate, diammonium phosphate, urea nitrate phosphate and ammonium polyphosphate) did not influence significantly the grain yield of rice or the cowpea fodder yield.

Khandaker, M. M. (2003) conducted an experiment to determine the optimum rate and effect of different time of P application on the growth and yield of rice. Phosphorus application enhances all the growth parameters and increased the grain and straw yields. Application of P @ 30, 45, 60 and 75 kg per ha exerted more or less similar effects on growth parameters. Phosphorus application @ 30 kg per ha produces statistically similar grain and straw yields as well as the total yield compared to those with 45, 60 and 75 kg P/ha, respectively but superior to the plants treated with P @ 15 kg per ha and the control. Different rate of P application exerted strongly positive correlation with grain yield. number of productive tillers per plants, total spikelets per panicle and filled grains per panicle. And also found no significant correlation with 1000-grain weight, plant height and panicle length.

A pot experiment was set up Mujeeb *et al*. (2008) to investigate the effect of application of FYM and DAP on maize, grown in three different soils. They applied diammonium phosphate to supply 80 mg P_2O_5 per kg soil while farmyard manure was added @ 50g pot^{-1}. Shoot dry matter of plants and P uptake were recorded. Physiological and agronomic P efficiencies and apparent P recovery were computed. Results regarding effect of P sources from DAP on yield parameters (shoot dry matter = 17.28g/pot for FYM and 17.76 g/pot for DAP) and various P efficiencies were significantly better (agronomic efficiency FYM 9.91 g/g and 11.13 g/g for DAP) than P sources from FYM.

Iqbal (2017) conducted a field experiment at BRRI, Gazipur and at BRRI regional station, Sonagazi, Feni during Boro season of 2014-15. A new fertilizer, NP compound (NPC) was evaluated and compared the performances with di-ammonium phosphate (DAP). At Gazipur site, phosphorus (P) control plot produced only 1.97 t ha^{-1} grain yield that increased with added P along with two N rates. Highest number of panicle and grain per panicle were found from the DAP treated plots. In case of straw and grain yield highest was found from DAP. At Sonagazi site, application of P either from DAP or NPC could not increase rice grain yields compared to P control plot.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to find out the efficacy of di-ammonium phosphate (DAP) fertilizer for the growth and yield of BRRI dhan89 as boro rice. The details of the materials and methods i.e. location of experimental site, soil and climate condition of the experimental plot, materials used, design of the experiment, data collection and data analysis procedure that used in 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 the period from November 2019 to May 2020 in boro season.

3.1.2 Site description of the experimental plot

The research work was conducted in the experimental area of research farm field, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is $23^0$74/N latitude and $90^0$35/E longitude with an elevation of 8.2 meter from sea level.

3.1.3 Climatic condition

The geographical location of the experimental site was under the subtropical climate which 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 (Edris *et al*., 1979). Details of the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e-Bangla Nagar, Dhaka and details has been presented in Appendix-1.

3.1.4 Soil characteristics of the experimental plot

The soil belongs to “The Modhupur Tract”, AEZ-28 (FAO, 1988). Top soil was Silty Clay in texture. Soil pH was 6.4 and had organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land. The initial soil samples at a depth of 0-15 cm were collected prior to transplanting. The details of the initial soil have been presented in Appendix-2.

3.2 Experimental details

3.2.1 Planting material

BRRI dhan89 was used as the test crop in this experiment. This variety was developed at the Bangladesh Rice Research Institute (BRRI) through crossing between BRRI dhan 29 and *Oryza rufipogon*. It is recommended for boro season and average plant height of the variety is 106 cm. The aromatic grains are small and white. It requires about 154-158 days completing its life cycle with an average yield of 8.0 t ha^{-1}.

3.2.2 Treatment of the experiment

The experiment comprised of single factor:

1. T_1 =No Fertilizer

2. T_2 =Recommended Fertilizer Dose ($N_{140}P_{20(\text{from TSP})}\ K_{70}S_{15}Zn_{1.5}$ kg/ha

3. T_3 =$N_{140}P_{20(\text{from DAP})}K_{70}S_{15}Zn_{1.5}$ kg/ha)

4. T_4 =$N_{100}P_{20(\text{from TSP})}K_{70}S_{15}Zn_{1.5}$ kg/ha

5. T_5 =$N_{100}P_{20(\text{from DAP})}K_{70}S_{15}Zn_{1.5}$ kg/ha

6. T_6 =$N_{140}P_{15(\text{from TSP})}K_{70}S_{15}Zn_{1.5}$ kg/ha

7. T_7 =$N_{140}P_{15(\text{from DAP})}K_{70}S_{15}Zn_{1.5}$ kg/ha

8. T_8 =$N_{180}P_{10(\text{from TSP})}K_{70}S_{15}Zn_{1.5}$ kg/ha

9. T_9 =$N_{180}P_{10(\text{from DAP})}K_{70}S_{15}Zn_{1.5}$ kg/ha

3.2.3 Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications, where the experimental area was divided into three blocks representing the replications to reduce soil heterogenetic effects. Each block was divided into 9 unit plots as treatments with raised bunds around. Thus the total numbers of plots were 27. The size of unit plot was 7 m^2 (3.5 m × 2 m). Layout of the experiment was done on December 14, 2019 with the distances between plot to plot and replication to replication were 0.5 m and 1.0 m, respectively.

3.3 Crop Management

3.3.1 Seed Collection

Healthy seeds of BRRI dhan89 was collected from the Breeding Division, BRRI, Joydebpur, Gazipur.

3.3.2 Sprouting of seed

The seeds were soaked in water in bucket for 24 hours. Then seeds were taken out of water and kept thickly in gunny bags. The seeds started sprouting after 48 hours and became suitable for sowing after 72 hours.

3.3.3 Raising of seedlings

Seedlings were raised on a high land in the south-east side of the Research farm of SAU. Seeds were sown in the seedbed on November 05, 2019 for raising seedlings. The nursery beds were prepared by puddling with repeated ploughing followed by laddering. The sprouted seeds were sown as uniformly as possible. Irrigation was gently provided to the bed as and when needed. Proper care was taken to raise seedlings in the nursery bed. The bed was kept weed free throughout the period of seedling raised.

3.3.4 Collection and preparation of initial soil sample

The initial soil samples were collected before land preparation from a 0-15 cm soil depth. The samples were collected by means of an auger from different location covering the whole experimental plot and mixed thoroughly to make a composite sample. After collection of soil samples, the plant roots, leaves etc. were picked up and removed. Then the sample was air-dried and sieved through a sieve and stored in a clean plastic container for physical and chemical analysis.

3.3.5 Preparation of experimental field

The experimental field was ploughed on December 09, 2019 by three successive ploughing and cross ploughing with a tractor drawn plough and subsequently leveled by laddering. All weeds and other plant residues of previous crop were removed from the field. Immediately after final land preparation, the field layout was made on December 14, 2019 according to experimental specification.

3.3.6 Fertilizer application

The fertilizers N, P, K, S and Zn in the form of urea, TSP, DAP, MoP, Gypsum and zinc sulphate respectively were applied. The one third amount of urea and entire amount of TSP, DAP, MoP, gypsum and zinc sulphate were applied during the final land preparation. Rest urea was applied in two equal installments at tillering and panicle initiation stages.

3.3.7 The uprooting of seedlings

From nursery bed 40 days old seedlings were uprooted carefully on December 14, 2019 and were kept in soft mud in shade**.** The seedbeds were made wet by application of water in previous day before uprooting the seedlings to minimize mechanical injury of roots.

3.3.8 Transplanting of seedlings

Seedlings were transplanted on December 15, 2019 in the well-puddled experimental plots. Spacing was given 25 cm × 15 cm for all the plots. Soil of the plots was kept moist without allowing standing water at the time of transplanting. Two seedlings of BRRI dhan89 were transplanted hill^{-1}.

3.4 Inter-cultural operations

3.4.1 Gap filling

After one week of transplanting gap filling was done to maintain population number. After transplanting the seedlings gap filling was done whenever it was necessary using the seedling from the previous source.

3.4.2 Weeding

Weed infestation was a severe problem during the early stage of crop establishment. The experimental plots were infested with some common weeds. To minimize weed infestation, manual weeding through hand pulling was done three times during entire growing season.

3.4.3 Irrigation and drainage

Irrigation was done by alternate wetting and drying from transplanting to maximum tillering stage. From panicle initiation (PI) to hard dough stage, a thin layer of water (2-3 cm) was kept on the plots. Water was removed from the plots during ripening stage.

3.4.3 Insect and pest control

There was no infection of diseases in the field but leaf roller (*Chaphalocrosis medinalis*) was observed in the field and used Diazinon 60 EC @ 1.12 L ha^{-1}.

3.5 Harvesting and post harvest processing

Maturity of crop was determined when 90% of the grains become golden yellow in color. The harvesting of BRRI dhan89 was done on May 14, 2017. Hills from the central one m2 area of each plot were harvested for collecting data on crop yield. The harvested crop of each plot was bundled separately, tagged properly and brought to the clean threshing floor. The crops were threshed by pedal thresher and then grains were cleaned. The grain and straw weights for each plot were recorded after proper sun drying and then converted into ton $hectare^{-1}$. The grain yield was adjusted at 14% moisture level.

3.6 Data collection on yield components and yield

3.6.1 Plant height

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

3.6.2 Effective tillers hill^{-1}

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

3.6.3 Non-effective tillers hill^{-1}

The total number of non-effective tillers hill^{-1} was 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.

3.6.4 Length of panicle

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

3.6.5 Filled grains panicle^{-1}

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

3.6.6 Unfilled grains panicle^{-1}

The total numbers of unfilled grain was collected randomly from selected 10 plants of a plot on the basis of not grain in the spikelet and then average numbers of unfilled grains panicle-1 was recorded.

3.6.7 Weight of 1000-grain

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

3.6.8 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 to ton hectare^{-1} (t ha^{-1}).

3.6.9 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 ton $hectare^{-1}$ (t ha^{-1}).

3.6.10 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 (10 meshes) sieve. The soil samples were kept in plastic container to determine the physical and chemical properties of soil.

3.7 Post harvest soil analysis

Soil samples were analyzed for both physical and chemical characteristics viz. organic matter, pH, total N and available P, available sulphur and exchangeable K contents. 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 matter

Organic carbon in soil sample was determined by wet oxidation method. The underlying principle was used to oxidize the organic matter with 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 $FeSO_4$ solution. 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 (Page *et al.*, 1982).

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 gm 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 2000C and added 3 ml H_2O_2 and then heating at 3600C 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 10 N 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-B) × N × 0.014 × 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 was determined by 1N NH_4OAc (pH 7) extraction methods and by using flame photometer (Page *et al*., 1982).

3.8 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference due to the application of di-ammonium phosphate (DAP) fertilizer on yield contributing characters & yield of BRRI dhan89, nutrient content in grain & straw and soil properties of post harvest soil. The mean values of all the characters were calculated and analysis of variance was performed by the F (variance ratio) test. The significance of the difference among the treatment means was estimated by the Duncan‟s Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to investigate the efficacy of di-ammonium phosphate (DAP) fertilizer for the growth and yield of BRRI dhan89 as boro rice. Data on different growth parameter, yield contributing characters, yield, nutrient content in grain & straw, nutrient uptake by grain & straw and characteristics of post harvest soil was recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix (IV-VI). The results have been presented and possible interpretations given under the following headings:

4.1 Plant height

Different levels of nutrients showed significant differences on plant height of BRRI dhan89 at harvest (Appendix IV). At harvest, the longest plant (108.92 cm) was observed from $T_5=N_{100}P_{20(\text{from DAP})}K_{70}S_{15}Zn_{1.5}$ kg/ha, the shortest plant (91.48 cm) was recorded from T_1 (No Fertilizer) at same DAT (Figure 1). Data revealed that with the increase of nitrogen fertilizer, plant height increased. Optimum level of nitrogen (N) is essential for vegetative growth but excess N may cause excessive vegetative growth, prolong the growth duration and delay crop maturity with reduction in grain yield. Andrade and Amorim (1996) also observed that increasing level of N increased plant height. Yasmin *et al*. (2020) found that the higher plant height was obtained from DAP treated treatment than TSP treated treatment.

4.2 Number of effective tillers hill^{-1}

Number of effective tillers hill^{-1} of BRRI dhan89 showed statistically significant differences due to different levels of nutrients (Appendix: IV). All the treatments significantly produced higher number of effective tiller per hill over control (T_1 treatment). The maximum number of effective tillers hill^{-1} (13.54) was recorded from $T_5=N_{100}P_{20(\text{from DAP})}K_{70}S_{15}Zn_{1.5}$ kg/ha which was statistically similar (12.98) with T_7, whereas the minimum number (8.05) was found from T_1 (No Fertilizer) treatment which was followed (8.29) by T_4 (Table 1). This result is similar with the findings of Alam *et al.* (2009b). Rahman, M.M. (2007) reported that application of phosphate fertilizer increases tiller number in boro rice.

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

Different levels of nutrients showed significant differences on number of non-effective tillers hill^{-1} of BRRI dhan89 (Appendix: IV). The maximum number of non-effective tillers hill^{-1} (4.36) was found from T_9 ($N_{180}P_{10(from\ DAP)}K_{70}S_{15}Zn_{1.5}$ kg/ha) which was statistically similar with (3.86) T_8 while the minimum number (1.42) was observed from T_1 (No Fertilizer) which is statistically identical (1.78) with T_5 (Table 1). Akinrinde and Gaizer (2006) found similar result.

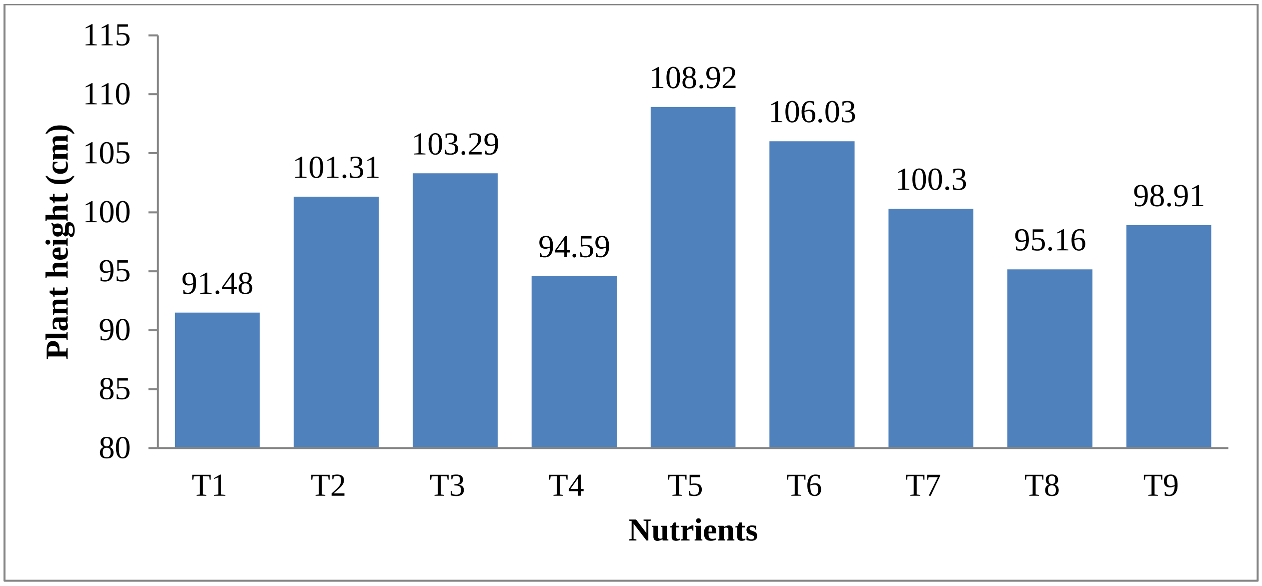

Fig. 1. Effect of nutrients on plant height of BRRI dhan89.

Where, 1. T_1 =No Fertilizer, T_2 =Recommended Fertilizer Dose ($N_{140}P_{20(from\ TSP)}$ $K_{70}S_{15}Zn_{1.5}$ kg/ha, T_3 =$N_{140}P_{20(from\ DAP)}K_{70}S_{15}Zn_{1.5}$ kg/ha), T_4 =$N_{100}P_{20(from\ TSP)}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_5 =$N_{100}P_{20(from\ DAP)}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_6 =$N_{140}P_{15(from\ TSP)}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_7 =$N_{140}P_{15(from\ DAP)}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_8 =$N_{180}P_{10(from\ TSP)}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_9 =$N_{180}P_{10(from\ DAP)}K_{70}S_{15}Zn_{1.5}$ kg/ha

4.4 Panicle length

Panicle length of BRRI dhan89 varied significantly due to the different levels of nutrients (Appendix: IV). The longest panicle (26.79 cm) was found from T_3 which was closely followed (25.12 cm) by T_9 ($N_{180}P_{10(from\ DAP)}K_{70}S_{15}Zn_{1.5}$ kg/ha) while the shortest panicle (21.06 cm) was recorded from T_1 (No Fertilizer) (Figure 2). The plants fertilized with TSP and DAP produced higher panicle length than that for P- control plants. Alam *et al.* (2009a) found similar trend of result they reported that plant height, penicle length and growth rate varied significantly due to variation of P. Yasmin *et al*. (2020) found that application of DAP fertilizer led to an increased of P availability at proper time of demand which effects on growth and yield.

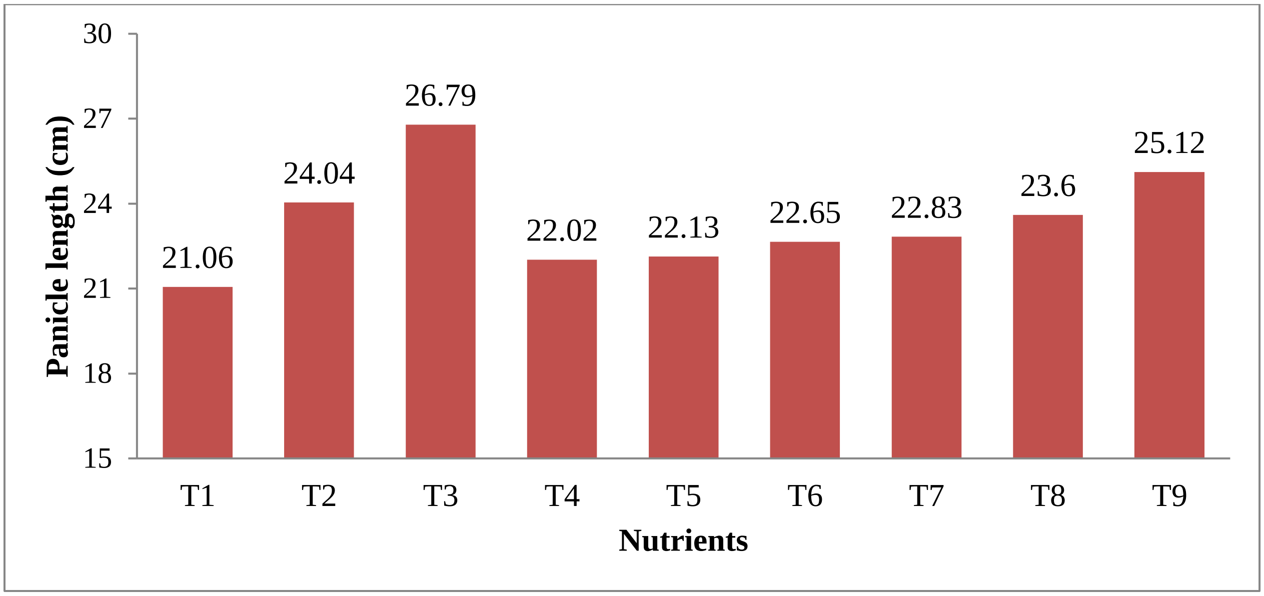

Fig. 2. Effect of nutrients on penicle length (cm) of BRRI dhan89.

Where, 1. T_1 =No Fertilizer, T_2 =Recommended Fertilizer Dose ($N_{140}P_{20(from\ TSP)}$ $K_{70}S_{15}Zn_{1.5}$ kg/ha, T_3 =$N_{140}P_{20(from\ DAP)}K_{70}S_{15}Zn_{1.5}$ kg/ha), T_4 =$N_{100}P_{20(from\ TSP)}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_5 =$N_{100}P_{20(from\ DAP)}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_6 =$N_{140}P_{15(from\ TSP)}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_7 =$N_{140}P_{15(from\ DAP)}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_8 =$N_{180}P_{10(from\ TSP)}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_9 =$N_{180}P_{10(from\ DAP)}K_{70}S_{15}Zn_{1.5}$ kg/ha

Table1. Effect of nutrients on effective tiller and non-effective tiller of BRRI dhan89.

Treatment	Effective tiller	Non-effective tiller
T_1	8.05 e	1.42 d
T_2	10.37 c	3.06 c
T_3	12.14 b	2.63 c
T_4	8.29 de	2.79 c
T_5	13.54 a	1.78 d
T_6	10.15 c	3.18 bc
T_7	12.98 ab	2.92 c
T_8	9.27 cd	3.86 ab
T_9	11.84 b	4.36 a
CV%	6.42	14.36
LSD .05	1.1925	0.7186

Where, 1. T_1 =No Fertilizer, T_2 =Recommended Fertilizer Dose ($N_{140}P_{20(from\ TSP)}$ $K_{70}S_{15}Zn_{1.5}$ kg/ha, T_3 =$N_{140}P_{20(from\ DAP)}K_{70}S_{15}Zn_{1.5}$ kg/ha), T_4 =$N_{100}P_{20(from\ TSP)}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_5 =$N_{100}P_{20(from\ DAP)}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_6 =$N_{140}P_{15(from\ TSP)}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_7 =$N_{140}P_{15(from\ DAP)}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_8 =$N_{180}P_{10(from\ TSP)}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_9 =$N_{180}P_{10(from\ DAP)}K_{70}S_{15}Zn_{1.5}$ kg/ha

4.5 Number of filled grains panicle^{-1}

Different levels of nutrients showed significant differences on number of filled grains panicle^{-1} of BRRI dhan89 (Appendix: V). The maximum number of filled grains panicle^{-1} (166.66) was recorded from T_5 =$N_{100}P_{20(from\ DAP)}K_{70}S_{15}Zn_{1.5}$ kg/ha which was statistically similar with T_7, whereas the minimum number (108.24) was found from T_1 (No Fertilizer) which was followed (129.00) by T_2 and they are statistically similar (Table 2). Mahadkar *et al.* (1998) revealed that, DAP fertilizer gave superior performance over TSP fertilizer which is similar with the findings of this experiment.

4.6 Number of unfilled grains panicle^{-1}

Number of unfilled grains panicle^{-1} of BRRI dhan89 varied significantly due to the different levels of nutrients (Appendix: V). The maximum number of unfilled grains panicle^{-1} (28.37) was recorded from T_9 ($N_{180}P_{10(from\ DAP)}K_{70}S_{15}Zn_{1.5}$ kg/ha) which was statistically similar (24.89 and 24.92) with T_5 and T_2 while the minimum number (12.44) was observed from T_7 (N_{140} $P_{15(from\ DAP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha) which was followed (20.40, 21.22 and 21.22) by T_6, T_1 and T_4 and they are statistically similar (Table 2).

Table 2. Effect of nutrients on filled grain (gm) and un-filled grain of BRRI dhan89.

Treatment	Filled grain (gm)	Un-filled grain (gm)
T_1	108.24 d	21.22 bcd
T_2	129.00 cd	24.89 ab
T_3	135.56 c	19.39 d
T_4	130.00 c	21.45 bcd
T_5	166.66 a	24.92 ab
T_6	136.33 c	20.40 cd
T_7	162.78 ab	12.44 e
T_8	138.55 c	23.33 bc
T_9	143.11 bc	28.37 a
CV%	8.87	10.02
LSD .05	21.338	3.7836

Where, T_1=No Fertilizer, T_2=Recommended Fertilizer Dose ($N_{140}P_{20(from\ TSP)}$ $K_{70}S_{15}Zn_{1.5}$ kg/ha, T_3=$N_{140}P_{20(from\ DAP)}K_{70}S_{15}Zn_{1.5}$ kg/ha), T_4=$N_{100}P_{20(from\ TSP)}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_5=$N_{100}P_{20(from\ DAP)}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_6=$N_{140}P_{15(from\ TSP)}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_7=$N_{140}P_{15(from\ DAP)}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_8=$N_{180}P_{10(from\ TSP)}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_9=$N_{180}P_{10(from\ DAP)}K_{70}S_{15}Zn_{1.5}$ kg/ha

4.7 Weight of 1000 grains

Different levels of nutrients showed significant differences on weight of 1000 grains of BRRI dhan89 (Appendix: V). The highest weight of 1000 grains (26.38 g) was recorded from T_5=$N_{100}P_{20(\text{from DAP})}K_{70}S_{15}Zn_{1.5}$ kg/ha which was statistically similar (25.56 g) with T_7, whereas the lowest weight (19.24 g) was found from T_1 (No Fertilizer) which was followed (20.59 g) by T_4 (Figure 3). Gökmen and Sencar (1999) reported that in case of 1000 grain weight and yield DAP was superior to TSP, which is similar with this result.

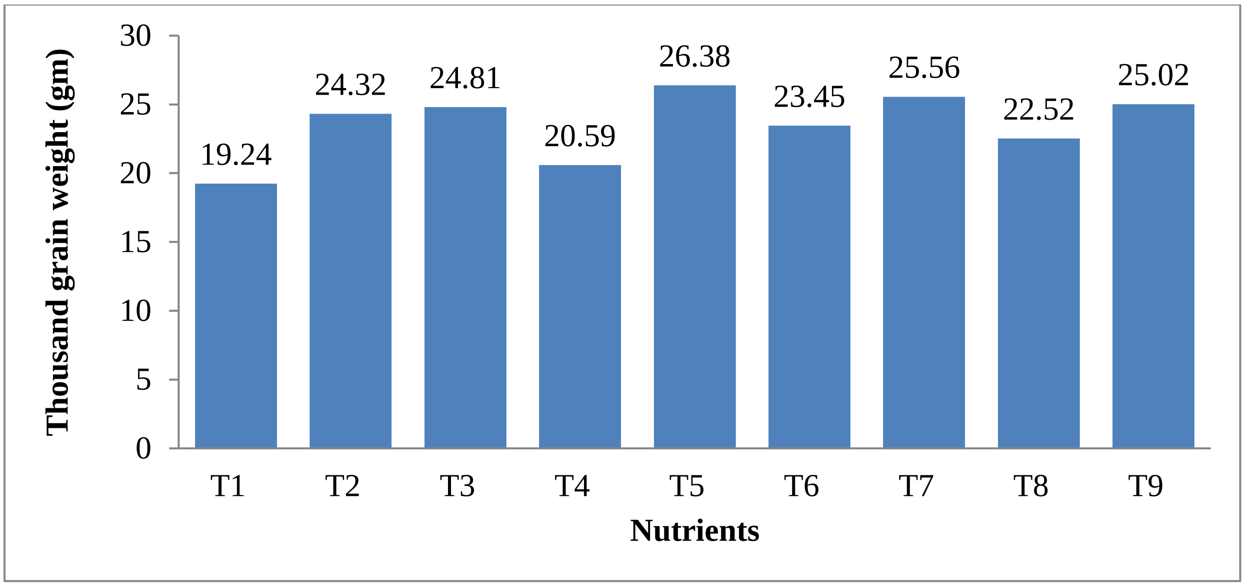

Fig. 3. Effect of nutrients on weight of 1000 grains (gm) of BRRI dhan89.

Where, T_1=No Fertilizer, T_2=Recommended Fertilizer Dose ($N_{140}P_{20(\text{from TSP})}$ $K_{70}S_{15}Zn_{1.5}$ kg/ha, T_3=$N_{140}P_{20(\text{from DAP})}K_{70}S_{15}Zn_{1.5}$ kg/ha), T_4=$N_{100}P_{20(\text{from TSP})}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_5=$N_{100}P_{20(\text{from DAP})}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_6=$N_{140}P_{15(\text{from TSP})}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_7=$N_{140}P_{15(\text{from DAP})}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_8=$N_{180}P_{10(\text{from TSP})}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_9=$N_{180}P_{10(\text{from DAP})}K_{70}S_{15}Zn_{1.5}$ kg/ha

4.8 Grain yield

Grain yield of BRRI dhan89 varied significantly due to the different levels of nutrients (Appendix V). The highest grain yield (8.48 t ha^{-1}) was recorded from T_5 =$N_{100}P_{20(\text{from DAP})}K_{70}S_{15}Zn_{1.5}$ kg/ha which was followed (7.81 t ha^{-1}) by T_7 =$N_{140}P_{15(\text{from DAP})}K_{70}S_{15}Zn_{1.5}$ kg/ha and they were statistically similar, whereas the lowest grain yield (4.64 t ha^{-1}) was found from T_1 (No Fertilizer) (Figure 4). Sahrawat *et al*. (2001) stated that grain yields of the rice cultivars were significantly increased by fertilizer P. In this case application of P increased grain yield significantly by about 02 to 1.4 t/ha over control BRRI (1988). Yasmin *et al*. (2020), Mahadkar *et al*. (1998) revealed that, DAP fertilizer gave superior performance over TSP fertilizer which is similar with the findings of this experiment. Dwibvedi (1997) noticed that application of nitrogen significantly increased in grain yield, straw yield as well as harvest index.

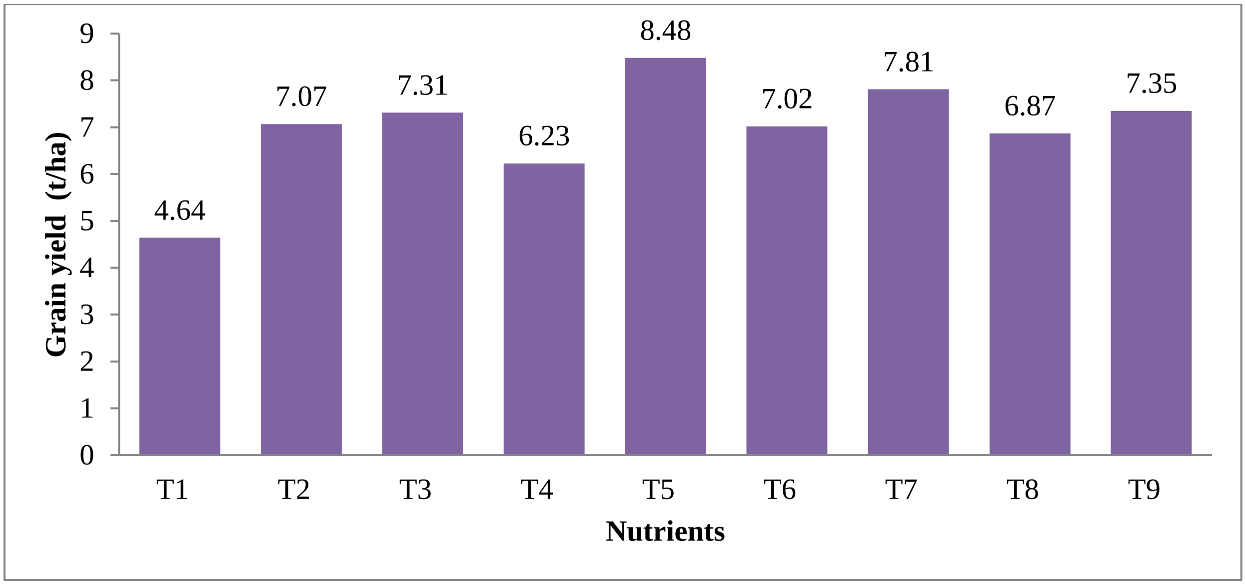

Fig. 4. Effect of nutrients on grain yield (t/ha) of BRRI dhan89.

Where, T_1=No Fertilizer, T_2=Recommended Fertilizer Dose ($N_{140}P_{20(\text{from TSP})}$ $K_{70}S_{15}Zn_{1.5}$ kg/ha, T_3=$N_{140}P_{20(\text{from DAP})}K_{70}S_{15}Zn_{1.5}$ kg/ha), T_4=$N_{100}P_{20(\text{from TSP})}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_5=$N_{100}P_{20(\text{from DAP})}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_6=$N_{140}P_{15(\text{from TSP})}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_7=$N_{140}P_{15(\text{from DAP})}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_8=$N_{180}P_{10(\text{from TSP})}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_9=$N_{180}P_{10(\text{from DAP})}K_{70}S_{15}Zn_{1.5}$ kg/ha

4.9 Straw yield

Different levels of nutrients showed significant differences on straw yield of BRRI dhan89 (Appendix: V). The highest straw yield (10.90 t ha^{-1}) was recorded from T_9 ($N_{180}P_{10(\text{from DAP})}K_{70}S_{15}Zn_{1.5}$ kg/ha) which was followed (9.36 t ha^{-1}) by T_8, whereas the lowest straw yield (6.25 t ha^{-1}) was found from T_1 (No Fertilizer) which was followed (7.63 t ha^{-1}) by T_4 (Figure 5).

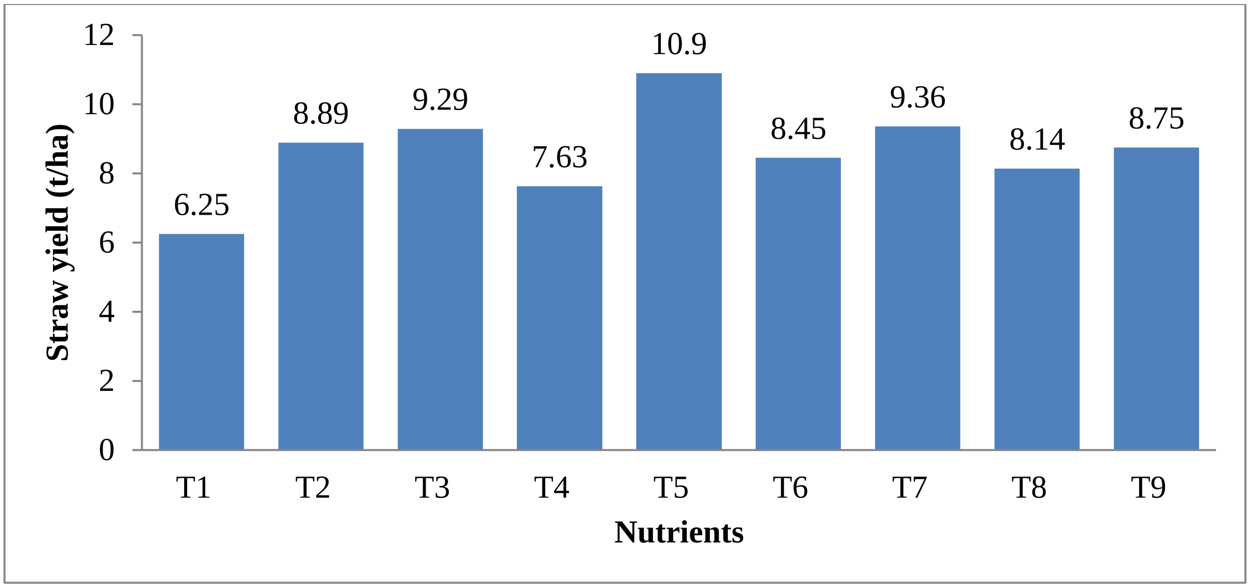

Fig. 5. Effect of nutrients on straw yield (t/ha) of BRRI dhan89.

Where, T_1=No Fertilizer, T_2=Recommended Fertilizer Dose ($N_{140}P_{20(from\ TSP)}$ $K_{70}S_{15}Zn_{1.5}$ kg/ha, $T_3=N_{140}P_{20(from\ DAP)}K_{70}S_{15}Zn_{1.5}$ kg/ha), $T_4=N_{100}P_{20(from\ TSP)}K_{70}S_{15}Zn_{1.5}$ kg/ha, $T_5=N_{100}P_{20(from\ DAP)}K_{70}S_{15}Zn_{1.5}$ kg/ha, $T_6=N_{140}P_{15(from\ TSP)}K_{70}S_{15}Zn_{1.5}$ kg/ha, $T_7=N_{140}P_{15(from\ DAP)}K_{70}S_{15}Zn_{1.5}$ kg/ha, $T_8=N_{180}P_{10(from\ TSP)}K_{70}S_{15}Zn_{1.5}$ kg/ha, $T_9=N_{180}P_{10(from\ DAP)}K_{70}S_{15}Zn_{1.5}$ kg/ha

4.10 pH

Statistically non significant variation was recorded for pH in post harvest soil due to different levels of nutrients (Appendix: IV). The highest pH (6.13) was observed from T_4 (N_{100} $P_{20(from\ TSP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha) whereas the lowest pH (5.70) was found from T_3 (N_{140} $P_{20(from\ DAP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha) (Table 3).

4.11 Organic matter

Statistically non significant variation was recorded for organic matter in post harvest soil due to different levels of nutrients (Appendix: IV). The highest organic matter (1.29%) was observed from T_4 (N_{100} $P_{20(from\ TSP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha), whereas the lowest organic matter (1.15%) was found from T_3 (N_{140} $P_{20(from\ DAP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha) (Table 3).

4.12 Total N

Statistically significant variation was recorded for total N in post harvest soil due to different levels of nutrients (Appendix: IV). The highest total N (0.864 %) was observed from T_9 ($N_{180}P_{10(from\ DAP)}K_{70}S_{15}Zn_{1.5}$ kg/ha) whereas the lowest total N (0.384 %) was found from T_1 (No Fertilizer) which was followed (0.512%) by T_2 (Table 3).

4.13 Available P

Different levels of nutrients showed statistically significant variation was recorded for available P in post harvest soil (Appendix: IV). The highest available P (25.53 ppm) was observed from T_3 (N_{140} $P_{20(\text{from DAP})}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha) which was closely followed (24.95 ppm and 24.75 ppm) with T_5 and T_2 and they were statistically similar whereas the lowest available P (17.42 ppm) was found from T_1 (No Fertilizer) (Table 3).

4.14 Exhalable K

Statistically significant variation was recorded for exchangeable K in post harvest soil due to different levels of nutrients (Appendix: IV). The highest exchangeable K (0.160 me%) was observed from T_9 ($N_{180}P_{10(\text{from DAP})}K_{70}S_{15}Zn_{1.5}$ kg/ha) which were statistically similar (0.156 and 148 me%) with T_8 and T_6, whereas the lowest exchangeable K (0.097 me%) was found from T_1 (No Fertilizer) (Table 3).

Table 3. Effect of nutrients on pH, organic matter (%), total N (%), available P (ppm) and exchangeable K (me%) of BRRI dhan89.

Treatment	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me%)
T_1	5.85	1.16	0.384 h	17.42 f	0.097 c
T_2	5.90	1.17	0.512 g	24.75 ab	0.134 b
T_3	5.70	1.15	0.656 f	25.53 a	0.135 b
T_4	6.13	1.29	0.640 f	24.05 b	0.140 b
T_5	5.95	1.21	0.736 e	24.95 ab	0.147 b
T_6	6.05	1.24	0.774 d	22.88 c	0.148 ab
T_7	5.80	1.25	0.832 bc	23.66 bc	0.141 b
T_8	6.00	1.22	0.800 b	21.09 cd	0.156 ab
T_9	5.95	1.20	0.864 a	20.45 e	0.160 a
LSD(0.05)	NS	NS	0.047	1.032	0.017
CV(%)	2.250	3.75	7.24	4.15	6.75

Where, T_1=No Fertilizer, T_2=Recommended Fertilizer Dose ($N_{140}P_{20(\text{from TSP})}$ $K_{70}S_{15}Zn_{1.5}$ kg/ha, T_3=$N_{140}P_{20(\text{from DAP})}K_{70}S_{15}Zn_{1.5}$ kg/ha), T_4=$N_{100}P_{20(\text{from TSP})}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_5=$N_{100}P_{20(\text{from DAP})}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_6=$N_{140}P_{15(\text{from TSP})}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_7=$N_{140}P_{15(\text{from DAP})}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_8=$N_{180}P_{10(\text{from TSP})}K_{70}S_{15}Zn_{1.5}$ kg/ha, T_9=$N_{180}P_{10(\text{from DAP})}K_{70}S_{15}Zn_{1.5}$ kg/ha

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was conducted at the Research Farm, Sher-e-Bangla Agricultural University, Dhaka during the period from November 2019 to May 2020 in boro season to find out the efficacy of di-ammonium phosphate (DAP) fertilizer for the growth and yield of BRRI dhan89 as boro rice. The experimental field belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28. The soil of the experimental field belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon soil series. The experiment consisted of nine treatments viz.T_1 (No fertilizer; Control), T_2 (Recommended Fertilizer Dose, N_{140} $P_{20\ (from\ TSP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha), T_3 (N_{140} $P_{20(from\ DAP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha), T_4 (N_{100} $P_{20(from\ TSP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha), T_5 (N_{100} $P_{20\ (from\ DAP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha), T_6 (N_{140} $P_{15(from\ TSP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha), T_7 (N_{140} $P_{15(from\ DAP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha), T_8 (N_{180} $P_{10(from\ TSP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha) and T_9 (N_{180} $P_{10(from\ DAP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha). BRRI dhan89 was used as a test crop for the experiment. The experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. The experiment was laid out following split plot design with three replications. There were 27 unit plots. The size of unit plot was 7 m^2 (3.5 m × 2 m). Results revealed that the entire treatments had significant effect on different growth yield and yield contributing parameters and also nutrient content in post-harvest soil.

Results also revealed that the maximum number of non-effective tillers $hill^{-1}$ (4.36), the maximum number of unfilled grains $panicle^{-1}$ (28.37) were observed from treatment,T_9 (N_{180} $P_{10(from\ DAP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha). The longest plant height (108.92 cm), highest number of effective tillers $hill^{-1}$ (13.54), the maximum number of filled grains $panicle^{-1}$ (166.66), maximum weight of 1000 grains (26.38 g), the maximum grain yield (8.48 t ha^{-1}) and the maximum straw yield (10.90 t ha^{-1}) were T_5 =$N_{100}P_{20(from\ DAP)}$ $K_{70}S_{15}Zn_{1.5}$ kg/ha. The longest panicle (26.79 cm) was found from T_3 (N_{140} $P_{20(from\ DAP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha) and the highest pH (6.13) the highest organic matter (1.29%) was observed from T_4 (N_{100} $P_{20(from\ TSP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha). The result also indicated that the highest value of the N and K content in post-harvest soil was obtained from treatment T_9 (N_{180} $P_{10(from\ DAP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha) whereas the highest available P (25.53 ppm) was observed from T_3 (N_{140} $P_{20(from\ DAP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha).

On the other hand, the minimum plant height (91.48 cm), the shortest panicle (21.06 cm), the minimum number of effective tiller hill^{-1} (8.05), the minimum number of non-effective tillers hill^{-1} (1.42), the minimum number of filled grains panicle^{-1} (108.24), lowest weight of 1000 grains (19.24 g), the minimum grain yield (4.64 t ha^{-1}), the minimum straw yield (6.25 t ha^{-1}), lowest total N (0.384 %), lowest available P (17.42 ppm) and the lowest exchangeable K (0.097 me%) parameters were found from T_1 (No fertilizer). While the minimum number of unfilled grain (12.44) was observed from T_7 (N_{140} $P_{15(from\ DAP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha), the minimum pH (5.70), the lowest organic matter (1.15%) was found from T_3 (N_{140} $P_{20(from\ DAP)}$ K_{70} S_{15} $Zn_{1.5}$ kg/ha).

It can be concluded that the treatment T_5 ($N_{100}P_{20(from\ DAP)}$ $K_{70}S_{15}Zn_{1.5}$ kg/ha) gave the best results regarding growth, yield and yield contributing parameters and it can be more beneficial for farmers to get better yield and economic return.

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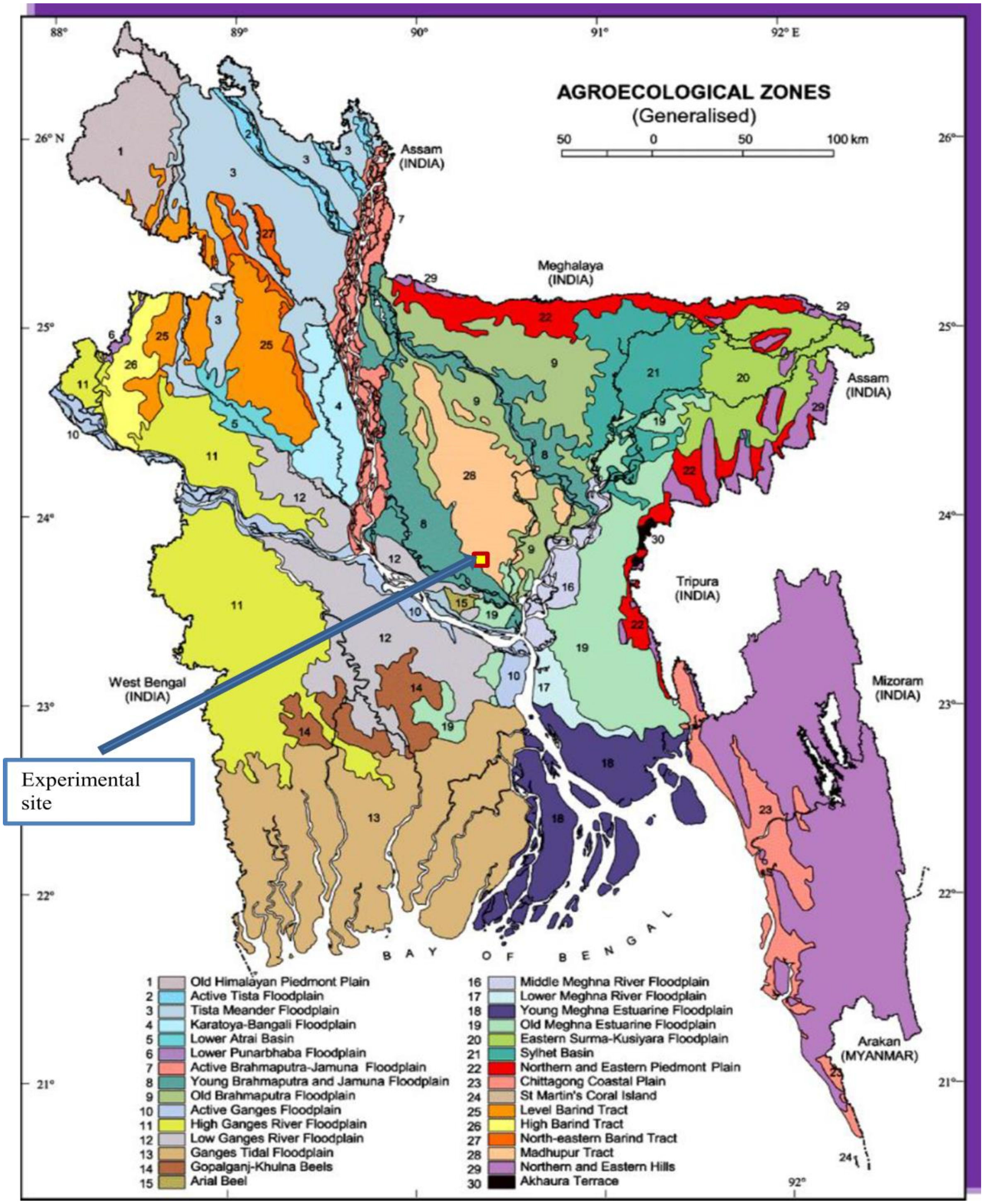
APPENDICES

Appendix-I. Map showing the experimental site



Appendix II:Characteristics of Sher-e-Bangla Agricultural University soil, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Sher-e-Bangla Agricultural
AEZ	Madhupur Tract (28)
General soil type	Shallow Red Brown Terrace Soil
Land Type	High land
Soil Series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Fellow-Tomato

B. Physical and chemical properties of initial soil

CHARACTERISTICS	**VALUE**
Partial Size Analysis	
% Sand	27
% Silt	43
% Clay	30
Textural Class	
PH	5.98
Organic carbon (%)	0.87
Organic matter (%)	1.12
Total N (%)	0.05
Available P (ppm)	20.00
Exchangeable K (me/100 gm soil)	0.12
Available S (ppm)	18

Appendix III: Monthly record of annual temperature, rainfall, relative humidity, soil temperature and sunshine of the experimental site during the period from September 2019 to March 2020 (Site-Dhaka).

Year	Month	Air temperature			Relative humidity (%)	Rainfall (mm)	Sunhine
		Maximum	Minimum	Average			
2019	September	31.35	25.15	28.25	71.02	26	20.33
	October	30.60	24.2	27.40	75.87	04	206.9
	November	29.85	18.50	24.17	70.12	00	235.2
	December	26.76	16.72	21.74	70.63	00	190.5
2020	January	24.05	13.82	18.93	62.04	00	197.6
	February	28.90	18.03	23.46	68.79	09	220.5
	March	32.24	22.10	27.17	78.82	68.5	208.2

Source: Bangladesh Meteorological Department (Climatic Division), Agargaon, Dhaka-1212.

Appendix IV: Analysis of variance of the data on plant height, panicle length, effective tiller, and non-effective tiller BRRI dhan89 as influenced by different nutrients.

Source of variation	Degree of freedom	Mean square			
		Plant height	Panicle length	Effective tiller	Non-effective tiller
Replication	2	2.5897	0.03611	1.2324	0.05908
Different level of nutrients	2	95.6459**	9.27405**	11.9651**	2.50756**
Error	16	2.4998	0.41590	0.4746	0.17234

** **:** Significant at 0.01 level of probability

Appendix V: Analysis of variance of the data on Filled grain, Non-filled grain, Thousand grain weight Grain yield and Straw yield BRRI dhan89 as influenced by different nutrients.

Source of variation	Degree of freedom	Mean square				
		Filled grain	Non-filled grain	Thousand grain weight	Grain yield	Straw yield
Replication	2	10.533	7.6651	0.3689	0.03833	0.55028
Different level of nutrients	2	935.228**	60.2440**	16.8126**	3.47168**	4.92143**
Error	16	151.966	4.7782	0.2920	0.19543	0.52789

** **:** Significant at 0.01 level of probability

Appendix VI: Analysis of variance of the data on pH, organic matter (%), total N (%), available P (ppm), exchangeable K (meq/100 g soil) BRRI dhan89 as influenced by different nutrients.

Source of variation	Degrees of freedom	Mean Square				
		pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me%)
Replication	2	0.017	0.007	0.0002	0.074	0.0001
Different level of nutrients	2	0.077^{NS}	0.009^{NS}	0.110**	17.637**	0.002**
Error	16	0.035	0.007	0.001	2.141	0.001

** : Significant at 0.01 level of probability and ^{NS} : Non-significant

Plate 1: Experimental view

Plate 1: Experimental view

Plate.2 : Harvesting Stage

Plate.3: Processing Stage