EFFECT OF ORGANIC AND INORGANIC FERTILIZERS MANAGEMENT ON GROWTH AND YIELD OF RICE (*Oryza sativa* L.)

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CERTIFICATE

This is to certify that thesis entitled, **Effect of organic and inorganic fertilizers management on growth and yield of rice (*Oryza sativa* L.)** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Department of Soil Science,** embodies the result of a piece of *bona fide* research work carried out by Pranta saha, Registration No. 15-06449 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated: June, 2022
Dhaka, Bangladesh

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Professor Dr. Mohammad Mosharraf Hossain
Supervisor

Dedicated To

My Beloved Parents

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EFFECT OF ORGANIC AND INORGANIC FERTILIZERS MANAGEMENT ON GROWTH AND YIELD OF RICE (*Oryza sativa* L.)

ABSTRACT

A pot experiment was conducted at Sher-e-Bangla Agricultural University to the effect of organic and inorganic fertilizers management on growth and yield of rice (BRRI dhan29). The experiment was set up at the premise of the Department of Soil science at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, during the period from January 2022 to May 2022. BRRI dhan29 was considered as test crops. There were eight treatments combinations consisting of different source of organic and inorganic fertilizer. The treatments were *viz*. T_0: Control (No fertilizer applied); T_1: 100% RDF (RDF=Recommended dose of fertilizer. Here, N_{120} P_{20} K_{40} S_{20} $Zn_{2.5}$ kg/ha); T_2: 100% Cowdung (10ton/ha); T_3: 100% Poultry Manure(5ton/ha); T_4: 75%RDF+25% Cowdung; T_5: 50% RDF+50% poultry manure; T_6: 25%RDF+75% Cowdung; T_7: 25% RDF+75% Poultry manure. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Different data on growth and yield contributing parameters were collected and analyzed statistically. It was observed that most of the parameters varied significantly due to different combination of organic and inorganic fertilizers management. In case of different treatments performance, T_4 (75%RDF+25% Cowdung) treatment showed best performance in BRRI dhan29 cultivation in terms of plant height, tillers per hill, length of leaves (cm), number of effective tillers hill^{-1}, number of non-effective tillers hill^{-1}, filled grains panicle^{-1} , unfilled grains panicle^{-1} and panicle length and yield contributing parameters of rice which was total grains per panicle, percentage of grain sterility, grain yield (t/ha), straw yield (t/ha), biological yield (t/ha) and harvest index (%) of rice. In term of grain yield, the highest grain yield (7.84 ton/ha) was observed from T_1 (no T_4 (75%RDF+25% Cowdung) combination of organic and inorganic fertilizers management treatment which was significantly different from others treatment and closely followed by T_1 (100% RDF (RDF=Recommended dose of fertilizer. Here, N_{120} P_{20} K_{40} S_{20} $Zn_{2.5}$ kg/ha). So, from this study, it can be concluded that among different treatments, T_4 (75%RDF+25% Cowdung) showed best combination of organic and inorganic fertilizers management on growth and supported to make sure the more yield of BRRI dhan29.

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SYMBOLS AND ABBREVIATIONS	ELABORATIONS
%	Percent
et all	And others
J	Journal
No.	Number
Cm	Centimeter
Agric.	Agriculture
ºC	Degree centigrade
Etc.	Etcetera
TSP	Triple Super Phosphate
MP	Muriate of Potash
BARI	Bangladesh Agricultural Research Institute
LSD	Least Significant Difference
RCBD	Randomized Completely Block Design
Res.	Research
SAU	Sher-e-Bangla Agricultural University
Viz.	Namely
@	At the rate of
BRRI	Bangladesh Rice Research Institute
i.e.	That is
BBS	Bangladesh Bureau of Statistics
CV%	Percentage of Co-efficient of Variance
g	Gram
kg	Kilogram
mg	Miligram
t	Ton
Agril.	Agricultural
BARC	Bangladesh Agricultural Research Council
UNDP	United Nations Development Programme
AEZ	Agro-ecological Zones

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa*) is one of the most important staple cereal foods in human nutrition and major food grain for more than one third of the world's population (Karmakar, 2016; FAO, 2003). Rice is grown in more than a hundred countries with a total harvested area of nearly 163 million hectares, producing more than 755 million tons every year (FAO, 2020). In world, 90.6% rice is produced in Asian countries like China, India, Vietnam, Indonesia etc. (FAO, 2020). Rice is an excellent source of carbohydrates containing approximately 87 % in grain. It contains 7 to 8 % of protein, which has higher digestibility, biological value and more nutritious, possesses lower crude fiber and lower fat (1 to 2%). Nearly twenty percent of the world's dietary energy is provided by rice alone, which is higher than either wheat or maize (Sharada and Sujathamma, 2018). The human population is rapidly increasing, and which needs a substantial increase in agricultural productivity worldwide. To feed the world population, productivity must be increased by 70% for an additional 2.3 billion people by 2050 (Tilman *et al.*, 2011).

Rice (*Oryza sativa*) is the most important cereal crop and the staple dietary item for the people in Bangladesh and the agriculture sector of the country is largely dominated by rice cultivation. Bangladesh is now the third largest global rice producing country (USDA, 2020). About 76% of the people live in rural areas, and 40.6% of the total manpower is involved in agriculture. In Bangladesh, agriculture contributes 14.23% of the gross domestic product (GDP) of the country (BBS, 2019). Bangladesh has a long history of rice cultivation. Rice is grown throughout the country except in the southeastern hilly areas. The agro-climatic conditions of the country are suitable for growing rice year-round (Israt *et al.*, 2016). The total area and production of rice are about 11.8 million hectares and 35.30 million metric tons, respectively (FAO, 2020). Rice is cultivated in 71% of net cropped area in Bangladesh (USDA, 2020). The average yield of rice in Bangladesh is 4.53 ton per ha which is comparatively lower than those other

Southeast Asian countries like China, Japan, Korea and Indonesia etc. (USDA, 2020). Due to ever-rising population, food security has become a key concern in Bangladesh. Consequently, maintenance of soil fertility is necessary for sustainable agriculture and future food security (Majumdar *et al*., 2016).

Increasing cropping intensity, use of modern varieties (high yielding varieties and hybrids), cultivation of high biomass potential crops, nutrient leaching and unbalanced fertilizer application, with no or little addition of organic manure have resulted in nutrient mining from Bangladesh soils (BARC, 2018). To stop nutrient mining, it is not justified to increase the use of only inorganic fertilizers but the use of organic sources of plant nutrients viz. cow dung, mustard oil cake, poultry manure, compost, green manure should also be considered. Many farmers use higher number of inorganic fertilizers while they seldom use organic fertilizers e.g. compost, mustard oil cake, poultry manure, cow dung. This practice creates imbalance use of fertilizers, which in turn produces a negative impact on crop production. The beneficial aspects of cow dung, mustard oil cake, poultry manure and compost in increasing crop growth and productivity and maintaining soil fertility have been proven. To increase the efficiency of manure and fertilizer in rice cultivation, it is necessary to identify the suitable combination of manure and fertilizer (Mitu *et al*., 2017).

To achieve the higher yield of rice, inorganic fertilizers were used with little or no addition of organic manure. Even though the inorganic fertilizers were resulted in higher crop yield, over reliance on them associated with declined soil properties and degraded soils and in turn decreased yield in subsequent period (Hepperly *et al*., 2009). In the western world the present farming system totally depends on chemical fertilizers, growth regulators, pesticides for enhancing crop productivity. Several ill effects in human health and environmental hazards were documented due to the use of chemical fertilizer (Padmanabhan, 2013). The most important and essential plant nutrient is nitrogen (N) and will increase the crop yield positively (Salman *et al*., 2012). N is required for all non-legume crops on all soil types. Nitrogen is supplied by indigenous sources such as soil minerals, soil organic matter, rice straw, manure, and water through rain or irrigation. In which crop residues are not returning to land nowadays due to intensive use as animal feed and fuel. Soil organic matter can only be replenished in the short term by the application of organic matter such as manures (Glaser *et al*., 2001).

Therefore, to make the soil well supplied with all the plant nutrients in the readily available form and to maintain good soil health, it is necessary to use organic manures in conjunction with inorganic fertilizers to obtain optimum yields (Rama Lakshmi *et al*., 2012). Organic matter is called the heart of soil and amendments of soil; by applying organic matter solely or in combination with inorganic fertilizers can be a biologically and economically viable approach to maximize rice yield sustainably along with a significant reduction in methane emission from rice fields (Swift, R.S. 1996; Baldock, J. A. and Nelson, P. N., 2000). Applying organic manure such as beef cattle feedlot manure that contains essential nutrients in addition to C for improving soil physical and chemical properties (Eghball, 2002). Application of organic manure in combination with chemical fertilizer has been reported to increase absorption of N, P and K in sugarcane leaf tissue in the plant and ratoon crop, compared to chemical fertilizer alone (Bokhtiar and Sakurai, 2005). The organic and inorganic fertilizer has helped to sustain soil fertility and crop productivity in rice (Nelson, P. N., 2000), mint and mustard cropping sequence with the use of farmyard manure (FYM), NPK and *Sesbania* green manuring (Chand, 2006). Therefore, the present study was undertaken with the following objectives:

i) To investigate the effect of organic and inorganic fertilizers management on growth and yield of (BRRI dhan29) rice, and
ii) To find out suitable combination of organic and inorganic fertilizers for maximum yield of BRRI dhan29.

CHAPTER II

REVIEW OF LITERATURE

Growth and yield contributing characters of rice are considerably depends on manipulation of basic components of crop production. The basic components include variety, environment and cultural practices (planting density, fertilizer, irrigation etc.). Among the factors nutrient management plays a vital role for manipulation of the growth and yield of rice. High yielding varieties (HYV) are generally more adaptive to appropriate nutrient application. For getting more production both organic and inorganic fertilizers should apply in rice field with proper management. The available relevant reviews related to effect of organic and inorganic fertilizers on growth and yield of rice in the recent past have been presented and discussed under the following headings:

2.1. Effect of organic fertilizers on rice production

Application of chemical fertilizers may increase its yield and using rate is rapidly increasing day by day. But the imbalanced and excess use of chemical fertilizers degrades the soil and the environment (Higa 1991). Among this condition, the use of organic amendments with inorganic fertilizers has long been recognized as an effective means of improving soil structure, enhancing soil fertility (Follet *et al.* 1981), increasing microbial diversity and populations (Barakan *et al.* 1995), microbial activity (Zink and Allen 1998), improving the moisture-holding capacity of soils and increasing crop yields.

2.1.1. Effect of cowdung on growth and yield of rice

Lukman *et al.* (2016) reported that the combined application of cow dung and NPK fertilizer significantly increased most of the results obtained with regards to locations compared to the control plots. The growth and yield parameters of rice considered were significantly affected by the treatments except one thousand grain weight. Application of 8 t ha^{-1} of cow dung in combination with 400 kg ha^{-1} NPK 20:10:10 gave the highest grain yield (5.77 t ha^{-1}) at Sokoto and it is recommended that application of 12 t ha^{-1} of cow dung in combination with 300 kg ha^{-1} NPK 20:10:10 resulted in the best soil nutrient enrichment and yield of rice.

Sarkar (2014) found that the application of 75% RD of inorganic fertilizers + 50% cow dung showed superiority in terms of plant height (123.3 cm) and total tillers hill^{-1} (13.87) where those were also highest in combination of BRRI dhan34 × 75% RD of inorganic fertilizers + 50% cow dung. Nutrient management of 75% RD of inorganic fertilizers + 50% cow dung (5 t ha$^{-1)}$ gave the highest grain yield (3.97 t ha^{-1}) and the lowest grain yield (2.87 t ha^{-1}) was found in control. The highest grain yield (4.18 t ha^{-1}) was found in BRRI dhan34 coupled with 75% RD of inorganic fertilizers + 50% cow dung and the lowest grain yield (2.7 t ha^{-1}) was found in BRRI dhan37 in control.

A experiment was conducted by Muktadir (2014) to find out the response of urea and cow dung on two Boro rice varieties under wetland cultivation and result showed that tallest plant (101.40 cm), more effective tillers hill^{-1} (23.90), longest panicle (33.14 cm), more grains panicle^{-1} (219.30), highest 1000–grain weight (33.10 g), highest yield of grain, straw and biological (6.53, 7.96 and 14.49 t ha^{-1}) obtained by application of 3.84 ton cow dung ha^{-1} + 196.0 kg Urea ha^{-1} (V_2T_4) .

Rifat–E–Mahbuba (2013) found that the Application of N as PU, USG alone or in combination with cow dung significantly increased yield components, grain and straw yields of BRRI dhan28 rice. The treatment T_3 (78 kg N ha^{-1} from USG) produced the highest grain yield of 5.85 t ha^{-1} and straw yield of 5.50 t ha^{-1} due to the treatment T_6. The treatment T_2 (104 kg N ha^{-1} from USG) performed better than T_1 and T_4, indicating the superiority of USG over PU. The N, P and K uptake by BRRI dhan28 rice were influenced profoundly due to the application of USG alone or in combination with cow dung. The overall results indicate that application of USG in combination with cow dung could be considered more effective in rice production.

Nyalemegbe *et al.* (2010) found that combining 10 t ha^{-1} of cow dung with 45 kg N ha^{-1} urea gave higher yields comparable to those under high levels of nitrogen application (i.e., 90 and 120 kg N ha^{-1}) applied solely.

Hoshain (2010) conducted an experiment to investigate the effect of cow dung and nitrogen on rice cv. BRRI dhan50. He showed that highest number of effective tillers $hill^{-1}$, number of grain $panicle^{-1}$, grain yield ((6.13 t ha^{-1}) and biological yield were obtained from the combination of 6 t ha^{-1} cow dung with 120 kg N ha^{-1}.

Aziz (2008) reported that effective tillers $hill^{-1}$, panicle length, 1000 grain weight and grain yield were highest in 15 t ha^{-1} cow dung application.

Lawal and Lawal (2002) conducted an experiment to evaluate the growth and yield of low land rice during rainy season in Nigeria to varying cow dung rates and placement method of fertilizer and showed that 1000 grain weight was significantly increased.

Islam *et al.* (2008) showed that the highest plant height (109.49 cm), number of effective tillers $hill^{-1}$ (9.43), number of total tiller $hill^{-1}$ (13.33), grain yield (6.13 t ha^{-1}) and harvest index (46.04%) were obtained from the combination of 50% recommended fertilizer with 5 t ha^{-1} cow dung.

Saleque *et al.* (2004) showed that application of one third of recommended inorganic fertilizers with *5* t ha^{-1} Cowdung increased the low land rice yield than other treatments and gives yield 8.87t ha^{-1}.

Mannan *et al.* (2000) reported that manuring with cowdung (up to 10 t ha^{-1}) in addition to recommended inorganic fertilizers with late Nitrogen application improved grain and straw yield and quality of transplant aman rice over inorganic fertilizer alone.

2.1.2. Effect of poultry manure on growth and yield of rice

A field experiment was conducted by Hoque *et al.* (2018) at two locations i.e. at Soil Science Field of Bangladesh Agricultural University and at Farmer’s field of Fakirakanda village of Mymensingh Sadar to evaluate the effects of different organic fertilizers on the growth and yield of rice (BRRI dhan28). The experiments at each location containing seven treatments were laid out in a randomized complete block design with three replications. The treatments were T_0: Control, T_1: 75% RFD; T_2: 100% RFD, T_3: 75% RFD + Kazi Jaibo Shar (5 t ha^{-1}), T_4: 75% RFD + Kazi Jaibo Shar (3 t ha^{-1}), T_5: 75% RFD + Poultry manure (3 t ha^{-1}) and T6: 75% RFD + Cow dung (5 t ha^{-1}). They reported that application of poultry manure as well as Kazi Jaibo Shar showed positive effects on yield attributes, grain and straw yields of rice, nutrient (N, P, K and S) contents and uptake by grain, straw and in total. The performance of 75% RFD with 3 t ha^{-1} poultry manure was the best in producing yield components, grain and straw yields of rice.

Ali *et al.* (2018) conducted a field experiment to investigate the influence of plant nutrient management on the yield performance of transplant *Aman* rice varieties. Results revealed that among the treatments, USG 1.8 g/4 hills and P, K, S, Zn + poultry manure 2.5 t ha^{-1} exhibited its superiority to other treatments in terms of plant height (131.0 cm), number of total tillers $hill^{-1}$ (10.67), number of effective tillers $hill^{-1}$ (9.13), grains $panicle^{-1}$ (92.71), 1000 grain weight (26.82), grain yield (6.0 t $ha^{-1)}$ and straw yield (8.35 t ha^{-1}).

A field experiment was conducted by Islam *et al.* (2018) at the Soil Science farm of Bangladesh Agricultural University, Mymensingh during the Aman season of 2011 for investigating the integrated effect of prilled urea (PU) and urea super granules (USG) with poultry manure (PM) on field water property, growth and yield of BRRI dhan49. There were seven treatments such asT_1: Control, T_2: 56 kg N ha^{-1} as USG; T_3: 83.5 kg N ha^{-1} as PU; T_4: 56 kg N ha^{-1} as USG+PM (3.0 t ha^{-1}); T_5: 83.5 kg N ha^{-1} as PU+PM (3.0 t ha^{-1}); T_6: 112.5 kg N ha^{-1} as USG; T_7: 165.0 kg N ha^{-1} as PU. They concluded that application of USG in combination with poultry manure produced NH4+-N slowly and steadily due to deep placement by keeping most of the urea nitrogen in the soil and out of the irrigation water. This resulted in continuous supply of available N throughout the growth period of rice plant, which ultimately gave the higher yield. The highest grain yield (5389 kg ha^{-1}) and straw yield (6921 kg ha^{-1}) was produced from T_4 (56 kg N ha^{-1} as USG+PM 3.0 t ha^{-1}).

A field experiment was conducted by Tazmin *et al.* (2015) to evaluate the effect of combined level of poultry manure and NPKS fertilizers on the performance of Boro rice. Results showed that the highest number of total tillers $hill^{-1}$ (14.90), number of non-effective tillers $hill^{-1}$ (4.328), panicle length (20.35), number of grains $panicle^{-1}$ (708.6), number of total spikelets (837.7), grain yield (4.64 t ha^{-1}) and straw yield (5.68 t ha^{-1}) were produced when the crop was fertilized with poultry manure at 2.5 t ha^{-1} with 75% NPKS.

An experiment was conducted by Rouf (2014) in a net house of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from June to November 2013 in aman season to find out effect of fertilizer and manure on the nutrient availability and yield of T. Aman rice in different soil. BRRI dhan33 was used as the test crop in this experiment. The experiment comprised of two factors, Factor A: Soils from two different locations, S_1: SAU soil, S_2: Shingair soil (collected from Shingair Manikgonj) and Factor B: Levels of fertilizers and manures T_0: Control condition i.e. no fertilizers and manures; T_1: Recommended dose of fertilizer ($N_{120}P_{25}K_{60}S_{20}Zn_2$), T_2: 50% NPKSZn + 5-ton cow dung ha^{-1}, T_3: 50% NPKSZn + 5 ton compost ha^{-1} and T_4: 50% NPKSZn + 3.5 ton poultry manure ha^{-1}. Results revealed that the highest grain yield (123.65 g pot^{-1}) was found from T_4 (50% NPKSZn + 3.5-ton poultry manure ha^{-1}), while the lowest grain yield (33.70 g pot^{-1}) was obtained from T_0.

Issaka *et al.* (2014) conducted a field experiment for three years to examine the effects of inorganic fertilizer (IF), poultry manure (PM) and their combinations on rice yield and possible residual effects. In 2011 SPAD values for IF and PM/ IF combinations (except 2.0 t ha^{-1} PM + 22.5-15-15 kg N: P_2O_5: K_2O ha^{-1}) were significantly higher in the sixth week onwards than PM. Number of panicles/plant and number of panicles m^2 were significantly higher for 90-60-60 kg N: P_2O_5: K_2O ha^{-1} and 2.0 t ha^{-1} PM + 22.5-15-15 kg N: P_2O_5: K_2O ha^{-1} than 6.0 and 4.0 t ha^{-1} PM resulting in significantly higher grain yield. Grain yield of IF was similar to grain yield of PM/IF combinations. In 2012 the residual effects showed a significantly higher SPAD value for the 6.0 t ha^{-1} PM. Also 6.0 t ha^{-1} PM, 4.0 t ha^{-1} PM and 4.0 t ha^{-1} PM + 30 kg N ha^{-1} had significantly high number of panicles $plant^{-1}$ and number of panicles m^{-2} than IF. Residual effect of PM applied at 4.0 t ha^{-1} and above gave significantly higher grain yield than IF. Mean grain yield for the three years showed that 4 t ha^{-1} PM + 30 kg N ha^{-1} and 2 t ha^{-1} PM + 22.5-15-15 kg N: P_2O_5: K_2O ha^{-1} gave significantly higher yields than the other treatments.

A field experiment was conducted by Rahman (2013) to study the effect of various organic manures and inorganic fertilizers with different water management on the growth and yield of Boro rice. BRRI dhan29 was used as the test crop in this experiment. 8 levels of fertilizer plus manure, as T_0: Control, T_1: 100% ($N_{120}P2_5K_{60}S_{20}Zn_2$) Recommended dose of Fertilizer, T2: 50% NPKSZn + 5 ton cowdung ha^{-1}, T_3: 70% NPKSZn + 3 ton cow-dung ha^{-1}, T_4: 50% NPKSZn + 5 ton compost ha^{-1}, T_5: 70% NPKSZn + 3 ton compost ha^{-1}, T_6: 50% NPKSZn + 3.5 ton poultry manure ha^{-1} and T_7: 70% NPKSZn + 2.1 ton poultry manure ha^{-1} were used in this experiment. Results showed that the highest grain yield (7.40 ton ha^{-1}) was found from T_7 (70% NPKSZn + 2.1 ton poultry manure ha^{-1}) treatment which was closely similar to T_6 (50% NPKSZn + 3.5 ton poultry manure ha^{-1}) treatment and lowest yield was obtained from T_0 treatment.

Fakhrul Islam *et al.* (2013) studied the fertilizer and manure effect on the growth, yield and nutrient concentration of BRRI dhan28 at Sher–e–Bangla Agricultural University research farm, Dhaka. The T5 (50% RDCF + 4 ton PM ha^{-1}) showed the highest effective tillers $hill^{-1}$, plant height, panicle length, 1000 grain wt., grain yield (5.92 kg $plot^{-1}$) and straw yield (5.91 kg $plot^{-1}$). The higher grain and straw yields were obtained organic manure plus inorganic fertilizers than full dose of chemical fertilizer and manure.

Akter (2011) conducted an experiment and result revealed that the treatment T_4 (75% Urea + 25% N from poultry manure, 2.9 t ha^{-1}) produced the highest grain yield of 6334 kg ha^{-1} and straw yield of 8175 kg ha^{-1}. The lowest grain and straw yields (3112 and 3489 kg ha^{-1}, respectively) were found in control when no nitrogen was not applied from either fertilizers or manures Further, the treatment T_7 (100% Urea +2.0 t ha^{-1} poultry manure) performed better than T_2, T_3,T_5 and T_6 indicating the superiority of poultry manure over cow dung and compost. The N, P, K and S contents and uptake by BRRI dhan29 were profoundly influenced due to application of Urea in combination with cow dung, compost and poultry manure.

Rashid *et al.* (2011) examine the effect of urea– nitrogen, cow dung, poultry manure and urban wastes on growth and yield of transplant *Boro* rice, cv. BRRI dhan29. Among the treatments, T_6 ($N_{50\%}$ + $PM_{50\%}$) produced 43.39% higher number of effective tiller $hill^{-1}$, maximum number of filled grains $panicle^{-1}$ (121), highest weight of 1000 grains (29.30 g), maximum grain yield (5.54 t ha^{-1}) and maximum straw yield (5.89 t ha^{-1}) than control treatment. Application of 47.5 kg N along with 9.5 t poultry manure ha^{-1} produced the maximum panicle length (27.03 cm) with an increase of 18.03 percent over control treatment. The lowest number of filled grains $panicle^{-1}$ (89), lowest weight of 1000 grains (21.17 g), lowest grain yield (3.06 t ha^{-1}) and the lowest straw yield (3.39 t ha^{-1}) was noted in control treatment.

Hossaen *et al.* (2011) studied on the yield and yield attributes of *Boro* Rice due different organic manure and inorganic fertilizer. Results showed at 30, 50, 70, 90 DAT and at harvest stage the tallest plant (24.18, 31.34, 44.67, 67.05 and 89.00 cm) and the greatest number of total tiller $hill^{-1}$ (5.43, 11.64, 21.01 and 17.90) at same DAT was recorded from T_5 (70% NPKS + 2.4 t PM ha^{-1}) and the lowest was observed from T_0 (control) in every aspect. The maximum number of effective tillers $hill^{-1}$ (13.52), the longest panicle (24.59 cm), maximum number of total grain $plant^{-1}$ (97.45), the highest weight of 1000 seeds (21.80 g), the maximum grain yield (7.30 t ha^{-1}) and straw yield (7.64 t ha^{-1}) was recorded from T_5 treatment compared to control (T_0).

An experiment was conducted by Hossain *et al.* (2010) to study the effect of Urea, poultry manure (PM) and cowdung (CD) on the nutrient content and uptake by BRRI dhan29. They stated that application of poultry manure, cowdung and Urea significantly influenced the yield and yield components of BRRI dhan29 and N, P, K and S contents and uptake. The overall results indicate that application of PM 3 t ha^{-1} in combination with N 100 kg ha^{-1} can reduce the use of N fertilizer at a substantial level. The findings of the study suggest that integrated use of manure and fertilizer is more important for sustainable production of BRRI dhan29.

Hasanuzzaman *et al.* (2010) conducted an experiment to observe the comparative performance of different organic manures and inorganic fertilizers on the growth and productivity of transplanted rice. The experiment comprises of 10 treatments viz. T_1 (Control), T_2 (Green manure @ 15 t ha^{-1}), T_3 (Green manure @ 15 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ i.e.50% NPK), T_4 (Poultry manure @ 4 t ha^{-1}), T_5 (Poultry manure @ 4 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ i.e. 50% NPK), T_6 (Cowdung @ 12 t ha^{-1}), T_7 (Cowdung @ 12 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ i.e. 50% NPK), T_8 (Vermicompost @ 8 t ha^{-1}), T_9 (Vermicompost @ 8 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$ i.e. 50% NPK) and T_{10} ($N_{80}P_{12}K_{72}S_{10}$ i.e.100% NPK). They reported that plant characters, yield attributes and yield were significantly influenced by different treatments. Except plant height, total tiller per hills and biological yield all the parameters were found to be highest with the treatment T_5 (Poultry manure @ 4 t ha^{-1} + $N_{40}P_6K_{36}S_{10}$i.e. 50% NPK).

Nyalemegbe *et al.* (2010) found that combining 10 t ha^{-1} poultry manure with 60 kg N ha^{-1}, gave higher yields comparable to those under high levels of nitrogen application (i.e., 90 and 120 kg N ha^{-1}) applied solely.

Rahman *et al* (2009) conducted an experiment to evaluate the effect of Urea in combination with poultry manure and cow dung on BRRI dhan29. Experiment results showed that the application of manures and different doses of Urea fertilizers significantly increased the yield components and grain and straw yields of BRRI dhan29. The treatment receiving N 80 kg ha^{-1} and PM 3 t ha^{-1} produced the highest grain yield of 5567.29 kg ha^{-1} and straw yield of 6991.78 kg ha^{-1}.

Umanah *et al.* (2003) find out the effect of different rates of poultry manure on the growth, yield component and yield of upland rice cv. Faro 43 in Nigeria, during the 1997 and 1998 early crop production seasons. The treatments comprised 0, 10, 20 and 30 t/ha poultry manure. There were significant differences in plant height, internode length, tiller number, panicle number per stand, grain number/panicle, and dry grain yield. There was no significant difference among the treatments for 1000-grain weight.

Channbasavana and Biradar (2001) reported that the application of poultry manure @ 3 t ha^{-1} gave 26% and 19% higher grain yield than that of the control 1998 and 1999, respectively.

2.2. Effect of inorganic fertilizers:

2.2.1. Effect of nitrogen fertilizer on growth and yield of rice

Among the nutrients nitrogen (N) is very important for the production of modern varieties that are responsible for growth, yield and yield contributing characters of rice. N has a noble role on growth characteristics, yield and yield contributing components of rice through the process of photosynthesis, flowering to fruiting and maturity period (Nath, 2018). Nitrogen fertilizers has significant effect for boosting rice yields also recognized widely, particularly after the development of modern varieties. Nitrogen nutrient acts as a major part of protoplasm, protein and chlorophyll. It also plays a remarkable role in increasing cell size which in turn increases yield (Adhikari, 2018). For better grain development it is required to use adequate amount of nitrogen at early and mid-tillering and at panicle initiation stage (Awan, 2011). Excess or low nitrogenous fertilizer addresses some physiological problems which are prolonging growing period, lodging of plants, delayed in maturity, diseases and insect-pests susceptibility and ultimately reduces grain yield (Uddin, 2003).

A experiment conducted by Zhang *et al.* (2020) and the results showed that with the increase of nitrogen dose in a certain range, LAI, plant height, the number of tillers, net photosynthetic rate (NPn), the transpiration rate (Tr), and the grain yield increased while the lodging index (LI), the nitrogen agronomic utilization rate (AE) and nitrogen partial productivity (PFPN) decreased. Additionally, with the increase of nitrogen application, the grain yield index (HI) and nitrogen contribution rate (FCRN) of rice presented a parabolic trend.

Karim *et al.* (2019) conducted an experiment to observe the effect of urea fertilizer on the yield of two Boro rice varieties (BRRI dhan29 and BRRI dhan58). The result showed that plant height influenced due to urea application. Result also showed that longest panicle (21.4 cm), highest grain yield (6.7 t ha^{-1}) and straw yield (7.91 t ha^{-1}) were obtained by application of 300kg urea ha^{-1}.

Elhabet (2018) concluded that Nitrogen is one of constituent of chlorophyll and improves the activity of synthetase enzyme that increases the biosynthesis of chlorophyll. Nitrogen always increases the uptake of both phosphorus and potassium that enhance the nods and buds to emerge more tillers as a result to increase in cell division and elongation.

Yesmin (2016) stated that applications of different forms of N significantly increased the yield components and grain and straw yields of BRRI dhan63. The performance of granular urea was superior to prilled urea. The treatment T_3 (1 USG in between 4 hills) produced the highest grain yield of 6.60 t/ha and straw yield of 7.43t/ha. The lowest grain yield 4.07t/ha and straw yield 4.53t/ha were found in control (T8: No nitrogen fertilizer) treatment.

Islam (2016) demonstrated a field experiment to study the effect of urea and NPK briquette on growth and yield of T. aman rice. The highest grain yield was found from the treatment of 52 Kg N ha-^{1} as one 1.8 g urea briquette/4 hills of rice.

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

Azarpour *et al.* (2014) conducted an experiment on growth and yield of three rice varieties (Khazar, Ali Kazemi and Hashemi) due to the effect of different nitrogen fertilizer. Results of growth analysis indicated that, nitrogen increasing rates of fertilizer caused the increment of growth indexes and yield of rice.

Haque (2013) conducted an experiment to investigate the effect of five nitrogen levels viz. 0, 40, 80, 100 and 140 kg N ha^{-1} and he found the longest plant, highest number of total, effective tillers $hill^{-1}$, grains $panicle^{-1}$, grain and straw yields were observed with 100 kg N ha^{-1} followed by 140 kg N ha^{-1}.

Maqsood *et al.* (2013) reported that the nitrogen application at 100 kg N ha^{-1} provided a maximum paddy yield (4.39 and 4.67 t ha^{-1}) in both years. They also stated that higher paddy yield and yield components, as well as greater economic benefits, can be obtained at 100 kg N ha^{-1} nitrogen application.

Islam *et al.* (2013) concluded that, the highest grain yield (5.42 t ha^{-1}) and straw yield (6.38 t ha^{-1}) were obtained by application two pellets of USG (1.8g)/4 hills and three pellets of USG (2.7g)/4 hills.

Xiang *et al.* (2013) demonstrated a field experiment to study the effect of deep placement of nitrogen fertilizer on growth, yield and nitrogen uptake of aerobic rice. They showed that urea and USG deep placement increased grain yield of aerobic rice by 1.66 t ha^{-1} and the soil significantly reduced nitrogen loss by ammonia volatilization.

Hasanuzzaman *et al.* (2012) conducted an experiment on growth and yield of rice due to evaluate the effect of nitrogen fertilizer viz. 0, 80, 120, 160, 200 kg N ha^{-1}, USG @ 75 kg N ha^{-1}. Results indicated that N had a significant effect on effective tillers $hill^{-1}$, filled grains $panicle^{-1}$ and 1000 grain weight. They also stated that application of nitrogen created significantly variation in grain yield, straw yield, biological yield and harvest index. USG gave the highest yield (9.42 t ha^{-1}) which was followed by 160 kg N ha^{-1} (8.58 t ha^{-1}). The increase in yield by the use of USG and 160 kg N ha^{-1} was 76.74% and 60.98%, respectively over control treatment (zero nitrogen).

Khorshidi *et al.* (2011) reported that the effect of nitrogen fertilizer had no significant difference on 1000 seeds weight and number of grains $panicle^{-1}$. The effect of fertilizers on rice yield showed that application of 100 kg of nitrogen had the highest yield of 5733 kg ha^{-1}. Data also indicated that yield had the highest positive correlation with panicle and harvest index.

Kandil *et al.* (2010) found that the increasing nitrogen fertilizer levels up to 80 kg N ha^{-1} resulted in marked increases in number of tillers m^{-2}, panicle length, panicle weight, filled grains $panicles^{-1}$, 1000 grain weight, grain and straw yields ha^{-1} and harvest index in both seasons. They also stated that addition of 144 kg N ha^{-1} recorded the tallest plants and the highest number of panicles m^{-2}.

Artacho *et al.* (2009) reported that rice plants require nitrogen during their vegetative stage to prime growth and tillering, which will determine the potential number of panicles. In their study, they found an increase in rice yield, panicle density, spikelet sterility and dry matter production, in relation with increased N fertilization; these results are consistent with the findings by several other studies (Djaman *et al.*, 2016; Fageria *et al.*, 2011; Fageria and Baligar, 1999; Fageria and Baligar, 2001; Hirzel *et al.*, 2011).

Ahammed (2008) observed that leaf area increased with increasing level of nitrogen application from 40 kg N ha^{-1} up to 120 kg N $ha^{-1.}$

Salem (2006) reported that the nitrogen levels had a positive and significant effect on growth parameters of rice plants in Boro season. Increasing nitrogen levels up to 70 kg ha^{-1} significantly increased leaf area index and plant height. The highest plant height at harvest was recorded about 92.81 cm when rice plants were fertilized with the highest nitrogen level of 70 kg ha^{-1}. On the contrary, the lowest value of the height was recorded about 80.21 cm when rice plants received no nitrogen fertilizer.

Rahman *et al.* (2005) experimented the different nitrogen level on rice and found that the grain yield of rice was increased with increasing nitrogen levels and the highest yield (4.19 t ha^{-1}) was attained with 150 kg N ha^{-1} while further increase in nitrogen level decreased the grain yield. It was estimated that the grain yield with 150 kg N ha^{-1} was 35.8, 18.9, 5.0 and 6.0% higher than those obtained with 0, 50,100 and 200 kg N ha^{-1} respectively.

Meena *et al.* (2003) reported that between two levels of N 100 and 200 kg ha^{-1}, application of 200 kg ha^{-1} significantly increased the plant height (127.9 cm) of rice and total number of tillers $hill^{-1}$ (16.3).

Bayan and Kandasamy (2002) observed that effective tiller $hill^{-1}$ was significantly affected by the level of N and recommended doses of N (Urea) 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}.

Sarker *et al.* (2001) obtained the nitrogen responses of a *Japonica* (Yumel vitachi) 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 grain and straw yields significantly but harvest index was not increased significant.

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.

2.2.2. Effect of potassium on growth and yield of rice

Potassium is the most abundant nutrient in plants including rice plant. This is especially true for improved cultivars that uptake K considerably up to four-fold higher than native cultivars (Dobbermann *et al.* 1998; Bahmanyar and Mashaee 2010).

Maryam and Ebrahim (2014) conducted an experiment to investigate the effect of nitrogen and potassium fertilizers on yield and yield components of a rice cultivar "Hashemi". The results revealed that the effect of potassium on height and the number of tiller was quite significant and it had significant effect on the number of filled grain. The fertilizer level of 90 kg ha^{-1} possessed the highest yield (5714 kg ha^{-1}). The highest number of tiller (526.7 tillers per m^{-2}) obtained at the fertilizer level of 90 kg ha^{-1} nitrogen with and 150 kg ha^{-1} potassium. The highest number of tiller obtained when 90 kg ha^{-1} nitrogen with 150 kg ha^{-1}

potassium and 90 kg ha^{-1} with 75 kg ha^{-1} potassium were applied to gain 578.3 and 546.7 tillers per m^{-2} , respectively.

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

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

Diba *et al.* (2005) reported a positive effect of K fertilizer use on rice yield contributing parameters.

Bijay Singh *et al.* (2004) stated that potassium (K) removal by rice wheat cropping system in the Indo-Gangetic Plains and in China ranges from 132 to 324 kg ha^{-1} in dependence from the cropping system and the productivity. They also stated that long- term on-farm experiments conducted in different Asian countries indicated that initial rice yield increase due to K application was not significant.

Effect of zinc on growth and yield of rice

Zinc is one of the most important micronutrients essential for plant growth especially for rice grown under submerged condition. Zinc is required in a large number of enzymes and plays an essential role in DNA transcription. To give impetus to the vegetative growth zinc plays a vital role especially under low temperature ambient and rhizosphere regime. Adequate availability of zinc to young and developing plants is certain promise for sufficient growth and development (Singh *et al.* 2012). Zn deficiency is the most widespread micronutrient disorder in lowland rice and application of Zn along with NPK fertilizer increases the grain yield dramatically in most cases (Fageria *et al.*, 2011; Singh *et al.*, 2011).

An experiment was conducted by Kamal *et al.* (2017) to see the effect of K, S and Zn application on the performance of growth, yield and yield contributing characters of BRRI dhan56 under the acidic soil in Sylhet region. Result revealed that all the characters except 1000 grain weight were affected significantly due to application of K, S and Zn. Results also showed that the treatment $K_{80}S_{12}Zn_{1.8}$ produced the highest plant height (100.40 cm), effective tillers hill^{-1} (8.13), longest panicle (27.87 cm) and grains panicle^{-1} (146.60), highest grain yield 4.38 t ha^{-1} and straw yield 6.03 t ha^{-1}.

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

Muthukumararaja and Sriramachandrasekhara (2012) reported that Zinc deficiency in flooded soil is impediment to obtain higher rice yield. Zinc deficiency is corrected by application of suitable zinc fertilizer. The results revealed that rice responded significantly to graded dose of zinc applied. The highest grain (37.53 g pot^{-1}) and straw yield (48.54 g pot^{-1}) was noticed at 5 mg Zn kg^{-1} which was about 100% and 86% greater than control (no zinc) respectively.

An experiment was carried out by Yadi *et al.* (2012) and they used three zinc fertilizer doses viz. 0, 20 and 40 kg ha^{-1}. The results showed that the most panicle number m^{-2} and harvest index had observed in 40 kg Zn ha^{-1} compared to control treatment. The highest zinc content in grain, zinc uptake in grain and straw, and nitrogen uptake in grain were observed in 40 kg Zn ha^{-1}, as the most zinc content in straw, nitrogen, potassium, phosphorus and sulphur content in grain and straw, and nitrogen uptake in straw were observed highest with application of 40 and 20 kg Zn ha^{-1}.

Mustafa *et al.* (2011) conducted a study to evaluate the effect of different methods and timing of zinc application on growth and yield of rice. Experiment was comprised of eight treatments viz., control, rice nursery root dipping in 0.5% Zn solution, $ZnSO_4$ application at the rate of 25 kg ha^{-1} as basal dose, foliar application of 0.5% Zn solution at 15, 30, 45, 60 and 75 days after transplanting. Maximum productive tillers per m^2 (249.80) were noted with basal application at the rate 25 kg ha^{-1} 21% $ZnSO_4$ and minimum (220.28) were recorded with foliar application at 60 DAT @ 0.5% Zn solution. They also stated that Zinc application methods and timing had significantly pronounced effect on paddy yield. Results showed that maximum paddy yield (5.21 t ha^{-1}) was achieved in treatment Zn (21% $ZnSO_4$) as basal application at the rate of 25 kg ha^{-1} and minimum paddy yield (4.17 t ha^{-1}) was noted in Zn (0.5% Zn solution) as foliar application at 75 DAT.

Khan *et al.* (2007) demonstrated a pot experiment to evaluate the effect of different levels of zinc application on the yield and growth components of rice at eight different soil series. Zn as $ZnSO_4.7H_2O$ (21%) was applied as 0, 5, 10 and 15kg ha^{-1} along with the basal doses of 120 kg N, 90 kg P_2O_5 and 60 kg K_2O ha^{-1}. Experiment results showed that the increasing levels of Zn in these soil series significantly influenced yield and yield components of rice.

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

2.2.3. Effect of phosphorus on growth and yield of rice

Phosphorus deficit is a most important restrictive factor in plant growth and recognition of mechanisms that increase plant phosphorus use efficiency is important (Alinajoatisisie & Mirshekari, 2011). Phosphorus is a major component in ATP, the molecule that provides" energy" to that plant for such processes as photosynthesis, protein synthesis, nutrient translocation, nutrient uptake and respiration. Phosphorus is also a component of other compounds necessary for protein synthesis and transfer of genetic material DNA, RNA (Wilson *et al.*, 2006). Phosphorus application to rice increased P accumulation but did not consistently increase rice yields because flooding decreased soil P sorption and increased P diffusion (Delong *et al.*, 2002).

Imrul *et al.* (2016) carried out a field to investigate the influence of nitrogen and phosphorus on the growth and yield of BRRI dhan57. Four levels of nitrogen N_0: 0 kg N ha^{-1}, N_1: 90 kg N ha^{-1}, N_2: 120 kg N ha^{-1}, N_3: 150 kg N $ha^{-1}$and three levels of phosphorous P_0: 0 kg P_2O_5 ha^{-1}, P_1: 25 kg P_2O_5 $ha^{-1}$and P_2: 35 kg P_2O_5 ha^{-1}were used in this experiment. Results revealed that the highest 1000 grain weight (20.85 g), grain yield (4.95 t ha^{-1}), straw yield (5.39 t ha^{-1}) and biological yield (10.34 t ha^{-1}) were found in the treatment combination N_2P_2 and also found highest in each individual under N_2 and P_2 treatments.

An experiment was conducted by Uddin *et al.* (2015) to on the performance study of rice regarding to growth, yield and yield contributing characters of rice BRRI dhan57 under the AEZ-28. The result obtained from the study, it was found that all the traits were statistically significant due to Phosphorus whereas 40 kg P $ha^{–1}$ recorded the tallest plant (109.70 cm) at harvest and maximum tillers $hill^{–1}$ (17.58) at 85 DAT. 40 kg P $ha^{–1}$ also recorded the greater results on effective tillers $hill^{–1}$ (13.67), panicle length (22.04 cm), filled grains $panicle^{–1}$ (138.60), 1000-grain weight (30.75 g), weight of grain, straw and biological yield 5.12, 8.39 and 13.51 t $ha^{–1}$, respectively and harvest index (37.85%) at harvest while without phosphorus obtained the lower results on the above.

A field experiment was conducted by Kabir (2014) to study the performance of BRRI dhan56 regarding to growth, yield and yield contributing characters under the AEZ-28. Experiment concluded that all the traits were statistically significant due to phosphorus whereas the tallest plant (109.70 cm) and maximum tillers hill^{-1} (15.99) was found in treatment P_2 (40 kg P ha^{-1}) at harvest. Treatment P_2 (40 kg P ha^{-1}) also recorded the maximum results on effective tillers hill^{-1} (13.67), filled grains panicle^{-1} (138.60), 1000 grain weight (26.73 g), grain, straw and biological yield (5.12, 8.39 and 13.51 t ha^{-1} , respectively) and harvest index (37.85%) at harvest while P_0 (control) obtained the minimum results on the above traits (7.98, 110.0, 22.83 g, 3.77 t ha^{-1} , 7.05 t ha^{-1} , 10.82 t ha^{-1} and 34.82%, respectively).

Yosef Tabar (2012) demonstrated and experiment in order to investigate the effect of nitrogen and phosphorus fertilizer on spikelet structure and yield in rice (*Oryza sativa*). He used phosphorus fertilizer at 4 level 0 (control), 30, 60 and 90 kg ha^{-1}. Results revealed that increasing the level of phosphorus up to 26.4 kg ha^{-1} also significantly increased the number of spikelets panicle^{-1}. Application of phosphorus increases the total number of spikelets panicle^{-1} in rice thereby contributing to increment in grain yield. Maximum grain and biological yield was (44.70) and (91.20) respectively that observed for 90 kg ha^{-1} phosphorus fertilizer and minimum of these was (36.50) and (76.38) respectively obtained for (control) 0 kg ha^{-1} phosphorus fertilizer. Maximum harvest index was 47.92 observed for 90 kg ha^{-1} phosphorus fertilizer and minimum of that were 47.79 obtained for (control) 0 kg P ha^{-1}.

Panhawar *et al.* (2011) Phosphorus is important for plant growth and promotes root development, tillering and early flowering and performs other functions like metabolic activities, particularly in synthesis of protein. He also stated that phosphorus fertilizer application has been reported to increase upland rice yield.

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. Experiment concluded that application of 10 kg P ha^{-1} significantly increased the grain yield but when 20 and 30 kg P ha^{-1} applied the grain yield difference was not significant. They also stated that for T. Aman optimum and economic rate of P 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 phosphorus balance was observed up to 10 kg P ha^{-1}.

Wilson *et al.* (2006) reported that phosphorus is also a component of other compounds necessary for protein synthesis and transfer of genetic material DNA, RNA.

2.2.4. Effect of sulphur on growth and yield of rice

Sulphur (S) is involved in amino acid and protein synthesis, enzymatic and metabolic activities in plants, which account for approximately 90% of organic S in the plant (Singh *et al.* 2012). Its deficiency is fast emerging in areas under oilseeds and pulses due to higher removal of S by crops (Singh & Kumar, 2009). The sulphur requirement of rice varies according to the nitrogen supply. When S becomes limiting, addition of N does not change the yield or protein level of plants. Sulphur is required early in the growth of rice plants. If it is limiting during early growth, then tiller number and therefore final yield will be reduced (Blair & Lefroy, 1987).

An experiment was conducted by Uddin *et al.* (2015) to study the effect of sulphur on growth, yield and yield contributing characters of rice BRRI dhan57 under the AEZ-28. The result obtained from the study, it was found that 20 kg S ha^{-1} obtained the tallest plant (109.40 cm) at harvest and maximum tillers $hill^{-1}$ (16.28) at 85 DAT. The maximum effective tillers $hill^{-1}$ (12.12), longest panicle (21.35), higher weight of grain, straw and biological yield 4.75, 8.08 and 12.82 t ha^{-1}, respectively and harvest index (36.90%) were taken in 20 kg S ha^{-1} at harvest. It was also observed the minimum non effective tillers $hill^{-1}$ (2.83) and unfilled grains $panicle^{-1}$ (12.04) whereas all the Sulphur levels were produced statistically similar filled grains $panicle^{-1}$ and 1000 grain weight at harvest due to non-significant variation.

An experiment was carried out by Afroz *et al.* (2014) to study the effect of sulphur and boron on growth and yield of aman rice. Experiment concluded that the combined application of S and B significantly increased the number of effective tillers $hill^{-1}$, panicle length, grain and straw yields of rice. The highest number of effective tillers hill^{-1}, the highest panicle length and the highest grain and straw yields were found in 12 kg S + 1 kg B ha^{-1} treatment.

Kabir (2014) conducted An experiment at the Research Field of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, during the period from July, 2013 to December, 2013 to study the performance of BRRI dhan56 regarding to growth, yield and yield contributing characters under the AEZ-28. Results revealed that all the traits were significant except plant height at 55DAT and filled grains panicle$^{–1}$ whereas 20 kg S ha$^{–1}$ obtained the tallest plant (109.40 cm) at harvest and maximum tillers hill$^{–1}$ (14.75) at harvest. The maximum effective tillers hill$^{–1}$ (12.12), 1000 grain weight (27.52 g), grain, straw and biological yield (4.75, 8.08 and 12.83 t ha$^{–1}$, respectively) and harvest index (36.90%) were observed in S_2 (20 kg S ha$^{–1}$) at harvest.

Mondal (2014) conducted an experiment during the period from July to December, 2013 in T. Aman season in the experimental area Agronomy farm field of Sher-e- Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka AEZ No. 28 (The Modhupur Tract) to find out the influence of nitrogen and sulphur on yield of T. Aman rice (BRRI dhan34). In this experiment three different levels of sulphur 0, 8 and 12 kg S ha^{-1} used as treatment. Results showed that the longest plant (114.30 cm) was recorded from 8 kg S ha^{-1}.

A field experiment was conducted by Dixit *et al.* (2012) to study the effect of sulphur and zinc on yield, quality and nutrient uptake by hybrid rice grown in sodic soil and found that application of 40 kg S ha^{-1} recorded significantly high grain and straw yield, protein content and sulphur uptake.

Jawahar and Vaiyapuri (2011) conducted a field experiment to study the effect of sulphur and silicon fertilization on yield, nutrient uptake and economics of rice. The treatments comprised four levels of sulphur 0, 15, 30 and 45 kg ha^{-1} and silicon. Results showed that among the different levels of sulphur, sulphur at 45 kg ha^{-1} recorded higher values for yield (grain and straw) and nutrient uptake (NPKS) of rice, respectively.

Islam *et al.* (2009) conducted a field experiment to evaluate the effects of different rates and sources of sulphur on the yield, yield components, nutrient content and nutrient uptake of rice (cv. BRRI dhan30). They reported that the grain and straw yields as well as the other yield contributing characters like effective tillers hill^{-1}, panicle length, filled grains panicle^{-1} and 1000 grain weight were significantly influenced due to application of sulphur. Results concluded that the highest grain yield of 5293 kg ha^{-1} and straw yield of 6380 kg ha^{-1} were obtained from 16 kg S ha^{-1} applied as gypsum. The lowest grain yield (4200 kg ha^{-1}) and straw yield (4963 kg ha^{-1}) were recorded with S control treatment. The application of sulphur significantly increased N, P, K and S uptake.

2.3. Combined effects of organic and inorganic fertilizers on growth and yield of rice

Tumpa *et al.* (2020) found that the combination of organic and inorganic fertilizers had significant positive effects of on the growth, yield, and yield components of wet season rice BRRI dhan87. Among the treatments, T_4 (N_{83} P_{15} K_{55} S_{10} $Zn_{1.5\ kg\ ha}$$^{-1}$ + 75 kg ha^{-1} mustard oil cake) performed the best to attaining highest yield and harvest index. Moreover, mustard oil cake performed the best compared to poultry manure and Cowdung applied along with chemical fertilizers.

Nyalemegbe *et al.* (2010) found that combining 10 t ha^{-1} of cow dung with 45 kg N ha^{-1}urea, or 10 t ha^{-1} poultry manure with 60 kg N ha^{-1}, gave yields comparable to those under high levels of nitrogen application (i.e., 90 and 120 kg N ha^{-1}) applied solely.

Buri *et al.* (2006) in an experiment with poultry manure, cattle manure, and rice husks, applied solely or in combination with mineral fertilizer (using urea or sulphate of ammonia as N source), found that a combination of a half rate of organic amendments and a half rate of mineral fertilizer significantly contributed to the growth and yield of rice.

Rahman (2001) reported that in rice-rice cropping pattern, the highest grain yield of Boro rice was obtained by NPKS and Zn fertilizer treatment while in T. Aman rice the 75% or 100% of NPKS Zn fertilizers + GM with or without cowdung gave the highest or a comparable yield. Application of cowdung along with NPKSZn resulted in markedly higher uptake of nutrient in Boro rice. In T. Aman rice application of NPKS (SIR) with GM and/or CD showed higher N, P, K, S and Zn uptake. The total N content and the available N, P, K, S and Zn status in soil increased slightly due to manuring. The whole results suggested that the integrated use of fertilizer with manure (*Sesbania*, cowdung) could be and efficient and practice for ensuring higher crop yields without degradation of soil fertility.

Mathew and Nair (1997) reported that cattle manure when applied alone or in combination with chemical fertilizer (NPK) increased the organic C content, total N, available P and K in rice soils.

Sarker and Singh (1997) reported that organic fertilizers when applied alone or in combination with inorganic fertilizers increase the level of organic carbon in soil as well as the total N, P and K contents of soil.

Islam (1995) found a significant yield increase with fertilizers with cowdung compared to N fertilizer alone in T. Aman rice. In the following rice, the yields with N fertilizer and residual of cowdung were higher than N fertilizer alone.

CHAPTER III

MATERIALS AND METHODS

The pot experiment was conducted during the period from January 2022 to May 2022 at the premise of the Department of Soil science, Sher-e-Bangla Agricultural University, Dhaka. The experiment was designed to study the effect of organic and inorganic fertilizers management on growth and yield of Rice (BRRI dhan29). The materials and methods followed in this experiment are presented in this chapter under the following headlines-

3.1. Experimental period

The experiment was conducted at the in front of Soil Science Department of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh in Boro season during January 2022 to May 2022.

3.2. Description of the experimental site

3.2.1. Location of site

The experimental site is geographically situated at 23°77′ N latitude and 90°33′ E longitude at an altitude of 8.4 meter above sea level. The experimental field belongs to the Agro-ecological zone (AEZ) of "The Madhupur Tract", AEZ-28 (BARC, 2018). The morphological, physical and chemical characteristics of the soil are shown in the Tables 1 and 2.

3.2.2. Soil

The soil of the experimental field belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon soil series. Soil pH was 6.7 and has 0.45 percent organic carbon. The land was above flood level and sufficient sunshine was available during the experimental period. Initial soil samples from 0-15 cm depths were collected from the experimental field. The physicochemical properties of the soil in the experimental field are presented in Table 1 and 2.

3.2.3. Climate

The climate of the experimental area under the sub-tropical climate that is characterized by high temperature, high humidity and high 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 to November 2019 have been presented in Appendix II. This was a region of complex relief and soils developed over the Madhupur clay, where floodplain sediments buried the dissected edges of the Madhupur Tract leaving small hillocks of red soils as ‘islands’ surrounded by floodplain.

Table1. Morphological characteristics of the experimental field.

Morphology	**Characteristics**
General Soil Type	Shallow Red Brown Terrace Soil
Parent material	Madhupur clay
Topography	Fairly level
Drainage	Well drained
Flood level	Above flood level

Source: (BARC, 2018)

Table 2. Initial physical and chemical characteristics of the soil

Characteristics	Value
Mechanical fractions: % Sand (0.2-0.02 mm) % Silt (0.02-0.002 mm) % Clay (<0.002 mm)	22.52 56.74 20.74
Textural class	Silt Loam
pH (1: 2.5 soil- water)	6.7
Organic C (%)	0.45
Organic Matter (%)	1.17
Total N (%)	0.07
Available P (mg kg^{-1})	19.83
Exchangeable K (meg /100 g)	0.131
Available S (mg kg^{-1})	14.45

3.3. Planting materials

The variety used as the test crop is BRRI dhan29. The seeds of this variety were collected from Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur. It is a recommended variety of rice which was developed by Bangladesh Rice Research Institute.

3.4. Experimental details

The experiment was conducted to justify effect of organic and inorganic fertilizers management on growth and yield of Rice (BRRI dhan29). Cowdung was applied in the pot @ 10 t ha^{-1} and poultry manure was applied in the pot @ 5 t ha^{-1} during rice cultivation. Recommended dose of fertilizer and combination of organic and inorganic fertilizer also used in pot during cultivation period.

3.5. Experimental design and layout

The pot experiment was laid out single factor following randomized complete block design (RCBD), with three replications. The size of the individual pot was 25 cm diameter and 28cm on height and total numbers of pots were 24.

3.6. Treatments:

There were eight treatments as follows:

1. T_0: Control (No fertilizer applied)
2. T_1: 100% RDF (RDF=Recommended dose of fertilizer. Here, N_{120} P_{20} K_{40} S_{20} $Zn_{2.5}$ kg/ha)
3. T_2: 100% Cowdung (10ton/ha)
4. T_3: 100% Poultry Manure(5ton/ha)
5. T_4: 75%RDF+25% Cowdung
6. T_5: 50% RDF+50% poultry manure
7. T_6: 25%RDF+75% Cowdung
8. T_7: 25% RDF+75% Poultry Manure

3.7. Pot preparation

The pots were filled with the soil of Sher-e-Bangla Agricultural university experiment field. Before filling the soils, the pots are fertilized with the amount of fertilizer per pot were calculated as per treatment mentioned in 3.6.

3.8. Fertilizer Application

Full amounts of TSP, MP, Gypsum and Zinc sulphate were applied as basal dose before transplanting of rice seedlings. Urea were applied in 3 equal splits: one third was applied at basal before transplanting, one third at active tillering stage (30 DAT) and the remaining one third was applied at the time of panicle initiation stage (55 DAT). Fertilizers were applied into the core and outside the core during final land preparation.

3.9. Raising of seedlings

The seedlings of rice were raised wet-bed methods. Seeds (95% germination) @ 5 kg per ha were soaked and incubated for 48 hour and sown on a well-prepared seedbed. During seedling growing, no fertilizers were used. Proper water and pest management practices were followed whenever required.

3.10. Transplanting

Fifty days old seedlings of BRRI dhan29 were carefully uprooted from the seedling nursery and transplanted in 5 March 2022 in well puddle pot. Each pot contained four seedlings. Two seedlings per hill were used following a spacing of 20 cm × 15 cm. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings of same age whenever required.

3.11. 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.

3.11.1. Irrigation

Necessary irrigations were provided to the pots when required during the growing period of rice crop.

3.11.2. Gap filling

Seedlings in some hills were died off and those were replaced by healthy seedling within 10 days of transplantation.

3.11.3. Weeding

The pots were infested with some common weeds, which were removed by uprooting them from the pot three times during the period of the cropping season.

3.11.4. Insect and Pest Control

There was no infestation of diseases in the field but leaf roller (*Chaphalocrosis medinalis*, Pyralidae, Lepidoptera) was observed in the field and was controlled by spraying Malathion @ 1.12 Liter per ha.

3.11.5. Crop Harvest

The crop was harvested at full maturity when 80-90% of the grains were turned into straw colored on September 2022. The crop was cut at the ground level and pot wise crop was bundled separately and brought to the threshing floor. Data on yield attributes and yield parameters were taken from those plants.

3.12. General observations of the experimental field

Regular observations were made to see the days after transplanting of the crop. In general, the crop looked nice with normal green plants which were vigorous and luxuriant in the treatment pots than that of control pots.

3.13. Collection of data

All growth characters data were taken from the extra three replicated growth pots. The sampling data were:-

1. Plant height
2. Number of tillers per hill
3. Number of effective tillers/hills
4. Number of non-effective tillers/hill
5. Number of filled grain/panicle
6. Number of unfilled grain/ panicle

7. Panicle length (cm)
8. Sterility (%)
9. Weight of grain/plant
10. 1000 grain weight
11. Straw yield/ha
12. Grain yield/ha
13. Biological yield, and
14. Harvest Index

3.14. Procedure of taking data

3.14.1. Plant height (cm)

The height of the rice plants was recorded at 25, 50, 75 DAT and at harvest, beginning from the ground level up to tip of the flag leaf was counted as height of the plant. The average height of two hills was considered as the height of the plant for each pot.

3.14.2. Number of tillers per hill

Total tiller number was taken at 25, 50, 75 DAT and at harvest. The average number of tillers of two hills was considered as the total tiller no hill^{-1}.

3.14.3. Effective and non-effective tillers hill^{-1}

Tillers having at least single grain in the panicle were considered as effective tiller.

3.14.4. Number of filled grains and unfilled grain panicle^{-1}

Number of filled grains from 2 hills were counted and average of which gave the number of filled grains panicle ^{1}. Presence of any food material inside the grains was considered a filled grain.

3.14.5. Grain sterility (%)

The grain sterility percentage was calculated by dividing number of unfilled grains with number of total grains and then multiply by 100.

Grain sterility percentage= (Number of unfilled grains / Number of total grains) x 100

3.14.6. Weight of 1000-grain (g)

One thousand cleaned dried grains were randomly collected from the seed stock obtained from 2 hills of each pot and were sun dried properly at 14% moisture content and weight by using an electric balance.

3.14.7. Grain and straw yield (t ha^{-1})

Two hills pot^{-1} were harvested for yield measurement. The crop of each pot was bundled separately, tagged properly and brought to threshing floor and brought to threshing floor. The bundles were dried in open sunshine, threshed and then grains were cleaned. The grain and straw weights for each pot were recorded after proper drying in sun after that the weight was converted to t/ ha.

3.14.8. Biological yield (t ha^{-1})

Biological yield was calculated by using the following formula:

Biological yield = Grain yield + straw yield

3.14.9. Harvest index (%)

Harvest index is the relationship between grain yield and biological yield. It was calculated by using the following formula

Harvest index = (Grain yield) / (Biological yield) ×100

3.15. Statistical analysis

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with a statistical tool Statistix 10.0 and the mean differences were adjusted by Least Significance Difference (LSD) test at 5% level of significance (Gomez and Gomez, 1984).

CHAPTER IV

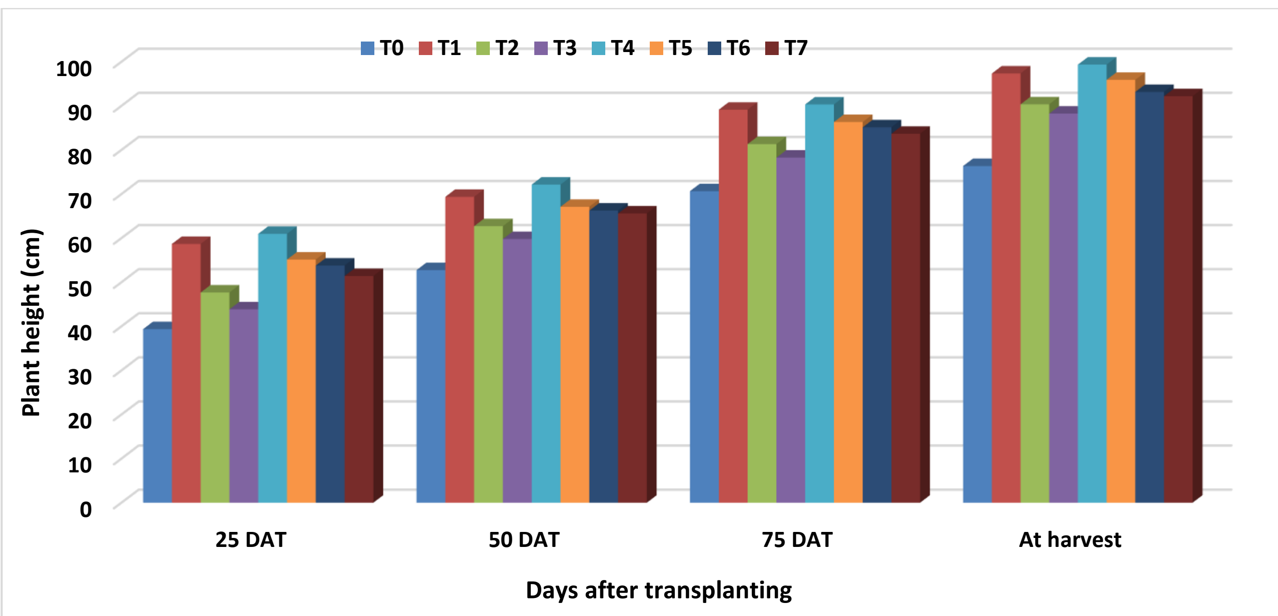
RESULTS AND DISCUSSION

The present study was carried out on the effect of organic and inorganic fertilizers management on growth and yield of Rice (BRRI dhan29). Performance of eight treatments was investigated and the findings of the present study have been discussed under different characters on infestation by insect pest. The result of the study showed marked variation in different characters and the variation of different characters are presented in the following Tables, Figures and Plates.

4.1. Effect of organic and inorganic fertilizers on plant height of rice (BRRI dhan29)

A significant variation was found due to the organic and inorganic fertilizers management on plant height at different days after transplanting (DAT) in figure 1. At the early growth stage (25 DAT), plant height ranged from 39.35 to 60.98 cm. The tallest plant (60.98 cm) was recorded from T_4 which was closely followed by T_1 (58.68 cm), $T_{5,}$ T_6 and T_7. The shortest plant (39.35 cm) was found in T_0 when the crop was not fertilized and it was significantly lower than all other treatments and followed by T_2 and T_3 (figure 1). Similar results were also obtained from Alim (2012) and Islam *et al.* (2007). Ali *et al.* (2001) reported that plant height, total tillers hill^{-1}, leaf area index (LAI), dry matter production and straw yield were influenced by MOC application. But after 50 DAT, it was found in T_4 treatment appeared as (72.14 cm) the tallest height which was closely followed by (69.36 cm) in $T_{2,}$ $T_{5,}$ T_6 and $T_{7.}$ On the other hand, the shortest in height was observed from (57.74 cm) in T_0 which was closely followed by the plants belong to (62.71 cm) T_2 treatment and T_3 treatment. But after 75 DAT, it was found in T_4 treatment appeared as (90.32 cm) the tallest height which was closely followed by (89.12 cm) in T_2 and followed by $T_{5,}$ T_6 and $T_{7.}$ On the other hand, the shortest in height was observed from (70.65 cm) in T_0 which was significantly lower than all other treatments and followed by (62.71 cm) T_2 treatment and T_3 treatment. But after at harvest, it was recorded in T_4 treatment appeared as (99.36 cm) the tallest height which was closely followed by (97.34 cm) in T_2 and followed by T_5, T_6 and T_7. On the other hand, the shortest in height was observed from (76.35 cm) in T_0 which was significantly lower than all other treatments and followed by (90.35 cm) T_2 treatment and T_3 treatment. From the results in **figure (1)** showed significant variations at the total growing stage of BRRI dhan29. Among different treatments, T_4 (75%RDF+25% Cowdung) showed best combination of organic and inorganic fertilizers management on growth and supported to make sure the more yield of rice. As a result, the order of effect of organic and inorganic fertilizers management on growth and yield of rice (BRRI dhan29) in terms of plant heights at total growing stage of rice is $T_4 > T_1 > T_5 > T_6 > T_7 > T_2 > T_3 > T_0$.

Figure 1. Effect of organic and inorganic fertilizers management on growth and yield of rice (BRRI dhan29) in terms of plant heights at total growing stage of rice



[T_0: Control (No fertilizer applied); T_1: 100% RDF (RDF=Recommended dose of fertilizer. Here, N_{120} P_{20} K_{40} S_{20} $Zn_{2.5}$ kg/ha); T_2: 100% Cowdung (10ton/ha); T_3: 100% Poultry Manure(5ton/ha); T_4: 75%RDF+25% Cowdung; T_5: 50% RDF+50% poultry manure; T_6: 25%RDF+75% Cowdung; T_7: 25% RDF+75% Poultry Manure]

4.2. Organic and inorganic fertilizers on number of tillers per hill of Rice (BRRI dhan29)

From the results in table 1 showed significant variation due to the organic and inorganic fertilizers management on number of tillers per hill at different days after transplanting (DAT). At the early growth stage (25 DAT), number of tillers per hill ranged from 4.33 to 9.33. The maximum number of tillers per hill was recorded from (9.33) T_4 which was significantly difference from others treatment and followed by T_1 (7.83) and followed by T_5, T_6 and T_7. The minimum number of tillers per hill was found in (4.33) T_0 when the crop was not fertilized and it was significantly lower than all other treatments and followed by T_2 and T_3 treatment (Table 1). But after 50 DAT, the maximum number of tillers per hill was recorded from (11.50) T_4 which was significantly difference from others treatment and followed by T_1 (9.83) and followed by T_5, T_6 and T_7. The minimum number of tillers per hill was found in (5.80) T_0 when the crop was not fertilized and it was significantly lower than all other treatments and followed by T_2 and T_3 treatment. But after 75 DAT, the maximum number of tillers per hill was recorded from (22.62) T_4 which was significantly difference from others treatment and followed by T_1 (21.57) and followed by T_5, T_6 and T_7. The minimum number of tillers per hill was found in (10.97) T_0 when the crop was not fertilized and it was significantly lower than all other treatments and followed by T_2 and T_3 treatment. From the results in **Table (1)** showed significant variations at the total growing stage of BRRI dhan29. Among different treatments, T_4 (75%RDF+25% Cowdung) showed best combination of organic and inorganic fertilizers management on growth and supported to make sure the more yield of rice. As a result, the order of effect of organic and inorganic fertilizers management on growth and yield of rice (BRRI dhan29) in terms of number of tillers per hills at total growing stage of rice is $T_4 > T_1 > T_5 > T_6 > T_7 > T_2 > T_3 > T_0$.

Table 1. Effect of organic and inorganic fertilizers management on growth and yield of rice (BRRI dhan29) in terms of number of tillers per hill at total growing stage of rice

Treatment	Number of tillers $hill^{-1}$		
	25 DAT	50 DAT	75 DAT
T_0	4.33 e	5.8 e	10.97 f
T_1	7.83 b	9.83 b	21.57 b
T_2	6.19 c	7.86 c	18.41 d
T_3	5.15 d	6.85 d	18.17 e
T_4	9.33 a	11.5 a	22.62 a
T_5	7.67 b	9.67 b	20.83 c
T_6	6.83 c	8.33 c	20.38 c
T_7	6.67 c	8.17 c	19.49 d
$LSD_{(0.05)}$	0.79	0.88	0.73
CV(%)	6.71	5.88	4.74

In a column having similar letters (s) are statistically similar and those having dissimilar letter (s) differ significantly at 0.05 level of probability.

[T_0: Control (No fertilizer applied); T_1: 100% RDF (RDF=Recommended dose of fertilizer. Here, N_{120} P_{20} K_{40} S_{20} $Zn_{2.5}$ kg/ha); T_2: 100% Cowdung (10ton/ha); T_3: 100% Poultry Manure(5ton/ha); T_4: 75%RDF+25% Cowdung; T_5: 50% RDF+50% poultry manure; T_6: 25%RDF+75% Cowdung; T_7: 25% RDF+75% Poultry Manure]

4.3. Organic and inorganic fertilizers on number of effective tillers hill^{-1}, non-effective tillers hill^{-1}, filled grains panicle^{-1} and unfilled grains panicle^{-1} of Rice (BRRI dhan29)

From the results in figure 2 and table 2 showed significant variation due to the organic and inorganic fertilizers management on number of effective tillers hill^{-1}, non-effective tillers hill^{-1}, filled grains panicle^{-1} and unfilled grains panicle^{-1} of Rice (BRRI dhan29) at different days after transplanting (DAT).

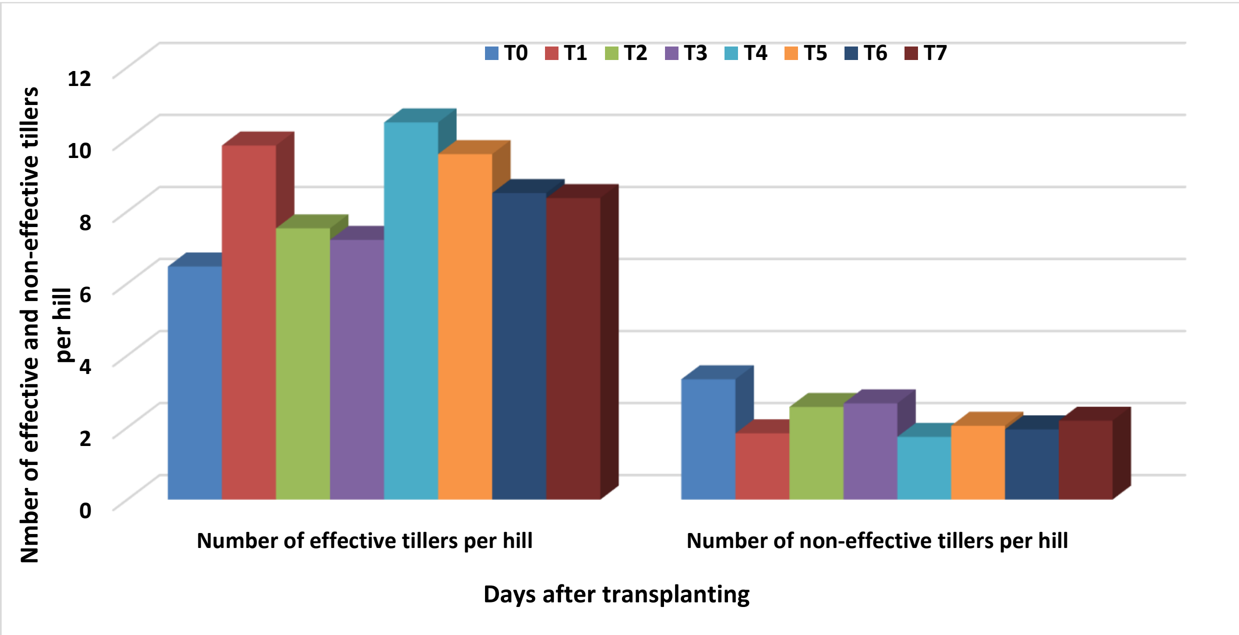
4.3.1. Number of effective tillers hill^{-1}

The number of effective tillers per hill ranged from 6.47 to 10.47. The maximum number of effective tillers per hill was recorded from (10.47) T_4 which was significantly difference from others treatment and followed by T_1 (9.83) and followed by $T_{5,}$ T_6 and T_7. The minimum number of effective tillers per hill was found in (6.47) T_0 when the crop was not fertilized and it was significantly lower than all other treatments and followed by T_2 and T_3 treatment (figure 2).

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

The number of non-effective tillers per hill ranged from 1.74 to 3.34. The lowest number of non-effective tillers per hill was recorded from (1.74) T_4 which was significantly difference from others treatment and followed by T_1 (9.83) and followed by $T_{5,}$ T_6 and T_7. The highest number of non-effective tillers per hill was found in (3.34) T_0 when the crop was not fertilized and it was significantly lower than all other treatments and followed by T_2 and T_3 treatment (figure 2).

Figure 2. Effect of organic and inorganic fertilizers management on growth and yield of rice (BRRI dhan29) in terms of number of effective tillers hill^{-1} and non-effective tillers hill^{-1} at total growing stage of rice



4.3.3. Number of filled grains panicle^{-1}

Number of filled grains panicle^{-1} ranged from 1.74 to 3.34. The highest number of filled grains panicle^{-1} was recorded from (152.35) T_4 which was identically similar T_1 (148.63) and followed by T_5, T_6 and T_7. The lowest number of filled grains panicle^{-1} was found in (109.92) T_0 when the crop was not fertilized and it was significantly lower than all other treatments and followed by T_2 and T_3 treatment (Table 2).

4.3.4. Number of unfilled grains panicle^{-1}

Number of unfilled grains panicle^{-1} ranged from 1.74 to 3.34. The minimum number of unfilled grains panicle^{-1} was recorded from (16.31) T_4 which was significantly difference from others treatment and followed by T_1 (18.74) and followed by T_5, T_6 and T_7. The maximum number of unfilled grains panicle^{-1} was found in (26.51) T_0 when the crop was not fertilized and it was significantly lower than all other treatments and followed by T_2 and T_3 treatment (Table 3). From the results in **Table (2)** showed significant variations at the total growing stage of BRRI dhan29. Among different treatments, T_4 (75%RDF+25% Cowdung) showed best combination of organic and inorganic fertilizers management on growth and supported to make sure the more yield of rice. As a result, the order of effect of organic and inorganic fertilizers management on growth and yield of rice (BRRI dhan29) in terms of number of effective tillers hill^{-1}, non-effective tillers hill^{-1}, filled grains panicle^{-1} and unfilled grains panicle^{-1} at total growing stage of rice is $T_4 > T_1 > T_5 > T_6 > T_7 > T_2 > T_3 > T_0$.

Table 2. Effect of organic and inorganic fertilizers management on growth and yield of rice (BRRI dhan29) in terms of number of filled grains panicle^{-1} and unfilled grains panicle^{-1} of at total growing stage of rice

Treatment	Number of filled grains panicle^{-1}	Number of unfilled grains panicle^{-1}
T_0	109.92 e	26.51 a
T_1	148.63 a	18.74 d
T_2	125.97 d	23.15 b
T_3	123.56 d	23.87 b
T_4	152.35 a	16.31 e
T_5	142.30 b	19.13 d
T_6	140.60 bc	21.71 c
T_7	135.64 c	22.91 b
LSD$_{(0.05)}$	**4.90**	**1.35**
CV(%)	**2.08**	**6.65**

In a column having similar letters (s) are statistically similar and those having dissimilar letter (s) differ significantly at 0.05 level of probability.

[T_0: Control (No fertilizer applied); T_1: 100% RDF (RDF=Recommended dose of fertilizer. Here, N_{120} P_{20} K_{40} S_{20} $Zn_{2.5}$ kg/ha); T_2: 100% Cowdung (10ton/ha); T_3: 100% Poultry Manure(5ton/ha); T_4: 75%RDF+25% Cowdung; T_5: 50% RDF+50% poultry manure; T_6: 25%RDF+75% Cowdung; T_7: 25% RDF+75% Poultry Manure]

4.4. Organic and inorganic fertilizers on percentage of grain sterility of Rice (BRRI dhan29)

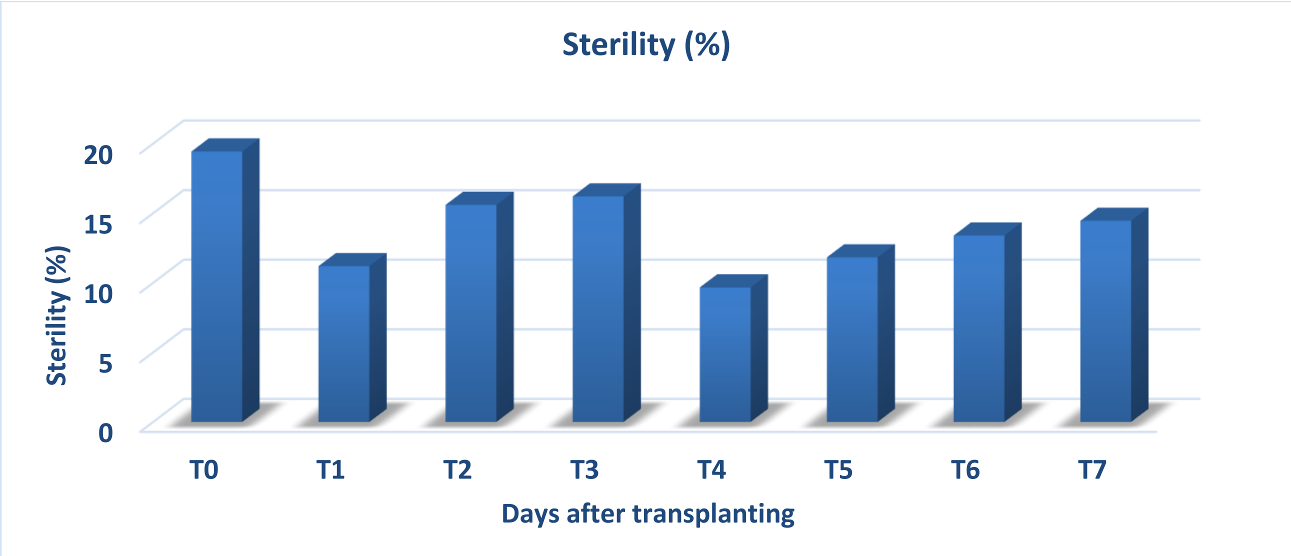
From the results in figure 3 showed significant variation due to the organic and inorganic fertilizers management on percentage of grain sterility of rice (BRRI dhan29) at different days after transplanting (DAT).

4.4.1. Sterility (%)

The lowest percentage of grain sterility was recorded from (9.66%) T_4 which was significantly difference from others treatment and followed by T_1 (11.19%) and followed by T_5, T_6 and T_7. The highest percentage of grain sterility was found in (19.43%) T_0 when the crop was not fertilized and it was significantly lower than all other treatments and followed by T_2 and T_3 treatment (figure 3).

From the results in **figure (3)** showed significant variations at the total growing stage of BRRI dhan29. Among different treatments, T_4 (75%RDF+25% Cowdung) showed best combination of organic and inorganic fertilizers management on growth and supported to make sure the more yield of rice.

Figure 3. Effect of organic and inorganic fertilizers management on growth and yield of rice (BRRI dhan29) in terms of percentage of grain sterility of at total growing stage of rice



[T_0: Control (No fertilizer applied); T_1: 100% RDF (RDF=Recommended dose of fertilizer. Here, N_{120} P_{20} K_{40} S_{20} $Zn_{2.5}$ kg/ha); T_2: 100% Cowdung (10ton/ha); T_3: 100% Poultry Manure(5ton/ha); T_4: 75%RDF+25% Cowdung; T_5: 50% RDF+50% poultry manure; T_6: 25%RDF+75% Cowdung; T_7: 25% RDF+75% Poultry Manure]

4.5. Organic and inorganic fertilizers on panicle length (cm), number of total grains per panicle and 1000 grain weight of Rice (BRRI dhan29)

From the results in table 3 showed significant variation due to the organic and inorganic fertilizers management on panicle length (cm), number of total grains per panicle and 1000 grain weight of Rice (BRRI dhan29) at different days after transplanting (DAT).

4.5.1. Panicle length (cm)

The number of panicle length ranged from 19.21 to 26.31. The maximum panicle length was recorded from (26.31 cm) T_4 which was significantly difference from others treatment and followed by T_1 (24.78) and followed by T_5, T_6 and T_7. The minimum panicle length was found in (19.21 cm) T_0 when the crop was not fertilized and it was significantly lower than all other treatments and followed by T_2 and T_3 treatment (Table 4). Hossaen M. A. (2008) and Haque (1999) noted a significant increase in panicle length due to the application of organic and chemical fertilizers.

4.5.2. Number of total grains per panicle

The number of total grains per panicle ranged from 136.43 to 168.78. The highest number of total grains per panicle was recorded from (168.78) T_4 which was closely followed by T_1 (167.41) and followed by T_5, T_6 and T_7. The least number of total grains per panicle was found in (136.43) T_0 when the crop was not fertilized and it was significantly lower than all other treatments and followed by T_2 and T_3 treatment (Table 4). Hossaen M. A. (2008) and Haque (1999) noted a significant increase in panicle length due to the application of organic and chemical fertilizers.

4.5.3. 1000 grain weight

The maximum 1000 grain weight was recorded from (23.49) T_4 which was identically similar with T_1 (23.37) and followed by $T_{5,}$ T_6 and T_7. The minimum number of 1000 grain weight was found in (21.52) T_0 when the crop was not fertilized and it was significantly lower than all other treatments and followed by T_2 and T_3 treatment (Table 4). The result obtained from the present study was similar with the findings of Fatima *et al.* (2019).

From the results in **Table (3)** showed significant variations at the total growing stage of BRRI dhan29. Among different treatments, T_4 (75%RDF+25% Cowdung) showed best combination of organic and inorganic fertilizers management on growth and supported to make sure the more yield of rice.

As a result, the order of effect of organic and inorganic fertilizers management on growth and yield of rice (BRRI dhan29) in terms of panicle length (cm), number of total grains per panicle and 1000 grain weight at total growing stage of rice is $T_4 > T_1 > T_5 > T_6 > T_7 > T_2 > T_3 > T_{0.}$

Table 3. Effect of organic and inorganic fertilizers management on growth and yield of rice (BRRI dhan29) in terms of panicle length (cm), number of total grains per panicle and 1000 grain weight of at total growing stage of rice

Treatment	Panicle length (cm)	Number of total grains per panicle	1000 grain weight
T_0	19.21 d	136.43 d	21.52 a
T_1	24.78 b	167.41 ab	23.37 a
T_2	22.14 c	148.51 c	22.49 a
T_3	22.36 c	147.34 c	22.15 a
T_4	26.31 a	168.78 a	23.49 a
T_5	24.21 b	161.03 ab	23.28 a
T_6	24.01 b	162.91 ab	23.04 a
T_7	23.57 b	158.55 b	22.84 a
$LSD_{(0.05)}$	1.23	9.81	0.39
CV(%)	2.99	3.58	1.70

In a column having similar letters (s) are statistically similar and those having dissimilar letter (s) differ significantly at 0.05 level of probability.

[T_0: Control (No fertilizer applied); T_1: 100% RDF (RDF=Recommended dose of fertilizer. Here, N_{120} P_{20} K_{40} S_{20} $Zn_{2.5}$ kg/ha); T_2: 100% Cowdung (10ton/ha); T_3: 100% Poultry Manure(5ton/ha); T_4: 75%RDF+25% Cowdung; T_5: 50% RDF+50% poultry manure; T_6: 25%RDF+75% Cowdung; T_7: 25% RDF+75% Poultry Manure]

4.6. Organic and inorganic fertilizers on grain yield (t/ha), straw yield (t/ha), biological yield (t/ha) and harvest index (%) of Rice (BRRI dhan29)

From the results in table 4 showed significant variation due to the organic and inorganic fertilizers management on grain yield (t/ha), straw yield (t/ha), biological yield (t/ha) and harvest index (%) of Rice (BRRI dhan29) at different days after transplanting (DAT).

4.6.1. Grain yield (ton/ha)

Grain yield (t/ha) ranged from 5.11 to 7.84. The maximum grain yield (t/ha) was recorded from (7.84) T_4 which was significantly difference from others treatment and followed by T_1 (7.71) and followed by $T_{5,}$ T_6 and T_7. The minimum grain yield (t/ha) was found in (5.11) T_0 when the crop was not fertilized and it was significantly lower than all other treatments and followed by T_2 and T_3 treatment (Table 4). Hossaen M. A. (2008) and Haque (1999) reported that the highest grain yield (6.69 t ha^{-1}) was obtained from BRRI dhan29 due to the application of organic and chemical fertilizers.

4.6.2. Straw yield (t/ha)

Straw yield (t/ha) ranged from 6.54 to 8.59. The highest straw yield (t/ha) was recorded from (8.25) T_5 which was identically similar T_4 (8.09) and followed by $T_{5,}$ T_6 and T_7. The least straw yield (t/ha) was found in (6.54) T_0 when the crop was not fertilized and it was significantly lower than all other treatments and followed by T_2 and T_3 treatment (Table 4). Hossaen M. A. (2008) and Haque (1999) reported that the highest straw yield (6.69 t ha^{-1}) was obtained from BRRI dhan29 due to the application of organic and chemical fertilizers.

4.6.3. Biological yield (t/ha)

The highest biological yield (t/ha) was recorded from (16.83) T_4 which was closely followed by T_1 (15.93) and followed by $T_{5,}$ T_6 and T_7. The highest biological yield (t/ha) was found in (11.65) T_0 when the crop was not fertilized and it was significantly lower than all other treatments and followed by T_2 and T_3 treatment (Table 4).

4.6.4. Harvest index (%)

The maximum harvest index (%) was recorded from (49.21%) T_4 which was identically similar with T_6 (47.77%) and followed by T_5, T_1 and T_7. The minimum harvest index (%) was found in (43.86%) T_0 when the crop was not fertilized and it was significantly lower than all other treatments and followed by T_2 and T_3 treatment (Table 4).

From the results in **Table (4)** showed significant variations at the total growing stage of BRRI dhan29. Among different treatments, T_4 (75%RDF+25% Cowdung) showed best combination of organic and inorganic fertilizers management on growth and supported to make sure the more yield of rice.

As a result, the order of effect of organic and inorganic fertilizers management on growth and yield of rice (BRRI dhan29) in terms of grain yield (t/ha), straw yield (t/ha), biological yield (t/ha) and harvest index (%) at total growing stage of rice is $T_4 > T_1 > T_5 > T_6 > T_7 > T_2 > T_3 > T_0$.

Table 4. Effect of organic and inorganic fertilizers management on growth and yield of rice (BRRI dhan29) in terms of grain yield (t/ha), straw yield (t/ha), biological yield (t/ha) and harvest index (%) of at total growing stage of rice

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
T_0	5.11 f	6.54 d	11.65 f	43.86 b
T_1	7.11 b	8.05 a	15.16 ab	46.90 ab
T_2	6.49 de	7.26 c	13.75 de	47.20 ab
T_3	6.41 e	7.11 c	13.52 e	47.41 ab
T_4	7.84 a	8.09 a	15.93 a	49.21 a
T_5	7.08 bc	8.25 a	15.33 bc	46.18 ab
T_6	6.98 c	7.83 b	14.82 cd	47.77 ab
T_7	6.85 cd	7.76 b	14.61 c-e	46.88 ab
$LSD_{(0.05)}$	0.53	0.39	1.25	3.87
CV(%)	4.35	2.55	4.60	4.98

In a column having similar letters (s) are statistically similar and those having dissimilar letter (s) differ significantly at 0.05 level of probability.

[T_0: Control (No fertilizer applied); T_1: 100% RDF (RDF=Recommended dose of fertilizer. Here, N_{120} P_{20} K_{40} S_{20} $Zn_{2.5}$ kg/ha); T_2: 100% Cowdung (10ton/ha); T_3: 100% Poultry Manure(5ton/ha); T_4: 75%RDF+25% Cowdung; T_5: 50% RDF+50% poultry manure; T_6: 25%RDF+75% Cowdung; T_7: 25% RDF+75% Poultry Manure]

CHAPTER V

SUMMARY AND CONCLUSION

A pot experiment was conducted with 8 different treatments at total growing stage to effect of organic and inorganic fertilizers management on growth and yield of Rice (BRRI dhan29). The experiment was set up at the premise of the Department of Soil science of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, during the period from January 2022 to June 2022. BRRI dhan29 was considered as test crops. There were eight treatments combinations consisting of different source of organic and inorganic fertilizer. The treatments were *viz.* T_0: Control (No fertilizer applied); T_1: 100% RDF (RDF=Recommended dose of fertilizer. Here, N_{120} P_{20} K_{40} S_{20} $Zn_{2.5}$ kg/ha); T_2: 100% Cowdung (10ton/ha); T_3: 100% Poultry Manure(5ton/ha); T_4: 75%RDF+25% Cowdung; T_5: 50% RDF+50% poultry manure; T_6: 25%RDF+75% Cowdung; T_7: 25% RDF+75% Poultry manure. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Different data on growth, yield contributing parameters and yield were collected and analyzed statistically. It was observed that most of the parameters varied significantly due to different combination of organic and inorganic fertilizer management.

In terms of growth parameters of rice, the highest plant height (60.98 cm, 72.14 cm, 90.32 cm and 99.36 cm at 25 DAT, 50 DAT, 75 DAT and at harvest, respectively), the highest number of tillers per hill (9.33, 11.50 and 22.62 at 25 DAT, 50 DAT and 75 DAT, respectively), the highest number of effective tillers hill^{-1} **(**10.47), the lowest number of non-effective tillers hill^{-1} (1.74), the maximum number of filled grains panicle^{-1} (152.35), the lowest number of unfilled grains panicle^{-1} (16.31) and highest panicle length (26.31) were recorded in control treatment T_4 (75%RDF+25% Cowdung) combination of organic and inorganic fertilizers management.

In terms of yield parameters of rice, the highest number of total grains per panicle (168.78),the minimum percentage of grain sterility (9.66%), the maximum 1000 grain weight (23.49), the maximum grain yield (t/ha) (7.84), the maximum straw yield (t/ha) (8.25), the highest biological yield (t/ha) (15.93) and the maximum harvest index (%) (49.21%) were recorded in control treatment T_4 (75%RDF+25% Cowdung) combination of organic and inorganic fertilizers management whereas the growth and yield contributing were obtained with T_0 (no fertilizer applied) treatment.

From the above results it can be stated that BRRI dhan29 under the present study was respond on combination of organic and inorganic fertilizer management. So, from this study, it can be concluded that Among different treatments, T_4 (75%RDF+25% Cowdung) showed best combination of organic and inorganic fertilizers management on growth and supported to make sure the more yield of rice.

As a result, the order of effect of organic and inorganic fertilizers management on growth and yield of rice (BRRI dhan29) in terms of plant height at total growing stage of rice is $T_4 > T_1 > T_5 > T_6 > T_7 > T_2 > T_3 > T_0$.

Conclusion

It can thus be concluded from the research results that the combination of organic and inorganic fertilizers had significant positive effects of on the growth, yield, and yield components of wet season rice BRRI dhan29. Among the treatments, T_4 (75%RDF+25% Cowdung) performed the best to attaining highest yield and harvest index. The vegetative and yield contributing characteristics like plant height, number of tiller, grains panicle^{-1}, panicle length, 1000-grain weight, followed the similar trend to yield. Therefore, the treatment T_4 (75%RDF+25% Cowdung) might be recommended for sustainable and successful cultivation of BRRI dhan29 to obtained better performance and higher yield.

Recommendations

Considering the findings of the present experiment, further studies in the following areas may be suggested:

- BRRI dhan29 should be chosen among the test boro rice varieties for getting higher grain yield with organic and inorganic fertilizer combination in different locations of Bangladesh.

CHAPTER VI

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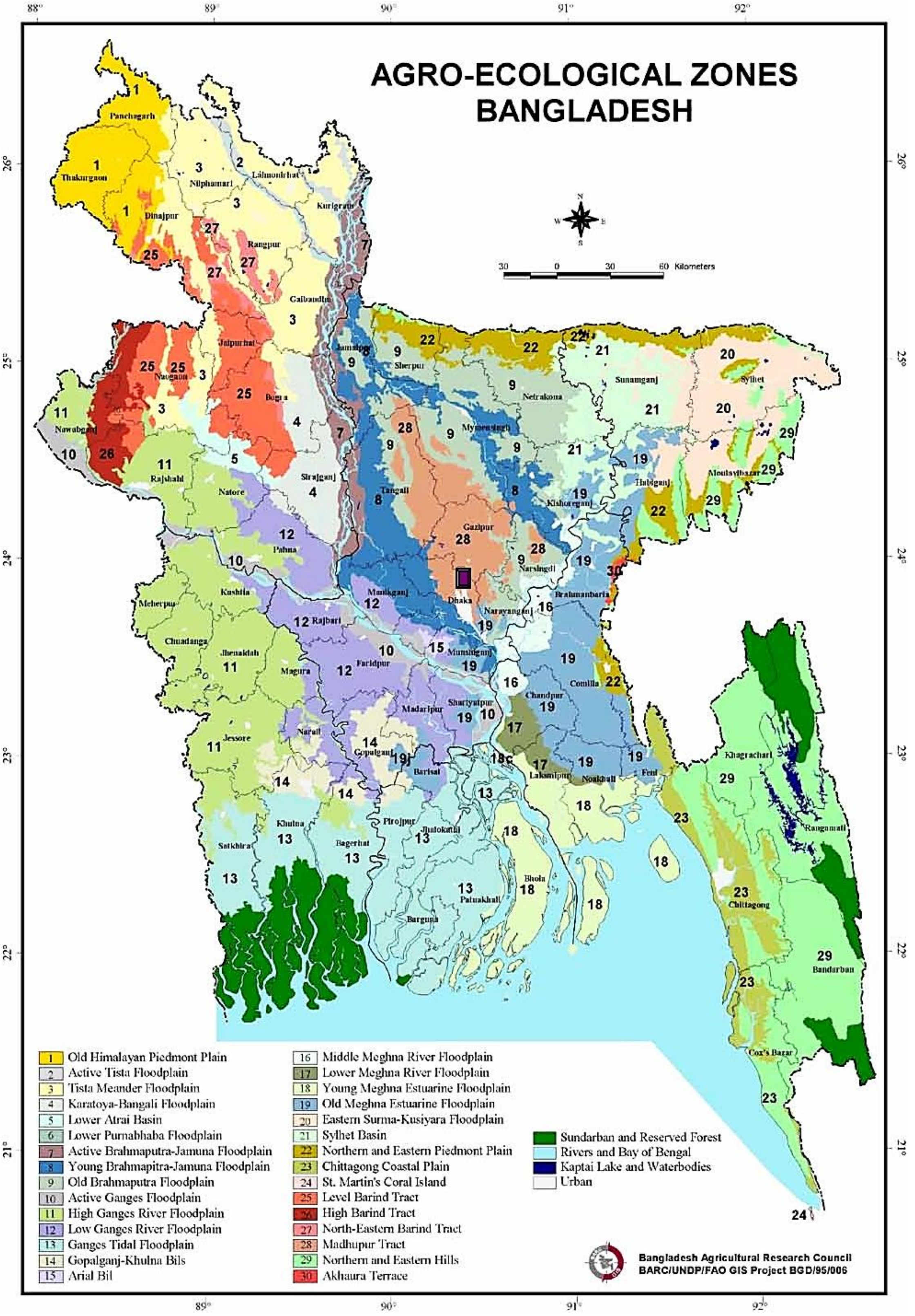
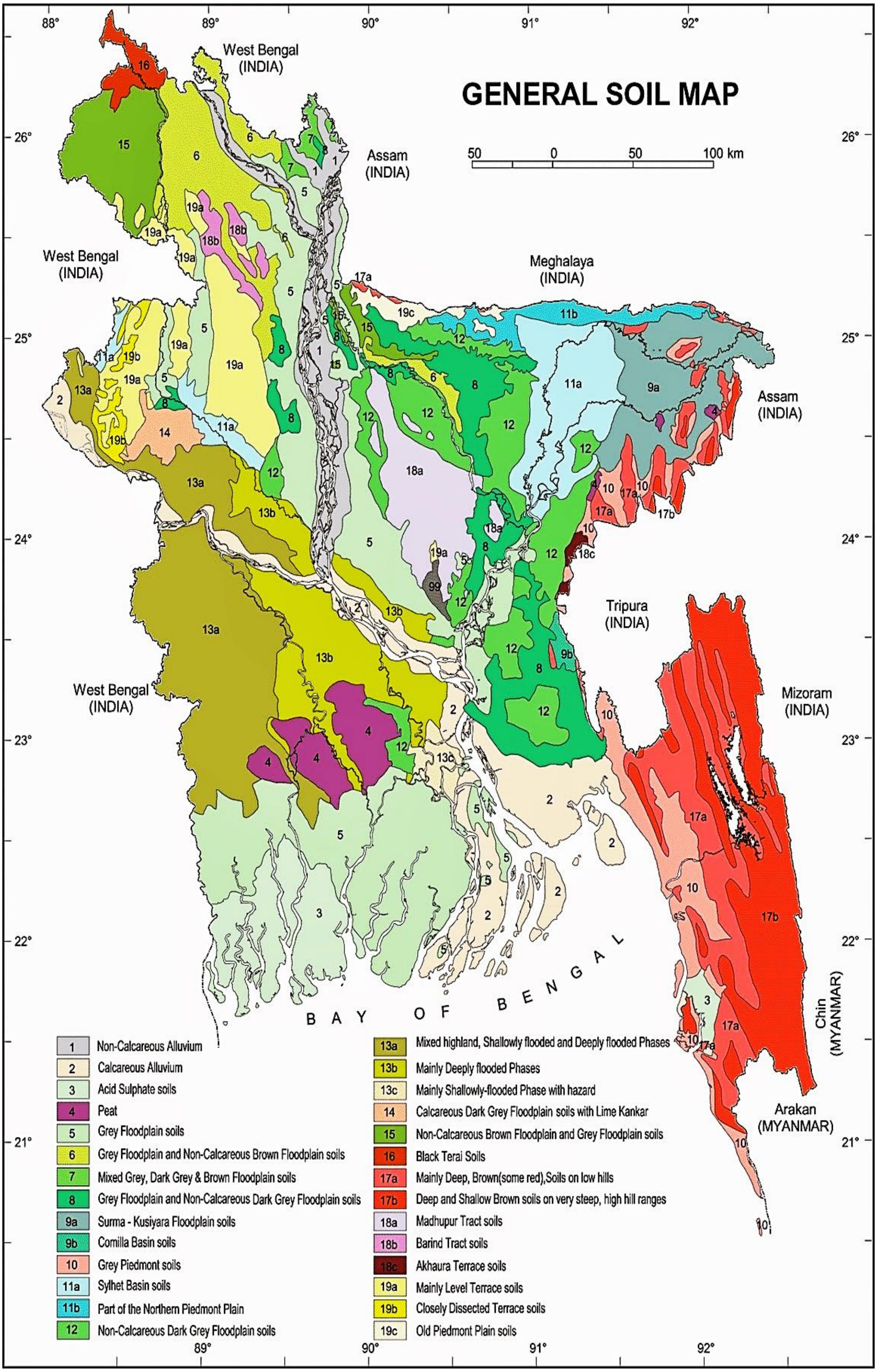
APPENDICES

Appendix I (A): Map showing the experimental sites under study.



Appendix I (B): Map showing the general soil types in Bangladesh



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

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture farm, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping Pattern	Potato-Aus rice-T.aman rice

B. Physical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% Clay	30

Source: Soil Resource Development Institute (SRDI), Khamarbari, Farmgate, Dhaka-1215

Appendix III: Monthly average temperature, relative humidity, and total rainfall of the experimental site during the period from January 2022 to May 2022

Year	Month	Temperature			Relative Humidity (%)	Total Rainfall (mm)	Sunshine (Hour)
		Max (°C)	Min (°C)	Mean (°C)			
2021 - 2022	June	34	28	30	73	88.6	300
	July	33	27	30	76	46.53	268
	August	34	27	30	76	66.92	302
	September	34	27	30	71	64.14	292.5
	October	33	26	30	59	33	238
	November	33	25	29	51	12.3	210.5
	December	30	20	25	49	11.1	205
	January	27	15	21	45	8	201
	February	28	18	23	47	9	203
	March	32	22	27	54	13	207
	April	35	26	30	60	15	210
	May	34	25	28	64	20	220

Source: Bangladesh Metrological Department (Climate and weather division) Agargaon, Dhaka.

Appendix IV: Effect of organic and inorganic fertilizers management on growth and yield of rice (BRRI dhan29) in terms of plant heights at total growing stage of rice

Treatment	Plant height (cm)			
	25 DAT	50 DAT	75 DAT	At harvest
T_0	39.35 f	52.74 f	70.65 f	76.35 e
T_1	58.68 ab	69.36 ab	89.12 ab	97.34 ab
T_2	47.68 de	62.71 de	81.32 de	90.35 d
T_3	43.85 e	59.81 e	78.26 e	88.25 d
T_4	60.98 a	72.14 a	90.32 a	99.36 a
T_5	55.15 bc	67.10 bc	86.34 a-c	95.89 a-c
T_6	53.78 c	66.25 b-d	85.14 b-d	93.15 b-d
T_7	51.41 cd	65.59 cd	83.67 cd	92.19 cd
$LSD_{(0.05)}$	**4.12**	**3.61**	**4.37**	**4.97**
CV(%)	**4.58**	**3.20**	**6.87**	**9.12**

In a column having similar letters (s) are statistically similar and those having dissimilar letter (s) differ significantly at 0.05 level of probability.

[T_0: Control (No fertilizer applied); T_1: 100% RDF (RDF=Recommended dose of fertilizer. Here, N_{120} P_{20} K_{40} S_{20} $Zn_{2.5}$ kg/ha); T_2: 100% Cowdung (10ton/ha); T_3: 100% Poultry Manure(5ton/ha); T_4: 75%RDF+25% Cowdung; T_5: 50% RDF+50% poultry manure; T_6: 25%RDF+75% Cowdung; T_7: 25% RDF+75% Poultry Manure]

Appendix V: Effect of organic and inorganic fertilizers management on growth and yield of rice (BRRI dhan29) in terms of Number of effective tillers hill^{-1}, Number of non-effective tillers hill^{-1} and Sterility (%) at total growing stage of rice

Treatment	Number of effective tillers hill^{-1}	Number of non-effective tillers hill^{-1}	Sterility (%)
T_0	6.47 e	3.34 a	19.43 a
T_1	9.83 b	1.84 d	11.19 e
T_2	7.53 d	2.57 b	15.59 b
T_3	7.21 de	2.67 b	16.20 b
T_4	10.47 a	1.74 d	9.66 f
T_5	9.59 b	2.05 cd	11.82 e
T_6	8.51 c	1.95 d	13.39 d
T_7	8.37 c	2.19 bc	14.45 c
$LSD_{(0.05)}$	**0.81**	**0.36**	0.89
CV(%)	**5.35**	**8.94**	5.89

In a column having similar letters (s) are statistically similar and those having dissimilar letter (s) differ significantly at 0.05 level of probability.

[T_0: Control (No fertilizer applied); T_1: 100% RDF (RDF=Recommended dose of fertilizer. Here, N_{120} P_{20} K_{40} S_{20} $Zn_{2.5}$ kg/ha); T_2: 100% Cowdung (10ton/ha); T_3: 100% Poultry Manure(5ton/ha); T_4: 75%RDF+25% Cowdung; T_5: 50% RDF+50% poultry manure; T_6: 25%RDF+75% Cowdung; T_7: 25% RDF+75% Poultry Manure]

Plate 1: preparation of pot with supervisor sir

Plate 2: Seedling establishment after transplanting

Plate 3: Collecting of data