

**EFFECTS OF FERTILIZERS AND MANURES WITH DIFFERENT  
IRRIGATION MANAGEMENT ON THE YIELD AND NUTRIENT  
CONCENTRATION IN BRRI DHAN 32**

**BY**

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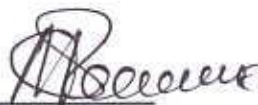
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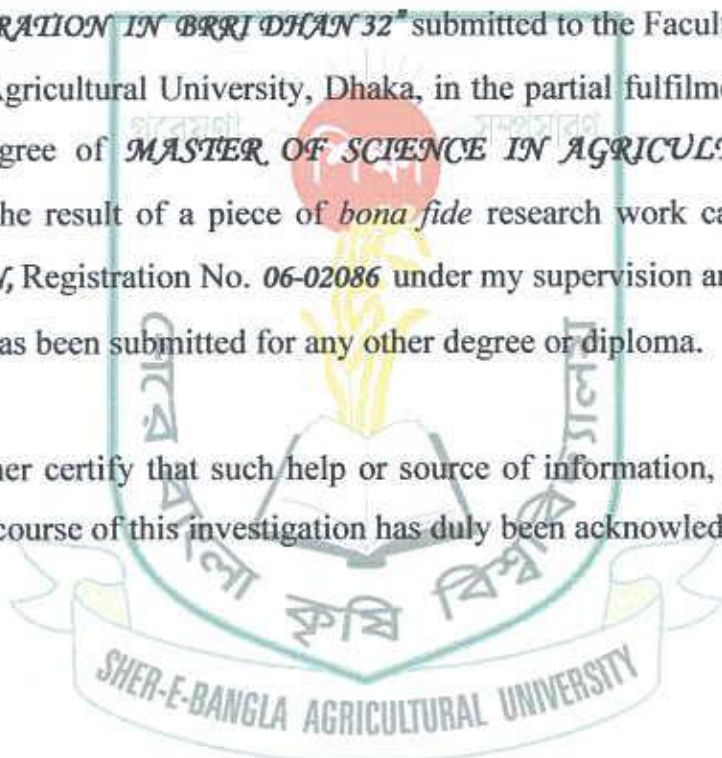
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## CERTIFICATE

This is to certify that the thesis entitled, "EFFECTS OF FERTILIZERS AND MANURES WITH DIFFERENT IRRIGATION MANAGEMENT ON THE YIELD AND NUTRIENT CONCENTRATION IN BRRI DHAN 32" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfilment of the requirements for the degree of *MASTER OF SCIENCE IN AGRICULTURAL CHEMISTRY*, embodies the result of a piece of *bona fide* research work carried out by *MATUUR RAHAMAN*, Registration No. 06-02086 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.



A handwritten signature in black ink, appearing to read "Abdur Razzaque".

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*DEDICATED*  
*TO*  
*MY BELOVED PARENTS*

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## ABSTRACT

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from June 2012 to December 2012 to know the effect of fertilizers and manures with different irrigation management on the yield and nutrient concentration in BRRI dhan 32. The experiment consisted of 2 factors i. e. irrigation and fertilizer plus manure. Three levels of irrigations ( $I_1$  = Continuous flooding,  $I_2$  = saturated condition and  $I_3$  = Alternate wetting and drying) were used with 8 levels of fertilizers plus manures, such as  $T_0$ : Control,  $T_1$ :  $N_{120}P_{25}K_{60}S_{20}Zn_2$  (Recommended dose),  $T_2$ : 50% NPKSZn + 5 ton cowdung  $ha^{-1}$ ,  $T_3$ : 70% NPKSZn + 3 ton cowdung  $ha^{-1}$ ,  $T_4$ : 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. At the harvest, the yield parameters and total yield were recorded; the irrigation had no significant single effect on the yield and yield parameters while the highest yields were obtained from saturated condition. The yield contributing characters and yields were significantly affected by fertilizer and manure and the highest effective tillers/hill, plant height, panicle length, number of filled grain per panicle, grain yield and straw yield were found from 50% NPKSZn + 2.1 ton poultry manure/ha treatment and lowest in control treatment. The yield parameters were significantly influenced by combined application of irrigation and fertilizer and the highest grain (5.34 t/ha) and straw yields (7.40 t/ha) were recorded from saturated condition with 50% NPKSZn + 2.1 ton poultry manure/ha. Irrigation did not significantly influence the grain nutrient concentration. The higher levels of N concentration were recorded from saturated condition treatment. The highest levels of P and K concentration in grain were showed in continuous flooding. The T. Aman rice grain and straw nutrient concentrations were significantly affected by the application of fertilizers and manures. The higher grain nutrient concentrations were found in the treatments where fertilizers were used in combination with poultry manure. The highest N concentration in grain was recorded from 50% NPKSZn + 2.1 ton poultry manure/ha. The highest concentrations of grain P and K were recorded from 70% NPKSZn + 3 ton compost  $ha^{-1}$  treatment and lowest from  $T_0$  treatment.

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Chapter 1  
Introduction

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## CHAPTER I

### INTRODUCTION

Rice (*Oryza sativa* L.) belongs to the cereal crops under Gramineae family. It is one of the world's most widely consumed grains which play a unique role in combating global hunger. It is the staple food of Bangladesh. Almost all the people depend on rice and have tremendous influence on agrarian economy of Bangladesh. Among the three types of rice, boro rice covers about 56.66% of total rice area and it contributes 43.24% of the total rice production in the country (BBS, 2008). Rice is intensively cultivated in Bangladesh covering about 80% of arable land. Rice alone constitutes 95% of the food grain production in Bangladesh. Unfortunately, the yield of rice is low in Bangladesh as compared to that of other rice growing countries like South Korea and Japan where the average yield is 7.00 and 6.22 t/ha, respectively (FAO, 1999). On the other hand, the demand for increasing rice production is mounting up to feed the ever-increasing population of this country.

In Bangladesh total cultivable land is 90,98,460 hectare and near about 70 per cent of this land is occupied by rice cultivation. In the year 2011, the total production of rice was 3,35,41,099 metric ton. Hybrid rice varieties was cultivated in 6,53,000 hectare of land and total production is 28,82,000 metric ton in the year of 2010-2011. On the other hand, HYV (High Yielding Varieties) was cultivated in 40,67,000 hectare land and the total production of rice was 156,32,000 metric ton. The average rice production of hybrid varieties was 4.41 metric ton and HYV varieties were 3.84 metric ton in the year 2010 – 2011(BBS, 2011).

A suitable combination of organic and inorganic plant nutrients is necessary for sustainable agriculture that can ensure food production with high quality. Nambiar (1991) views that integrated use of organic manure and chemical fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining better soil fertility. The long-term research at BARI revealed that the application of cowdung @ 5 t/ha/year improved rice productivity as well as prevented the soil resources from degradation (Bhuiyan, 1994). Poultry manure is another good source of nutrients in soil. Meelu and Singh (1991) showed that 4 t/ha poultry manure along with 60 kg N/ha as urea produce grain yield of crop similar to that with 120 kg N/ha as urea alone.

Organic manure can supply a good amount of plant nutrients thus can contribute to crop yields. Thus, it is necessary to use fertilizers and manures in an integrated way in order to obtain sustainable crop yield without affecting soil fertility. The integrated approach by using the organic and inorganic sources of nutrients helps improve the efficiency of nutrients. Mineralization and immobilization are biochemical in nature and are mediated through the activities of microorganisms. The rate and extent of mineralization determines crop availability of nutrients. The transformation of N, P and S in soil depends on the quality and quantity of organic matter as well as soil fertility and microbial activity.

Depleted soil fertility is a major constrain to higher crop production in Bangladesh. The increasing land use intensity has resulted in a great exhaustion of nutrients in soils. Farmers of this country use on an average 102 kg nutrients/ha annually (70 kg N + 24 kg P + 6 kg K + 2 kg S) while the crop removal is about



200 kg/ha (Islam *et al.*, 1994). In Bangladesh, most of the cultivated soils have less than 1.5% organic matter while a good agricultural soil should contain at least 2% organic matter. Moreover, this important component of soil is declining with time due to intensive cropping and use of higher dose of chemical fertilizers with little or no addition of organic manure in the farmer's field. In addition, rapid mineralization of soil organic matter occurs due to humid tropic climatic conditions of Bangladesh. Cycling of organic matter in soil is a pre-requisite for efficient cycling of nutrients. Unless due attention is paid to the improvement and maintenance of soil organic matter it may not be possible to achieve the goal to increase and sustained productivity of crop.

Soil organic matter improves the physicochemical properties of the soil and ultimately promotes crop production. Evidences from different AEZ of the country have shown a decrease in the content of organic matter by the range of 15 to 30% over the last 20 years (Miah, 1994). Therefore, it would not be wise to depend only on inherent potentials of soils for higher crop production. More recently, attention was focused on the global environmental problems; utilization of organic wastes, FYM, compost, vermicompost and poultry manures as the most effective measure for the purpose.


The application of different fertilizers and manures influences the physical and chemical properties of soil and enhances the biological activities. It is also positively correlated with soil porosity and enzymatic activity. Organic fertilizer enhances soil porosity by increasing regular and irregular pores and causes a prime effect of native soil organic matter. Applications of both chemical and

organic fertilizers need to be applied for the improvement of soil physical properties and supply of essential plant nutrients for higher yield.

The frequency of irrigation and the amount of water required depend on such factors as cultivar, soil type, season, amount of rainfall and diseases; therefore, it is difficult to give definite recommendation. Over irrigation, as well as under irrigation may lower yields. Efficient water management thus plays a vital role in rice production. This can be achieved by adopting improved irrigation practices. Although both timing and the amount of water applied affect irrigation efficiency, timing has greater effect on the yield and quality of a crop. Therefore, a judicious irrigation schedule is needed to avoid over or under irrigation and for profitable rice cultivation. Irrigation is one of the most important factor on the growth and yield of boro rice. Yang *et al* (2004) reported that application of chemical fertilizers with farmyard manure or wheat straw in alternate wetting and drying condition increased N, P, & K uptake by rice plants & increased 1000 grain weight & grain yield of rice.

Considering the situation stated above the present study was undertaken with the following objectives:

- i. To develop a suitable integrated dose of inorganic fertilizers combined with different manures for T. aman rice.
- ii. To evaluate the effect of combined application of inorganic and organic fertilizer with different water management on the yield, yield components and quality of T. aman rice.



Chapter 2  
Review of literature

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## Chapter II

### REVIEW OF LITERATURE

Soil organic matter and nutrients are most essential factors for sustainable soil fertility and crop productivity and organic matter is the store house of plant nutrients. Sole and combined used of cowdung, poultry manure, compost, and inorganic fertilizers act as source of essential plant nutrients. Experimental evidences in the use of cowdung, poultry manure, compost, and nitrogen, phosphorus, potassium and sulphur showed an intimate effect on the yield and yield attributes of rice. Yield and yield contributing characters of rice are considerably influenced by different doses of NPKS fertilizers and cowdung, poultry manure & compost manure and their combined application. Some literature related to the "Effect of level of various organic manure and inorganic fertilizers with different water management practices on the yield and yield attributes of T. aman rice cv. BRRI dhan32" are reviewed below-

#### 2.1 Effect of chemical fertilizer on the growth and yield of rice

Asif *et al.* (2000) reported that NPK levels significantly increased the panicle length, number of primary and secondary branches panicle<sup>-1</sup> when NPK fertilizers were applied at the dose of 180-90-90 kg ha<sup>-1</sup>. This might be attributed due to the adequate supply of NPK.

Haq *et al.* (2002) conducted an experiment with twelve treatments combination of N, P, K, S, Zn and Diazinon. They found that all the treatments significantly increase the grain and straw yield of BRRI dhan 30 rice over control. 90 kg N +



50 kg P<sub>2</sub>O<sub>5</sub> + 40 kg K<sub>2</sub>O + 10 kg S + 4 kg Zn ha<sup>-1</sup> + diazinon gave the height grain and straw yield.

Rasheed *et al.* (2003) reported that the effect of different NP levels i.e., 0-0, 25-0, 50-25, 75-50, 100-75 and 125-100 kg ha<sup>-1</sup> on yield and yield attributes of rice Bas-385. Yield attributes (No. of effective tillers per hill, spikelet per panicle, normal kernels per panicle, 1000-grain weight) were improved linearly with increasing NP levels up to 100-75 kg/ha. The NP level of 100-75 kg/ha resulted in the highest grain yield of 4.53 t/ha with minimum kernel abnormalities (Sterility, abortive kernels and opaque kernels) as against the minimum of 2.356 t/ha in the control (0-0) followed by 25-0 kg NP/ha with maximum kernel abnormalities.

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

Amin *et al.* (2004) conducted an experiment to evaluate the effect of increased plant density and fertilizer dose on yield of rice variety IR-6. They found that increased fertilizer dose of NPK increase plant height.

Saha *et al.* (2004) conducted an experiment in 2002-2003 to create and compare a suitable fertilizer recommendation model for lowland rice. Five different fertilizer recommendation models were tested and compared with one check plot. Results show that the application of different packages estimated by different fertilizer

models significantly influence panicle length, panicle numbers, spikelet number per panicle, total grains panicle<sup>-1</sup>, number of filled grain and unfilled grain per panicle. The combination of NPK that gives the height result was 120-13-70-20 kg/ha NPKS.

Ndaeyo *et al.* (2008) conducted an experiment in Nigeria with five rice varieties (WAB340- 8-8-2HI, WAB881-10-37-18-8-2-HI, WAB99-1-1, WAB224-8-HB, WAB189-B-B-B-8-HB) and four rates of NPK (15:15:15) fertilizer (0, 200, 400 and 600kg/ha). The results showed that 600kg/ha NPK (15:15:15) fertilizer rate significantly ( $P < 0.05$ ) increased plant height, number of leaves and tillers per plant in both years. The 400kg/ha rate increased the number of panicles per plant, length of central panicle per plant and the overall grain yields, straw yield over other rates by 4-32% and 2-21% in 2005 and 2006, respectively.

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



## **2.2 Combined effect of chemical fertilizer and manure on the growth and yield of rice**

### **2.2.1 Combined effect of chemical fertilizer and cowdung on the growth and yield of rice**

Mannan *et al.* (2000) reported that manuring with cowdung up to 10 t/ha in addition to recommended inorganic fertilizers with late N application improved grain and straw yields and quality of transplant aman rice over inorganic fertilizer alone.

Saitoh *et al.* (2001) conducted an experiment to evaluate the effect of organic fertilizers (cowdung and poultry manure) and pesticides on the growth and yield of rice and revealed that the yield of organic manure treated and pesticide free plots were 10% lower than that of chemical fertilizer and pesticide treated plot due to a decreased in the number of panicle. Yearly application of manure increased the total carbon and nitrogen content in soil.

Dao and Cavigelli (2003) reported that animal manure had long been used as an organic source of plant nutrients and organic matter to improve the physical and fertility condition of agricultural lands.

Tripathy *et al.* (2004) found significantly higher seed yield under the residual effects of the blended cowdung and NPK fertilizer compared to the control.

Saleque *et al.* (2004) conducted a field experiment to determine the effect of different doses of chemical fertilizers alone or in combination with cowdung (CD) and rice husk ash on yield of lowland rice-rice cropping sequence. Cowdung and ash were applied on dry season rice only and found the application of cowdung

and ash increased rice yield by about 1 t/ha per year over that obtained with chemical fertilizer alone, the treatments, which showed positive yield trend, also showed positive total P uptake trend and positive yield trends were attributed to the increasing P supplying power of the soil.

Saleque *et al* (2004) showed that application of one third of recommended inorganic fertilizers with 5 t cowdung increased the low land rice yield than other treatments and gives yield 8.87t ha<sup>-1</sup>.

Rahman *et al.* (2009) conducted a field experiment to study the effect of urea N in combination with poultry manure and cowdung in rice and found application of manures and different doses of urea N fertilizer significantly increased the yield components and grain and straw yields.

### **2.2.2 Combined effect of chemical fertilizer and poultry manure on the growth and yield of rice**

Channbasavana and Biradar (2001) reported that the application of poultry manure @ 3 t/ha gave 26% and 19% higher grain yield than that of the control 1998 and 1999, respectively. Eneji *et al.* (2001) observed that average across the soils, the level of extractable Fe increased by 5% in chicken manure and 71% in cattle manure; Mn by 61% in chicken manure and 172% in swine manure and Cu by 327% in chicken manure and 978% in swine manure. Mixing these manures before application reduce the level of extractable trace elements.

Vanju and Raju (2002) conducted a field experiment on integrated nutrient management practice in rice crop. Different combinations of chemical fertilizer with poultry manure (PM) 2 t/ ha gave highest grain and straw yield.

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.

Channabasavanna (2003) conducted a field experiment to evaluate the efficient utilization of poultry manure with inorganic fertilizers in wetland rice and found that the grain yield increased with each increment of poultry manure application and was maximum at 3 t poultry manure/ha. Poultry manure at 2 ton /ha recorded significantly higher values for seed yield and its attributes. The study proved the superiority of poultry manure over farmyard manure (FYM). It was evident from the study that one ton of poultry manure was equivalent to 7 ton FYM which produced at per seed yields. Agronomic efficiency of N (AEN) at 75% NPK (112.5:56.3:56.3 kg NPK/ha) was equivalent to 2 t poultry manure/ha. The results showed that an increase in poultry manure and fertilizer increased rice seed yield. The AEN decreased with an increase in the application of poultry manure and NPK fertilizer.

Miah *et al.* (2004) found 5.6-6 t/ha-grain yields with application of 2 t/ha poultry manure plus 120 kg N/ha in Boro season.

Reddy *et al.* (2005) carried out a field experiment on black clay soils in Gangavati, Karnataka, India, to evaluate the performance of poultry manure (PM) as a substitute for NPK in irrigated rice (cv. IR 64). The application of PM at 5 t/ha recorded a significantly higher grain yield (5.25 t/ha) than the control and FYM application at 7.5 t/ha, significantly improved the soil P and K status, and increased the N content of the soil. Poultry manure at 5 t/ha resulted in higher gross returns (30592 Rupees/ha) over other levels of PM and FYM. However, net returns and benefit cost ratios were comparable between 5 and 2 t PM/ha, and between 100 and 75% NPK. The application of 2 t PM/ha and 75% NPK was found economical.

Miah *et al.* (2006) stated that an application of poultry manure with soil test basis (STB), IPNS and AEZ based fertilizer gave higher grain yield compared to other organic materials.

### **2.2.3 Combined effect of chemical fertilizer and compost on the growth and yield of rice**

Farid *et al.* (1998), Incorporation of compost or rice straw and subsequent decomposition increased and maintained organic matter level at 2.5% that was higher than that in traditionally managed rice soil (<2%).

Application of composted coir pith improves the soil available K status and increases the uptake of K by grain and straw yield of rice. Application of 50 kg N with green leaf manure gave the highest grain and straw yield in both season, followed composted coir pith (Chittra and Janaki, 1999).

Composts from organic wastes, such as segregated waste, green botanical waste and food processing waste are becoming available in increasing quantities. These supply a complex mixture of nutrients in organic and mineral forms and are also used as soil condition to maintain and improve soil structure (HDRA, 1999).

Tamaki *et al.* (2002) observed that the correlation between growth and yield and duration of organic farming (compost mixed with straw) in comparison with conventional farming. In inorganic farming plant height of rice was shorter and short number/hill was lesser than in conventional farming, but both of these values increased as the duration of organic farming increased. The maximum tiller number was smaller and panicle number was also smaller than in inorganic farming. However, both the panicle number and panicle length increased as the duration organic farming increased. The grain- straw ratio was higher in organic farming than the conventional farming. These results suggest that the growth and yield of rice increased with continuous organic farming and the yield increased with increase in panicle number/hill and grain number/panicle.

Keeling *et al.* (2003) determined the green waste compost and provided with additional fertilizers and showed consistently that the response of rice rape to compost and fertilizer applied together than the response to the individual

additives, but only very stable compost was used (> 10 months processing). Experiments with <sup>15</sup>N-labeled fertilizer showed that rice was able to utilize the applied N-more efficiently when cultivated with the stable compost.

Elsharaeay *et al.* (2003) found the effect of compost of the some plant residues i.e. rice straw and cotton stalk on some physical and chemical properties of the sandy soil. Application of cotton stalks or rice straw composts significantly improved the physical properties of the tasted soil, i.e., bulk density, hydraulic conductivity and moisture content namely field capacity, wilting point and available water, concerning the effect of compost application on the availability of N, P and K in the cultivated soil, rice straw was better than cotton stalks.

Davarynejad *et al.* (2004) conducted an experiment to investigate the effect of manure and municipal compost and their enrichment with chemical fertilizers on growth and yield of rice. Results showed that compost alone did not increase grain yield. However, when enriched with different levels of chemical fertilizer the highest amount of grain yield was produced. The yield was comparable to the yield obtained from 40 t/ha of compost. This indicated that compost might be an appropriate substitute for manure and half of chemical fertilizer needed for soil.

Aga *et al.* (2004) assessed the effect of compost on the growth and yield of rice. Plant growth characters such as plant height were highest with application of 15 t compost/ha. Grain yield increased significantly with the graded levels of compost application @ 10 t/ha but the response decreased with the increase of compost from 10 to 15 t/ha.



Nayak *et al* (2007) reported that application of compost and inorganic fertilizer increased microbial growth in soil, vegetative growth and maximum tillering of rice.

### 2.3 Effect of irrigation on the growth and yield of rice

Qinghua *et al.* (2002) carried out an experiment in rainproof containers to study the response of different varieties (Sanyou 10 and 923 and Zhensan 97B ) of rice to three water treatments ( flooded, intermittent and dry condition ) and observed that grain yields in the dry cultivation treatment amounted to 6.3, 6 and 3.7 t/ha for the varieties Sanyou 10 and 923 and Zhensan 97B respectively. Under intermittent irrigation, yields of Sanyou 10 and 923 were 8% and 10% higher, 9.5 and 8.8 t/ha, respectively than under flooded condition. The highest yield of Zhensan 97B (5.3 t/ha) was obtained under flooded condition.

Gani *et al.* (2002) reported that intermittent ( alternate wet and drying ) irrigation consistently performed better than continuously flooded irrigation, that is it produced more effective tillers, leaf area, and biomass.

Uphoff and Randriamiharisoa (2002) observed that continuous flood irrigation constrain root growth of rice and contribute to root degeneration and it also limit soil microbial life to anaerobic populations. Keeping paddy fields flooded also restricts biological nitrogen fixation to anaerobic processes and affect plant growth.

McHugh *et al.* (2002) observed highest yield of rice grain was obtained in case of alternate wet and drying system (6.7 t/ha) than nonflooded (5.9 t/ha) and

continuously flooded irrigation ( 5.9 t/has ). This result suggest that by combining alternate wet and drying irrigation with system of rice intensification practices, farmers can increase grain yields while reducing irrigation water demand.

Ebrahim *et al.* (2011) conducted experiment with four water management (I<sub>1</sub>: submerge irrigation, I<sub>2</sub>: 5 day interval, I<sub>3</sub>: 8 day interval, I<sub>4</sub>: 11 day interval) and showed highest grain yield was found from submerge irrigation (I<sub>1</sub>) and also 90 kg /ha nitrogen fertilizer consumption.

Thakur *et al.* (2011) observed that system of rice intensification practices with alternate wet and drying improve rice plants morphology and it benefits physiological processes that results in higher grain yield water productivity.

Zhao *et al.* (2011) found that total water use efficiency and irrigation water use efficiency was increased with system of rice intensification (SRI) by 54.2 and 90% respectively. Thus, SRI offered significantly greater water saving while at the same time producing more grain yield of rice in these trials 11.5% more compared to traditional flooding.

Lin *et al.* (2011) reported that intermittent water application with SRI management, grain yield increased by 10.5 and 11.3%, compared to standard irrigation practice (continuous flooding). They also reported that intermittent irrigation with organic material application improved the functioning of rhizosphere and increased yield of rice.



## Chapter 3

# Materials and Methods

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## Chapter III

### MATERIALS AND METHODS

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from June 2012 to December 2012 to study the effect of fertilizer and manure with different irrigation management practices on the yield and nutrient concentration of T. Aman rice variety BRRI dhan 32. This chapter includes materials and methods that were used in conducting the experiment. The details are presented below under the following headings -

#### 3.1 Experimental site and soil

The experiment was conducted in typical rice growing silt loam soil at the Sher-e-Bangla Agricultural University Farm, Dhaka during the *T. aman* season of 2012. The morphological, physical and chemical characteristics of the soil are shown in Appendix I and II.

#### 3.2 Climate

The climate of the experimental area is characterized by high temperature, high humidity and medium rainfall with occasional gusty winds during the *kharif* season (March-September) and a scanty rainfall associated with moderately low temperature in the *rabi* season (October-March). The weather information regarding temperature, rainfall, relative humidity and sunshine hours prevailed at the experimental site during the cropping season June to November 2012 have been presented in Appendix III.

### **3.3 Planting material**

BRRRI dhan 32 was used as the test crop in this experiment. This variety was developed at the Bangladesh Rice Research Institute. It is recommended for cultivation during *T. aman* season.

### **3.4 Land preparation**

The land was first opened on 10 June , 2012 by a tractor and prepared thoroughly by ploughing and cross ploughing with a power tiller followed by country plough. Laddering helped breaking the clods and leveling the land followed every ploughing. Before transplanting each unit of plot was cleaned by removing weeds, stubbles and crop residues. Finally each plot was prepared by puddling.

### **3.5 Experimental design and layout**

The experiment was laid out in split plot design with three replications. The layout of the experiment was prepared for distributing the irrigation to the main plots and fertilizer to the sub plots. Thus there were 72 (3 levels of irrigation  $\times$  8 fertilizer treatments  $\times$  3 replications) unit plot each of 3 m  $\times$  3 m size. The distance maintained between two main plots and two sub plots were 1.0 m and 0.5 m, respectively. The 3 levels of irrigation were applied in 3 main plots of a block and 8 fertilizer treatments were applied randomly in each main plot (Appendix IV).

### **3.6 Treatments**

The experiment consists of 2 factors i.e. irrigation and fertilizer plus manure. Details of factors are presented below:

### Factor A: Irrigation

$I_1$  = Continuous flooding (3-4 cm water)

$I_2$  = saturated condition (disappearance of water on the surface)

$I_3$  = alternate wetting & drying

### Factor B: Fertilizers and manures

$T_0$ : Control

$T_1$ :  $N_{120}P_{25}K_{60}S_{20}Zn_2$  (Recommended dose)

$T_2$ : 50% NPKSZn + 5 ton cowdung  $ha^{-1}$

$T_3$ : 70% NPKSZn + 3 ton cowdung  $ha^{-1}$

$T_4$ : 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  $ha^{-1}$

$T_7$ : 70% NPKSZn + 2.1 ton poultry manure  $ha^{-1}$



### 3.7 Fertilizer application

The amount of N, P, K, S and Zn fertilizers required per plot were calculated as per the treatments. Full amount of TSP, MP, gypsum and zinc sulphate was applied as basal dose before transplanting of rice seedlings. Urea were applied in 3 equal splits: one third was applied as basal before transplanting, one third at

active tillering stage (30 DAT) and the remaining one third was applied at 5 days before panicle initiation stage (55 DAT).

### 3.8 Organic manure incorporation

Three different types of organic manure viz. cowdung, poultry manure and compost were used. The rates of manure were 5 & 3, 5 & 3 and 3.5 & 2.1 ton/ha for cowdung, compost and poultry manure per plot were calculated as per the treatments, respectively. Cowdung, poultry manures and compost were applied before four days of final land preparation. Chemical compositions of the manures used have been presented in Table 1.

**Table 1. Important nutrients content in cowdung, poultry manure and compost (oven dry basis)**

Sources of organic manure	Nutrients content (%)			
	N	P	K	S
Cowdung	1.26	0.29	0.74	0.24
Poultry manure	2.2	1.99	0.82	0.29
Compost	1.19	0.28	1.20	0.32

### **3.9 Raising of seedlings**

The seedlings of rice were raised on wet-bed. Seeds (95% germination) @ 5 kg/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**

Forty days old seedlings of BRRI dhan 32 were carefully uprooted from the seedling nursery and transplanted in well puddled plots. Two seedlings per hill were used following a spacing of 15 cm × 25 cm. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings 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**

Irrigations were provided to the plots as per treatment.



### **3.11.2 Weeding**

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

### **3.11.3 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 used Malathion @ 1.12 L ha<sup>-1</sup>.

### **3.12 Crop harvest**

The crop was harvested at full maturity when 80-90% of the grains turned into straw color. The crop was cut at the ground level and plot wise crop was bundled separately and brought to the threshing floor. Ten hills of rice plant were selected randomly from the plants for measuring yield contributing characters.

### **3.13 Yield components**

#### **3.13.1 Total no. of effective tiller hill<sup>-1</sup>**

The total number of effective tillers hill<sup>-1</sup> was counted as the number of panicle bearing hill plant<sup>-1</sup>. Data on effective tiller hill<sup>-1</sup> were counted from 10 selected hills and average value was recorded.

### **3.13.2 Total no. of non effective tiller hill<sup>-1</sup>**

The total number of in-effective tiller hill<sup>-1</sup> was counted as the number of non-panicle bearing plant hill<sup>-1</sup>. Data on non effective tiller hill<sup>-1</sup> were counted from 10 randomly selected hills and average value was recorded.

### **3.13.3 Plant height**

The height of plant was recorded in centimeter (cm) at harvesting stage. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the panicle.

### **3.13.4 Length of panicle**

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

### **3.13.5 Straw yield**

Straw obtained from each unit plot were sun-dried and weighed carefully. The dry weight of straw of the respective unit plot yield was converted to t ha<sup>-1</sup>.

### **3.13.6 Grain yield**

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of the respective unit plot yield was converted to t ha<sup>-1</sup>.

### **3.14 Chemical analysis of plant samples**

#### **3.14.1 Collection and preparation of plant samples**

Grain and straw samples were collected after threshing for N, P and K analyses. The plant samples were dried in an oven at 70 °C for 72 hours and then ground by a grinding machine (wiley-mill) to pass through a 20-mesh sieve. The samples were stored in plastic vial for analyses of N, P and K. The grain and straw samples were analyzed for determination of N, P and K concentrations. The methods used were as follows:

#### **3.14.2 Digestion of plant samples with sulphuric acid for N**

For the determination of nitrogen an amount of 0.5 g oven dry, ground sample were taken in a micro kjeldahl flask. 1.1 g catalyst mixture ( $K_2SO_4$ :  $CuSO_4 \cdot 5H_2O$ : Se in the ratio of 100: 10: 1), and 7 mL conc.  $H_2SO_4$  were added. The flasks were heated at 160°C and added 2 mL 30%  $H_2O_2$  then heating was continued at 360 °C until the digests become clear and colorless. After cooling, the content was taken into a 50 mL volumetric flask and the volume was made up to the mark with de-ionized water. A reagent blank was prepared in a similar manner. Nitrogen in the digest was estimated by distilling the digest with 10 N NaOH followed by titration of the distillate trapped in  $H_3BO_3$  indicator solution with 0.01N  $H_2SO_4$ .

#### **3.14.3 Digestion of plant samples with nitric-perchloric acid for P and K**

A sub sample weighing 0.5 g was transferred into a dry, clean 100 mL digestion vessel. Ten mL of di-acid ( $HNO_3$ :  $HClO_4$  in the ratio 2:1) mixture was added to

the flask. After leaving for a while, the flasks were heated at a temperature slowly raised to 200°C. Heating were stopped when the dense white fumes of HClO<sub>4</sub> appeared. The content of the flask were boiled until they became clean and colorless. After cooling, the content was taken into a 100 mL volumetric flask and the volume was made up to the mark with de-ionized water. P and K were determined from this digest by using different standard methods.

### 3.14.4 Determination of P and K from plant samples

#### 3.14.4.1 Phosphorus

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Plant samples (grain and straw) were digested by diacid (Nitric acid and Perchloric acid) mixture and P content in the digest was measured by blue color development (Olsen *et al.*, 1954). Phosphorus in the digest was determined by using 1 mL of grain extract sample from 100 mL digest by developing blue color with reduction of phosphomolybdate complex and the color intensity was measured colorimetrically at 660 nm wavelength and readings were calibrated with the standard P curve (Page *et al.*, 1982).

#### 3.14.4.2 Potassium

Five milli-liter of digest sample of the grain and 10 mL for the straw were taken and diluted to 50 ml volume to make desired concentration so that the flame photometer reading of samples were measured within the range of standard solutions. The concentrations were calibrated by using standard curves.

### 3.15 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant differences of different treatments on yield and yield contributing characters of BRRI dhan 32. The mean values of all the characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).





## Chapter 4

# Results and Discussion

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## Chapter IV

### RESULTS AND DISCUSSION

The results of different yield attributes, yield and nutrient concentrations in the grains and straw of T. aman BRRI dhan 32 are presented this chapter.

#### 4.1 Effective tiller

The effect of irrigation on the number of effective tillers hill<sup>-1</sup> of BRRI dhan 32 is presented in Table 2. The effective tillers hill<sup>-1</sup> of BRRI dhan 32 did not vary significantly due different irrigation regimes. The treatment I<sub>2</sub> (saturated condition) contained the highest number of effective tillers hill<sup>-1</sup> (7.27) and I<sub>3</sub> (alternate wetting and drying) had the lowest number of effective tillers hill<sup>-1</sup> (6.94).

As to the effect of different doses of fertilizers and manures the number of effective tillers hill<sup>-1</sup> of BRRI dhan 32 varied significantly (Table 3). Among the different doses of fertilizers, T<sub>7</sub> (70% NPKS + 2.1 ton poultry manure ha<sup>-1</sup>) showed the highest number of effective tillers hill<sup>-1</sup> (7.56) followed by T<sub>4</sub> (50% NPKSZn + 5 ton compost ha<sup>-1</sup>) (7.36) and T<sub>6</sub> treatment (7.31). The lowest number of effective tillers hill<sup>-1</sup> (6.64) was observed with T<sub>0</sub> where no fertilizer was applied. Nayak *et al.* (2007) reported a significant increase in effective tillers hill<sup>-1</sup> due to the application of chemical fertilizers with organic manure. Similar results were also found by Rahman *et al.* (2009) and Reddy *et al.* (2004)

**Table 2. The effect of irrigation on effective tillers per hill and non-effective tillers per hill of BRRI dhan 32**

Treatments (irrigation )	No. of effective tillers hill <sup>-1</sup>	No. of non-effective tillers hill <sup>-1</sup>
I <sub>1</sub>	7.15	1.57
I <sub>2</sub>	7.27	1.56
I <sub>3</sub>	6.94	1.63
SE (±)	NS	NS

**Table 3. The Effect of different doses of fertilizers and manures on effective tillers hill<sup>-1</sup> and non-effective tillers hill of BRRI dhan 32**

Treatments	No. of effective tiller hill <sup>-1</sup>	No. of non-effective tiller hill <sup>-1</sup>
T <sub>0</sub>	6.64 c	1.42
T <sub>1</sub>	7.31 ab	1.29
T <sub>2</sub>	6.76 bc	1.56
T <sub>3</sub>	7.27 abc	1.82
T <sub>4</sub>	7.36 ab	1.82
T <sub>5</sub>	6.77 bc	1.82
T <sub>6</sub>	7.31 ab	1.76
T <sub>7</sub>	7.56 a	1.21
SE (±)	0.181	NS

Figures having similar letter(s) in a column do not differ significantly whileas figures with dissimilar letter(s) differ significantly as per DMRT at 5% level of significance



The number of effective tillers hill<sup>-1</sup> of BRR1 dhan 32 under study varied significant due to the combined effect of different treatment (Table 4). The highest number of effective tillers hill<sup>-1</sup> (8.07) was recorded with the treatment combination I<sub>2</sub>T<sub>7</sub> (saturated condition in combination with 50% NPKSZn + 2.1 ton poultry manure/ha). While the lowest number of effective tillers/hill (6.07) was found in I<sub>1</sub>T<sub>0</sub> (Alternate wetting and drying + control treatment) treatment combination.

#### 4.2 Non-effective tiller

The effect of irrigation on the non-effective tillers hill<sup>-1</sup> of BRR1 dhan 32 is presented in Table 2. There was no significant variation observed on the non-effective tillers hill<sup>-1</sup> when the field was irrigated with three different irrigations. The lowest number of non-effective tillers hill<sup>-1</sup> (1.56) was found in I<sub>2</sub> (saturated condition) and I<sub>3</sub> (alternate wetting and drying) irrigation showed highest number of non-effective tillers/hill (1.63).

Different doses of fertilizers and manures did not have significant effect in respect of non effective tillers hill<sup>-1</sup> of BRR1 dhan 32 under study (Table 3). Among the different doses of fertilizers, the lowest number of non-effective tillers hill (1.21) was found in T<sub>7</sub> (70% NPKS + 2.1 ton poultry manure ha<sup>-1</sup>) and the highest number of non-effective tillers hill<sup>-1</sup> (1.82) was observed with T<sub>3</sub> (70% NPKSZn + 3 ton cowdung ha<sup>-1</sup>), T<sub>4</sub> (50% NPKSZn + 5 ton compost ha<sup>-1</sup>) and T<sub>5</sub> (70% NPKSZn + 3 ton compost ha<sup>-1</sup>) treatments.

**Table 4. Interaction effect of fertilizer and irrigation on effective and non-effective tillers hill<sup>-1</sup> of BRR1 dhan 32**

Treatment	No. of effective tiller hill-1	No. of non-effective tiller hill <sup>-1</sup>
I <sub>1</sub> T <sub>0</sub>	6.47 bc	1.47
I <sub>1</sub> T <sub>1</sub>	7.27 abc	1.40
I <sub>1</sub> T <sub>2</sub>	7.27 abc	1.40
I <sub>1</sub> T <sub>3</sub>	7.13 abc	1.47
I <sub>1</sub> T <sub>4</sub>	7.00 abc	1.86
I <sub>1</sub> T <sub>5</sub>	7.07 abc	1.53
I <sub>1</sub> T <sub>6</sub>	7.80 ab	1.80
I <sub>1</sub> T <sub>7</sub>	7.20 abc	1.60
I <sub>2</sub> T <sub>0</sub>	7.65 ab	1.01
I <sub>2</sub> T <sub>1</sub>	7.47 abc	1.40
I <sub>2</sub> T <sub>2</sub>	6.93 abc	1.53
I <sub>2</sub> T <sub>3</sub>	7.93 a	2.10
I <sub>2</sub> T <sub>4</sub>	7.27 abc	1.47
I <sub>2</sub> T <sub>5</sub>	6.40 bc	1.93
I <sub>2</sub> T <sub>6</sub>	6.47 bc	2.13
I <sub>2</sub> T <sub>7</sub>	8.07 a	0.08
I <sub>3</sub> T <sub>0</sub>	6.07 c	1.13
I <sub>3</sub> T <sub>1</sub>	7.20 abc	1.67
I <sub>3</sub> T <sub>2</sub>	6.20 c	1.73
I <sub>3</sub> T <sub>3</sub>	6.73 abc	1.80
I <sub>3</sub> T <sub>4</sub>	7.8 ab	2.13
I <sub>3</sub> T <sub>5</sub>	6.47 bc	2.00
I <sub>3</sub> T <sub>6</sub>	7.67 ab	1.33
I <sub>3</sub> T <sub>7</sub>	7.40 abc	1.27
<b>SE (±)</b>	0.41	NS
<b>CV (%)</b>	9.91	12.08

In a column figures having similar letter(s) do not differ significantly while as figures with dissimilar letter(s) differ significantly as per DMRT at 5% level of significance.

The number of non-effective tillers hill<sup>-1</sup> of BRR1 dhan 32 did not vary significantly due to the combined effect of different doses of fertilizer and irrigation (Table 3). The highest number of non-effective tillers hill<sup>-1</sup> (2.13) was recorded with the treatment combination I<sub>2</sub>T<sub>6</sub> (saturated condition with 50% NPKS + 3.5 ton poultry manure ha<sup>-1</sup>) and I<sub>3</sub>T<sub>4</sub> (alternate wetting and drying with 50% NPKSZn + 5 ton compost ha<sup>-1</sup>). The lowest number of non-effective tillers hill<sup>-1</sup> (0.08) was found in I<sub>2</sub>T<sub>7</sub> (saturated condition with 70% NPKS + 2.1 ton poultry manure ha<sup>-1</sup>) treatment combination.

#### 4.3 Plant height

The effects of irrigation on the plant height of BRR1 dhan 32 are presented in Table 5. There was no significant variation observed on the plant height of BRR1 dhan 32 when the field was given different regimes of irrigation. I<sub>3</sub> (alternate wetting and drying) treatment produced the highest plant height (121.80 cm) and I<sub>2</sub> (saturated condition) irrigation treatment gave the lowest plant height (120.60 cm).

Rice plant showed significant variation was observed in plant height of BRR1 dhan 32 when fertilizers of different doses were applied (Table 6). The treatment T<sub>7</sub> (50% NPKSZn + 2.1 ton poultry manure/ha) produced the highest plant height (124.80 cm). On the other hand lowest plant height (105.80 cm) was observed in the T<sub>0</sub> treatment where no fertilizer was applied. Plant height was significantly influenced by the application of organic manure and chemical fertilizers reported by Nayak *et al.* (2007). Similar results were also reported by Aga *et al.* (2004) and Reddy *et al.* (2004).

**Table 5. The effect of different regimes of irrigation on the plant height and panicle length of BRR1 dhan 32**

Treatment	Plant height (cm)	Panicle length (cm)
I <sub>1</sub>	121.60	25.06
I <sub>2</sub>	120.60	25.45
I <sub>3</sub>	121.80	25.20
SE (±)	NS	NS

**Table 6. The effect of different fertilizers and manures on the plant height and panicle length of BRR1 dhan 32**

Treatments	Plant height (cm)	Panicle length (cm)
T <sub>0</sub>	105.80 b	23.36 b
T <sub>1</sub>	123.30 a	24.70 ab
T <sub>2</sub>	124.40 a	25.25 ab
T <sub>3</sub>	122.70 a	26.05 a
T <sub>4</sub>	125.00 a	25.55 a
T <sub>5</sub>	123.40 a	25.31 ab
T <sub>6</sub>	121.20 a	25.16 ab
T <sub>7</sub>	124.80 a	26.51 a
SE (±)	1.28	0.55

Figures having similar letter(s) in a column do not differ significantly while as figures with dissimilar letter(s) differ significantly as per DMRT at 5% level of significance.

Combined application of different regimes of irrigation and different doses of fertilizers and manures had no significant effect on variation of the plant height of BRRI dhan 32 (Table 7). The lowest plant height (103.6 cm) was observed in the treatment combination of  $I_1T_0$  (Continuous flooding with no fertilizer). On the other hand, the highest plant height (128.9 cm) was recorded with  $I_3T_7$  (alternate wetting and drying + 70% NPKS + 2.1 ton poultry manure  $ha^{-1}$ ) treatment.

#### 4.4 Panicle length

The effects of different regimes of irrigation on the panicle length of BRRI dhan 32 are presented in Table 5. Insignificant variation was observed on the panicle length when the field was treated with three different regimes of irrigation. The longest panicle (25.45 cm) was observed in  $I_2$  treatment and  $I_1$  (continuous flooding) irrigation showed the lowest panicle length (25.06 cm).

Significant variation in respect of panicle length of BRRI dhan 32 was observed when different doses of fertilizers and manures were applied in the field (Table 6). The longest panicle (26.51 cm) was obtained from  $T_7$  treatment, which was statistically identical to  $T_3$  (26.05 cm) (70% NPKSZn + 3 ton cowdung  $ha^{-1}$ ) and  $T_4$  (25.55 cm) (50% NPKSZn + 5 ton compost  $ha^{-1}$ ) and all other treatments except control. The control treatment produced the shortest panicle (23.36 cm). Rahman *et al.* (2009) noted a significant increase in panicle length due to the application of organic manure and chemical fertilizers. Babu *et al.* (2001) and Reddy *et al.* (2004) also reported similar results.

**Table 7. Interaction effect of different fertilizers and manures and irrigation regunes on the plant height and panicle length of BRRI dhan 32**

Treatments	Plant height (cm)	Panicle length (cm)
I <sub>1</sub> T <sub>0</sub>	103.6	22.58
I <sub>1</sub> T <sub>1</sub>	126.2	24.82
I <sub>1</sub> T <sub>2</sub>	123.9	26.09
I <sub>1</sub> T <sub>3</sub>	117.9	26.31
I <sub>1</sub> T <sub>4</sub>	121.4	26.1
I <sub>1</sub> T <sub>5</sub>	125.1	26.08
I <sub>1</sub> T <sub>6</sub>	121.4	26.19
I <sub>1</sub> T <sub>7</sub>	125.4	25.14
I <sub>2</sub> T <sub>0</sub>	105.9	22.83
I <sub>2</sub> T <sub>1</sub>	120.5	25.17
I <sub>2</sub> T <sub>2</sub>	124.4	25.47
I <sub>2</sub> T <sub>3</sub>	123.7	25.89
I <sub>2</sub> T <sub>4</sub>	121.2	25.17
I <sub>2</sub> T <sub>5</sub>	121.7	25.08
I <sub>2</sub> T <sub>6</sub>	119.6	24.72
I <sub>2</sub> T <sub>7</sub>	127.5	27.96
I <sub>3</sub> T <sub>0</sub>	107.9	24.65
I <sub>3</sub> T <sub>1</sub>	123.3	24.11
I <sub>3</sub> T <sub>2</sub>	125.0	27.90
I <sub>3</sub> T <sub>3</sub>	126.3	25.96
I <sub>3</sub> T <sub>4</sub>	124.9	25.37
I <sub>3</sub> T <sub>5</sub>	123.3	24.75
I <sub>3</sub> T <sub>6</sub>	122.5	24.57
I <sub>3</sub> T <sub>7</sub>	128.9	24.26
SE (±)	NS	NS
CV (%)	4.39	6.51

Combined application of different doses of fertilizers and manures and irrigation regimes did not have any significant variation on the panicle length of BRR1 dhan 32 under study (Table 7). The lowest panicle length (22.58 cm) was observed in the treatment combination of  $I_1T_0$  (continuous flooding with no fertilizer) and the highest panicle length (27.96 cm) was recorded with  $I_2T_7$  (saturated condition with 70% NPKSZn + 2.4 ton poultry manure/ha) treatment.

#### 4.5 Number of filled grain per panicle

Number of filled grains per panicle was not significantly influenced by irrigation regimes (Table 8).  $I_2$  (saturated condition) showed the highest number of filled grain per panicle (105.00) and  $I_1$  (continuous flooding) irrigation regimes showed lowest number of filled grain per panicle (97.14).

Significant variation was observed in number of filled grain per panicle of BRR1 dhan 32 when different doses of fertilizers and manures were applied (Table 9). The highest number of filled grain per panicle (112.30) was recorded in  $T_7$  treatment, which was statistically similar to  $T_2$  and  $T_3$ . The lowest number of filled grain per panicle (85.59) was recorded in  $T_0$  (control treatment). Similar result was found by Rahman *et al.* (2009).

**Table 8. The effect of different irrigation regimes on the number of filled grain per panicle, straw and grain yield of BRRI dhan 32**

Treatments	Number of filled grain panicle <sup>-1</sup>	Straw yield (t ha <sup>-1</sup> )	Grain yield (t ha <sup>-1</sup> )
I <sub>1</sub>	97.14	5.98	4.37
I <sub>2</sub>	105.00	6.53	4.81
I <sub>3</sub>	100.10	6.52	4.58
SE (±)	NS	NS	NS

**Table 9. The effect of different doses of fertilizers and manures on the number of filled grains per panicle, straw yield and grain yield of BRRI dhan 32**

Treatments	Number of filled grain panicle <sup>-1</sup>	Straw yield (t ha <sup>-1</sup> )	Grain yield (t ha <sup>-1</sup> )
T <sub>0</sub>	85.59 b	5.21 b	3.79 b
T <sub>1</sub>	95.85 ab	6.71 a	4.81 ab
T <sub>2</sub>	110.1 a	6.78 a	4.74 ab
T <sub>3</sub>	108.3 a	6.10 ab	4.56 ab
T <sub>4</sub>	103.3 ab	6.29 ab	4.48 ab
T <sub>5</sub>	101.1 ab	6.65 a	4.5 ab
T <sub>6</sub>	89.31 b	6.55 ab	4.85 ab
T <sub>7</sub>	112.3 a	6.48 a	4.98 a
SE (±)	5.048	0.35	0.18

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT at 5% level of significance.



The number of filled grain per panicle was not significantly influenced by the combined effect of different doses of fertilizers and manures and irrigation regims (Table 10). The highest number of filled grain per panicle (135.40) was recorded with the treatment combination I<sub>2</sub>T<sub>7</sub> and the lowest number of filled grains panical<sup>-1</sup> (70.00) was found in I<sub>1</sub>T<sub>0</sub> treatment combination.

#### 4.6 Straw yield

The effect of different regimes of irrigation on the straw yield of BRRI dhan 32 under the present study is presented in Table 8. The straw yield was not significantly influenced when the field was treated with different regimes of irrigations. I<sub>2</sub> showed the highest straw yield (6.53 t/ha) and I<sub>1</sub> irrigation showed the lowest straw yield (5.98 t ha<sup>-1</sup>).

Significant variation was observed on the straw yield of BRRI dhan 32 when different doses of fertilizer were applied (Table 9). The highest yield of straw (6.71 t/ha) was recorded in T<sub>2</sub> (50% NPKSZn + 3 ton cowdung/ha) treatment which was statistically similar to T<sub>1</sub> and T<sub>7</sub> treatments. The lowest straw yield (5.21 t/ha) was recorded in the T<sub>0</sub> treatment. Rahman *et al.* (2009) reported that the application of organic manure and chemical fertilizers increased the straw yields of BRRI dhan 32. These findings are corroborated with the work of Mannan *et al.* (2000). It is clear that organic manures in combination with inorganic fertilizers increased vegetative growth of plants and thereby increased straw yield of BRRI dhan 32.

**Table 10. Interaction effect of different doses of fertilizers and manures and irrigation on the number of filled grain per panicle, straw yield/plot and grain yield/plot of BRRI dhan 32**

Treatment	Number of filled grain per panicle	Straw yield (t/ha)	Grain yield (t/ha)
I <sub>1</sub> T <sub>0</sub>	70.00	5.00	3.71
I <sub>1</sub> T <sub>1</sub>	91.47	6.75	4.96
I <sub>1</sub> T <sub>2</sub>	114.40	5.56	4.66
I <sub>1</sub> T <sub>3</sub>	116.90	5.78	4.25
I <sub>1</sub> T <sub>4</sub>	113.20	6.01	4.19
I <sub>1</sub> T <sub>5</sub>	110.70	6.23	4.01
I <sub>1</sub> T <sub>6</sub>	97.20	6.19	4.16
I <sub>1</sub> T <sub>7</sub>	101.30	6.32	5.04
I <sub>2</sub> T <sub>0</sub>	83.71	5.15	3.86
I <sub>2</sub> T <sub>1</sub>	100.40	6.78	5.24
I <sub>2</sub> T <sub>2</sub>	105.10	7.00	4.89
I <sub>2</sub> T <sub>3</sub>	97.83	6.23	4.46
I <sub>2</sub> T <sub>4</sub>	86.97	6.24	4.46
I <sub>2</sub> T <sub>5</sub>	104.80	6.55	4.96
I <sub>2</sub> T <sub>6</sub>	87.71	6.86	5.23
I <sub>2</sub> T <sub>7</sub>	135.40	7.40	5.34
I <sub>3</sub> T <sub>0</sub>	103.00	5.46	3.81
I <sub>3</sub> T <sub>1</sub>	95.72	6.59	4.23
I <sub>3</sub> T <sub>2</sub>	111.00	7.35	4.59
I <sub>3</sub> T <sub>3</sub>	110.00	6.28	4.97
I <sub>3</sub> T <sub>4</sub>	109.70	6.61	4.78
I <sub>3</sub> T <sub>5</sub>	96.79	7.17	4.52
I <sub>3</sub> T <sub>6</sub>	83.02	6.58	5.15
I <sub>3</sub> T <sub>7</sub>	91.30	6.10	4.55
SE (±)	NS	NS	NS
CV (%)	20.91	16.35	11.92

The combined application of different doses of fertilizers and manures and irrigation regimes did not have significant effect on the straw yield of BRRI dhan 32 (Table 10). The highest straw yield (7.40 kg ha<sup>-1</sup>) was recorded with the

treatment combination I<sub>2</sub>T<sub>7</sub>, which was statistically similar to that of I<sub>3</sub>T<sub>2</sub> and the lowest straw yield (5.00 kg ha<sup>-1</sup>) was found in I<sub>1</sub>T<sub>0</sub> treatment combination.

#### 4.7 Grain yield

The results on the effect of irrigation on the grain yield of BRRI dhan 32 are presented in Table 8. It was observed that the variation was not significantly influenced due to three different irrigation regims on the grain yield. I<sub>2</sub> (saturated condition) produced the highest grain yield (4.81 t ha<sup>-1</sup>) and I<sub>1</sub> (continuous flooding) irrigation regims gave lowest grain yield (4.37 t ha<sup>-1</sup>).

Application of different doses of fertilizers and manures induced significant variations in grain yield of BRRI dhan 32 (Table 9). The application of fertilizers and manures had positive effect on the grain yield. The grain yield increase to a considerable extent was observed in the integrated use of fertilizers and manures compared to chemical fertilizer alone. Among the different doses of fertilizers, T<sub>7</sub> (50% NPKSZn + 2.1 ton poultry manure/ha) showed the highest grain yield (4.98 t ha<sup>-1</sup>), which was statistically similar to that of T<sub>6</sub> and T<sub>1</sub> treatments. The lowest grain yield (3.79 t/ha) was observed with T<sub>0</sub> where no fertilizer was applied. Rahman *et al.* (2009) reported the grain yield was significantly increased due to application of organic manure and chemical fertilizers. This is also in agreement with the findings of Miah *et al.* (2006), and Miah *et al.* (2004).

The grain yield of BRRI dhan 32 did not vary significantly due to the combined effect of different doses of fertilizers and manures and irrigation regimes (Table 10). The highest grain yield (5.34 t ha<sup>-1</sup>) was recorded with the treatment

combination I<sub>2</sub>T<sub>7</sub> (saturated condition +50% NPKSZn + 2.1 ton ha<sup>-1</sup> poultry manure) treatment combinations and the lowest grain yield (3.71 t ha<sup>-1</sup>) was found in I<sub>1</sub>T<sub>0</sub> (continuous flooding with control treatment) treatment combination. *Lin et al.* (2011) reported that irrigation with organic material application increased yield of BRRRI dhan 32.

#### 4.8 N concentration in grains of BRRRI dhan 32

The effect of different irrigation regims on N concentration in grain of BRRRI dhan 32 are presented in Table 11. There were no significant variations observed on N concentration in grains when the field was treated with three different irrigation regims. The grain contained (1.18% N) in I<sub>2</sub> (saturated condition) and I<sub>1</sub> (alternate wetting & drying) contained in (1.12% N).

Statistically significant variation in nitrogen concentrations was found due to the application of different doses of fertilizers and manures are presented in Table 12. The nitrogen concentration in T. aman BRRRI dhan 32 grain significantly increased due to application of fertilizers and manure. The higher levels of grain N concentrations were recorded in the combined application of fertilizers and manures compared to that with the chemical fertilizers alone. The highest N concentration in grain (1.33%) was recorded from T<sub>7</sub> (50% NPKSZn + 2.1 ton poultry manure/ha). The lowest N concentration in grain (0.99%) was found from T<sub>0</sub> treatment. A significant increase in N content in BRRRI dhan 32 grain due to the application of organic manure and fertilizers has been reported by different investigators (Azim, 1999 and Hoque, 1999).

The result on the combined effect of different doses of fertilizers and manures and irrigation regims on N concentration of BRRI dhan 32 was significantly varied (Table 13). The highest N (1.39%) concentration in grain was recorded with the treatment combination I<sub>3</sub>T<sub>7</sub> (alternate wetting and drying +50% NPKSZn + 2.1 ton ha<sup>-1</sup> poultry manure), which was closely similar to that of I<sub>3</sub>T<sub>6</sub>, I<sub>2</sub>T<sub>7</sub>, I<sub>1</sub>T<sub>7</sub>, and I<sub>1</sub>T<sub>1</sub> treatment combinations. The lowest N concentration (0.88%) in grain BRRI dhan 32 was found in I<sub>3</sub>T<sub>0</sub> (alternate wetting and drying + control treatment) treatment.

#### **4.9 P concentration in grain**

Results on the effect of irrigation regims on P concentration in grain of BRRI dhan 32 are presented in Table 11. P concentration in rice grain was nont found to vary significantly when the field was treated with three different irrigation regims. The highest P concentration in grain (0.26%) was in I<sub>1</sub> (continuous flooding) and the lowest P concentration in grain (0.25%) was obtained from I<sub>3</sub> (alternate wetting & drying) irrigation.

**Table 11. The effect of irrigation on NPK concentration in grain of BRRRI dhan 32**

Treatments	Concentration in grain (%)		
	N	P	K
I <sub>1</sub>	1.165	0.261	0.273
I <sub>2</sub>	1.182	0.255	0.257
I <sub>3</sub>	1.118	0.247	0.266
SE (±)	NS	NS	NS

**Table 12. Effect of fertilizers and manures on NPK concentration in grains of BRRRI dhan 32**

Treatments	Concentration in grain (%)		
	N	P	K
T <sub>0</sub>	0.988 d	0.215 b	0.200 d
T <sub>1</sub>	1.202 abc	0.269 a	0.250 c
T <sub>2</sub>	1.067 cd	0.252 a	0.261 c
T <sub>3</sub>	1.060 cd	0.259 a	0.251 c
T <sub>4</sub>	1.102 bcd	0.260 a	0.300 ab
T <sub>5</sub>	1.259 a	0.276 a	0.307 a
T <sub>6</sub>	1.230 ab	0.246 ab	0.269 bc
T <sub>7</sub>	1.33 a	0.257 a	0.283 abc
SE (±)	0.0036	0.0085	0.0123

Figures having similar letter(s) in a column do not differ significantly while as figures with dissimilar letter(s) differ significantly as per DMRT at 5% level of significance.

**Table 13. Combined effect of fertilizers and manures and irrigation regims on NPK concentration in grains of BRR1 dhan 32**

Treatments	Concentration (%) in grain		
	N	P	K
I <sub>1</sub> T <sub>0</sub>	0.992 fgh	0.208 ef	0.217
I <sub>1</sub> T <sub>1</sub>	1.344 ab	0.315 a	0.250
I <sub>1</sub> T <sub>2</sub>	0.960 gh	0.237 c-f	0.242
I <sub>1</sub> T <sub>3</sub>	1.088 c-h	0.284 a-d	0.242
I <sub>1</sub> T <sub>4</sub>	1.131 b-g	0.246 b-f	0.333
I <sub>1</sub> T <sub>5</sub>	1.344 ab	0.304 ab	0.333
I <sub>1</sub> T <sub>6</sub>	1.184 a-g	0.227 d-f	0.283
I <sub>1</sub> T <sub>7</sub>	1.280 a-d	0.271 a-e	0.283
I <sub>2</sub> T <sub>0</sub>	1.024 e-h	0.184 f	0.183
I <sub>2</sub> T <sub>1</sub>	1.269 a-e	0.249 b-e	0.250
I <sub>2</sub> T <sub>2</sub>	1.120 b-h	0.297 abc	0.242
I <sub>2</sub> T <sub>3</sub>	1.216 a-f	0.281 a-d	0.242
I <sub>2</sub> T <sub>4</sub>	1.120 a-g	0.259 a-e	0.292
I <sub>2</sub> T <sub>5</sub>	1.216 a-f	0.252 a-e	0.308
I <sub>2</sub> T <sub>6</sub>	1.163 a-g	0.263 a-e	0.258
I <sub>2</sub> T <sub>7</sub>	1.328 abc	0.252 a-e	0.283
I <sub>3</sub> T <sub>0</sub>	0.949 gh	0.252 a-e	0.200
I <sub>3</sub> T <sub>1</sub>	0.992 fgh	0.242 b-f	0.250
I <sub>3</sub> T <sub>2</sub>	1.120 b-h	0.223 def	0.300
I <sub>3</sub> T <sub>3</sub>	0.875 h	0.211 ef	0.271
I <sub>3</sub> T <sub>4</sub>	1.056 d-h	0.276 a-d	0.275
I <sub>3</sub> T <sub>5</sub>	1.216 a-f	0.272 a-e	0.279
I <sub>3</sub> T <sub>6</sub>	1.344 a-b	0.249 b-e	0.267
I <sub>3</sub> T <sub>7</sub>	1.392 a	0.249 b-e	0.283
<b>SE (±)</b>	<b>0.0723</b>	<b>0.0146</b>	<b>NS</b>
<b>CV (%)</b>	<b>10.85</b>	<b>9.97</b>	<b>13.89</b>

Figures having similar letter(s) in a column do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT at 5% level of significance

Results on phosphorous concentrations in grains of BRRI dhan 32 were found to vary significantly due to the application of different doses of fertilizers and manures (Table 12). The highest P concentration in grain (0.276%) was recorded from T<sub>5</sub> (70% NPKSZn + 3 ton compost ha<sup>-1</sup>) which were closely similar to that in treatments T<sub>7</sub> and T<sub>1</sub>. The lowest P concentration in grain (0.215%) was found from T<sub>0</sub> (control treatment). A significant increase in P content in BRRI dhan 32 straw was due to the application of organic manure and fertilizers (Azim, 1999 and Hoque, 1999).

It was apparent from the results in table 13 that P concentration in grains of BRRI dhan 32 varied significantly due to the combined effect of different doses of fertilizers and manures and irrigation regims. The highest P concentration (0.315%) was recorded with the treatment combination I<sub>1</sub>T<sub>1</sub> (continuous flooding with N<sub>120</sub>P<sub>25</sub>K<sub>60</sub>S<sub>20</sub>Zn<sub>2</sub>), which was statistically similar to that of I<sub>2</sub>T<sub>7</sub>, I<sub>2</sub>T<sub>6</sub>, I<sub>1</sub>T<sub>7</sub> treatments and the lowest P concentration (0.184%) was found in I<sub>2</sub>T<sub>0</sub> (saturated condition + control treatment) treatment.

#### **4.10 K concentration in grain of BRRI dhan 32**

The effect of different irrigation regims on K concentration in grains of BRRI dhan 32 have been presented in Table 11. Results show that the variation in K concentration in grain of BRRI dhan 32 was not signifecantly influenced by different regimes of irrigations. I<sub>1</sub> (continuous flooding) showed K concentration of 0.273% in grain and I<sub>2</sub> (saturated condition) showed the K concentration of 0.257% in grains.



The variation of potassium concentrations in grains of BRRI dhan 32 showed statistically significant variation due to the application of different doses of fertilizers (Table 12). The highest K concentration in grain (0.307%) was recorded from T<sub>5</sub> (70% NPKSZn + 3 ton compost ha<sup>-1</sup>) and the lowest K concentration (0.20%) was found from T<sub>0</sub> (control treatment). Singh *et al.* (2001) revealed that potassium content in grain was increased due to combined application of organic manure and chemical fertilizers.

The combined effect of different doses of fertilizer and irrigation on K concentration in grains of BRRI dhan 32 under study was not significantly different (Table 13). The highest K concentration (0.333%) was recorded with the treatment combination I<sub>1</sub>T<sub>4</sub> (continuous flooding +50% NPKSZn + 5 ton compost ha<sup>-1</sup>) and at was lowest (0.183%) in I<sub>2</sub>T<sub>0</sub> (saturated condition + control treatment) treatment.





## Chapter 5

# Summary and Conclusion

## Chapter V

### SUMMARY AND CONCLUSION

The experiment was conducted in the Agricultural Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from June to December 2012 to know the effect of fertilizers and manures with different irrigation management practices on the yield attributes, yield and nutrient concentration in *T. Aman* rice variety BRRI dhan 32. The experiment consisted of 2 factors i. e. irrigation and fertilizer plus manure. Three levels of irrigations as  $I_1$  = continuous flooding,  $I_2$  = saturated condition and  $I_3$  = alternate wetting and drying were used with 8 levels of different fertilizers plus manures, as  $T_0$ : control,  $T_1$ :  $N_{120}P_{25}K_{60}S_{20}Zn_2$  (recommended dose),  $T_2$ : 50% NPKS + 5 ton cowdung  $ha^{-1}$ ,  $T_3$ : 70% NPKSZn + 3 ton cowdung  $ha^{-1}$ ,  $T_4$ : 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% NPKS + 2.1 ton poultry manure  $ha^{-1}$  were used. The total number effective tillers  $hill^{-1}$ , plant height, panicle length, number of filled grain  $panicle^{-1}$ , grain yield and straw yield were not significantly influenced by single effect of irrigation. The highest number of effective tillers  $hill^{-1}$ , panicle length, number of filled grain yield and straw yield were observed from  $I_2$  treatment. The highest plant height was observed in  $I_3$ .

Yield contributing characters and yields were significantly influenced by fertilizers and manures. The highest effective tillers  $hill^{-1}$  (7.56), plant height (124.80 cm), panicle length (26.51 cm), number of filled grain per panicle (112.30), grain yield

(4.98 kg plot<sup>-1</sup>) and straw yield (6.77 kg plot<sup>-1</sup>) were found from T<sub>7</sub> (50% NPKSZn + 2.1 ton poultry manure ha<sup>-1</sup>) treatment. The lowest values were obtained from T<sub>0</sub> treatment. Number of non effective tillers hill<sup>-1</sup> and grain yield were significantly influenced by combined application of irrigation and fertilizers and manures.

The combined effect of irrigation and different doses of fertilizers and manures on all the parameter except effective tiller per hill of rice was not significantly different. The highest values of effective tillers hill<sup>-1</sup> (8.07), panicle length (27.96 cm), number of filled grain per panicle (135.40), grain yield (5.34 kg plot<sup>-1</sup>) and straw yield (7.40 kg plot<sup>-1</sup>) were observed from I<sub>2</sub>T<sub>7</sub> (saturated condition in combination with 50% NPKSZn + 2.1 ton poultry manure ha<sup>-1</sup>) treatment.

The nutrient concentration in T. aman rice plant was not significantly affected by irrigation. The higher levels of N concentration were recorded from I<sub>2</sub> treatment. The highest levels of P and K concentration in grain were recorded in I<sub>1</sub> (Continuous flooding) treatment.

The nutrients concentration in T. Aman rice plant varied significantly due to application of different fertilizers and manures. The highest N concentration in grain (1.33%) was recorded from T<sub>7</sub> (50% NPKSZn + 2.1 ton poultry manure ha<sup>-1</sup>) treatment. The highest concentrations of P (0.276%), K (0.307%), were recorded from T<sub>5</sub> (70% NPKSZn + 3 ton compost ha<sup>-1</sup>) treatment and lowest value was observed in T<sub>0</sub> treatment.

The combined effect of different fertilizers and manures and irrigation regims significantly influenced the grain N and P concentration. The highest N (1.39%)

concentration in grain of rice under study was recorded with the treatment combination I<sub>3</sub>T<sub>7</sub> (saturated condition +50% NPKSZn + 2.1 ton poultry manure/ha). The highest P concentration in grain of rice (0.315%) was recorded with the treatment combination I<sub>1</sub>T<sub>1</sub> (continuous flooding with N<sub>120</sub>P<sub>25</sub>K<sub>60</sub>S<sub>20</sub>Zn<sub>2</sub>). The highest K concentration in grain of rice (0.333%) was recorded with the treatment combination I<sub>1</sub>T<sub>4</sub> (Continuous flooding +50% NPKSZn + 5 ton compost ha<sup>-1</sup>).

From the above discussion it can be concluded that continuous flood irrigation or alternate wetting and drying had no significant effect on yield and yield contributing characters, the saturated condition is preferable than continuous flood irrigation. The application of 70% NPKSZn + 2.1 ton poultry manure ha<sup>-1</sup> and saturated condition was most favorable for improving yield and yield contributing characters of BRRI dhan 32 in T. aman season.

Before making any recommend when under mentioned follow up the following recommendations and works may be undertaken:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance.
2. Program with different combination of NPK along with different dosed of organic manures and different water management practices may be under taken.



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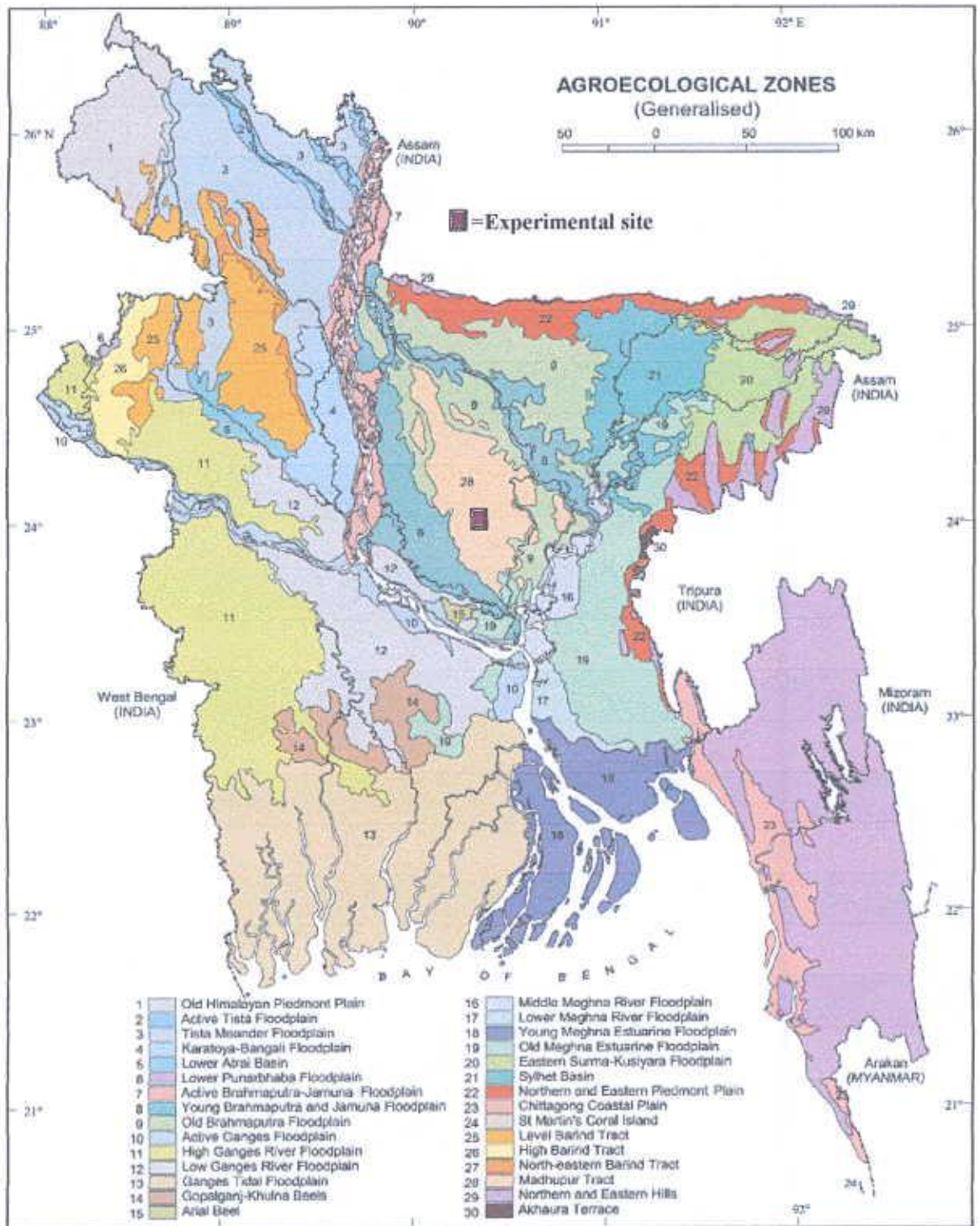
# Appendices

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## APPENDICES

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



## Appendix II. Morphological characteristics of the experimental field

Morphology	Characteristics
Location	SAU Farm, Dhaka.
Agro-ecological zone	Madhupur Tract (AEZ- 28)
General Soil Type	Deep Red Brown Terrace Soil
Parent material	Madhupur Terrace.
Topography	Fairly level
Drainage	Well drained
Flood level	Above flood level

(FAO and UNDP, 1988)

## Appendix III. Initial physical and chemical characteristics of the soil

Characteristics	Value
Mechanical fractions:	
% Sand (2.0-0.02 mm)	22.26
% Silt (0.02-0.002 mm)	56.72
% Clay (<0.002 mm)	20.75
Textural class	Silt Loam
pH (1: 2.5 soil- water)	5.9
Organic Matter (%)	1.09
Total N (%)	0.028
Available K (ppm)	15.625
Available P (ppm)	7.988
Available S (ppm)	2.066

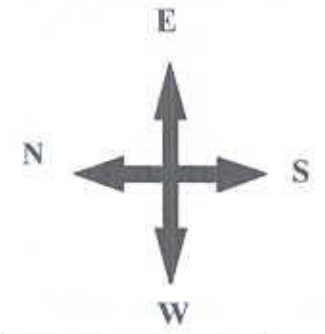
**Appendix III. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from June to November 2012**

Month	Air temperature ( $^{\circ}\text{C}$ )			RH (%)	Total rainfall (mm)
	Maximum	Minimum	Mean		
June	33.25	25.07	29.18	79.58	310
July	33.00	26.72	29.86	77.00	167
August	34.00	27.05	30.53	78.55	350
September	32.85	26.15	29.50	79.05	165
October	33.20	25.50	29.35	75.5	170
November	30.00	20.90	25.45	69.30	0

**Source: Metrological Centre, Agargaon, Dhaka (Climate Division)**

Appendix IV. Layout and design of the experimental plot

R3			R2			R2		
I <sub>3</sub>	I <sub>2</sub>	I <sub>1</sub>	I <sub>3</sub>	I <sub>2</sub>	I <sub>1</sub>	I <sub>3</sub>	I <sub>2</sub>	I <sub>1</sub>
I <sub>3</sub> T <sub>2</sub>	I <sub>2</sub> T <sub>8</sub>	I <sub>1</sub> T <sub>3</sub>	I <sub>3</sub> T <sub>2</sub>	I <sub>2</sub> T <sub>8</sub>	I <sub>1</sub> T <sub>3</sub>	I <sub>3</sub> T <sub>2</sub>	I <sub>2</sub> T <sub>8</sub>	I <sub>1</sub> T <sub>3</sub>
I <sub>3</sub> T <sub>3</sub>	I <sub>2</sub> T <sub>7</sub>	I <sub>1</sub> T <sub>6</sub>	I <sub>3</sub> T <sub>3</sub>	I <sub>2</sub> T <sub>7</sub>	I <sub>1</sub> T <sub>6</sub>	I <sub>3</sub> T <sub>3</sub>	I <sub>2</sub> T <sub>7</sub>	I <sub>1</sub> T <sub>6</sub>
I <sub>3</sub> T <sub>5</sub>	I <sub>2</sub> T <sub>2</sub>	I <sub>1</sub> T <sub>5</sub>	I <sub>3</sub> T <sub>5</sub>	I <sub>2</sub> T <sub>2</sub>	I <sub>1</sub> T <sub>5</sub>	I <sub>3</sub> T <sub>5</sub>	I <sub>2</sub> T <sub>2</sub>	I <sub>1</sub> T <sub>5</sub>
I <sub>3</sub> T <sub>1</sub>	I <sub>2</sub> T <sub>3</sub>	I <sub>1</sub> T <sub>8</sub>	I <sub>3</sub> T <sub>1</sub>	I <sub>2</sub> T <sub>3</sub>	I <sub>1</sub> T <sub>8</sub>	I <sub>3</sub> T <sub>1</sub>	I <sub>2</sub> T <sub>3</sub>	I <sub>1</sub> T <sub>8</sub>
I <sub>3</sub> T <sub>4</sub>	I <sub>2</sub> T <sub>6</sub>	I <sub>1</sub> T <sub>7</sub>	I <sub>3</sub> T <sub>4</sub>	I <sub>2</sub> T <sub>6</sub>	I <sub>1</sub> T <sub>7</sub>	I <sub>3</sub> T <sub>4</sub>	I <sub>2</sub> T <sub>6</sub>	I <sub>1</sub> T <sub>7</sub>
I <sub>3</sub> T <sub>8</sub>	I <sub>2</sub> T <sub>5</sub>	I <sub>1</sub> T <sub>4</sub>	I <sub>3</sub> T <sub>8</sub>	I <sub>2</sub> T <sub>5</sub>	I <sub>1</sub> T <sub>4</sub>	I <sub>3</sub> T <sub>8</sub>	I <sub>2</sub> T <sub>5</sub>	I <sub>1</sub> T <sub>4</sub>
I <sub>3</sub> T <sub>6</sub>	I <sub>2</sub> T <sub>4</sub>	I <sub>1</sub> T <sub>1</sub>	I <sub>3</sub> T <sub>6</sub>	I <sub>2</sub> T <sub>4</sub>	I <sub>1</sub> T <sub>1</sub>	I <sub>3</sub> T <sub>6</sub>	I <sub>2</sub> T <sub>4</sub>	I <sub>1</sub> T <sub>1</sub>
I <sub>3</sub> T <sub>7</sub>	I <sub>2</sub> T <sub>1</sub>	I <sub>1</sub> T <sub>2</sub>	I <sub>3</sub> T <sub>7</sub>	I <sub>2</sub> T <sub>1</sub>	I <sub>1</sub> T <sub>2</sub>	I <sub>3</sub> T <sub>7</sub>	I <sub>2</sub> T <sub>1</sub>	I <sub>1</sub> T <sub>2</sub>



Unit plot size:  
3m x 3m

**Factor A: Irrigation**  
 I<sub>1</sub>- Continuous flooding  
 I<sub>2</sub>- saturated condition  
 I<sub>3</sub>- alternate wetting & drying

**Factor B: Fertilizer plus manure**  
 T<sub>0</sub>: Control  
 T<sub>1</sub>: N<sub>120</sub>P<sub>25</sub>K<sub>60</sub>S<sub>20</sub>Zn<sub>2</sub>  
 T<sub>2</sub>: 50% NPKS + 5 ton cowdung ha<sup>-1</sup>  
 T<sub>3</sub>: 70% NPKSZn + 3 ton cowdung ha<sup>-1</sup>  
 T<sub>4</sub>: 50% NPKSZn + 5 ton compost ha<sup>-1</sup>  
 T<sub>5</sub>: 70% NPKSZn + 3 ton compost ha<sup>-1</sup>  
 T<sub>6</sub>: 50% NPKS + 3.5 ton poultry manure ha<sup>-1</sup>  
 T<sub>7</sub>: 70% NPKS + 2.1 ton poultry manure