EFFECT OF VARIOUS ORGANIC MANURE AND INORGANIC FERTILIZER ON THE YIELD AND QUALITY OF BORO RICE

BY

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CERTIFICATE

This is to certify that the thesis entitled "**Effect of Various Organic Manure and Inorganic Fertilizer on the Yield and Quality of Boro Rice**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE in Soil Science, embodies the result of a piece of *bonafide* research work carried out by **Md. Akter Hossaen**, Registration number: **07-02591** 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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TO

MY BELOVED PARENTS

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Dhaka Bangladesh ***The Author***

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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 2007 to April 2008 to study the effect of various organic manure and inorganic fertilizer on the yield and quality of boro rice. BRRI dhan29 was used as the test crop in this experiment. The experiment consisted of 8 treatments. Such as T_0: Control, T_1: 100% $N_{100}P_{15}K_{45}S_{20}$ (Recommended dose), T_2: 50% NPKS + 5 ton cowdung/ha, T_3: 70% NPKS + 3 ton cowdung/ha, T_4: 50% NPKS + 4 ton poultry manure/ha, T_5: 70% NPKS + 2.4 ton poultry manure/ha, T_6: 50% NPKS + 5 ton vermicompost/ha and T_7: 70% NPKS + 3 ton vermicompost/ha. At 30, 50, 70, 90 DAT and at harvest the tallest plant (24.18 cm, 31.34 cm, 44.67 cm, 67.05 cm and 89.00 cm) was recorded from T_5 and the lowest (16.20 cm, 20.65 cm, 32.58 cm, 49.10 cm and 64.59 cm) was observed from T_0. The maximum number of effective tillers per hill (13.52) was recorded from T_5 and the minimum (6.07) was observed from T_0. The highest length of panicle (24.59 cm) was recorded from T_5 and the lowest length of panicle (16.45 cm) was observed from T_0. The maximum number of total grain per plant (97.45) was recorded from T_5 and the minimum (69.13) was observed from T_0. The highest weight of 1000 seeds (21.80 g) was recorded from T_5 and the lowest (16.73 g) was observed from T_0. The highest grain yield (7.30 t/ha) was recorded from T_5 again the lowest (2.06 t/ha) was observed from T_0. The highest straw yield (7.64 t/ha) was recorded from T_5 and the lowest (4.63 t/ha) was observed from T_0. The highest N concentration in grain (0.761%) was recorded from T_5 and the lowest (0.566%) was observed from T_0. The highest P concentration in grain (0.293%) was recorded from T_5 and the lowest (0.201%) was observed from T_0. The highest K concentration in grain (0.358%) was recorded from T_5 again the lowest (0.262%) was observed from T_0. The highest S concentration in grain (0.126%) was recorded from T_5 and the lowest (0.075%) was observed from T_0. The highest N concentration in straw (0.505%) was recorded from T_5 and the lowest (0.334%) was observed from T_0. The highest P concentration in straw (0.087%) was recorded from T_5 and the lowest (0.051%) was observed from T_0. The highest K concentration in straw (1.175%) was recorded from T_5 and the lowest (0.778%) was observed from T_0. The highest S concentration in straw (0.098%) was recorded from T_5 and the lowest (0.058%) was observed from T_0. The highest N uptake by grain (55.53 kg/ha) was recorded from T_5 and the lowest (0.566 kg/ha) was observed from T_0. The highest P uptake by grain (21.38 kg/ha) was recorded from T_5 and the lowest (4.14 kg/ha) was observed from T_0. The highest K uptake by grain (26.12 kg/ha) was recorded from T_5 and the lowest (5.39 kg/ha) was observed from T_0. The highest P uptake by straw (6.65 kg/ha) was recorded from T_5 and the lowest (2.36 kg/ha) was observed from T_0. The highest K uptake by straw (89.78 kg/ha) was recorded from T_5 and the lowest (36.10 kg/ha) was observed from T_0. The highest pH of post harvest soil (6.35) was recorded from T_3 and the lowest (5.70) was observed from T_2. The highest organic matter in post harvest soil (1.445%) was recorded from T_6 and the lowest (1.150%) was observed from T_3. The highest available phosphorus in post harvest soil (25.53 ppm) was recorded from T_5 and the lowest (19.42 ppm) was observed from control. The highest exchangeable potassium in post harvest soil (0.166 me%) was recorded from T_5 and the lowest (0.103 me%) was observed from control.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1
INTRODUCTION

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food of Bangladesh. Almost all the people depend on rice and has tremendous influence on agrarian economy of Bangladesh. Among the three types of rice, boro rice covers about 56.66% of total rice area and it contributes to 43.24% of the total rice production in the country (BBS, 2008). Rice is intensively cultivated in Bangladesh covering about 80% of arable land. Rice alone constitutes 95% of the food grain production in Bangladesh. Unfortunately, the yield of rice is low 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 (1991) views that integrated use of organic manure and chemical fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining better soil fertility. The long-term research at BARI revealed that the application of cowdung @ 5 t/ha/year improved rice productivity as well as prevented the soil resources from degradation (Bhuiyan, 1994). Poultry manure is another good source of nutrients in soil. Meelu and Singh (1991) showed that 4 t/ha poultry manure along with 60 kg N/ha as urea produce grain yield of crop similar to that with 120 kg N/ha as urea alone.

Organic manure can supply a good amount of plant nutrients thus can contribute to crop yields. Thus, it is necessary to use 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 (Islam *et al.*, 1994). In Bangladesh, most of the cultivated soils have less then 1.5% organic matter while a good agricultural soil should contain at least 2% organic matter. Moreover, this important component of soil is declining with time due to intensive cropping and use of higher dose of chemical fertilizers with little or no addition of organic manure in the farmer's field. In addition, rapid mineralization of soil organic matter occurs due to humid tropic climatic conditions of Bangladesh. Cycling of organic matter in soil is a pre–requisite for efficient cycling of nutrients. Unless due attention is paid to the improvement and maintenance of soil organic matter it may not be possible 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. Considering the present situation the present study was undertaken with the following objectives:

i. To develop a suitable integrated doses of inorganic fertilizers and organic manures for Boro rice.
ii. To evaluate the effects of different levels of inorganic fertilizers and organic manures on the yield, yield components and quality of Boro rice.
iii. To investigate any improvement in soil fertility due to the use of organic manure in combination with chemical fertilizers.

CHAPTER 2

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Soil organic manure and inorganic fertilizer is the essential factor for sustainable soil fertility and crop productivity because is the store house of plant nutrients. Sole and combined use of cowdung, poultry manure, vermicompost, and inorganic fertilizer acts as a source of essential plant nutrients. Experimental evidences in the use of cowdung, 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 cowdung, poultry manure & vermicompost manure and their combined application. Some literature related to the "Effect of level of various organic manure and inorganic fertilizer on the yield and yield attributes *boro* rice cv. BRRI dhan29" are reviewed below-

2.1 Effect on organic manure on the yield of rice

Organic matter is considered as the life of the soil and is the store house of plant nutrients. Organic matter is the principle source of NPKS and other nutrient elements, increases the soil buffering capacity, protect soil erosion and maintain healthy community of soil organisms.

2.1.1 Effect of farmyard manure (cowdung) on yield of rice

Rajput and Warsi (1991) conducted a field experiment and reported that rice yield was increased to 34.44 kg/ha with the application at FYM of 10 t/ha. Indulker and Malewar (1991) stated that application of 10 t/ha FYM alone produced grain yield of 2.19 t/ha and the untreated control gave 2.06 t/ha. Sharma and Mitra (1991) reported a significant increase in N, P and K uptake and also the nutritional status of soil with 5 t/ha of FYM of rice based cropping system.

Gurung and Sherchan (1993) reported that the application of cowdung with chemical fertilizers produced significantly higher grain yield than that of chemical fertilizers alone.

Kant and Kumar (1994) reported that the increasing rates of amendments with FYM increased the number of effective tillers per hill significantly, number of grain/panicle, weight of 1000 grains also increased over the control. At the maximum level of FYM (30 t/ha) the increase of 48% tillers/hill, 14% number of grain per panicle and 4.5% weight of 1000 grains over the control were recorded. They also reported that higher rate of FYM (30 t/ha) resulted 22% increase in grain yield over the untreated plots.

Thakur and Patel (1998) conducted field experiments during *kharif* season of 1993 and 1994 to study the effect of split application of 60 or 80 kg N/ha on growth, yield and nitrogen uptake by rice with and without 5 t FYM/ha and proposed that both N rates increased yields attributes, yield, plant N content and N uptakes of rice compared with N or application of FYM alone. N rates and use of split doses had no effect. The highest grain yield (3.84 t/ha) was recorded with the application of 80 kg N/ha in three split doses with 5 t/ha FYM during both the years, 60 kg N in three split doses with 5 t/ha FYM gave seed grain 3.85 t/ha.

A field experiment was conducted by Gupta *et al.* (1999) on clay loam soil in 1993 in Jummu and Kasmir using rice cv. PC-19 as test crop with 0-100 kg P_2O_5/ha and 0 or 10 t FYM. The crop also received a basal dressing of N, K and Zn. Grain yield was highest with 100 kg P_2O_5 + FYM (5.20 t/ha).

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

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

2.1.2 Effect of poultry manure on the yield of rice

Singh *et al*. (1987) found from a field trial in a loamy sand soil where poultry manure was applied as a N source for wet land rice cv. PR106, 0, 60, 120, 180 kg N/ha as urea in equal split applications 7, 21 and 42 days after transplanting and as poultry manure at 60, 120, and 180 kg N/ha produced the rice grain yields equivalent to those with 37, 96 and 168 kg N/ha as urea, respectively. On basis of N uptake, poultry manure N was 80% as efficient as urea N at all of application.

Maskina *et al*. (1986) studied the response of wet land rice to N application in a loamy sand soil amended with cattle manure (60 kg N/ha) and poultry manure (80 kg N/ha). In absence of urea, poultry manure increased the rice grain yield by 98% which was 2.6 times higher than cattle manure 93.7%. Urea equivalents to cattle and poultry manures varied from 21 to 53 and 50 to 123 kg N/ha, respectively. Apparent recovery in the crop of N from poultry manure ranged from 38% to 82% compared with 51 to 69% from urea and 20 to 25% from cattle manure and pig manure. Besides chemical fertilizers, another good source of nutrients is soils. Experiments on the agronomic efficiency of poultry manure that 4 t/ha poultry manure along with 60 kg N/ha as urea produced grain yield of rice similar to that with 120 kg N/ha on urea alone.

Budhar *et al*. (1991) studied the effect of farm waste low land rice. They found that grain yield of IR 60 was the highest with application of poultry manure (6.63 t/ha) followed by *Sesbania rostrata* (6.64 t/ha) and the lowest with no manure application (5.17 t/ha). They also found that the plant height was significantly influenced by the basal incorporation of farm waste.

Govindasamy et al. (1994) reported that the use of poultry litter was more economical at high target yield of rice that at low target yields and it was more economic in use of fresh litter than composted litter.

Jeong *et al*. (1996) studied the effect of organic matter application in rice growth and grain quality. They reported that 5 ton fermented chicken manure/ha in rice field increases N content in plants. Gupta (1995) conducted field trials on different organic manure in India and reported that the application of the pig manure (10 t /ha) produced the highest grain yield (4.5 t/ha) followed by poultry manure and FYM which produced yield of 4.1 and 3.9 t/ha of rice grain, respectively. The increase of rice yield with organic manure was 34 to 55% higher over control and 5 to 22% higher over NPK fertilizer.

Xu *et al.* (1997) observed that application of organic matter affected soil pH value as well as nutrient level. They also observed that pig manure was high influencing soil methane production when was followed by chicken manure. Cattle manure was the least in influencing were not significant in influencing soil methane production.

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.

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

2.1.3 Effect of compost on the yield of rice

Anzai *et al.* (1989) found out the effect of successive application of rice straw compost on the growth and yield of rice with low and high soil nitrogen levels, respectively. The growth rice in the soil supplemented with rice straw compost was retarded initially and restored after the panicle formation stage. The yield was lower than that in the soil supplied with chemical fertilizer due to decrease in the percentage of ripened grains. Successive applications of 30 ton compost/ha produced more number of grain m^{-2} but a lower percentage of ripened grains and yield than that where chemical fertilizer was applied. The growth and yield of paddy rice in the soil to which rice straw ash was applied were almost equal to those obtained with chemical fertilizer.

Organic matter content of particular soil is an indicator of its productivity. It helps binding the soil particles into aggregates thereby improving drainage and reducing erosion, reduce leaching loss of nutrients through enhanced action exchanged activity, increase water holding capacity, support the activities of micro organisms, increase the benefits from chemical fertilizer and promote the production of beneficial plant hormones (BARC, 1997).

Vermicompost was tested in pot experiment for its ability to replace a proportion of the urea fertilizer applied to rice. Compared with N fertilizer alone, supplying one-third or one-quarter of N as vermi compost increased plant height, grain yield and yield components of rice (Rini and Srivastava, 1997).

A study in typical clayey rice soil (Aeric Albaquept) of Bangladesh was conducted by 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 organic 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 their in organic 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 composts and provider with additional fertilizer and showed consistently that the response of wheat rape to compost and fertilizer applied together was greater than responses to the individual additives, but only when very stable compost was used (>10 months processing). Experiments with 15_N labeled fertilizer showed that wheat was able to utilize the applied N more efficiently when cultivated in 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.

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.

2.2 Effect of Inorganic fertilizer on the yield of rice

2.2.1 Effect of nitrogen

Of the 16 essential nutrient elements nitrogen is the major and primary elements for the growth and development and better yield of crops. Plants response best to nitrogen compared to other nutrient elements. Urea has been found to be very effective nitrogenous fertilizers. Nitrogen is play pivotal role at yield and yield attributes of rice.

BRRI (1992) reported that both grain and straw yields of rice were increased significantly up to 80 kg N/ha. Application of nitrogen from 120 to 160 kg nitrogen/ha significantly reduced the yield which was assumed to be due to excessive vegetative growth follower by lodging after flowering.

Ahmed and Hossain (1992) observed that plant height of wheat were 7939, 82.3 and 84.4 cm with 45, 90 and 135 kg N/ha, respectively. Plant height increased with increasing nitrogen doses. Chandra *et al.* (1992) carried out an experiment during 1979-1980 at varanasi, Uttar Pradesh (India) and reported that plant height and dry matter increased with increasing the rate of N up to 120 kg/ha. Further increment of 3 kg N/ha decreased this parameter.

Awasthi and Bhan (1993) reported that increasing levels of nitrogen up to 60 kg/ha influenced LAI and dry matter production of rice. Patel and Upadhaya (1993) found that plant height of rice increased significantly with increasing rate of N up to 150 kg/ha.

Kumar *et al.* (1995) observed a field experiment with four levels of nitrogen (0, 60, 120 and 180 kg N/ha) and reported that productive tillers increased significantly with the increase of N doses from 0-120 kg N/ha, but differences in productive tillers between 120 and 180 kg N/ha were not significant.

Effective tillers/m^2 responded significantly to the application of N fertilizer (Behera, 1995). Effective tillers increased significantly with increase the level of N fertilizer up to 80 kg N/ha. Patel and Upadhyay (1993) conducted an experiment with 3 levels of N (90, 120 and 150 kg/ha) and reported that total and effective tillers m^{-2} increased significantly with increasing rates of N up to 120 kg/ha.

Andrade and Amorim (1996) observed that increasing level of applied N increased plant height, panicle/m^2, grains/panicle and grain yield significantly. Palm *et al.* (1996) conducted a field trial at Waraseoni in the 1989-90 rainy season and observed that yield of rice cv. R. 269 was the highest (4.47 t/ha) when 100 kg N/ha was applied 30% basally, 40% at tillering and 30% at panicle initiation stage.

Khanda and Dixit (1996) reported that the increased levels of applied nitrogen significantly influenced the grain yields. They found that maximum grain and straw yields of 4.58 and 6.21 t/ha were obtained from 90 kg N/ha, respectively. Adhikary and Rahman (1996) reported that rice grain yield/ha in various treatments of N showed significant effect. The highest yield was obtained from 100 kg N/ha (4.52 t/ha) followed by 120 kg N/ha (4.46 t/ha) and 80 kg N/ha (4.40 t/ha).

Verma and Achraya (1996) observed that LAI increased significantly at maximum tillering and flowering stages with increasing levels of nitrogen. BINA (1996) stated that the effect of different levels of nitrogen was significant only for number of tillers/hill, effective tillers/hill, straw yield and crop duration. The highest number of total and productive tillers/hill was obtained from the highest level (120 kg/ha) of N application.

Dwibvedi, (1997) noticed that application of nitrogen significantly increased in growth, yield and yield components, grain yield, straw yield as well as harvest index with 60 kg N/ha. BRRI, (1997) reported during *boro* and transplant *aman* to determined rice seed yield. The experiment was laid out with four nitrogen levels 0, 50, 100 and 150 kg/ha and noted that seed yield increased gradually with the gradual increase of nitrogen.

Islam and Bhuiya (1997) studied the effect of nitrogen and phosphorus on the growth, yield and nutrient uptake of deep-water rice. They observed that nitrogen and phosphorus fertilization significantly increased the number of fertile tiller/m^2 and also that of grains/panicle, which in turn resulted in significant increase in grain yield. The application of 60 kg N/ha alone gave 22% yield benefit over control.

Singh *et al.* (1998) studied the performance of three hybrids KHR 1, Pro Agro 103 and MGR 1 using Jaya and Rasi as standard checks at four levels of N (0, 60, 120, and 180 kg/ha). They observed that the varieties responded linearly to the applied N level up to 120 kg/ha.

Kumar and Sharma (1999) conducted a field experiment with 4 levels of nitrogen (0, 40, 80 and 120 kg N/ha) and observed that dry matter accumulation in rice increased from 0-40 kg N/ha at 40 DAS, 0-120 kg N/ha at 60 DAS, 0-80 kg/ha at 80 DAS. Nitrogen application also hastened the growth and resulted in higher percentage of total dry matter accumulation in early stage of crop growth.

Bellido *et al.* (2000) evaluate a field experiment with 4 levels of nitrogen (0, 50, 100 and 150 kg N/ha) and reported that the amount of total dry matter was significantly greater at the N fertilizer rates of 100 and 150 kg nitrogen/ha.

BRRI, (2000) reported that the grain yield was linearly increased with increasing nitrogen rates. Chopra and Chopra (2000) cited that seed yield increased linearly up to 80 kg N/ha. Castro and Sarker (2000) conducted field experiment to see the effects of N applications as basal (80, 60, and 45kg N/ha) and top dressing (10, 30 and 45 kg/ha) on the yield and yield components of Japonica rice and obtained high effective tiller, percentage of ripened grains and high grain yields from 45 kg N/ha (basal) and 45 kg N/ha (top dressing). Singh *et al.* (2000) stated that each increment dose of N significantly increased grain and straw yields of rice over its preceding dose. Consequently the crop fertilized with 100 kg N/ha gave maximum grain yield (2647 kg/ha).

Pully *et al*. (2000) observed that increased yield associated with application of nitrogen stage, although booting stage nitrogen application had no effect or shoot growth or nitrogen uptake. These preliminary results suggested a single application of nitrogen is sufficient to maintain healthy rice growth, alleviating the need for additional N application after flooding. Rice may be responded to N applied as late as booting, but only when the rice is N limited and not severely N stressed.

Singh *et al.* (2000) claimed each incremental dose of nitrogen gave significantly higher straw yield. Geethdevi *et al*. (2000) found that 120 kg N/ha in the form of urea, 50% nitrogen was applied in four splits resulted in higher number of tillers, filled grains/panicle and higher grain weight/hill. Bayan and Kandasamy (2002) noticed that the application of recommended doses of nitrogen in four splits at 10 days after sowing active tillering, panicle initiation and at heading stages recorded significantly lower dry weight of weeds and increased crop growth viz. effective tillers/m^2.

Munnujan *et al*. (2001) treated 4 levels of nitrogen fertilizer (0, 40, 80, and 160 kg/ha) application at three levels each planting density (20, 40 and 80 hill/m) and conducted that the highest grain yield (3.8 t/ha) was obtained with 180 kg N/ha, which was similar to the yield obtained at 80 kg N/ha (3.81 t/ha).

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.

Slaton *et al.* (2001) showed that the highest yield was obtained lower N-rates when applied in a single pre-flood (SPF) application but with intermediate and high nitrogen rates when applied in splits application. The total number of kernels/panicle, Lodging and harvest grain moisture generally increased with higher nitrogen rates. Total milled rice percentage was very affected by N rates or method of application in this trial.

Angayarkanni and Ravichandran (2001) conducted a field experiment in Tamil Nadu, India from July to October 1997 to determine the best split application of 150 kg N/ha for rice cv. IR20.They found that applying 16.66% of the recommended N as basal, followed by 33.33% N at 10 DAT, 25% N at 20 DAT and 25% N at 40 DAT recorded the highest grain (6189.4 kg/ha) and straw (8649.6 kg/ha) yields, response ratio (23.40) and agronomic efficiency (41.26).

Duhan and Singh (2002) reported that the rice yield and uptake of nutrients increased significantly with increasing N levels. Moreover, the application along with various green manures (GM) showed additive effect on the yield and uptake of micronutrients. Under all GM treatments, the yield and uptake were always higher with 120 kg/ha than with lower level of nitrogen.

Mondal and Swamy (2003) found that application of N (120 kg/ha) as urea in equal splits during transplanting, tillering, panicle initiation and flowering resulted in the highest number of panicle, number of grains/panicle, 1000-grain weight, straw yield and harvest index. Shrirame *et al.* (2000) conducted an experiment during the kharif 1996 in Nagpur, Maharastra, India on rice cv. TNRH-10, TNRH-13 and TNRH-18 were grown at 1, 2, and 3 seedlings/hill one seedling/hill showed significantly higher harvest index.

2.2.2 Effect of Phosphorus

Hassan *et al.* (1993) carried out an experiment and observed the yield response of Basmati 385 rice to 0, 33, 66 and 99 kg/ha P. All treatments received 128-62-4.2 kg NKZn/ha. They observed that yield increased significantly up to 33 kg P/ha for all soil P test values, but significant response to the next higher dose was observed only when test values were less than or equal to 11 mg P/kg.

Subba *et al.* (1995) reported that phosphorus applied @50 mg P/kg soil as SSP increased the grain and straw yields significantly.

Ghosal *et al.* (1998) conducted a field experiment in Bihar on rice cv. Pankaj with 10–40 kg P/ha as triple super phosphate (TSP), highly reactive Morocco Rock Phosphate (HRMRP), Florida Rock Phosphate (FRP) and stated that yield increased with increasing P rates of four sources. They further proposed that grain yield was the highest with TSP followed by PAPR, HRMRP and FRP.

Sarkunan *et al.* (1998) conducted a pot experiment to find out the effect of P and S on yield of rice under flooded condition, on a P and S deficient sandy loam soil. They found increased yield with increasing level of P from 16.9 to 42.5 g/pot. Sulphur addition at 25 mg/kg resulted in 9% increase in grain yield. The treatment combination of 100 mg P and 10 mg S/kg soil gave significantly higher grain yield than other treatments.

Sahrawat *et al.* (2001) conducted a field experiment for six years (1993-1998) to determine the response of four promising upland rice cultivars with 0, 45, 90, 135, and 180 kg/ha as triple super phosphate (TSP). Only once used in 1993 and its residual value in 1994, 1995, 1996 and 1998 stated that grain yields of the rice cultivars were significantly increased by fertilizer P in 1993 and by the fertilizer P residues in the subsequent years although the magnitude of response decreased rapidly with time since the fertilizer was not applied.

2.2.3 Effect of Potassium

Haque (1992) worked with rice cv. BR 11 during August – December of 1988 without fertilizers, one with NPKS and Zn, fertilizers and one with each individual nutrient missing and proposed that grain yield ranged from 2.27 t/ha without fertilizers to 4.59 t/ha with all nutrients.

Prasad (1993) conducted a field experiment in Bihar, India and state that all crops responded significantly to K application in a K deficient calcareous soil. The magnitude of the response was higher in kharif crops particularly rice, groundnut and ragi (*Eleusine coracana*) than in *rabi* crops. Potassium uptake increased with increasing levels of potash application. Potassium uptake by different cropping sequence was in order: rice–wheat (221 kg/ha), sorghum–mustard (205 kg/ha), groundnut-oats (204 kg/ha) and ragi-lentil (181 kg/ha), respectively.

Chowdhury *et al.* (1994) conducted field experiment during dry and wet seasons with cv. BR 3 and BR 11 and observed that application of N, P, K and S from urea, TSP, MP and Gypsum, respectively gave similar grain yields of 5.6-5.7 t/ha in the wet season. Saleque *et al.* (1998) conducted six on farm trials on K deficient Barind soil of Bangladesh to evaluate the response of rice to K fertilizers and observed that application of 30 kg K/ha significantly increased grain yield at all the test locations. Potassium application increased K content only in the straw but not the grain.

Channadasppa *et al.* (1998) reported from a field experiment in 1993-1994 in Karnataka with rice cv. IR 64 that the split application of P and K did not significantly affect grain yield.

2.2.4 Effect of Sulphur

Rashid *et al.* (1992) reported that elemental S, produced rice yield o f 18, 9.2 and 5.8% more when applied at transplanting, 15 or 30 days after transplanting, respectively. The plots treated with gypsum gave significantly higher yields than those treated with pyrite followed by pressmud and farmyard manure. Islam and Hossain (1993) reported that the application of 20 kg S/ha with NPK significantly increased the grain yield of BR11 rice.

Hoque and Jahiruddin (1994) studied the effect of single and multiple applications of S and Zn in a continuous rice cropping system and noted that crop yields were increased by S (20 kg/ha as gypsum) and not generally by Zn. They also observed that although added gypsum had residual effect up to 3rd crop application in every crop produced comparatively higher grain yield of rice.

Akther *et al.* (1994) carried out field experiments on silty and sandy loam soils of farmer's field at four sites in Bangladesh. At one site S application increased grain yields and another site of S application decreased grain yields. There was no yield response to Zn application. At one site, 50 kg S + 5kg Zn/ha gave the highest grain yield (5.98 t/ha) compared to control yield of (4.61 t/ha) while at another site 25 kg S +10 kg Zn decreased grain yield.

Chowdhury *et al.* (1996) stated that application of Zn single or in combination with S increased the straw and grain yields of rice. They further reported the highest yield showing 33.6% increased over control which was obtained from the treatments, $Zn_{12}S_{45}$, Zn_8S_{45} and $Zn_{12}S_{30}$. Straw yield ranges from 5.1 t/ha in Zn_0S_0 treatment to 6.6 t/ha in $Zn_{12}S_{45}$ treatment.

Vaiyapuri and Sriramachandrasekharan (2001) conducted an experiment on integrated use of green manure (12.5 t/ha) with graded level of sulphur (0, 20, and 40 kg/ha) applied through three different sources in rice cv. ADT 37. They reported that the highest rice yield (5.3 t/ha) was obtained when green manure was applied along with pyrite 20 kg S/ha, which was comparable with pyrite applied at 40 kg/ha in the absence of green manure.

Peng *et al.* (2002) conducted a field experiment where one hundred and sixteen soil samples were collected from cultivated soils in Southeast Fujian, China. Field experiment showed that there was a different yield increasing efficiency by applying S at the doses of 20 - 60 kg/ha to of rice plant. The increasing rate of rice was 2.9-15.5%.

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.

2.3. Combined effect of organic manure and inorganic fertilizer on the yield of rice

2.3.1 Combined effect of nitrogen fertilizer and poultry manure

Maskina *et al.* (1986) observed that 120 kg N/ha was significantly superior to 60 kg N/ha in terms of dry matter, plant height and seedling quality for rice. Addition of poultry manure, azolla and FYM improved the quality of seedling by 54, 21 and 10%, respectively compared with N alone and the use of healthy seedlings improved yield significantly.

Govindasamy *et al.* (1994) reported that the use of poultry litter was more economical at high target yields of rice than at low target yields and it was more economic on use of fresh litter than compost.

Bijay *et al.* (1996) reported that in a field trial in 1987-1989 in Ludhiana, Punjab, India, irrigated rice cv. PR106 was given 60, 120 or 180 kg N/ha/year as poultry manure, urea or poultry manure + urea. In the first year, poultry manure did not perform better than urea but by the third year, 120 and 180 kg N/ha as poultry manure produced significantly higher grain yield of rice during three years while the yield decreased with urea. Apparent N recovery by rice decreased from 45 to 18% from 1987 to 1989 in the case of urea, but it remained almost the same (35, 33 and 37%) for poultry manure. Thus urea N values of poultry manure calculated from yield or N uptake data following two different applications averaged 80, 112 and 127% in 1987, 1988 and 1989, respectively. Poultry manure and urea applied in a 1:1 ratio basis produced yields in between the yields from the two sources applied alone.

Singh and Vinodumar (1996) measured a field experiment in India where irrigated rice was given 60, 120 or 180 kg N/ha/year as poultry manure or poultry manure + urea. In the first year, poultry manure did not perform better than urea but in the third year, 120 kg and 150 kg N as poultry manure produced significantly higher grain yields than the same rates of urea. Poultry manure sustained the grain of rice during the three years while the yield decreased with urea.

Sengar *et al.* (2000) stated that the application of chemical fertilizer in combination with manures sustained or improved the fertility status of the soil. They evaluated the efficiency of different fertilizer in rainfed lowlands at the Zonal Agricultural Research Station, Jagdalpur, Madhya Pradesh, India and found that the application of N fertilizer and manures significantly increased the yield compared with the control.

Singh *et al.* (2000) studied a field trial in loamy sand soil where poultry manure was applied as an N source for wet land rice @ 0, 60, 120 and 180 kg N/ha as urea. On the basis of N uptake, poultry manure N was 80% as efficient as urea at all rates of application.

Rajni Rani *et al.* (2001) observed a pot experiment a glasshouse of Varanasi, Uttar Pradesh, India during kharif season to assess the response of rice to different treatment combinations of vermicompost (CV), poultry manure (PM) and nitrogen fertilizers. Results showed that all integrated treatments significantly increased plant height, number of effective panicles per pot and dry weight/panicle over the treatment heaving full N dose (T_1) through urea. Grain yield ranged from 6.5-20.0 g/pot among the combinations tried but T_2 was the most effective treatment for having the highest grain yield. They further proposed that agronomical efficiency was higher in case of integrated treatments than using fertilizer alone. Finally they concluded that the combined application of 2/3 N through fertilizer + 1/3 N through manure has a greater potential management for rice crops.

Channabasavanna *et al.* (2001b) observed that grain yield increased with each treatment of poultry manure application and was maximum in 3 ton poultry manure/ha which was 26 and 19% higher than that of control during 1998 and 1999, respectively and they significantly increased up to 2 ton poultry manure/ha.

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.

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.

Reddy *et al.* (2004) observed a field study for two years (2001 and 2002) on the farmers fields in Kolar district (eastern dry zone, Karnataka, India) to study the effect of different organic manures on growth and yield of paddy under tank irrigation. Poultry manure and sewage sludge produced better growth components, viz., plant height, number of tillers/hill, total dry matter/plant and yield components like number of panicle/hill and panicle length.

2.4 Combined effect of nitrogen and mixed organic fertilizer on the yield of rice

Liang-Yunjiang *et al.* (1999) observed that a mathematical model which analyzed the effect of application of organic and inorganic fertilizer on yields of rice growing on paddy soils was established. The model was used to study the effect of various factors on yields and to produce a strategy for optimization of management for high rice yields.

Yamagata (2000) was conducted a field experiment to determined the growth response of upland rice (*Oryza sativa* L.) and maize (*Zea mays*) to organic nitrogen by amending the soil with an inorganic N source (ammonium sulfate) and with an organic N source. N uptake was highest under the RBS treatment, but the inorganic N concentration in soil was lower when organic and inorganic N was applied together as compared to inorganic N alone. Upland rice also took up more N than maize in a pot experiment with RBS without differences in root spread. A study was also conducted to determined the N uptake mechanism of upland rice by determining the protease activity in pot soils of the crops and measuring 15 N abundance in pot trails with 15 N-labelled RBS. Results show the possibility of different protein uptake by upland rice which is attributed to the high response of upland rice to organic N fertilizer, since N in protein form was taken up resulting in less competition for soil N by microorganisms.

Do Thi Thanh Ren *et al.* (2004) was found that in order to improve the yield of rice cultivated on acid soil, 2 field experiments and 1 pot experiment were conducted continuously for 5 and 2 crops, respectively (1197-2000), in Tri Ton district. An Giang province Soil for the pot experiment was taken from the 2 field experiment to study the residual effect on nitrogen availability. Both organic and inorganic nitrogen had a positive effect on the rice yield. Compared with the treatments being fertilized at the same doses of N, a significantly higher yield was obtained in the treatment of mixed organic N fertilizer and manure. The effect was found only in the first crop. From the second crop onward rice yield were not different among treatments (mixed fertilizers, inorganic N fertilizer and manure only). Manure only treatment resulted in rice yield equal to the treatment with 120 kg N/ha in the form of urea. Supplying N in both organic and inorganic forms over several resulted in an accumulation of nitrogen in the soil, which became available for rice grown.

2.5 Combined effect of nitrogen and compost fertilizer on the yield of rice

Miyazaki *et al.* (1986) found a field experiment with 0-30 t compost/ha + 0 or 80 kg N/ha for rice growing on a wet Andosol. Application of 10 and 30 t compost/ha increased soil ammonium N in the plough layer by 1 and 3 mg/100 g dry soil, respectively. Compost application increased soil N content, 60% of compost N remained in the soil and 50% of the N released by decomposition was taken up by the rice plants. Increased N uptake increased total DM yield and spikelet number. In cooler year, however, the percentage of ripened grains was lower with heavy application of compost than in warm years. Compost @ 20 t/ha gave a relatively stable high rice yield.

The effect of soil fertility and crop performance of different organic fertilizers (rice straw, farm yard, water hyacinth compost and tank silt) at different rates and in combination with N fertilizer was studied (Sharma and Mittra, 1991). Increasing the rates of FYM and water hyacinth compost application up to 15 t/ha increased rice yield but increasing the rate of rice straw beyond 5 t/ha did not.

Singh and Singh (2000) reported that the effect of sewage sludge-based compost in the growth attributes and yield of rice during 1997, in Allhabad, Uttar Pradesh, India. The treatment were control, Jamuna compost at 2520 g/ha + urea at 986.60 g/ha, Jamuna compost at 5040 g/ha + urea at 657.33 g/ha , Jamuna compost at 7560 g/ha + urea at 328.60 g/ha, Jamuna compost at10083 g/ha + urea at 1315 g/ha. All the treatment equally received P and 2268.75 g/ha and potash at 403.33 g/ha. The plant height was highest at 100% urea application compared to 76.7 cm in Jamuna compost at 105 days after sowing. Similar effect was observed in the number of tillers m^{-2} row length. The fresh and dry weight at rice samples from 100% urea application was 102.8 g and 22.1 g, respectively, in sludge-based jamuna compost at 75 DAS. The highest grain yield of 44.58 q/ha was observed in 100% urea application, and it was the least in Jamuna compost (13.74 q/ha). However, application of Jamuna compost, alone with urea at 25 and 50%, showed and increase in growth and yield parameters of rice, which was on par with 100% urea application.

Zhang *et al*. (1996) measured various crop response to a mixed municipal solid waste (refuse) bio-solids co-compost (named Nutrin plus) and examined the fate of certain metals associated with Nutri plus compost. There were six treatments cheek, 50, 100 and 200 t compost/ha, NPKS (75 kg N/ha, 20 kg P/ha, 45 kg K/ha,and 18 kg S/ha), PK (2 kg P, 45 kg K/ha), and three crops: rape, wheat and bearly. The research results showed that the compost slightly increased heavy metal concentrations in the soil but did not cause any phytotoxicity to crops. Yield from 100 and 200 t/ha application was higher with compost than with NPKS treatment. However, the yield of 50 t/ha compost application was similar to that of NPKS treatment. The compost apparently was more beneficial in the year of application. The results suggest that Nutri plus compost application generated positive yield response in all three crops. Crop yield increased as the application rate increased.

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.

Aal *et al.* (2003) measured then usefulness of supplementing different organic materials viz., water hyacinth compost (HC), town refuse compost (TR) to minimize consuming chemical fertilizers. The results showed that the application of organic materials either alone in combination with chemical fertilizer caused a substantial increase in total N, available P, K and micronutrients (Fe, Mn, Cu, Zn) as well as wheat yield (straw and grain). The importance of organic farming practices in desert sandy soils was emphasized to minimize chemical fertilizer consumption and to avoid environmental pollution.

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.

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.

2.6 Combined effects of organic manure and chemical fertilizers on rice

The concept of integrated nutrient management is the continuous improvement of soil productivity through appropriate use of fertilizers and organic manure including green manure. Considerable work has been done in India, China, Thailand, Philippines and other countries of the world with respect to the use of green manure (GM), poultry manure (PM) and farmyard manure (FYM) as alternative or supplementary sources of nutrients. In Bangladesh, only limited attempts have been made in this perspective.

Maskina *et al.* (1986) studied the effect of N application on wetland rice in a loamy sand soil amended with cattle manure (60 kg N/ha) or PM (80 kg N/ha). The absence of urea N: PM increases the rice grain yield by 98%, which was 2.6 times higher than cattle manure (37%). Rice yield increased linearly with N rates whether or not the soil was amended with organic manure. Urea N equivalent to cattle and PM varied from 21 to 53 kg/ha and 50 to 123 kg/ha respectively. Apparent recovery of N from poultry manure ranged from 38 to 82% compared with 51 to 69% from urea and 20 to 25% from cattle manure and pig manure.

Maskina *et al.* (1986) conducted an experiment with different organic manure as a nitrogen source in rice wheat rotation. They observed that yield with poultry manure and 80 kg urea N/ha were high as those were with 160 kg urea N/ha alone. Yield with farmyard manure or pig manure and 80 kg fertilizers N/ha were equal to 120 kg N/ha fertilizer alone. They also reported that application of any one of the manure added to rice had residual effect equivalent to 30 kg N and 11 kg/ha in wheat.Besides chemical fertilizers, organic manure like poultry manure is another good source of nutrient of soil. Experiments on the use and agronomic efficiency of poultry manure showed that 4 t/ha poultry manure along with 60 kg N/ha as urea produced grain yield of rice similar to that with 120 kg N/ha as urea alone (Meelu and Singh. 1991).

Ali (1994) carried out several experiments on integrated nutrient management at different places of Bangladesh. They reported that when Boro rice received total chemical fertilizers followed by Aman rice receiving the same, the combined yield increase over the control was 96 and 86% for grain and straw, respectively. But these figures were 125 and 102% when Boro rice crop was fertilized with 100% chemical fertilizers + 5 t FYM/ha followed by Aman rice with only 100% chemical fertilizer.

Miah (1994) stated that only the first crop following the application recovered one-fifth to one-half of the nutrient supplied by animal manure, reminder was held as humus to very slow decomposition, 2.4% element being released per annum. Islam (1995) found a significant yield increase with fertilizers with cowdung compared to fertilizer-N alone in T. Aman rice. In the following rice, the yields with fertilizer-N + residual of cowdung were higher than fertilizer-N alone. Flynn *et al.* (1995) studied the residual effect of broiler litter as a supplemental of mineral N and concluded that broiler litter applied in autumn at the rate of 9 t/ha reduced the mineral N from 44 kg to 22 kg/ha.

Gupta (1995) conducted field trial on different organic manure in India and reported that the application of field manure (10 t/ha) produced the highest grain yield (4.5 t/ha) followed by PM and FYM which produced yields of 4.1 and 3.9 t/ha of rice grain respectively. The increase in rice yield with organic manure was 34 to 55% higher over control and 5 to 22% higher over NPK fertilizers. Gupta *et al.* (1996) concluded that the rate of application of poultry manure could be reduced by 80 kg/ha of soil with the application of 1% poultry manure (PM). Organic C and available P contents of soil after harvest were increased with PM applications.

Singh *et al.* (1996) carried out a field experiment in India where irrigated rice was given 60, 80 or 120 kg N/ha per year as poultry manure, urea, poultry manure + urea respectively. In the first year, PM did not perform better than urea but in the fourth year, 120 g and 150 kg N as PM produced significantly higher grain yield than the same rate as urea. The PM help to sustain the grain yield of rice during the 3 years while the yield decreased with urea application.

Hossain *et al.* (1997) conducted a field experiment to evaluate the effect of integrated nutrient management on rice cropping in Old Brahmaputra Floodplain soil and found that the grain yield of BR 11 rice increased significantly due to the application of fertilizer alone or in combination with manures over control.

Devi *et al.* (1997) conducted a field trail (1987-93) to develop a system for integrated nutrient supply for a rice-rice cropping sequence. Application of 45:45:45 kg NPK/ha as mineral fertilizers and 45 kg N/ha as FYM in the kharif seasons followed by 90:45:45 kg mineral NPK/ha in the rabi seasons gave the highest yields in all years expect 1993. When application of half of the N in the *kharif* season or crop residues or green manure gave the highest yield.

Goshal *et al.* (1998) in an experiment with rice found increased grain and dry matter yield when inorganic N fertilizer (50 kg N/ha) was applied alone or when a combination of organic (10 t FYM/ha) and inorganic N fertilizer (25 kg N/ha) were applied as compared with organic sources (20 t FYM/ha) alone. Islam (1995) found a significant yield increased with fertilizer N + cowdung compared to fertilizer-N alone in T-Aman rice. In the following Boro rice yields with fertilizer-N + residual effect of cowdung were higher than the fertilizer N alone.

Mondal and Chettri (1998) conducted field experiment during 1991-93 in West Bengal, India to study integrated nutrient management for high productivity and fertility building under a rice based cropping system with application of S as ammonium sulfate along with green manure in suit and farmyard manure to rice only. The result showed maximum grain yields of rice (4.96 and 5.77 t/ha) in the wet and dry seasons, respectively.

Yadav (1998) conducted long-term fertilizer experiments on a rice-wheat cropping system at four locations in India. Long-term rice-wheat cropping system resulted in depletion of soil organic carbon and available N and P at two locations but increased in organic carbon, available N and K at the third location. The available P and K content of the soil also increased at the fourth location.

Singh *et al.* (1999) conducted field experiment during the rainy and winter seasons of 1990-91 to 1992-93 at Bari Bhag, Uttar Pradesh, India using recommended rates of N, P, K and Zn (120, 60, 40, 20 kg/ha) respectively, or 10 t/ha of FYM or rice straw 25 or 50% recommended rates (R.R) : N+RRP, K and Zn. Rice yield was the highest with FYM + S50 RRN, followed by the RRN, P, K and Zn.

Abedin Miah and Mosleahuddain (1999) conducted a long term fertility trail in Sonatala silt-loam soil at Bangladesh Agricultural University farm, Mymensingh to evaluate the effects of continued fertilization and manureing on soil properties and yield of crops. Grain yield of rice increased due to N, P, K and S application but the rate of increase varied in different seasons. Residual S showed remarkable decrease in the yield in Aman season. The yield of Aman showed a decreasing trend over the years but the yield of Aus remained almost static. The NPKSZn treatment maintained its superiority both in T-Aman and Aus rice although the performance of NFYM was very close to NPKSZn treatment. In general, the response of T-Aman to S containing treatments showed a decreasing trend over the years. The availability of P, S and Zn increased in soil due to long continued application. P fertilization also improved the micronutrient status of soil. No considerable changes in K status were noted due to K application. Nutrient balance study showed a severe loss of most of the nutrients through soil degradation.

Rahman (2001) reported that in rice-rice cropping pattern, the highest grain yield of Boro rice was recorded in the soil test basis (STB) N P K S Zn fertilizers treatment while in T. Aman rice the 75% or 100% of N P K S Zn (STB) fertilizers plus GM with or without cow dung gave the highest or a comparable yield. The mean yearly N, P, K, S and Zn uptake by rice (Boro + T. Aman) increased with increasing supply of nutrients. Application of cow dung along with N P K S Zn (STB) resulted in markedly higher uptake of nutrients in Boro rice. In T. Aman rice, application of NPKS (STB) with GM and / or CD showed higher N, P, K, S, Zn uptake than that of NPKS (FRG) and NPK (FP) treatments. The total N content and the available N, P, K, S, and Zn status in soils increased slightly due to manuring. The whole results suggested that the integrated use of fertilizers with manure (viz. *Sesbania*, cow dung) could be an efficient practice for ensuring higher crop yields without degradation of soil fertility.

Rajni Rani *et al.* (2001) conducted a pot experiment in a glass house of Varanasi, Utter Pradesh, India during *kharif* season to assess the response of rice to different combinations of vermicompost (VC), poultry manure (PM) and nitrogen fertilizers. Results showed that at integrated treatments significant increase in plant height, number of effective panicle over the treatment having full nitrogen dose through urea.

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

Organic materials are widely used to maintain soil fertility and improve soil properties in intensive cropping systems especially in traditional agriculture. Studies at IRRI showed that the total N, exch. K and available P in soil increased by green manuring. The application of FYM increased organic C, total N, available P, Exch. K and CEC than GM (IRRI, 1979). Application of NPK at 100-150% based on the initial soil test showed appreciable improvement in available soil N, P, and K. Organic C content was highest under FYM treatment. Depletion of P was highest under 100% treatment and K under 100% N and P treatment (Singh and Nambiar, 1984).

Bair (1990) stated that sustainable production of crop can not be maintained by using chemical fertilizers only and similarly it is not possible to obtain higher crop yield by using organic manure alone. Sustainable crop production might be possible through the integrated use of organic manure and chemical fertilizers.

Prasad and Kerketta (1991) conducted an experiment to assess the soil fertility, crop production and nutrient removal under different cropping sequences in the presence of recommended doses of fertilizers and cultural practices along with 5 t/ha compost applied to the crops. There was an overall increase in organic C, increase in total N (83.9%), available N (69.9%), available P (117.3%) and CEC (37.7%).

Bhandari *et al.* (1992) reported that an application of fertilizers or their combined use with organic manure increased the organic C status of soil. The NPK fertilizers at 100% level and their combined use with organic N sources also increased the available N and P by 5.22 kg and 0.8-3.8 kg/ha from their initial values.

Meelu *et al.* (1992) reported that organic C and total N increased significantly when *sesbania* and *crotolaria* were applied in the preceded rice crop for two wet seasons. More (1994) reported from 3-years study that application of 25 t/ha FYM + 20 t/ha press mud decreased the soil pH and increased organic matter content and available N, P and K in soil. Medhi *et al.* (1996) reported that incorporation of organic and inorganic sources of N increased soil solution NH_4-N to a peak and then declined to very low levels.

Nahar *et al.* (1995) had examined the soil condition after one crop cycle (rice wheat). Addition of organic matter during the rice crop doubled the organic C content compared to its original status. Total and available N contents were also significantly improved by addition of organic matter, but had less impact on soil exchangeable cations.

Palm *et al.* (1996) stated that organic materials influence nutrient availability nutrients added through mineralization – immobilization pattern as an energy sources for microbial activities and as precursors to soil organic matter and by reducing P sorption of the soil.

Nimbiar (1997b) 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.

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 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 2007 to April 2008 to study the effect of various organic manure and inorganic fertilizer on the yield and quality 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 2007-2008. The morphological, physical and chemical characteristics of the soil are shown in the Table 1 and 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-February). The weather information regarding temperature, rainfall, relative humidity and sunshine hours prevailed at the experimental site during the cropping season December 2007 to April 2008 have been presented in Appendix I.

Table 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 Terrace.
Topography	Fairly level
Drainage	Well drained
Flood level	Above flood level

(FAO and UNDP, 1988)

Table 2. Initial physical and chemical characteristics of the soil

Characteristics	Value
Mechanical fractions:	
% Sand (2.0-0.02 mm)	22.26
% Silt (0.02-0.002 mm)	56.72
% Clay (<0.002 mm)	20.75
Textural class	Silt Loam
Consistency	Granular and friable when dry.
pH (1: 2.5 soil- water)	5.8
CEC (cmol/kg)	17.9
Organic C (%)	0.686
Organic Matter (%)	1.187
Total N (%)	0.08
Exchangeable K (cmol/kg)	0.12
Available P (mg/kg)	19.85
Available S (mg/kg)	14.40

3.3 Planting material

BRRI dhan29 was used as the test crop in this experiment. This variety was developed at the Bangladesh Rice Research Institute 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 24 October, 2007 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 randomized complete block design (RCBD), where the experimental area was divided into four blocks representing the replications to reduce soil heterogenetic effects. Each block was divided into eight unit plots as treatments with raised bunds around. Thus the total number of unit plot size was 2 m × 2 m and ailes separated plots from each other. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively.

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

Three different types of organic manure (vermicompost, cowdung and poultry manure) were used in the study. The experiment consisted of 8 treatments. The treatments were be as follows:

T_0: Control

T_1: 100% $N_{100}P_{15}K_{45}S_{20}$ (Recommended dose)

T_2: 50% NPKS + 5 ton cowdung/ha

T_3: 70% NPKS + 3 ton cowdung/ha

T_4: 50% NPKS + 4 ton poultry manure/ha

T_5: 70% NPKS + 2.4 ton poultry manure/ha

T_6: 50% NPKS + 5 ton vermicompost/ha

T_7: 70% NPKS + 3 ton vermicompost/ha

3.8 Fertilizer application

The amounts of N, P, K and S fertilizers required per plot were calculated as per the treatments. Full amounts of TSP, MP and gypsum 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. cowdung, poultry manure and vermicompost were used. The rates of manure were 3 & 5, 2.4 & 4 and 3 & 5 ton/ha for cowdung, poultry manure and vermicompost per plot were calculated as per the treatments, respectively. Cowdung, 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. Chemical compositions of the cowdung, poultry manure and vermicompost (oven dry basis)

Sources of organic manure	Nutrient content					
	C (%)	N (%)	P (%)	K (%)	S (%)	C: N
Cowdung	36	1.48	0.29	0.75	0.21	24
Poultry manure	29	2.19	1.98	0.81	0.34	8
Vermicompost	48	2.99	0.28	1.65	0.32	15

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 dhan29 were carefully uprooted from the seedling nursery and transplanted on 12 January, 2008 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 24 April, 2008. The crop was cut at the ground level and plot wise crop was bundled separately and brought to the threshing floor.

3.14 Yield components

3.14.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 30, 50, 70, 90 days and 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.

3.14.2 Number of tillers/hill

The number of tillers/hill was recorded at the time of 30, 50, 70 and 90 days by counting total tillers. Data were recorded as the average of 10 hills selected at random from the inner rows of each plot.

3.14.3 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.

3.14.4 In-effective tiller/hill

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

3.14.5 Total tiller/hill

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

3.14.6 Length of panicle

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

3.14.7 Filled grain per panicle

The total numbers of filled grain was collected randomly from selected 10 plants of a plot on the basis of grain in the spikelet and then average numbers of filled grain per panicle was recorded.

3.14.8 Unfilled grain per panicle

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

3.14.9 Total grain per panicle

The total numbers of grain was collected randomly from selected 10 plants of a plot by adding filled and unfilled grain and then average numbers of grain per panicle was recorded.

3.14.10 Weight of 1000 seeds

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

3.14.11 Grain yield

Grains obtained from each unit plot were sun-dried and weighted carefully. The dry weight of grains of central 1 m^2 area and five sample plants were added to the respective unit plot yield to record the final grain yield/plot and finally converted to t ha^{-1}.

3.14.12 Straw yield

Straw obtained from each unit plot were sun-dried and weighted carefully. The dry weight of straw of central 1 m^2 area and five sample plants were added to the respective unit plot yield to record the final straw yield/plot and finally converted to t/ha.

3.14.13 Biological yield

Grain yield and straw yield together were regarded as biological yield. the biological yield was calculated with the following formula:

Biological yield = Grain yield + Straw yield.

3.14.14 Harvest index

Harvest index was calculated from the grain and straw yield of rice for each plot and expressed in percentage.

$$HI = \frac{\text{Economic yield (grain weight)}}{\text{Biological yield (Total dry weight)}}$$

3.15 Chemical analysis of plant samples

3.15.1 Collection of plant samples

Grain and straw samples were collected after threshing. The samples were finely ground by using a Wiley-Mill with stainless contact points to pass through a 60-mesh sieve. The samples were stored in plastic vial for analyses of N, P, K and S.

3.15.2 Preparation of plant samples

The plant samples were dried in an oven at 70 ^{0}C for 72 hours and then ground by a grinding machine to pass through a 20-mesh sieve. The grain and straw samples were analyzed for determination of N, P, K and S concentrations. The methods were as follows:

3.15.3 Digestion of plant samples with sulphuric acid for N

For the determination of nitrogen an amount of 0.2 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 5 ml conc. H_2SO_4 were added. The flasks were heated at 120^{0}C and added 2.5 ml 30% H_2O_2 then heated was continued at 180 ^{0}C until the digests became clear 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. 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.

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

A sub sample weighing 0.5 g was transferred into a dry, clean 100 ml digestion vessel. Ten ml of di-acid (HNO_3: $HClO_4$ in the ratio 2:1) mixture was added to the flask. After leaving for a while, the flasks were heated at a temperature slowly raised to 200^{0}C. Heating were stopped when the dense white fumes of $HClO_4$ 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.

3.15.5 Determination of P, K and S from plant samples

3.15.5.1 Phosphorus

Phosphorus was digested from the plant sample (grain and straw) with 0.5 M $NaHCO_3$ solutions, pH 8.5 (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 extract 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).

3.15.5.2 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 absorbance of sample were measured within the range of standard solutions. The absorbances were measured by atomic absorption flame photometer.

3.15.5.3 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 (Hunter, 1984).

3.16 Nutrient Uptake

After chemical analysis of straw and grain samples the nutrient contents were calculated and from the value of nutrient contents, nutrient uptakes were also calculated by following formula:

Nutrient uptake (Kg/ha) = Nutrient content (%) × Yield (kg/ha)/100

3.17 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.

3.18 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:

3.18.1 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.

3.18.2 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).

3.18.3 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 $K_2Cr_20_7$ in presence of conc. H_2SO_4 and conc. H_3PO_4 and to titrate the excess $K_2Cr_20_7$ solution with 1N $FeSO_4$. 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).

3.18.4 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 6 ml H_2SO_4 were added. The flasks were swirled and heated 200 ^{0}C and added 3 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 100 ml volumetric flask and the volume was made up to the mark with distilled water. A reagent blank was prepared in a similar manner. These digests were used for nitrogen determination (Page *et al.*, 1982).

Then 20 ml digest solution was transferred into the distillation flask, Then 10 ml of H_3BO_3 indicator solution was taken into a 250 ml conical flask which is marked to indicate a volume of 50 ml and placed the flask under the condenser outlet of the distillation apparatus so that the delivery end dipped in the acid. Add sufficient amount of 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:

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

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

3.18.5 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).

3.18.6 Exchangeable 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).

3.18.7 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.

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

CHAPTER 4

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

The experiment was conducted to determine the effect of various organic manure and inorganic fertilizer on the yield and yield contributing characters of boro rice. Data on different growth parameter and yield was recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix II-VI. The results have been presented and possible interpretations given under the following headings:

4.1 Yield contributing characters and yield of rice

4.1.1 Plant height

Statistically significant variation was recorded for plant height of BRRI dhan29 due to the application of various organic manure and inorganic fertilizer at 30, 50, 70, 90 DAT and at harvest (Appendix II). At the different days after transplanting (DAT) the highest plant height (24.18 cm, 31.34 cm, 44.67 cm, 67.05 cm and 89.00 cm) was recorded from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically similar (23.95 cm, 30.80 cm, 44.25 cm, 65.70 cm and 86.54 cm) with T_3 (70% NPKS + 3 ton cowdung/ha) at 30, 50, 70, 90 DAT and at harvest, respectively. On the other hand, at the same DAT the lowest plant height (16.20 cm, 20.65 cm, 32.58 cm, 49.10 cm and 64.59 cm) was observed from T_0 as control condition which was closely followed (19.70 cm, 24.88 cm, 39.85 cm, 58.20 cm and 76.23 cm) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 4). From the data it was revealed that all the treatments produced significantly taller plants compared to the control treatment. The combined application of fertilizers with manure increased the plant height compared to single application of recommended dose of fertilizers. Plant height was significantly influenced by the application of organic manure and chemical fertilizers reported by Babu *et al.* (2001) earlier from an experiment. Similar results also reported by Rajani Rani *et al.* (2001), Singh *et al.* (1999), Hossain *et al.* (1997) and Sharma and Mitra (1991) also observed similar results.

4.1.2 Number of total tillers per hill

Number of tillers per hill of BRRI dhan29 at growth stages showed statistically significant variation due to the application of various organic manure and inorganic fertilizer at 30, 50, 70 and 90 DAT (Appendix II). At the different days after transplanting (DAT) the maximum number of total tillers per hill (5.43, 11.64, 21.01and 17.90) was observed from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically identical (5.01, 11.09, 20.54 and 16.78) with T_3 (70% NPKS + 3 ton cowdung/ha) at 30, 50, 70 and 90 DAT, respectively (Table 4). Again at the same DAT the minimum number of total tillers per hill (2.51, 4.60, 10.29 and 7.26) was observed from T_0 as control condition which was closely followed (3.39, 7.30, 15.40 and 11.47) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 4). It was revealed that all the treatments produced significantly maximum number of tiller compared to the control treatment.

4.1.3 Number of effective tillers/hill

A statistically significant variation was recorded for number of effective tillers per hill of BRRI dhan29 due to the application of various organic manure and inorganic fertilizer (Appendix III). The maximum number of effective tillers per hill (13.52) was found from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically identical (13.23) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the minimum number of effective tillers per hill (6.07) was recorded from T_0 as control condition which was closely followed (9.20) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 5). BRRI dhan29 responded significantly better to chemical fertilizers when applied at the recommended doses than the manure when applied singly or combined application of 70% of manure and chemical fertilizers. Chander and Pandey (1996) reported a significant increase in effective tillers hill^{-1} due to application of higher doses of nitrogen.

4.1.4 Number of in-effective tillers/hill

Number of in-effective tillers per hill of BRRI dhan29 varied significantly due to the application of various organic manure and inorganic fertilizer (Appendix III). The maximum number of in-effective tillers per hill (4.32) was obtained from T_0 as

Table 4. Effect of various organic manure and inorganic fertilizer on plant height and number of total tiller per hill of boro rice BRRI dhan29

Treatment	Plant height (cm) at					Number of total tiller per hill at			
	30 DAT	50 DAT	70 DAT	90 DAT	at harvest	30 DAT	50 DAT	70 DAT	90 DAT
T_0	16.20 c	20.65 d	32.58 c	49.10 e	64.59 e	2.51 e	4.60 e	10.29 f	7.26 f
T_1	21.90 ab	29.17 ab	42.41 ab	62.42 bc	83.60 bc	4.13 c	9.59 bc	16.92 de	13.79 cd
T_2	21.20 ab	27.65 bc	42.00 ab	60.81 cd	80.90 c	3.95 c	8.81 cd	17.40 cd	13.09 de
T_3	23.95 a	30.80 ab	44.25 a	65.70 ab	86.54 ab	5.01 ab	11.09 ab	20.54 ab	16.78 ab
T_4	21.65 ab	29.58 ab	42.53 ab	64.58 abc	86.09 ab	4.66 b	9.69 bc	18.49 cd	15.12 bc
T_5	24.18 a	31.34 a	44.67 a	67.05 a	89.00 a	5.43 a	11.64 a	21.01 a	17.90 a
T_6	19.70 b	24.88 c	39.85 b	58.20 d	76.23 d	3.39 d	7.30 d	15.40 e	11.47 e
T_7	22.20 ab	29.17 ab	43.10 ab	65.00 ab	86.43ab	4.64 b	9.65 bc	19.01 bc	14.96 bcd
Significance level	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
$LSD_{(0.05)}$	2.723	3.037	3.097	3.773	3.580	0.458	1.565	1.695	1.834

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.01 level of probability

T_0: Control
T_1: 100% $N_{100}P_{15}K_{45}S_{20}$ (Recommended dose)
T_2: 50% NPKS + 5 ton cowdung/ha
T_3: 70% NPKS + 3 ton cowdung/ha
T_4: 50% NPKS + 4 ton poultry manure/ha
T_5: 70% NPKS + 2.4 ton poultry manure/ha
T_6: 50% NPKS + 5 ton vermicompost/ha
T_7: 70% NPKS + 3 ton vermicompost/ha

control condition which was statistically similar (4.12) by T_5 (70% NPKS + 2.4 ton poultry manure/ha) and T_3. On the other hand, the minimum number of in-effective tillers per hill (2.27) was found from T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 5).

4.1.5 Total tillers/hill

Statistically significant variation was recorded for number of total tillers per hill of BRRI dhan29 due to the application of various organic manure and inorganic fertilizer (Appendix III). The maximum number of total tillers per hill (17.65) was observed from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically identical (17.04) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the minimum (10.40) was obtained from T_0 (control condition) which was closely followed (11.47) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Figure 1).

4.1.6 Length of panicle

Length of panicle of BRRI dhan29 showed statistically significant variation due to the application of various organic manure and inorganic fertilizer (Appendix III). The highest length of panicle (24.59 cm) was recorded from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically identical (23.37 cm) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the lowest length of panicle (16.45 cm) was observed from T_0 as control condition which was closely followed (20.93 cm) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 5). BRRI dhan29 responded significantly better-combined application of 70% chemical fertilizers with organic manure. Haque (1999) and Azim (1996) noted a significant increase in panicle length due to the application of organic manure and chemical fertilizers. Babu *et al.* (2001), Ahmed and Rahman (1991) and Apostol (1989) also reported similar results.

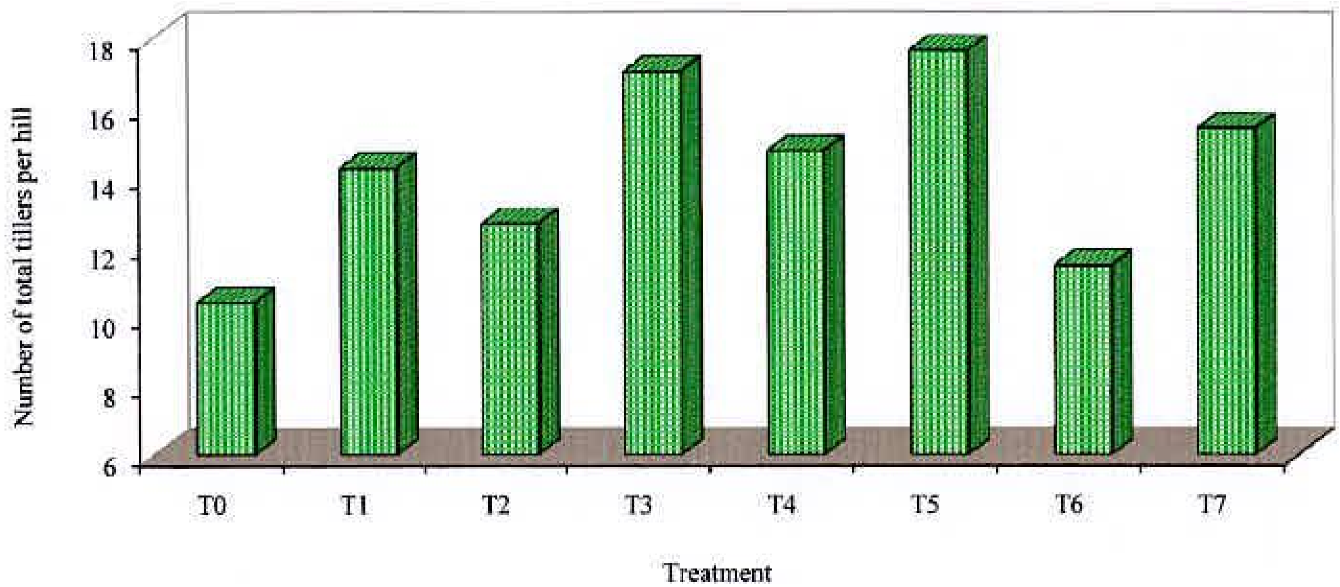

Figure 1. Effect of various organic manure and inorganic fertilizer on total tiller per hill of boro rice BRRI dhan29

T_0: Control	T_1: 100% $N_{100}P_{15}K_{45}S_{20}$ (Recommended dose)
T_2: 50% NPKS + 5 ton cowdung/ha	T_3: 70% NPKS + 3 ton cowdung/ha
T_4: 50% NPKS + 4 ton poultry manure/ha	T_5: 70% NPKS + 2.4 ton poultry manure/ha
T_6: 50% NPKS + 5 ton vermicompost/ha	T_7: 70% NPKS + 3 ton vermicompost/ha

4.1.7 Number of filled grain/plant

Due to the application of various organic manure and inorganic fertilizer statistically significant variation was recorded for number of filled grain per plant of BRRI dhan29 (Appendix III). The maximum number of filled grain per plant (91.63) was found from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically identical (89.85) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the minimum (55.72) was recorded from T_0 as control condition which was closely followed (74.70) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 5).

4.1.8 Number of unfilled grain/plant

Number of unfilled grain per plant of BRRI dhan29 showed statistically significant variation due to the application of various organic manure and inorganic fertilizer (Appendix III). The minimum number of unfilled grain per plant (5.83) was recorded from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was closely followed (7.12) by T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the maximum number of unfilled grain per plant (13.40) was recorded from T_0 as control condition which was closely followed (9.57) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 5).

4.1.9 Number of total grain/plant

A statistically significant variation was recorded for number of total grain per plant of BRRI dhan29 due to the application of various organic manure and inorganic fertilizer (Appendix III). The maximum number of total grain per plant (97.45) was found from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically identical (96.97) with T_3, T_4, T_5, T_7 and T_1 (70% NPKS + 3 ton cowdung/ha). On the other hand, the minimum number of total grain per plant (69.13) was recorded from T_0 as control condition which was closely followed (84.27) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Figure 2). The effect of manure on increasing the number of grains panicle^{-1} was more pronounced as compared to fertilizers. This might be due to more availability of nutrient from the manure. Grains/panicle significantly increased due to the application of organic manures and chemical fertilizers (Razzaque, 1996). These results are also in agreement with Hoque (1999) and Azim (1996).

Table 5. Effect of various organic manure and inorganic fertilizer on yield contributing characters and yield of boro rice BRRI dhan29

Treatment	Number of effective tiller /hill	Number of non-effective tiller/hill	Total tiller/hill	Length of panicle (cm)	Number of filled grain/plant	Number of unfilled grain/ plant	Number of total grain/plant	Weight of 1000 Seed (g)	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
T_0	6.07 d	4.32 a	10.40 d	16.45 d	55.72 e	13.40 a	69.13 d	16.73 c	2.06 f	4.63 e	6.69 d	30.81 e
T_1	11.32 b	2.93 cd	14.26 b	22.91 abc	84.13 bc	8.17 c	92.29 ab	20.60 ab	5.53 d	6.52 bc	12.05 b	45.89 bcd
T_2	9.77 c	2.88 cd	12.66 c	21.97 bc	80.28 c	8.77 bc	89.05 bc	20.33 ab	4.80 e	5.86 cd	10.66 c	44. 92 cd
T_3	13.23 a	3.82 ab	17.04 a	23.37 ab	89.85 a	7.12 d	96.97 a	21.50 ab	6.99 ab	7.50 a	14.49 a	48.22 ab
T_4	11.60 b	3.14 c	14.74 b	22.88 abc	88.22 ab	8.12 c	96.35 a	21.10 ab	6.32 c	7.38 a	13.70 a	46.26 bcd
T_5	13.52 a	4.12 a	17.65 a	24.59 a	91.63 a	5.83 e	97.45 a	21.80 a	7.30 a	7.64 a	14.94 a	48.84 a
T_6	9.20 c	2.27 d	11.47 cd	20.93 c	74.70 d	9.57 b	84.27 c	19.88 b	4.55 e	5.67 d	10.22 c	44.53 d
T_7	12.23 b	3.18 bc	15.41 b	22.83 abc	88.15 ab	6.66 de	94.81 a	21.42 ab	6.44 bc	7.21 ab	13.65 a	47.17 abc
Significance level	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
$LSD_{(0.05)}$	0.974	0.643	1.290	1.927	5.151	0.963	5.081	1.518	0.608	0.751	1.243	2.295

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_0: Control
T_1: 100% $N_{100}P_{15}K_{45}S_{20}$ (Recommended dose)
T_2: 50% NPKS + 5 ton cowdung/ha
T_3: 70% NPKS + 3 ton cowdung/ha
T_4: 50% NPKS + 4 ton poultry manure/ha
T_5: 70% NPKS + 2.4 ton poultry manure/ha
T_6: 50% NPKS + 5 ton vermicompost/ha
T_7: 70% NPKS + 3 ton vermicompost/ha

4.1.10 Weight of 1000 Seeds

Weight of 1000 seeds of BRRI dhan29 showed statistically significant variation due to the application of various organic manure and inorganic fertilizer (Appendix III). The highest weight of 1000 seeds (21.80 g) was found from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically identical (21.50 g) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the minimum weight of 1000 seeds (16.73 g) was observed from T_0 as control condition which was closely followed (19.88 g) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 5). Abedin *et al.* (1999) reported that the combined application of organic manure and chemical fertilizers increased the 1000-grain weight of rice. Apostol (1989) observed that application of organic manure and chemical fertilizer increased 1000-grain weight of rice. Hoque (1999) also recorded that 1000-grain weight were increased by the application of organic manure. Statistically similar thousand-grain-weight was observed in maximum treatments.

4.1.11 Grain yield

Due to the application of various organic manures and inorganic fertilizer grain yield of BRRI dhan29 showed statistically significant differences (Appendix III). The highest grain yield (7.30 t/ha) was obtained from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically identical (6.99 t/ha) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the lowest grain yield (2.06 t/ha) was found from T_0 as control condition which was closely followed (4.55 t/ha) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 5). Application of NPKS increasing the grain yield of BRRI dhan29 as compared to poultry manure and cowdung. It is noticed here that treatment T_3 (70% NPKS+3 t ha^{-1} cowdung) failed to produce the highest grain yield due to lodging. Devivedi and Thakur (2000) 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 Rajni Rani *et al.* (2001), Haque *et al.* (2001), Ahmed and Rhaman (1991).

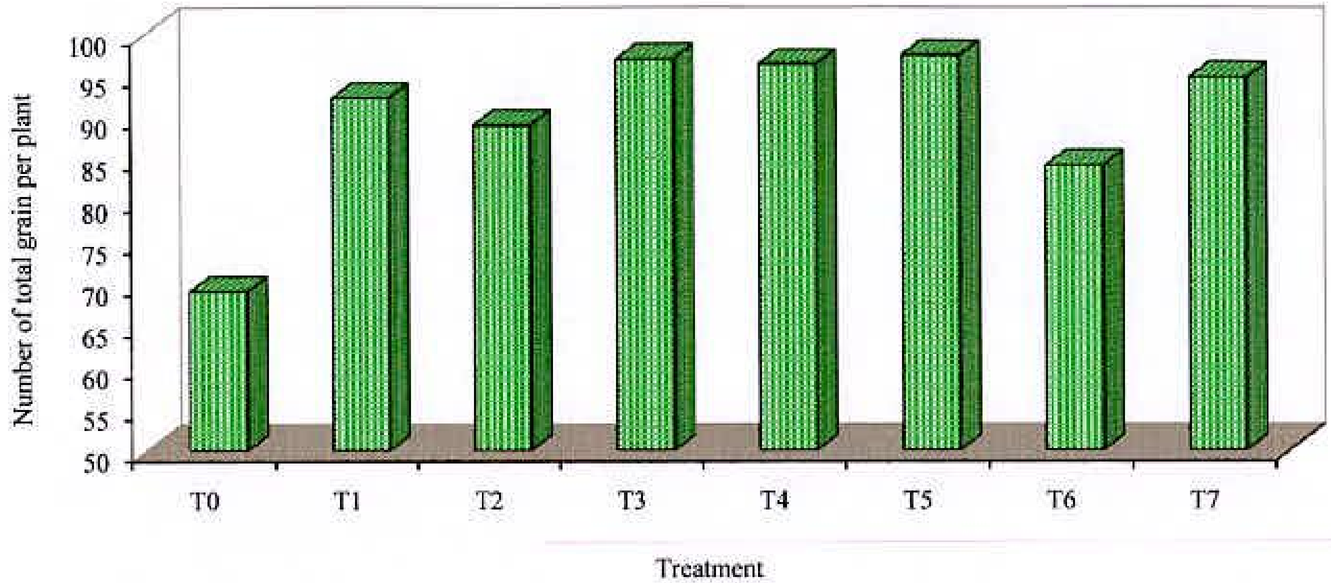

Figure 2. Effect of various organic manure and inorganic fertilizer on total grain per plant of boro rice BRRI dhan29

T_0: Control

T_1: 100% $N_{100}P_{15}K_{45}S_{20}$ (Recommended dose)

T_2: 50% NPKS + 5 ton cowdung/ha

T_3: 70% NPKS + 3 ton cowdung/ha

T_4: 50% NPKS + 4 ton poultry manure/ha

T_5: 70% NPKS + 2.4 ton poultry manure/ha

T_6: 50% NPKS + 5 ton vermicompost/ha

T_7: 70% NPKS + 3 ton vermicompost/ha

4.1.12 Straw yield

Straw yield of BRRI dhan29 varied significantly due to the application of various organic manure and inorganic fertilizer (Appendix III). The highest straw yield (7.64 t/ha) was obtained from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically identical (7.50 t/ha) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the lowest straw yield (4.63 t/ha) was found from T_0 as control condition which was closely followed (5.67 t/ha) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 5). Ahmed and Rahman (1991) reported that the application of organic manure and chemical fertilizers increased the straw yields of rice. These findings are well corroborated with the work of Islam (1997) and Khan (1998). It is clear that organic manure in combination with inorganic fertilizers encouraged vegetative growth of plants and thereby increasing straw yield.

4.1.13 Biological yield

Biological yield of BRRI dhan29 showed statistically significant variation due to the application of various organic manure and inorganic fertilizer (Appendix III). The highest biological yield (14.94 t/ha) was recorded from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically identical (14.49 t/ha) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the lowest biological yield (6.69 t/ha) was obtained from T_0 as control condition which was closely followed (10.22 t/ha) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 5 and Figure 3).

4.1.14 Harvest index

Harvest index of BRRI dhan29 showed statistically significant variation due to the application of various organic manure and inorganic fertilizer (Appendix III). The highest harvest index (48.84%) was found from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically identical (48.22%) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the lowest harvest index (30.81%) was observed from T_0 as control condition which was closely followed (44.53%) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Tabla 5 and Figure 4).

4.2 NPKS concentration in grain and straw

4.2.1 N concentration in grain

Statistically significant variation was recorded for N concentration in grain of BRRI dhan29 due to the application of various organic manure and inorganic fertilizer (Appendix IV). The highest N concentration in grain (0.761%) was observed from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically identical (0.717%) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the lowest N concentration in grain (0.566%) was recorded from T_0 as control condition which was closely followed (0.657%) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 6). Application of chemical fertilizers increased the N content in rice grain markedly. A significant increase in N content in rice grain and straw due to the application of organic manure and fertilizers have been reported by many investigators (Verma, 1991; Jeong *et al.* 1996; Azim, 1999 and Hoque, 1999).

4.2.2 P concentration in grain

Phosphorous concentration in grain of BRRI dhan29 showed statistically significant variation due to the application of various organic manure and inorganic fertilizer (Appendix IV). The highest P concentration in grain (0.293%) was recorded from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically identical (0.284%) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the lowest P concentration in grain (0.201%) was found from T_0 as control condition which was closely followed (0.215%) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 6). An increase in P contents both in rice grain and straw due to the application of poultry manure and chemical fertilizers was reported by many investigators (Razzaque, 1996; Azim, 1999 and Hoque, 1999). Verma (1991) also reported that incorporation of organic manure significantly increased the concentration of P in rice grain and straw.

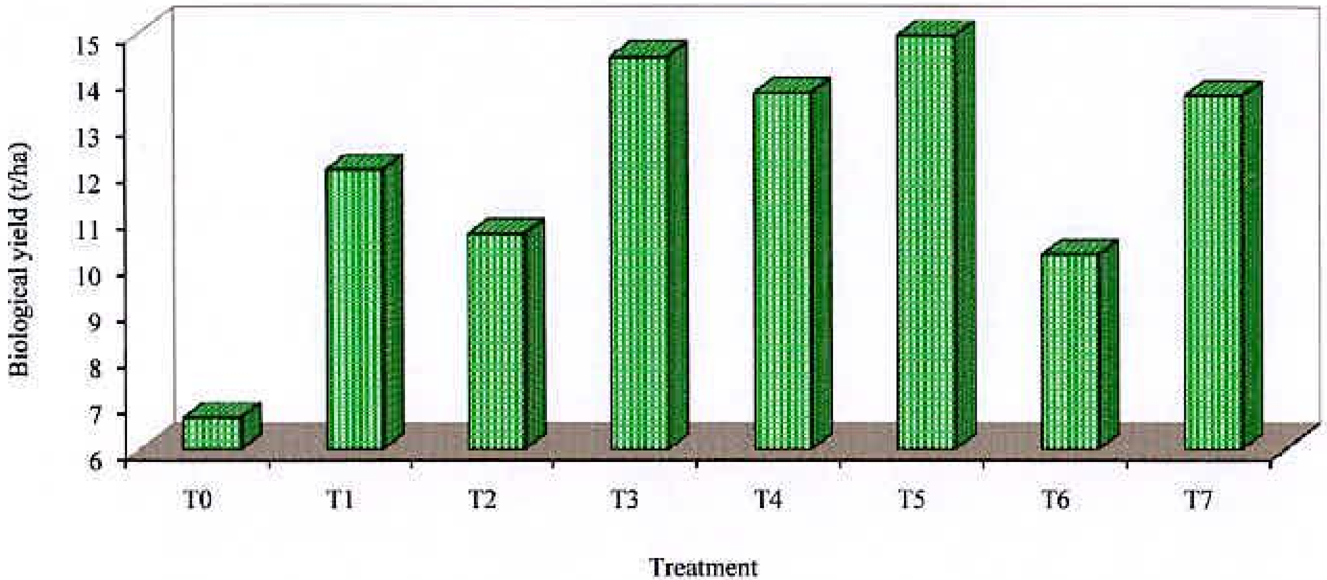

Figure 3. Effect of various organic manure and inorganic fertilizer on biological yield of boro rice BRRI dhan29

T_0: Control

T_1: 100% $N_{100}P_{15}K_{45}S_{20}$ (Recommended dose)

T_2: 50% NPKS + 5 ton cowdung/ha

T_3: 70% NPKS + 3 ton cowdung/ha

T_4: 50% NPKS + 4 ton poultry manure/ha

T_5: 70% NPKS + 2.4 ton poultry manure/ha

T_6: 50% NPKS + 5 ton vermicompost/ha

T_7: 70% NPKS + 3 ton vermicompost/ha

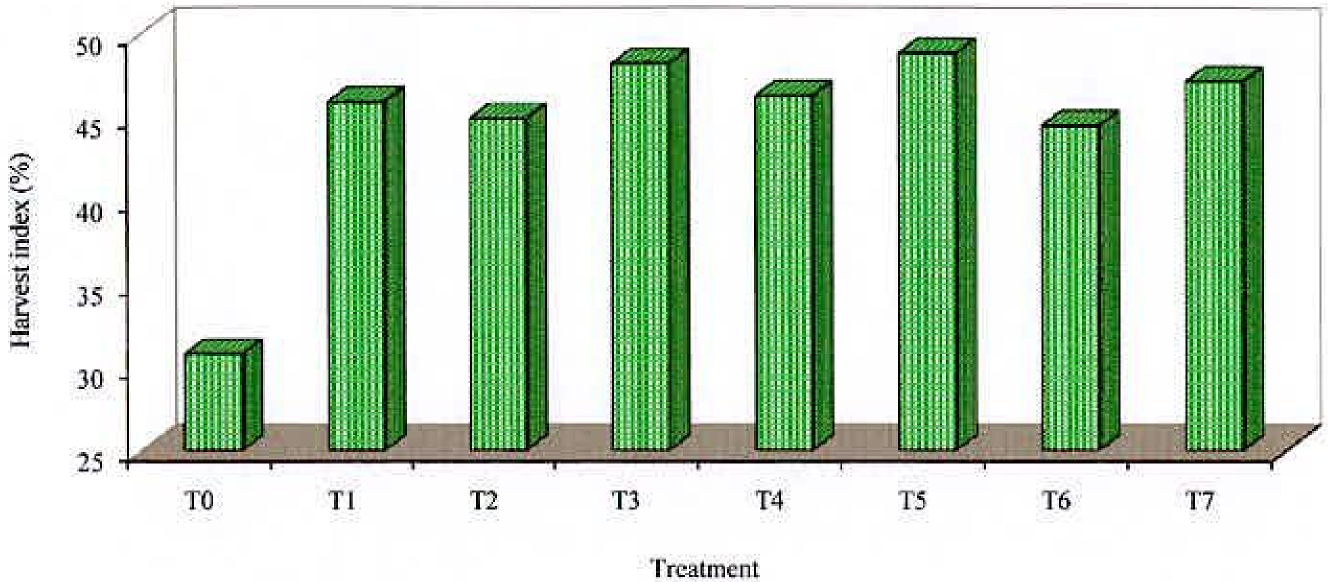

Figure 4. Effect of various organic manure and inorganic fertilizer on harvest index of boro rice BRRI dhan29

T_0: Control

T_1: 100% $N_{100}P_{15}K_{45}S_{20}$ (Recommended dose)

T_2: 50% NPKS + 5 ton cowdung/ha

T_3: 70% NPKS + 3 ton cowdung/ha

T_4: 50% NPKS + 4 ton poultry manure/ha

T_5: 70% NPKS + 2.4 ton poultry manure/ha

T_6: 50% NPKS + 5 ton vermicompost/ha

T_7: 70% NPKS + 3 ton vermicompost/ha

Table 6. Effect of various organic manure and inorganic fertilizer on N, P, K and S concentrations in grain and straw of boro rice BRRI dhan29

Treatment	Concentration (%) in grain				Concentration (%) in straw			
	N	P	K	S	N	P	K	S
T_0	0.566 d	0.201 f	0.262 e	0.075 c	0.334 e	0.051c	0.778 d	0.058 d
T_1	0.688 bc	0.262 cd	0.315 bcd	0.109 b	0.444 c	0.074 ab	1.137 a	0.088 abc
T_2	0.654 c	0.232 e	0.304 cd	0.106 b	0.408 d	0.066 bc	1.039 bc	0.076 bc
T_3	0.717 ab	0.284 ab	0.344 a	0.125 a	0.501 a	0.084 a	1.149 a	0.091 ab
T_4	0.672 bc	0.250 d	0.319 bc	0.110 b	0.443 c	0.068 b	1.070 b	0.079 bc
T_5	0.761 a	0.293 a	0.358 a	0.126 a	0.505 a	0.087 a	1.175 a	0.098 a
T_6	0.657 c	0.215 f	0.301 d	0.104 b	0.401 d	0.064 bc	0.991 c	0.073 c
T_7	0.699 bc	0.276 bc	0.328 b	0.115 ab	0.483 b	0.077 ab	1.150 a	0.087 abc
Significance level	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
$LSD_{(0.05)}$	0.047	0.015	0.015	0.015	0.015	0.015	0.066	0.015

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_0: Control

T_1: 100% $N_{100}P_{15}K_{45}S_{20}$ (Recommended dose)

T_2: 50% NPKS + 5 ton cowdung/ha

T_3: 70% NPKS + 3 ton cowdung/ha

T_4: 50% NPKS + 4 ton poultry manure/ha

T_5: 70% NPKS + 2.4 ton poultry manure/ha

T_6: 50% NPKS + 5 ton vermicompost/ha

T_7: 70% NPKS + 3 ton vermicompost/ha

4.2.3 K concentration in grain

Potassium concentration in grain of BRRI dhan29 differ significantly due to the application of various organic manuAre and inorganic fertilizer (Appendix IV). The highest K concentration in grain (0.358%) was obtained from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically identical (0.344%) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the lowest K concentration in grain (0.262%) was observed from T_0 as control condition which was closely followed (0.301%) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 6). Potassium contents both in grain and straw of rice increased due to application of organic and chemical fertilizers (Islam, 1997 and Khan, 1998). Singh *et al.* (2001) also revealed that Potassium content in grain and straw were increased due to combined application of organic manure and chemical fertilizers.

4.2.4 S concentration in grain

Due to the application of various organic manure and inorganic fertilizer S concentration in grain of BRRI dhan29 showed statistically significant differences (Appendix IV). The highest S concentration in grain (0.126%) was recorded from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically identical (0.125%) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the lowest S concentration in grain (0.075%) was recorded from T_0 as control condition which was closely followed (0.104%) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 6). Azim (1999) and Hoque (1999) reported that application of sulphur from manure and fertilizers increased S content both in grain and straw. Hossain (1996) also reported the similar results.

4.2.5 N concentration in straw

Statistically significant variation was recorded for N concentration in straw of BRRI dhan29 due to the application of various organic manure and inorganic fertilizer (Appendix IV). The highest N concentration in straw (0.505%) was found from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically identical (0.501%) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the lowest N concentration in straw (0.334%) was obtained from T_0 as control condition which was closely followed by T_6 (0.401%) as 50% NPKS + 5 ton vermicompost/ha (Table 6).

4.2.6 P concentration in straw

Phosphorous concentration in straw of BRRI dhan29 showed statistically significant variation due to the application of various organic manure and inorganic fertilizer (Appendix IV). The highest P concentration in straw (0.087%) was found from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically identical (0.084%) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the lowest P concentration in straw (0.051%) was recorded from T_0 as control condition which was closely followed (0.064%) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 6).

4.2.7 K concentration in straw

Due to the application of various organic manure and inorganic fertilizer K concentration in straw of BRRI dhan29 varied significantly (Appendix IV). The highest K concentration in straw (1.175%) was recorded from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically identical (1.149%) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the lowest K concentration in straw (0.778%) was found from T_0 as control condition which was closely followed (0.991%) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 6).

4.2.8 S concentration in straw

Sulphur concentration in straw of BRRI dhan29 showed statistically significant variation due to the application of various organic manure and inorganic fertilizer (Appendix IV). The highest S concentration in straw (0.098%) was obtained from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically identical (0.091%) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the lowest S concentration in straw (0.058%) was found from T_0 as control condition which was closely followed (0.073%) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 6).

4.3 NPKS uptake by grain and straw

4.3.1 N uptake by grain

Statistically significant variation was recorded for N uptake by grain of BRRI dhan29 due to the application of various organic manure and inorganic fertilizer (Appendix V). The highest N uptake by grain (55.53 kg/ha) was recorded from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was closely followed (50.11 kg/ha) by T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the lowest N uptake by grain (0.566 kg/ha) was recorded from T_0 as control condition which was closely followed (0.657 kg/ha) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 7). Sengar *et al.* (2000) reported that the N uptake by rice grain and straw increased significantly with the combined application of organic manure and chemical fertilizers. Rahman (2001); Duhan and Singh (2002); Azim (1999) and Hoque (1999) also reported similar results.

4.3.2 P uptake by grain

Potassium uptake by grain of BRRI dhan29 showed statistically significant variation due to the application of various organic manure and inorganic fertilizer (Appendix V). The highest P uptake by grain (21.38 kg/ha) was observed from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically identical (19.85 kg/ha) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the lowest P uptake by grain (4.14 kg/ha) was observed from T_0 as control condition which was closely followed (9.79 kg/ha) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 7). Sengar *et al.* (2000) observed that the highest P uptake by rice grain was recorded with the combined application of organic manure and phosphatic fertilizers. Similar results were also obtained by Gupta *et al.* (1995).

4.3.3 K uptake by grain

Due to the application of various organic manure and inorganic fertilizer K uptake by grain of BRRI dhan29 showed statistically significant differences (Appendix V). The highest K uptake by grain (26.12 kg/ha) was found from T_5 (70% NPKS + 2.4

Table 7. Effect of various organic manure and inorganic fertilizer on N, P, K and S uptake by grain and straw of boro rice BRRI dhan29

Treatment	Uptake by grain (kg/ha)				Uptake by straw (kg/ha)			
	N	P	K	S	N	P	K	S
T_0	11.65 f	4.14 e	5.39 f	1.54 f	15.49 f	2.36 d	36.10 e	2.68 e
T_1	38.09 d	14.50 c	17.40 d	6.05 cd	28.99 d	4.83 b	74.15 c	5.73 c
T_2	31.40 e	11.11 d	14.58 e	5.08 de	23.94 e	3.87 c	60.95 d	4.46 d
T_3	50.11 b	19.85 a	24.05 b	8.83 a	37.56 ab	6.30 a	86.16 ab	6.82 b
T_4	42.46 cd	15.78 c	20.17 c	6.98 bc	32.66 c	5.03 b	78.86 bc	5.83 c
T_5	55.53 a	21.38 a	26.12 a	9.19 a	38.58 a	6.65 a	89.78 a	7.49 a
T_6	29.89 e	9.79 d	13.70 e	4.73 e	22.75 e	3.63 c	56.20 d	4.14 d
T_7	45.05 c	17.76 b	21.14 c	7.40 b	34.84 bc	5.56 b	82.86 abc	6.27 bc
Significance level	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
$LSD_{(0.05)}$	4.697	1.726	2.034	0.993	3.490	0.734	9.287	0.596

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_0: Control

T_1: 100% $N_{100}P_{15}K_{45}S_{20}$ (Recommended dose)

T_2: 50% NPKS + 5 ton cowdung/ha

T_3: 70% NPKS + 3 ton cowdung/ha

T_4: 50% NPKS + 4 ton poultry manure/ha

T_5: 70% NPKS + 2.4 ton poultry manure/ha

T_6: 50% NPKS + 5 ton vermicompost/ha

T_7: 70% NPKS + 3 ton vermicompost/ha

ton poultry manure/ha) which was statistically identical (24.05 kg/ha) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the lowest K uptake by grain (5.39 kg/ha) was observed from T_0 as control condition which was closely followed (13.70 kg/ha) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 7). Sengar *et al.* (2000) reported that application of chemical fertilizer and organic manure significantly increased the K uptake by rice. Similar results were also found by Sharma and Mitra (1991), Cassman (1995), Azim (1996) and Hoque (1999).

4.3.4 S uptake by grain

Sulphur uptake by grain of BRRI dhan29 showed statistically significant variation due to the application of various organic manure and inorganic fertilizer (Appendix V). The highest S uptake by grain (9.19 kg/ha) was obtained from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically identical (8.83 kg/ha) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the lowest S uptake by grain (1.54 kg/ha) was observed from T_0 as control condition which was closely followed (4.73 kg/ha) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 7). Poongothai *et al.* (1999) observed that application of sulphur enhanced significantly S uptake by rice. Azim (1999) and Hoque (1999) recorded the higher uptake of S with the application of manure and fertilizers either alone or in combinations. Similar results were also reported by Sengar *et al.* (2000) and Rahman (2001).

4.3.5 N uptake by straw

Nitrogen uptake by straw of BRRI dhan29 showed statistically significant variation due to the application of various organic manure and inorganic fertilizer (Appendix V). The highest N uptake by straw (38.58 kg/ha) was recorded from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically identical (37.56 kg/ha) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the lowest N uptake by straw (15.49 kg/ha) was observed from T_0 as control condition which was closely followed (22.75 kg/ha) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 7).

4.3.6 P uptake by straw

Statistically significant variation was recorded for P uptake by straw of BRRI dhan29 due to the application of various organic manure and inorganic fertilizer (Appendix V). The highest P uptake by straw (6.65 kg/ha) was found from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically identical (6.30 kg/ha) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the lowest P uptake by straw (2.36 kg/ha) was observed from T_0 as control condition which was closely followed (3.63 kg/ha) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 7).

4.3.7 K uptake by straw

Potassium uptake by straw of BRRI dhan29 showed statistically significant variation due to the application of various organic manure and inorganic fertilizer (Appendix V). The highest K uptake by straw (89.78 kg/ha) was recorded from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically identical (86.16 kg/ha) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the lowest K uptake by straw (36.10 kg/ha) was found from T_0 as control condition which was closely followed (56.20 kg/ha) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 7).

4.3.8 Sulphur (S) uptake by straw

Sulphur (S) uptake by straw of BRRI dhan29 showed statistically significant variation due to the application of various organic manure and inorganic fertilizer (Appendix V). The highest S uptake by straw (7.49 kg/ha) was observed from T_5 (70% NPKS + 2.4 ton poultry manure/ha) which was statistically identical (6.82 kg/ha) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the lowest S uptake by straw (2.68 kg/ha) was observed from T_0 as control condition which was closely followed (4.14 kg/ha) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 7).

4.4 pH, organic matter and NPKS in post harvest soil

4.4.1 pH

Statistically non significant variation was recorded for pH in post harvest soil due to the application of different organic manure and inorganic fertilizer in BRRI dhan29

(Appendix VI). The highest pH of post harvest soil (6.13) was found from T_3 (70% NPKS + 3 ton cowdung/ha) and the lowest pH in post harvest soil (5.70) was recorded from T_2 as 50% NPKS + 5 ton cowdung/ha (Table 8). Bharadwaj and Tyagi (1994) reported that the soil pH reduce due to the application of FYM plus pressmud. Similar results were also observed by Islam (1997), Khan (1998) and Swarup and Singh (1994).

4.4.2 Organic matter

Organic manure in post harvest soil showed statistically non-significant differences due to the application of different organic manure and inorganic fertilizer in BRRI dhan29 (Appendix VI). The highest organic matter in post harvest soil (1.290%) was recorded from T_3 (70% NPKS + 3 ton cowdung/ha) and the lowest organic matter in post harvest soil (1.150%) was observed from T_2 (50% NPKS + 5 ton cowdung/ha) (Table 8). Zhang *et al.* (1996) showed that the combined application of organic manure and chemical fertilizers increased organic matter content in soil. Organic carbon also increased due to application of organic manure as reported by Haque *et al.* (2001), Mathew and Nair (1997), Azim (1999) and Hoque (1999).

4.4.3 Total Nitrogen

Total nitrogen in post harvest soil showed statistically significant differences due to the application of different organic manure and inorganic fertilizer in BRRI dhan29 (Appendix VI). The highest total nitrogen in post harvest soil (0.864%) was recorded from T_5 as 70% NPKS + 2.4 ton poultry manure which was statistically identical (0.832%) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the lowest total nitrogen in post harvest soil (0.0384%) was obtained from control which was closely followed (0.512%) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 8).

Table 8. Effect of various organic manure and inorganic fertilizer on the post harvest soil of boro rice BRRI dhan29

Treatment	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me /100 g soil)	Available S (ppm)
T_0	5.85	1.160	0.0384	19.42 d	0.103 d	12.52 f
T_1	5.90	1.170	0.736	24.05 ab	0.154 ab	18.00 cd
T_2	5.70	1.150	0.656	23.12 bc	0.133 c	16.93 de
T_3	6.13	1.290	0.832	24.88 ab	0.158 a	19.86 ab
T_4	5.95	1.210	0.640	23.66 ab	0.141 bc	17.44 cde
T_5	6.05	1.240	0.864	25.53 a	0.166 a	20.66 a
T_6	5.80	1.245	0.512	21.09 cd	0.128 c	16.05 e
T_7	6.00	1.200	0.800	24.95 ab	0.152 ab	18.90 bc
Significance level	NS	NS	0.01	0.01	0.01	0.01
$LSD_{(0.05)}$	--	--	0.047	2.152	0.015	1.644

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_0: Control

T_1: 100% $N_{100}P_{15}K_{45}S_{20}$ (Recommended dose)

T_2: 50% NPKS + 5 ton cowdung/ha

T_3: 70% NPKS + 3 ton cowdung/ha

T_4: 50% NPKS + 4 ton poultry manure/ha

T_5: 70% NPKS + 2.4 ton poultry manure/ha

T_6: 50% NPKS + 5 ton vermicompost/ha

T_7: 70% NPKS + 3 ton vermicompost/ha

Several workers reported that organic manure had a positive influenced on total and available N content of soil. Similar were also observed by Razzaque (1996); Hoque (1999) and Azim (1999).

4.4.4 Available phosphorus

Available phosphorus in post harvest soil showed statistically significant differences due to the application of different organic manure and inorganic fertilizer in BRRI dhan29 (Appendix VI). The highest available phosphorus in post harvest soil (25.53 ppm) was recorded from T_5 as 70% NPKS + 2.4 ton poultry manure which was statistically identical (24.88 ppm) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the lowest available phosphorus in post harvest soil (19.42 ppm) was found from control which was closely followed (21.09 ppm) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 8). Similar results were also found by Zhang *et al.* (1996); Mathew and Nair (1997); Hoque (1999) and Azim (1999).

4.4.5 Exchangeable potassium

Due to the application of different organic manure and inorganic fertilizer in BRRI dhan29Exchangeable potassium in post harvest soil showed statistically significant differences (Appendix VI). The highest exchangeable potassium in post harvest soil (0.166 me%) was recorded from T_5 as 70% NPKS + 2.4 ton poultry manure which was statistically identical (0.158 me%) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the lowest exchangeable potassium in post harvest soil (0.103 me%) was observed from control which was closely followed (0.128 me%) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 8). Zhang *et al.* (1996) reported that the combined application of poultry manure with chemical fertilizer increased exchangeable K content in soil. Mathew and Nair (1997) observed that application of cattle manure increased the exchangeable K content in soil. Similar results were also reported by Sharma and Sharma (1999), Hoque (1999) and Azim (1999).

4.4.6 Available sulphur

Available sulphur in post harvest soil showed statistically significant differences due to the application of different organic manure and inorganic fertilizer in BRRI dhan29 (Appendix VI). The highest available sulphur in post harvest soil (20.66 ppm) was obtained from T_5 as 70% NPKS + 2.4 ton poultry manure which was statistically identical (19.86 ppm) with T_3 (70% NPKS + 3 ton cowdung/ha). On the other hand, the lowest available sulphur in post harvest soil (12.52 ppm) was observed from control which was closely followed (16.05 ppm) by T_6 as 50% NPKS + 5 ton vermicompost/ha (Table 8). Shahidduzaman (1997) also found that the application of organic manure increase available S content in soil compared to application of chemicals fertilizers. Similar results were obtained by Hoque (1999) and Azim (1999).

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 2007 to April 2008 to study the effect of various organic manure and inorganic fertilizer on the yield and quality of boro rice. BRRI dhan29 was used as the test crop in this experiment. The experiment consisted of 8 treatments. Such as T_0: Control, T_1: 100% $N_{100}P_{15}K_{45}S_{20}$ (Recommended dose), T_2: 50% NPKS + 5 ton cowdung/ha, T_3: 70% NPKS + 3 ton cowdung/ha, T_4: 50% NPKS + 4 ton poultry manure/ha, T_5: 70% NPKS + 2.4 ton poultry manure/ha, T_6: 50% NPKS + 5 ton vermicompost/ha and T_7: 70% NPKS + 3 ton vermicompost/ha. The experiment was laid out in a randomized complete block design with four replications.

At 30, 50, 70, 90 DAT and at harvest the tallest plant (24.18 cm, 31.34 cm, 44.67 cm, 67.05 cm and 89.00 cm) was recorded from T_5 and the lowest (16.20 cm, 20.65 cm, 32.58 cm, 49.10 cm and 64.59 cm) was observed from T_0. At 30, 50, 70 and 90 DAT the maximum number of total tillers per hill (5.43, 11.64, 21.01and 17.90) was recorded from T_5 again the minimum (2.51, 4.60, 10.29 and 7.26) was observed from T_0. The maximum number of effective tillers per hill (13.52) was recorded from T_5 and the minimum (6.07) was observed from T_0. The maximum number of in-effective tillers per hill (4.32) was recorded from T_0 and the minimum (2.27) was observed from T_6. The maximum number of total tillers per hill (17.65) was recorded from T_5 and the minimum (10.40) was observed from T_0. The highest length of panicle (24.59 cm) was recorded from T_5 and the lowest length of panicle (16.45 cm) was observed from T_0. The maximum number of filled grain per plant (91.63) was recorded from T_5 and the minimum (55.72) was observed from T_0. The minimum number of unfilled grain per plant (5.83) was recorded from T_5 and the maximum (13.40) was observed from T_0. The maximum number of total grain per plant (97.45) was recorded from T_5 and the minimum (69.13) was observed from T_0. The highest weight of 1000 seeds (21.80 g) was recorded from T_5 and the lowest (16.73 g) was observed from T_0. The highest grain yield (7.30 t/ha) was recorded from T_5 again the lowest (2.06 t/ha) was observed from T_0. The highest straw yield (7.64 t/ha) was recorded from T_5 and the lowest (4.63 t/ha) was observed from T_0. The highest biological yield (14.94 t/ha) was recorded from T_5 and the lowest (6.69 t/ha) was observed from T_0. The highest harvest index (48.84%) was recorded from T_5 and the lowest harvest index (30.81%) was observed from T_0.

The highest N concentration in grain (0.761%) was recorded from T_5 and the lowest (0.566%) was observed from T_0. The highest P concentration in grain (0.293%) was recorded from T_5 and the lowest (0.201%) was observed from T_0. The highest K concentration in grain (0.358%) was recorded from T_5 again the lowest (0.262%) was observed from T_0. The highest S concentration in grain (0.126%) was recorded from T_5 and the lowest (0.075%) was observed from T_0. The highest N concentration in straw (0.505%) was recorded from T_5 and the lowest (0.334%) was observed from T_0. The highest P concentration in straw (0.087%) was recorded from T_5 and the lowest (0.051%) was observed from T_0. The highest K concentration in straw (1.175%) was recorded from T_5 and the lowest (0.778%) was observed from T_0. The highest S concentration in straw (0.098%) was recorded from T_5 and the lowest (0.058%) was observed from T_0.

The highest N uptake by grain (55.53 kg/ha) was recorded from T_5 and the lowest (0.566 kg/ha) was observed from T_0. The highest P uptake by grain (21.38 kg/ha) was recorded from T_5 and the lowest (4.14 kg/ha) was observed from T_0. The highest K uptake by grain (26.12 kg/ha) was recorded from T_5 and the lowest (5.39 kg/ha) was observed from T_0. The highest S uptake by grain (9.19 kg/ha) was recorded from T_5 again, the lowest (1.54 kg/ha) was observed from T_0. The highest N uptake by straw (38.58 kg/ha) was recorded from T_5 and the lowest (15.49 kg/ha) was observed from T_0. The highest P uptake by straw (6.65 kg/ha) was recorded from T_5 and the lowest (2.36 kg/ha) was observed from T_0. The highest K uptake by straw (89.78 kg/ha) was recorded from T_5 and the lowest (36.10 kg/ha) was observed from T_0. The highest S uptake by straw (7.49 kg/ha) was recorded from T_5 and the lowest (2.68 kg/ha) was observed from T_0.

The highest pH of post harvest soil (6.35) was recorded from T_3 and the lowest (5.70) was observed from T_2. The highest organic matter in post harvest soil (1.445%) was recorded from T_6 and the lowest (1.150%) was observed from T_3. The highest total nitrogen in post harvest soil (0.054%) was recorded from T_5 and the lowest (0.024%) was observed from control. The highest available phosphorus in post harvest soil (25.53 ppm) was recorded from T_5 and the lowest (19.42 ppm) was observed from control. The highest exchangeable potassium in post harvest soil (0.166 me%) was recorded from T_5 and the lowest (0.103 me%) was observed from control. The highest available sulphur in post harvest soil (20.66 ppm) was recorded from T_5 and the lowest (12.52 ppm) was observed from control.

From the above discussion it can be concluded that application of 70% NPKS + 2.4 ton poultry manure/ha was most favorable for improving yield and yield contributing characters of BRRI dhan 29 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 combination may be included for further study.

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APPENDICES

APPENDICES

Appendix I. Monthly record of air temperature, rainfall, relative humidity, soil temperature and Sunshine of the experimental site during the period from December 2007 to April 2008

Month	*Air temperature (°c)		*Relative humidity (%)	*Rain fall (mm) (total)	*Sunshine (hr)
	Maximum	Minimum			
December, 2007	22.4	13.5	74	00	6.3
January, 2008	24.5	12.4	68	00	5.7
February, 2008	27.1	16.7	67	30	6.7
March, 2008	31.4	19.6	54	11	8.2
April, 2008	33.6	23.6	69	163	6.4

* Monthly average,

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka - 1212

Appendix II. Analysis of variance of the data on plant height and number of total tiller per hill of boro rice BRRI dhan 29 as influenced by various organic manure and inorganic fertilizer

Source of variation	Degrees of freedom	Mean square								
		Plant height (cm) at					Number of total tiller per hill at			
		30 DAT	50 DAT	70 DAT	90 DAT	at harvest	30 DAT	50 DAT	70 DAT	90 DAT
Replication	3	0.949	0.193	0.827	3.750	0.500	0.082	0.303	0.571	0.520
Treatment	7	25.798**	50.313**	59.793**	134.903**	249.370**	3.506**	19.912**	46.538**	44.314**
Error	21	3.430	4.266	4.435	6.583	5.927	0.097	1.133	1.328	1.555

**: Significant at 0.01 level of probability

Appendix III. Analysis of variance of the data on yield contributing characters and yield of boro rice BRRI dhan29 as influenced by various organic manure and inorganic fertilizer

Source of variation	Degrees of freedom	Mean square											
		Effective tiller /hill	Non-effective tiller/hill	Total tiller/hill	Length of panicle (cm)	Number of filled grain/ plant	Number of unfilled grain/ plant	Number of total grain/ plant	Weight of 1000 Seed (g)	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
Replication	3	0.159	0.027	0.238	0.720	3.131	0.401	2.488	0.887	0.019	0.045	0.109	0.356
Treatment	7	24.09**	1.941**	26.29**	24.46**	560.4**	21.66**	366.9**	10.59**	11.58**	4.652**	30.63**	132.8**
Error	21	0.439	0.191	0.769	1.717	12.268	0.429	11.941	1.066	0.171	0.261	0.715	2.435

**: Significant at 0.01 level of probability

Appendix IV. Analysis of variance of the data on N, P, K and S concentrations in grain and straw of boro rice BRRI dhan29 as influenced by various organic manure and inorganic fertilizer

Source of variation	Degrees of freedom	Mean square							
		Concentration (%) in grain				Concentration (%) in straw			
		N	P	K	S	N	P	K	S
Replication	3	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Treatment	7	0.013**	0.004**	0.003**	0.001**	0.013**	0.001**	0.069**	0.001**
Error	21	0.001	0.0001	0.0001	0.000	0.0001	0.0001	0.002	0.0001

**: Significant at 0.01 level of probability

Appendix V. Analysis of variance of the data N, P, K and S uptake by grain and straw of boro rice BRRI dhan29 as influenced by various organic manure and inorganic fertilizer

Source of variation	Degrees of freedom	Mean square							
		Uptake by grain (kg/ha)				Uptake by straw (kg/ha)			
		N	P	K	S	N	P	K	S
Replication	3	1.651	0.080	0.318	0.030	0.645	0.059	10.088	0.018
Treatment	7	758.372 **	130.855 **	175.170 **	24.584* *	262.227 **	8.272**	1332.382 **	9.888**
Error	21	10.203	1.378	1.914	0.456	5.634	0.249	39.883	0.164

**: Significant at 0.01 level of probability

Appendix VI. Analysis of variance of the data on the post harvest soil of boro rice BRRI dhan29 as influenced by various organic manure and inorganic fertilizer

Source of variation	Degrees of freedom	Mean square					
		pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me %)	Available S (ppm)
Replication	3	0.017	0.007	0.0001	0.074	0.0001	0.319
Treatment	7	0.077	0.009	0.110**	17.637**	0.002**	25.703**
Error	21	0.035	0.007	0.001	2.141	0.0001	1.250

*: Significant at 0.05 level of probability; **: Significant at 0.01 level of probability