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ABSTRACT

A field experiment was conducted at the Soil Science Field Laboratory Khulna University (KU), Khulna during aman season of 2018 to evaluate the effects of manures and fertilizers for maximizing the yield of BBRI dhan49. The soil of the experimental field belongs to 'Sonatala' Soil Series having silt loam texture, pH 6.18, organic matter content 2.15%, total N 0.124%, available P 6.51 ppm, exchangeable K 0.074me/100 g soil, available S 14.85 ppm and CEC 12.5 me/100 g soil. The experiment containing six treatments was laid out in a randomized complete block design (RCBD) with four replications. The treatments were T_0= Control, T = STB-CF (HYG), T_2= CD + STB-CF (HYG), T_3= PM + STB-CF (HYG), T_4= COM + STB-CF (HYG) and T_5= Farmers' practice (FP). Organic manures including cowdung, poultry manure and compost were applied to the experimental plots @ 5, 3 and 5 t ha^{-1}, respectively. The recommended dozes of N, P, K and S supplied from urea, TSP, MoP and gypsum were 90, 15, 60 and 15 kg ha^{-1}, respectively. Yield contributing characters like plant height, effective tillers hill^{-1}, panicle length, grains panicle^{-1} and filled grains panicle^{-1} and grain and straw yields of BRRI dhan49 were significantly influenced by the application of manures and fertilizers. The highest grain yield of 4.87 t ha^{-1} was observed in the treatment T_3 [PM + STB-CF (HYG)] and the lowest value of 3.61 t ha^{-1} was found in T_0 (control). The straw yield ranged from 4.10 to 5.51 t ha^{-1} in different treatments. The NPKS contents and uptake by BRRI dhan49 were markedly influenced by manures and fertilizers. The treatment T_3 [PM + STB-CF (HYG)] was found to be the best combination of manures and fertilizers for obtaining the maximum yield of rice.

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CHAPTER 1

INTRODUCTION

Bangladesh is an agro-based country with a large population. The population of Bangladesh was 142.32 million and growth rate is 1.34 % in the year 2011 (BBS, 2011). Most of the people of the country depend on agriculture. The agriculture of our country is governed by intensive rice (*Oryza sativa)* cultivation. Rice (*Oryza sativa)* is the staple food crop in Bangladesh and the cropping pattern of the country is predominately rice-based. In Bangladesh, rice dominates over all other crops and covers 77 % of the total cropped area and 93% farmers grow rice. The total area and production of rice in Bangladesh are about 11.7 million hectares and 31.98 million metric tons, respectively (BBS, 2011).

The soil fertility status is gradually declining. The stagnating trend in the yield of major crops of the country has become an alarming issue for the scientist and policy makers (Bhuiyan, 1994). Low organic matter content of the soil, imbalanced use of chemical fertilizers, less use of organic manures and inadequate attention given for its improvement and maintenances have made the situation difficult (Karim *et al.* 1994).

Before 1980's, deficiency of NPK was a major problem of Bangladesh soil but there after along with NPK deficiencies of S and Zn are frequently reported (Islam *et al*. 1986, Haque and Jahiruddin, 1994). Presently, there has been a great increase in fertilizer use yet the production of different nutrients used in the country is not balanced.

In general, organic manures play a vital role in improving soil physical, chemical and biological properties in addition to supplying sustain quantities of plant nutrients. Nambiar (1991) reviewed that integrated use organic manure chemical NPK fertilizers would be quite promising only in providing greater stability in production, but also in maintaining soil fertility status.

Soil organic matter plays an important role in maintaining soil fertility and productivity. Organic matter acts as a reservoir of plant nutrients especially N, P, K and S and micro-nutrients and prevent leaching of the nutrients. The problem of nutrient deficiencies as well as nutrient mining caused by intensive cropping with HYV of rice and nutrient imbalance can be minimized by judicious application of nutrients through organic manures. Losses of soil organic matter can only be replenished in the short term by application of organic matter such as manures.

Cowdung and poultry manure are the most popular and promising bulky organic manures produced from solid and liquid excreta of farm animals. They contain considerable amounts of essential nutrient elements required by plant growth. These are one kind of store house of nutrients of plants. Hence an improvement and addition of a good amount of cowdung and poultry manure to the crop field is essential for fertility and productivity and maintenances of the soil.

Many farmer's use more amount of urea fertilizer than needed while they use less amount of other fertilizers such as triple superphosphate, muriate of potash and gypsum. They seldom use micronutrient fertilizers e.g. zinc sulphate, boric acid. This practice creates imbalance use of fertilizers which in turn produces a negative impact on crop production (Rijpma and Jahiruddin, 2004). Continuous use of inorganic fertilizer deteriorates soil properties and causes a nutrient imbalance of soil in addition to causing micronutrient deficiency. Further more, chemical fertilizers pollute soil and water making our environment even more harmful for both terrestrial as well as aquatic life. Application of inorganic fertilizer has always been expensive inputs for crop production, especially in a developing country like Bangladesh. In near future chemical fertilizer is likely to be even more costly. This situation is in turn will pose a serious threat to food security of vast millions of people of this country. In addition, global environment pollution can be reduced considerably by reducing the chemical fertilizers and increasing amount of organic fertilizers. It is true that production of crops can not be maintained by using only chemical fertilizers and similarity it is not possible obtain higher crop yield by using organic manures alone (Bair, 1990).

The problem of nutrient deficiencies as well as nutrient mining caused by intensive cropping with high yielding varieties of rice and nutrient imbalance can be minimized by judicious application of nutrients through organic manures or chemical fertilizers. The present research work was, therefore, undertaken with the following objectives.

1. To study the effect of manures and fertilizers on the growth and yield of BRRI dhan49

2. To evaluate the effect of manures and fertilizers on the nutrient content and uptake by

BRRI dhan49.

CHAPTER 2
REVIEW OF LITERATURE

Organic matter is the main sources of nutrient availability and maintenances of better physical, chemical and biological status of soil. Soil organic matter is the essential factor for sustainable soil fertility and crop productivity. An attempt has been made present a brief and pertinent review of literature in this chapter. Attention has been paid to the application of cowdung, poultry manure and chemical fertilizers on the growth, yield and nutrient content of rice. Research works on rice and it response to manures and fertilizers have been carried out in the different rice growing countries of the world by many researchers. Available information's are reviewed below.

Effect of manures on the growth and yield of rice

Das (2011) observed that the highest grain yield highest grain (4.47 t ha^{-1}) was produced in treatment P_3 (PM at 7 t ha^{-1}) and the lowest grain yield (3.09 t ha^{-1}) was produced in treatment P_1 (no application of PM).

Murad (2011) observed the highest number of grains panicle (14.04) in T_7 (PM at 5 t ha^{-1}) and the lowest number of grains panicle (95.35) in T_1 (control).

Bastida *et al.* (2010) conducted an experiment and reported that compost has the unique ability to improve soil properties and the growing media physically, chemically and biologically.

Mohammadi *et al.* (2009) showed that long term application of fertilizers containing P, especially organic fertilizers usually increase the water soluble and available P of soil and at the same time may result in P accumulation in soil. Organic fertilizers may also increase the movement of P in the profile that could result in surface and ground water pollution. Average organic content in the soil increased as result of organic fertilizer applications. The increase was proportional to the rate of application and was highest for dairy manure and lowest for urban solid compost. Effect of sewage sludge application on available p content of soil was greater than its effect on the water extractable P.

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Tejada *et al*. (2009) conducted an experiment and reported that among the advantages of compost as soil amendment is its potential to maintain soil organic matter, faster nutrient availability and increase soil microbial abundance and activity, thus enhancing soil quality and fertility.

Mobasser *et al*. (2005) reported that numbers of panicle/m were significantly higher in cowdung treated plots compared with the unfertilized control.

Ogbodo *et al.* (2005) conducted a field study to compare the response of rice to organic and inorganic manures at Abakaliki, Southeastern Nigeria, between 2002 and 2003 cropping seasons (April- November). However, organic manure application doses of over 20 t ha^{-1} reduced plant growth and grain yield. Sewage sludge and poultry droppings at 20 t ha^{-1} were therefore concluded to be a viable alternative to urea in rice production in the study area.

Reddy *et al.* (2004) conducted a field study for two years (2001 and 2002) on the farmers field 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. PM and sewage sludge produced better growth components, viz., plant height, numbers of tillers hill, panicle length and 1000-grain weight.

Blum *et al.* (2003) in a greenhouse study reported that poultry manure at 30 kg^{-1} increased the number (approx.15-50%) and fresh mass (approx. 90200%) of emerging plants of Exposicao and Caipira. Soil pH and soil concentrations of Ca, K, Mg, N, P and Zn increased with increased poultry manure rates. The fruit yield of squash increased with the incorporation of poultry manure to the soil at 30 g kg^{-1}.

Umanah *et al.* (2003) conducted a field experiment to study the effect of different rates of PM on the growth, yield components and yield of upland rice cv. Faro43 in Nigeria, during the 1997 and 1998 early crop production seasons. The treatments comprised 0, 10, 20 and 30 t PM ha^{-1}. There was significant differences in plant height, internodes length, number of tillers $hill^{-1}$, panicle number stand number of grains panicle, and dry grain yield. There was no significant variation among treatments for 1000 grain weight.

Usman *et al.* (2003) conducted a field experiment to study the effect of organic amendment (FYM, PM) on the performance of rice cv. Basmti-2000 in Faisalabad, Pakistan. PM showed the maximum leaf area index (46.46 %). The treatment also produced the highest number of grains/panicle, 1000-grain weight and straw yield.

BRRI (2001) reported that application of only cowdung as a nitrogen source the sterility percentage (22%) over control (13%).

Saitoh *et al.* (2001) conducted a field study on the effects of organic fertilizers (cow and chicken manure) and pesticide on the growth and yield of rice cv. Nipponbare were examined from 1990 to 1999 in a paddy field in Okayama, Japan. In this experiment, rice was grown by pesticide-free organic cultivation with only 10% yield reduction. A possibility of cultural and biological control of weeds and insects was discussed.

Singh *et al.* (2001) reported that the application of FYM @ 10 t ha^{-1} produced 4.64% higher yield than the control.

Hemalatha *et al.* (2000) studied on the influence of organic manures: dhaincha, sun hemp and FYM on rice productivity, quality and soil fertilizer. They reported that all the sources of organic manures improved the rice yield, quality and soil fertility.

Bhattacharya *et al.* (1996) carried out an experiment in plastic pots 5 kg capacity with one hole at bottom and filled with 4 kg soil. They reported that the application of 2.59 g kg^{-1} FYM could produce about 2.0 g pot^{-1} grain as well as straw yield than no FYM treated soil.

Effect of fertilizer on the growth and yield of rice

Awan (2011) carried out an experiment to study the effect of different nitrogen 1evels (110,133 & 156 kg ha^{-1}) in combination with different row spacing (15 cm, 22.5 cm & 30 cm) at Rice Research Institute Kala Shah Kaku during the crop growing season 2006 & 2007. Treatment RS_2N_3 , where 156 kg N ha^{-1} were applied with 22.5 cm row to row and plant to plant spacing had maximum values of plant height (79.07 cm), tillers m^{-2} (594), panicle length (25.40 cm), No of grains $panicle^{-1}$ (132.97), grain yield (546l.03 kg ha^{-1}), straw yield (9662.03 kg ha^{-1}) and least value of sterility % age (5.7%). All these parameters were statistically similar with the treatment RS_1N_3 (15 cm spacing with 156 kg N ha^{-1} except panicle length. Statistically minimum values of ill parameters were recorded under the treatments RS_1N_3 (15cm spacing with 110 kg N ha^{-1}) and RS_3N_1 (30 cm spacing with 110 kg N ha^{-1}) except panicle length, 1000-grain weight and sterility % age.

Jun *et al.* (2011) conducted an experiment in a rice field with different crop rotation systems and nitrogen application rates, surface water nitrogen content nitrogen loss via runoff , soil fertility and rice yield were determined. Based on the experiment, chemical nitrogen fertilizer application during rice season in alfaafa-rice or rye- rice rotation systems can be reduced, and not in wheat-rice rotation system in Yixing, Jiangsu province. Alfaafa-rice or rye- rice rotation systems enhanced soil nitrogen content, promoted rice nitrogen absorption and significantly improved rice yield.

Srinivasarao *et al.* (2011) reported a result in the large scale negative K balances in Indian agriculture. In agroecosystem, K is contributed by many sources like animal manure, crop residue, compost, rice burning residue, irrigation water and rain etc. Similarly, besides crop K removal, K is lost to deeper layers by rain or irrigation water by leaching.

Jawahar *et al.* (2010) conducted a field experiment at Experimental Farm, Annamalai University, Annarnalai Nagar, Tamil Nadu, India during 2008-2009 to stud) the effect of sulphur and silicon fertilization on growth and yield of rice. The treatments comprised four levels of sulphur (0, 15, 30, and 45 kg ha-1) and four levels of silicon (0, 40, 80 and 120 kg ha-1). Among the different levels of sulphur and silicon, sulphur @ 45 kg ha-1 and silicon @ 120 kg ha-1 recorded higher values for growth (plant height, tillers plant-1 and dry matter production), yield attributing (panicles m-2 and grain panicle-1) characters and yield (grain and straw) of rice, respectively.

Das *et al*. (2008) conducted a field experiment to find out an optimum fertilizer dose and split application of nitrogen at different growth stages of hybrid rice under irrigated mid land situations. They found that N application in four equal splits i.e., as basal, at tillering, at panicle initiation stage and at booting stage gave higher economic return.

Islam *et al.* (2008) conducted an experiment at the Agronomy field Laboratory, Department of Agronomy, Hajee Mohammad Danesh Science and Technology University, Dinajpur during the period from July to December, 2007 to investigate the effect of nitrogen (N) and number of seedlings hill^{-1} on the yield and yield components of transplant aman rice cv. BRRI dhan33. Five levels of N (viz. 40, 60, 80, 100 and 120 kg ha^{-1} and four levels of seedlings hill^{-1} (viz. 1, 2, 3 and 4 seedlings hill^{-1} nerve taken as treatment combination. The highest grain yield 4.27 t ha^{-1} was recorded with the N_4 (100 kg N ha^{-1}). Among four levels of seedlings, three seedlings hill^{-1}(S_3) was the best in respect of plant height, tillers hill^{-1}, effective tillers hill^{-1}, grains panicle^{-1} and grain yield (4.07 t ha^{-1}).The treatment combination N produced the highest 1000-grain weight followed by N, S, and N and grain yield (4.90 t ha^{-1}), on the other hand the lowest grain yield 2.60 t ha^{-1} was recorded from N_1S_3.

Walker *et al.* (2008) conducted a field experiment in Louisiana, Mississippi and Missouri during 2005 and 2006 to evaluate early-season application of N fertilizer (zero N or 22 kg of N per ha as ammonium sulfate) to the cultivars Cheniere and Wells planted at four seeding rates (81, 161, 323, and 645 seeds m^{-2}) on two soil textures. On silt loam and clay soils, grain yields reached a plateau at seeding rates of 161 and 323 seeds m^{-2}, respectively. On clay soils, regardless of seeding rate, grain yields were increased by approximately 200 kg ha^{-1} when 22 kg of N per ha was applied to two-leaf stage rice compared with no starter N. Starter N did not increase rice grain yields on silt loam soils; however, the data suggested that a potential production savings can be realized by reducing the seedling rate on silt loam soils to 161 seeds /m^2 as long as an environment void of undue plant stress can be provided.

Abbasi *et al.* (2007) studied the effects of N fertilizer levels and its spilt application on yield and yield components of rice. The highest number of fertile tiller was obtained in the fifth and sixth treatments with double and triple split applications of 120 Kg N ha^{-1}. They suggested that triple split application of 80 Kg N ha^{-1} would be best for rice production.

Bahmaniar *et al.* (2007) conducted an experiment in order to consider effects of various levels of nitrogen and potassium application on kernel processing characteristics of rice cultivars, and found that application of nitrogen cause an increase in amount of bran production and have shown significant effects on percentages of bran, head and brewer's rice, husking efficiency and transformation degree.

Dinesh *et al.* (2007) conducted a field experiment during rainy season of 2003 at the research farm of the Indian Agricultural Research Institute, New Delhi to study the effect of N and S levels on productivity and nutrient uptake in aromatic rice. The percentages increase in the grain yield of rice at application of 20. 40 and 60 kg ha^{-1} over the control were in order of 6.5, 7.3 and 8.8% respectively. Based on the total N uptake (grain + straw) there were 49.9, 63.9 and 70.4% increase in the N uptake over the control with 50, 100 and 150 kg N ha^{-1}, respectively. From this field study it can be concluded that aromatic rice requires 100 kg N and 20 kg S ha^{-1} for increased productivity and uptake of N, P, K and S, under transplanted puddle condition.

Singaravel *et al.* (2007) conducted an experiment to study the effects of recommended NPK rates (120:38:38 kg ha^{-1}) with or without Kiecite (a foliar micronutrient mixture containing 1.0% Fe, 0.5% Mn, 5% Zn, 0.35% Cu and 0.05% B) at 0.50, 1.0, 1.5 or 2.0% on the performance of rice (cv. ADT 43) were studied in Annamalai, Tamil Nadu. India, from July to October 2003. They reported that NPK + 1.0% Kiecite significantly enhanced the growth and yield of rice.

Chu-Van-Hach *et al*. (2006) conducted a field experiment in Vietnam during the rainy and summer seasons of 2004 to study the effects of N fertilizer on the growth yield components and economic efficiency of rice cultivars. During the rainy season, the main plots consisted of 5 rates of N fertilizer (urea) i.e. 0 (control), 30, 60, 90 and I20 kg ha^{-1}. In the summer season, the 5 rates of N fertilizer were control 0, 40, 80,120 and 160 kg N ha^{-1}.The results showed that the application of N fertilizer at 60 kg ha^{-1} resulted in the greatest economic efficiency during the rainy season for all cultivars; further increase in the rate of N fertilizer beyond 90 kg N ha^{-1} gave a negative EENA value. During the dry season following the application of 80 kg N ha-1 the EENA was highest for all cultivars. At higher nitrogen rates (120-160 kg N ha^{-1}). EENA values were lower.

Dwivedi *et al*. (2006) conducted a field experiment to evaluate the effect of nitrogen levels on growth and yield of hybrid rice. They found that 184.07 kg ha^{-1} was the optimum rate for higher yield.

Haque *et al.* (2006) conducted a field experiment during the Aman season of 2004-2005 at Bangladesh Agricultural University farm soil with the objective to ascertain the effects of different rates and sources of potassium on growth and yield of rice cv. BR11. The treatments comprised of 5 potassium levels (0, 10, 20, 40 and K_2O ha^{-1} from sources as KCl and K_2SO_4. Results indicated that increasing potassium level up to 40 kg K ha^{-1} increased the rice yield and all yield components. The highest grain yield (6.50 t ha^{-1}) was obtained when KCI was applied @ 40 kg ha^{-1}, but it was similar with the effect of 40 kg K_2O ha^{-1} from K_2SO_4 ha^{-1}. Furthermore, application of potassium significantly increased N, P and K contents in rice over the-control.

Khan *et al.* (2006) conducted field experiments in rainy (kharif) season of 1999 and 2000 to study the effect of 3 integrated N management options using farmyard manure, green manure and wheat straw incorporation on yield and N nutrition of rice (*Oryza sativa* L.) Use of green manure in combination with urea gave the yield of rice grain and straw as farmyard manure or wheat straw incorporated in conjunction with urea at 150 kg ha^{-1}.These 3 integrated nitrogen management options were found at par with urea-N alone at 150 kg ha^{-1} in grain yield. Incorporation of wheat straw 4 weeks before rice planting did not show any adverse effect on rice growth. Green manure in conjunction with urea gave higher total N uptake than urea alone at 150 kg N ha^{-1}.

Bowen *et al.* (2005) conducted an experiment during the boro (irrigated dry season) and aman (wet season) seasons of 2000-04, as on-farm trials in 7 districts (Bogra. Chandpur, Jessore, Kishoreganj, Mymensingh, Pabna and Tangail) in Bangladesh to study the efficacy of the urea deep placement (UDP and farmer's practice FP: split application of broadcast urea) in enhancing rice yield and N use. The yield increase under UDP was achieved using much less urea ferti1izer. UDP resulted in higher grain yield and N fertilizer use efficiency than FP. The average UDP grain yield benefit over FP was 1120 kg ha^{-1} during the boro season and 890 kg ha^{-1} during the aman season.

Haque and Chowdhury (2004) observed that dry matter yield of rice plants significantly increased at both maximum tillering and panicle initiation stage in treatment with rice straw and S applied together. There were significant increases in all yield contributing attributes of the crop except 1000-grain weight in both rice straw and S treatments over control. Grain and straw yields of rice significantly increased due to application of rice straw and S together over control treatment.

Hu *et al.* (2004) conducted a field experiment in Zhejiang, China, to investigate the K uptake, distribution and use efficiency of hybrid and conventional rice under different low-K stress conditions. The grain yield and total K uptake by rice increased, while the K use efficiency of rice decreased significantly. The interaction effect between cropping pattern and K application was also significant. The phase from panicle initiation to flowering was critical for K uptake by rice and more than half of the total plant K was accumulated during this phase.

Wang (2004) conducted a field experiment in Taiwan to investigate the effect placement of fertilizer and nitrogen top dressing on rice yield and to develop a simple method for diagnosing the level of nitrogen (N) top-dressing during panicle initiation stage. The deep placement of nitrogen fertilizer promoted nitrogen uptake, grain nitrogen and nitrogen harvest index, resulted in a higher dry matter production, harvest index and a higher grain yield of rice plant compared with conventional nitrogen application. Similarly, top-dressing of nitrogen at panicle initiation stage also increased nitrogen uptake, dry matter production, nitrogen harvest index, and grain yield of rice plants.

Bhadoria and Prakash (2003) carried out held experiments in West Bengal, India, to evaluate the relative efficiency of organic manures in combination with chemical fertilizers (CF) against application of only CF in improving the productivity of rice in a lateritic soil. The uptake of N, P and K by rice plants was significantly greater in treatments with organic manures in con with chemical fertilizer.

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 experiments showed that there was a different yield increasing efficiency with application S at the doses of 20-60 kg ha^{-1} to rice plant. The increasing rate of rice yield was 2.9-15.5% over control. A residual effect was also observed.

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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^{-1} 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^{-1}) and straw (8649.6 kg ha^{-1}) yields, response ratio (23.40) and agronomic efficiency (41.26).

Raju and Reddy (2001) conducted a field investigation at Agricultural Research Station, Maruteru, Andhra Pradesh, India to the response of both hybrid and conventional rice to sulphur (@ 20 kg ha^{-1}) and zinc (@10 kg ha^{-1}) applications. Significant improvement in grain yield was observed due to sulphur application.

Sahrawat *et al.* (2001) conducted a held experiment for six years (1993-1998) to determine the response of four promising upland rice cultivars with 0, 45 kg 90 kg, 135 kg and 180 kg ha^{-1} as triple super phosphate (TSP). They 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 applied.

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 N and K while the inorganic sources mostly did not show positive effect. Soil p^H decreased slightly from the initial status.

Zhang *et al.* (2000) carried out an experiment to study the agronomic performance of a newly developed site specific nutrient management (SSNM) technique for nitrogen fertilizer application to directly sown early rice against farmers fertilizer practice (FFM) in Jinhua, Zhejiang, China. Results showed that SSNN increased the rice yield significantly and improves N use efficiency substantially.

Carrers *et al.* (1996) stated that grain yield increased with increasing amount of N fertilizer up to 70 kg N ha^{-1} N rates appeared to affect grain yield by causing variations in the number of panicles m^{-2}.

Chander and Pandey (1996) cited that application of 120 kg N ha^{-1} resulted in significant increase in effective tillers m^{-2} and grain yield compared to 60 kg N ha^{-1} in both the year (1993 and 1994).

Khanda and Dixit (1996) reported that the grain and straw yields were significantly influenced by the increased levels of nitrogen. The maximum grain and straw yields of 45.8 and 62.1q ha^{-1} were obtained at 90 kg N ha^{-1}. The increase over 0, 30 and 60 kg N was 49.8, 20.7, and 3.7% for grain and 56.1, 25.2 and 10.1% for straw, respectively.

Kumar *et al.* (1996) cited that grain yield increased with increasing levels of N. The increase in grain yield at 160 kg N over the control was 42.0 percent.

Azad *et al.* (1995) observed that panicle length of rice plants increased significantly with the increases of nitrogen levels from 0 to 75 kg N ha^{-1}.

Hussain and Sharma (1991) reported that application of nitrogen increase grain number $panicle^{-1}$ up to 80 kg N ha^{-1}. Nitrogen application @ 120 kg ha^{-1} did not significantly increase the grain number panicle and the lowest value was observed in the control.

Singh and Yadav (1990) reported that grain yield of rice increased with increasing NPK rate and with increasing pyrites rate at the high and medium NPK application rates. Yield increase with Zn application was similar to those with intermediate pyrite rates.

BRRI (1989) carried out many investigations and concluded that grain and straw yields were strongly influenced by nitrogen.

Phongpan *et al.* (1988) observed that the grain yield and straw yield of rice increased significantly with increasing rates of urea application. They also observed that N uptake by rice increased significantly with increasing rates of urea application.

Mondal *et al.* (1987) reported that increasing rates of N from 40 to 160 kg N ha^{-1} increased the number of panicles unit area.

2.3 Combined effect of manures and chemical fertilizers on the growth and yield of rice

Badruzzaman *et al.* (2010) conducted an experiment to investigate the effects of nine treatments of organic manures (PM: poultry manure and FYM= Farmyard yard manure) in combination with chemical fertilizers (NPKSZn) on crop productivity and soil fertility in a wheat-rice experiment in Bangladesh. Organic manures had direct and residual effects on rice and wheat yields, but the effect of poultry was dominant. Plots with FYM plus 75% NPKSZn produced equivalent or higher yields as 100% NPKSZn. The pm direct to wheat produced 12% higher yield than 100% NPKSZn.

Hossain *et al.* (2010) conducted field experiments in consecutive 2002 and 2003 at a farmer's field in Bogra district of Bangladesh to ascertain the effects of composted press mud (PM) and cowdung (CD) on rice. Two levels PM and CD (5 and 10 tha^{-1}) individually or in combination with two levels of chemical fertilizer; (CF=NPKSZn) @ 50 and 75% of the recoaramended dose were applied. One control and one 100% CF were also include. PM @ 10 t ha^{-1} in combination with 75% CF performed either the highest or identical to the maximum grain, straw and TDM (total dry matter) yields and also influenced the yield contributing characters during two consecutive years. The highest grain (5.62 t ha^{-1}) and straw (6.96 t ha^{-1}) yields in 2002 were obtained from PM 10 t ha^{-1}+75% CF against control (2.2 and 2.64 t ha a). In 2003, the highest grain (6.81 t ha^{-1}) and straw (8.24 t ha^{-1}) yields were recorded by the treatment CD 10 t ha^{-1}+ 75% CF whereas lowest recorded in control (2.61 t ha^{-1}, 3.20 t ha^{-1}, respectively). Rice yield and yield attributes significantly increased with the increasing amount of composted PM in combination with 50 or 25% reduced recommended rate of CF. The overall findings suggest that the composted PM combined with 5O or 75% CF can be an efficient practice for ensuring higher rice yield without deteriorating soil fertility.

Gana (2009) showed that the effect of residual fertility rates was significant on percent organic carbon, organic matter exchange capacity (CEC) with the least value been obtained from the untreated control, followed by the separately applied inorganic and organic fertilizers. Plots treated with combined application of cattle manure with inorganic fertilizers rates gave better performance of weeds, growth parameters and yield than plots treated with separated application of 10 t ha^{-1} cattle manure and 120 kg N ha^{-1}, 26 kg P ha^{-1}, 37 kg K ha^{-1} inorganic fertilizers.

Asagi *et al.* (2007) evaluatedd the effects of the application of sewage sludge(SS) on the growth indices, yield and nutrient uptake in rice *(Oryza sativa* L. cv. Koshihikari) grown in a low fertility soil were investigated and were compared with the effects of the application of chemical fertilizer (CF) and no fertilizer (NF). The application of SS increased plant growth indices in comparison with the NF treatment; however, at harvest, the dry weight of the plants grown in the SS-treated soil was 30% lower than that of plants in the CF-treated soil. The amounts of uptake by rice From CF, SS and the soil were determined using the A value method. The amounts of N uptake from the fertilizer and soil in the CF treatment were 0.137 and 0.054 g pot^{-1}, respectively and those in the SS treatment were 0.130 and 0.017 g pot^{-1}, respectively. The N use efficiencies of the plants in the CF and SS-treated soils were 68.3 and 43.0%, respectively. Therefore, the relative, efficiency of SS to CF was 62.9%. In comparison to the NF and CF treatments, the application of SS increased the soil microbial activity; this was determined by assaying the fluorescein diacetate esterase activity. At harvest, the pf1 of the SStreated soil was higher than that of the soils in the NF and CF treatments and the electrical conductivity (EC) of the CF-treated soil was higher than that of the soils in the NF and SS treahnents.

Golabi *et al*. (2007) Observed that one of the major problems in agricultural soils is their low organic matter content, which results from rapid decomposition due to the hot and humid environment. Composted organic material is frequently applied on agricultural fields as an amendment to provide nutrients and also to increase the organic matter content and to improve the physical and chemical properties of soils. Our goal is to develop management strategies that can use available organic wastes on the farm for improving soil quality for better crop production while conserving resources and preserving environmental quality.

Kavitha and Subramanian (2007) conducted a field experiment at Tamil Nadu Agricultural University Coimbatore, India, to study the effect of enriched municipal solid waste compost application on growth, plant nutrient uptake and yield of rice in 2004. The growth attributes (viz., plant height, leaf area index, number of tillers and dry matter production) differed significantly due to different treatments. These attributes increased significantly owing to the application of enriched compost, having enhanced nutrient level that leads to the continuous availability of nutrients in available form to the plants. The highest grain yield and straw yield were observed in the treatment combination of 25% of enriched compost and 75% of recommended dose of inorganic fertilizer with value of 5.22 t and 8.65 t ha^{-1}, respectively. Application of 5 t ha^{-1} enriched MSWC in combination with 25% N through inorganic fertilizer recorded grain yield of 4.33 t ha^{-1}. The lowest grain yield (3.78 t ha^{-1}) was recorded in treatment where the compost was applied alone.

Singh *et al.* (2006) conducted an experiment during kharif 2004, on an Inceptisol in Varanasi, Uttar Pradesh, India to evaluate the effects of chemical fertilizer (urea), cowdung and biofertilizer (Azospirillum) on the yield of rice and physicochemical properties of the soil. Application of chemical fertilizer, cowdung and Azospirilluni, individually or in combinations, significantly increased the yield attributes (plant height, number of tillers, panicle length, grain yield and straw yield) over the control. The treatment comprising 80 kg N ha^{-1} + Azospiriiiz.im + 2.5 t cowdung ha^{-1} was superior over all other treatments in terms of rice yield.

Mashkar *et al.* (2005) conducted a field experiment at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh, during August to December 1995 to study the transplanted aman rice. Four varieties, namely, BR1O, BR1I, BR22 and BR23 and five fertilizer application treatments namely, F1i= inorganic fertilizers (IF), F= 1F + cowdung 5t ha^{-1}, F3 = 1F + cowdung 10 t ha^{-1}, F4 with N application + cowdung 5 t ha^{-1} and F5= 1F with N application + cowdung 10 t ha^{-1} Manuring with cowdung up to 10 t ha^{-1} in addition to recommended inorganic fertilizers with N application improved gram and straw yields and qualities of transplant rice over inorganic fertilizers alone.

Silva *et al.* (2005) conducted a field experiment to evaluate the possibilities of increasing crop yields and soil nutrients by combined application of organic manure (straw, cattle manure, Poultry manure and compost) and chemical fertilizers under rice crop rotation in 2004 yala and 2004/2005 maha seasons. Results of the experiment revealed that higher crop growth and yield can be obtained by combining organic manures and chemical fertilizers. Among the organic manure and chemical fertilizer combinations tested, poultry manure + NPK showed the highest (493% in yala and 256% in maha) and rice straw + NPK combinations showed the lowest (361% in yala and 145% in maha) grain yields and increase of soil nutrient status, respectively. They concluded that the combined application of poultry manure and chemical fertilizer is better compared to the organic manure + NPK combinations in sustaining crop yield and soil nutrient (status).

Saleque *et al.* (2004) conducted an experiment from 1990-1999 on a Chhiata clay loam soil in Bangladesh to determine the effect of different doses of chemical fertilizers alone or in combination with cowdung and rice husk ash on yield of lowland rice, six treatment viz. absolute control (T_1) 1/3 of recommended fertilizer doses (T_2) 2/3 of recommended doses (T_3) full doses of recommended fertilizer (T_4). T_2 +5 t cowdung and 2.5 t ash ha^{-1} (T_5) and T_3 + 5 t cowdung ha^{-1} + 2.5 t ash ha^{-1}(T_6) were compared. They found that application of cowdung and ash (T_5 and T_6 increased rice yield by about 1 t ha^{-1} $year^{-1}$ over that obtained with chemical fertilizer alone.

Yogananda *et al.* (2004) conducted a field experiment to determine the efficiency of urban composts alone or in combination with fertilizers on the performance of' hybrid rice (*Oryza scrtiva*). Application of 4.25 t urban compost + 100-50-50 kg NPK ha^{-1} produced significantly the highest grain yield (53.6 q ha^{-1}) and at par with the application of 8.5 t urban compose + 50-50 kg PK ha^{-1} (51.6 q ha^{-1}). Application of fertilizer alone produced the lowest grain and straw yields (39.9 t and 66.9 q ha^{-1}, respectively). The results showed that combined application of either 8.5 t of urban compost + 50-50 kg PK or 4.25 t urban compost + 100-50-50 kg NPK ha^{-1} to hybrid rice was better than NPK fertilizer alone.

Caravaca *et al.* (2003) conducted a field experiment in a silt-loam soil to evaluate the effect of the addition of a composted urban residue on soil aggregate stability, bulk density and chemical properties and on the establishment of *Pistacia lentiscus* and Retama sphaerocarpa seedlings. The composted residue was applied 6.7 kg m^{-2} before planting. The nutrient content (NPK) total organic C and water soluble C increased and bulk density decreased, in the rhizosphere soil oh both shrub species by the composted residue. The addition of composted residue significantly increased the soil aggregate stability by about 22% for both shrub species. The beneficial effect of the composted residue on soil quality still persisted 18 months after addition. Composted residue addition to soil can be considered an effective preparation method of a degraded area for carrying out successful revegetation programs with Mediterranean shrubs under semiarid conditions. Improvement of physical-chemical soil quality is a key step for carrying out revegetation programs of degraded lands in Mediterranean semiarid areas. Organic residue addition may restore the quality of these areas.

Wang and Yang (2003) investigated changes of soil quality attributes in field plots after 3-5 years of annual paddy-upland crop rotation with various fertilizations since 1995. Other than the amendments of green manure, compost and peat, chemical fertilizer N in the amounts of 33% and 67% of established N rate were complemented. Spring rice *(Oryza saliva* L.) was planted each year. After the harvests of three to five rice crops from 1998 through 2000, surface soil samples were collected from the plots of each treatment. Applications of organic materials to the plots prevented soil pH from decreasing, and increased the amounts of soluble salts. After rice harvest, the soil water contents at 0.033 MP a tension were significantly greater in soils amended with peat and compost than that with chemical fertilizer and the check. The bulk density of surface soils of the field plots amended with organic materials was significantly lower than that of the check. Although chemical fertilizer played a significant role in governing the maize and rice yields, it did not significantly contribute to the improvement of some soil quality attributes.

Duhan and Singh (2002) reported that the rice yield and uptake of nutrient increased significantly with increasing N levels. Moreover, the application of N along with various green manures (GM) showed additive effects on the yield and uptake of micronutrients. Under all GM treatments the yield uptake was always higher with 120 kg N ha^{-1} than with lower level of nitrogen.

Sarfraz *et al.* (2002) conducted a field experiment to determine the effect of potassium and sulphur. They applied 110: 90: 70: 20 kg ha^{-1} N, P, K and S, respectively. They attributes increased significantly owing to the application of enriched compost, having enhanced nutrient level that leads to the continuous availability of nutrients in available form to the plants. The highest grain yield and straw yield were observed in the treatment combination of 25% of enriched compost and 75% of recommended dose of inorganic fertilizer with value of 5.22 t and 8.65 t ha^{-1}, respectively. Application of 5 t ha^{-1} enriched MSWC in combination with 25% N through inorganic fertilizer recorded grain yield of 4.33 t ha^{-1}. The lowest grain yield (3.78 t ha^{-1}) was recorded in treatment where the compost was applied alone.

Channabasavanna and Biradar, (2001) conducted an experiment with 4 sources of organic manure (FYM 7 t ha^{-1}, rice husk 5 tha^{-1}, poultry manure 2 tha^{-1}) with one control and 3 levels of zinc (0, 25 and 50 kg ZnSO4 ha^{-1}). Application of poultry manure with 25 kg ZnSO4 ha^{-1} I gave significantly higher yields over rest of the treatments. The residual effect was more prominent, when rice husk was applied. They also cited that organic manure increased panicle $hill^{-1}$ and seed panicle.

Channabasavanna and Biradar, (2001) found the response of rice cv.IRI-429 to poultry manure and NPK under irrigated conditions was studied n a field experiment conducted during the 1998 and 1999 wet seasons (August-December) in Karnataka, India. Grain yield increased with each increment of poultry manure application and was maximum at 3 t ha^{-1} poultry manure during both years, which were 26 and 19% higher than that of the control during 1998 and 1999, respectively. The results showed that an increase in poultry manure and fertilizer increased rice seed yield.

Jeegardeeswari *et al.* (2001) reported that grain yield of rice was the highest (5500 kg ha^{-1}) in the green manure + NPK treatment and FYM and urban compost with or without K fertilizer showed higher K uptake compared to green manuring.

Manna *et al.* (2001) conducted a pot culture experiment to assess the quality of microbial enriched phosphocompost and to evaluate the comparative effectiveness of enriched compost and chemical fertilizer on rice crop yields. Fresh cowdung was made into slurry with water and mixed with straw. Farmers are advised to fertilize their crops with cowdung slurry enriched in phosphocompost at the rate of 10t ha^{-1} to obtain more yield and sustain soil quality.

Singh *et al.* (2001) studied the effect of PM under irrigated condition with nitrogen in rice wheat cropping system in an Alfisols of Bilaspur, Madhya Pradesh, India. The treatments consisted of PM 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 in combination. Root and shoot biomass was higher in 100 percent N through PM, followed by 75 % N through PM and 25 % N through area.

Babu and Reddy (2000) conducted a field experiment to study the effect of NPK fertilizers, FYM and poultry manure on rice. NPK at 100:50:50 kg ha^{-1}, 10 t FYM ha^{-1}, 5 t FYM + 50 kg N ha^{-1} or 3 t ha^{-1} poultry manure were applied. Grain yields were the highest with 5 t FYM + 50 kg N ha^{-1}.

Brahmachari and Mondal, (2000) reported that the highest grain yield of rice was obtained when both organic and inorganic sources of nutrients N: P: K at 30: 60: 30 kg ha^{-1} and FYM 10 t ha^{-1} were applied.

Dixit and Gupta, (2000) revealed that application of FYM at 10 t ha^{-1} and blue green algae(BGA) inoculation either alone or in combination, increased the economic yield of rice. The average increase in the grain yield due to BGA was 0.24t ha^{-1}(7.5%) while combined use of FYM and BGA showed the increase of 0.60 t ha^{-1} (19.2%). Addition of FYM and BGA showed positive change in organic carbon and N content of the soil. Average P and K content also showed increasing tendency due to the treatment. Highest economic yield of the crop was noted in the treatments combination of N_{120} P_{60} K_{60} and FYM + BGA.

Ghosh *et al.* (1994) in an experiment with rice found increased grain yield when inorganic (50 kg N ha^{-1}) was applied alone or when combinations with organic (10 t FYM ha^{-1}) and inorganic N fertilizer (29 kg N ha^{-1}) were applied as compared with organic sources (20 t FYM ha^{-1}) alone.

CHAPTER 3

MATERIALS AND METHODS

This chapter describes the materials used and methods followed in the experiment. The experiment was carried out at the Soil Science Field Laboratory Khulna University (KU), Khulna during aman season of 2018 using BRRI dhan49 as the test crop.

Experimental site and soil

The experiment was conducted at the Soil Science Field Laboratory Khulna University (KU), Khulna during aman season of 2018. The morphological, physical and chemical characteristics of the soil are presented in Table 3.1

Table 3.1 Morphological, physical and chemical characteristics of the Experimental soil

A. Morphological characteristics

Morphological feature	Characteristics
Location	Soil Science Field Laboratory Khulna University (KU), Khulna during aman season of 2018
AEZ	Old Brahmaputra Floodplain
Land type	Medium high land
General soil type	Non-calcareous Dark Grey Floodplain Soil
Parent material	Brahmaputra river borne deposit
Soil series	Sonatola
Drainage	Moderate
Topography	Fairly leveled
Cropping pattern	Rice-Rice

B. Physical and chemical characteristics

Characteristics		Value
Particle size analysis	Sand (%)	76.4
	Silt (%)	14.00
	Clay (%)	18.36
Textural class		Silt loam
p^H		6.18
Organic matter (%)		2.15
Total nitrogen (%)		0.124
Available phosphorus (ppm)		6.51
Exchangeable K (me/100 g soil)		0.074
Available sulphur (ppm)		14.85
CEC (me/100 g soil)		12.50

Climate

The climate of the area is characterized by relatively high temperature with humidity and heavy rainfall with occasional gusty winds during kharif season (16 March - 15 October) and low temperature and humidity during rabi season (16 October - 15 March).

Land preparation

The land was prepared by ploughing and cross ploughing with power tiller and country plough. Then the land was laddered with traditional tools. All kinds of weeds, stubbles and crop residues were removed from the field before final ploughing and leveling.

Rice crop

BRRI dhan49, a high yielding variety of rice was used as the test crop in this experiment. The variety vas released by Bangladesh Rice Research Institute, Joydebpur, Gazipur in 2008. Life cycle of this variety is 135 days in aman season. Insect and pest attacks are comparatively less in BRRI dhan49.

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3. 5 Lay out of the experiment

The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. There were six different treatment combinations. Each block was subdivided into six unit plots. The treatments were randomly distributed to the unit plots in each block. The total numbers of plots were 24. The unit plot size was 4.O m x 2.5 m. The spacing between the plants was separated from each other by a space of 25 cm. The lay out of the experiment has been shown in Fig. 3.1

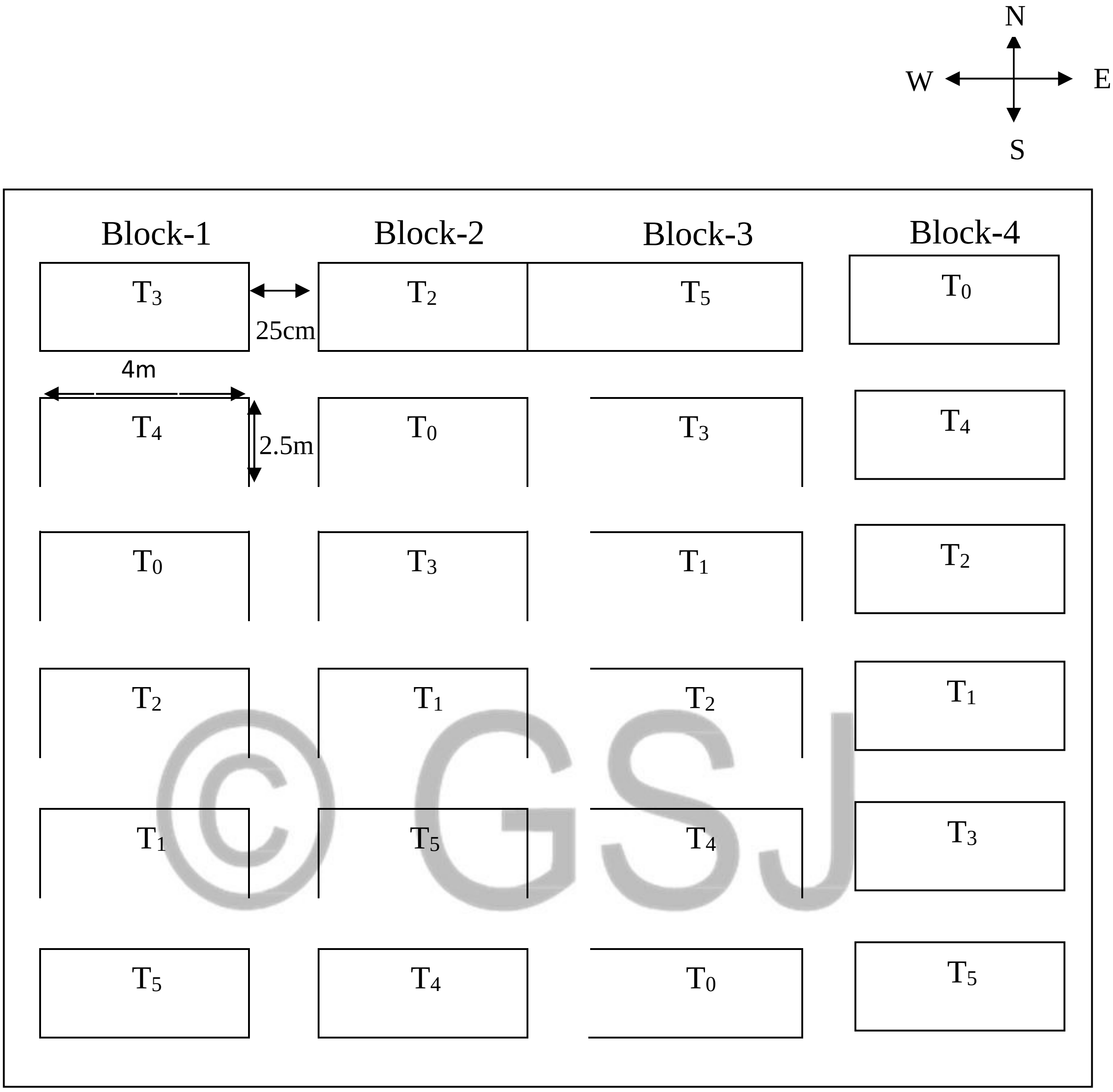

Fig. 3.1 Layout of the experiment

Treatments

The experiment comprised of six treatments including control. The treatments employed for the experiment were as follows.

T_0 = Control

T_1 = STB-CF (HYG)

T_2 = CD+ STB-CF (HYG)

T_3 = PM + STB-CF (HYG)

T_4 = COM+ STB-CF (HYG)

T_5= FP

Here, STB = Soil Test Basis, CF = Chemical Fertilizer, HYG = High Yield Goal, CD = Cowdung, PM = Poultry Manure, COM = Compost, FP = Farmer's Practice. Organic manures including cowdung, poultry manure and compost were applied to the experimental plots @ 5, 3 and 5 t ha^{-1}, respectively. The recommended dozes of N, P, K and S supplied from urea, TSP, MoP and gypsum were 90, 15, 60 and 15 kg ha^{-1}, respectively.

Application of manures and fertilizers

Triple super phosphate (TSP), muriate of potash (MoP), and gypsum were applied as basal dose to all the experimental plots. The amounts of N, P, K, and S in cowdung and poultry manure were deducted from recommended N, P, K and S fertilizer doses. Urea was applied in three equal splits. The first dose of urea was applied at 15 days after transplanting of rice seedlings. The rest doses of urea were top dressed at 30 days after transplanting (active tillering stage) and 45 days after transplanting (panicle initiation stage). Cowdung, poultry manure and compost were incorporated in the plots as per treatments at 10 days before transplanting of the rice seedlings. The manure was mixed thoroughly with the soil. The chemical composition of the cowdung, poultry manure and compost are presented in Table 3.2

Table 3.2 Nutrient contents in cowdung, poultry manure and compost

Name of manures	Nutrient contents (%)			
	N	P	K	S
Cowdung	0.57	0.47	0.67	0.20
Poultry manure	1.18	1.50	0.98	0.39
Compost	0.89	0.30	0.45	0.46

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Transplanting of rice seedlings

The seedling of BRRI dhan49 was transplanted on 11 August, 2018 maintaining plant spacing of 20cm x 20cm. Three healthy seedlings were transplanted in each hill.

Intercultural operations

Intercultural operations were done for ensuring and maintaining the normal growth of the crop. The following intercultural operations were done.

Irrigation

Necessary irrigations were provided to the plots from the deep tube well as and when necessary during the growing period of the crop.

Weeding

The crop was infested with some weeds that were uprooted by hand weeder at 15 and 40 days after transplanting.

Insect and pest control

There was no serious infestation of insect pest and disease in the field and no control measures were adapted.

Harvesting

The crop was harvested at full maturity on December 22, 2018. The harvested crop of each plot was bundled separately and brought to the threshing floor. Grain and straw yields were recorded plot wise and expressed as t ha^{-1} on 14% moisture basis.

Collection and preparation of plant samples

Five hills were randomly selected from each plot at maturity to record the yield contributing characters like plant height (cm), numbers of total tillers $hill^{-1}$, numbers of effective tillers $hill^{-1}$, panicle length (cm), numbers of spike $panicle^{-1}$, numbers of grains $panicle^{-1}$ and 1000-grain weight (g). The selected hills were collected before crop harvest and necessary information's were recorded accordingly. Grain and straw yields were recorded plot wise and expressed as sun dry basis. Grain and straw samples were kept for chemical analysis.

Procedure of recording data

Plant height

The plant height was measured from the ground level to the top of the panicle. From each plot, plants of 5 hills were measured and averaged.

Panicle length

Measurement was done from basal node of the rachis to apex of each panicle. Each observation was an average of 5 hills.

Number of tillers hill^{-1}

Five hills were taken randomly from each plot and total number of tillers hill^{-1} was recorded. The number of effective tillers hill^{-1} was also recorded.

Number of spikes hill^{-1}

Five spikes were taken randomly from each plot and total number of spikes hill^{-1} was recorded. The number of effective spikes hill^{-1} was also recorded.

Filled grains panicle^{-1}

Five panicles were taken randomly and the filled and unfilled grains panicle^{-1} were counted and averaged.

1000-grain weight

1000-grains were taken from each plot and weighed in an electrical balance.

Grain and straw yields

Grain and straw yields were obtained from each plot and weighed carefully. The yields were expressed as t ha^{-1} and the grain yield was adjusted with 14% moisture basis whereas the straw yield was expressed on sun dry basis.

Chemical analysis of grain and straw samples

Preparation of samples

The representative grain and straw samples were dried in an oven at 65°C for about 24 hours before they were ground by a grinding machine. The prepared sample was then stored in paper bags and finally they were kept into desiccators until analysis.

Digestion of plant samples for total nitrogen determination

For the determination of nitrogen O.1 g oven dry ground plant sample (both grain and straw separately) were taken in a digestion vessel. Into the vessel 1.1 g catalyst mixture (K_2SO_4: $CuSO_45H_2O$: Se=100:10:1), 3 ml 30% H_2O_2 and 5 ml H_2SO_4 were added. The flasks were swirled and allowed to stand for about 10 minutes. Then heating was continued until the digest was clear and colorless. After cooling, the content was taken into 100 ml volumetric flasks and the volumes were made up to the mark with distilled water. A reagent blank was prepared in a similar manner. These digests were used for nitrogen determination.

Digestion of plant samples for P, K and S determination

Plant samples of 0.5g (grain and straw separately) were transferred into 100 ml digestion vessel. Ten ml of di-acid mixture ($HN0_3$: $HCl\ 0_4$ = 2:1) were added into the vessel. After leaving for a while the flasks were heated at a temperature slowly raised to 200°C. Heating was stopped when the dense white fume of $HCl0_4$ occurred. After cooling, the contents were taken into a 50 ml volumetric flask and the volume was made with distilled water. The digests were used for the determination of P, K and S.

Determination of N, P, K and S from plant samples

Nitrogen

Total N content of plant samples was determined following micro-kjeldahl method. After completion of digestion 35% NaOH was added with the digest for distillation. Finally the titration of distillate trapped in H_3B0_3 with 0.01 $(NH_4)_2SO_4$ was done until the color changed from green to pink.

Phosphorus

Phosphorus was extracted from plant sample with 0.5 M $NaHC0_3$ solution at p^H 8.5 following the method of Olsen *et al.* (1954). Using 1 ml digest for grain samples and 2 ml digest for straw sample from 50 ml extract. The phosphorus was determined by developing blue color by $SnC1_2$ reduction of phosphomolybdate complex and the color intensity was measured calorimetrically at 660 nm wave lengths.

Potassium

Potassium was determined by using 5 ml of digest samples for grain and 2 ml for the straw were taken and diluted 50 ml volume to make desired concentration. The K was determined from the extract by using Flame photometer.

Sulphur

Sulphur was determined by using 5 ml digest (both in grain and straw). Sulphur was determined by developing turbidity by adding 1 ml acid seed solution (20 ppm S as K_2SO_4 in 6N HCl) and 0.5 gm $BaCl_2$ crystal. The intensity of turbidity was measured by spectrophotometer at 420 nm wave length.

Statistical analysis

The analysis of variance for crop characters and also for the nutrient content of the plant samples were done following the ANOVA technique and the mean results in case of significant F-value were adjudged by the Duncan's Multiple Range Test (DMRT).

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CHAPTER 4

RESULTS

The experiment was carried out at Soil Science Field Laboratory Khulna University (KU), Khulna during study the response of BRRI dhan49 to nutrients supplied from manures and fertilizers. The results are presented in this chapter. The ANOVAs of different characters of BRRI dhan49 are presented in Appendices.

Yield components of BRRI dhan49

Plant height

The plant height of BRRI dhan49 increased significantly due to application of organic manures and chemical fertilizers (Table 4.1). All the treatments significantly increased the plant height over control and the highest value (94.25 cm) was recorded due to the application of poultry manure @ 3 t ha^{-1} in combination with chemical fertilizers T_3 [PM + STB-CF (HYG)] which was statistically similar with T_2 **[**CD + STB-CF (HYG)]. The lowest plant height (78.88 cm) was obtained in control (T_0). The treatments may be ranked in the order of $T_3 > T_2 > T_4 > T_1 > T_5 > T_0$ in terms of plant height.

Effective tillers hill^{-1}

Table 4.1 reveals the effect of manures and fertilizers on the number of effective tillers hill^{-1}. All the treatments caused an increasing effect on the number of effective tillers hill^{-1}over control. The number of effective tillers hill^{-1} due to different treatments ranged from 9.00 to 13.50 and the minimum number was obtained in the control. The treatment T_3 [PM + STB-CF (HYG)] recorded the highest number of effective tillers hill^{-1} which was similar with T_4 [COM + STB-CF (HYG)].

Panicle length

Panicle length of rice plant was significantly influenced by different treatments (Table 4.1). Panicle length ranged from 19.33 to 25.55 cm. The maximum panicle length of 25.55 cm was recorded in T_3 [PM+ STB-CF (HYG)] treatment which was statistically similar with T_2 [CD+ STB-CF (HYG)] and T_4 [COM+ STB-CF (HYG)] treatments with valued of 25.45cm, 25.38 cm respectively. The lowest panicle length of 19.33cm was recorded in the control (T_0). The treatments T_1 [STB-CF (HYG)] and T_5 (FP) also increased the panicle length over the control.

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Table 4.1 Effect of manures and fertilizers on the yield components of BRRI dhan49

Treatment	Plant height (cm)	Effective tillers hill^{-1}(No.)	Panicle length (cm)	Grain panicle^{-1} (No.)	Filled grains panicle^{-1} (No.)	1000-grain weight (g)
To	78.88e	9.00d	19.33c	112.25d	99.00c	19.27
T_1	91.55c	11.50c	24.13b	128.75c	118.75b	21.45
T_2	93.85ab	12.50b	25.45a	133.50ab	121.25ab	23.24
T_3	94.25a	13.50a	25.55a	133.75a	122.00a	23.35
T_4	92.78bc	13.25a	25.38a	131.00bc	119.50ab	22.51
T_5	90.23d	12.00bc	23.85b	130.25c	118.75b	21.00
SE±	1.10	0.35	0.45	1.58	1.69	0.30
CV (%)	3.34	2.12	2.45	3.58	4.25	6.12
LS	**	**	**	**	**	NS

Figure(s) in a column having common letter (s) do not differ significantly at 5% level of significance.

Grains panicle^{-1}

Results in Table 4.1 shows that the number of grains panicle^{-1} was significantly influenced due to different treatments under study. The number of grains panicle^{-1} ranged from 112.2 to 133.7. The treatment T_3 [PM + STB-CF (HYG)] produced the highest number of grains panicle^{-1} which was statistically similar with T_2 [CD + STB-CF (HYG)]. The lowest value was obtained in the treatment T_0 (112.25). The results indicated that PM and CD had a beneficial effect in producing more grains panicle^{-1}.

Filled grains panicle^{-1}

The number of filled grains panicle^{-1} was significantly increased due to application of organic manures and chemical fertilizers (Table 4.1). The number of filled grains panicle^{-1}varied from 99.00 to 118.75. The highest number of filled grains panicle^{-1}was obtained in T_3 [PM + STB-CF (HYG)] treatment which was statistically similar with the treatment T_2 [CD + STB-CF (HYG)] and T_4 [COM+ STB-CF (HYG)] but significantly superior to rest of the treatments. The treatment T_1 [STB-CF (HYG)] and T_5 (FP) also produced significantly higher number of filled grains panicle^{-1}over control (T_0).

1000-grain weight

Table 4.1 shows the effect of organic manures and chemical fertilizers on 1000-grain weight of BRRI dhan49. The 1000-grain weight was not influenced significantly due to application of organic manures and chemical fertilizers. The 1000-grain weight ranged from 19.27 to 23.35 g. The highest value was obtained in T_3 [PM + STB-CF (HYG)] treatment and the lowest 1000-grain weight was noted in the control (T_0).

Grain yield

Results in Table 4.2 show that the grain yield of BRR1 dhan49 was significantly influenced due to different treatments. The grain yield ranged from 3.61 to 4.87 t ha^{-1}. The lowest grain yield was obtained in the control (To). The highest grain yield was achieved in the treatment T_3 [PM + STB-CF (HYG)] which was identical with T_1 [STB-CF (HYG)] and T_4 [COM + STB-CF (HYG)] treatments. The grain yield due to different treatments may be ranked in the order of T_3> T_1> T_2> T_4 > T_5> T_0. The treatment under study resulted in 18.28% to 34.90% yield increase over control.

The treatment T_3 [PM + STB-CF (HYG)] gave the highest (34.90%) and the lowest (18.28%) yield increase over control, respectively. Table 4.2 reveals that BRRI dhan49 responded better to the nutrients supplied from organic manures rather than to chemical fertilizers.

Straw yield

Straw yield of BRRI dhan49 was also influenced significantly by different treatments under study. The straw yield ranged from 4.10 to 5.51 t ha^{-1} (Table 4.2). It was observed that the treatment T_3 [PM + STB-CF (HYG)] produced the highest straw yield which might be due to quick release of nutrients from poultry manure. The lowest straw yield was obtained in the treatment T_0 (control). The straw yields due to different treatments may be ranked in the order of T_3> T_2> T_4> T_1> T_5>T_0. The treatments under study resulted in 22.43% to 34.39% increase in straw yield over control. Table 4.2 shows that the treatment T_3 [PM + STB-CF (HYG)] gave the highest straw yield increase of 34.39% over control. Table 4.2 also indicates that organic manures served as the better source of nutrients in producing straw yields of rice.

Table 4.2 Effects of manures and fertilizers on the yield of BRRI dhan49

Treatment	Grain yield ($t\ ha^{-1}$)	Increase over control (%)	Straw yield ($t\ ha^{-1}$)	Increase over control (%)
T_0	3.61c	-	4.10c	-
T_1	4.68a	29.64	5.11ab	24.63
T_2	4.59ab	27.15	5.30ab	29.26
T_3	4.87a	34.90	5.51a	34.39
T_4	4.50ab	24.65	5.24ab	27.80
T_5	4.27b	18.28	5.02b	22.43
SE ±	0.10	-	0.10	-
CV (%)	2.55	-	1.99	-
LS	**	-	**	-

Figure(s) in a column having common letter (s) do not differ significantly at 5% level of significance.

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Nutrient content in grain and straw of BRRI dhan49

Nitrogen content

Table 4.3 reveals that nitrogen content in grain and straw of BRRI dhan49 was significantly influenced due to different treatments. The N content in rice grain and straw ranged from 1.156% to 1.294% and 0.575% to 0.678%, respectively. The treatment T_3 [PM + STB-CF (HYG)] resulted the maximum N content both in grain and straw and the minimum value was recorded in the control (To). The N content in grain was comparatively higher than that of straw. The treatments T_1 [STB-CF (HYG)], T_2 [CD + STB-CF (HYG)], T_4 [COM + STB-CF (HYG)] and T_5 (FP) exerted statistically similar effect on the N content of rice grain.

Phosphorus content

Results in Table 4.3 indicate that phosphorus content both in grain and straw of rice was significantly influenced due to the different treatments. In case of grain, phosphorus content varied from 0.201% in control to 0.218% in T_2 [CD + STB-CF (HYG)]. It was observed that the treatment T_2 [CD + STB-CF (HYG)] was statistically similar with T_1 [STB-CF (HYG)], T_2 [CD + STB-CF (HYG)], T_3 [PM + STB-CF (HYG)], T_4 [COM + STB-CF (HYG)] and T_5 (FP) treatments. In case of straw, phosphorus content varied from 0.073% in control to 0.093% in T_2 [CD + STB-CF (HYG)] treatment. The highest value was found in T_2 [CD + STB-CF (HYG)] treatment and the lowest value was recorded in the T_0 (control). All the treatments increased phosphorus content both in grain and straw compared to the control. The grain P content was higher in all the treatments than that of the straw.

Table 4.3 Effect of manures and fertilizers on N, P, K and S content of BRRI dhan49

Treatment	Grain (%)				Straw (%)			
	N	P	K	S	N	P	K	S
T_0	1.156b	0.201b	0.199c	0.119b	0.575	0.073b	1.097d	0.093
T_1	1.211ab	0.211ab	0.217b	0.123ab	0.637	0.081ab	1.167c	0.102
T_2	1.260a	0.218a	0.234a	0.137a	0.665	0.093a	1.299a	0.113
T_3	1.294a	0.215ab	0.243a	0.138a	0.678	0.092a	1.277a	0.119
T_4	1.246a	0.213ab	0.231ab	0.128ab	0.658	0.088ab	1.223b	0.106
T_5	1.225ab	0.208ab	0.217b	0.122ab	0.616	0.080ab	1.198bc	0.100
SE ±	0.013	0.001	0.004	0.002	0.011	0.002	0.015	0.002
CV (%)	2.05	3.36	6.25	6.78	3.58	5.47	4.58	5.21
LS	*	**	**	**	NS	**	**	NS

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Potassium content

Potassium content both in grain and straw was affected positively and significantly due to application of organic manures and chemical fertilizers (Table 4.3). Potassium content in grain due to different treatments varied from 0.199% to 0.243%. The highest value was found in T_3 [PM + STB-CF (HYG)] treatment. The lowest value was recorded in the T_O (control). In case of straw, potassium content ranged from 1.097% to 1.299%. The highest K content was found in the treatment T_2 [CD + STB-CF (HYG)] which was statistically similar with T_3 [PM + STB-CF (HYG)] but significantly different from all other the treatments. It was observed that the K content in rice straw was higher than that in grain in all the treatments.

Sulphur content

Results in Table 4.3 indicate that sulphur content both in grain and straw of rice was significantly influenced by different treatments. The S content in rice grain and straw ranged from 0.119% to 0.138% and 0.093% to 0.119%, respectively. The treatment T_3 [PM + STB-CF (HYG)] resulted the maximum N content both in grain and straw and the minimum value was recorded in the control (To). All the treatments caused an increasing effect on the S content of rice grain and the effect of poultry manure was more pronounced compared to cowdung and fertilizer nitrogen and also, sulphur and zinc.

Nutrient uptake by BRRI dhan49

Nitrogen uptake

Results in Table 4.4 indicate that the N uptake by grain and straw of BRRI dhan49 was significantly influenced due to different treatments. The N uptake by grain and straw ranged from 41.83 to 63.01 kg ha^{-1} and 23.5 to 37.20 kg ha^{-1}, respectively. The maximum N uptake by grain was recorded in T_3 [PM + STB-CF (HYG)]. The minimum N uptake of 41.83kg ha^{-1} was recorded in the control. The treatment T_3 was statistically similar with T_1 [STB-CF (HYG)], T_2 [CD + STB-CF (HYG)], and T_4 [COM+ STB-CF (HYG)] but significantly different from other treatments. Poultry manure was found superior to inorganic fertilizers and increased the N uptake in all the cases. The maximum N uptake by straw was recorded in T_3 [PM + STB-CF (HYG)] treatment which was statistically similar with the treatments T_2 [CD + STB-CF (HYG)] and T_4 [COM + STB-CF (HYG)] but significantly different from all other treatments. The minimum N uptake by straw of 23.53 kg ha^{-1} was recorded in the control.

The highest total N uptake of 100.21 kg ha^{-1} by BRRI dhan49 was recorded in T_3 [PM + STB-CF (HYG)] treatments. The total N uptake due to different treatments may be ranked in order of $T_3>T_2>T_4>T_1>T_5>T_0$. Results in Table 4.4 further shows that N uptake by grain was higher than that by straw.

Table 4.4Effect of manures and fertilizers on N and P uptake by BRRI Dhan49

Treatment	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})		
	Grain	**Straw**	**Total**	**Grain**	**Straw**	**Total**
T_0	41.83c	23.53c	65.36d	7.25d	2.98d	10.22d
T_1	56.66ab	32.53b	89.19bc	9.84ab	4.14c	13.98b
T_2	57.80ab	35.26ab	93.06ab	10.00ab	4.90ab	14.90ab
T_3	63.01a	37.20a	100.21a	10.46a	5.05a	15.51a
T_4	56.02ab	34.44ab	90.46bc	9.55bc	4.59b	14.14b
T_5	52.42b	30.98b	83.41c	8.87c	4.02c	12.89c
SE ±	1.59	1.02	2.46	0.24	0.15	0.38
CV (%)	4.58	5.47	3.85	6.45	7.55	8.96
LS	**	**	**	**	**	**

Figure(s) in a column having common letter (s) do not differ significantly at 5% level of significance.

Phosphorus uptake

Results in Table 4.4 show that the P uptake by BRRI dhan49 both in grain and straw was significantly influenced by different treatments. The ranges of P uptake observed in grain and straw were 7.25 to 10.46 kg $ha^{-1}$and 2.98 to 5.05 kg ha^{-1}, respectively. The highest P uptake by grain was recorded in T_3 [PM + STB-CF (HYG)] treatment. The lowest P uptake by grain was found in the control. In case of straw, the highest P uptake was recorded in T_3 [PM + STB-CF (HYG)] treatment which was statistically similar T_2 [CD + STB-CF (HYG)] treatments. The lowest value was recorded the control (T_0). The treatments T_1 [STB-CF (HYG)] and T_5 (FP) was statistically similar in their effects on P uptake by straw**.**

Total P uptake by grain and straw was also significantly influenced by the various treatments. The total P uptake by BRRI dhan49 varied from 10.22 to 15.51 kg ha^{-1}. The highest total P uptake was recorded in the T_3 [PM + STB-CF (HYG)] treatment and the lowest value was recorded in the control (T_0). The treatment T_3 [PM + STB-CF (HYG)] was statistically similar with T_2 [CD + STB-CF (HYG)] treatments. The total P uptake by BRRI dhan49 due to different treatments ranked in the order of $T_3 > T_2 > T_4 > T_1 > T_5 > T_0$.

Potassium uptake

Potassium uptake by BRRI dhan49 was significantly affected due to the application of manures and chemical fertilizers (Table 4.5). The K uptake by grain varied from 7.20 to 11.80 kg ha^{-1} while the values for straw ranged from 44.98 to 70.36 kg ha^{-1}. The highest K uptake of 11.80 kg ha^{-1} by grain was recorded in T_3 [PM + STB-CF (HYG)] treatment which was statistically similar with the treatments T_2 [CD+ STB-CF (HYG)] treatments. In case of straw, the highest K uptake of 70.36 kg ha^{-1} was also recorded in T_3 [PM+ STB-CF (HYG)] treatment which was statistically similar with the treatments T_2 [CD + STB-CF (HYG)] but significantly superior to all other treatments. The total K uptake by BRRI dhan49 was also influenced significantly due to the application of organic manures and chemical fertilizers. The total K uptake by BRRI dhan49 ranged from 52.18 to 82.16 kg ha^{-1}. The highest and lowest total K uptakes were recorded in T_3 [PM + STB-CF (HYG)] and in control (T_0), respectively.

Table 4.5 Effect of manures and fertilizers on K and S uptake by BRRI dhan49

Treatment	K uptake (kg ha^{-1})			S uptake (kg ha^{-1})		
	Grain	**Straw**	**Total**	**Grain**	**Straw**	**Total**
T_0	7.20d	44.98d	52.18d	4.28d	3.80d	8.08e
T_1	10.15bc	59.59c	69.74c	5.73bc	5.19c	10.92cd
T_2	10.73ab	68.83ab	79.56ab	6.27ab	5.98ab	12.24ab
T_3	11.80a	70.36a	82.16a	6.71a	6.52a	13.24a
T_4	10.36bc	64.15bc	74.50bc	5.76bc	5.56bc	11.31bc
T_5	9.27c	60.09c	69.36c	5.21c	5.01c	10.22d
SE ±	0.33	1.87	2.15	0.18	0.19	0.36
CV (%)	12.14	4.58	5.58	6.33	6.58	7.28
LS	0.614	2.960	3.191	0.277	0.289	0.514

Figure(s) in a column having common letter (s) do not differ significantly at 5% level of significance.

Sulphur uptake

Sulphur uptake by BRRI dhan49 was significantly increased due to the application of organic manures and chemical fertilizers (Table 4.5). Sulphur uptake by grain and straw ranged from 4.28 to 6.71 kg ha^{-1} and 3.80 to 6.52 kg ha^{-1}, respectively**.** In case of grain, the highest S uptake was recorded in T_3 [PM + STB-CF (HYG)] treatment. The lowest uptake was recorded in the control. The treatment T_3 [PM + STB-CF (HYG)] was statistically identical with T_2 [CD + STB-CF (HYG)] but significantly different from all other treatments**.** In case of straw, the highest S uptake by BRRI dhan49 was recorded in T_3 [PM + STB-CF (HYG)] treatment. The treatment T_3 [PM + STB-CF (HYG)] was statistically similar with T_2 [CD + STB-CF (HYG)] but significantly different from all other treatments. The lowest uptake was recorded in control (T_0). The amount of S uptake both in grain and straw was significantly higher over control.

The total S uptake was also significantly influenced by different treatments. The total S uptake ranged from 8.08 to 13.24 kg ha^{-1}. The treatment T_3 [PM + STB-CF (HYG)] gave the highest total S uptake which was statistically similar with T_2 [CD + STB-CF (HYG)] treatments but significantly different from all other treatments. The total S uptake by BRRI dhan49 due to different treatments ranked in the order of $T_3 > T_2 > T_4 > T_1 > T_5 > T_0$.

CHAPTER 5

DISCUSSIONS

In the present study the effects of manures and fertilizers on the growth parameters and yield as well as nutrient content and uptake by BRRI dhan49 has been elaborated. From the results it is observed that the yield contributing characters such as plant height, number of effective tillers hill^{-1}, panicle length, grains panicle^{-1}, filled grains panicle^{-1}, and 1000-grain weight are higher in T_3 treatment where poultry manure was applied in combination with fertilizers on IPNS basis as compared to those observed in other treatments. Organic manures were found better source of nutrients regarding their effects on yield attributes of rice. Among the manures, the poultry manure showed superior performance on the plant height. This might be due to slow release of nutrients from poultry manures and efficient utilization of nutrients by plants. These results are in agreement with Parvez *et al.* (2008) who observed that the plant height of rice was significantly influenced by the incorporation of organic manures and fertilizers. The effect of poultry manure and cowdung was more pronounced in producing the number of effective tillers hill^{-1} as compared to chemical fertilizers. These results are well corroborated with the findings of Rajni Rani *et al.* (2001) who found increased number of effective tillers hill^{-1} with the integrated use of vermicompost, PM and nitrogenous fertilizers in rice. The results reveal that cowdung, compost and poultry manure and compost influenced markedly the panicle length. These results are in agreement with Singh *et al.* (2005) who found increased panicle length with the application of urea, cowdung, and Azospirillum, individually or in combinations. A significant increase in panicle length due to of organic manures and fertilizers nitrogen, sulphur, zinc and boron was also noted by Hoque (1999) and Azim (1999). Mondal *et al.* (1990) observed that the number of spikelet's panicle^{-1} of rice was increased with the increasing NPK rates and FYM application. Similar results were also reported by Chander and Pandey (1996). Razzaque (1996) noted a significant increase in grains panicle^{-1} due to application of organic manures and fertilizer nitrogen. The effect of poultry manure was more pronounced in producing filled grains panicle^{-1}. Umanah *et al.* (2003) reported that poultry manure increased the grains per panicle. Azim (1999) and Hoque (1999) noted significant increase in filled grains panicle^{-1}with the application of organic manures and fertilizers. These results are well corroborated with the findings of Rahman *et al.* (2009) who found an insignificant response of urea-N and manures on 1000-grain weight of BRRI dhan29.

Poultry manure was found more effective in producing grain yields of BRRI dhan49 as compared to the cowdung and chemical fertilizers. These results are in agreement with the findings of Rajni Rani *et al.* (2001), Rahman *et al*. (2009) and Parvez *et al.* (2008). **P**oultry manure also demonstrated superior effect in producing straw yield of rice as compared to cowdung and chemical fertilizers. Ahmed and Rahman (1991) reported that the application of organic manure and chemical fertilizers increased straw yields of rice.

It is clear that the application of organic manures had positive influences on the N uptake by BRRI dhan49. Significant increase in N uptake by rice grain and straw with the application of organic manures and fertilizers was reported by Azim (1999) and Hoque (1999). Dongarwar *et al.* (2003) observed that the P uptake by rice grain was increased with the combined application of manures and fertilizers. Rahman *et al.* (2009) also found similar results with a trial on BRRI dhan29 using urea and manures. All the treatments receiving poultry manure and cowdung significantly increased the total K uptake by rice. It was observed that the K uptake by grain was much less than that by straw. These results are well corroborated with Meena *et al.* (2003) who reported that application of organic manure and chemical fertilizers significantly increased the K uptake by rice. The S uptake by rice was also influenced significantly due to application of manures and fertilizers. These results are in agreement with Akter (2011) and Malika (2011) who found positive effects on S uptake by rice with application of manures and fertilizers.

CHAPTER 6

SUMMARY

An experiment was conducted at the Soil Science Field Laboratory Khulna University (KU), Khulna during aman season of 2018 with a view to evaluating effects of manures and fertilizers for maximizing the yield of BRRI dhan49. The soil of the experimental site belongs to the 'Sonatala' series under the AEZ-9 (Old Brahmaputra Floodplain). The soil was silt loam in texture containing pH 6.18, organic matter content 2.15%, total N 0.124%, available P 6.51 ppm, exchangeable K 0.074 me/100 g soil, available S 14.85 ppm and CEC 12.5 me/100 g soil. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 6 treatments andfour replications. The treatments were T_0 [Control], T_1 [STB-CF (HYG)], T_2 [CD + STB-CF (HYG)], T_3 [PM + STB-CF (HYG)], T_4 [COM+ STB-CF (HYG)] and T_5 (FP). Organic manures were applied to the plots 10 days before transplanting of rice seedlings and the manures were mixed thoroughly with the soil. The recommended doses of N, P, K and S supplied from urea, TSP, MoP and gypsum were 90, 15, 60 and 15 kg ha^{-1}, respectively. The TSP, MoP and gypsum were applied to the plots as basal during final land preparation. Urea was applied in three equal splits. Thirty five days old seedlings were carefully uprooted from a seedbed and transplanted in the experimental plots maintaining three seedlings per hill and 20 cm x 20 cm plant spacing. Intercultural operations were done for ensuring and maintaining proper growth and development of crop. At maturity, the crop was harvested. Grain and straw yields were recorded and the grain yield was expressed on 14% moisture basis while the straw yields on sundry basis. The grain and straw samples were analyzed for N, P, K and S contents. Then nutrient uptake was calculated. All the data were statistically analyzed by F-test and the mean differences were adjudged by Duncan's New Multiple Range Test (DMRT). The results of the experiment are summarized below.

Application of manures and fertilizers had a significant effect on the yield components of BRRI dhan49. The tallest plant height of 94.25 cm was found in T_3 [PM + STB-CF (HYG)]. The shortest plant of 78.88 cm was obtained in control (T_0). The maximum panicle length of 25.55 cm was recorded in T_3 [PM + STB-CF (HYG)] treatment and the lowest panicle length of 19.33 cm was recorded in the control (T_0). The number of effective tillers $hill^{-1}$ due to different treatments ranged from 9.00 to 13.50 and the minimum number was obtained in the control. The number of grains $panicle^{-1}$ ranged from 112.25 to 133.75. The treatment T_3 [PM + STB-CF

(HYG)] produced the highest number of grains panicle^{-1}. The lowest value was obtained in the treatment T_0 (112.25). The number of filled grains panicle^{-1}varied from 99.00 to 118.75. The highest number of filled grains panicle^{-1}was obtained in T_3 [PM + STB-CF (HYG)] treatment. The lowest number of filled grains panicle^{-1} was obtained in T_0 treatment and 1000-grain weight were significantly influenced due to different treatments. It may be mentioned here that the application of organic and inorganic fertilizers showed the better performance in the yield components of rice.

The grain and straw yields of BRRI dhan49 responded significantly to the application of manures and fertilizers. The grain yield ranged from 3.61 to 4.87 t ha^{-1}. The lowest grain yield was obtained in the control (To). The highest grain yield was achieved in the treatment T_3 [PM + STB-CF (HYG)]. The straw yield was also significantly influenced due to combined use of manures and fertilizers. The straw yield ranged from 4.10 to 5.51 t ha^{-1}. It was observed that the treatment T_3 [PM + STB-CF (HYG)] produced the highest straw yield which might be due to supply of higher amount of slow release N from poultry manure. The lowest straw yield was obtained in the treatment T_0 (control).

The NPKS contents of BRRI dhan49 varied significantly due to the addition of manures and fertilizers. The N content in rice grain and straw ranged from 1.156% to 1.294% and 0.575% to 0.678%, respectively. The treatment T_3 [PM + STB-CF (HYG)] resulted the maximum N content both in grain and straw and the minimum value was recorded in the control (To). The N content in grain was comparatively higher than that of straw. In case of grain, phosphorus content varied from 0.201% in control to 0.218% in T_2 [CD + STB-CF (HYG)]. The grain P content was higher in all the treatments than that of the straw. The treatment T_2 [CD + STB-CF (HYG)] resulted the highest phosphorus content both in grain and straw of rice. Potassium content in grain due to different treatments varied from 0.199% to 0.243%. The highest value was found in T_3 [PM + STB-CF (HYG)] treatment. The lowest value was recorded in the T_0 (control). In case of straw, potassium content ranged from 1.097% to 1.299%. It was observed that the K content in rice straw was higher than that in grain in all the treatments. In case of grain, sulphur content varied from 0.119% to 0.138%. The treatment T_3 [PM + STB-CF (HYG)] resulted the maximum N content both in grain and straw and the minimum value was recorded in the control (To). Sulphur content in grain was higher than that of straw. Organic manures influenced greatly in increasing the S content in grain and straw compared to cowdung and fertilizers.

There was also a significant effect of different treatments on NPKS uptake by grain and straw of BRRI dhan49. The N uptake by grain and straw ranged from 41.83 to 63.01 kg ha^{-1} and 23.53 to 37.20 kg ha^{-1} respectively. The maximum N uptake by grain was recorded in T_3 [PM+ STB-CF (HYG)]. The minimum uptake of 41.83kg $ha^{-1}$was recorded in the control. The minimum N uptake by straw of 23.53 kg ha^{-1} was recorded in the control. The highest total N uptake of 100.21kg ha^{-1} by BRRI dhan49 was recorded in T_3 [PM + STB-CF (HYG)] treatments. The ranges of P uptake observed in grain and straw were 7.25 to 10.46 kg $ha^{-1}$and 2.98 to 5.05 kg ha^{-1}, respectively. The highest P uptake by grain was recorded in T_3 [PM + STB-CF (HYG)] treatment. The lowest P uptake by grain was found in the control. In case of straw, the highest P uptake was recorded in T_3 [PM + STB-CF (HYG)] treatment. The lowest value was recorded the control (T_0). Total P uptake by grain and straw was also significantly influenced by the various treatments. The total P uptake by BRRI dhan49 varied from 10.22to 15.51 kg ha^{-1}. The highest total P uptake was recorded in the T_3 [PM + STB-CF (HYG)] treatment and the lowest value was recorded in the control (T_0). The total P uptake by BRRI dhan49 due to different treatments ranked in the order of T_3> T_2> T_4> T_1>T_5>T_0. The K uptake by grain varied from 7.20 to 11.80 kg ha^{-1} while the values for straw ranged from 44.98 to 70.36 kg ha^{-1}. The highest K uptake of 11.80 kg ha^{-1} by grain was recorded in T_3 [PM + STB-CF (HYG)]. In case of straw, the highest K uptake of 70.36 kg ha^{-1} was also recorded in T_3 [PM + STB-CF (HYG)] treatment. The total K uptake by BRRI dhan49 ranged from 52.18 to 82.16 kg ha^{-1}. The highest and lowest total K uptakes were recorded in T_3 [PM + STB-CF (HYG)] and in control (T_0), respectively. Sulphur uptake by grain and straw ranged from 4.28 to 6.71 kg ha^{-1} and 3.80 to 6.52 kg ha^{-1}, respectively. In case of grain and straw, the highest S uptake was recorded in T_3 [PM + STB-CF (HYG)] and T_0 (Control) treatment. The total S uptake ranged from 8.08 to 13.24 kg ha^{-1}. The total S uptake by BRRI dhan49 due to different treatments ranked in the order of T_3> T_2> T_4> T_1> T_5> T_0.

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CHAPTER 7

CONCLUSIONS

From the present study it is observed that the application of manures and fertilizers showed better performance in respect of grain yield and yield contributing characters, nutrient content and nutrient uptake as compared to the application of fertilizers only. The performance of poultry manure was better than that of cowdung and compost for the growth and yield of rice. Application of poultry manure @ 3 t ha^{-1} in association with chemical fertilizers will be rewarding for the maximization of rice yield.

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Appendix 1: Monthly average temperature, rainfall, relative humidity, sunshine hour during the research period (August to December, 2011) at BAU campus, Mymensingh

Month	Air Temperature (0^0C)			Relative humidity (%)	Rain fall ((mm)	Sunshine (hrs)
	Maximum	Minimum	Average			
August	31.32	26.28	28.08	86.94	741.00	119.50
September	32.17	26.08	29.13	84.43	239.50	171.00
October	32.34	23.78	28.06	76.45	17.10	229.10
November	28.75	16.87	22.81	82.23	00.00	208.90
December	24.48	13.64	19.06	83.58	00.00	155.30

Source: Weather yard, Dept. of Irrigation and water management, BAU, Mymensingh.

Appendix 2: Analysis of variance for various yield contributing characters and yield of BRRI dhan49

Source of variation	Degree of freedom	Plant height (cm)	Effective tillers $hill^{-1}$	Panicle length (cm)	Grain $panicle^{-1}$	Filled grain $panicle^{-1}$	1000-grain weight(g)	Grain yield	Straw yield
Replication	3	0.207	0.708	0.043	7.611	4.708	0.479	0.096	0.042
Factor A	5	133.133**	10.642**	22.617**	260.5**	302.542**	15.214**	0.777**	0.968**
Error	15	0.153	0.775	0.048	3.011	3.008	0.421	0.057	0.061

Appendix 3: Analysis of variance for NPKS content by BRRI dhan49

Source of variation	Degree of freedom	N(grain)	N (straw)	P(grain)	P (straw)	K(grain)	K (straw)	S(grain)	S (straw)
Replication	3	0.003	0.001	0.002	0.002	0.001	0.004	0.002	0.002
Factor A	5	0.009*	0.006NS	0.0002**	0.0002**	0.001**	0.022**	0.001**	0.001**
Error	15	0.003	0.003	0.0001	0.0001	0.0001	0.001	0.0001	0.0001

Appendix 4: Analysis of variance for NPKS uptake by BRRI dhan49

Source of variation	Degree of freedom	N Uptake			P Uptake			K Uptake			S Uptake		
		Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Replication	3	28.969	0.965	26.525	0.843	0.104	0.709	0.633	6.219	6.903	0.44	0.055	0.399
Factor A	5	204.071**	92.81**	567.327**	5.271**	2.289**	14.15**	9.795**	334.161**	454.557**	2.871**	3.498**	12.638**
Error	15	18.868	7.392	28.159	0.248	0.07	0.466	0.663	15.426	17.935	0.135	0.147	0.466