EFFECT OF DIFFERENT ORGANIC AND INORGANIC FERTILIZERS ON SOIL FERTILITY AND THE YIELD OF BORO RICE (BRRI Dhan29)

A THESIS

BY

MST. MASKURA KHATUN

Student No. 1605350

Semester: July-December, 2017

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MASTER OF SCIENCE (MS)

IN

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DECEMBER, 2017

DEDICATED

TO

MY BELOVED

PARENTS

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The Author

ABSTRACT

A field experiment was carried out at the Research Field, Department of Soil Science, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during the period from December 2016 to May 2017 in Rabi season to evaluate the efficacy of different organic and inorganic fertilizers on soil fertility and the yield of Boro rice (BRRI Dhan29). The experiment was laid out in a Randomized Complete Block Design (RCBD) having eight treatments with three replications. The treatments were as follows; T_0: Control, T_1: 100% $N_{75}P_{12}K_{45}S_9$ (Recommended dose), T_2: 50% NPKS + 6 t cowdung ha^{-1}, T_3: 75% NPKS + 3 t cowdung ha^{-1}, T_4: 50% NPKS + 6 t poultry manure ha^{-1}, T_5: 75% NPKS + 3 t poultry manure ha^{-1}, T_6: 50% NPKS + 6 t vermicompost ha^{-1} and T_7: 75% NPKS + 3 t vermicompost ha^{-1}. The experimental soil belongs to the Old Himalayan Piedmont Plain (AEZ-1). The soil was sandy loam in texture having pH 5.97, organic matter content 0.98%, total N 0.05%, available P 11.21 ppm, exchangeable K 0.10 m.e.100 g^{-1} soil and available S 11.01 ppm. Application of organic and inorganic fertilizers resulted in a considerable influence on the properties of the post-harvest soils such as the highest pH (6.02) was recorded from T_4 and T_6, maximum levels of organic matter content (1.54%), total N (0.08%), available P (22.10ppm) and available S (16.51ppm) were found in T_4, the highest exchangeable K (0.16) was observed in T_6. At harvest stage the tallest plant (94.37 cm) and the greatest number of total tiller per hill (22.10) was recorded from T_4 and the lowest was observed in T_0 treatment. The longest panicle (26.48 cm), maximum number of total grain per plant (178.3), the highest weight of 1000 seeds (21.96 g), the maximum grain yield (10.33 t ha^{-1}) and straw yield (15.67 t ha^{-1}) was recorded from T_4 treatment whereas the lowest number of effective tillers per hill (8.89) , the shortest panicle (18.21 cm), the minimum total grain per plant (102.4) , the lowest weight of 1000 seeds (17.10 g), the lowest grain yield (4.63 t ha^{-1}) and straw yield (6.73 t ha^{-1}) was observed from T_0 treatment. Although the highest biological yield was recorded from T_4 treatment but statistically similar result was found from T_5 treatment. It was obvious that fertility of soil and yield of rice can be increased substantially with the judicious application of organic manure with chemical fertilizer. The findings of the study showed that the performance of the treatment T_4 was the best among all treatments. This study recommends that amendment of soil with 50% NPKS + 6 t poultry manure ha^{-1} might be an efficient practice for achieving sustainable soil fertility and crop yield.

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ABBREVIATIONSANDACRONYMS

AEZ	:	Agro Ecological Zone
ANOVA	:	Analysis of Variance
BARI	:	Bangladesh Agricultural Research Institute
BAU	:	Bangladesh Agricultural University
BBS	:	Bangladesh Bureau of Statistics
DAP	:	Diammonium Phosphate
et al.	:	And others
FAO	:	Food and Agricultural Organization
Fig.	:	Figure
ha	:	Hectare
K	:	Potassium
MOP	:	Muriate of Potash
N	:	Nitrogen
P	:	Phosphorous
PPM	:	Parts Per Million
S	:	Sulphur
SOP	:	Sulphate of Potash
TSP	:	Triple Super Phosphate
t ha^{-1}	:	Ton per hectare
UNDP	:	United Nations Development Programme
Viz.	:	Namely

CHAPTER I

INTRODUCTION

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INTRODUCTION

Rice (*Oryza sativa*) is the staple food of Bangladesh. Rice plays absolutely dominant role in Bangladesh agriculture as it covers 77.96 percent of total cropped area (AIS, 2007). Among the three types of rice, boro rice covers about 54.56% of total rice area, which contributes 41.94% of the total rice production in the country (BBS, 2016). Rice is intensively cultivated in Bangladesh covering about 80% of arable land. Unfortunately, the yield of rice is low considering the other rice growing countries like Japan and China where the average yield is 6.7 and 6.3 t ha^{-1}, respectively (FAO, 2004). Continuous use of inorganic fertilizers leads to deterioration in soil physical, chemical and biological properties. It is true that sustainable production of crops cannot be maintained by using only chemical fertilizers and similarly it is not possible to obtain higher crop yield by using organic manure alone (Bair, 1990). A judicious combination of organic and inorganic sources of nutrients is necessary for sustainable agriculture that can ensure food production with high quality (Nambiar, 1991). 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.

Fertilizer is a major input of modern farming contributing about 50% of the world’s crop production (Pradhan, 1992). In intensive cropping, continuous use of high levels of chemical fertilizers often leads to nutritional imbalance in soil and decline crop productivity (Nambair, 1994).

Use of organic matter to meet the nutrient requirements of crops would be an invertible practice in years to come, particularly for resource poor farmers. Furthermore, ecological and environment concerns over the increased and indiscriminate uses of inorganic fertilizers have made research on uses of organic materials as sources of nutrients very necessary (Giller, 1995) (Ayoub, 1999).

The long-term research at BARI revealed that the application of cowdung @ 5 t ha^{-1} $year^{-1}$ 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^{-1} poultry manure along with 60 kg N ha^{-1} as urea produce grain yield of crop similar to that with 120 kg N ha^{-1} as urea alone. Organic manure can supply a good amount of plant nutrients and therefore can contribute to crop yields. Therefore, it is necessary to use fertilizer and manure in an integrated way in order to obtain sustainable crop yield without declining soil fertility. The increasing land use intensity has resulted in a great exhaustion of nutrient in soils. In Bangladesh, most of the cultivated soils have less than 1.5% organic matter while a good agricultural soil should contain at least 2% organic matter.

It is well known that inorganic fertilizers supply only nutrients in soil but organic manure supplies nutrients and at the same time improves soil quality. The long term impact of chemical fertilizers on soils and environment is harmful. Use of unbalanced nutrients in the soils may be harmful in the long run causing soils an unproductive one. Sustainable production of crops cannot be maintained by using chemical fertilizers and similarly higher yield cannot possible by using only organic manures. Proper identification and management of soil fertility problems are prerequisite for boosting crop production and sustaining higher yields over a long period of time. So use of organic manure in integration with inorganic fertilizers is very important in improving soil fertility and crop productivity.

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. 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 given on the utilization of organic wastes, farm yard manure (FYM), compost, vermicompost and poultry manures as the most effective measure for the improving soil fertility and thereby crop productivity. 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.

Therefore this study will be conducted to develop a suitable integrated dose of inorganic fertilizers and organic manures (cowdung, PM and vermicompost) for Boro rice and to observe the effects of different levels of inorganic fertilizers and organic manures on the yield as well as soil fertility. The present investigation was conducted with the following objectives:

1. To study the combined application of organic & inorganic fertilizer on the yield of rice.
2. To develop a suitable integrated dose of inorganic fertilizers and organic manures for Boro rice.
3. To study the effect of organic & inorganic fertilizers on the soil fertility.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

A number of research works have been done on the Effect of different organic manures & inorganic fertilizers on soil fertility and the yield of rice in different rice growing countries including Bangladesh. A better understanding of the effects of manures and fertilizers on rice in local soils may facilitate the development of suitable soil management practices for better production of this crop. In this episode, an attempt has been made to review some of the available research related to this study. Available information are reviewed and presented here under different suitable sub-heads.

2.1 Effects of organic fertilizers on the growth, yield and soil fertility of rice

Sharma *et al.* (2001) stated that organic matter is an important soil component influencing the physical, chemical and microbiological properties of soil to a great extent. All physical properties of soil are affected by changes in organic matter levels of soil. Decrease in bulk density with the addition of organic matter has been reported by many workers.

Bhattacharya *et al.* (2003) reported significantly higher plant height both at 45 and 90 days after transplanting of rice with 9.0 t FYM and 1.0 liter humic acid ha^{-1} both being at par. The application of 7.0 t FYM and 1.0 liter humic acid ha^{-1} resulted in the highest dry matter accumulation at 45 and 90 days after transplanting.

Mann and Ashraf (2000) reported that organic manures increased soil organic matter content and thus total nitrogen.

Sharma (1983) revealed that applications of organic manures have significant effect on growth and development of crop plants with the application of FYM @ 10 t ha^{-1} to each crop in a rice-wheat sequence.

Sharma (1992) reported a significant increase in the plant height, number of shoots m^{-2} and dry matter accumulation of both rice and wheat crops at Palampur. The residual effect of FYM @ 10 t ha^{-1} applied to preceding crop of rice/wheat was also significant on plant growth of the succeeding crop over no FYM.

Studies of Abeysekerra *et al.* (2001) documented that organic manures enhanced the mineral nitrogen contents in the soil irrespective of the source of green manure.

Suresh *et al.* (2000) while studying the effect of application of enriched FYM with single super phosphate and phospho-bacteria in rice found significant improvement in crop emergence, plant height, leaf area index and panicle m^{-2}.

Mondal *et al.* (1990) stated that the number of panicles m^{-2} and spikelets per panicle, percentage of filled grains and 1000-grain weight increased with increasing NPK rates and FYM application.

Singh *et al.* (1996) opined that a significant increase in grain and straw yields of rice and wheat was obtained with the application of 10t FYM ha^{-1} to rice.

Chettri *et al.* (2003) from Bhutan reported that the Farmers' practice of applying seven tons farmyard manure per hectare appeared adequate to produce stable rice yields of 4-6 t ha^{-1}.

Mann and Ashraf (2000) from Pakistan stated that high rate of farmyard manure (20 t ha^{-1}) in combination with lower N (49 kg ha^{-1}) gave significant increase in paddy yield.

Mannan *et al.* (2000) documented that manuring with cowdung up to 10 t ha^{-1} in addition to recommended inorganic fertilizers with late N application improved grain and straw yields and quality of autumn rice over the inorganic fertilizer alone.

Azim *et al.* (1999) stated that application of manures alone or in combination with fertilizers exerted positive significant influence on grain and straw yield of BRRI Dhan29.

Saitoh *et al.* (2001) conducted an experiment to evaluate the effects of organic fertilizers (cowdung and chicken manure) and pesticides on the growth and yield of rice and revealed that the yield of organic manure treated and pesticide free plot was 10% lower than that of chemical fertilizers and pesticide treated plot due to a decrease in the number of panicles.

Russo (2001) conducted a field trail to compare the effect of organic fertilizer and traditional fertilizers N, P, K total of 200-150-200 units. The results were found as the plot treated with traditional fertilizer suffered from plant disease and damaged by lodging. So, the yields were found more than twice from the organic fertilizer plot. It was also observed that the straw yields from the traditional fertilizer were very much higher.

Reddy *et al.*(2004) carried out a field experiment for two years (2001 and 2002) on the farmers' field in the Kolar District (eastern dry zone, Karnataka, India) to study the effects of different organic manures on the growth and yield of paddy under tank irrigation. Application of poultry manures (9) or sewage sludge (9 t ha^{-1}) to paddy produced grain yields at par with recommended doses of fertilizers + 10 tons of farmyard manure (FYM), but both were higher (67 and 69%, respectively) then FYM of urban compost alone. Poultry manure and sewage sludge produced better growth components, viz., plant height and number of tillers per hill, total dry matter per plant and yield components like number of panicles per hill and panicle weight.

Umanah *et al.* (2003) studied the effects of different rates of poultry manure on the growth, yield components and yield of upland rice cv. Faro 43 in Nigeria, during the 1997 and 1998 early crop production seasons. The treatments were 0, 10, 20 and 30 t poultry manure ha^{-1}. There were significant differences in plant height, internode length, tiller number, panicle number stand^{-1}, grain number panicle^{-1} and dry grain yield. However, there was no significant difference among treatments for 100 grain weight.

2.2 Effects of inorganic fertilizers on the growth and yield of rice

At a study by Jaggi *et al.* (2001) found that to meet the demand of the current population of more than one billion in India, the estimated minimum food grain production target is 230 million tones. The estimated nutrient removal to produce the targeted food grains and other agricultural crops is around 34.33 million tons as against the fertilizer consumption of about 18 million tons leaving a gap of about 16.33 million tons. Thus, widening gap between nutrient addition and crop removal has resulted in deterioration of soil health.

The chemical fertilizers are invariably applied to meet the nutritional requirements of the crops. However, these materials are also known to influence the physico-chemical properties of soil. Among various chemical fertilizers, the less mobile fertilizers in soil system exert more pronounced effect on soil properties by way of their accumulation in soil when used continuously for long time. Long-term fertilizer trials in rice-wheat cropping system by Swarup and Singh (1989) showed significant reduction in available N, P and K contents in plots where no fertilizer was applied.

Narang *et al.* (1990) reported appreciable improvement of organic carbon, available P and K after two years use of chemical fertilizers. Similarly, long-term fertilizer studies in rice-wheat cropping system by Brar *et al.* (1995) indicated significant increase in organic carbon, available P and K in soil with increase in fertilizer levels beside meagre improvement in available N status.

Based upon long-term fertilizer studies in rice-wheat cropping system at various locations in India, Hegde (1998) reported an increase in organic carbon, available N, P and K status in soil with increase in fertilizer levels. Increase in organic carbon, bulk density and available water capacity with increase in NPK levels was also reported by Sarkar (1998).

In long-term fertilizer experiment in rice-wheat cropping system, Kumar *et al.* (2000) also obtained significant increase in organic carbon and available N, P and K contents in soil with increase in fertilizer levels over control.

Yadav *et al.* (2005) found that 100% NPK to both crops increased organic carbon and available P content by 0.06% and 3.5 kg ha^{-1}, respectively, while available K content decreased by 3.5 kg ha^{-1}.

Wang *et al.* (2006) in an experiment found that soil microbial biomass to carbon added with organic fertilizers increased faster than added with inorganic fertilizer.

Also Yangchun *et al.* (2007) observed that the application of organic manures with a reduced amount of commercial chemical fertilizer increased the content of soil organic C, microbial biomass carbon compared to the treatment with inorganic fertilizer alone.

Masto (2006) reported that application of farmyard manure plus NPK fertilizer significantly increased soil organic carbon and microbial biomass compared to the treatment with NPK fertilizer alone.

The importance of fertilization on plant growth and development hardly needs any emphasis. A significant improvement in growth parameters of wheat (Choudhary and Thakuria, 1997) and rice (Singh *et al.,* 1996) with the application of nitrogen has been reported by many workers.

Sharma (1992) reported that plant height, number of shoots and dry matter accumulation of both rice and wheat increased consistently with increase in fertilizer levels from 50 to 150% of the recommended NPK in rice-wheat cropping system at Palampur.

Singh and Jain (2000) observed significant increase in plant height, number of tillers m^{-2} and total biomass production with increase in NPK levels in rice crop.

At Palampur, Choudhary (2000) recorded significant increase in plant height, dry matter accumulation and number of tillers m^{-2} in wheat with increase in fertilizer levels upto 120 kg N, 60 kg P_2O_5 and 30 kg K_2O ha^{-1}.

Mendhe *et al.* (2002) documented that nitrogen @ 125 kg ha^{-1} significantly increased plant height (130.09 cm) and number of effective tillers per hill (9.29) as compared to application of nitrogen @ 75 and 100 kg ha^{-1}.

Meena *et al.* (2003) observed significantly increase in plant height, total number of tillers, dry matter accumulation with increasing nitrogen application upto 220 kg ha^{-1}.

Sarkar *et al.* (2004) found that the plant height and leaf area duration increased with the increasing levels of nitrogen upto 80 kg N ha^{-1} in combination with green manuring crops.

Long-term fertility studies in wheat-rice sequence by Gurung and Sherchan (1993) in Nepal indicated that wheat yield increased with increase in fertilizer application. The residual effects of fertilizers were also significant on succeeding rice crop in terms of grain yield.

Pramanick and Das (1997) had also documented the residual effects of application of chemical fertilizers to wheat on yield of succeeding rice crop.

Sharma and Gupta (1998) reported that increase in grain yield of wheat due to increase in fertilizer level to proceeding maize or rice.

Long-term fertility management studies have emphasized that balanced fertilization was must to realize the higher-yields and yield sustainability in rice-rice (Katyal and Gangwar, 2000) and rice-wheat cropping systems (Katyal *et al.,* 2000).

Kumar *et al.* (2000) reported that increase in crop productivity of rice-wheat cropping system with efficient use of chemical fertilizers.

Number of panicles and 1000-grain weight (Garcia and Azevedo, 2000) and grain yield (Mendhe *et al.,* 2002) increased with increase in nitrogen levels upto 150 kg N ha^{-1}; number of grains per panicle responded quadratically to nitrogen.

Supatnekar *et al.* (2002) reported that N at 50-125 per cent increased grain from 5.7 to 52.8 per cent and straw yield from 20.1 to 100.3 per cent over the control.

In West Bengal, Maiti *et al.* (2003) found that the application of 140 kg nitrogen ha^{-1} resulted in the highest grain yield, number of panicles, number of filled grains per panicle and 1000-grain weight.

Raghuwanshi *et al.* (2003) and Manjapa (2004) also concluded that grain and straw yields of rice increased with increase in the level of nitrogen.

In north Bihar, Pandey *et al.* (2004) reported that rice responded significantly upto 150 kg N ha^{-1} in influencing yield attributing characters and grain and straw yields.

Numerous field studies on fertilizer management in rice and wheat crops have shown an increase in nutrient accumulation and their uptake with increase in level of fertilization through chemical fertilizers. Jadhav (1990) reported that N, P and K uptake by wheat increased significantly with increase in the level of fertilizers ascribed to higher grain and straw yields along with higher nutrient contents in the crop with higher levels of fertilizers.

Narang *et al.* (1990) also reported an increase in uptake of N, P, K with increase in fertility levels. Increase in NPK levels from 50 to 150 per cent of the recommended in rice-wheat cropping system resulted in significant increase in N, P and K contents and uptake by grains and straw of rice and wheat at Palampur (Sharma, 1992).

In rice-wheat system, Kachroo and Dixit (2005) reported highest N P K uptake when both the crops were fertilized with 100% NPK; whereas K uptake was highest when 50% N in rice was substituted by green leaf manuring and wheat crop was fertilized with 100% NPK.

2.3 Combined effect of organic manures and inorganic fertilizers on growth, yield and soil fertility of rice

It is widely recognized that neither organic manures nor chemical fertilizers used separately can achieve the yield sustainability at a higher order under the modern intensive farming, in which the nutrient turnover in the soil-plant system has been quite high. Integrated plant nutrient supply system involving conjunctive use of chemical fertilizers and organics assume great significance particularly in rice-wheat cropping system mainly due to two reasons. First, the system requires the application of higher amounts of nutrients than used at present and the present level of fertilizer availability and economic conditions of large number of Indian farmers do not allow this. Secondly, it leads to soil health deterioration because of high nutrient requirement. Several studies have also indicated that in intensive cropping systems the sustainability could be achieved only through integration of inorganic and organic sources of nutrients (Hegde *et al.,* 1999; Prasad, 1999).

Findings of a long-term study in rice-wheat cropping system by Kumar and Yadav (1995) revealed that integrated use of organic manures and chemical fertilizers significantly improved the soil organic matter, available N and P and DTPA extractable Zn, Cu, Mn and Fe contents compared to sole application of chemical fertilizers.

In a long-term fertility experiment in rice-wheat cropping system, Katyal *et al.* (2001) also reported a marked effects of organics and chemical N fertilization on organic carbon and available P and K contents.

Findings of Sharma *et al.* (2001) in rice-wheat cropping system revealed that integrated use of organic manures like FYM and green manuring with chemical fertilizers significantly improved the organic carbon, cation exchange capacity and available N, P, K and S contents as well as build-up of micronutrient cations in the soil. Besides this, a marked increase in water holding capacity was also observed with the integrated use of organics and chemical fertilizers.

Tolanur and Badanur (2003) reported that available N, P and K contents increased significantly with the application of various organic sources of nutrients in combination with fertilizers over the fertilizers alone.

Singh and Singh (2003) also opined that increase in organic carbon, available N, P and K contents in soil by the application of FYM or green manure.

In rice-wheat experiment, Yadav *et al.* (2005) found that 100% NPK to both crops maintained higher values of organic carbon and available phosphorus in the soil, while available potassium was maximum when 25% N in rice was substituted by green leaf manuring and 75% NPK applied in wheat. An increase of 20 kg ha^{-1} available phosphorus was also recorded when 25% N in rice substituted by green leaf manuring and 75% NPK were applied in wheat.

Gupta *et al.* (2006) reported that application of NPK through fertilizers upto 75% of recommended levels in both the crops markedly reduced P, K, S and Zn contents of sol from their initial status upto completion of 17 crop-cycle of the rice-wheat sequence. However, Organic Carbon, N, K, S and Zn contents of soil showed rising trend with maintaining stability of P contents under all integrated nutrient management treatments.

Singh (2006) found that the available N, P, K and Zn status of the soil decreased appreciably in the control plots on continuous cropping of rice and wheat grown in sequence. The application of organic manures and chemical fertilizers individually and in combination increased the available N by 7.1-94.5 kg ha^{-1} after rice and 19.7-106.2 kg ha^{-1} after wheat over control.

Sharma (1992) stated that integrated use of 10 t FYM ha^{-1} with 50 to 150 per cent of recommended NPK in rice or wheat or in both the crops resulted in significant increase in the number of shoots and dry matter accumulation by both the crops.

Kumar (1996) obtained favorable effects of combined use of FYM @ 10 t ha with chemical fertilizers on plant height and leaf area index of wheat.

However, Sharma and Bali (1998) reported the superiority of 120 kg N ha^{-1} over 120 kg N ha^{-1} along with incorporation of rice stubbles in terms of plant population and number of effective tillers of wheat crop in a rice-wheat cropping system.

Based on three years studies in rice-wheat cropping system, Singh and Verma (1999) found that application of 10 t FYM ha^{-1} along with 50 per cent N and 100 per cent P, K and Zn produced significantly taller plants and higher number of tillers per hill over recommended N, P, K and Zn dose in rice.

Suresh *et al.* (2000) reported that application of enriched FYM with single super phosphate and phosphobacteria in rice, resulted in significant improvement in crop emergence, plant height, leaf area index and panicles m^{-2}.

Pramanik *et al.* (2004) obtained the best performance of *Sesbania rostrata* along with recommended fertilizer doses in respect of plant height and total number of tillers $hill^{-1}$.

Singh *et al.* (2006) opined that all the growth and yield parameters improved significantly due to integrated nutrient management practices over rest of the treatment.

Halepyati (1991) reported that application of 50 per cent P_2O_5 of rice to *Sesbania rostrata* and remaining 50 per cent to rice crop recorded 30 and 13 per cent higher grain yield of rice when compared with application of all 100 per cent P_2O_5 to rice and all 100 per cent P_2O_5 to *Sesbania rostrata,* respectively.

Budhar *et al.* (1991) recorded significantly higher grain yield of rice with the application of green manures over control but observed no difference in productive tillers per hill, panicles m^{-2}, filled grains per panicle and 1000-grain weight.

Verma (1991) concluded that application of 10 t FYM ha^{-1} to paddy could save 50 per cent of chemical fertilizer requirement under Palampur conditions.

Studies conducted at Palampur by Sharma (1992) indicated that application of 10 t FYM ha^{-1} along with 50 to 150 per cent recommended NPK to rice or wheat significantly increased the grain and straw yields.

The studies carried out by Hundal *et al.* (1992) revealed that green manures *viz.,* cowpea, dhaincha and sunnhemp raised with phosphorus application resulted in significantly higher yield than direct application of P to rice.

Meelu *et al.* (1992) reported that green manuring with dhaincha, sunnhemp, soybean and cowpea increased the grain yield significantly as compared to the control and the residual effect from green manure on dry season rice was not significant during first year but was significant during second year.

Budhar and Palaniappan (1997) also reported that partial substitution of nutritional requirement with green manure recorded almost similar or comparable yield with that under full recommended dose through fertilizers.

Ram and Saha (1999) observed that the grain and straw yields of rice was comparatively lower when nitrogen fertilizer was applied as urea alone in comparison to the treatment where organic manures like FYM, PMor *Sesbania* green manure and chemical nitrogen fertilizer were applied in 50:50 combinations.

Singh and Verma (1999) reported that application of FYM @ 10 t ha^{-1} along with 50 per cent of recommended nitrogen significantly increased yield attributes (*viz.,* number of tillers, panicle length, grains per panicle and test weight) and grain and straw yield of rice over 100% NPK through chemical fertilizers. Residual effects of FYM applied to rice were significant in influencing the yield of wheat in the sequence.

Sharma *et al.* (2000) stated that green manuring combined with 40 kg ha^{-1} to rice recorded grain and straw yields significantly higher over incorporation of green manure alone as well as over application of 120 kg N ha^{-1} to rice.

Yaduvanshi (2001) reported that mean rice and wheat yields obtained from combined application of 100% recommended NPK through inorganic fertilizers + organic manures (FYM or *Sesbania* green manure) were significantly higher than those obtained under the application of 100% NPK through chemical fertilizers alone.

Singh *et al.* (2001) revealed that application of 5 t FYM ha^{-1} or incorporation of 5 t FYM ha^{-1} or incorporation of 4 t rice straw ha^{-1} or green manure in rice along with recommended NPK fertilizers increased the grain yield of rice significantly over variable doses of NPK supplied through inorganic fertilizers, FYM maintained its superiority over other organics with respect to grain yield.

Singh and Singh (2003) reported that application of 100% NPK + FYM resulted in significant increase in grain yield of wheat as compared to 100% or 150% NPK alone.

Mondal *et al.* (2003) revealed that number of filled grains per panicle and grain yield were recorded with the application of 75% NPK + FYM @ 4 t ha^{-1} were comparable with those obtained under 50% NPK + FYM @ 8 t ha^{-1} or 100% NPK alone. Similar findings were also reported by Dutta and Bandyopadhyaya (2003).

Premi (2003) reported that recommended dose of nitrogen through chemical fertilizers produced as much grain yield of rice as that obtained from green manuring with dhaincha or sunnhemp along with 25% of recommended dose of nitrogen indicating a saving of 90 kg N ha^{-1} in the form of chemical fertilizers.

Patro *et al.* (2005) obtained highest total productivity of rice-wheat with *Sesbania* green manure along with 180 kg N ha^{-1} applied to rice and 150 kg N ha^{-1} applied to wheat in sequence.

Similarly, Singh (2006) found that 25 or 50% of recommended N through FYM, pressmud and paddy straw and the rest of recommended N through inorganic fertilizers gave significantly higher grain and straw yields of both rice and wheat over 75% of recommended N through organic sources and 25% recommended N through inorganic fertilizers.

Brar *et al.* (1995) documented that a successive increase in uptake of N, P and K in rice was observed with increase in FYM application from 0 to 12 t ha^{-1} in rice which also had a significant residual effect on the uptake of these nutrients in succeeding wheat crop.

In another study, Jana and Ghosh (1996) reported that total N, P and K uptake by rice under 75% NPK through fertilizers + 25% through FYM or *Sesbania* green manure was at par with that under 100% NPK through chemical fertilizers.

A large number of findings indicated that integrated use of chemical fertilizers and organics significantly increased N, P and K uptake in rice and wheat (Rathore *et al.,* 1995; Brar *et al.,* 1995), N uptake in wheat (Rajput, 1995), grain P content and K uptake in wheat (Kumar, 1996) and N, P and K uptake in wheat (Sharma and Bali, 1998; Singh and Sharma, 2000) in rice-wheat cropping system.

Studies by Singh *et al.* (2002) revealed that application of nitrogen in combination with green manures, FYM and blue green algae significantly enhanced the uptake of N, P and K by rice grain and straw over absolute control, nitrogen alone and green manuring.

Singh *et al.* (2006) reported that 25% RDN through pressmud + 75% RDF through organic fertilizers resulted in highest uptake of N, P and K by rice + wheat crops.

Similarly, Gupta *et al.* (2006) found that total N, P, K uptake by rice-wheat system significantly increased with fertilizers alone and in combination with different organic manures such as FYM, wheat straw and green manure.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The present research work was conducted at the Research Field, Department of Soil Science, Hajee Mohammad Danesh Science and Technology University, Dinajpur. During the period from December 2016 to May 2017 in Rabi season to study the effect of different organic & inorganic fertilizers on soil fertility and the yield of Boro rice (BRRI Dhan29). In this chapter I have described the materials and methodologies for present investigation.

3.1 Description of the experimental site

3.1.1 Location

Geographically the experimental field is located between 25.13^0 N latitude, 88.23^0 E longitudes and at an elevation of 37.5 m above the mean sea level (Appendix-I). The land belongs to the Old Himalayan Piedmont Plain, Agro-ecological Zone-1 (AEZ-1) (UNDP and FAO, 1988). The topography of the field was medium high. The field is situated at the north site of the Central Mosque of Hajee Mohammad Danesh Science and Technology University, Dinajpur.

3.1.2 Climate and Weather

The experimental area possesses sub-tropical climate. Usually the rainfall is medium during Kharif season (April-September) and scanty in Rabi season (October-March). Their temperature was moderately low during the Rabi season and increases as the season proceeds towards Kharif season with occasional gusty winds. Weather information regarding air temperature (^{0}C), rainfall (mm), relative humidity (%) and sunshine hours prevailed at the experiment site during the study period i.e. December to April (Appendix-II).

3.1.3 Soil

The soil of the experimental plot was sandy loam with p^H 5.97. The initial soil (0-15 cm depth) test revealed that the soil contained 0.05 % total Nitrogen, 11.21 ppm phosphorus, 0.10 m.e./100g available potassium, 11.01 ppm sulphur. General soil type was Non-calcareous flood plain and the parent material of this soil was alluvial deposit.

Table 3.1 Physical, chemical and morphological characteristics of the initial soil of experimental field

Characteristics	Value
%Sand	56.00
%Silt	34.00
%Clay	10.00
Textural class	Sandy loam
pH	5.97
Organic Matter (%)	0.98
Total Nitrogen (%)	0.05
Phosphorus (ppm)	11.21
Potassium (m. e./100g soil)	0.10
Sulphur (ppm)	11.01
Parent material	Alluvial deposit
General soil type	Non-Calcareous Brown Floodplain
Drainage	Moderately well drained
Flood level	Above flood level
Topography	High land

3.2 Planting Materials

BRRI Dhan29 was used for the study purpose. BRRI Dhan29 seeds were used in winter season. It was collected from Bangladesh Agriculture Development Corporation (BADC), Nashipur, Dinajpur. It was developed by Bangladesh Rice Research Institute (BRRI), Gazipur and it was released in 1994.

Features are given below:

Origin: B 802-118-4-2. Season: Boro (October-May)

Yield: 7.5 ton/hac. Life Cycle: 160 Days (Seed to Seed)

Planting Distance: 20 cm x 15 cm

Plant Height: 95 cm, Plant is strong, medium resistant to leaf & sheath blight disease.

3.3 Treatment

The experiment was conducted to investigate the effect of different organic & inorganic fertilizers on soil fertility and the yield of Boro rice (BRRI Dhan29). The experiment consist eight (8) treatments with three (3) replications. Those are given below:

T_0	Control
T_1	100% NPKS (Recommended dose)
T_2	50% NPKS + 6 t cow dung/ha
T_3	75% NPKS + 3 t cow dung/ha
T_4	50% NPKS + 6 t PM/ha
T_5	75% NPKS + 3 t PM/ha
T_6	50% NPKS + 6 t vermicompost/ha
T_7	75% NPKS + 3 t vermicompost/ha

3.4 Experimental Design & Layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with 3 replications. The whole area was divided into 3 blocks and each block was divided into 8 units. The total number of treatments was 8 in the present experiment. As each treatment was replicated 3 times, therefore the total number of plots was 24. The unit plot size was 2.5 m x 2 m (5 m^2). The distance maintained between two blocks and two plots were 1.0 m and 0.5 m respectively.

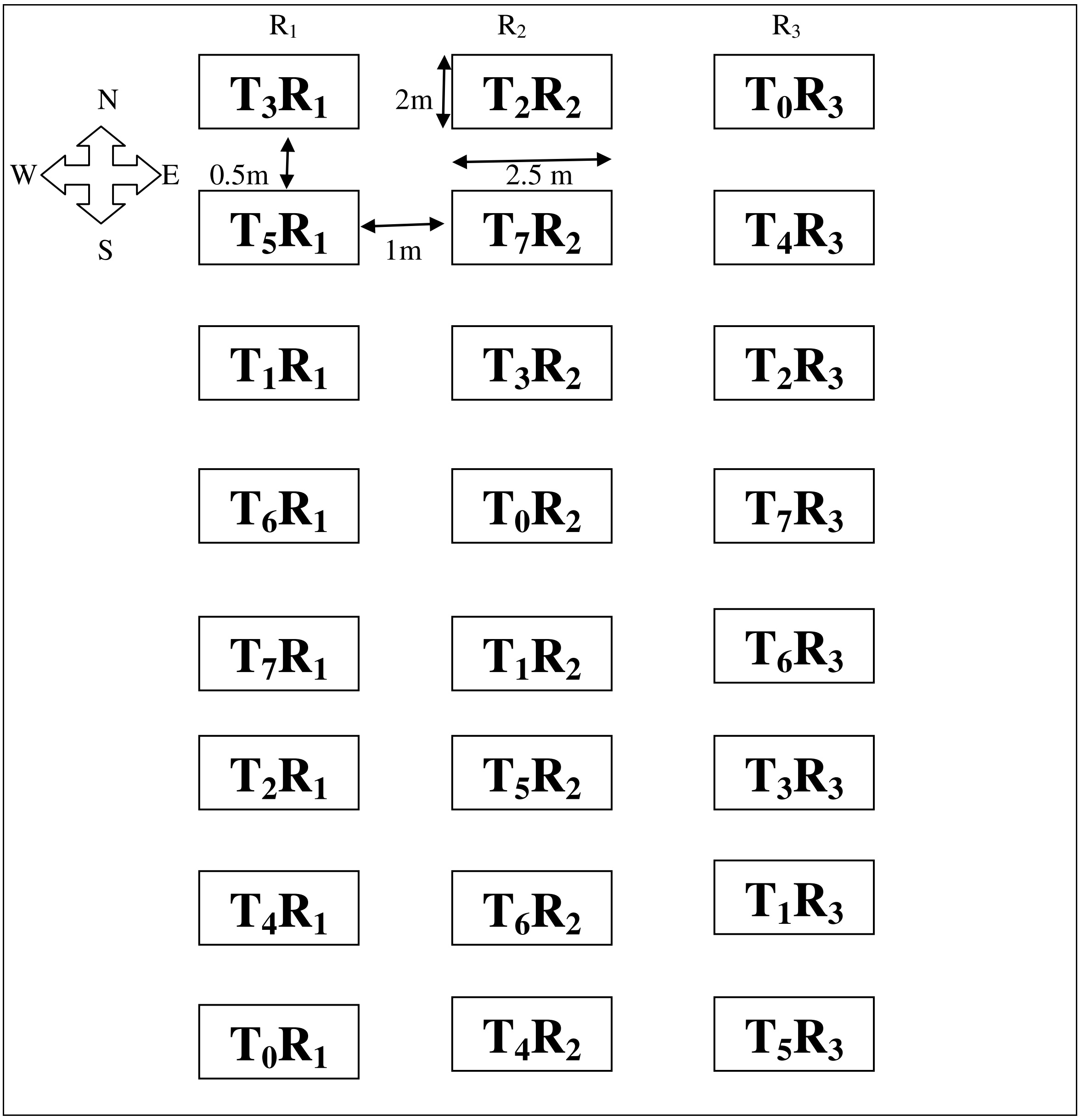

Fig. 3.1 Layout of experimental field

3.5 Land Preparation

The land was first opened on 24 December, 2016 by a tractor and prepared thoroughly by ploughing and cross ploughing with a power tiller and country plough. Finally each plot was prepared by puddling. The experiment was laid out in a randomized complete block design (RCBD), with three blocks. Each block was divided into eight unit plots as treatments with raised bunds around. The unit plot size was 2.5 m x 2 m (5 m^2). The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively.

3.6 Fertilizer Application

Full amounts of TSP, MoP and gypsum were applied as basal dose. Urea was 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 before panicle initiation stage (55 DAT). The recommended dose was $N_{75}P_{12}K_{45}S_9$ (Fertilizer Recommendation Guide, 2012). The rates of manure were 3 & 6, 3 & 6 and 3 & 6 t ha^{-1} for cow dung, poultry manure and vermicompost and per plot requerments were calculated as per the treatments, respectively. As organic manure cowdung, PM and vermicompost were applied before four days of final land preparation. Chemical compositions of the manures have been given below:

Chemical compositions of organic manure (oven dry basis)

Name of organic manure	Nutrient content (%)				
	C	N	P	K	S
Cowdung	36	1.92	0.29	0.75	0.21
Poultry manure	29	2.19	1.98	0.81	0.34
Vermicompost	30	1.48	0.28	1.27	0.32

3.7 Seed Sowing & Transplanting

Seeds (95% germination) @ 5 kg ha^{-1} were soaked and incubated for 48 hour and sown on a well-prepared seed bed. Seeds were sown on the 1st December, 2016. Forty days old seedlings of BRRI Dhan29 were carefully uprooted from the seed bed and transplanted on 10 January, 2017 in the field.

3.8 Irrigation

Water is very essential for rice crop. Usually the rainfall is low in boro season. For this reasons, regular irrigation is very essential for rice crop.

3.9 Weeding

Weeding is an important intercultural operation for rice cultivations. The first, second and final weeding were done by 20, 40 and 60 days respectively after transplanting.

3.10 General Observation

The experimental field was frequently observed to notice any change in plant character and attack of pest and diseases on the crop. There was no pest and disease in the field during the experimental period and hence no control measures were adopted.

3.11 Harvesting

Rice plants were harvested at 3 May, 2017 when full maturity came. The crops were harvested plot wise and brought to a clean threshing floor of farm house. The yield of the grain and straw per plot were recorded after threshing, winnowing and drying.

3.12 Collection of plant Sample

Ten hills were randomly selected from each plot at maturity to record the yield contributing characters. Grain and straw samples were kept for chemical analysis.

3.13 Data Recorded at Harvest

The following parameters were recorded at harvest:

- Plant Height
- Number of Tillers hill^{-1}
- Panicle Length
- Number of Grains panicle^{-1}
- Number of Filled Grains panicle^{-1}
- Number of Unfilled Grains panicle^{-1}
- Weight of 1000 grains
- Grain Yield

- Straw Yield
- Biological Yield

3.14 Procedures of Data Collection

The data were recorded on yield and yield components of rice. The yield and yield components were: Plant Height, Number of Tillers hill^{-1}, Panicle Length, Number of Grains panicle^{-1}, Number of Filled Grains panicle^{-1}, Number of Unfilled Grains panicle^{-1}, Weight of 1000 grains, Grain Yield, Straw Yield and Biological Yield.

3.14.1 Plant Height (cm)

Plant height was measured from the ground level of a plant to the top of a panicle at harvest time. Plants of 10 hills measured and averaged from each plot.

3.14.2 Number of Tillers hill^{-1}

10 hills were taken at random from each plot and the total numbers of tillers hill^{-1} were calculated.

3.14.3 Panicle Length (cm)

Measurement was taken from the basal node of the raches to the apex of each panicle. Each observation was an average of 10 hills.

3.14.4 Number of Grains panicle^{-1}

Presence of any food material in any spikelet was considered as a grain and total number of such grains present on each panicle was counted physically.

3.14.5 Number of Filled Grains panicle^{-1}

10 panicles were taken at random from each plot and the filled grains panicle^{-1} were counted and averaged.

3.14.6 Number of Unfilled Grains panicle^{-1}

10 panicles were taken at random from each plot and the unfilled grains panicle^{-1} were counted and averaged.

3.14.7 Weight of 1000 grains

1000 grains were randomly selected from sample of each plot and were dried in an oven and adjusting at 14% moisture content and weighted by an electric balance.

3.14.8 Grain Yield (kg ha^{-1})

Grains obtained from each unit plot were sun dried and weighted carefully. The dry weights of grains of 10 sample plants were added to the respective unit plot to record the trail grain yield per plot. The grain yield was finally converted to kg /ha.

3.14.9 Straw Yield (kg ha^{-1})

Straw obtained from each unit plot including the straw of 10 sample plants were dried in the sun and weighted to record the final straw yield per plot and then converted to kg ha^{-1}.

3.14.10 Biological Yield (kg ha^{-1})

Biological yield was calculated by using the following formula:

Biological Yield (kg ha^{-1}) = Grain Yield (kg ha^{-1}) + Straw Yield (kg ha^{-1}).

3.15 Collection of Soil Sample

3.15.1 Initial soil sample

The initial soil sample was collected before land preparation from the plough depth layer (0-15 cm). 10 samples were taken by means of an auger from 10 locations covering the whole experimental plot and mixed thoroughly to make a composite sample. The composite sample was air dried, grinded and sieved through a 20 mesh sieve and stored in a plastic bag for physical and chemical analyses.

3.15.2 Post harvest soil sample

After harvesting the crop, 10 samples were collected from each plot at 0-15 cm depth. The soil samples were air dried, grinded and sieved through a 20 mesh sieve. Prepared soil samples were stored in plastic bags for chemical analysis only.

3.16 Analysis of Soil Sample

The Soil samples were collected from the each plot after harvesting the crop. From each plot 5 samples were taken at 15 cm depth randomly. Then the soil was air dried, crushed and sieved with 60 mesh sieves separately. The samples were then stored in plastic container with tag for subsequent analysis.

The following analysis of soil sample were done-

- Soil p^H
- Soil phosphorus (P)
- Soil nitrogen (N)
- Soil potassium (K)
- Soil sulphur (S)
- Organic matter content
- Textural class

3.16.1 Soil p^H

Soil p^H was determined using a glass electrode p^H meter at soil: water (1: 2.5) ratio. The suspension was allowed to stand for one hour with occasional shaking before determination (Jackson, 1967).

3.16.2 Available phosphorus (P)

Available Phosphorus was extracted from the soil with 0.5M sodium bicarbonate solution, p^H 8.5 (Olsen *et al*). The phosphorus in the extract was determined by developing blue color using $SnCl_2$ reduction of phosphomolybdate complex. The absorbance of the phosphomolybdate blue color was measured at 660nm wave length in a spectrophotometer and available Phosphorus was calculated with the help of standard curve.

3.16.3 Total nitrogen (N)

Soil nitrogen was determined by Micro- Kjeldahl method. The soil samples (1.0 g) were digested with 3 ml concentrated H_2SO_4 and 1.1 g catalyst mixture (K_2SO_4: $CuSO_4$. 5 H_2O: Se powder in the ratio of 100: 10: 1).N was estimated by distilling the digest with

40% NaOH followed by titration of the distillate trapped in H_3BO_3 indicator solution with 0.01 N H_2SO_4 (Page *et al.,* 1989).

3.16.4 Available potassium (K)

Available K was determined by ammonium acetate extraction method using flame photometer as described by page *et al.* (1989).

3.16.5 Available sulphur (S)

Available S was determined by extracting the soil sample with 0.01M $Ca(H_2 PO_4)_2$. The S content in the extract was estimated turbidimetrically and the intensity of turbidity was measured by spectrophotometer at 420 nm wavelength.

3.16.6 Organic matter content

Organic carbon content was determined volumetrically by wet oxidation method using $K_2Cr_2O_7$ and H_2SO_4 mixture, and $FeSO_4$ solution was used for titration as outlined by Jackson (1967). The OM content was calculated by multiplying the percent organic carbon with the Bemmelen factor of 1.724 (Piper, 1950).

3.16.7 Textural class

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

3.17 Chemical analyses of plant samples

Plant samples for chemical properties were analyzed in the laboratory of the Department of Agricultural Chemistry, HSTU, Dinajpur. The soil chemical properties under the study were total nitrogen, phosphorus, potassium and sulphur

3.17.1 Preparation of plant samples

Both the grain and straw samples were dried in an oven at 60^0C for 24 hours and then grinded by a grinding mill. The prepared samples were then put in paper bags and kept in desiccators until analyses.

3.17.2 Digestion and determination of total nitrogen from plant samples

For the determination of nitrogen, 0.1g oven dry grind plant samples (both grain and straw) as taken in a micro kjeldahl flask. 1.1g catalyst mixture (K_2SO_4 : $CuSO_4$: $5H_2O$: Se =100 : 10 : 1), 3ml 30% H_2O_2 and 5ml conc. H_2SO_4 were added into the flasks. The flasks were swirled and allowed to stand for 10 minutes. Then heating was continued until the digest was clear and colorless. After cooling, the content was taken into 100ml volumetric flasks and the volumes were made up to the mark with distilled water. A reagent blank was prepared in the same way. These digests were used for nitrogen determination.

3.17.3 Digestion of plant samples for P, K and S determinations

Plant samples of 0.5g were transferred into dry clean 100ml kjeldahl flasks. 10ml of diacid mixture (HNO_3 : $HClO_4$ = 2 : 1) were added into the flasks. After leaving for a while, the flasks were heated slowly upto 200^0C. The contents of the flasks were boiled until they became sufficiently clear and colorless. After cooling, the digests were taken into 50ml volumetric flasks and the volumes were made up to the mark with distilled water. The digests were used for determinations of P, K and S.

3.17.4 Determinations of N, P, K and S from Plant samples

Nitrogen (N)

After completion of digestion, 40% NaOH was added with the digests for distillation. The evolved ammonia was trapped in 4% H_3BO_3 solution and 5 drops of the mixed indicator of bromocressol green ($C_{21}H_{14}O_5Br_4S$) and methyl red ($C_{10}H_{10}N_3O_3$) solution. Finally the distillates were titrated with the standard 0.01N H_2SO_4 until the color changed from green to pink (Bremner and Mulvaney, 1982).

Phosphorus (P)

Phosphorus was determined using 1ml digest for grain samples and 2ml digest for straw samples from 50ml extract. The phosphorus in the extract was determined by developing blue color using $SnCl_2$ reduction of phosphomolybdate complex. The absorbance of the phosphomolybdate blue color was measured at 660nm wave length in a spectrophotometer and available P was calculated with the help of standard curve.

Potassium (K)

Five ml digest samples for grain and 2 ml for straw were taken and diluted to 50 ml volume to make desired concentration so that the absorbance of samples could be measured within the range of standard solutions. The absorbances were finally measured by an atomic absorption flame photometer.

Sulphur (S)

Sulphur was determined following the procedure as done in soil analysis by using 5 ml of digest from 50 ml extract and reading were taken by spectrophotometer at 420 nm of wave length.

3.18 Statistical analyses

All the collected data analyzed for ANOVA using the randomized complete block design (RCBD) with the help of the computer package program MSTAT- C. The differences among the treatment means were evaluated by the Duncan's New Multiple Range Test (DMRT) as outlined by Gomezn and Gomez, 1984.

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

The present experiment was conducted to determine the effect of different organic & inorganic fertilizers on soil fertility and the yield of Boro rice (*BRRI Dhan29*). The result has been presented in various tables, figures and possible explanations have been given under the following headings.

4.1 Yield and yield contributing characters of rice

Yield contributing characters such as Plant Height, Number of Tillers hill^{-1}, Panicle Length, Number of Grains panicle^{-1}, Number of Filled Grains panicle^{-1}, Number of Unfilled Grains panicle^{-1}, Weight of 1000 grains, Grain Yield, Straw Yield and Biological Yield.

4.1.1 Plant height

Plant height of rice (BRRI Dhan29) responded significantly due to application of organic and inorganic fertilizers (Table 4.1). All the treatments gave significantly higher plant height over the T_0 (control). Plant height ranged from 73.25 to 94.37 cm. The tallest plant height (94.37) was recorded in the treatment T_4 (50% NPKS + 6 t poultry manure/ha) which was closely followed by the treatment T_5 (75% NPKS + 3 t poultry manure/ha). The shortest plant height (73.25) was recorded from the control treatment $T_{0.}$ Treatments may be ranked in the order of $T_4 > T_5 > T_7 > T_1 > T_6 > T_3 > T_2 > T_0$.The dose of both organic and inorganic fertilizers had positive effects on plant height. A similar effect of FYM with N, P and K was reported by Kobayahi *et al.* (1989).

4.1.2 Number of tillers hill^{-1}

Application of organic and inorganic fertilizers responded significantly on the number of effective tillers hill^{-1} of rice (Fig 4.1 and Table 4.1). The maximum tillers hill^{-1} (22.10) was found in the treatment T_4 which was statistically superior to the other treatments. The minimum tillers hill^{-1} (8.89) was observed from the control treatment (T_0). Ahmad and Rahman (1991) found that increased number of effective tillers hill^{-1} of rice with the integrated use of organic and inorganic fertilizers.

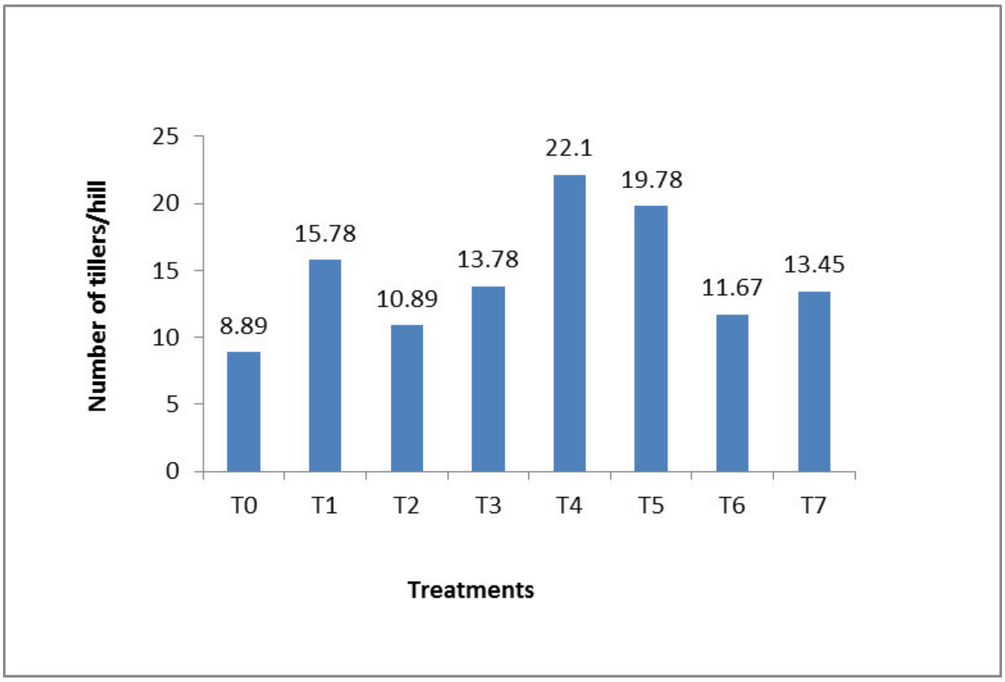

Fig. 4.1: Effects of organic and inorganic fertilizers on Number of tillers hill^{-1} of rice (BRRI Dhan29)

T_0= Control

T_1= 100% NPKS

T_2= 50% NPKS + 6 t cow dung/ha

T_3= 75% NPKS + 3 t cow dung/ha

T_4 = 50% NPKS + 6 t PM/ha

T_5= 75% NPKS + 3 t PM/ha

T_6= 50% NPKS + 6 t vermicompost/ha

T_7= 75% NPKS + 3 t vermicompost/ha

4.1.3 Panicle length (cm)

Panicle length of BRRI Dhan29 significantly influenced due to application of organic and inorganic fertilizers (Table 4.1). The Panicle length varied from 18.21 to 26.48 cm. The highest Panicle length (26.48) was recorded in the treatment T_4 which was statistically identical with T_1, T_3, T_5 and T_7. On the other hand the lowest panicle length (18.21) was found in the T_0 (control). Ahmad and Rahman (1991) also observed that combined application of organic and inorganic fertilizers increased the Panicle length of rice.

4.1.4 Number Filled Grains panicle^{-1}

The number of filled grains panicle^{-1} was significantly affected due to application of cowdung, poultry manure, vermicompost and chemical fertilizers. The number of filled grains panicle^{-1} ranged from 90.20 to 170.20 (Table 4.1). The highest number of filled grains panicle^{-1} (170.20) was recorded in the treatment T_4 which statistically similar to T_5 treatment. On the other hand the number of filled grains panicle^{-1} was lowest (90.20) obtained in the T_0 treatment. Umanah *et al.* (2003) stated that poultry manure increased the grains panicle^{-1}.

4.1.5 Number Unfilled Grains panicle^{-1}

The effect of different levels of organic and inorganic fertilizers was significant as observed on number of unfilled grains panicle^{-1}. The number of unfilled grains panicle^{-1} ranged between 6.10 and 12.20 (Table 4.1). The highest number of unfilled grains panicle^{-1} (12.20) was recorded in the treatment T_0 (control). On the other hand the number of unfilled grains panicle^{-1} was lowest (6.10) obtained in the T_5 treatment which was statistically identical with T_1, T_2, T_3, T_4 and T_7 treatments.

4.1.6 Number of Total Grains panicle^{-1}

Combined applications of organic and inorganic fertilizers ensured favorable growth of rice and ultimate result was the maximum number of grains panicle^{-1}. Results in Table 4.1 indicated that number of Grains panicle^{-1} of rice varied significantly due to application of organic and inorganic fertilizers. The highest Grains panicle^{-1} (178.3) was recorded in the treatment T_4 which was statistically same as T_5 treatment. On the other hand the Grains panicle^{-1} was lowest (102.4) obtained in the T_0 treatment. Treatments may be ranked in the order of $T_4 > T_5 > T_1 > T_7 > T_3 > T_6 > T_2 > T_0$.

4.1.7 1000-grains weight

Variation in 1000-grains weight was observed with the application of organic and inorganic fertilizers (Table 4.1). The highest 1000-grains weight (21.96g) was recorded from the treatment T_4 which was superior to other treatments. The lowest weight (17.10g) was recorded under T_0 (control). Treatments may be ranked in the order of $T_4 > T_1 > T_5 > T_3$, $T_7 > T_2 > T_6 > T_0$. Apostol (1989) viewed that organic fertilizers along with inorganic fertilizers improved 1000-grains weight in rice.

Table 4.1 Effects of organic and inorganic fertilizers on the Plant Height, Number of Tillers hill^{-1}, Panicle Length, Number of Grains panicle^{-1}, Number of Filled Grains panicle^{-1}, Number of Unfilled Grains panicle^{-1}, Weight of 1000 grains in BRRI Dhan29.

Treatments	**Plant height at harvest (cm)**	**Number of tillers/ hill**	**Length of panicle (cm)**	**Number of filled grains/ panicle**	**Number of unfilled grains/ panicle**	**Number of total grains/ panicle**	**Weight of 1000 seed (g)**
T_0	73.25 e	8.89 f	18.21 d	90.20 f	12.20 a	102.4 f	17.10 e
T_1	89.04 b	15.78 c	24.69abc	158.1bc	8.63bc	166.8bc	21.20 b
T_2	81.85 d	10.89 e	23.68 bc	130.8 e	7.81bc	138.6 e	20.50 c
T_3	86.30 c	13.78 d	24.71abc	151.8cd	6.21 c	158.0cd	20.98 b
T_4	94.37 a	22.10 a	26.48 a	170.2 a	8.12bc	178.3 a	21.96 a
T_5	93.42 a	19.78 b	25.24 ab	164.2ab	6.10 c	170.3ab	21.10 b
T_6	87.20 c	11.67 e	22.92 c	147.8 d	9.51 b	157.3 d	19.76 d
T_7	90.54 b	13.45 d	24.61abc	157.2bcd	8.10bc	165.3bcd	20.98 b
LSD value	1.65	1.67	2.04	9.34	2.38	8.56	0.30
CV %	1.08	6.54	4.89	3.65	16.28	3.16	0.85
Level of significance	*	*	*	*	*	*	*

In a column having common letters do not differ significantly at 5% level of significance.

CV% = Coefficient of variation
LSD = Level of Significance

Here,

T_0= Control
T_1= 100% NPKS
T_2= 50% NPKS + 6 t cow dung/ha
T_3= 75% NPKS + 3 t cow dung/ha
T_4 = 50% NPKS + 6 t PM/ha
T_5= 75% NPKS + 3 t PM/ha
T_6= 50% NPKS + 6 t vermicompost/ha
T_7= 75% NPKS + 3 t vermicompost/ha

4.2 Grain and straw yield of Rice

4.2.1 Grain yield

The grain yield of Boro rice (*BRRI Dhan29*) was significantly influenced by the different treatments. Application of different levels of organic and inorganic fertilizers showed variation in between the treatments due to the variation for grain yield (Fig. 4.2 and Appendix III). The grain yield varied from 4.63 to 10.33 t ha^{-1}. The highest grain yield was recorded in the treatment T_4 (50% NPKS + 6 t poultry manure/ha) which was closely followed by T_5 treatment (75% NPKS + 3 t poultry manure/ha) and the lowest grain yield was recorded in the T_0 (control) treatment. The result clearly indicated that organic source of nutrients gave significantly higher grain yield over inorganic fertilizers. The study revealed that integrated use of poultry manure with inorganic fertilizers reductase fertilizer without any remarkable yield decline. Bodruzzaman *et al.* (2010) and Asit *et al.* (2007) also found almost the similar results. There is a good deal of evidence that organic manure reduce more than 50% nitrogenous fertilizers for rice cultivation (Sing *et al.*, 2001 and Mann and Ashraf, 2000).

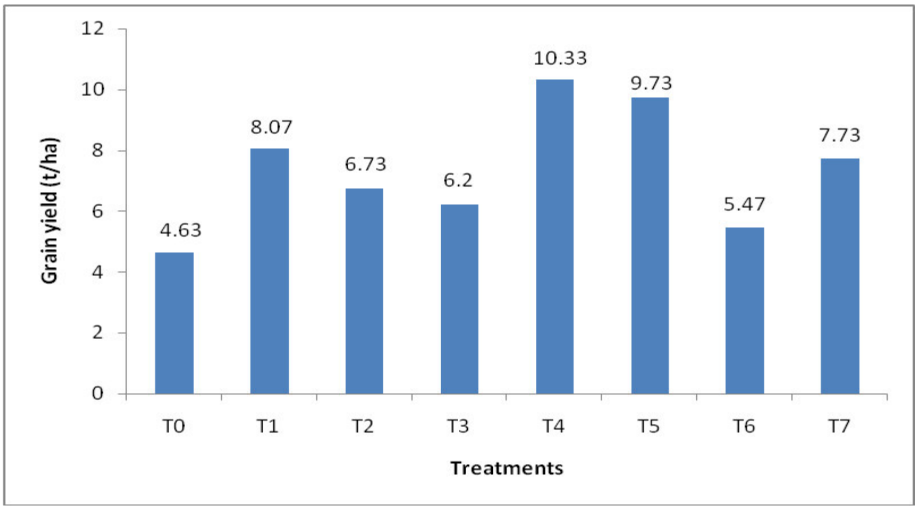

Fig. 4.2: Performance of grain yield on Boro rice (*BRRI Dhan29*)

4.2.2 Straw yield

Application of organic and inorganic fertilizers at different levels showed the variation for straw yield per hectare (Fig. 4.3 and Appendix III). The increased straw yield might be accounted for the superior growth of plant as well as increased number of tillers hill^{-1}. The highest straw yield (15.67 t ha^{-1}) was recorded in the treatment T_4 which was statistically identical with T_5 treatment. On the other hand the lowest straw yield (6.73 t ha^{-1}) obtained from the control treatment T_0. The results showed that the application of organic and inorganic fertilizers induced higher straw yield of rice. Rajput and Warsi (1992) observed that combined application of organic and inorganic fertilizers significantly increased the straw yield of rice.

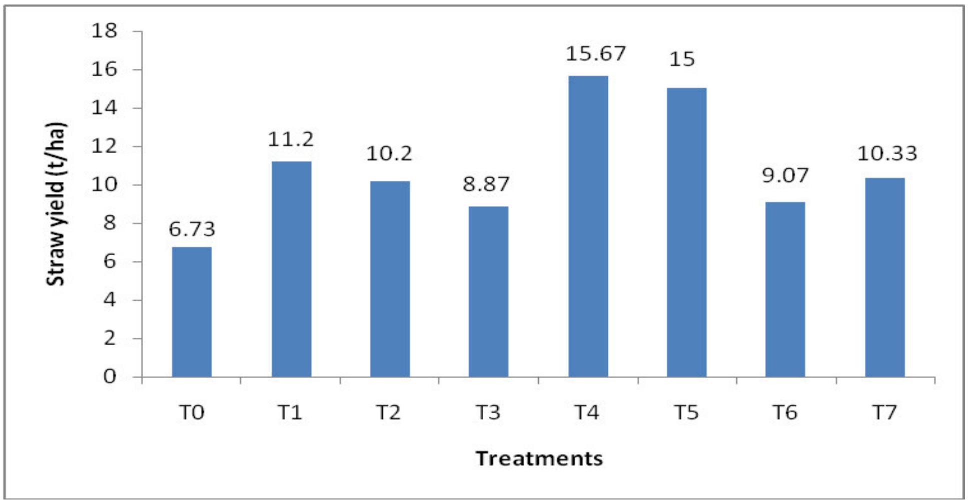

Fig. 4.3: Performance of Straw yield on Boro rice (*BRRI Dhan29*)

4.2.3 Biological yield

Biological yield is the total yield of grain and straw. It was significantly affected due to application of different organic and inorganic fertilizers (Appendix III). The biological yield varied from 11.37 to 26.00 t ha^{-1}. The highest biological yield (26.00 t ha^{-1}) was recorded in the treatment T_4 (50% NPKS + 6 t poultry manure/ha) which was statistically similar to T_5 treatment (75% NPKS + 3 t poultry manure/ha) and the lowest biological yield (11.37 t ha^{-1}) was recorded in the T_0 (control) treatment. Treatments may be ranked in the order of $T_4 > T_5 > T_1 > T_7 > T_2 > T_3 > T_6 > T_0$. The results showed that the application of organic and inorganic fertilizers induced higher biological yield of BRRI Dhan29.

Among organic fertilizers poultry manure was superior to cowdung and vermicompost and increased rate also had positive effect in it.

4.3 Effect of organic manure and chemical fertilizers on nutrient content in grain and straw

Grain and straw of BRRI Dhan29 were analyzed for determining N, P, K and S content of grain and straw have been presented and discussed under the following sub-section.

4.3.1 Nitrogen content in rice grain and straw

The Nitrogen content in rice grain and straw of BRRI Dhan29 was significantly influenced by combined application of organic and inorganic fertilizers than single application of chemical fertilizers (Appendix IV). The grain Nitrogen content varied from 0.94 to 1.36%. The highest grain Nitrogen content (1.36%) was observed in the treatment T_4 which was statistically similar to T_1, T_2, T_3, T_5, T_6 and T_7 treatments. The lowest grain Nitrogen content (0.94%) was observed in the treatment T_0 (control). The straw Nitrogen content ranged from 0.49 to o.73%. The highest straw Nitrogen content (0.73%) was observed in the treatment T_4 which was statistically not significant. The lowest straw Nitrogen content (0.49 %) was observed in the treatment T_0 (control). Verma (1991) reported that in a crop rotation with FYM the concentration of N in paddy grain increased significantly. Hossain (2009) observed that combined application of organic and inorganic fertilizers significantly affect the N content in rice grain and straw.

4.3.2 Phosphorus content in rice grain and straw

The Phosphorus content in rice grain and straw of BRRI Dhan29 was also significantly influenced by combined application of organic and inorganic fertilizers than single application of chemical fertilizers. The highest Phosphorus content in grain (0.38%) was observed in the treatment T_4 which was statistically similar by T_5 treatment and the lowest (0.22%) was recorded in the T_0 (control). Treatments may be ranked in the order of $T_4 > T_5 > T_1 > T_2, T_3, T_7 > T_6 > T_0$. The straw Phosphorus content varied from 0.06 to 0.09% (Appendix IV). The highest Phosphorus content in straw (0.09%) was observed in the treatment T_4 (50% NPKS + 6 t poultry manure/ha) which was statistically similar to another treatments and the lowest (0.06 %) was found in the T_0 (control). Kadu *et al.* (1991) reported that P content of rice grain and straw was highest with NPK + FYM application.

4.3.3 Potassium content in rice grain and straw

Data in Appendix IV indicated that Potassium content in rice grain and straw were significantly influenced by the different treatments over control. The K contents in grain and straw varied from 0.25 to 0.45 % and 1.16 to 1.71 % respectively. It was evident from the results that poultry manure was more K accumulating than that of cowdung and vermicompost. The highest K content in grain (0.45 %) was found in the treatment T_4 (50 % NPKS + 6 t poultry manure/ha) which was statistically similar by T_5 treatment (75 % NPKS + 3 t poultry manure/ha) and the lowest (0.25 %) was recorded in the T_0 (control). In straw, the highest K content (1.71 %) was found in treatment T_4 which was statistically similar by T_1, T_2, T_3, T_5, T_7. The lowest K content (1.16 %) was in T_0 treatment which was statistically different from another treatment.

4.3.4 Sulphur content in rice grain and straw

Data in Appendix IV indicated that Sulphur content in grain and straw insignificantly affected by various treatments under study. Sulphur content in rice grain and straw varied from 0.07 to 0.10 % and 0.06 to 0.09 % respectively. In grain and straw highest value was observed in T_4 (50 % NPKS + 6 t poultry manure/ha) and lowest value was in T_0 (control) treatment and they were statistically identical to all other treatments. Golam (2007) observed that combined application of organic and inorganic fertilizers significantly affect the sulphur content in rice grain and straw.

4.4 Chemical properties of the collected soil after harvesting

4.4.1 Soil pH

The post-harvest soil was acidic where soil pH ranged from 5.97 to 6.02 (Table 4.2). Soil pH was slightly increased in all the treatments. There was no significant difference among the treatments of the post-harvest soil. The study proved that soil reaction remained more or less same in the post-harvest soils compared to initial soil.

4.4.2 Organic matter content in soil

The application of inorganic and organic fertilizers has a significant effect on organic matter in soil. Organic and inorganic fertilizers increased the soil organic matter in different treatments (Fig 4.4 and Table 4.2).

Soil organic matter content of the post-harvest soil was higher than the initial soil (Table 3.1). The highest soil organic matter content 1.54 % was found in the T_4 treatment. The lowest soil organic matter 0.86 % was found in the T_0 (control).

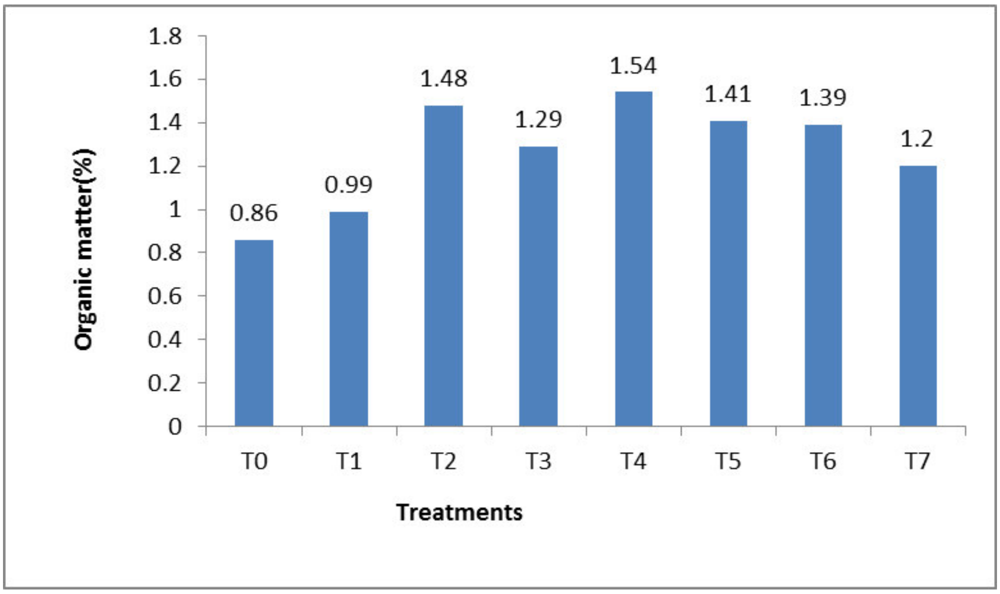

Fig. 4.4: Presence of Organic matter (%) in post-harvest soil

4.4.3 Total nitrogen in soil

Total nitrogen (N) content in the post-harvest soil insignificantly affected by various treatments under this study (Table 4.2). Soil nitrogen of the post-harvest soil was higher than the initial soil (Table 3.1) except T_0 treatment. The total N content of the post-harvest soil ranged between 0.04 and 0.08 % as compared to the initial soil (0.05%) was noted. The highest (0.08%) soil nitrogen was found in T_4 treatment. The lowest (0.04%) soil nitrogen was found from the control treatment T_0. Sreelatha *et al.* (2006) also reported that organic manures had a positive influence on total and available N content of soil.

Table 4.2 Effects of organic and inorganic fertilizers on the soil pH, organic matter content, total N of the post-harvest soil

Treatment	pH	OM (%)	Total N (%)
T_0	5.97	0.86 c	0.04
T_1	5.99	0.99 bc	0.05
T_2	6.01	1.48 a	0.07
T_3	6.00	1.29 ab	0.06
T_4	6.02	1.54 a	0.08
T_5	6.01	1.41 a	0.07
T_6	6.02	1.39 a	0.07
T_7	6.00	1.20 abc	0.06
LSD	0.66	0.35	0.06
CV %	6.28	15.64	21.27
Level of significance	NS	*	NS

In a column having common letters do not differ significantly at 5% level of significance.

CV% = Coefficient of variation

LSD = Level of Significant

NS = Not significant

* = Significant

Here,

T_0= Control

T_1= 100% NPKS

T_2= 50% NPKS + 6 t cow dung/ha

T_3= 75% NPKS + 3 t cow dung/ha

T_4 = 50% NPKS + 6 t PM/ha

T_5= 75% NPKS + 3 t PM/ha

T_6= 50% NPKS + 6 t vermicompost/ha

T_7= 75% NPKS + 3 t vermicompost/ha

4.4.4 Available phosphorus in soil

The available phosphorus content of the post-harvest soil varied significantly by different treatments (Table 4.3). Available phosphorus varied from 10.05 to 22.10 ppm. The maximum (22.10) phosphorus content was observed in the treatment T_4 which was closely followed by T_5 treatment. The lowest (10.05) phosphorus content was observed in the T_0 (control).

4.4.5 Exchangeable potassium in soil

The exchangeable potassium (K) content of the post-harvest soil was influenced considerably due to the application of organic and inorganic fertilizers (Table 4.3). The exchangeable K content of initial soil (Table 3.1) was 0.10 m.e. 100 g^{-1} soil and the values of post-harvest soil ranged from 0.08 to 0.16 m.e. 100 g^{-1} soil. The highest exchangeable K was found in the treatment T_6 (50% NPKS + 6 t Vermicompost/ha) and the lowest value was found in the T_0 (control). The exchangeable potassium (K) content of the post-harvest soil was statistically similar under different treatments.

4.4.6 Available Sulphur

Results in Table 4.3 indicated that the post-harvest soil which content available sulphur (S) was different for the different treatments. The available S content in the studied soil ranged from 10.24 to 16.51 ppm. The highest S content soil was found in the treatment T_4 which was statistically similar to those in T_1, T_2, T_5, T_6 and T_7 treatments. The lowest S content in soil was observed from the controlled treatment T_0 which was statistically similar to T_3 treatment.

Table 4.3 Effects of organic and inorganic fertilizers on the available P, S and exchangeable K of the post-harvest soil.

Treatments	Available P (ppm)	Exchangeable K (m.e. 100 g^{-1} soil)	Available S (ppm)
T_0	10.05 d	0.08 b	10.24 b
T_1	11.68 cd	0.10 ab	13.16 ab
T_2	15.67 bc	0.11 ab	14.36 ab
T_3	13.40 cd	0.10 ab	11.23 b
T_4	22.10 a	0.14 ab	16.51 a
T_5	20.31 ab	0.12 ab	14.21 ab
T_6	16.10 bc	0.16 a	15.16 ab
T_7	14.23 cd	0.14 ab	13.41 ab
LSD value	4.62	0.06	4.46
CV %	17.07	14.63	18.81
Level of significance	*	*	*

In a column having common letters do not differ significantly at 5% level of significance.

CV% = Coefficient of variation

LSD = Level of Significance

* = Significant

Here,

T_0= Control
T_1= 100% NPKS
T_2= 50% NPKS + 6 t cow dung/ha
T_3= 75% NPKS + 3 t cow dung/ha
T_4 = 50% NPKS + 6 t PM/ha
T_5= 75% NPKS + 3 t PM/ha
T_6= 50% NPKS + 6 t vermicompost/ha
T_7= 75% NPKS + 3 t vermicompost/ha

4.5 Correlation and regression analysis

The statistical relationship between different selected parameters of rice has been found out. The correlation co-efficient and regression lines of those parameters were also shown in figure with equations.

4.5.1: Relationship between Plant height (at harvest) and Grain yield

The relationship between Plant height (at harvest) and Grain yield has been found out. The correlation co-efficient (R^2=0.1013) was found significant at 5% level of probability.

The line of regression of Y (grain yield) on X (plant height) having equation y=0.2593x+6.1932 is shown in Figure 4.7. The positive slope indicates that the plant height and grain yield are directly correlated i.e., increase in plant height results in an increase in grain yield of rice.

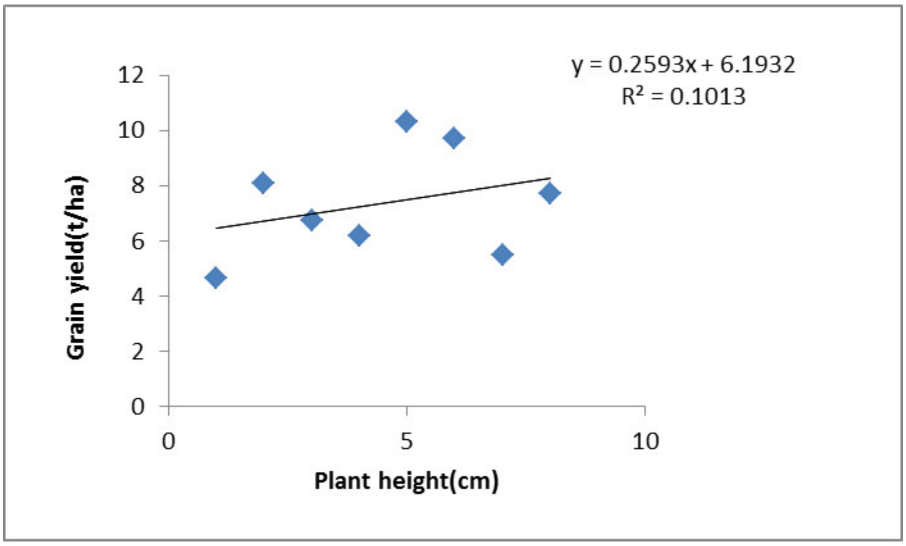

Fig. 4.5: Relationship between Plant height (at harvest) and Grain yield.

4.5.2 Relationship between Number of tiller/hill and Grain yield

The relationship between number of tiller/hill and grain yield has been found out. The correlation co-efficient (R^2=0.8927) was found significant at 5% level of probability.

The line of regression of Y (grain yield) on X (number of tiller/hill) having equation y=0.4202x+1.2448 is shown in Figure 4.8. The positive slope indicates that the plant height and number of tiller/hill are directly correlated i.e., increase in plant height results in an increase in number of tiller/hill of rice.

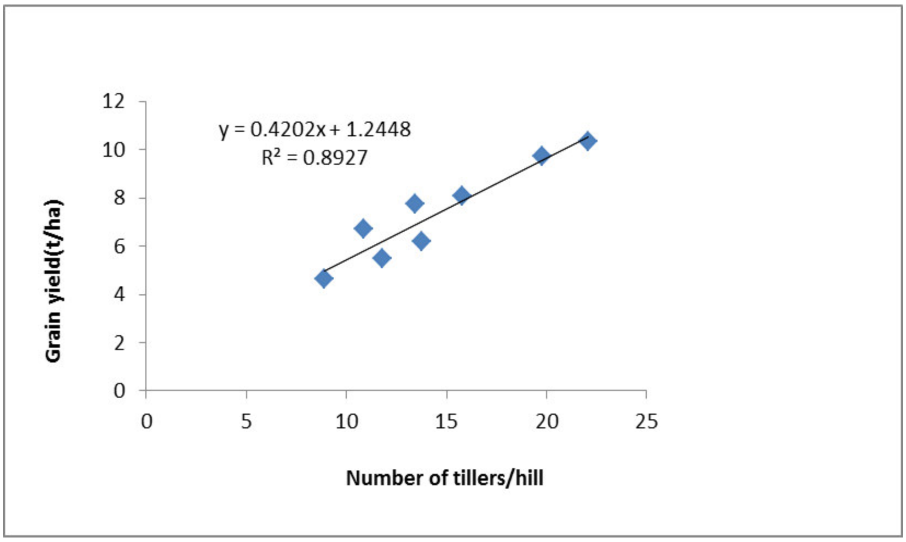

Figure 1

Fig. 4.6: Relationship between number of tiller/hill and Grain yield.

4.5.3 Relationship between Organic matter (%) and Grain yield

The relationship between content of organic matter (%) in post-harvest soil and grain yield has been found out. The correlation co-efficient (R^2=0.2409) was found significant at 5% level of probability.

The line of regression of Y (grain yield) on X (organic matter (%) in post-harvest soil) having equation y=4.0834x+2.1741 is shown in Figure 4.9. The positive slope indicates that the plant height and organic matter (%) in post-harvest soil are directly correlated i.e., increase in organic matter (%) results in an increase in plant height of rice

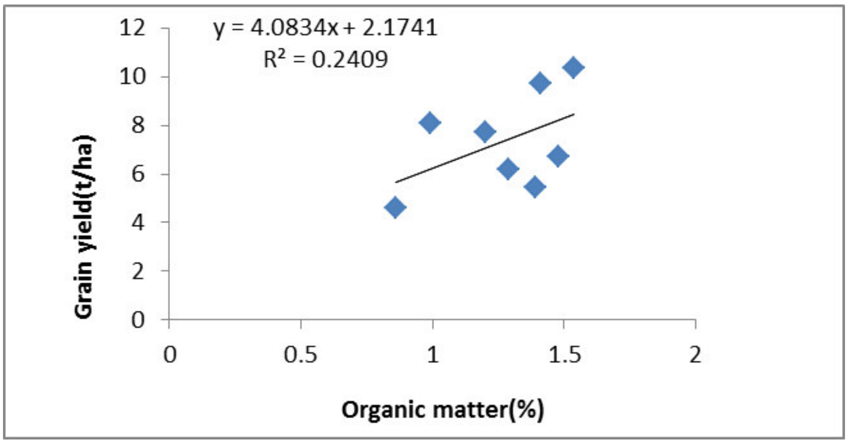

Fig. 4.7: Relationship between Grain yield and Organic matter (%) in post-harvest soil.

CHAPTER V

SUMMARY AND CONCLUSIONS

CHAPTER V

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Summary

The experiment was conducted at Soil Science Research Field, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during the period of December 2016 to May 2017 with a view to evaluate the effects of organic and inorganic fertilizers on the growth and yield of Boro rice (*BRRI* Dhan29). The experimental soil belongs to the Old Himalayan Piedmont Plain (AEZ 1). The soil was sandy loam in texture having pH 5.97, organic matter content 0.98 %, total N 0.05 %, available P 11.21 ppm, exchangeable K 0.10 m.e. 100 g^{-1} soil and available S 11.01 ppm. The experiment was laid out in a Randomized Complete Block Design (RCBD). There were eight treatments with three replications in the experiment. So the total numbers of plots were 24. The unit plot size was $5m^2$ (2 m×2.5 m). Different levels of inorganic and organic fertilizers were used as treatment viz. T_0= Control, T_1=100% recommended doses of inorganic fertilizers, T_2=50% NPKS + 6 t cowdung/ha, T_3=75% NPKS + 3 t cowdung/ha, T_4=50% NPKS + 6 t poultry manure/ha, T_5=75% NPKS + 3 t poultry manure/ha, T_6=50% NPKS + 6 t vermicompost/ha, T_7=75% NPKS + 3 t vermicompost/ha. Recommended doses of 163 kg ha^{-1} urea, 60 kg ha^{-1} TSP, 90 kg ha^{-1} MOP, 50 kg ha^{-1} Gypsum (Fertilizer Recommendation Guide, 2012) were applied respectively. The rates of manure were 3 & 6, 3 & 6 and 3 & 6 t ha^{-1} for cowdung, PM and vermicompost per plot were calculated as per the treatments respectively. Full amounts of TSP, MoP and gypsum were applied as basal dose. Urea was 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 before panicle initiation stage (55 DAT). Seeds were sown on the 1st December, 2016 and transplanted on 10 January, 2017 in the field. The crop was allowed to grow until maturity and intercultural operations such as weeding and irrigation were done whenever required in order to support normal growth of the plant. At maturity, the crop was harvested on 3 May, 2017. Plot wise yield and yield components were recorded.

Soil samples were collected before fertilizers application and after harvest. Initial and post-harvest soil samples were analyzed for physical and chemical properties of soil using the standard methods. All the data were statistically analyzed by F-test and the mean differences were judged by Duncan's Multiple Range Test (DMRT).

The results revealed that the yield components such as, Plant Height, Number of Tillers hill^{-1}, Panicle Length, Number of Grains panicle^{-1}, Number of Filled Grains panicle^{-1}, Number of Unfilled Grains panicle^{-1}, Weight of 1000 grains, Grain Yield, Straw Yield and Biological Yield responded significantly due to application organic and inorganic fertilizers.

The tallest plant height (94.37 cm) was found in the treatment T_4 which was statistically identical with T_5. The shortest plant height (73.25cm) was observed in T_0 (control). The maximum tillers hill^{-1} (22.10) was recorded in the treatment T_4. The minimum tillers hill^{-1} (8.89) was observed in the T_0 (control). The treatment T_4 produced the highest panicle length (26.48 cm). The lowest panicle length (18.21 cm) was obtained from the controlled treatment T_0. The maximum number of total grains plant^{-1} (178.3) was recorded from the treatment T_4 and the minimum total grains plant^{-1} (102.4) was observed in the T_0 (control). The highest 1000-grains weight (21.96 g) was noticed at T_4 treatment and the lowest (17.10 g) was observed in the T_0 (control). The application of recommended doses of inorganic fertilizers in combination with organic fertilizers remarkably increased the grain and straw yields of Boro rice (*BRRI Dhan29*). The maximum grain yield of 10.33 t ha^{-1} was found in T_4 treatment which was closely followed by T_5 treatment and the minimum grain yield (4.63 t ha^{-1}) was recorded in the T_0 (control). The treatment T_4 gave the highest straw yield (15.67 t ha^{-1}) while the T_0 (control) gave the lowest value (6.73 t ha^{-1}). In grain and straw the percentage of N, P and S content was also higher in T_4 treatment and lower in T_0 treatment.

Application of organic and inorganic fertilizers resulted in a considerable influence on the properties of the post-harvest soils such as pH, organic matter content, total N, available P, exchangeable K and available S. In post-harvest soil application of inorganic fertilizers give positive result. It also increases soil fertility status. The highest p^H value (6.02) was observed in T_4 and T_6 and lowest p^H value (5.97) was found in T_0 which were statistically insignificant. Soil organic matter percentage was highest (1.54 %) in T_4

treatment which was statistically identical with T_2, T_3, T_5, T_6 and T_7. The lowest OM value (0.86 %) was found in T_0 treatment.

The total higher levels of N, available P and available S (0.08%, 22.10 ppm and 16.51 ppm respectively) were found in T_4 treatment and lowest (0.04%, 10.05 ppm and 10.24 ppm respectively) was in T_0 treatment. Only Exchangeable K was highest (0.16 m.e./100 g soil) in T_6 treatment and lowest (0.08 m.e./100g soil) was in T_0 treatment. So the treatments may be ranked in the order of $T_4 > T_5 > T_2 > T_7 > T_3 > T_6 > T_2 > T_0$.

Finally it can be concluded from the present study that the application of organic manures with the recommended doses of inorganic fertilizers showed better performance in respect of grain yield, yield contributing characters and also increase fertility status in soil. On the other hand, only inorganic fertilizers may give a good performance in grain yield and yield contributing characters but it decrease soil nutrient status. Here 50% NPKS + 6 t poultry manure/ha (T_4) give better performance than another combination in all aspects. So, organic fertilizers will be profitable for rice cultivation.

So the combined application of organic fertilizers with inorganic fertilizers will be beneficial for rice cultivation.

Conclusions

From the results of the study it may be concluded that:

i. Combined application of organic and inorganic fertilizers can significantly increase the yield and yield contributing characters and 50% NPKS + 6 t poultry manure/ha (T_4) also produced the maximum yield of rice.
ii. Application of 50% NPKS + 6 t poultry manure/ha (T_4) can increase the amount of organic matter content, total N, available P, exchangeable K and available S in soil to some extent.

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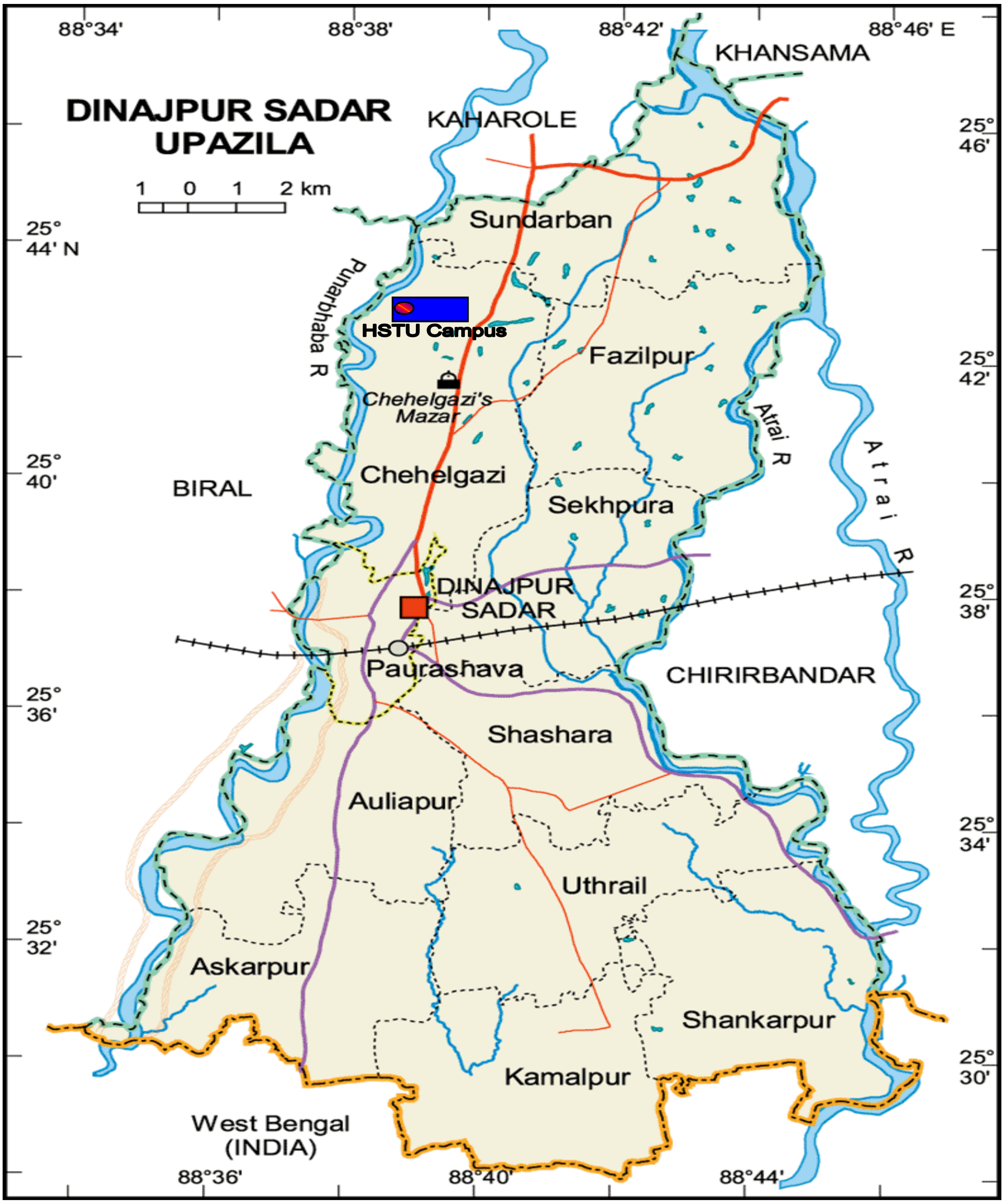
APPENDICES

APPENDICES

Appendix I: Experimental site (Map of Dinajpur Sadar Upazila showing the HSTU campus)



Appendix II. Monthly recorded air temperature, relative humidity and rainfall during December, 2016 to April, 2017.

Year	**Month**	**** Air temperature (^oC)**			****Humidity (%)**	****Rainfall (mm)**
		Maximum (0^oC)	Minimum (0^oC)	Average (0^oC)		
2016	December	26.4	12.1	19.25	85	7
2017	January	25	9.7	17.35	81	4
	February	28.1	12.5	20.3	77	0
	March	28.7	15.1	21.9	78	97
	April	31.4	19.5	25.45	83	207

**Monthly average

Source: Wheat Research Centre, Nashipur, Dinajpur.

Appendix III. Effect of different organic & inorganic fertilizers on the Grain yield, Straw yield and Biological yield of Boro rice (BRRI Dhan29).

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological Yield (t ha^{-1})
T_0	4.63 d	6.73 d	11.37 e
T_1	8.07 b	11.20 b	19.27 b
T_2	6.73 bc	10.20 bc	16.93 bcd
T_3	6.20 c	8.87 c	15.07 cd
T_4	10.33 a	15.67 a	26.00 a
T_5	9.73 a	15.00 a	24.73 a
T_6	5.47 cd	9.07 bc	14.53 d
T_7	7.73 b	10.33 bc	18.07 bc
LSD value	1.34	1.98	3.13
CV %	10.42	10.39	9.79
Level of significance	*	*	*

In a column having common letters do not differ significantly at 5% level of significance.

CV% = Coefficient of variation

LSD = Level of Significance

* = Significant

Here,

T_0= Control
T_1= 100% NPKS
T_2= 50% NPKS + 6 t cow dung/ha
T_3= 75% NPKS + 3 t cow dung/ha
T_4 = 50% NPKS + 6 t PM/ha
T_5= 75% NPKS + 3 t PM/ha
T_6= 50% NPKS + 6 t vermicompost/ha
T_7= 75% NPKS + 3 t vermicompost/ha

Appendix IV. N, P, K and S contents in Grain and Straw of BRRI Dhan29 as influenced by different treatments.

Treatments	N %		P %		K %		S %	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_0	0.94 b	0.49 a	0.22 d	0.06 a	0.25 e	1.160 c	0.07 a	0.06 a
T_1	1.28 a	0.67 a	0.31 bc	0.07 a	0.36 bc	1.610 ab	0.09 a	0.08 a
T_2	1.22 a	0.64 a	0.29 bc	0.07 a	0.31 cd	1.550 ab	0.08 a	0.07 a
T_3	1.27 a	0.65 a	0.29 bc	0.07 a	0.34 cd	1.590 ab	0.08 a	0.07 a
T_4	1.36 a	0.73 a	0.38 a	0.09 a	0.45 a	1.710 a	0.10 a	0.09 a
T_5	1.31 a	0.69 a	0.34 ab	0.08 a	0.41 ab	1.670 a	0.08 a	0.08 a
T_6	1.17 a	0.59 a	0.27 cd	0.07 a	0.29 de	1.400 b	0.07 a	0.06 a
T_7	1.19 a	0.61 a	0.29 bc	0.07 a	0.30 de	1.500 ab	0.07 a	0.06 a
LSD value	0.21	0.21	0.06	0.06	0.06	0.21	0.06	0.06
CV %	9.77	19.61	11.91	21.42	8.88	7.85	20.32	21.30
Level of significance	*	NS	*	NS	*	*	NS	NS

In a column having common letters do not differ significantly at 5% level of significance.

CV% = Coefficient of variation

LSD = Level of Significance

NS =Not Significant

* = Significant

Here,

T_0= Control
T_1= 100% NPKS
T_2= 50% NPKS + 6 t cow dung/ha
T_3= 75% NPKS + 3 t cow dung/ha
T_4 = 50% NPKS + 6 t PM/ha
T_5= 75% NPKS + 3 t PM/ha
T_6= 50% NPKS + 6 t vermicompost/ha
T_7= 75% NPKS + 3 t vermicompost/ha

Appendix V: Showing some photographs of research plots and operational activities during conducting experiment