EFFECTS OF FERTILIZERS AND MANURES WITH DIFFERENT IRRIGATION MANAGEMENT ON THE YIELD AND NUTRIENT CONCENTRATION IN BRRI dhan29

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This is to certify that the thesis entitled, *"EFFECTS OF FERTILIZERSAND MANURES WITH DIFFERENT IRRIGATION MANAGEMENT ON THE GROWTH, YIELD AND NUTRIENT CONCENTRATION OF BRRI dhan29"* 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 ***MD. SHAHADAT HOSSAIN,*** Registration No. ***06-02090*** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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ABSTRACT

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from December 2012 to May 2013 know the effect of fertilizers and manures with different irrigation management on the yield and nutrient concentration in BRRI dhan29. 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 yield was obtained from continuous flooded condition. The yield contributing characters and yields were significantly affected by fertilizer and manure. The highest grain yield and straw yield were found from Recommended dose of fertilizer though it was statistically similar with 70% NPKSZn+2.1 ton poultry manure/ha treatment and lowest in control treatment. The yield parameters were not significantly influenced by combined application of irrigation and fertilizer. Though the highest grain yield (7.36 t/ha) was recorded from Alternate wetting and drying with 70% NPKSZn+2.1 ton poultry manure/ha. Irrigation significantly influenced the grain nutrient concentration except K concentration. The higher levels of P and K concentration were recorded from Alternate wetting and drying treatment. The grain nutrient concentrations of BRRI dhan29 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 P concentration in grain was recorded from alternate wetting and drying with 50% NPKSZn + 3.5 ton poultry manure ha^{-1}. The higher concentrations of grain K and S were found in the treatments where fertilizers were used in combination with poultry manure.

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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. Amang 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 nutrient application or management. 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 then 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 sustain 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 cause attention as the most effective measure for the purpose of addressing them.

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 on native soil organic matter. 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 Boro 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 Boro rice.

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. amanrice 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^{-1} when NPK fertilizers were applied at the dose of 180-90-90 kg ha^{-1}.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_2O_5 + 40 kg K_2O + 10 kg S + 4 kg Zn ha^{-1} + 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^{-1} 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^{-1}, number of filled grain and unfilled grain per panicle. The combination of NPK that gives the height result was 120-13-70-20 kg/ha 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 two 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 Cavegelli (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^{-1}.

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 afield 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 maximuma 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, Karnakata, 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 rations 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 15 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 Zhensan97B) 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 Zhensan97B (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/ha). 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_1: submerge irrigation, I_2: 5 day interval, I_3: 8 day interval, I_4: 11 day interval) and showed highest grain yield was found from submerge irrigation (I_1) 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 and water economy.

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 functiong of rhizosohere and increased yield of rice.

Chapter III

MATERIALS AND METHODS

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from December 2012 to May 2013 to study the effect of fertilizer and manure with different irrigation management practices on the yield and nutrient concentration ofBoro ricevariety BRRI dhan29. 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 *Boro* season of 2012-13. The morphological, physical and chemical characteristics of the soil are shown in Appendix II and III.

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 December 2012 to May2013 have been presented in Appendix IV.

3.3 Planting material

BRRI dhan29 was used as the test crop in this experiment. This variety was developed at the Bangladesh Rice Research Institute. It is recommended for cultivation duringBoroseason.

3.4Land preparation

The land was first opened on 10 November, 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 plotdesign 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 × 8 fertilizer treatments × 3 replications) unit plot each of 3x3 m^2 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 V).

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: Fertilizerand 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, gypsumand 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 activetillering 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 incowdung, 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 (*Chaphalocrosismedinalis*, Pyralidae, Lepidoptera) was observed in the field and wasMalathion @ 1.12 L ha^{-1}.

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 tillers hill^{-1}

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

3.13.2Total no. of non effective tillerhill^{-1}

The total number of in-effective tillerhill^{-1} was counted as the number of non-panicle bearing planthill^{-1}. Data on non effective tillerhill^{-1} 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 tha^{-1}.

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^{-1}.

3.14 Chemical analysis of manure and initial soil samples

3.14.1 Total nitrogen

Total N content of soil were determined followed by the Micro Kjeldahl method. One gram of oven dry ground soil sample was taken into micro kjeldahl flask to which 1.1 gm catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se in the ratio of 100: 10: 1), and 7 ml H_2SO_4 were added. The flasks were swirled and heated 160 ^{0}C and added 2 ml H_2O_2 and then heating at 360 ^{0}C was continued until the digest was clear and colorless. After cooling, the content was taken into 50 ml volumetric flask and the volume was made up to the mark with distilled water. A reagent blank was prepared in a similar manner. These digests were used for nitrogen determination (Page *et al.*, 1982).

Then 20 ml digest solution was transferred into the distillation flask, Then 10 ml of H_3BO_3 indicator solution was taken into a 250 ml conical flask which is marked to indicate a volume of 50 ml and placed the flask under the condenser outlet of the distillation apparatus so that the delivery end dipped in the acid. Add sufficient amount of 10N-NaOH solutions in the container connecting with distillation apparatus. Water runs through the condenser of distillation apparatus was checked. Operating switch of the distillation apparatus collected the distillate. The conical flask was removed by washing the delivery outlet of the distillation apparatus with distilled water.

Finally the distillates were titrated with standard 0.01 N H_2SO_4 until the color changes from green to pink.

The amount of N was calculated using the following formula:

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

Where,

T = Sample titration (ml) value of standard H_2SO_4

B = Blank titration (ml) value of standard H_2SO_4

N = Strength of H_2SO_4

S = Sample weight in gram

3.14.2 Available phosphorus

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

3.14.3 Available potassium

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

3.14.4 Available sulphur

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

3.15 Chemical analysis of plant samples

3.15.1 Collection and preparationof plant samples

Grain and straw samples were collected after threshing for P, K and S analyses.The plant samples were dried in an oven at 70^0C 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 ofP, K and S. The grain samples were analyzed for determination of P, K and S concentrations. The methods used were as follows:

3.15.2 Digestion of plant samples with nitric-perchloric acid for P,K and S

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^{0}C. Heating were stopped when the dense white fumes of $HClO_4$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. Pand K were determined from this digest by using different standard methods.

3.15.3 Determination of P,K and S from plant samples

3.15.3.1 Phosphorus

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 mLdigest 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).

3.15.3.2 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 byusing standard curves.

3.15.3.3Sulphur

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 byusing standard curves.

3.16 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 dhan29. The mean values of all the characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

Chapter IV

RESULTS AND DISCUSSION

The results of different yield attributes, yield and nutrient concentrations in the grains and straw ofbororiceBRRI dhan29 are presented this chapter.

4.1 Effective tiller

The effect of irrigation on the number of effective tillers hill^{-1} of BRRI dhan29 is presented in Table 2. The effective tillershill^{-1} of BRRI dhan29did not vary significantly due to different irrigation regimes. The treatment I_3(alternate wetting and drying) contained the highest number of effective tillershill^{-1} (13.03) followed by I_2 (Saturated condition) (12.89) and I_1 (Continuous flooded) had thelowest number of effective tillershill^{-1} (12.52).

As to the effect of different doses of fertilizers and manures the number of effective tillershill^{-1}of BRRI dhan29varied significantly (Table 3). Among the different doses of fertilizers, T_7 (70% NPKSZn + 2.1 ton poultry manure ha^{-1}) showed the highest number of effective tillershill^{-1} (14.07) which was followed by and statistically similar with T_1 ($N_{120}P_{25}K_{60}S_{20}Zn_2$) (13.87),$T_6$ (50% NPKSZnZn + 3.5 ton poultry manure ha^{-1}) (13.73), T_5 (70% NPKSZn + 3 ton compost ha^{-1})(13.22),T_3 (70% NPKSZn + 3 ton cowdung ha^{-1}) (13.22) and T_4(50% NPKSZn + 5 ton compost ha^{-1}) (12.73) treatment. The lowest number of effective tillershill^{-1} (10.53) was observed with T_0 where no fertilizer was applied.Nayak*et al.* (2007) reported a significant increase in effective tillershill^{-1} 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 of BRRI dhan29

Treatments (irrigation)	No. of effective tillers hill^{-1}
I_1	12.52
I_2	12.89
I_3	13.03
SE (±)	**NS**

I_1=Continuous flooded, I_2=Saturated condition and I_3=Alternate wetting and drying

Table 3.The Effect of different doses of fertilizers and manures on effective tillershill^{-1} of BRRI dhan29

Treatments	No. of effective tiller hill^{-1}
T_0	10.53c
T_1	13.87a
T_2	11.13bc
T_3	13.22a
T_4	12.73ab
T_5	13.22a
T_6	13.73a
T_7	14.07a
SE (±)	**0.562**

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

T_0 = Control , T_1 =$N_{120}P_{25}K_{60}S_{20}Zn_2$ or Recommended dose of fertilizer, 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}

Table 4. Interaction effect of fertilizer and irrigation on tillershill^{-1}of BRRI dhan29

Treatment	No. of effective tiller hill^{-1}
I_1T_0	10.87
I_1T_1	13.07
I_1T_2	10.80
I_1T_3	13.53
I_1T_4	13.80
I_1T_5	12.33
I_1T_6	13.20
I_1T_7	12.53
I_2T_0	9.67
I_2T_1	14.60
I_2T_2	10.80
I_2T_3	13.07
I_2T_4	12.40
I_2T_5	13.40
I_2T_6	14.53
I_2T_7	14.67
I_3T_0	11.07
I_3T_1	13.93
I_3T_2	11.80
I_3T_3	13.07
I_3T_4	12.00
I_3T_5	13.93
I_3T_6	13.47
I_3T_7	15.00
SE (±)	**NS**
CV (%)	**13.15**

The number of effective tillers $hill^{-1}$ of BRRI dhan29 under study varied insignificantly due to the combined effect of different treatment (Table 4). Though the highest number of effective tillers $hill^{-1}$ (15.00) was recorded with the treatment combination I_3T_7 (Alternate wetting and drying in combination with 70% NPKSZn + 2.1 ton poultry manure/ha). While the lowest number of effective tillers/hill (9.67) was found in I_2T_0 (saturated condition in combination with no chemical fertilizer or manure) treatment combination.

4.2 Plant height

The effects of irrigation on the plant height ofBRRI dhan29 are presented in Table 5. There was no significant variation observed on the plant height of BRRI dhan29 when the field was given different regimes of irrigation. I_2 (Saturated condition)treatment produced the highest plant height (84.70 cm) and I_3(alternate wetting and drying) irrigation treatment gave the lowest plant height (83.61 cm).

Significant variation was observed in plant height of BRRI dhan29when fertilizers of different doses were applied (Table 6). The treatment T_6 (50% NPKSZn + 3.5 ton poultry manure ha^{-1})produced the highest plant height (87.55 cm) which was statistically similar with T_1 (85.57 cm), T_2 (50% NPKSZn + 5 ton cowdung ha^{-1}) (86.46 cm), T_3 (70% NPKSZn + 3 ton cowdung ha^{-1}) (86.57 cm), T_4 (50% NPKSZn + 5 ton compost ha^{-1}) (84.20 cm), T_5 (70% NPKSZn + 3 ton compost ha^{-1}) (84.83 cm) and T_7 (70% NPKSZn + 2.1 ton poultry manure ha^{-1}) (84.53 cm)treatment. On the other hand lowest plant height (73.02 cm) was observed in the T_0 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) andReddy*et al.* (2004).

Table 5.The effect of different regimes of irrigation on the plant height and panicle length of BRRI dhan29

Treatment	Plant height (cm)	Panicle length (cm)
I_1	83.95	24.77
I_2	84.70	24.27
I_3	83.61	24.64
SE (±)	**NS**	**NS**

I_1=Continuous flooded, I_2=Saturated condition and I_3=Alternate wetting and drying

Table 6.The effect of different fertilizers and manures on the plant height and panicle length of BRRI dhan29

Treatments	Plant height (cm)	Panicle length (cm)
T_0	73.02b	22.47c
T_1	85.57a	25.04ab
T_2	86.46a	24.57ab
T_3	86.57a	24.74ab
T_4	84.20a	24.75ab
T_5	84.83a	25.68a
T_6	87.55a	24.41b
T_7	84.53a	24.84ab
SE (±)	**1.05**	**0.34**

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.

T_0= Control , T_1 =$N_{120}P_{25}K_{60}S_{20}Zn_2$ or Recommended dose of fertilizer, 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}

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 dhan29 (Table 7). The lowest plant height (71.56 cm) was observed in the treatment combination of I_2T_0 (Saturated condition with no fertilizer). On the other hand, the highest plant height (88.73 cm) was recorded with I_2T_6 (Saturated condition with 50% NPKSZn + 3.5 ton poultry manure ha^{-1}) treatment.

4.4 Panicle length

The effects of different regimes of irrigation on the panicle length of BRRI dhan29 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 (24.77 cm) was observed in I_1 (Continuous flooded) while I_2 (Saturated condition) showed the lowest panicle length (24.27 cm).

Significant variation was observed in respect of panicle length of BRRI dhan29when different doses of fertilizers and manures were applied in the field (Table 6). The longest panicle (25.68 cm) was obtained from T_5 (70% NPKSZn + 3 ton compost ha^{-1})treatment, which was statistically identical to T_1 (25.04 cm), T_2 (24.57 cm), T_3 (24.74cm), T_4 (24.75 cm) and T_7 (24.84 cm). The control treatment produced the shortest panicle (22.47 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 regimeson the plant height and panicle length of BRRI dhan29

Treatments	Plant height (cm)	Panicle length (cm)
I_1T_0	74.10	22.86
I_1T_1	83.60	24.98
I_1T_2	88.43	24.32
I_1T_3	87.48	24.92
I_1T_4	84.46	25.12
I_1T_5	83.98	25.93
I_1T_6	87.71	24.75
I_1T_7	87.83	25.33
I_2T_0	71.56	21.64
I_2T_1	86.23	25.44
I_2T_2	84.86	24.57
I_2T_3	86.18	24.86
I_2T_4	84.30	23.94
I_2T_5	86.08	25.04
I_2T_6	88.73	24.45
I_2T_7	83.18	24.22
I_3T_0	73.40	22.90
I_3T_1	86.87	24.70
I_3T_2	86.08	24.83
I_3T_3	86.03	24.44
I_3T_4	83.84	25.18
I_3T_5	84.42	26.06
I_3T_6	86.20	24.03
I_3T_7	82.58	24.96
SE (±)	**NS**	**NS**
CV (%)	**3.75**	**4.11**

Combined application of different doses of fertilizers and manures and irrigation regimes did not have any significant variation on the panicle length of BRRI dhan29 under study (Table 7). The lowest panicle length (21.64 cm) was observed in the treatment combination of I_2T_0 (Saturated condition with no fertilizer) and the highest panicle length (27.96 cm) was recorded with I_3T_5 (Alternate wetting and drying with 70% NPKSZn + 3 ton compost ha^{-1}) treatment combination.

4.5Number of filled grain per panicle

Number of filled grains per panicle was not significantly influenced by irrigationregimes (Table 8). I_1(Continuous flooded) showed the highest number of filled grain per panicle (117) and I_3 (Alternate wetting and drying) irrigation regimes showed lowest number of filled grain per panicle(114).

Significant variation was observed in number of filled grain per panicle of BRRI dhan29 when different doses of fertilizers and manures were applied (Table 9). The highest number of filled grain per panicle (129) was recorded in $T_2$and T_6treatments, which were statistically similar toall the other treatments except the one of control fertilizer. The lowest number of filled grain per panicle (83) was recorded in T_0 (control treatment). Similar result was found by Rahman *et al.*(2009).

The number of filled grain per panicle was not significantly influenced by the combined effect of different doses of fertilizers and manures and irrigation regimes (Table 10). The highest number of filled grain per panicle (138) was recorded with the treatment combinations I_1T_2 (Continuous flooded with 50% NPKSZn + 5 ton cowdung ha^{-1}) and I_1T_6 (Continuous flooded with50% NPKSZn + 3.5 ton poultry manure ha^{-1}) while the lowest number of filled grains panical⁻

[1](73.00) was found in I_2T_0 (Saturated condition with control fertilizer) treatment combination.

Table 8.The effect of different irrigation regimes on the number of filled grain per panicle, straw and grain yield of BRRI dhan29

Treatments	Number of filled grain panicle^{-1}	Straw yield (tha^{-1})	Grain yield (tha^{-1})
I_1	117	7.02	6.38
I_2	114	6.81	6.05
I_3	114	6.81	6.19
SE (±)	NS	NS	NS

I_1=Continuous flooded, I_2=Saturated condition and I_3=Alternate wetting and drying

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 dhan29

Treatments	Number of filled grain panicle^{-1}	Straw yield (t ha^{-1})	Grain yield (t ha^{-1})
T_0	83b	4.03c	3.47d
T_1	107a	7.72a	7.05a
T_2	129a	6.91b	6.40abc
T_3	113a	7.48ab	6.91ab
T_4	121a	6.81b	6.21c
T_5	116a	7.23ab	6.32bc
T_6	129a	7.61a	6.78abc
T_7	121a	7.25ab	7.01a
SE (±)	6.66	0.19	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.

T_0= Control , T_1 =$N_{120}P_{25}K_{60}S_{20}Zn_2$ or Recommended dose of fertilizer, 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}

4.6 Straw yield

The effect of different regimes of irrigation on the straw yield of BRRI dhan29 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_1 showed the highest straw yield (7.02t ha^{-1}) while $I_2$and I_3 irrigation showed the lower straw yield (both 6.81 tha^{-1}).

Significant variation was observed on the straw yield of BRRI dhan29 when different doses of fertilizer were applied (Table 9). The highest yield of straw (7.72 t ha^{-1}) was recorded in T_1 (Recommended dose of fertilizer) treatment which was statistically similar to T_3(7.48t ha^{-1}), T_5(7.23 t ha^{-1}), T_6(7.61 t ha^{-1}) and T_7(7.25 t ha^{-1}) treatments. The lowest straw yield (4.03t ha^{-1}) was recorded in the T_0 treatment. Rahman *et al.* (2009) reported that the application of organic manure and chemical fertilizers increased the straw yields of BRRI dhan32. These findings are corroborated with the work of Manna*net 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 dhan29.

Table 10. Interaction effect of different doses of fertilizers and manures and irrigation on the number of filled grain per panicle, straw yield/plot andgrain yield/plot of BRRI dhan29

Treatment	Number of filled grain per panicle	Straw yield(t/ha)	Grain yield (t/ha)
I_1T_0	88	5.57	3.43
I_1T_1	97	7.37	6.86
I_1T_2	138	7.23	6.78
I_1T_3	121	7.32	7.29
I_1T_4	117	7.27	6.55
I_1T_5	108	7.08	6.31
I_1T_6	138	7.04	6.53
I_1T_7	127	7.65	7.31
I_2T_0	73	6.33	3.48
I_2T_1	122	6.94	7.26
I_2T_2	124	6.70	5.82
I_2T_3	117	7.74	6.69
I_2T_4	126	7.18	6.40
I_2T_5	115	7.18	6.30
I_2T_6	121	7.13	6.36
I_2T_7	115	7.46	6.06
I_3T_0	87	4.97	3.51
I_3T_1	101	6.71	7.03
I_3T_2	124	7.10	6.60
I_3T_3	101	7.58	6.75
I_3T_4	120	7.24	5.67
I_3T_5	127	7.15	6.35
I_3T_6	129	6.88	6.23
I_3T_7	123	6.96	7.36
SE (±)	**NS**	**NS**	**NS**
CV (%)	**17.37**	**6.05**	**9.14**

The combined application of different doses of fertilizers and manures and irrigation regimes did not have significant effect on the straw yield of BRRI dhan29 (Table 10). The highest straw yield (7.74 t ha^{-1}) was recorded with the treatment combination I_2T_3, which was closely followed byI_3T_3(7.58 t ha^{-1}) and the lowest straw yield (4.97t ha^{-1})was found in I_3T_0 treatment combination.

4.7 Grain yield

The results on the effect of irrigation on the grain yield of BRRI dhan29 are presented in Table8. It was observed that the variation was not significantly influenceddue to three different irrigationregimes on the grain yield. I_1(Continuous flooded) produced the highest grain yield (6.38tha^{-1}) and I_2(saturated condition) irrigation regimes gave lowest grain yield (6.05t ha^{-1}).

Application of different doses of fertilizers and manures induced significant variations in grain yield of BRRI dhan29 (Table 9).The application of fertilizers and manures had positive effect on the grain yield. The grain yield increased to a considerable extentdue to the integrated use of fertilizers and manures compared to chemical fertilizer alone. Among the different doses of fertilizers, T_1 (Recommended dose of fertilizer) showed the highest grain yield (7.05t ha^{-1}), which was closely followed by T_7 (7.01 t ha^{-1}). T_1 and T_7 were statistically similar withT_2(6.40 t ha^{-1}), T_3 (6.91 t ha^{-1}) and T_6(6.78 t ha^{-1}) treatments. The lowest grain yield (3.47 t ha^{-1}) was observed with T_0 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 dhan29 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 (7.36t ha^{-1})was recorded with the treatment combination I_3T_7 (Alternate wetting and dryingwith 70% NPKSZn + 2.1 ton ha^{-1} poultry manure) treatment combination and the lowest grain yield (3.43 t ha^{-1})was found in I_1T_0 (continuous flooded with control fertilizer treatment) treatment combination. *Lin et al.* (2011) reported that irrigation with organic material application increased yield of BRRI dhan29.

4.8P concentration in grains of BRRI dhan29

The effect of different irrigation regimeson P concentration in grain of BRRI dhan29 are presented in Table 11. There were no significant variations observed on P concentration in grains when the field was treated with three different irrigationregimes. The highest P concentration in grain was recorded in I_3 (Alternate wetting and drying) (0.310 % P)and lowest was from I_2(Saturated condition)(0.283 %P) irrigation treatment.

Statistically significant variation in P concentrations was found due to the application of different doses of fertilizers and manures are presented in Table 12. The P concentration in BRRI dhan29 grain significantly increased due to application of fertilizers and manure. The higher levels of grain P concentrations were recorded in the combined application of fertilizers and manures compared to that with the chemical fertilizers alone. The highest P concentration in grain (0.330%) was recorded from T_6 (50% NPKSZn + 3.5 ton poultry manure ha^{-}

^{1})which was statistically similar with T_1 (0.324%), T_2 (0.327%), T_5 (0.294%) and T_7 (0.308%) fertilizer treatments. The lowest P concentration in grain (0.215%) was found from T_0 treatment.A significant increase in P content in BRRI dhan29 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 irrigationregimes onPconcentration ofBRRI dhan29 was significantly varied (Table 13). The highest P (0.392%) concentration in grain was recorded with the treatment combination I_3T_6 (alternate wetting and dryingwith 50% NPKSZn + 3.5 ton poultry manure ha^{-1}) which was similar to that of I_1T_1 (0.359%), I_1T_2 (0.345%), I_2T_7 (0.338%),I_3T_2 (0.346%),and I_3T_3 (0.346%) treatment combinations. The lowest P concentration (0.210%) in grain BRRI dhan29was found in I_2T_0 (Saturated condition with control fertilizers and manures treatment).

4.9 K concentration in grain of BRRI dhan29

The effect of different irrigation regimes on K concentration in grains of BRRI dhan29 have been presented in Table 11. Results show that the variation in K concentration in grain of BRRI dhan29 was not significantly influenced by different regimes of irrigations. I_3(alternate wetting and drying) showed higher K concentration of 0.284% in grain and I_2 (saturated condition) showed the lower K concentration of 0.250% in grains.

The variation of potassium concentrations in grains of BRRI dhan29 showed statistically significant variation due to the application of different doses of fertilizers (Table 12). The highest K concentration in grain (0.333%) wasrecorded from T_3 (70% NPKSZn + 3 ton cowdung ha^{-1}) and T_4 (50% NPKSZn + 5 ton compost ha^{-1}) which were statistically similar with T_6 (0.306%) and T_7 (0.306%) fertilizer treatments. The lowest K concentration (0.150%) was found from T_0 (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 dhan29 under study was also differed significantly (Table 13). The highest K concentration (0.400%) was recorded with the treatment combination I_3T_3 (Alternate wetting and drying with 70% NPKSZn + 3 ton cowdung ha^{-1}) and at was lowest (0.150%) in I_1T_0 (Continuous flooded with control treatment).

4.10S concentration in grain

Results on the effect of irrigationregimes on S concentration in grain of BRRI dhan29 are presented in Table 11. S concentration in rice grain was found to vary significantly when the field was treated with three different irrigationregimes. The highest S concentration in grain (0.171%) was in I_1 (continuous flooding) and the lowest Sconcentration in grain (0.143%) was obtained from I_3 (alternate wetting & drying) irrigation.

Table 11.The effect of irrigation on PKS concentration in grain of BRRI dhan29

Treatments	Concentration in grain (%)		
	P	K	S
I_1	0.289 b	0.271b	0.171 a
I_2	0.283 b	0.250c	0.165 a
I_3	0.310 a	0.284a	0.143 b
SE (±)	**0.0043**	**0.0174**	**0.0084**

I_1=Continuous flooded, I_2=Saturated condition and I_3=Alternate wetting and drying

Table 12. Effect of fertilizers and manures on PKS concentration in grains of BRRI dhan29

Treatments	Concentration in grain (%)		
	P	K	S
T_0	0.215 d	0.150 c	0.117 e
T_1	0.324 ab	0.200 c	0.150 d
T_2	0.327 a	0.217 c	0.166 c
T_3	0.288 bc	0.333 a	0.173 b
T_4	0.267 c	0.333 a	0.161 c
T_5	0.294 a-c	0.274 b	0.148 d
T_6	0.330 a	0.306 ab	0.183 a
T_7	0.308 ab	0.306 ab	0.176 b
SE (±)	0.0098	0.0151	0.0061

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.

T_0= Control , T_1 =$N_{120}P_{25}K_{60}S_{20}Zn_2$ or Recommended dose of fertilizer, 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}

Table 13.Combined effect of fertilizers and manures and irrigationregimes on PKSconcentration in grains of BRRI dhan29

Treatments	Concentration (%) in grain		
	P	K	S
I_1T_0	0.214 jk	0.150 e	0.127 j
I_1T_1	0.359 ab	0.200 de	0.143 f-i
I_1T_2	0.345 a-d	0.200 de	0.169 cd
I_1T_3	0.281 d-i	0.300 bc	0.146 f-h
I_1T_4	0.262 g-k	0.350 ab	0.165 de
I_1T_5	0.278 e-i	0.367 ab	0.171 cd
I_1T_6	0.284 c-h	0.300 bc	0.226 a
I_1T_7	0.289 c-h	0.300 bc	0.218 a
I_2T_0	0.210 k	0.200 de	0.115 k
I_2T_1	0.299 b-h	0.200 de	0.172 cd
I_2T_2	0.290 c-h	0.250 cd	0.180 c
I_2T_3	0.237 h-k	0.300 bc	0.199 b
I_2T_4	0.248 h-k	0.300 bc	0.180 c
I_2T_5	0.330 b-f	0.250 cd	0.139 g-i
I_2T_6	0.313 b-g	0.250 cd	0.170 cd
I_2T_7	0.338 a-e	0.250 cd	0.162 de
I_3T_0	0.221 i-k	0.183 de	0.109 k
I_3T_1	0.315 b-g	0.200 de	0.136 h-j
I_3T_2	0.346 a-c	0.200 de	0.148 fg
I_3T_3	0.346 a-c	0.400 a	0.173 cd
I_3T_4	0.291 c-h	0.350 ab	0.138 g-j
I_3T_5	0.274 f-j	0.207 de	0.134 ij
I_3T_6	0.392 a	0.367 ab	0.154 ef
I_3T_7	0.297 b-h	0.367 ab	0.149 fg
SE (±)	**0.170**	**0.0262**	**0.0106**
CV (%)	**10.01**	**16.91**	**11.52**

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 S concentrations in grains of BRRI dhan29were found to vary significantly due to the application of different doses of fertilizers and manures (Table 12). The highest S concentration in grain (0.183%) was recorded from T_6(50% NPKSZn + 3.5 ton poultry manure ha^{-1}) which were closely followed by the treatmentsT_7 and T_3. The lowest S concentration in grain (0.117%) was found from T_0(control treatment).A significant increase ofS content in BRRI dhan32 straw was founddue to the application of organic manure and fertilizers (Azim, 1999 and Hoque, 1999).

It was apparent from the results in table 13 thatS concentration in grainsof BRRI dhan29 varied significantly due to the combined effect of different doses of fertilizers and manures and irrigation regimes. The highest S concentration (0.226%) was recorded with the treatment combination I_1T_7 (continuous flooding with 70% NPKSZn + 2.1 ton poultry manure ha^{-1}), which was statistically similar to that of I_1T_6(0.218%) treatmentcombination and the lowest S concentration (0.115%) was found in I_2T_0 (saturated condition + control treatment)treatment.

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 December 2012 to May 2013 to know the effect of fertilizers and manures with different irrigation management practices on the yield attributes, yield and nutrient concentration in BRRI dhan29. 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% 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.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 $hill^{-1}$ was observed from I_3 while The highest number of effective tillers $hill^{-1}$, longest panicle, highest number of filled grain, highest grain yield and straw yield were observed from I_1 treatment. The highest plant height was observed in I_2.

Yield contributing characters and yields were significantly influenced by fertilizers and manures. The highest effective tillers hill^{-1} (14.07) was found from T_7 (50% NPKSZn + 2.1 ton poultry manure ha^{-1}) treatment. The highest plant height (87.55 cm) and number of filled grain per panicle (129) were recorded in T_6 (50% NPKSZn + 3.5 ton poultry manure ha^{-1}) though T_7 (50% NPKSZn + 2.1 ton poultry manure ha^{-1}) showed statistically similar results. Highest panicle length (25.68 cm) was found from T_5 (70% NPKSZn + 3 ton compost ha^{-1}) but it was statistically similar with T_7 (50% NPKSZn + 2.1 ton poultry manure ha^{-1}) (24.84 cm). Highest straw yield (7.72 t ha^{-1}) was recorded in T_1 which was statistically similar with T_6 (7.61 t ha^{-1}) and T_7 (7.25 t ha^{-1}). Highest grain yield (7.05 t ha^{-1}) was recorded in T_1 which was statistically similar with T_6 (6.78 t ha^{-1}) and T_7 (7.01t ha^{-1}) treatment. Lowest results for all parameters were recorded from control treatment.

All the growth, yield and yield related parameters of rice were not significantly differed due to the combined effect of irrigation and different doses of fertilizers and manures. The highest values of effective tillers hill^{-1} (15.00) was from I_3T_7, panicle length (26.06 cm) was from I_3T_5, number of filled grain per panicle (138) was from I_1T_2 and I_1T_6 , grain yield (7.36 t ha^{-1}) was from I_3T_7 and straw yield (7.74 t ha^{-1}) was observed from I_2T_3 (saturated condition in combination with 70% NPKS + 3 ton cowdung ha^{-1}) treatment combination.

The nutrient concentration in T. aman rice plant was significantly affected by irrigation except potassium. The highest P and K concentration in grain was recorded in I_3 (Alternate wetting and drying) (0.310 % P and 0.284% K) and lowest was from I_2 (Saturated condition) (0.283 % P and 0.250% K). The highest S concentration in grain (0.171%) was in I_1 (continuous flooding) and the lowest S concentration in grain (0.143%) was obtained from I_3 (alternate wetting & drying) irrigation.

The nutrients concentration in rice plant varied significantly due to application of different firtilizers and manures. The highest P concentration in grain (0.330%) was recorded from T_6 (50% NPKSZn + 3.5 ton poultry manure ha^{-1}) which was statistically similar with T_1 (0.324%), T_2 (0.327%), T_5 (0.294%) and T_7 (0.308%) treatment. The lowest P concentration in grain (0.215%) was found from T_0 treatment. The highest K concentrations in grain (0.333%) were recorded from T_3 (70% NPKSZn + 3 ton cowdung ha^{-1}) and T_4 (50% NPKSZn + 5 ton compost ha^{-1}) which were statistically similar with T_6 (0.306%) and T_7 (0.306%). The highest S concentration in grain (0.183%) was recorded from T_6 (50% NPKSZn + 3.5 ton poultry manure ha^{-1}) which were closely followed by the treatments T_7 and T_3 treatments.

The combined effect of different fertilizers and manures and irrigation regimes significantly influenced the grain P, K and S concentration. The highest P (0.392%) concentration in grain was recorded with the treatment combination I_3T_6 (alternate wetting and drying with 50% NPKS + 3.5 ton poultry manure ha^{-1}). The highest K concentration (0.400%) was recorded with the treatment combination I_3T_3

(Alternate wetting and drying with 70% NPKSZn + 3 ton cowdung ha^{-1}) and at was lowest (0.150%) in I_1T_0 (Continuous flooded with control treatment). The highest S concentration (0.226%) was recorded with the treatment combination I_1T_7 (continuous flooding with 70% NPKSZn + 2.1 ton poultry manure ha^{-1}), which was statistically similar to that of I_1T_6 (0.218%) treatment and the lowest S concentration (0.115%) was found in I_2T_0 (saturated condition + control treatment) treatment.

From the above discussion it can be concluded that alternate wetting and drying had better effect on yield and yield contributing characters, so it is preferable than the saturated condition and continuous flood irrigation. The application of 70% NPKSZn + 2.1 ton poultry manure ha^{-1} and alternate wetting and drying was most favorable for improving yield and yield contributing characters of BRRI dhan29 in Boro season.

The following recommendations can be 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 NPKSZn along with different doses of organic manures and different water management practices may be under taken.

REFERENCES

Aga, F. A., Singh, J. K., Singh, D. K. and Peer, F. A. (2004). Effect of different levels of compost on growth and yield of rice. *Environ. and Ecol.* **22** (2): 353-356.

Amin, M., Khan, M. A., Khan, E. A. and Ramzan, M. (2004). Effect of increased plant density and fertilizer dose on the yield of rice variety Ir-6. *J. Res. Sci.*, 2004, **15**(1), 09-16

Asif, M., Aslam, M., Jabbar, A., Rafique, K., Babar, M.R. and Ehsanullah. (2000). Panicle Structure, Kernel Quality and Yield of Fine Rice as Influenced by NPK Rates and Split Nitrogen application. *Int. J. Agri. Biol.,* **2** (4): 306-308.

Azim, S. M. A. (1999). Effect of sulphur, zinc and boron supplied from manure and fertilizers on BRRI 29. M.S. Thesis, Dept. Soil Sci., (Jan-June, 1999. Sem.), BAU, Mymensingh.

Babu, S., Marimuthu, R., Manivanna, V, and Ramesh-Kumer, S. (2001). Effect of organic and inorganic manures on growth and yield of rice. *Agric. Sci. Digest.* **21**(4): 232-234.

BBS (Bangladesh Bureau of Statistics). (2011). Statistical Yearbook of Bangladesh. Statistics Division, Ministry of Planning, Govt. of Peoples Republic of Bangladesh. Dhaka. Bangladesh. pp. 81.

BBS (Bangladesh Bureau of Statistics). (2008). Statistical Yearbook of Bangladesh. Statistics Division, Ministry of Planning, Govt. of Peoples Republic of Bangladesh. Dhaka. Bangladesh. pp. 71.

Bhuiyan, N. I. (1994). Crop production trends and need of sustainability in agriculture. Paper presented at the workshop. Integrated Nutrient Management for Sustainable Agriculture held at SRDI, Dhaka, Bangladesh in June 26-28. 1994.

Channabasavanna, A. S. (2003). Efficient utilization of poultry manure with inorganic fertilizer in wet land rice. J. Maharashtra Agric. Univer. 27(3): 237-238.

Channbasavana, A. S. and Biradar, D. P. (2001). Response of irrigated rice to the application of poultry manure and inorganic fertilizers N, P and K in Karnataka, India. *Int. Rice Res. Newsl.* **26**(2): 64-65.

Chittra, L. and Janaki, P. (1999). Impact of various organic sources on K uptake and yield of rice Thambirabarani river tract of Tamil Nadu. *Madrass Agric. J.* **86** (1-3): 46-48.

Dao, T. H. and Cavegelli, M. A. (2003). Mineralization carbon, nitrogen and water extractable phosphorous release from composted manure and manure amended soils. Agron. J. 95: 405-413.

Davarynejad, G. H., Haghnia, G. H. and Lakzian, A. (2004). Effect of municipal compost in combination with chemical fertilizers and manure on growth and yield of rice. *Agril. Sci. and Tech.* **18** (1): 101-108.

Ebrahim, A., Tarighi, F., Moradi, M. and Bozorgi, H. R. (2011). Evaluation effect of different nitrogen fertilization rates under irrigation management in rice farming. *World Applied Sciences Journal.* **13**(5): 1248-1252.

Elsharaeay, M. A. O., Aziz, M. A., Laila and Ali, K. M. (2003). Effect of the application of plant residues composts on some soil properties and yield of wheat and corn plants. *Egyptian J. Soil Sci.* **43** (3): 421-434.

Eneji, A. E., Honna, T. and Yamamoto, S. (2001). Manuring effect on rice grain yield and extractable trace elements in soils. *J. Plant Nutrition.* **24** (7): 967-977.

FAO (Food and Agricultural Organization) (1999). Yearbook of Production, FAO Statistics Division. 605-607.

Farid, A. T. D., M. A. M. Miah and Karim, Z. (1998). Innovative residue management in a typical rice soil of Bangladesh. *Thai. J. Agril. Sci.* **31**(3): 360-368.

Gani, A., Rahman, A., Dahono, Rustam and Hengsdijk, H. (2002). Synopsis of water management experiments in Indonesia. *Water Wise Rice Production,* IRRI. 29-38.

Gomez, K. A. and Gomez, A. A. (1984). Statistical procedures for Agricultural Research. Jhon Wiley and Sons, New York.

Haq, M.T., Sattar, M.A., Hossain, M.M. and Hasan, M.M. (2002). Effects of Fertilizers and Pesticides on Growth and yield of Rice. *OnLine Journal of Biological Sciences.* **2**(2): 84-88.

HDRA (Henry Doubleday Research Association). (1999). Researching the use of compost in agriculture report on work for 1998. HDRA consultants Ltd., Conventry UK. p. 137.

Hoque, S. A. (1999). Nutrient requirements of wet land rice production. Proc. Int. Symp. On Paddy soils, September 15-19, Beijing, *China Academia Sinica*: 281-282.

Hunter, A. H. (1984). Soil Fertility Analytical Service in Bangladesh. Consultancy Report BARC, Dhaka.

Islam M. S., Howlader M. I. A., Rafiquzzaman S., Bashar H. M. K. and Al-Mamun M. H. (2008). Yield Response of Chili and T. Aman Rice to NPK Fertilizers in Ganges Tidal Floodplain. *J. Soil. Nature*. **2**(1): 07-13.

Islam. M.S., Amin. M. S., and Anwar. M. N. 1994. Integrated soil fertility management in Bangladesh. Paper presented at the Workshop on Integrated Nutrient Management for Sustainable Agriculture, held at Soil Resour.Dev. Inst.. Dhaka in June 26-28. 1994.

Keeling, A. A., McCallum, K. R. and Beckwith, C. P. (2003). Mature green waste compost enhances grown and nitrogen uptake in wheat (*Triticum aestivum* L.) and oilseed rape (*Brassica napus* L.) through the action of water extractable factors. *Bioresources Technology*. **90** (2): 127-132.

Lin, Xiangin, Zhu, D. and Xinjunlin. (2011). Effects of water management and organic fertilization with SRI crop practices on hybrid rice performance and rhizosphere dynamics . *Paddy and water Environment.* **9**: 33-39.

Mannan, M. A., Kamal, A. M. A. and Islam, R. (2000). Effect of manure and fertilizer on growth, yield and protein content of transplant aman rice. *Bangladesh J. Train. Dev.* **13**(1-2): 203-210.

McHugh, O. V., Steenhuis, T. S., Barison, J., Fernandes, E. C. M. and Uphoff, N. (2002). Farmer implementation of alternate wet and drying and nonflooded irrigation practicess in the System of Rice Intensification. *Water Wise Rice Production*, IRRI. 3-14.

Meelu, O. P. and Yadvinder Singh (1991). Integrated use of fertilizers and organic manure for higher returns. *Prog. Fmg. Punjab Agric. Univ.* **27**: 3-4.

Miah, M. A. M., Ishaque, M. and Saha, P. K. (2006). Integrated nutrient management for improving soil health and rice production. Proc. of twenty first BRRI-DAE joint workshops on bridging the rice yield gap for food security. BRRI, Gazipur, Bangladesh, 19-21 September, paper 11: 1-15.

Miah, M. A. M., Shah, A. L. and Ishaque, M. (2004). Nutrient management for different rice ecosystem. Proc. of the workshop on modern rice cultivation in Bangladesh. BRRI, Gazipur, Bangladesh. 19-21. April. 159: 179-199.

Nambiar, K. K. M. (1991). Long-term fertility effects on wheat productivity. In wheat for the Non-traditional Warm areas, Saunders D.A. ed., CIMMYT. pp 516-521.

Nayak, D. R., Babu, X. and Adhya, T. K. (2007). Long-term application of compost influences mineral biomass and enzyme activities in a tropical Aeric Endoaquept planted to rice under flooded condition. *Soil Microbiology & Biochemistry*. **39** (8): 1897-1906.

Ndaeyo, N.U., Iboko, K.U., Harry, G. I. and Edem, S. O. (2008). Growth and yield performances of some upland rice (*oryza sativa* l.) Cultivars as influenced by varied rates of NPK (15:15:15) fertilizer on an ultisol. *J. Trop. Agric. Food. Env. Ext.* 7 (3): 249 – 255.

Olsen, S. R., Cole, C. V., Watanabe, F. S. and Dean, L. A. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate, U.S. Dept. Agric. Circ., p. 929.

Page, A. L., Miller, R. H. and Keeney, D. R. (ed). (1982). Methods of analysis part 2, Chemical and Microbiological Properties, Second Edition American Society of Agronomy, Inc., Soil Science Society of American Inc. Madson, Wisconsin, USA. p p. 403-430.

Qinghua, S., Zeng, X., Li, M., Tan, X. and Xu, F. (2002). Effects of different water management practices on rice growth. *Water Wise Rice Production*, IRRI. 3-14.

Rahman, M. S., Islam, M. R., Rahman, M. M. and Hossain, M. I. (2009). Effect of cowdung, poultry manure and urea-N on the yield and nutrient uptake of BRRI dhan 29. *Bangladesh Res. Publications J.* **2**: 552-558.

Rasheed, M., Asif, M. and Ghafoor, A. (2003). Yield and yield attributes of fine rice BAS-385 as affected by different NP levels on farmer's field. *Pak. J. Agric. Sci.* Vol **40** (1-2).

Reddy, B. G. M., Pattar, P. S. and Kuchanur, P. H. (2004). Response of rice to poultry manure and graded levels of NPK under irrigated conditions.

Oryza-. 2005; 42(2): 109-111. Cuttack, India: Association of Rice Research Workers, Central Rice Research Institute.

Saha, P.K., Saleque, M.A., Panaullah, G.M. and Mazid Miah, M.A. (2004). Comparison of the fertilizer recommendation Models for low land rice. *Bangladesh J. Soil Sci.* **30** (1-2): 31-37.

Saitoh, K., Kuroda,T. and Kumano, S. (2001). Effect of organic fertilization and pesticide application on growth and yield of field- grown rice for 10 years. *Japanese J. Sci.* **70**(4): 530-540.

Saleque, H. A., Timsina, J., Panuallah, G. M., Ishque, M., Pathan, A. B. M. B. U., Conor, D. J., Saha, P. K., Quayyum, M. N. A., Humphroys, E. and Meisner, C. A. (2005). Nutrient uptake and apparent balances for rice-wheat sequences. 11. Phosphorus. J. Plant Nutrition 29: 156-171.

Saleque, M. A.. Nahar, U. A., Islam, A., Pathan, A. B. M. B. U., Hossain, A. T. M. S. and Meisner, C. A. (2004). Inorganic and organic phosphorus fertilizer effects on the phosphorus fractionation in wetland rice soils. Soil Sci. Soc. Am. J. 68: 1635-1644.

Singh, R. Singh, S. and Prasad, K. (2001). Effect of fertilizer, FYM and row spacing on transplanted rice. *Crop Res*. (Hisar). **22** (2): 296-299.

Singh, V.K., Dwivedi, B.S., Shukla, A.K. and Yadav, R.L. (2003). Effects of nitrogen and phosphorus fertilization on the growth and yield of rice (*Oryza sativa*) and wheat (*Triticum aestivum*) as influenced by the inclusion of forage cowpea (*Vigna unguiculata*) in rice-wheat system. *Indian J. Agril. Sci.* **73** (9): 482-489.

Tamaki, M., Itani, T. and Nakanu, H. (2002). Effect of continuous organic farming on the growth and yield of rice. *Japanese J. Crop Sci.* **71**(4): 439-445.

Thakur, Amod, K., Rath, S., Patil, D. U. and Kumar, A. (2011). Effects on rice plant morphology and physiology of water and associated management practices of the system of rice intensification and their implications for crop performance. *Paddy and water Environment.* **9**: 13-24.

Tripathy,R. K., Pandey, N., Mishra, P. K. and Rajput, R. S. (2004). Branching behavior and production of chickpea as influenced by residual effect of cowdung blended nutrients applied to hybrid rice and direct application of nutrients to chickpea under hybrid rice-chickpea cropping system.

Umanah, E. E., Ekpe, E. O., Ndon, B. A. , Etim, M. E., Agbogu, M. S. (2003). Effect of poultry manure on growth characteristics, Yield and Yield components of upland rice in South Eastern Nigeria. *J. Sust., Agric. Envir.* **5** (1): 105-110.

Uphoff, N. and Randriamiharisoa, R. (2002). Reducing water use in irrigated rice production with Madagascar System of Rice Intensification. *Water Wise Rice Production*, IRRI. 71-88.

Vanju, M. and Raju, A. S. (2002). Integrated nutrient management performance in rice crop. Abbakas Agric. Res. 2391: 177-182.

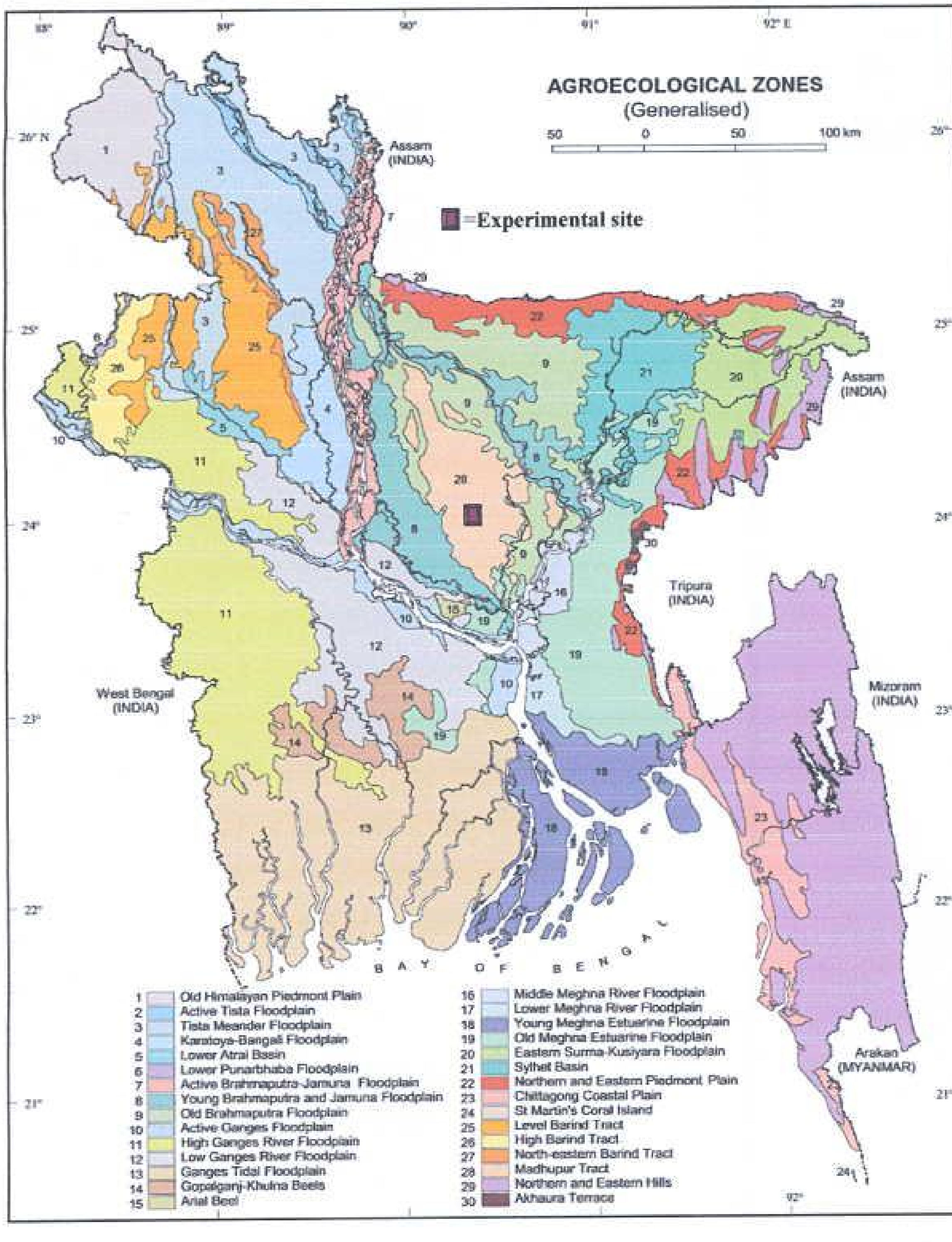
Vijay Kumar, and Singh, O. P. (2006). Effect of manures Nitrogen and Zinc fertilization on growth, yield, yield attributes and quality of rice (*Oryza sativa* L.). *Intl. J. Plant Sci. Muzaffarnagar.* **1**(2): 311-314.

Yang, C. M., Yang, L., Yang, Y. and Ouyang, Z. (2004). Rice root growth and nutrient uptake as influenced by organic manure in continuously and alternately flooded paddy soils. *Agricultural Water Management*. **70** (1): 67-81.

Zhao, Limei, Wu, L., Wu, M. and Li, Y. (2011). Nutrient uptake and water use efficiency as affected by modified rice cultivation methods with reduced irrigation. *Paddy Water Envir.* **9**: 25-32.

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

(SAU Farm, Dhaka)

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

(SAU Farm, Dhaka)

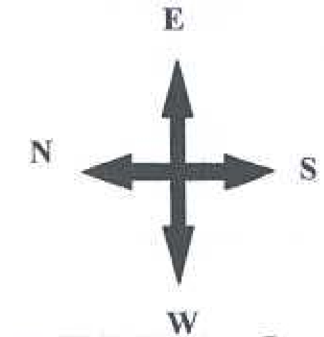
Appendix IV. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from December 2012 to May 2013

Month	Air temperature (^0C)			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 V. Layout and design of the experimental plot

R1			R2			R3		
I_3	I_2	I_1	I_3	I_2	I_1	I_3	I_2	I_1
I_3T_1	I_2T_7	I_1T_2	I_3T_1	I_2T_7	I_1T_2	I_3T_1	I_2T_7	I_1T_2
I_3T_2	I_2T_6	I_1T_5	I_3T_2	I_2T_6	I_1T_5	I_3T_2	I_2T_6	I_1T_5
I_3T_4	I_2T_1	I_1T_4	I_3T_4	I_2T_1	I_1T_4	I_3T_4	I_2T_1	I_1T_4
I_3T_0	I_2T_2	I_1T_7	I_3T_0	I_2T_2	I_1T_7	I_3T_0	I_2T_2	I_1T_7
I_3T_3	I_2T_5	I_1T_6	I_3T_3	I_2T_5	I_1T_6	I_3T_3	I_2T_5	I_1T_6
I_3T_7	I_2T_4	I_1T_3	I_3T_7	I_2T_4	I_1T_3	I_3T_7	I_2T_4	I_1T_3
I_3T_5	I_2T_3	I_1T_0	I_3T_5	I_2T_3	I_1T_0	I_3T_5	I_2T_3	I_1T_0
I_3T_6	I_2T_0	I_1T_1	I_3T_6	I_2T_0	I_1T_1	I_3T_6	I_2T_0	I_1T_1



Unit plot size: 3m x 3m

Factor A: Irrigation
I_1- Continuous flooding
I_2- saturatedcondition
I_3- alternate wetting & drying

Factor B: **Fertilizer plus manure**
T_0: Control
T_1: $N_{120}P_{25}K_{60}S_{20}Zn_2$
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