EFFECT OF FERTILIZER AND MANURE WITH DIFFERENT WATER MANAGEMENT ON THE GROWTH, YIELD AND QUALITY OF BRRI DHAN 28

BY

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This is to certify that the thesis entitled **"Effect of Fertilizer and Manure With Different Water Management on the Growth, Yield and Quality of BRRI Dhan 28"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Soil Science, embodies the result of a piece of *bona fide* research work carried out by **M. M. AL FAKFRUL ISLAM**, Registration number: **09-3760** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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ABSTRACT

The experiment was conducted in the farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from December 2010 to April 2011 to study the effect of various manure and inorganic fertilizer with different water management on the growth and yield of boro rice. BRRI dhan28 was used as the rice variety in this experiment. The experiment consists of 2 factors i.e. irrigation and fertilizer plus manure. Two levels of irrigations (I_0= Alternate wetting and drying and I_1= Continuous flooding) were used with 8 levels of fertilizer plus manure, as T_0: Control, T_1: 100% RDCF $N_{100}P_{15}K_{45}S_{20}Zn_2$, T_2: 10 ton cowdung/ha, T_3: 50% RDCF + 5 ton cow dung/ha, T_4: 8 ton poultry manure/ha, T_5: 50% RDCF + 4 ton poultry manure/ha, T_6: 10 ton vermicompost/ha and T_7: 50% RDCF + 5 ton vermicompost/ha with 16 treatment combinations and 3 replications. At the harvest, the yield parameters and yields were recorded and the grain and straw samples were analyzed for N, P, K and S. The irrigation had no significant single effect on the yield and yield parameters while the higher yields were obtained from continuous flooding (I_1). The Yield contributing characters and yields were significantly affected by fertilizer and manure and the highest effective tillers/hill (11.17), panicle length (22.90 cm), 1000 seed wt. (21.83 g), grain yield (5.92 kg/plot) and straw yield (5.91 kg/plot) were found from T_5 (50%RDCF + 4 ton poultry manure/ha) treatment and lowest in T_0 treatment. The higher grain and straw yields were found by the application of organic plus inorganic fertilizers compared to the use of chemical fertilizer alone. The yield parameters were significantly influenced by combined application of irrigation and fertilizer and the highest grain (5.93 kg/plot) and straw yields (6.42 kg/plot) were recorded from I_0T_5 (Alternate wetting and drying + 50% RDCF+ 4 ton poultry manure/ha) and lowest grain yield (3.64 kg/ha) from I_1T_0 (Continuous flooding + control) treatment combination and 63% grain yield increased over control. Irrigation did not significantly influence the grain and straw nutrient concentration and uptake while higher amounts of NPKS were up taken in continuous flooding. The boro rice grain and straw nutrient concentrations were significantly affected by the application of fertilizer and manure and application of fertilizer plus manure. The highest concentrations of grain N (1.392 %), P (0.280 %), K (0.356 %), S (0.128 %) and straw NPKS were recorded from T_5 treatment and lowest from T_0 treatment. Similarly, nutrient concentrations were recorded in I_0T_5 and I_1T_5 treatment combinations. The levels of organic matter and nutrient concentration were increased in the post harvest soils where manure plus inorganic fertilizer were used.

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CHAPTER 1
INTRODUCTION

INTRODUCTION

One of the world's most widely consumed grain play an unique role in combating global hunger is Rice. Its scientific name is *Oryza sativa* L. and belongs to the cereal crops under Gramineae family. Being the staple food of Bangladesh all of the people depend on rice and has tremendous influence on agrarian economy of Bangladesh. Boro rice covers about 56.66% of total rice area and it contributes to 43.24% of the total rice production in the country (BBS, 2008) among the three types of rice. 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 considering the 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.

A suitable combination of organic and inorganic sources of nutrients is necessary for sustainable agriculture that can ensure food production with high quality. Nambiar (1997 b) 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 fertilizer and manure 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 to 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 nutrient in soils. The 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 and Zn) while the crop removal is about 200 kg/ha. 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 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 is 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 priming 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 application of different levels of irrigation in boro rice affect the yield, nutrient accumulation and boro rice quality. More nutrients are leached out from soil when higher levels of irrigation water are added during boro rice growing period. Moisture levels affect the organic matter accumulation and mineralization. So, use of appropriate levels of irrigation in boro rice field is important for maintaining productivity and fertility. 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 present situation 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 effects of combined application of inorganic and organic fertilizer with different water management on the yield, yield components and quality of Boro rice.

iii. To investigate the improvement of soil fertility due to the use of organic manure in combination with chemical fertilizers.

iv. To compare the effects of inorganic, organic and organic plus inorganic fertilizers with different water management on the yield, yield parameters of boro rice.

CHAPTER 2
REVIEW OF LITERATURE

REVIEW OF LITERATURE

Organic manure and inorganic fertilizer are the essential factors for sustainable soil fertility and crop productivity because is the store house of plant nutrients. Sole and combined use of cow dung, poultry manure, vermicompost and inorganic fertilizer acts as a source of essential plant nutrients. Experimental evidences in the use of cow dung, poultry manure, vermicompost 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 fertilizer and cow dung, poultry manure & vermicompost and their combined application. Some literature related to the "Effect of level of various organic manure and inorganic fertilizer with different water management on the yield and yield attributes *boro* rice cv. BRRI dhan28" 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 increase the panicle length, number of primary and secondary branches panicle^{-1} when NPK fertilizer applied in 180-90-90 kg ha^{-1} this might be attributed to the adequate supply of NPK.

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

Singh and Singh (2002) carried out a field experiment to see the effect of different S levels (0, 20 and 40 kg/ha) on rice cv. Swarna and PR-108 in Varanasi, Utter Pradesh, India. They reported that plant height, tillers/m^2, dry matter production, panicle length and grains/panicle were significantly increased with increasing levels of S up to 40 kg/ha.

Haq *et al.* (2002) conducted an experiment with twelve treatments combination of N, P, K, S, Zn and Diazinon. He found 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 give 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 2.35 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 fertilizers. The tiller number and total dry matter production are closely correlated with yield depending on the rice cultivar (Tanaka, 1968) which can be greatly enhanced by applying proper nutrient.

Phaev *et al.* (2003) concluded that freshly applied P increased rice grain yield by 95%. In the first and second crops using residual P fertilizer, yields increased by 62 and 33% relative to the nil-P plot. Cumulative removal of P in four successive rice crops accounted for 30 and 55% of the 16.5 kg/ha in the form of harvested grain and whole plants.

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. He 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.

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

Rahman *et al.* (2007) conducted a field experiment using rice (cv. BRRI dhan 28) as a test crop and found that application of S had a significant positive effect on tillers/hill, plant height, panicle length and grains/panicle. They also indicated that application of S fertilizer at a recommended rate (20kg S/ha) might be necessary for obtaining higher grain yield as well as straw yield of Boro rice (cv BRRI dhan 28).

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 600 kg/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 400 kg/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 cow dung on the growth and yield of rice

Mannan *et al.* (2000) reported that manuring with cow dung 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 cow dung 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 cow dung (CD) and rice husk ash on yield of lowland rice-rice cropping sequence. Cow dung and ash were applied on dry season rice only and found the application of cow dung 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 cow dung 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 cow dung 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.

Singh *et al.* (2001) studied on the effect of poultry manure under irrigated condition with nitrogen in rice-wheat cropping system in an Alfisol of Bilapur, Madhya Pradesh, India. The treatment consisted of poultry manure alone and in combination with nitrogen fertilizer. Root and shoot biomass at different growth stages increased with the application of N and poultry manure alone and combination. Root and shoot biomass was higher in 100% N through poultry manure, followed by 75% N through poultry manure and 25% through urea.

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, internodes length, and 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.

Mahavisha *et al*. (2004) investigated a field study during the kharif season of 2001 in Andra Pradesh, India to investigate the effect of organic fertilizer sources on the growth and yield of rice. The crop growth and yield were higher with 125% recommended fertilizer + poultry manure and 100% RDF + poultry manure compared to the other treatments.

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.

XU *et al.* (2008) observed that application of half inorganic fertilizer and half organic manure (swine manure) increase nutrient absorption, panicle number, yield of rice & also increased soil organic matter.

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.

Vijay and Singh (2006) was conducted a field experiment during kharif season of 2003 and 2004 at J.V. college, Baraut, Uttar Pradesh, India, to study the effect of organic manures and fertilizer treatments on growth, yield and yield attributes of rice (*Oryza sativa* cv. Pusa Bashmati). The manure treatment comprises compost. Fertilizer treatments included N at 0, 40, 80 and 120 kg/ha. Application of compost significantly improved the growth, yield and yield attributes of rice during the years of experimentation. However, the organic manure compost did not show marked variation among the other treatments. Each unit increase in N levels led to significant increase in growth, yield and yield attributing characters of rice up to 80 kg N/ha over the during study.

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 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 no flooded (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 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.

2.4 Changes in soil fertility and properties due to integrated use of fertilizers with manure

Nimbiar (1997) 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 healthy soil fertility status. Intensive crop production systems have witnessed serious problems associated with loss of soil fertility as a result of excessive soil mining of plant nutrients and consequently reduction in productivity. Application of external source of plant nutrients is a key element in optimal management of soil organic matter, crop residues and manure for ensuring the bio-availability, the cycling and the balance of nutrients in the soil - plant systems.

Mathew and Nair (1997) reported that cattle manure when applied alone or in combination with chemical fertilizer (NPK) increased the organic C content, total N, available P and K in rice soils. Sarker and Singh (1997) reported that organic fertilizers when applied alone or in combination with inorganic fertilizers increase the level of organic carbon in soil as well as the total N, P and K contents of soil.

Xu *et al.* (1997) observed that application of organic matters affect soil pH value as well as nutrient level. Ravankar *et al.* (1999) reported that organic carbon; total N and available P_2O_5, K_2O, S and Zn in the soil were higher in the plots where nutrients were applied through organics than the inorganic sources.

Santhi *et al.* (1999) observed that application of 100% NPK plus FYM decreased the bulk density and increased the water holding capacity of soil. The decreased in bulk density in FYM treated plots might be ascribed to better aggregation. The water holding capacity was increased due to the improvement in structural condition of soil that was brought about mainly by the application of FYM in combination with NPK fertilizers.

Hemalatha *et al.* (2000) revealed that green manure significantly increased the soil fertility status, organic carbon, available soil N, P and K at post harvest soil. Zaman *et al.* (2000) reported that chemical properties like organic matter content, CEC, total N, exchangeable K, available P and S were favorably influenced by the application of organic sources of nitrogen and potassium while the organic sources mostly did not show positive effect. Soil pH decreased slightly compared to the initial status.

Aggelides and Londra (2000) conducted that the amendment compost improved all physical properties under consideration in the soils. The improvements were proportional to the compost rate. The results supported the Bulk density and penetration resistances were reduced. The reduction was greater in the loamy soil than in the clay soil. Mean weight diameter of the aggregates was reduced in both soils, while aggregate stability was increased.

Ayoola and Makinde (2009) concluded that after two years of application and cropping, enriched poultry manure increases soil N, P and K contents by 41.7%, 1.8% and 20.7%, respectively while fortified cow dung increases the nutrients by 25%, 0.33% and 3.4%, respectively, Although both organic manures increased the soil N and P, poultry manure gave higher values while the soil K, Ca and Mg contents were more increased with the cow dung than poultry manure.

The literature review discussed above indicates that organic manure can supply a good amount of plant nutrients and thus can contribute to crop yields. The properties of soils are also influenced by the inclusion of organic manure and crop residues in the soil fertility management system either directly or through residual action. The integrated approach by using the organic and inorganic sources of nutrients helps improve the efficiency of nutrients. Hence, an effort should be undertaken to investigate the effect of integrated nutrient management and irrigation on substance of crop productivity and maintenance of soil fertility in a rice cropping.

CHAPTER 3
MATERIALS AND METHODS

MATERIALS AND METHODS

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from December 2010 to April 2011 to study the effect of various organic manure and inorganic fertilizer with different water management on the growth and yield of boro rice. 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 2010-2011. The morphological, physical and chemical characteristics of the soil are shown in the Table 3.1 and 3.2.

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 2010 to May 2011 have been presented in Appendix I.

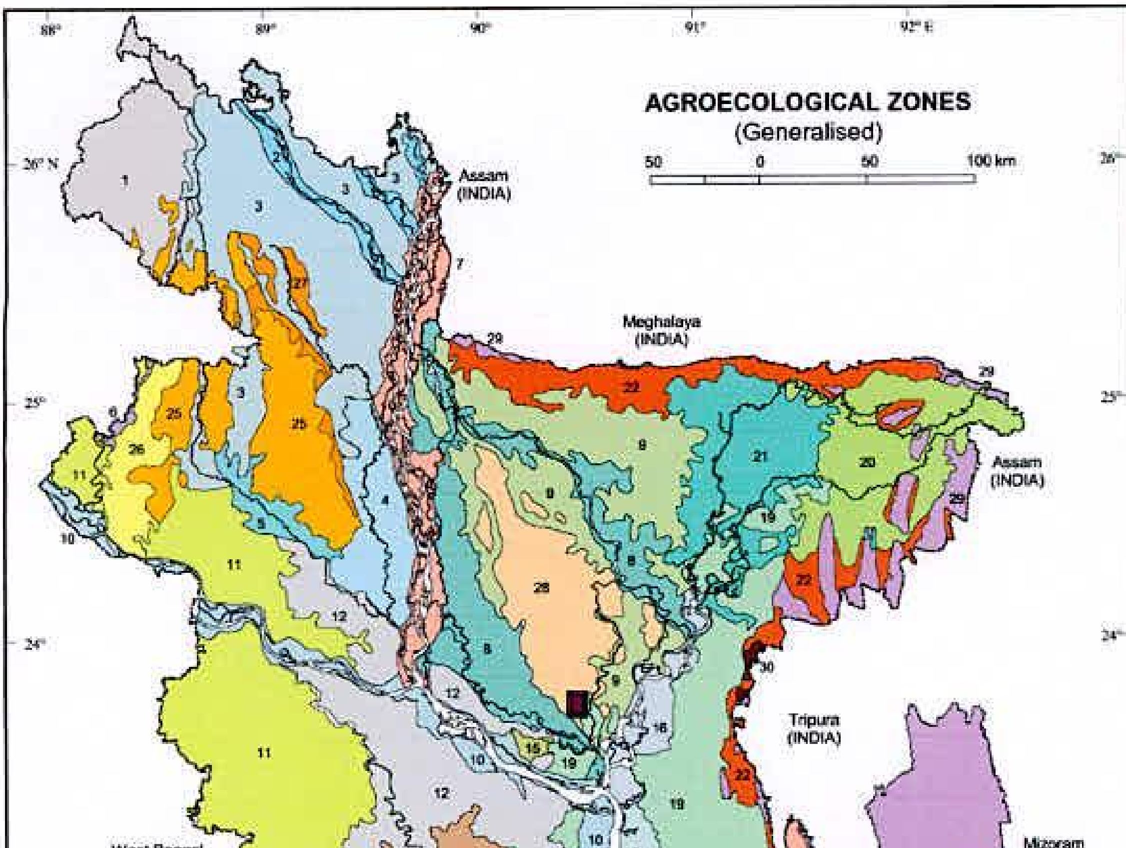


Figure 1. Map showing the experimental sites under study

Table 3.1. 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 Clay
Topography	Fairly level
Drainage	Well drained
Flood level	Above flood level

(FAO and UNDP, 1988)

Table 3.2. Initial physical and chemical characteristics of the soil

Characteristics	Value
Mechanical fractions: % Sand (2.0-0.02 mm) % Silt (0.02-0.002 mm) % Clay (<0.002 mm)	 22.26 56.72 20.75
Textural class	Silt Loam
pH (1: 2.5 soil- water)	6.1
Organic Matter (%)	1.09
Total N (%)	0.048
Available K (ppm)	15.62
Available P (ppm)	9.88
Available S (ppm)	8.06

3.3 Planting material

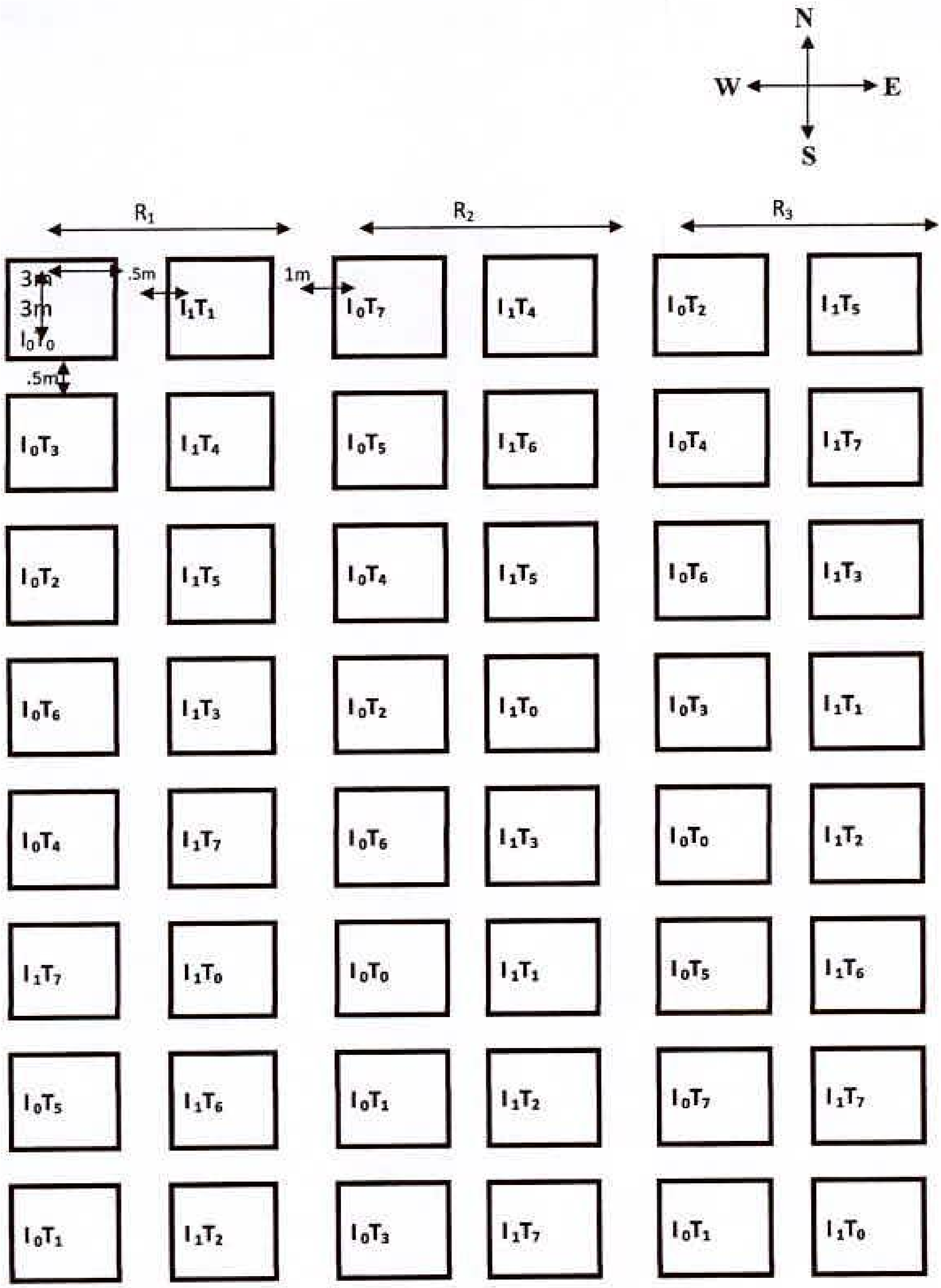
BRRI dhan28 was used as the test crop in this experiment. This variety was developed at the Bangladesh Rice Research Institute from the cross between BG 90-2 and BR51-46-5 in 1994. It is recommended for *Boro* season. Average plant height of the variety is 90-95 cm at the ripening stage. The grains are medium fine and white. It requires about 155-160 days completing its life cycle with an average grain yield of 5.0-5.5 t/ha (BRRI, 2004).

3.4 Land preparation

The land was first opened on 24th December, 2010 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 the weeds, stubbles and crop residues. Finally each plot was prepared by puddling.

3.5 Experimental design and layout

The experiment was laid out in a split plot design (SPD) with three replications. The layout was made distributing two irrigations (alternate wetting and drying and continuous flooding) to the main plots and fertilizer plus manure treatments to the sub plots. The total number of plots was 48, measuring 3 m × 3 m and ails separated plots from each other. The distance maintained between two main plots and two sub plots were 1.0 m and 0.5 m, respectively.



I_0 = Alternate wetting and drying
I_1 = Continuous flooding

Figure 2. Layout of the experimental plot.

3.6 Initial soil sampling

Before land preparation, initial soil samples at 0-15 cm depth were collected from different spots of the experimental field. The composite soil sample were air-dried, crushed and passed through a 2 mm (8 meshes) sieve. After sieving, the soil samples were kept in a plastic container for physical and chemical analysis of the soil.

3.7 Treatments

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

Factor A: Irrigation

I_0= Alternate wetting and drying

I_1= Continuous flooding

Factor B: Fertilizer plus manure

T_0: Control

T_1: RDCF, $N_{100}P_{15}K_{45}S_{20}Zn_2$

T_2: 10 ton cow dung/ha

T_3: 50% RDCF+ 5 ton cowdung/ha

T_4: 8 ton poultry manure/ha

T_5: 50% RDCF + 4 ton poultry manure/ha

T_6: 10 ton vermicompost/ha

T_7: 50% RDCF + 5 ton vermicompost/ha

Treatment combination

I_0T_0 = (Alternate wetting and drying + Control)

I_0T_1 = (Alternate wetting and drying + RDCF, $N_{100}P_{15}K_{45}S_{20}Zn_2$)

I_0T_2 = (Alternate wetting and drying + 10 ton cow dung/ha)

I_0T_3 = (Alternate wetting and drying + 50% RDCF + 5 ton cow dung/ha)

I_0T_4 = (Alternate wetting and drying + 8 ton poultry manure/ha)

I_0T_5 = (Alternate wetting and drying + 50% RDCF + 4 ton poultry manure/ha)

I_0T_6 = (Alternate wetting and drying + 10 ton compost/ha)

I_0T_7 = (Alternate wetting and drying + 50% RDCF + 5 ton compost/ha)

I_1T_0 = (Continuous flooding + Control)

I_1T_1 = {Continuous flooding + RDCF $N_{100}P_{15}K_{45}S_{20}Zn_2$)

I_1T_2 = (Continuous flooding + 10 ton cow dung/ha)

I_1T_3 = (Continuous flooding + 50% RDCF + 5 ton cow dung/ha)

I_1T_4 = (Continuous flooding + 8 ton poultry manure/ha)

I_1T_5 = (Continuous flooding + 50% RDCF + 4 ton poultry manure/ha)

I_1T_6 = (Continuous flooding + 10 ton vermicompost/ha)

I_1T_7 = (Continuous flooding + 50% RDCF + 5 ton vermicompost/ha)

3.8 Fertilizer application

The amounts of N, P, K, S and Zn fertilizers required per plot were calculated as per the treatments. Full amounts of TSP, MP, gypsum and Zinc sulphate were applied as basal dose before transplanting of rice seedlings. Urea were applied in 3 equal splits: one third was applied at basal before transplanting, one third at active tillering stage (30 DAT) and the remaining one third was applied at 5 days before panicle initiation stage (55 DAT).

3.9 Organic manure incorporation

Three different types of organic manure viz. cow dung, poultry manure and vermicompost were used. Cow dung, poultry manures and vermicompost were applied before four days of final land preparation. Chemical compositions of the manures used have been presented in Table 3.

Table 3.3. Chemical compositions of the cow dung, poultry manure and compost (oven dry basis)

Sources of organic manure	Nutrient content			
	N (%)	P (%)	K (%)	S (%)
Cowdung	1.46	0.29	0.74	0.24
Poultry manure	2.2	1.99	0.82	0.29
Vermiompost	2.89	0.28	1.60	0.32

3.10 Raising of seedlings

The seedlings of rice were raised wet-bed methods. 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.

3.11 Transplanting

Forty days old seedlings of BRRI dhan28 were carefully uprooted from the seedling nursery and transplanted on Ist January, 2011 in well puddled plot. Two seedlings per hill were used following a spacing of 20 cm × 20 cm. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings whenever required.

3.12 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.

3.12.1 Irrigation

Necessary irrigations were provided to the plots as and when required during the growing period of rice crop.

3.12.2 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.

3.12.3 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^{-1}.

3.13 Crop harvest

The crop was harvested at full maturity when 80-90% of the grains were turned into straw colored on 20^{th} May, 2010. 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.

3.14 Yield components

3.14.1 Total no. of effective tiller/hill

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

3.14.2 Total no. of non effective tiller/hill

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

3.14.3 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.

3.14.4 Length of panicle (cm)

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

3.14.5 No. of unfilled and filled grain per panicle

The total numbers of unfilled grains were calculated from selected 10 plants of a plot on the basis of not grain in the spikelet and then average numbers of unfilled grain per panicle was recorded. Similarly filled grains panicle^{-1} were counted

3.14.6 Weight of 1000 seeds (g)

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

3.14.7 Straw yield (kg)

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.

3.14.8 Grain yield (kg)

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}.

3.15 Chemical analysis of plant samples

3.15.1 Collection and preparation of plant samples

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

3.15.2 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: $CuSO_4.5H_2O$: Se in the ratio of 100: 10: 1), and 7 ml conc. H_2SO_4 were added. The flasks were heated at 160^{0}C and added 2 ml 30% H_2O_2 then heating was continued at 360 ^{0}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.

3.15.3 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 200^0C. Heating were stopped when the dense white fumes of $HClO_4$ occurred. The content of the flask were boiled until they were 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, K and S were determined from this digest by using different standard methods.

3.15.4 Determination of P, K and S from plant samples

3.15.4.1 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 for grain sample and 2 ml for straw sample from 100 ml digest by developing blue color with reduction of phosphomolybdate complex and the color intensity were measured colorimetrically at 660 nm wavelength and readings were calibrated with the standard P curve (Page *et al.*, 1982).

3.15.4.2 Potassium

Five milli-liter of digest sample for the grain and 10 ml for the straw were taken and diluted 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 measured by using standard curves.

3.15.4.3 Sulphur

Sulphur content was determined from the digest of the plant samples (grain and straw) with $CaCl_2$ (0.15%) solution as described by Page *et al.* 1982. The digested 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.

3.16 Post harvest soil sampling

After harvest of crop soil samples were collected from each plot at a depth of 0 to 15 cm. Soil sample of each plot were air-dried, crushed and passed through a two mm (10 meshes) sieve. The soil samples were kept in plastic container to determine the physical and chemical properties of soil.

3.17 Soil analysis

Soil samples were analyzed for both physical and chemical characteristics viz. organic matter, pH, total N and available P, K, and S contents. These results have been shown in the Table 8. The soil samples were analyzed by the following standard methods as follows:

3.17.1 Textural class

Mechanical analysis of soil were done by hydrometer method (Bouyoucos, 1926) and the textural class was determined by plotting the values of % sand, % silt and % clay to the Marshall's triangular co-ordinate following the USDA system.

3.17.2 Soil pH

Soil pH was measured with the help of a glass electrode pH meter, the soil water ratio being maintained at 1: 2.5 (Jackson, 1962).

3.17.3 Organic matter

Organic carbon in soil sample was determined by wet oxidation method of Walkley and Black (1935). The underlying principle was used to oxidize the organic matter with an excess of 1N $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and conc. H_3PO_4 and to titrate the excess $K_2Cr_2O_7$ solution with 1N $FeSO_4$. To obtain the content of organic matter was calculated by multiplying the percent organic carbon by 1.73 (Van Bemmelen factor) and the results were expressed in percentage (Page *et al.*, 1982).

3.17.4 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

3.17.5 Available phosphorus

Available P was extracted from the soil with 0.5 M $NaHCO_3$ solutions, pH 8.5 (Olsen *et al.*, 1954). Phosphorus in the extract was then determined by developing blue color with reduction of phosphomolybdate complex and the color intensity were measured colorimetrically at 660 nm wavelength and readings were calibrated the standard P curve (Page *et al.* 1982).

3.17.6 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).

3.17.7 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.

3.18 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference of different treatments on yield and yield contributing characters of BRRI dhan28. 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

RESULTS AND DISCUSSION

In this chapter the result of different yield attributes, yield and nutrient concentrations in the plant and grains and availability of different nutrients in the soil after harvest of rice are presented.

4.1 Effective tiller

4.1.1 Effect of irrigation on the effective tillers/hill of rice

The effects of irrigation on the effective tillers/hill of rice are presented in Table 4.1. Insignificant variation was observed on the effective tillers/hill of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_1 (Continuous flooding) showed the lowest number of effective tillers/hill (10.56) and I_0 (Alternate wetting and drying) irrigation showed highest number of effective tillers/hill (10.69).

Table 4.1 Effect of irrigation on effective tillers/hill of rice

Treatments (irrigation)	No. of effective tillers/hill
I_0	10.69
I_1	10.56
SE (±)	**NS**
CV	**8.17**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT.

I_0= Alternate wetting and drying

I_1= Continuous flooding

4.1.2 Effects of different doses of fertilizer and manure on the effective tillers/hill of rice

Different doses of fertilizers showed significant variations in respect of effective tillers/hill of rice (Table 4.2 & Figure 3). Among the different doses of fertilizers, T_5 (50%RDCF + 4 ton poultry manure/ha) showed the highest number of effective tillers/hill (11.17) which was statistically similar to all other treatments except T_0.The second highest number of effective tillers/hill was found in T_7 treatment where 50% RDCF plus 5 ton vermicompost was used. On the contrary, the lowest number of effective tillers/hill (9.70) was observed with T_0 where no fertilizer was applied. Nayak *et al.* (2007) reported a significant increase in effective tillers/hill due to application of chemical fertilizer with organic manure. Similar results also found by Rahman *et al.* (2009) and Reddy *et al.* (2005)

Table 4.2 Effects of different doses of fertilizer and manure on effective tillers/hill of rice

Fertilizer Treatment	No. of effective tillers/hill
T_0 (Control)	9.70b
T_1 (RDCF,N_{100} $P_{15}K_{45}$ $S_{20}Zn_2$)	10.49ab
T_2 (10 ton cow dung/ha)	10.45ab
T_3 (50%RDCF +5 ton cow dung/ha)	10.43ab
T_4 (8 ton poultry manure/ha)	10.91a
T_5 (50%RDCF + 4 ton poultry manure/ha)	11.17a
T_6 (10 ton Vermicompost/ha)	10.43ab
T_7 (50%RDCF +5 ton Vermicompost/ha)	11.0a
SE (±)	**0.30**
CV	**6.89**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT.

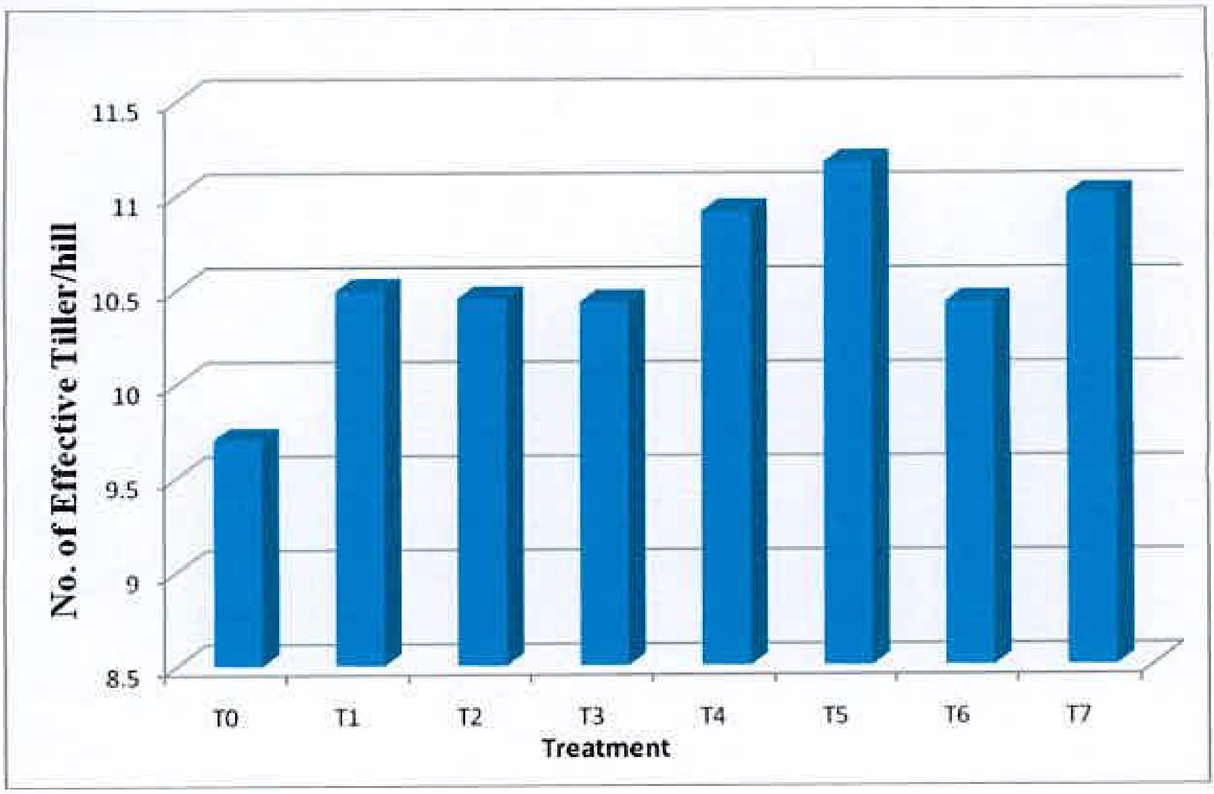


Figure 3. Effect of fertilizer and manure on effective tiller/hill of rice

4.1.3 Effects of combined use of fertilizer, manure and irrigation on the number of effective tillers/hill of Boro rice (BRRI dhan 28)

The combined effect of different doses of fertilizer and irrigation on the number of effective tillers/hill of rice was significant (Table 4.3). The highest number of effective tillers/hill of rice (11.87) was recorded with the treatment combination I_0T_7 (Alternate wetting and drying in combination with 50%RDCF + 4 ton poultry manure/ha),which was statistically similar to the I_1T_5, I_0T_5, I_0T_4 and I_1T_4 treatment. On the other hand, the lowest number of effective tillers/hill (9.47) was found in I_0T_0 (Alternate wetting and drying + control treatment) treatment combination.

Table 4.3 Interaction effect of fertilizer and irrigation on effective tillers/hill and non-effective tillers/hill of rice

Combined Treatment	No. of effective tillers/hill
I_OT_0	9.47c
I_OT_1	10.45abc
I_OT_2	10.23bc
I_OT_3	10.00bc
I_OT_4	11.22ab
I_OT_5	10.93abc
I_OT_6	10.53abc
I_OT_7	11.87a
I_1T_0	9.93bc
I_1T_1	10.53abc
I_1T_2	10.67abc
I_1T_3	10.87abc
I_1T_4	10.60abc
I_1T_5	11.40ab
I_1T_6	10.33bc
I_1T_7	10.13bc
SE (±)	**0.42**
CV	**6.89**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT.

4.2 Plant height

4.2.1 Effect of irrigation on the plant height of Boro rice (BRRI dhan 28)

The effects of irrigation on the plant height of rice are presented in Table 4.4. Insignificant variation was observed on the plant height of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_0 (Alternate wetting and drying) showed the lowest plant height (82.69 cm) and I_1 (Continuous flooding) irrigation showed highest plant height (83.83 cm).

Table 4.4 Effect of irrigation on the plant height and panicle length of rice

Treatments (irrigation)	Plant height (cm)	Panicle length (cm)
I_0	82.69	22.61
I_1	83.83	22.40
SE (±)	**NS**	**NS**
CV	**5.08**	**1.32**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT.

4.2.2 Effect of fertilizer on the plant height of Boro rice (BRRI dhan 28)

Rice plants showed significant variation in respect of plant height when fertilizers of different doses were applied (Table 4.5 & Figure 4). Among the different fertilizer doses, T_7 (50%RDCF + 5 ton vermicompost/ha) showed the highest plant height (85.11cm), which was statistically identical by (84.22 cm) T_4 (8 ton poultry manure/ha) and T_5 (85.11 cm) (50%RDCF +4 ton poultry manure /ha). On the other hand lowest plant height (77.74 cm) was observed in the T_0 treatment where no fertilizer was applied. Plant height wassignificantly influenced by the application of organic manure and chemical fertilizers reported by Nayak *et al.* (2007). Similar results also reported by Aga *et al.* (2004), Reddy *et al.* (2005).

Table 4.5 Effect of fertilizer and manure on the plant height and panicle length of rice

Fertilizer Treatment	Plant Height (cm)	Panicle Length (cm)
T_0 (Control)	77.74b	22.16b
T_1 (RDCF,N_{100} $P_{15}K_{45}$ $S_{20}Zn_2$)	83.00a	23.04a
T_2 (10 ton cow dung)	83.66a	22.20a
T_3 (50%RDCF +5 ton cow dung/ha)	81.64ab	22.19a
T_4 (8 ton poultry manure/ha)	84.22a	22.17a
T_5 (50%RDCF + 4 ton poultry manure/ha)	84.72a	22.90a
T_6 (10 ton Vermicompost/ha)	84.15a	22.74a
T_7 (50%RDCF +5 ton Vermicompost/ha)	85.11a	22.64a
SE (±)	**1.29**	**0.34**
CV	**3.82**	**4.32**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT.

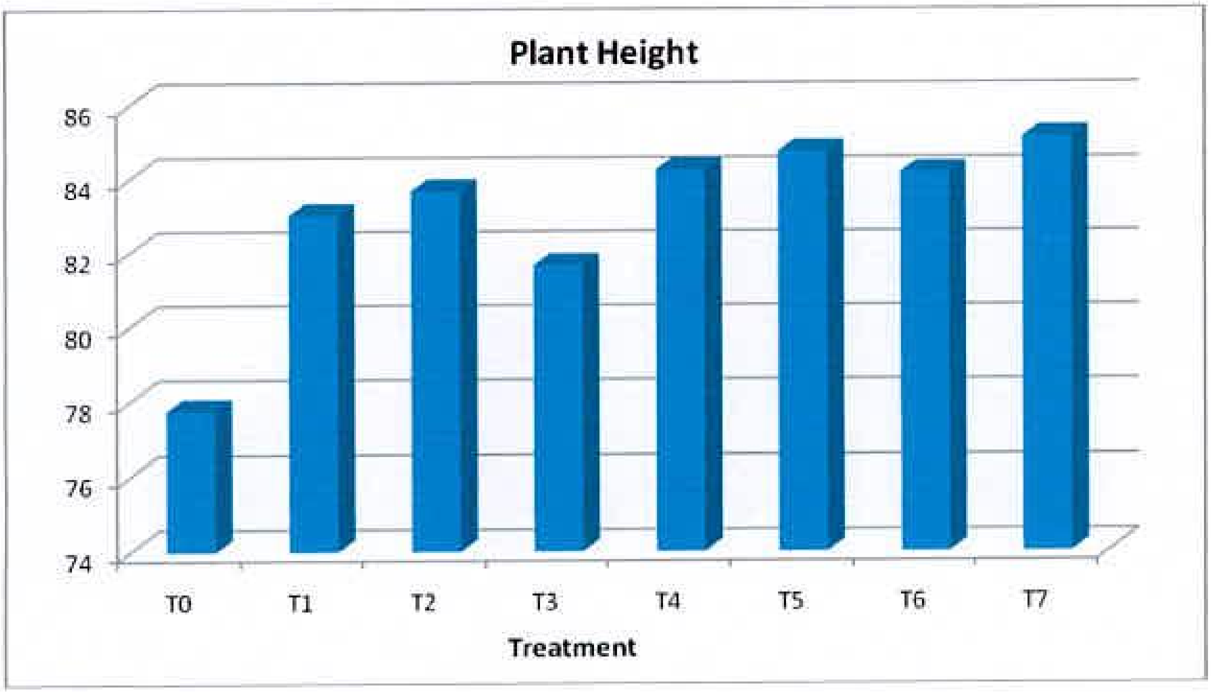


Figure 4. Effect of fertilizer and manure on plant height of rice

4.2.3 Interaction effects of fertilizer and irrigation on the plant height of rice

Combined application of different doses of fertilizer, manure and irrigation had insignificant variation on the plant height of rice (Table 4.6). The lowest plant height (79.13 cm) was observed in the treatment combination of I_1T_0 (Continuous flooding + No fertilizer). On the other hand, the highest plant height (86.08 cm) was recorded with I_1T_6 (Continuous flooding + No fertilizer +10 ton Vermicompost/ha) treatment.

Table 4.6 Interaction effect of fertilizer and irrigation on the plant height and panicle length of rice

Combined Treatment	Plant Height (cm)	Panicle Length (cm)
I_0T_0	81.01	21.73
I_0T_1	83.32	23.22
I_0T_2	82.22	22.29
I_0T_3	80.03	22.88
I_0T_4	85.46	22.03
I_0T_5	82.30	22.66
I_0T_6	82.22	23.27
I_0T_7	84.92	22.78
I_1T_0	79.13	22.60
I_1T_1	82.69	22.85
I_1T_2	84.11	22.11
I_1T_3	83.24	21.49
I_1T_4	83.98	22.30
I_1T_5	85.47	23.13
I_1T_6	86.08	22.21
I_1T_7	85.96	22.49
SE (±)	**NS**	**NS**
CV	**5.08**	**4.32**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT.

4.3 Panicle length

4.3.1 Effect of irrigation on the panicle length of rice

The effects of irrigation on the panicle length of rice are presented in Table 4.4. Insignificant variation was observed on the panicle length of rice when the field was irrigated with two different irrigations. Between this two irrigations, I_0 (alternate wetting and drying) showed the highest panicle length (22.61 cm) and I_1 (continuous flooding) irrigation showed lowest panicle length (22.40 cm).

4.3.2 Effects of different doses of fertilizer and manure on the panicle length of rice

Rice plants showed significant variation in respect of panicle length when different doses of fertilizer and manures were applied (Table 4.5). Among the different fertilizer doses, T_5 (50%RDCF + 4 ton poultry manure/ha) showed the highest panicle length (22.90 cm), which was statistically identical by T_1 (23.04 cm) (RDCF,N_{100} $P_{15}K_{45}$ $S_{20}Zn_2$) and T_6 (22.74 cm) (10 ton Vermicompost/ha). On the other hand lowest panicle length (22.16 cm) was observed in the T_0 treatment where no fertilizer was applied. 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), Reddy *et al.* (2005) also reported similar results.

4.3.3 Interaction effects of fertilizer and irrigation on the panicle length of rice

Combined application of different doses of fertilizer and irrigation had insignificant variation on the panicle length of rice (Table 4.6). The lowest panicle length (21.73 cm) was observed in the treatment combination of I_0T_0 (Alternate wetting and drying + No fertilizer). On the other hand, the highest plant height (21.36 cm) was recorded with I_0T_6 (Alternate wetting and drying + 10 ton Vermicompost/ha) treatment.

4.4 Number of filled grain per panicle

4.4.1 Effect of irrigation on the number of filled grain per panicle of rice

The effects of irrigation on the number of filled grain per panicle of rice are presented in Table 4.7. Insignificant variation was observed on the number of filled grain per panicle of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_0 (Alternate wetting and drying) showed the highest number of filled grain per panicle (132) and I_1 (Continuous flooding) irrigation showed lowest number of filled grain per panicle (131).

4.7 Effect of irrigation on the no. of filled grains/panicle of rice

Treatments	No. of filled grain/panicle	1000 seed weight (gm)
I_0	132	20.25 a
I_1	131	21.21 b
SE (±)	**NS**	**0.78**
CV	**7.13**	**6.53**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT.

4.4.2 Effect of fertilizer on the number of filled grain per panicle of rice

Filled grain per panicle of rice when different doses of fertilizer were applied (Table 4.8). The highest number of filled grain per panicle (136) was recorded in T_5 (50%RDCF + 4 ton poultry manure/ha) treatment which was statistically similar to allover treatments except T_0.The lowest number of filled grain per panicle (114.44) was recorded in T_0 (Control treatment). Similar result was found by Rahman *et al.* (2009).

Table 4.8 Effect of fertilizer on the no. of filled grain/panicle of rice

Treatments	No. of filled grain/panicle	1000 seed weight (gm)
T_0 (Control)	114 b	19.83
T_1 (RDCF,N_{100} $P_{15}K_{45}$ $S_{20}Zn_2$)	135 a	21.33
T_2 (10 ton cow dung/ha)	135 a	19.83
T_3 (50%RDCF +5 ton cow dung/ha)	132 a	21.00
T_4 (8 ton poultry manure/ha)	133 a	20.33
T_5 (50%RDCF + 4 ton poultry manure/ha)	136 a	21.83
T_6 (10 ton Vermicompost/ha)	130 a	21.50
T_7 (50%RDCF +5 ton Vermicompost/ha)	130 a	20.17
SE (±)	**3.74**	**NS**
CV	**7.01**	**6.53**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT.

4.4.3 Interaction effects of fertilizer and irrigation on the number of filled grain per panicle of rice

The combined effect of different doses of fertilizer and irrigation on the number of filled grain per panicle was insignificant (Table 4.9). The highest number of filled grain per panicle of rice (138.72) was recorded with the treatment combination I_0T_1 (Alternate wetting and drying + RDCF,N_{100} $P_{15}K_{45}$ $S_{20}Zn_2$ treatment. On the other hand, the lowest number of filled grain (121.97) was found in I_0T_0 (Alternate wetting and drying + No Fertilizer) treatment combination.

Table 4.9 Interaction effects of fertilizer and irrigation on the no. of filled grain/panicle of rice

Treatments	No. of filled grain/panicle
I_0T_0	121.97
I_0T_1	138.72
I_0T_2	138.63
I_0T_3	135.86
I_0T_4	130.04
I_0T_5	133.23
I_0T_6	129.42
I_0T_7	126.84
I_1T_0	125.26
I_1T_1	132.11
I_1T_2	131.98
I_1T_3	128.81
I_1T_4	136.62
I_1T_5	132.83
I_1T_6	131.17
I_1T_7	133.11
SE (±)	**NS**
CV (%)	**7.13**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT.

4.5 1000 seed wt. of rice

4.5.1 Effect of irrigation on the 1000 seed wt. of rice

The effects of irrigation on the 1000 seed wt. of rice are presented in Table 4.10. inignificant variation was observed on the 1000 seed wt. of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_0 (Alternate wetting and drying) showed the lowest 1000 seed wt. (20.25 g) and I_1 (Continuous flooding) irrigation showed highest1000 seed wt. (21.21 g).

Table 4.10 Effect of irrigation on the 1000 seed wt. of Boro rice (BRRI dhan 28)

Irrigation Treatment	**1000 Seed wt.(gm)**
I_0 (Alternate wetting and drying)	20.25a
I_1 (Continuous flooding)	21.21b
SE (±)	**0.78**
CV	**6.53**

4.5.2 Effect of fertilizer and manure on the 1000 seed wt. of rice

Rice plants showed significant variation in respect of 1000 seed wt. of rice when fertilizers of different doses were applied (Table 4.11). Among the different fertilizer doses, T_5 (50%RDCF + 4 ton poultry manure/ha) showed the highest 1000 grain wt. (21.83 g) which was statistically identical by (21.50 g) T_6 (10 t0n vermicompost/ha). On the other hand, the lowest 1000 grain wt. (19.83 g) was observed in the T_0 treatment where no fertilizer was applied. Yang *et al.* (2004) also recorded that 1000-grain weight were increased by the application of chemical fertilizer with organic manure. Statistically similar thousand- grain weight was observed in maximum treatments.

Table 4.11 Integrated use of fertilizer on the 1000 seed wt.of rice

Fertilizer Treatment	1000 Seed wt.(gm)
T_0 (Control)	19.83
T_1 (RDCF,N_{100} $P_{15}K_{45}$ $S_{20}Zn_2$)	21.33
T_2 (10 ton cow dung/ha)	19.83
T_3 (50%RDCF +5 ton cow dung/ha)	21.00
T_4 (8 ton poultry manure/ha)	20.33
T_5 (50%RDCF + 4 ton poultry manure/ha)	21.83
T_6 (10 ton Vermicompost/ha)	21.50
T_7 (50%RDCF +5 ton Vermicompost/ha)	20.17
SE (±)	**NS**
CV	**6.53**

4.5.3 Interaction effects of fertilizer and irrigation on the 1000 seed wt. of rice

The combined effect of different doses of fertilizer and irrigation on the 1000 seed wt. of rice was insignificant (Table 4.12). The highest 1000 seed wt. of rice (22.33 g) was recorded with the treatment combination I_1T_5 (Continuous Flooding +50%RDCF + 4 ton poultry manure/ha). On the other hand, the lowest 1000 grain wt. (19.67) was found in both I_0T_0 (Alternate wetting and drying + control treatment) and I_0T_2 (Alternate wetting and drying + control treatment) treatment combination.

Table 4.12 Combined effects of irrigation and fertilizer on the 1000 seed wt.of rice

Combined Treatment	1000 Seed wt.(gm)
I_OT_0	19.67
I_OT_1	21.00
I_OT_2	19.67
I_OT_3	20.67
I_OT_4	19.00
I_OT_5	21.33
I_OT_6	19.67
I_OT_7	20.00
I_1T_0	22.33
I_1T_1	21.67
I_1T_2	20.00
I_1T_3	21.33
I_1T_4	21.67
I_1T_5	22.33
I_1T_6	20.00
I_1T_7	20.33
SE (±)	**NS**
CV	**6.53**

4.6 Grain yield

4.6.1 Effect of irrigation on the grain yield of rice

The effects of irrigation on the grain yield of rice are presented in Table 4.13. Insignificant variation was observed on the grain yield of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_1 (Continuous flooding) showed the highest grain yield (5.21 kg/plot) and I_0 (Alternate wetting and drying) irrigation showed lowest grain yield (4.98 kg/plot).

4.13 Effect of irrigation on the grain yield/plot of rice

Irrigation Treatment	Grain Yield (kg/plot)	Straw Yield(Kg/plot)
I_0 (Alternate wetting and drying)	4.98	5.28
I_1 (Continuous flooding)	5.21	5.32
SE (±)	**NS**	**NS**
CV	**8.44**	**10.01**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT.

4.6.2 Effects of different doses of fertilizer and manure on the grain yield of rice

Different doses of fertilizers showed significant variations in respect of grain yield/plot (Table 4.14 & Figure 5). The application of fertilizers and manure had a positive effect on the grain yield of boro rice. The higher levels of % grain yield increase were observed in the integrated use of fertilizer and manure compared to chemical fertilizer alone. Among the different doses of fertilizers, T_5 (50%RDCF + 4 ton poultry manure/ha) showed the highest grain yield/plot (5.92 kg/plot) which was statistically similar with the T_4 (8 ton poultry manure/ha) treatment. On the contrary, the lowest grain yield/plot (3.72 kg/plot) 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), Xu *et al.* (2008) and Miah *et al.* (2004).

Table 4.14 Effect of fertilizer on the grain yield/plot of rice

Fertilizer Treatment	Grain Yield (kg/plot)	Straw Yield (kg/plot)
T_0 (Control)	3.72e	4.60b
T_1 (RDCF,N_{100} $P_{15}K_{45}$ $S_{20}Zn_2$)	5.39bc	5.19ab
T_2 (10 ton cow dung/ha)	4.68d	5.25ab
T_3 (50%RDCF +5 ton cow dung/ha)	5.00cd	5.29ab
T_4 (8 ton poultry manure/ha)	5.64ab	5.40a
T_5 (50%RDCF + 4 ton poultry manure/ha)	5.92a	5.91a
T_6 (10 ton Vermicompos/hat)	5.21c	5.44a
T_7 (50%RDCF +5 ton Vermicompost/ha)	5.23c	5.32ab
SE (±)	**NS**	**0.22**
CV	**6.53**	**10.01**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT.

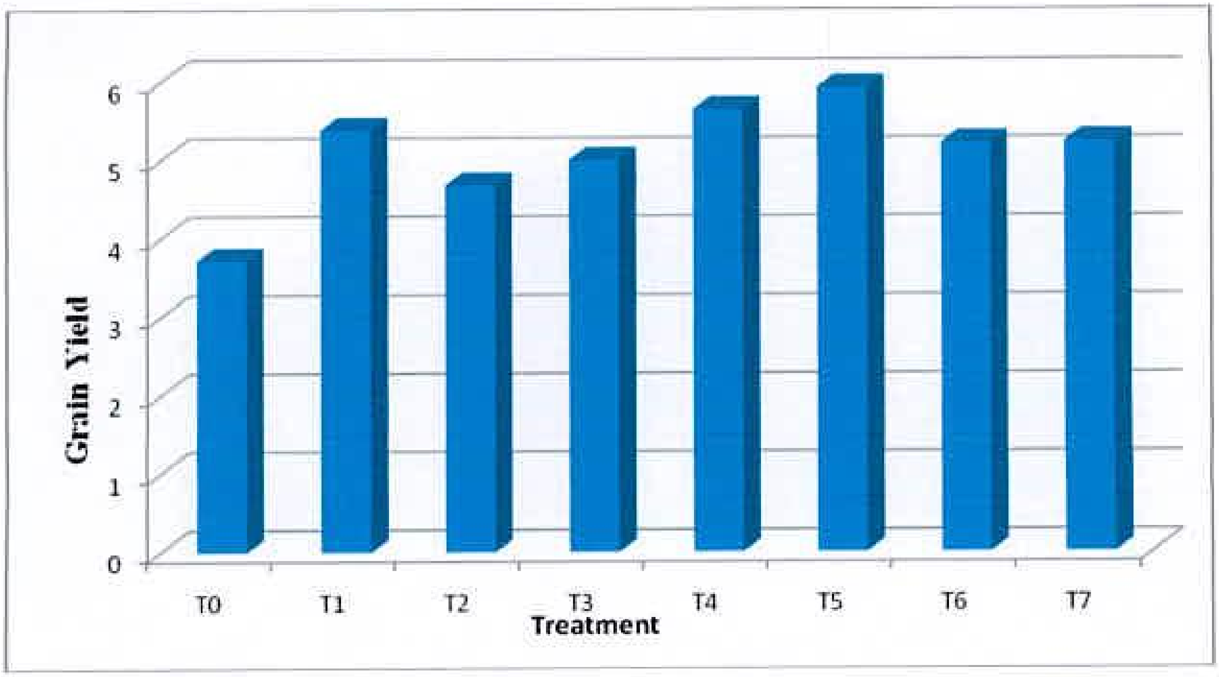


Figure 5. Effect of different doses of fertilizer and manure on grain yield of rice

4.6.3 Interaction effect of fertilizer and irrigation on the grain yield of rice

The combined effect of different doses of fertilizer and irrigation on the grain yield of rice was significantly different (Table 4.15). The highest grain yield of rice (5.93 kg/plot) was recorded with the treatment combination I_0T_5 (Alternate Wetting and Drying +50%RDCF + 4 ton poultry manure/ha) which was statistically similar to I_1T_5 (continuous flooding + RDCF, N_{100} $P_{15}K_{45}$ $S_{20}Zn_2$), I_0T_4, I_1T_4 and I_1T_1 treatment combinations. On the other hand, the lowest grain yield (3.79 kg/plot) was found in I_0T_0 (Alternate wetting and drying + control treatment) treatment combination. *Lin et al.* (2011) reported that irrigation with organic material application increased yield of rice.

Table 4.15 Interaction effect of fertilizer and irrigation on the grain yield/plot of rice

Treatments	Grain yield/plot (kg)
I_0T_0	3.79gh
I_0T_1	5.16bcde
I_0T_2	4.31fg
I_0T_3	4.75ef
I_0T_4	5.71ab
I_0T_5	5.93a
I_0T_6	5.14bcde
I_0T_7	5.06cde
I_1T_0	3.64h
I_1T_1	5.63abc
I_1T_2	5.05dc
I_1T_3	5.24bcde
I_1T_4	5.58abcd
I_1T_5	5.91a
I_1T_6	5.28bcde
I_1T_7	5.39abcd
SE (±)	**0.16**
CV (%)	**5.40**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT.

4.7 Straw yield

4.7.1 Effect of irrigation on the straw yield of rice

The effects of irrigation on the straw yield of rice are presented in Table 4.16. Insignificant variation was observed on the straw yield of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_1 (Continuous flooding) showed the highest straw yield (5.32 kg/plot) and I_0 (Alternate wetting and drying) irrigation showed lowest straw yield (5.28 kg/plot).

Table 4.16 Effect of irrigation on the straw yield of Boro rice (BRRI dhan 28)

Irrigation Treatment	Straw Yield (kg/plot)
I_0 (Alternate wetting and drying)	5.28
I_1 (Continuous flooding)	5.32
SE (±)	**NS**
CV	**10.01**

4.7.2 Effects of different doses of fertilizer and manure on the straw yield of boro rice

Significant variation was observed on the straw yield/plot of rice when different doses of fertilizer were applied (Table 4.17). The highest yield of straw/plot (5.91 kg/plot) was recorded in T_5 (50%RDCF + 4 ton poultry manure/ha) treatment which was statistically similar (5.44 kg/plot) with the T_6 and T_6 treatment. The lowest straw yield/plot (3.72 kg/plot) was recorded in the T_0 treatment where no fertilizer was applied. Rahman *et al.* (2009) reported that the application of organic manure and chemical fertilizers increased the straw yields of rice. These findings are corroborated with the work of Mannan *et al.*

(2000). It is clear that organic manure in combination with inorganic fertilizers vegetative growth of plants and thereby increased straw yield of rice.

Table 4.17 Integrated use of fertilizer on the yield of Straw of rice

Fertilizer Treatment	Straw Yield (kg/plot)
T_0 (Control)	4.60b
T_1 (RDCF,N_{100} $P_{15}K_{45}$ $S_{20}Zn_2$)	5.19ab
T_2 (10 ton cow dung/ha)	5.25ab
T_3 (50%RDCF +5 ton cow dung/ha)	5.29ab
T_4 (8 ton poultry manure/ha)	5.40a
T_5 (50%RDCF + 4 ton poultry manure/ha)	5.91a
T_6 (10 ton Vermicompost/ha)	5.44a
T_7 (50%RDCF +5 ton Vermicompost/ha)	5.32ab
SE (±)	**0.22**
CV	**10.01**

4.7.3 Interaction effect of fertilizer and irrigation on the straw yield of Boro rice

The combined effect of different doses of fertilizer and irrigation on the straw yield of rice was insignificant (Table 4.18). The highest straw yield of rice (6.42 kg) was recorded with the treatment combination I_0T_5 (Alternate wetting and drying + 50% RDCF + 4 ton poultry manure). On the other hand, the lowest straw yield (4.63 kg) was found in I_0T_0 (Alternate wetting and drying + control treatment) treatment combination

Table 4.18 Interaction effect of irrigation and fertilizer on the straw yield of Boro rice

Combined Treatment	Straw Yield (kg/plot)
I_0T_0	4.63b
I_0T_1	4.70b
I_0T_2	4.87b
I_0T_3	5.17b
I_0T_4	5.35ab
I_0T_5	6.42a
I_0T_6	5.47ab
I_0T_7	5.65ab
I_1T_0	4.57ab
I_1T_1	5.67ab
I_1T_2	5.63ab
I_1T_3	5.42ab
I_1T_4	5.45ab
I_1T_5	5.40ab
I_1T_6	5.41ab
I_1T_7	5.00b
SE (±)	**0.31**
CV	**10.01**

4.8 NPKS concentration in grain

4.8.1 Effect of irrigation on N concentration in grain

The effects of irrigation on N concentration in grain of rice are presented in Table 4.19. Insignificant variation was observed on N concentration in grain of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_0 (Alternate wetting and drying) showed the N concentration in grain (1.126%) and I_1 (Continuous flooding) irrigation showed the N concentration in grain (1.150%).

Table 4.19 Effect of irrigation on NPKS concentration in grain

Treatments	Concentration (%) in grain			
	N	P	K	S
I_0	1.126	0.243	0.314	0.109
I_1	1.150	0.242	0.314	0.110
SE (±)	**NS**	**NS**	**NS**	**NS**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT

4.8.2 Effect of different doses of fertilizer and manure on N concentration in grain

Nitrogen concentrations in grain of rice showed statistically significant variation due to the application of different doses of fertilizers are presented in Table 4.20. The nitrogen concentration in Boro rice grain significantly increased due to application of fertilizers and manure. The higher levels of grain N concentrations were recorded in the combined application of fertilizer and manure compare to the chemical fertilizer alone. The highest N concentration in grain (1.392%) was recorded from T_5 (50%RDCF + 4 ton poultry manure/ha) which was closely followed (1.350%) by T_4 (8 ton Poultry manure /ha). On the other hand, the lowest N concentration in grain (0.833%) was found from T_0 as control treatment. A significant increase in N content in rice grain due to the application of organic manure and fertilizers have been reported by investigators (Azim, 1999 and Hoque, 1999).

Table 4.20 Effect of fertilizer and manure on NPKS concentration of boro rice grain

Treatments	Concentration (%) in grain			
	N	P	K	S
T_0	0.833 c	0.201 e	0.237 e	0.082 d
T_1	1.083 bc	0.243 c	0.304 d	0.103 c
T_2	1.042 bc	0.226 d	0.303 d	0.105 bc
T_3	1.020 bc	0.253 bc	0.337 b	0.118 ab
T_4	1.350 a	0.255 bc	0.353 a	0.126 a
T_5	1.392 a	0.280 a	0.356 a	0.128 a
T_6	1.217 ab	0.211 e	0.300 d	0.105 bc
T_7	1.167 ab	0.267 ab	0.322 c	0.112 bc
SE (±)	**0.0732**	**0.0062**	**0.0043**	**0.0021**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT

4.8.3 Interaction effect of fertilizer and irrigation on N concentration of boro rice grain

The combined effect of different doses of fertilizer and irrigation on N concentration of rice was insignificant (Table 4.21). The highest N concentration in grain of rice (1.433%) was recorded with the treatment combination I_0T_5 (Alternate wetting and drying +50% RDCF + 4 ton poultry manure/ha) and similar N concentration was found in I_1T_5 treatment combination . On the other hand, the lowest N concentration in grain of rice (0.867%) was found in I_1T_0 (Continuous flooding + control treatment) treatment combination.

Table 4.21 Combined effects of fertilizer and irrigation on the NPKS concentration of boro rice grain

Treatments	Concentration (%) in grain			
	N	P	K	S
I_0T_0	0.867	0.200	0.240	0.083
I_0T_1	1.033	0.240	0.304	0.102
I_0T_2	1.083	0.226	0.303	0.105
I_0T_3	0.923	0.264	0.333	0.117
I_0T_4	1.267	0.255	0.350	0.124
I_0T_5	1.433	0.284	0.366	0.127
I_0T_6	1.133	0.206	0.299	0.105
I_0T_7	1.267	0.266	0.321	0.111
I_1T_0	0.800	0.202	0.234	0.081
I_1T_1	1.133	0.246	0.305	0.103
I_1T_2	1.000	0.227	0.302	0.104
I_1T_3	1.117	0.242	0.342	0.118
I_1T_4	1.350	0.256	0.356	0.129
I_1T_5	1.433	0.275	0.346	0.130
I_1T_6	1.300	0.216	0.301	0.105
I_1T_7	1.067	0.268	0.324	0.112
SE (±)	**NS**	**NS**	**NS**	**NS**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT

4.8.4 Effect of irrigation on P concentration in grain

The effects of irrigation on P concentration in grain of rice are presented in Table 4.19. Insignificant variation was observed on P concentration in grain of rice when the field was irrigated with two different irrigations. Similar P concentrations were observed in different irrigation treatments.

4.8.5 Effects of different doses of fertilizer and manure on P concentration of boro rice grain

Phosphorous concentrations in grain of rice showed statistically significant variation due to the application of different doses of fertilizers are presented in Table 4.20. The highest P concentration in grain (0.280%) was recorded from T_5 (50% RDCF + 4 ton poultry manure/ha) which was closely followed (0.267%) by T_7 as 50% RDCF + 5 ton vermicompost/ha. On the other hand, the lowest P concentration in grain (0.201%) was found from T_0 as control treatment which was closely followed (0.211%) by T_6 as 10 ton vermicompost/ha. A significant increase in P content in rice straw due to the application of organic manure and fertilizers has been reported by investigators (Azim, 1999 and Hoque, 1999).

4.8.6 Interaction effect of fertilizer and irrigation on P concentration of boro rice grain

The combined effect of different doses of fertilizer and irrigation on P concentration in grain of rice was insignificant (Table 4.21). The highest P concentration in grain of rice (0.284%) was recorded with the treatment combination I_0T_5 (Alternate wetting and drying +50% RDCF + 4 ton poultry manure/ha). On the other hand, the lowest P concentration in grain of rice (0.200%) was found in I_0T_0 (Alternate wetting and drying + control treatment) and I_1T_0 (Continuous Flooding + control) treatment combinations.

4.8.7 Effect of irrigation on K concentration in grain

The effects of irrigation on K concentration in grain of rice are presented in Table 4.19. Insignificant variation was observed on K concentration in grain of rice when the field was irrigated with two different irrigations. Similar K concentrations were observed in different irrigation treatments.

4.8.8 Effect of fertilizer and manure on K concentration in boro rice grain

Potassium concentrations in grain of rice showed statistically significant variation due to the application of different doses of fertilizers are presented in Table 4.20. The highest K concentration in grain (0.356%) was recorded from T_5 (50% RDCF + 4 ton poultry manure/ha) which was closely followed (0.353%) by T_4 as 8 ton poultry manure/ha. On the other hand, the lowest K concentration in grain (0.237%) was found from T_0 as control treatment. Singh *et al.* (2001) revealed that Potassium content in grain was increased due to combined application of organic manure and chemical fertilizers.

4.8.9 Interaction effect of fertilizer and irrigation on K concentration in grain

The combined effect of different doses of fertilizer and irrigation on K concentration in grain of rice was insignificant (Table 4.21). The highest K concentration in grain of rice (0.366%) was recorded with the treatment combination I_0T_5 (Alternate wetting and drying +50% RDCF + 4 ton poultry manure/ha). On the other hand, the lowest K concentration in grain of rice (0.240%) was found in I_0T_0 (Alternate wetting and drying + control treatment) treatment combination.

4.8.10 Effect of irrigation on S concentration of boro rice grain

The effects of irrigation on S concentration in grain of rice are presented in Table 4.19. Insignificant variation was observed on S concentration in grain of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_0 (Alternate wetting and drying) showed the S concentration in grain (0.109%) and I_1 (Continuous flooding) irrigation showed the S concentration in grain (0.110%).

4.8.11 Effects of different doses of fertilizer and manure on S concentration in boro rice grain

Sulphur concentrations in grain of rice showed statistically significant variation due to the application of different doses of fertilizers are presented in Table 4.20. The highest S concentration in grain (0.128%) was recorded from T_5 (50% RDCF + 4 ton poultry manure/ha) which was closely followed (0.126%) by T_4 as 8 ton poultry manure/ha. On the other hand, the lowest S concentration in grain (0.082%) was found from T_0 as control treatment.

4.8.12 Interaction effect of fertilizer and irrigation on S concentration in grain

The combined effect of different doses of fertilizer and irrigation on S concentration of grain was insignificant (Table 4.21). The highest S concentration in grain of rice (0.130%) was recorded with the treatment combination I_1T_5 (Continuous flooding + 50% RDCF + 4 ton poultry manure/ha). On the other hand, the lowest S concentration in grain of rice (0.083%) was found in I_0T_0 (Alternate wetting and drying + control treatment) treatment combination.

4.9 NPKS concentration in straw

4.9.1 Effect of irrigation on N concentration in boro rice straw

The effects of irrigation on N concentration in straw of boro rice are presented in Table 4.22. Insignificant variation was observed on N concentration in straw of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_0 (Alternate wetting and drying) showed the N concentration in straw (0.453%) and I_1 (Continuous flooding) irrigation showed the N concentration in straw (0.458%).

Table 4.22 Effect of irrigation on NPKS concentration in straw

Treatments	Concentration (%) in straw			
	N	P	K	S
I_0	0.453	0.066	1.149	0.109
I_1	0.458	0.067	1.136	0.073
SE (±)	NS	NS	NS	NS

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT

4.9.2 Effect of fertilizer on N concentration in boro rice straw

Nitrogen concentrations in straw of boro rice showed statistically significant variation due to the application of different doses of fertilizers are presented in Table 4.23. The N concentration of boro rice straw significantly increased due to the application of fertilizer and manure. The higher levels of N concentrations were found in the treatments where fertilizer and manure were applied combinedly. The highest N concentration in straw (0.564%) was recorded from T_5 (50% RDCF + 4 ton poultry manure/ha) which was closely followed (0.559%) by T_4 as 8 ton poultry manure/ha. On the other hand, the lowest N concentration in straw (0.331%) was found from T_0 as control treatment.

Table 4.23 Effect of fertilizer on NPKS concentration in straw

Treatments	Concentration (%) in straw			
	N	P	K	S
T_0	0.331 f	0.044 d	0.778 e	0.055
T_1	0.415 d	0.072 ab	1.159 c	0.068
T_2	0.402 de	0.057 cd	1.082 d	0.066
T_3	0.499 b	0.069 abc	1.097 d	0.086
T_4	0.559 a	0.083 a	1.286 b	0.090
T_5	0.564 a	0.083 a	1.456 a	0.080
T_6	0.398 e	0.066 bc	1.197 c	0.065
T_7	0.477 c	0.058 bcd	1.084 d	0.071
SE (±)	**0.0062**	**0.0019**	**0.0127**	**NS**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT

4.9.3 Interaction effect of fertilizer and irrigation on N concentration in straw

The combined effect of different doses of fertilizer and irrigation on N concentration of rice was insignificant (Table 4.24). The highest N concentration in boro rice straw (0.570%) was recorded with the treatment combination I_0T_5 (Alternate wetting and drying +50% RDCF + 4 ton poultry manure/ha). On the other hand, the lowest N concentration in straw of rice (0.330%) was found in I_0T_0 (Alternate wetting and drying + control treatment) treatment combination.

Table 4.24 Combined effects of fertilizer and irrigation on the NPKS concentration in boro rice straw

Treatments	Concentration (%) in straw			
	N	P	K	S
I_0T_0	0.330	0.043 f	0.773 g	0.054
I_0T_1	0.395	0.065 bcde	1.184 c	0.061
I_0T_2	0.402	0.059 cdef	1.033 ef	0.064
I_0T_3	0.501	0.071 abcd	1.140 cd	0.080
I_0T_4	0.562	0.084 ab	1.479 a	0.090
I_0T_5	0.570	0.089 a	1.482 a	0.093
I_0T_6	0.394	0.068 abcd	0.982 f	0.071
I_0T_7	0.473	0.052 def	1.119 cd	0.061
I_1T_0	0.332	0.045 ef	0.783 g	0.051
I_1T_1	0.435	0.079 abc	1.133 cd	0.074
I_1T_2	0.402	0.055 def	1.131 cd	0.068
I_1T_3	0.497	0.068 bcd	1.054 e	0.092
I_1T_4	0.557	0.082 ab	1.093 de	0.090
I_1T_5	0.559	0.078 abc	1.430 ab	0.067
I_1T_6	0.401	0.065 bcde	1.413b	0.059
I_1T_7	0.408	0.064 bcdef	1.049 e	0.081
SE (±)	**NS**	**0.0027**	**0.0179**	**NS**
CV (%)	**0.94**	**5.19**	**2.43**	**2.73**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT

4.9.4 Effect of irrigation on P concentration in boro rice straw

The effects of irrigation on P concentration in straw of rice are presented in Table 4.22. Insignificant variation was observed on P concentration in straw of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_0 (Alternate wetting and drying) showed the P concentration in straw (0.066%) and I_1 (Continuous flooding) irrigation showed the P concentration in straw (0.067%).

4.9.5 Effect of different doses of fertilizer and manure on P concentration in straw

The application of different levels of fertilizer and manure increased the P concentration of Boro rice. Phosphorous concentrations in straw of rice showed statistically significant variation due to the application of different doses of fertilizers are presented in Table 4.23. The highest P concentration in straw (0.083%) was recorded from T_5 (50% RDCF + 4 ton poultry manure/ha) and T_4 as 8 ton poultry manure/ha. On the other hand, the lowest P concentration in straw (0.044%) was found from T_0 as control treatment.

4.9.6 Interaction effect of fertilizer and irrigation on P concentration in straw of boro rice

The combined effect of different doses of fertilizer and irrigation on P concentration in straw of rice was significant (Table 4.24). The highest P concentration in straw of rice (0.089%) was recorded with the treatment combination I_0T_5 (Alternate wetting and drying +50% RDCF + 4 ton poultry manure/ha) which was followed (0.084) by I_0T_4 (Alternate wetting and drying +8 ton poultry manure/ha). On the other hand, the lowest P concentration in straw of rice (0.043%) was found in I_0T_0 (Alternate wetting and drying + control treatment) which was followed (0.045) by I_1T_0 (Continuous flooding + control treatment) treatment combination.

4.9.7 Effect of irrigation on K concentration in straw

The effects of irrigation on K concentration in straw of rice are presented in Table 4.22. Insignificant variation was observed on K concentration in straw of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_0 (Alternate wetting and drying) showed the highest K concentration in straw (1.149%) and I_1 (Continuous flooding) irrigation showed the lowest K concentration in straw (1.136%).

4.9.8 Effects different doses of fertilizer and manure on K concentration in boro rice straw

Potassium concentrations in straw of rice showed statistically significant variation due to the application of different doses of fertilizers are presented in Table 4.23. The highest K concentration in straw (1.456%) was recorded from T_5 (50% RDCF + 4 ton poultry manure/ha) treatment. On the other hand, the lowest K concentration in straw (0.778%) was found from T_0 as control treatment. Singh *et al.* (2001) revealed that Potassium content in grain was increased due to combined application of organic manure and chemical fertilizers.

4.9.9 Interaction effect of fertilizer and irrigation on K concentration in straw of boro rice

The combined effect of different doses of fertilizer and irrigation on K concentration in straw of rice was insignificant (Table 4.24). The highest K concentration in straw of rice (1.482%) was recorded with the treatment combination I_0T_5 (Alternate wetting and drying +50% RDCF+ 4 ton poultry manure/ha). On the other hand, the lowest K concentration in straw of rice (0.773%) was found in I_0T_0 (Alternate wetting and drying+ control treatment) treatment combination.

4.9.10 Effect of irrigation on S concentration in straw of boro rice

The effects of irrigation on S concentration in straw of rice are presented in Table 4.22. Insignificant variation was observed on S concentration in straw of rice when the field was irrigated with two different irrigations. Between these two irrigations, I_0 (Alternate wetting and drying) showed the S concentration in straw (0.109%) and I_1 (Continuous flooding) irrigation showed the S concentration in straw (0.073%).

4.9.11 Effect of fertilizer and manure on S concentration in straw of boro rice

Sulphur concentrations in straw of rice showed statistically significant variation due to the application of different doses of fertilizers are presented in Table 4.23. The S concentration in boro rice straw significantly increased due to application of fertilizer and manure. The highest S concentration in straw (0.090%) was recorded from T_4 (8 ton poultry manure/ha) which was statistically identical (0.086%) with T_3 as 50% RDCF + 5 ton cow dung/ha. On the other hand, the lowest S concentration in straw (0.055%) was found from T_0 as control treatment. Azim (1999) and Hoque (1999) reported that application of sulphur from manure and fertilizers increased S content both in grain and straw.

4.9.12 Interaction effect of fertilizer and irrigation on S concentration in straw of boro rice

The combined effect of different doses of fertilizer and irrigation on S concentration in straw of rice was insignificant (Table 4.24). The highest S concentration in straw of rice (0.093%) was recorded with the treatment combination I_0T_5 (Alternate wetting and drying +50% NPKSZn + 4 ton poultry manure/ha) which was statistically identical with I_1T_5, I_1T_4 and I_0T_5. On the other hand, the lowest S concentration in straw of rice (0.054%) was found in I_1T_0 (Continuous flooding + control treatment) treatment combination which was statistically identical (0.056%) with I_0T_0 (Alternate wetting and drying + control treatment).

4.10. pH, organic matter and NPKS status of post harvest soil

4.10.1 Effect of irrigation on pH of post harvest soil

Statistically non significant variation was recorded for pH in post harvest soil when the field was irrigated with two different irrigations (Table 4.25). Between these two irrigations, I_0 (Alternate wetting and drying) showed the highest pH (6.3) in post harvest soil and I_1 (Continuous flooding) irrigation showed the lowest pH (6.0) in post harvest soil.

Table 4.25 Effect of irrigation on the pH, organic matter and NPKS content in post harvest soil

Treatments	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Available K (m.eq/100g)	Available S (ppm)
I_0	6.3	1.15	0.066	28.04 a	0.034	28.92 a
I_1	6.0	1.13	0.085	29.92 b	0.035	36.11 b
SE (±)	**NS**	**NS**	**NS**	**0.128**	**NS**	**0.478**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT.

4.10.2 Effect of fertilizer on pH of post harvest soil

pH of post harvest soil showed statistically significant variation due to the application of different doses of fertilizers are presented in Table 4.26. The highest pH of post harvest soil (6.4) was recorded from T_1 (RDCF, $N_{100}P_{15}K_{45}S_{20}Zn_2$). On the other hand, the lowest pH of post harvest soil (6.0) was recorded from T_7 (50% RDCF + 5 ton vermicompost/ha).

Table 4.26 Effect of fertilizer and manure on the pH, organic matter and NPKS content in post harvest soil

Treatments	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Available K (m.eq/100g)	Available S (ppm)
T_0	6.1 ab	1.0 h	0.054	19.95 e	0.020 c	21.395 c
T_1	6.4 a	1.06 g	0.091	26.03 d	0.039 ab	29.755 abc
T_2	6.3 ab	1.13 f	0.093	31.89 ab	0.032 abc	33.232 abc
T_3	6.0 b	1.16 d	0.067	27.93 cd	0.037 ab	43.388 a
T_4	6.2 ab	1.22 b	0.062	32.14 ab	0.042 a	34.432 abc
T_5	6.1 ab	1.24 a	0.089	34.08 a	0.042 a	40.755 ab
T_6	6.1 ab	1.16 e	0.072	29.29 bcd	0.026 bc	27.873 bc
T_7	6.0 b	1.17 c	0.078	30.49 abc	0.034 abc	29.302 bc
SE (±)	**0.076**	**0.009**	**NS**	**1.015**	**0.005**	**3.842**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT.

4.10.3 Interaction effect of fertilizer and irrigation on pH of post harvest soil

The combined effect of different doses of fertilizer and irrigation on pH of post harvest soil was significant (Table 4.27). The highest pH of post harvest soil (6.5) was recorded with the treatment combination I_0T_1 (Alternate wetting and drying + RDCF,N_{100} $P_{15}K_{45}$ $S_{20}Zn_2$) which was followed (6.4) by I_0T_0 (Alternate wetting and drying + control treatment). On the other hand, the lowest pH of post harvest soil (5.9) was recorded with the treatment combination I_1T_3 (Continuous flooding +10 ton cow dung) which was statistically identical (5.9) with I_1T_6 (Alternate wetting and drying + 10 ton Vermicompost/ha).

Table 4.27 Combined effects of fertilizer and irrigation on the pH, organic matter and NPKS content in post harvest soil

Treatm-ents	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Available K(m.eq/100g)	Available S (ppm)
I_0T_0	6.4 abc	1.01 j	0.050	19.53	0.021	21.51 cd
I_0T_1	6.5 a	1.00 k	0.064	25.56	0.044	27.85 bcd
I_0T_2	6.4 abc	1.13 g	0.064	29.87	0.022	36.90 abc
I_0T_3	6.3 abcde	1.17 d	0.057	25.64	0.037	31.80 bcd
I_0T_4	6.3 abcd	1.22 b	0.067	29.52	0.040	28.76 bcd
I_0T_5	6.2 abcdef	1.27 a	0.088	32.72	0.037	37.75 abc
I_0T_6	6.4 abc	1.15 f	0.074	30.61	0.023	14.89 d
I_0T_7	6.0 bcdef	1.17 e	0.065	30.81	0.044	31.88 bcd
I_1T_0	5.9 ef	0.99 l	0.057	20.37	0.019	21.27 cd
I_1T_1	6.3 abcde	1.05 i	0.118	26.50	0.033	31.65 bcd
I_1T_2	6.2 abcdef	1.12 h	0.121	33.91	0.042	29.56 bcd
I_1T_3	5.9 f	1.16 f	0.078	30.22	0.037	54.97 a
I_1T_4	6.0 def	1.19 c	0.057	34.77	0.044	40.09 abc
I_1T_5	6.4 abc	1.22 b	0.091	35.44	0.047	43.75 ab
I_1T_6	5.9 f	1.17 e	0.069	27.97	0.030	40.85 abc
I_1T_7	6.0 cdef	1.18 d	0.091	30.18	0.025	26.72 bcd
SE (±)	**0.1087**	**0.0127**	**NS**	**NS**	**NS**	**5.434**

In a column figures having similar letter(s) do not differ significantly whereas figures with dissimilar letter(s) differ significantly as per DMRT.

4.10.4 Effect of irrigation on organic matter in post harvest soil

Statistically non significant variation was recorded for organic matter in post harvest soil when the field was irrigated with two different irrigations (Table 4.25). Between these two irrigations, I_0 (Alternate wetting and drying) showed the highest organic matter

(1.15%) in post harvest soil and I_1 (Continuous flooding) irrigation showed the lowest organic matter (1.13%) in post harvest soil.

4.10.5 Effect of fertilizer on organic matter in post harvest soil

Organic matter of post harvest soil showed statistically significant variation due to the application of different doses of fertilizers is presented in Table 4.26. The level of organic matter in post harvest soil increased due to combined application of fertilizer and manure. The highest organic matter of post harvest soil (1.24%) was recorded from T_5 (50%RDCF + 4 ton poultry manure/ha) which was followed (1.22%) by T_4 (8 ton poultry manure/ha). On the other hand, the lowest organic matter of post harvest soil (1.0%) was recorded from T_0 (Control treatment) which was followed (1.06%) by T_1 (RDCF,N_{100} $P_{15}K_{45}$ $S_{20}Zn_2$) treatment. Xu *et al.* (2008) reported that application of chemical fertilizer with organic manure increase soil organic matter.

4.10.6 Interaction effect of fertilizer and irrigation on organic matter in post harvest soil

The combined effect of different doses of fertilizer and irrigation on organic matter of post harvest soil was significant (Table 4.27). The level of organic matter increased in the post harvest soil due to application of chemical fertilizer plus manure. The highest organic matter of post harvest soil (1.27%) was recorded with the treatment combination I_0T_5 (Alternate wetting and drying +50%RDCF + 4 ton poultry manure/ha) which was followed (1.22%) by I_0T_4 (Alternate wetting and drying + 8 ton poultry manure/ha). On the other hand, the lowest organic matter of post harvest soil (0.99%) was recorded with the treatment combination I_1T_0 (Continuous flooding +control treatment) which was statistically identical (1.0%) with I_0T_1 (Alternate wetting and drying + RDCF,N_{100} $P_{15}K_{45}$ $S_{20}Zn_2$) treatment.

4.10.7 Effect of irrigation on the N content in post harvest soil

The effects of irrigation on the N content of post harvest soil are presented in Table 4.25. Total nitrogen in post harvest soil showed statistically significant differences when the field was irrigated with two different irrigations. Between these two irrigations, I_0 (Alternate wetting and drying) showed the lowest total N (0.066%) and I_1 (Continuous flooding) irrigation showed highest total N (0.085%).

4.10.8 Effect of fertilizer on the N content in post harvest soil

Total nitrogen in post harvest soil showed statistically insignificant differences due to the application of different organic manure and inorganic fertilizer in rice. The level of total N in post harvest soil increased due to combined application of fertilizer and manure. The highest total nitrogen in post harvest soil (0.095%) was recorded from T_2 as 10 ton cow dung/ha. On the other hand, the lowest total nitrogen in post harvest soil (0.054%) was obtained from control treatment. Ayoola & Makinde (2009) found that application of chemical fertilizer with organic manure increase N content in post harvest soil. Similar result also found by Reddy *et al.* (2005).

4.10.9 Combined effect of fertilizer and irrigation on the N content in post harvest soil

The combined effect of different doses of fertilizer and irrigation on the N content in post harvest soil of rice field was insignificant (Table 4.27).The higher soil N content was found in the treatments where manure plus inorganic fertilizer were used. The highest total nitrogen in post harvest soil (0.121%) was recorded from I_1T_2 (continuous flooding + 10 ton cowdung/ha). On the other hand, the lowest total nitrogen in post harvest soil (0.050%) was obtained from I_0T_0 (alternate wetting and drying plus control).

4.10.10 Effect of irrigation on the P content in post harvest soil

The effects of irrigation on the P content of post harvest soil are presented in Table 4.25. Available phosphorus in post harvest soil showed statistically significant variations when the field was irrigated with two different irrigations. Between these two irrigations, I_0 (Alternate wetting and drying) showed higher available phosphorus (28.04ppm) and I_1 (Continuous flooding) irrigation showed lower available phosphorus (29.99 ppm).

4.10.11 Effect of fertilizer on the P content in post harvest soil

Available phosphorus in post harvest soil showed statistically significant differences due to the application of different organic manure and inorganic fertilizer in rice. The level of available P in post harvest soil increased due to combined application of fertilizer and manure. The highest available phosphorus in post harvest soil (34.08 ppm) was recorded from T_5 as 50%RDCF + 4 ton poultry manure/ha which was statistically identical (32.15 ppm) with T_4 (8 ton poultry manure/ha). On the other hand, the lowest available phosphorus in post harvest soil (19.95 ppm) was obtained from T_0 (control treatment). Ayoola & Makinde (2009) found that application of chemical fertilizer with organic manure increase P content in post harvest soil. Similar result also found by Reddy *et al.* (2005).

4.10.12 Combined effect of fertilizer and irrigation on the P content in post harvest soil

The combined effect of different doses of fertilizer and irrigation on the available phosphorus in post harvest soil of rice field was insignificant (Table 4.27). The highest available phosphorus in post harvest soil (35.44 ppm) was recorded from I_1T_5 (Continuous flooding + 50 % RDCF + 4 ton poultry manure/ha). On the other hand, the lowest available phosphorus in post harvest soil (19.530ppm) was obtained from I_0T_0 (Alternate wetting and drying + control treatment) treatment combination.

4.10.13 Effect of irrigation on the K content in post harvest soil

The effects of irrigation on the K content of post harvest soil are presented in Table 4.25. Available potassium in post harvest soil showed statistically insignificant variations when the field was irrigated with two different irrigations. Between these two irrigations, I_0 (Alternate wetting and drying) showed available potassium (0.034 m.eq/100g) and I_1 (Continuous flooding) irrigation showed available potassium (0.035 m.eq/100g).

4.10.14 Effect of fertilizer on the K content in post harvest soil

Available potassium in post harvest soil showed statistically significant differences due to the application of different organic manure and inorganic fertilizer in rice. The level of available K in post harvest soil increased due to combined application of fertilizer and manure. The highest available potassium in post harvest soil (0.042 m.eq/100g) was recorded from T_4 as 8 ton poultry manure/ha same with T_5 as 50%RDCF + 4 ton poultry manure/ha. On the other hand, the lowest available potassium in post harvest soil (0.020 m.eq/1000g) was obtained from control treatment T_0. Ayoola & Makinde (2009) found that application of chemical fertilizer with organic manure increase K content in post harvest soil. Similar result also found by Reddy *et al.* (2005).

4.10.15 Combined effect of fertilizer and irrigation on the K content in post harvest soil

The combined effect of different doses of fertilizer and irrigation on the K content in post harvest soil of rice field was significant (Table 4.27). The highest available potassium in post harvest soil (0.047 m.eq/100g) was recorded from I_1T_5 (Continuous flooding + 50%RDCF + 4 ton poultry manure/ha) which was statistically identical (0.044 m.eq/100g) with I_0T_7 (alternate wetting and drying + 50%RDCF +5 ton Vermicompost). On the other hand, the lowest available potassium in post harvest soil (0.019 m.eq/100g) was obtained from I_1T_0 (Continuous flooding+ control treatment) which was closely followed (0.022 m.eq/100g) by I_0T_2 (Alternate wetting and drying + control treatment).

4.10.16 Effect of irrigation on the S content in post harvest soil

The effects of irrigation on the S content of post harvest soil are presented in Table 4.25. Available sulphur in post harvest soil showed statistically significant variations when the field was irrigated with two different irrigations. Between these two irrigations, I_0 (Alternate wetting and drying) showed available sulphur (28.92 ppm) and I_1 (Continuous flooding) irrigation showed higher available sulphur (36.11 ppm).

4.10.17 Effect of fertilizer on the S content in post harvest soil

Available sulphur in post harvest soil showed statistically significant differences due to the application of different organic manure and inorganic fertilizer in rice. The level of available S in post harvest soil increased due to combined application of fertilizer and manure. The highest available sulphur in post harvest soil (43.39 ppm) was recorded from T_3 as 50 % RDCF +5 ton cow dung/ha which was very close (40.75 ppm) to T_5

(750 % RDCF + 4 ton poultry manure/ha). On the other hand, the lowest available sulphur in post harvest soil (21.40 ppm) was obtained from T_0 (control) treatment.

4.10.18 Combined effect of fertilizer and irrigation on the S content in post harvest soil

The combined effect of different doses of fertilizer and irrigation on the S content in post harvest soil of rice field was significant (Table 4.27). The highest available sulphur in post harvest soil (54.98 ppm) was recorded from I_1T_3 (Continuous flooding + 50%RDCF +5 ton cow dung/ha). On the other hand, the lowest available sulphur in post harvest soil (14.90 ppm) was obtained from I_0T_6 (Alternate wetting and drying + 10 ton Vermicompost).

CHAPTER 5

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from December 2010 to May 2011 to study the effect of various organic manure and inorganic fertilizer with different water management on the growth and yield of boro rice. BRRI dhan28 was used as the rice variety in this experiment. The experiment consists of 2 factors i. e. irrigation and fertilizer plus manure. Two levels of irrigations (I_0 = Alternate wetting and drying and I_1 = Continuous flooding) were used with 8 levels of fertilizer plus manure, as T_0: Control, T_1: (RDCF, $N_{100}P_{15}K_{45}S_{20}Zn_2$), T_2: (10 ton cow dung/ha), T_3: (50% RDCF + 5 ton cow dung/ha), T_4: 8 ton poultry manure/ha), T_5: (50% RDCF + 4 ton poultry manure/ha), T_6: (10 ton vermicompost/ha) and T_7: (50% RDCF + 5 ton vermicompost/ha) with 16 treatment combination as I_0T_0 = (Alternate wetting and drying + Control), I_0T_1 = (Alternate wetting and drying + RDCF, $N_{100}P_{15}K_{45}S_{20}Zn_2$), I_0T_2 = (Alternate wetting and drying + 10 ton cow dung/ha), I_0T_3 = (Alternate wetting and drying + 50% RDCF + 5 ton cow dung/ha), I_0T_4 = (Alternate wetting and drying + 8 ton poultry manure/ha), I_0T_5 = (Alternate wetting and drying + 50% RDCF + 4 ton poultry manure/ha), I_0T_6 = (Alternate wetting and drying + 10 ton vermicompost/ha), I_0T_7 = (Alternate wetting and drying + 50% RDCF + 5 ton vermicompost/ha, I_1T_0 = (Continuous flooding + Control), I_1T_1 = (Continuous flooding + RDCF, $N_{100}P_{15}K_{45}S_{20}Zn_2$), I_1T_2 = (Continuous flooding + 10 ton cow dung/ha), I_1T_3 = (Continuous flooding + 50% RDCF + 5 ton cow dung/ha), I_1T_4 =(Continuous flooding + 8 ton poultry manure/ha), I_1T_5 = (Continuous flooding + 50% RDCF + 4 ton poultry manure/ha), I_1T_6 = (Continuous flooding + 10 ton vermicompost/ha), I_1T_7 = (Continuous flooding + 50% RDCF + 5 ton vermicompost/ha) and 3 replications. The total number of effective tillers/hill, plant height, panicle length, number of filled grains/panicle, grain yield and straw yield were not significantly affected by single effect of irrigation. The highest plant height and 1000 grain wt. grain yield and straw yield were observed in I_1 treatment while the panicle length, number of filled grains/panicle were higher in the I_0 treatment.

Yield contributing characters and yields were significantly affected by fertilizer and manure. The higher values of yield parameters and yields were recorded in the treatments where fertilizer plus manure were used. The highest effective tillers/hill (11.17), plant height (84.7 cm), panicle length (22.90 cm), 1000 grain wt. (21.83 g), grain yield (5.92

kg/plot) and straw yield (5.91 kg/plot) were found from T_5 treatment where 50% RDCF plus 4 ton poultry manure was used. On the other hand in lowest values were obtained from T_0 treatment. The number of effective tillers/hill, grain yield and straw yield were significantly influenced by combined application of irrigation and fertilizer. The highest grain yield (5.93 kg/plot) and straw yield (6.42 kg/plot) were recorded from I_0T_5. The lowest values of effective tillers/hill (9.47), plant height (81.03 cm), panicle length (21.73 cm), 1000 grain wt. (19.67 g) grain yield (3.79 kg/plot) and straw yield (4.63 kg/plot) were observed from I_0T_0 treatment combination.

The grain and straw nutrient concentration in boro rice plant was significantly affected by application of fertilizer and manure. The almost similar levels of N, P, K, S concentration were recorded from I_0 and I_1 treatments. The highest concentrations of grain N (1.392 %), P (0.280 %), K (0.356 %), S (0.128 %) were recorded from T_5 treatment and in all cases lowest value was observed in T_0 treatment and similarly the highest concentrations of straw N (0.564 %), P (0.083 %), K (1.456 %), S (0.080 %) were recorded from T_5 treatment and in all cases lowest value was observed in T_0 treatment.

The pH, organic matter and levels of N, P, K, S of post harvest soil were significantly affected by fertilizer and combined application of irrigation and fertilizer. The higher levels of organic matter and nutrient concentrations were found in the fertilizer treatments where manure plus inorganic fertilizers were used. The highest pH (6.4), organic matter (1.24%), were recorded from T_1, T_5, and the highest content of P (34.08 ppm), K (0.042 m.eq/100g), S (40.76 ppm) were recorded from T_5, and N (0.093%) is recorded from T_2, On the other hand, the lowest organic matter (1.0%), N (0.054%), P (19.95 ppm), K (0.20 m.eq/100g), S (21.395 ppm) were recorded from T_0 treatment. Similarly incase of combined fertilizer and irrigation application the highest pH (6.5), organic matter (1.27%), N (0.121%), P (35.44 ppm), K (0.047 m.eq/100g), S (54.977 ppm) were recorded from I_0T1, I_0T_5, I_1T_2, I_1T_5, I_1T_5, I_1T_3 treatment combinations respectively and the lowest pH (5.9), organic matter (1.0%), S (14.90 ppm) were found in I_1T_3, I_0T_1, I_0T_6 treatment combinations respectively and N (0.050%), P (19.53 ppm), K (0.019 m.eq/100g), concentrations were recorded from I_0T_0, I_0T_0 and I_1T_0 treatment combinations respectively.

From the above discussion it can be concluded that irrigation had no significant effect on yield and yield contributing characters and application alternate wetting and drying is preferable than flood irrigation and application of 50% RDCF + 4 ton poultry manure/ha and alternate wetting and drying + 50% RDCF plus 4 ton poultry manure/ha was most favorable for improving yield and yield contributing characters of BRRI dhan 28 in Boro season.

Before recommend findings of the present study, the following recommendations and suggestions may be made:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance.
2. Another combination of NPKS and others organic manures with different water management may be included for further study.

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APPENDIX

APPENDIX

APPENDIX

Appendix I. Monthly record of air temperature, rainfall, relative humidity, soil temperature and Sunshine of the experimental site during the period from December 2010 to April 2011

Month	*Air temperature (°c)		*Relative humidity (%)	*Rain fall (mm) (total)	*Sunshine (hr)
	Maximum	Minimum			
December, 2010	26.4	14.1	69	12.8	5.5
January, 2011	25.4	12.7	68	7.7	5.6
February, 2011	28.1	15.5	68	28.9	5.5
March, 2011	32.5	20.4	64	65.8	5.2
April, 2011	33.7	23.6	69	65.3	4.9
May, 2001	34.1	24.4	69	65.2	5.2

* Monthly average,

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka – 1207.