EFFECT OF FERTILIZER AND MANURE ON NUTRIENT AVAILABILITY AND YIELD OF BORO RICE IN DIFFERENT SOILS

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DECEMBER 2013

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REG. No. : 07-02509

A Thesis
submitted to the Department of Soil Science
Sher-E-Bangla Agricultural University, Dhaka
in partial fulfilment of the requirements
for the degree
of

MASTER OF SCIENCE (M.S.)
IN
SOIL SCIENCE
SEMESTER: JULY-DECEMBER, 2013

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CERTIFICATE

This is to certify that the thesis entitled, "EFFECT OF FERTILIZER AND MANURE ON NUTRIENT AVAILABILITY AND YIELD OF BORO RICE IN DIFFERENT SOILS" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN SOIL SCIENCE**, embodies the result of a piece of *bona fide* research work carried out by SYEDA SUMAYA SULTANA, Registration No. 07-02509 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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TO

MY BELOVED PARENTS

ACKNOWLEDGEMENTS

All praises are due to Almighty Allah, the Great, Gracious and Merciful, whose blessings enabled the author to complete this research work successfully.

The author likes to express her deepest sense of gratitude to her respected supervisor Prof. Dr. Md. Asaduzzaman Khan, Department of Soil Science, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh for his scholastic guidance, support, encouragement and invaluable suggestions and constructive criticism throughout the study period in conducting and successfully completing the research work and in the preparation of the manuscript.

The author also expresses her gratefulness to respected Co-Supervisor, A.T.M Shamsuddoha, Professor, Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka for his scholastic guidance, helpful comments and constant inspiration, inestimatable help, valuable suggestions throughout the research work and in preparation of the thesis.

The author expresses her sincere respect to the Chairman, Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka for his valuable suggestions and cooperation during the study period. The author also expresses heartfelt thanks to all the respected teachers of the Department of Soil Science, SAU, for their valuable suggestions, instuctions, cordial help and encouragement during the period of the study.

The author is also expressing sincere thanks to Mr. Subrata Kumar Shil, Marufa, Zakia, Neela and all of the official staffs of Soil Science department for providing their assistance during the experiment.

Finally the author is expressing her heartfelt thanks to her beloved parents Mr. Syed Golam Sarwar and Mrs. Syeda Bilkis Banu and her elder brother Mr. Syed Golam Rashed for the excellent co-operation and mental support during the period of the study..

Dhaka, Bangladesh ***The Auther***

December, 2013

ABSTRACT

The experiment was conducted in the net house of Soil Science Department at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2012 to May 2013 to study the effect of fertilizer and manure application on yield and yield components of rice and availability of nutrients in soil pore water during rice growing period. The experiment consists of 2 factors i.e. soils and fertilizer plus manure. Two soils (S_1= SAU Soil and S_2= Shingair Soil) and 5 levels of fertilizer and manure (T_0: Control, T_1: 100% $N_{120}P_{25}K_{60}S_{20}Zn_2$ (Recommended dose), T_2: 50% NPKS + 5 ton cowdung ha^{-1}, T_3: 50% NPKS + 5 ton compost ha^{-1}, T_4: 50% NPKS + 3.5 ton poultry manure ha^{-1}) were used for Boro rice (BRRI dhan29) cultivation in the earthen pots. There were 10 treatment combinations and 3 replications. Results revealed that variation of soils, fertilizer and manure application and their combination had significant effect on the yield and yield parameters. SAU soil showed better performance than Shingair soil. The highest plant height (79.43 cm), panicle length (25.95 cm), number of filled grain/panicle (166.65) and 1000 grain wt. (23.76 g) were obtained from T_4 and higher grain yield (94.22 g/pot) and straw yield (85.2 g/pot) were obtained from T_1 treatment and the lowest from T_0 treatment. The S_1T_4 treatment combination showed higher yield and yield contributing characters and the lowest was obtained from S_1T_0 and S_2T_0 treatment combinations. Pore water samples were collected at 20, 40 and 60 days after transplantation and analyzed for N, P, K and S content following standard methods. The N and P concentration in the pore water varied significantly with different soils, fertilizer plus manure and their combinations treatments and time. K and S concentration in pore water varied significantly with fertilizer plus manure treatments. The higher pore water N concentrations were found in SAU soil compared to Shingair soil. Higher pore water P and K concentrations were found in Shingair soil compared to SAU soil. Among the fertilizer treatments, significantly higher concentrations of N, P, K and S were found in the T_4 treatment compared to other fertilizer treatments. The grain and straw nutrient concentrations were significantly affected by the application of fertilizer and manure. The highest concentrations of grain N (1.290 %) from T_3, P (0.310 %) from T_1, K (0.274 %) from T_4 and S (0.094 %) was obtained from T_2 treatment and the lowest from T_0 treatment. The similar and higher concentrations of straw N, P, K, and S were found in all fertilizer treatments except control. The soil and fertilizer treatment combinations did not significantly affect the grain and straw nutrient concentrations.

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CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food for the people of Bangladesh and will continue to remain so in future. Rice production systems make a vital contribution to the reduction of hunger and poverty in Bangladesh. Besides, its economy is heavily dependent on this sector. The country needs substantial increase in rice production to provide her teeming millions with food and other basic needs of life. There are not many options but to raise level of rice production from the limited land resources under diverse climatic conditions for improving the living standard of her common people. The depleted soil fertility is a major constraint to higher crop production in Bangladesh. The increasing land use intensity has resulted in a great exhaustion of nutrients in soils. The farmers of this country use on an average 102 kg nutrients/ha annually (70 kg N + 24 kg P + 6 kg K + 2 kg S and Zn) while the crop removal is about 200 kg/ha (Islam et al., 1994). In Bangladesh, most of the cultivated soils have less than 1.5% organic matter while a good agricultural soil should contain at least 2% organic matter. Moreover, this important component of soil is declining with time due to intensive cropping and use of higher dose of chemical fertilizers with little or no addition of organic manure in the farmer's field. Rice-rice system is the most important cropping system in Bangladesh. Continuous cultivation of this highly exhaustive cropping sequence in most of the irrigated fertile lands has resulted in the decline of soil physico-chemical condition in general and particularly soil organic matter (SOM) content. This has led to a reduction in the total factor productivity and raised questions on the sustainability of this cropping system. This implies increased use organic manures and of fertilizers, optimum adoption of pest management strategies and shifting from mono-to double-and triple cropping on the same piece of land year after year.

It will, therefore, be necessary to place greater emphasis on strategic research to increase the efficiency of applied nutrients through integration with organic manures, which will help in accomplishing twin objectives of sustaining soil health and ensuring food security and environmental protection. Application of manure and fertilizer affects the nutrient availability in soil. The available nutrient moves downward with percolated water. The bioavailability, uptake and movement of nutrients in soil are dependent on a number of factors including the source and concentration of the nutrient, soil properties such as clay content, pH and redox conditions, ions and type and amount of organic matter. The transport of N, P, K and S in soil as well as its uptake by plants is governed by the difference of soil and the variation of added fertilizer. Yang et al. (2004) reported that application of chemical fertilizers with farmyard manure increased N,P and K uptake by rice plants and increased 1000 grain weight and grain yield of rice. Continuous flooded and saturated condition, fertilizer and manure application, cropping and without cropping may affect the N, P, K and S concentration in the soil pore waters. Anaerobic and aerobic conditions in paddy soil leads to nutrient mobilization and thus affect the availability of nutrients in pore-water. The application of manure or chemical fertilizer alone in paddy soil may affect the movement of nutrient in pore-water and accumulation of nutrient in rice plant. Mobility of nutrient in soil pore-water is still imperfectly understood .The pore-water nutrient concentrations were studied in this experiment with different levels of fertilizer, irrigation and presence or absence of rice plants.

The efficiency of used fertilizers in the rice field is greatly affected by the level of soil moisture during rice growing periods. Organic matter decomposition and nutrients mineralization are greatly affected by the soil moisture level. Anaerobic conditions in paddy soil lead to mobilization of some nutrients and thus affect nutrients bio availability to rice plants. To increase the efficiency of manure and fertilizer in rice cultivation, it is necessary to identify the suitable level and type of manure and fertilizer. The fate of added fertilizer in the soil and estimation of nutrient availability in the pore water is a new idea of research. Soil is a heterogeneous system, it is important to carry out studies to understand the fate of applied fertilizers in soil-water-plant system.

OBJECTIVES:

Considering the present situation the present study was undertaken with the following objectives:

i. To investigate the availability of N, P, K and S in pore water with different fertilizer management systems.
ii. To develop a suitable integrated dose of inorganic fertilizers combined with different organic fertilizers for Boro rice.
iii. To investigate the improvement of soil fertility due to the use of organic manure in combination with chemical fertilizers.
iv. To evaluate the effect of soil, fertilizer and manure on the yield and quality of Boro rice.

CHAPTER II

REVIEW OF LITERATURE

Soil organic manure and inorganic fertilizer are the essential factor for sustainable soil fertility and crop productivity because organic matter is the store house of plant nutrients. Soil and combined use of cow dung, compost, poultry manure and inorganic fertilizer acts as a source of essential plant nutrients. Experimental evidences in the use of cow dung, compost, poultry manure, and nitrogen, phosphorus, potassium and sulphur showed an intimate effect on the yield and yield attributes of rice. Yield and yield contributing characters of rice are considerably influenced by different doses of NPKS fertilizer, cow dung, compost, poultry manure and their combined application. Some literature related to the "EFFECT OF FERTILIZER AND MANURE ON THE NUTRIENT AVAILABILITY AND YIELD OF BORO RICE IN DIFFERENT SOILS." are reviewed below-

2.1 Effect of chemical fertilizer on the growth and yield of rice

Asif *et al.* (2000) reported that NPK levels significantly increased the panicle length, number of primary and secondary branches panicle^{-1} when NPK fertilizer applied in 180-90-90 kg ha^{-1} this might be attributed to the adequate supply of NPK.

Sarker *et al.* (2001) obtained the nitrogen responses of a Japonica (Yumelvitachi) and an Indica (Takanari) rice variety with different nitrogen levels viz. 0, 40, 80, and 120 kg N ha^{-1}. They observed that application of nitrogen increased grain and straw yields significantly but harvest index was not increased significantly.

Singh and Singh (2002) carried out a field experiment to see the effect of different S levels (0, 20 and 40 kg ha^{-1}) on rice cv. Swarna and PR-108 in Varanasi, Uttar Pradesh, India. They reported that plant height, tillers/m^2, dry matter production, panicle length and grains panicle^{-1} were significantly increased with increasing levels of S up to 40 kg ha^{-1}.

Haq *et al.* (2002) conducted an experiment with twelve treatments combination of N, P, K, S, Zn and Diazinon. They found that all the treatments significantly increased the grain and straw yields of BRRI dhan30 rice over control. 90 kg N + 50 kg P_2O_5 + 40 kg K_2O + 10 kg S + 4 kg Zn ha^{-1} + diazinon gave the highest grain and straw yields.

Rasheed *et al.* (2003) reported that the effect of different NP levels i.e., 0-0, 25-0, 50-25, 75-50, 100-75 and 125-100 kg ha^{-1} on yield and yield attributes of rice Bas-385. Yield attributes (No. of effective tillers per hill, spikelet per panicle, normal kernels per panicle, 1000-grain weight) were improved linearly with increasing NP levels up to 100-75 kg ha^{-1}. The NP level of 100-75 kg ha^{-1} resulted in the highest grain yield of 4.53 t/ha with minimum kernel abnormalities (Sterility, abortive kernels and opaque kernels) as against the minimum of 2.356 t ha^{-1} in the control (0-0) followed by 25-0 kg NP ha^{-1} with maximum kernel abnormalities.

Singh *et al.* (2003) reported that crop growth rate and relative growth rate such as total dry matter production was significantly influenced by NPK fertilizers. The tiller number and total dry matter production are closely correlated with yield depending on the rice cultivar which can be greatly enhanced by applying proper nutrient.

Phaev *et al*. (2003) concluded that freshly applied P increased rice grain yield by 95%. In the first and second crops using residual P fertilizer, yields increased by 62 and 33% relative to the P-control plot. Cumulative removal of P in four successive rice crops accounted for 30 and 55% of the 16.5 kg ha^{-1} in the form of harvested grain and whole plants.

Amin *et al.* (2004) conducted an experiment to evaluate the effect of increased plant density and fertilizer dose on yield of rice variety IR-6. They found that increased fertilizer dose of NPK increased plant height.

Saha *et al.* (2004) conducted an experiment in 2002-2003 to create and compare a suitable fertilizer recommendation model for lowland rice. Five different fertilizer recommendation models were tested and compared with one check plot. Results showed that the application of different packages estimated by different fertilizer models significantly influenced panicle length, panicle numbers, spikelet number per panicle, total grains per panicle, number of filled grain and unfilled grain per panicle. The combination of NPK gave the highest result (120-13-70-20 kg ha^{-1} NPKS).

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

Rahman *et al.* (2007) conducted a field experiment using rice (cv. BRRI dhan 29) as a test crop and found that application of S had a significant positive effect on tillers ha^{-1}, plant height, panicle length and grains $panicle^{-1}$. They also indicated that application of S fertilizer at a recommended rate (20 kg S/ha) might be necessary for obtaining higher grain yield as well as straw yield of Boro rice (cv BRRI dhan 29).

Ndaeyo *et al.* (2008) conducted an experiment in Nigeria with five rice varieties (WAB340-8-8-2HI, WAB881-10-37-18-8-2-HI, WAB99-1-1, WAB224-8-HB, WAB189-B-B-B-8-HB) and four rates of NPK (15:15:15) fertilizer (0, 200, 400 and 600 kg ha^{-1}). The results showed that 600 kg ha^{-1} NPK (15:15:15) fertilizer rate significantly ($P < 0.05$) increased plant height, number of leaves and tillers per plant in both years. The 400 kg ha^{-1} rate increased the number of panicles per plant, length of central panicle per plant and the overall grain yield, straw yield over other rates by 4-32% and 2-21% in 2005 and 2006, respectively.

Islam *et al.* (2008) conducted an experiment in 2001-2002, 2002-2003 and 2003-2004 to determine the response and the optimum rate of nutrients (NPK) for Chilli- Fallow-T. *aman* cropping pattern. They found that grain yield influenced significantly due to application of different rates of nutrients and 60-19-36 kg ha^{-1} NPK maximized the yield of T. Aman rice varieties in respect of yield and economics.

Wu-YuQiu (2013) conducted an experiment on Fuyou 33, a new rice variety derived from the cross Yanfeng 47xH1024. A field trial was conducted in 2012 in Liaoning with 5 treatments [N application 135 (E1), 187.5 (E2), 240 (E3), 242.5 (E4), and 345 kg/ha (E5)] replicated 3 times to investigate the effect of nitrogen application on growth characters and yield of Fuyou 33. It was found that increasing nitrogen amounts could increase harvested panicles, leaf area index in the full heading stage, photosynthetic rates of flag leaf, and dry weight accumulation in the maturity stage, but had a negative effect on productive panicle rates, high-efficiency leaf area rates and effective leaf area rates in the full heading stage, the rate of dry matter accumulation in the grain yield after heading, and harvest index. The highest yield was marked in E3 at 9.22 ton ha^{-1}

2.2 Combined effect of chemical fertilizer and manure on the growth and yield of rice

2.2.1 Combined effect of chemical fertilizer and cowdung on the growth and yield of rice

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

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

Dao and Cavegelli (2003) reported that animal manure had long been used as an organic source of plant nutrients and organic matter to improve the physical and fertility condition of agricultural lands.

Tripathy *et al*. (2004) found significantly higher seed yield under the residual effects of the blended cowdung and NPK fertilizer compared to the control.

Saleque *et al*. (2004) conducted a field experiment to determine the effect of different doses of chemical fertilizers alone or in combination with cowdung and rice husk ash on yield of lowland rice-rice cropping sequence. Cowdung and ash were applied on dry season rice only and found the application of cowdung and ash increased rice yield by about 1 t ha^{-1} per year over that obtained with chemical fertilizer alone, the treatments, which showed positive yield trend, also showed positive total P uptake trend and positive yield trends were attributed to the increasing P supplying power of the soil.

Saleque *et al.* (2004) showed that application of one third of recommended inorganic fertilizers with 5 t cowdung increased the low land rice yield than other treatments and gave yield 8.87t ha^{-1}.

Rahman *et al*. (2009) conducted a field experiment to study the effect of urea N in combination with poultry manure and cowdung in rice and found application of manures and different doses of urea N fertilizer significantly increased the yield components and grain and straw yields.

2.2.2 Combined effect of chemical fertilizer and compost on the growth and yield of rice

Farid *et al*. (1998), reported that incorporation of compost or rice straw and subsequent decomposition increased and maintained organic matter level at 2.5% that was higher than that in traditionally managed rice soil (<2%). Application of composted coir pith improves the soil available K status and increases the uptake of K by grains and straw yield of rice. Application of 50 kg N with green leaf manure gave the highest grain and straw yields in both season, followed composted coir pith (Chittra and Janaki, 1999).

Composts from organic wastes, such as segregated waste, green botanical waste and food processing waste are becoming available in increasing quantities. These supply a complex mixture of nutrients in organic and mineral forms and are also used as soil condition to maintain and improve soil structure (HDRA, 1999).

Tamaki *et al*. (2002) observed that the correlation between growth and yield and duration of organic farming (compost mixed with straw) in comparison with conventional farming. In inorganic farming plant height of rice was shorter and short number hill^{-1} was lesser than in conventional farming, but both of these values increased as the duration of organic farming increased. The maximum tiller number was smaller and panicle number was also smaller than in inorganic farming. However, both the panicle number and panicle length increased as the duration organic farming increased. The grain- straw ratio was higher in organic farming than the conventional farming. These results suggest that the growth and yield of rice increased with continuous organic farming and the yield increased with increase in panicle number hill ha^{-1} and grains number/panicle.

Keeling *et al*. (2003) determined the green waste compost and provided with additional fertilizers and showed consistently that the response of rice rape to compost and fertilizer applied together than the response to the individual additives, but only very stable compost was used (> 10 months processing). Experiments with 15 N-labeled fertilizer showed that rice was able to utilize the applied N-more efficiently when cultivated with the stable compost.

Elsharaeay *et al*. (2003) found the effect of compost of the some plant residues i.e. rice straw and cotton stalk on some physical and chemical properties of the sandy soil. Application of cotton stalks or rice straw composts significantly improved the physical properties of the tasted soil, i.e., bulk density, hydraulic conductivity and moisture content namely field capacity, wilting point and available water, concerning the effect of compost application on the availability of N, P and K in the cultivated soil, rice straw was better than cotton stalks.

Davarynejad *et al.* (2004) conducted an experiment to investigate the effect of manure and municipal compost and their enrichment with chemical fertilizers on growth and yield of rice. Results showed that compost alone did not increase grains yield. However, when enriched with different levels of chemical fertilizer the highest amount of grains yield was produced. The yield was comparable to the yield obtained from 40 t ha^{-1} of compost. This indicated that compost might be an appropriate substitute for manure and half of chemical fertilizer needed for soil.

Nayak *et al* (2007) reported that application of compost and inorganic fertilizer increased microbial growth in soil, vegetative growth and maximum tillering of rice.

Veerendra *et al* (2012) conducted an experiment to study the impact of integrated nutrient management on yield, economics and nutrient uptake of hybrid rice was conducted in sandy loam Udicustochrepts soil at Fertilizer Research Station, Pura of C.S. Azad University of Agriculture and Technology, Kanpur during Kharif 2007 and 2008. Results revealed that integrated treatments of bio fertilizers or organic manures registered significantly higher seed yield, net return and nutrient uptake over RDF alone.

2.2.3 Combined effect of chemical fertilizer and poultry manure on the growth and yield of rice

Singh and Sing (2000) studied the effect of poultry manure under irrigated condition with nitrogen in rice-wheat cropping system in an Alfisol of Bilapur, Madhya Pradesh, India. The treatment consisted of poultry manure alone and in combination with nitrogen fertilizer. Root and shoot biomass at different growth stages increased with the application of N and poultry manure alone and combination. Root and shoot biomass was higher in 100% N through poultry manure, followed by 75% N through poultry manure and 25% through urea.

Channbasavana and Biradar (2001) reported that the application of poultry manure @ 3 t ha^{-1} gave 26% and 19% higher grain yield than that of the control 1998 and 1999, respectively.

Eneji *et al*. (2001) observed that average across the soils, the level of extractable Fe increased by 5% in chicken manure and 71% in cattle manure; Mn by 61% in chicken manure and 172% in swine manure; and Cu by 327% in chicken manure and 978% in swine manure. Mixing these manures before application reduce the level of extractable trace elements.

Vanaja and Raju (2002) conducted a field experiment on integrated nutrient management practice in rice crop. Different combinations of chemical fertilizer with poultry manure 2 t/ ha gave highest grain and straw yield.

Umanah *et al*. (2003) find out the effect of different rates of poultry manure on the growth, yield component and yield of upland rice cv. Faro 43 in Nigeria, during the 1997 and 1998 early crop production seasons. The treatments comprised 0, 10, 20 and 30 t ha^{-1} poultry manure. There were significant differences in plant height, internode length, and tiller number, panicle number per stand, grain number panicle $^{-1}$, and dry grain yield. There was no significant difference among the treatments for 1000-grain weight.

Channabasavanna (2003) conducted a field experiment to evaluate the efficient utilization of poultry manure with inorganic fertilizers in wetland rice and found that the grain yield increased with each increment of poultry manure application and was maximum at 3 t poultry manure ha^{-1}. Poultry manure at 2 ton ha^{-1} recorded significantly higher values for seed yield and its attributes. The study proved the superiority of poultry manure over farmyard manure (FYM). It was evident from the study that one ton of poultry manure was equivalent to 7 ton FYM which produced at per seed yields. Agronomic efficiency of N (AEN) at 75% NPK (112.5:56.3:56.3 kg NPK ha^{-1}) was equivalent to 2 t poultry manure ha^{-1}. The results showed that an increase in poultry manure and fertilizer increased rice seed yield. The AEN decreased with an increase in the application of poultry manure and NPK fertilizer.

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

Miah *et al*. (2004) found 5.6-6 t/ha-grain yields with application of 2 t ha^{-1} poultry manure plus 120 kg N ha^{-1} in Boro season.

Reddy *et al*. (2005) carried out a field experiment on black clay soils in Gangavati, Karnakata, India, to evaluate the performance of poultry manure (PM) as a substitute for NPK in irrigated rice (cv. IR 64). The application of PM at 5 t ha^{-1} recorded a significantly higher grain yield (5.25 t/ha) than the control and FYM application at 7.5 t ha^{-1}, significantly improved the soil P and K status, and increased the N content of the soil. Poultry manure at 5 t ha^{-1} resulted in higher gross returns (30592 Rupees ha^{-1}) over other levels of PM and FYM. However, net returns and benefit cost rations were comparable between 5 and 2 t PM ha^{-1}, and between 100 and 75% NPK. The application of 2 t PM ha^{-1} and 75% NPK, was found economical.

Miah *et al*. (2006) stated that an application of poultry manure with soil test basis (STB), IPNS and AEZ based fertilizer gave higher grain yield compared to other organic materials.

Islam *et al.* (2013) conducted an experiment in Sher-e-Bangla Agricultural University and reported that the yield contributing characters and yields were significantly influenced by applied fertilizer and manure. The higher grain and straw yields were obtained organic manure plus inorganic fertilizers than full dose of chemical fertilizer and manure. The highest concentrations of grain and straw N, P, K, S were recorded where 50% RDCF + 4 ton poultry manure/ha was used.

Rao *et al.* (2013) conducted an experiment for three consecutive rabi seasons of 2009-10, 2010-11, and 2011-12 at Agricultural Research Station, Seethampeta, Andhra Pradesh, India on sandy clay loam soil with four organic manures (Farm yard manure, Neem leaf manure, Sheep manure and Poultry manure) and four scented rice cultures (Pusa basmathi 1, Tararoi basmathi, RNR 2465 and RNR 18833) with an objective to find out suitable organic manure and an outstanding scented rice variety under organic farming particularly for high altitude areas of Andhra Pradesh. Among organic manures supply of 60 kg N ha-1 through Poultry manure found superior in terms of yield attributes, yield, root biomass nutrient uptake and returns.

2.3 Movement of N, P, K and S in soil

Michael and Nancey (2000) conducted a study to determine the influence of recommended N fertilizer rate and timing on N movement in soil during the growing season. They found that for irrigated wheat in Arizona, most of the N fertilizer recovered in the top 2.4 of soil was in the surface soil, regardless of N fertilizer practices.

Anderson and Magdoff (2005) found that repeated application of organic forms of P could lead to significant leaching of P to ground water.

Savin *et al.* (2005) carried out a research study to determine just how far flood water moves fertilizer-N into silt-loam soil and to evaluate the short-term distribution of fertilizer-N following incorporation. They concluded that immediate and deeper movement into silt loam soil of urea applied N as compared to ammonium sulphate-applied N, but also raise concerns about the movement of urea-applied N if urea breaks down to ammonium at the soil surface before the flood water can incorporate fertilizer into the soil.

Jalali and Rowell (2009) concluded that "When applied K was displaced with the distilled water K was retained in the top 10 -12.5 cm depth of soil. In the undisturbed soil cores there is possibility of preferential flow and lack of K sorption. The application of gypsum and $CaCl_2$ in the reclamation of sodic soil would be expected to leach K from soils.

Abimbola *et al*. (2010) found that P could be lost through leaching especially at high rate of manure application. Irrigation activity enhanced in situ movement of P down the soil profile.

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

Nimbiar (1997 b) views that integrated use of organic manure and chemical fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining healthy soil fertility status. Intensive crop production systems have witnessed serious problems associated with loss of soil fertility as a result of excessive soil mining of plant nutrients and consequently reduction in productivity. Application of external source of plant nutrients is a key element in optimal management of soil organic matter, crop residues and manure for ensuring the bio-availability, the cycling and the balance of nutrients in the soil - plant systems.

Mathew and Nair (1997) reported that cattle manure when applied alone or in combination with chemical fertilizer (NPK) increased the organic C content, total N, available P and K in rice soils.

Xu *et al.* (1997) observed that application of organic matter affect soil pH value as well as nutrient level. They also reported that organic carbon, total N and available P_2O_5, K_2O, S and

Zn in the soil were higher in the plots where nutrients were applied through organics than the inorganic sources.

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

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

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

Krishna and Ram (2006) concluded that continuous cropping without fertilization leads to depletion of organic matter in soil leading to decrease in yield and nutrient uptake as compared to balanced fertilization along with organic manure which had beneficial effect on organic matter and ultimately increases yield of rice. In the fertilized plots nutrients were utilized from soil to meet the requirement of crops. Continuous cropping without fertilizer or manure lower crop yield due to declining soil fertility due to nutrient removal by crop.

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

Veerendra *et.al* (2012) conducted an experiment to study the effect of integrated nutrient management applied to rice in Udic ustochrepts on the performance of hybrid rice-mustard cropping system in a sandy loam soil. Integrated use of organic manures or biofertilizers with RDF improved the physical, chemical and biological properties of soil at completion of experiment.

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

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at Sher-e-Bangla Agricultural University net house during October 2012 to May 2013 to study the effect of fertilizer and manure application on yield and yield components of rice and availability of nutrients in soil pore water during rice growing periods. This chapter includes materials and methods that were used in conducting the experiment. The details are presented below under the following headings -

3.1 Experimental Site

The experiment was conducted in a net house of Soil Science Department at Sher-e-Bangla Agricultural University, Dhaka during October 2012 to May 2013.

3.2 Climate

The climate of the experimental area is characterized by a scanty rainfall associated with moderately low temperature in the *rabi* season (October-March). The weather information regarding temperature, rainfall, relative humidity and sunshine hours prevailed at the experimental site during the cropping season October 2012 to May 2013 have been presented in Appendix I.

3.3 Experimental set-up

Two different soils were collected from different AEZ by considering the difference of soil texture, pH and organic matter. There were used 30 earthen pots altogether and 14 kg soil was taken in each earthen pot. Some physicochemical properties of initial soils (0-15cm) of SAU and Shingair are shown in Table 3.1

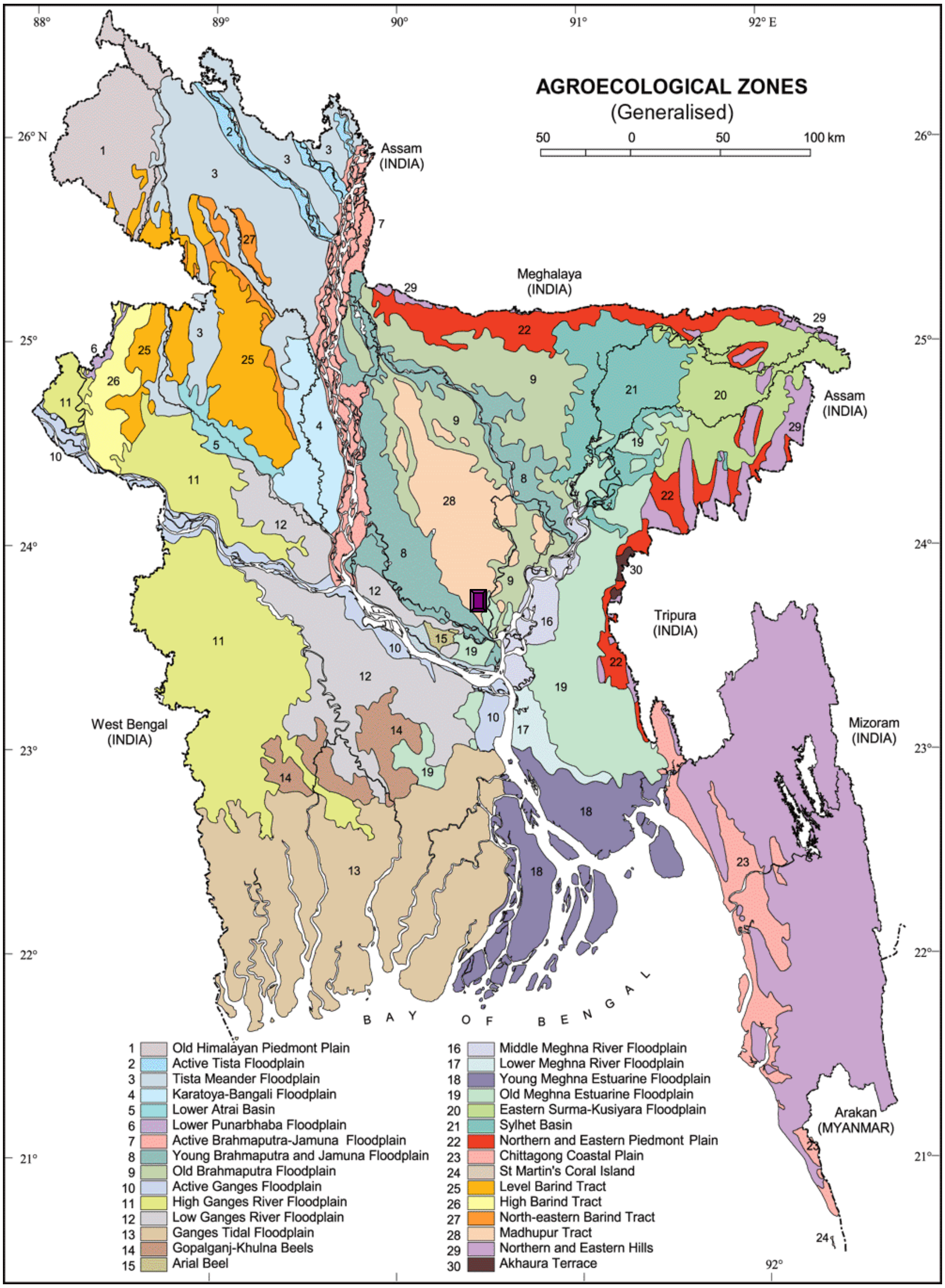

Fig. 1. Map showing the experimental sites under study

Table 3.1. Some physicochemical properties of initial soils (0-15 cm) of SAU and Shingair

Characteristics	SAU Soil	Shingair Soil
Textural class	Silt Loam	Clay loam
pH	6.4	6.5
Organic matter (%)	1.12	2.12
Total N (%)	0.08	0.12
Available P(ppm)	8.6	5.72
Exchangeable K (ppm)	18.6	28.6
Available S (ppm)	10.5	15.2

3.4 Planting material

BRRI dhan29 was used as the test crop in this experiment. This variety was developed at the Bangladesh Rice Research Institute from the cross between BG 90-2 and BR51-46-5 in 1994. It is recommended for Boro season. Average plant height of the variety is 90-95 cm at the ripening stage. The grains are coarse and white. It requires about 155-160 days completing its life cycle with an average grains yield of 5.0-5.5 t/ha (BRRI, 2004).

3.5 Experimental design and layout

The experimental design was a Randomized complete block design (RCBD) with two factors and three replicates for each treatment. The distance maintained between pot to pot and row to row were 40 cm and 1m respectively.

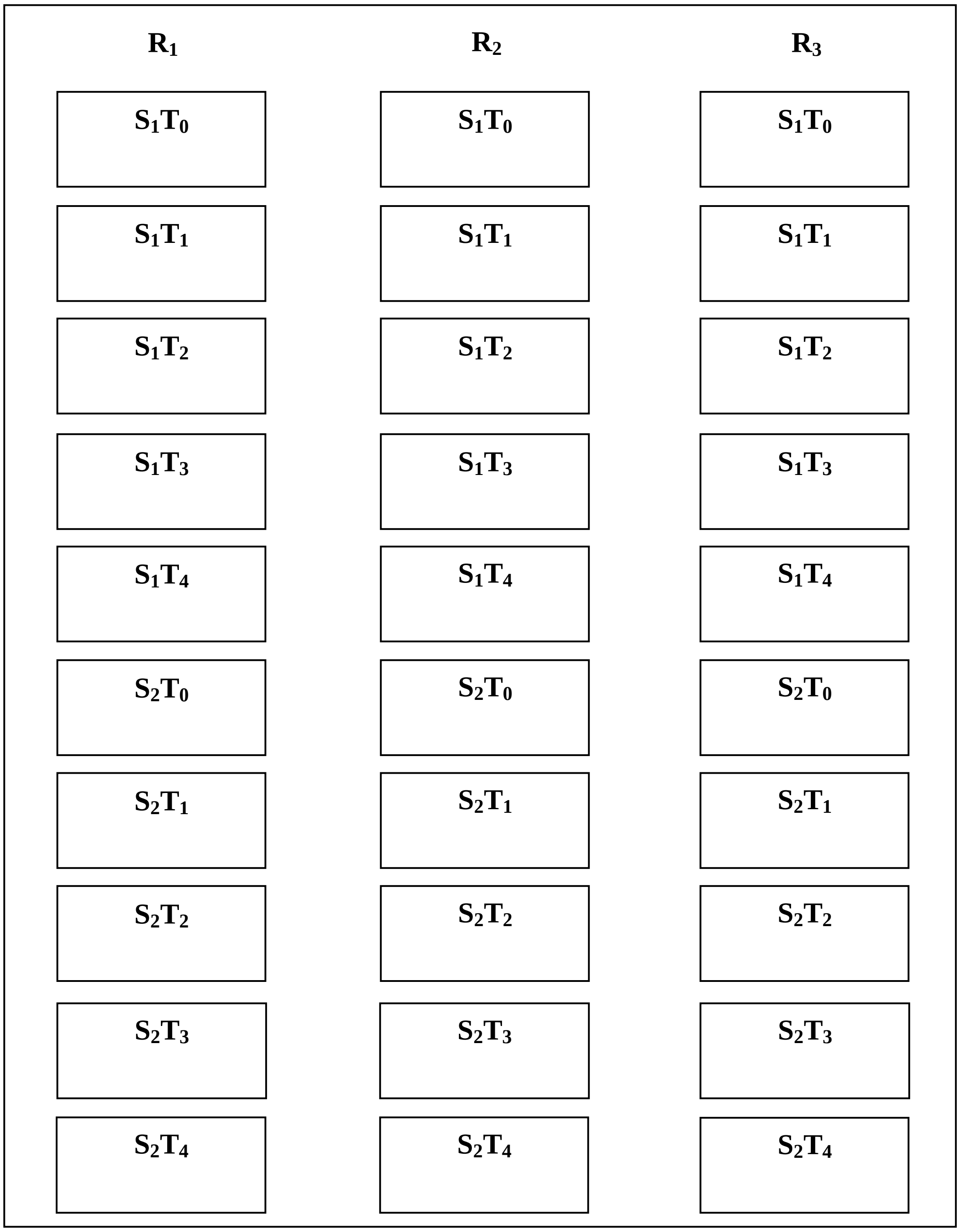

Fig. 2: Layout of the experiment in net house

3.6 Initial soil sampling

Initial soil samples were collected at 15 cm depth at from SAU campus, Dhaka and another from Shingair, Manikganj. The composite soil samples were air-dried, crushed and passed through a 2 mm (8 meshes) sieve. After sieving, the soil samples were kept in a plastic container for physical and chemical analysis of the soil.

3.7 Treatments

Factor A- soil

Soil-1 (S_1) = SAU Soil

Soil-2 (S_2) = Shingair Soil

Factor B (Fertilizer and manure)

T_0 : Control

T_1 : 100% Recommended dose of fertilizer ($N_{120}P_{25}K_{60}S_{20}Zn_2$)

T_2 : 50% NPKS + 5 ton cow dung ha^{-1}

T_3 : 50% NPKS + 5 ton compost ha^{-1}

T_4 : 50% NPKS+ 3.5 ton poultry manure ha^{-1}

3.8 Fertilizer and Manure application

The fertilizer and manure treatments were used in this experiment based on BARC fertilizer recommendation guide, 2005. Fertilizer and manure treatments were applied in the soils of the earthen pots during the Boro rice cultivation. The treatment wise required amounts of manures and N, P, K, S and Zn fertilizers per pot were applied by considering the soil weight in the pot. Full amounts of manure, TSP, MP, gypsum and zinc sulphate were applied at final pot preparation before transplanting of rice seedlings. 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 at 5 days before panicle initiation stage (55 DAT). Chemical compositions of the manures used have been presented in (Table 3.2).

Table 3.2. Chemical compositions of the cowdung, poultry manure and compost (oven dry basis)

Manure	Nutrient content			
	N (%)	P (%)	K (%)	S (%)
Cowdung	1.46	0.29	0.74	0.24
Poultry manure	2.2	1.99	0.82	0.29
Compost	1.52	0.28	1.60	0.32

3.9 Seedlings preparation

The seedlings of rice were prepared in raised wet-bed methods. Seeds (95% germination) @ 5 kg ha^{-1} were soaked and incubated for 48 hour and sown on a well-prepared seedbed. During seedling growing, no fertilizers were used. Proper water and pest management practices were followed whenever required.

3.10 Transplanting

Forty days old BRRI dhan29 seedlings were carefully uprooted from the seedling nursery and transplanted on 2nd week of December, 2012. Two seedlings for one hill (BRRI dhan29) were transplanted in the earthen pot. After one week of transplanting all earthen pots were checked for any missing seedlings, which were filled up with extra seedlings whenever required.

3.11 Intercultural operations

Intercultural operations were done to ensure normal growth of the crop. Plant protection measures were followed as and when necessary. The following intercultural operations were done.

3.11.1 Weeding

The pots were infested with some common weeds, which were removed three times by uprooting them from the soil cores during the period of the cropping season.

3.11.2 Irrigation management of soil

Traditional irrigation (2-3 cm continuous flooding) was applied on the soils of the pot as and when required during the growing period of Boro rice crop.

3.11.3 Insect and pest control

There was no infestation of diseases in the field but leaf roller (*Chaphalocrosismedinalis*, Pyralidae, Lepidoptera) was observed in the field and used Malathion @ 1.12 L ha^{-1}.

3.11.4 Pore water collection

Pore water was collected by using rhizon sampler (Rhizon MOM 10 cm length, 2.5 mm OD, Rhizosphere Research Products, Wageningen, and The Netherlands). It was buried diagonally in the middle of the soil of each pot for collecting soil solution. Soil pore-water samples were collected during Boro rice growing period at 30, 40 and 60 days after transplantation of rice seedlings and analyzed for N, P, K and S contens following standard methods.

3.12 Crop harvest

The Boro rice crop was harvested at full maturity when 80-90% of the grains were turned into straw colored on May, 2013. The crop was cut at the ground level. After harvest, the rice yield parameters and yield were recorded.

3.13 Yield components

3.13.1 Plant height

The height of plant was recorded in centimeter (cm) at harvesting stage. Data were recorded as the average of all the plants of each pot. The height was measured from the ground level to the tip of the panicle.

3.13.2 Length of panicle

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

3.13.3 No. of filled grain per panicle

The total numbers of filled grains were calculated from all the plants of a pot on the basis of grain in the spikelet and then average numbers of filled grain per panicle was recorded.

3.13.4 No. of unfilled grain per panicle

The total numbers of unfilled grains were calculated from all the plants of a pot on the basis of unfilled grain in the spikelet and then average numbers of unfilled grain per panicle was recorded.

3.13.5 Weight of 1000 seeds

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

3.13.6 Straw yield

Straw obtained from each pot (g pot^{-1}) were sun-dried and weighed carefully.

3.13.7 Grain yield

Grains obtained from each pot (g pot ha^{-1}) were sun-dried and weighed carefully.

3.14 Chemical analysis of plant samples

3.14.1 Collection and preparation of plant samples

Grains and straw samples were collected after threshing for N, P, K and S analyses. The plant samples were dried in an oven at 70 ^{0}C for 72 hours and then ground by a grinding machine (Wiley-mill) to pass through a 20-mesh sieve. The samples were stored in plastic vial for analyses of N, P, K and S. The grains and straw samples were analyzed for determination of N, P, K and S concentrations. The methods were as follows:

3.14.2 Digestion of plant samples with sulphuric acid for N analysis

For the determination of nitrogen an amount of 0.5 g oven dry, ground sample were taken in a micro kjeldahl flask. 1.1 g catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se in the ratio of 100: 10: 1), and 7 ml conc. H_2SO_4 were added. The flasks were heated at 160^{0}C and added 2 ml 30% H_2O_2 then heating was continued at 360 ^{0}C until the digests become clear and colorless. After cooling, the content was taken into a 50 ml volumetric flask and the volume was made up to the mark with de-ionized water. A reagent blank was prepared in a similar manner. Nitrogen in the digest was estimated by distilling the digest with 10 N NaOH followed by titration of the distillate trapped in H_3BO_3 indicator solution with 0.01N H_2SO_4.

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

A sub sample weighing 0.5 g was transferred into a dry, clean 100 ml digestion vessel. Ten ml of di-acid (HNO_3: $HClO_4$ in the ratio 2:1) mixture was added to the flask. After leaving for a while, the flasks were heated at a temperature slowly raised to 200^0C. Heating were stopped when the dense white fumes of $HClO_4$ occurred. The content of the flask were boiled until they were became clean and colorless. After cooling, the content was taken into a 100 ml volumetric flask and the volume was made up to the mark with de-ionized water. P, K and S were determined from this digest by using different standard methods.

3.14.4 Determination of P, K and S from plant samples

3.14.4.1 Phosphorus

Plant samples (grains and straw) were digested by di-acid (Nitric acid and Perchloric acid) mixture and P content in the digest was measured by blue color development (Olsen *et al.*, 1954). Phosphorus in the digest was determined by using 1 ml for grains sample and 2 ml for straw sample from 100 ml digest by developing blue color with reduction of phosphomolybdate complex and the color intensity were measured colorimetrically at 660 nm wavelength and readings were calibrated with the standard P curve (Page *et al*., 1982).

3.14.4.2 Potassium

Ten milli-liters of digest sample for the grains and five ml for the straw were taken and diluted 50 ml volume to make desired concentration so that the flame photometer reading of samples were measured within the range of standard solutions. The concentrations were measured by using standard curves.

3.14.4.3 Sulphur

Sulphur content was determined from the digest of the plant samples (grains and straw) as described by Page *et al*. (1982). The digested S was determined by developing turbidity by adding acid seed solution (20 ppm S as K_2SO_4 in 6N HCl) and $BaCl_2$ crystals. The intensity of turbidity was measured by spectrophotometer at 420 nm wavelength (Hunter, 1984).

3.15 Pore water analysis

Pore water samples were analyzed for both physical and chemical characteristics viz. total N and available P, K, and S contents. The pore water samples were analyzed by the following standard methods:

3.15.1 Total nitrogen

Total N content of pore water samples were determined followed by the Micro Kjeldahl method. 10 ml pore water was transferred into the distillation flask, Then 10 ml of H_3BO_3 indicator solution was taken into a 250 ml conical flask which is marked to indicate a volume of 50 ml and placed the flask under the condenser outlet of the distillation apparatus so that the delivery end dipped in the acid. Sufficient amount of 10N-NaOH solution was added in the container connecting with distillation apparatus. Water runs through the condenser of distillation apparatus was checked. By operating the switch of the distillation apparatus distillate was collected. The conical flask was removed by washing the delivery outlet of the distillation apparatus with distilled water.

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

The amount of N was calculated using the following formula:

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

Where,

T = Sample titration (ml) value of standard H_2SO_4

B = Blank titration (ml) value of standard H_2SO_4

N = Strength of H_2SO_4

S = Sample volume in millilitre

3.15.2 Inorganic phosphorus

Phosphorus in the pore water was determined by developing blue color with reduction of phosphomolybdate complex and the color intensity were measured colorimetrically at 660 nm wavelength and readings were calibrated the standard P curve (Page *et al*. 1982).

3.15.3 Inorganic potassium

Readily available K was determined in pore water by using flame photometer and calibrated with a standard curve (Page *et al*. 1982).

3.15.4 Inorganic sulphate

Inorganic S content in pore water was determined by turbidimetrically described by (Page *et al*. 1982). The pore water S was determined by developing turbidity by adding acid seed solution (20 ppm S as K_2SO_4 in 6N HCl) and $BaCl_2$ crystals. The intensity of turbidity was measured by spectrophotometer at 420 nm wavelength.

3.16 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference of different treatments on yield and yield contributing characters of BRRI dhan29. The mean values of all the characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The results of different yield attributes, yield, nutrient concentrations in the grains and straw and availability of different nutrients in the soil pore water are presented this chapter.

4.1 Effect of soil and fertilizer on the yield parameters and yield of Boro rice

4.1.1 Plant height

4.1.1.1 Effect of soils on the plant height of Boro rice (BRRI dhan29)

The effects of soils on the plant height of rice are presented in Table 4.1. The plant height was significantly influenced with the variation of two different soils. Between these two soils S_1 (SAU Soil) showed the higher (79.8 cm) plant height and S_2 (Shingair Soil) showed lower (74.57 cm) plant height.

Table 4.1. Effect of soils on plant height, panicle length, no. of filled grains, no. of unfilled grains, 1000 grain weight, grain yield and straw yield of Boro rice (BRRI dhan29).

Soil	Plant height(cm)	Panicle length(cm)	No. of filled grains/ Panicle	No. of unfilled grains/panicle	1000 grain weight (g)	Grain yield (g/pot)	Straw yield (g/pot
S_1	79.8 a	25.95 a	174.51 a	17.87 a	23.73 a	86.67 a	71.65
S_2	74.57 b	24.45 b	121.17 b	21.46 b	22.90 b	76.15 b	69.19
SE(±)	0.617	0.13	2.649	0.792	0.077	1.572	NS

In a column figures having similar letter(s) do not differ significantly at 5% level of significance whereas figures with dissimilar letter(s) differ significantly as per DMRT.

4.1.1.2 Effect of fertilizer and manure on the plant height of Boro rice (BRRI dhan29)

Rice plants showed significant variation in respect of plant height when different fertilizer treatments were applied (Table 4.2). Among the different fertilizer treatments, T_4 (50% NPKS+ 3.5 ton poultry manure ha^{-1}) gave highest plant height (79.43 cm) which was statistically similar to all other treatment except control. On the other hand the lowest (72.52 cm) plant height was observed in T_0 treatment where that received no fertilizer and manure. Plant height was significantly influenced by the application of organic manure and chemical fertilizers reported by Nayak *et al*. (2007). Similar results were also reported by Aga *et al*. (2004), Reddy *et al*. (2005).

Table 4.2. Effect of fertilizer and manure on plant height, panicle length, no. of filled grains, no. of unfilled grains, 1000 grain weight, grain and straw yields of Boro rice (BRRI dhan29).

Fertilizer	Plant height(cm)	Panicle length (cm)	No. of filled grains/ panicle	No. of unfilled grains/ panicle	1000 grain weight(g)	Grain yield (g/pot)	Straw yield (g/pot)
T_0	72.52b	23.95b	119.10c	24.52a	22.42 b	62.53 c	54.53c
T_1	78.81a	25.31a	146.04b	19.75ab	23.42 a	94.22 a	85.2a
T_2	77.18a	25.16a	159.99ab	17.73b	23.33 a	83.32b	71.72b
T_3	77.99a	25.63a	147.44b	17.07b	23.67 a	82.9 b	67.0b
T_4	79.43a	25.95a	166.65a	19.25b	23.76 a	84.08b	73.63b
SE(±)	0.975	0.206	4.189	1.252	0.122	2.486	2.892

In a column figures having similar letter(s) do not differ significantly at 5% level of significance whereas figures with dissimilar letter(s) differ significantly as per DMRT.

4.1.1.3 Interaction effects of soils and fertilizer and manure on the plant height of Boro rice (BRRI dhan29)

Combined application of different fertilizer and manure treatments and soils had significant variation on the plant height of rice (Table 4.3). The lowest (70.23 cm) plant height was observed in the treatment combination S_2T_0 (Shingair Soil + control treatment) treatment which was statistically similar to S_2T_2, S_2T_3 and S_1T_0 treatment combinations. On the other hand, the highest (83.14 cm) plant height was recorded with S_1T_2 (SAU soil + 50% NPKS + 5 ton cow dung ha^{-1}) treatment which was statistically similar to S_1T_4, S_1T_3 and S_2T_1 treatment combinations.

Table 4.3. Interaction effects of soils and fertilizer and manure on plant height, panicle length, no. of filled grains, no. of unfilled grains, 1000 grain weight, grain yield and straw yield of Boro rice (BRRI dhan29).

Soil and Fertilizer	Plant height (cm)	Panicle length (cm)	Filled grains $Panicle^{-1}$ (no.)	Unfilled grains $Panicle^{-1}$ (no.)	1000 grain weight (g)	Grain weight (g pot^{-1})	Straw yield (g pot^{-1})
S_1T_0	74.80 cd	23.71e	128.47c	20.82	22.67de	60.0 d	49.93
S_1T_1	77.47 bc	25.79 bc	166.41 b	18.68	24.17a	94.87a	87.67
S_1T_2	83.14 a	26.61ab	202.64a	17.55	23.83ab	91.47a	77.17
S_1T_3	80.50 ab	26.63ab	170.24b	15.47	24.0ab	89.6 ab	69.37
S_1T_4	83.08a	26.98a	204.81a	16.81	24.0 ab	97.4 a	74.10
S_2T_0	70.23d	24.17de	109.73c	28.22	22.17e	65.07cd	59.13
S_2T_1	80.15abc	24.82cde	125.66c	20.81	22.67de	93.57a	82.73
S_2T_2	71.21 d	23.72e	117.34c	17.92	22.83cde	75.17c	66.27
S_2T_3	75.47bcd	24.64cde	124.63c	18.66	23.33 bcd	76.2 bc	64.63
S_2T_4	75.79bcd	24.92cd	128.49c	21.69	23.52abc	70.77cd	73.17
SE(±)	1.38	0.291	5.925	NS	0.173	3.516	NS

In a column figures having similar letter(s) do not differ significantly at 5% level of significance whereas figures with dissimilar letter(s) differ significantly as per DMRT.

4.1.2 Panicle length

4.1.2.1 Effect of soils on the panicle length of Boro rice (BRRI dhan29)

The effects of soils on the panicle length of rice are presented in Table 4.1. The panicle length was significantly influenced with the variation of two different soils. Between these two soils S_1 (SAU Soil) showed the higher (25.95 cm) panicle length and S_2 (Shingair Soil) showed lower (24.45 cm) panicle length.

4.1.2.2 Effect of fertilizer and manure on the panicle length of Boro rice (BRRI dhan29)

Rice plants showed significant variation in respect of panicle length when different fertilizer treatments were applied (Table 4.2). Among the different fertilizer treatments, T_4 (50% NPKS+

3.5 ton poultry manure ha^{-1}) gave highest panicle length (25.95 cm) which was statistically similar to all other treatment except control. Rahman *et al.* (2009) noted a significant increase in panicle length due to the application of organic manure and chemical fertilizers. Babu *et al*. (2001), Reddy *et al*. (2005) also reported similar results.

4.1.2.3 Interaction effects of soils and fertilizer and manure on the panicle length of Boro rice (BRRI dhan29)

Combined application of different fertilizer and manure treatments and soils had significant variation on the panicle length of rice (Table 4.3). The highest (26.98 cm) panicle length was recorded with S_1T_4 (SAU Soil + 50% NPKS+ 3.5 ton poultry manure ha^{-1}) treatment which was statistically similar to S_1T_3 and S_1T_2 treatment combinations. On the other hand, the lowest (23.71 cm) panicle length was observed in the treatment combination S_1T_0 (SAU Soil + No fertilizer) treatment which was statistically similar to S_2T_0 S_2T_1 and S_2T_2 treatment combinations.

4.1.3 Number of filled grains per panicle

4.1.3.1 Effect of soils on the number of filled grains per panicle of Boro rice (BRRI dhan29)

The effects of soils on the number of filled grain per panicle of rice are presented in Table 4.1.The number of filled grains per panicle was significantly influenced with the variation of two different soils. Between these two soils S_1 (SAU Soil) showed the higher (174.51) number of filled grain per panicle and S_2 (Shingair Soil) showed lower (121.17) number of filled grain per panicle.

4.1.3.2 Effect of fertilizer and manure on the number of filled grains per panicle of Boro rice (BRRI dhan29)

Rice plants showed significant variation in respect of number of filled grains per panicle when different doses of fertilizer and manures were applied (Table 4.2). Among the different fertilizer doses, T_4 (50% NPKS+ 3.5 ton poultry manure ha^{-1}) gave highest number of filled grains per panicle (166.65) which was statistically similar to T_2 (50% NPKS + 5 ton cow dung ha^{-1}) treatment. On the other hand the lowest (119.10) number of filled grains per panicle was observed in T_0 treatment where that received no fertilizer and manure. Similar result was found by Rahman *et al.* (2009).

4.1.3.3 Interaction effects of soils and fertilizer and manure on the number of filled grains per panicle of Boro rice (BRRI dhan29)

Combined application of different doses of fertilizer, manure and soils had significant variation on the number of filled grains per panicle of rice (Table 4.3). The highest (204.81) number of filled grains per panicle was recorded with S_1T_4 (SAU Soil + 50% NPKS+ 3.5 ton poultry manure ha^{-1}) treatment combination which was statistically similar to S_1T_2 treatment combinations. On the other hand, the lowest (109.73) number of filled grains per panicle was observed in the treatment combination S_2T_0 (Shingair Soil + control) treatment which was statistically similar to S_1T_0, S_2T_1, S_2T_2, S_2T_3 and S_2T_4 treatment combinations.

4.1.4 Number of unfilled grains per panicle

4.1.4.1 Effect of soils on the number of unfilled grains per panicle of Boro rice (BRRI dhan29)

The effects of soils on the number of unfilled grain per panicle of rice are presented in Table 4.1. The number of unfilled grains per panicle was significantly influenced with the variation of two different soils. Between these two soils S_2 (Shingair soil) showed the higher (21.46) number of unfilled grain per panicle and S_1 (SAU soil) showed lower (17.87) number of unfilled grain per panicle.

4.1.4.2 Effect of fertilizer and manure on the number of unfilled grains per panicle of Boro rice (BRRI dhan29)

Rice plants showed significant variation in respect of number of unfilled grains per panicle when different doses of fertilizer and manures were applied (Table 4.2). Among the different fertilizer doses, T_0 treatment where that received no fertilizer and manure gave highest number of unfilled grains per panicle (24.52). On the other hand rest of the treatments showed lower and similar result in respect of number of unfilled grains per panicle.

4.1.4.3 Interaction effects of soils and fertilizer and manure on the number of unfilled grains per panicle of Boro rice (BRRI dhan29)

Combined application of different fertilizer and manure treatments and soils had insignificant variation on the number of unfilled grains per panicle of rice (Table 4.3). The number of unfilled grains per panicle was not significantly influenced by combined application of soil and fertilizer. The highest number of unfilled grains per panicle (28.22) was obtained from S_2T_0

treatment combination. The lowest number of unfilled grains per panicle (15.47) was obtained from S_1T_3.

4.1.5 1000 grain weight.

4.1.5.1 Effect of soils on the 1000 grain wt. of Boro rice (BRRI dhan29)

The effects of soils on the 1000 grain wt. of rice are presented in Table 4.1. The 1000 grain wt. was significantly influenced with the variation of two different soils. Between these two soils S_1 (SAU soil) showed the higher 1000 grain wt. (23.73 g) and S_2 (Shingair soil) showed lower 1000 grain wt. (22.90 g).

4.1.5.2 Effect of fertilizer and manure on the 1000 grain wt. of Boro rice (BRRI dhan29)

Rice plants showed significant variation in respect of 1000 grain wt. when different fertilizer treatments were applied (Table 4.2). Among the different fertilizer doses, T_4 (50% NPKS+ 3.5 ton poultry manure ha^{-1}) gave highest 1000 grain wt. (23.76 g) which was statistically similar to all other treatment except control. On the other hand the lowest 1000 grain wt. (22.42 g) was observed in T_0 treatment where that received no fertilizer and manure. Yang *et al.* (2004) recorded that 1000-grain weight increased by the application of chemical fertilizer with organic manure. Statistically similar 1000-grain weight was observed in all the treatments except control.

4.1.5.3 Interaction effects of fertilizer and manure and soils on the 1000 grain wt. of Boro rice (BRRI dhan29)

Combined application of different fertilizer and manure treatments and soils had significant variation on the 1000 grain wt. of rice (Table 4.3). The lowest (22.17 g) 1000 grain wt. was observed in the treatment combination S_2T_0 (Shingair soil + control treatment) treatment which was statistically similar to S_1T_0, S_2T_1 and S_2T_2 treatment combinations. On the other hand, the highest (24.17 g) 1000 grain wt. was recorded with S_1T_1 (SAU soil + Recommended dose of fertilizer) treatment which was statistically similar to S_1T_2 (SAU soil + 50% NPKS + 5 ton cow dung ha^{-1}), S_1T_3 (SAU soil +50% NPKS and 5 ton compost ha^{-1}), S_1T_4 (SAU Soil + 50% inorganic fertilizer and 3.5 ton poultry manure/ha)and S_2T_4 (Shingair soil + 50% inorganic fertilizer and 3.5 ton poultry manure ha^{-1}) treatment combinations.

4.1.6 Grain yield

4.1.6.1 Effect of soils on the grain yield of Boro rice (BRRI dhan29)

The effects of soils on the grain yield of rice are presented in Table 4.1. The grain yield was significantly influenced with the variation of two different soils. Between these two soils S_1 (SAU Soil) showed the higher grain yield (86.67 g/pot) and S_2 (Shingair Soil) showed lower grain yield (76.15 g/pot).

4.1.6.2 Effects of different doses of fertilizer and manure on the grain yield of Boro rice (BRRI dhan29)

Different fertilizers treatments showed significant variations in respect of grain yield (Table 4.2). The application of fertilizers and manure had a positive effect on the grain yield of boro rice. Among the different fertilizer treatments, T_1 (RDCF) showed the highest grain yield pot^{-1} (94.22 g pot^{-1}). On the contrary, the lowest grain yield/pot (62.53 g pot^{-1}) was observed with T_0 where no fertilizer was applied.

4.1.6.3 Interaction effect of fertilizer, manure and soils on the grain yield of Boro rice (BRRI dhan29)

The combined effect of different fertilizer and soils on the grain yield of rice was significantly different (Table 4.3). The highest grain yield (97.40 g pot^{-1}) was obtained from S_1T_4 (SAU soil + 50% inorganic fertilizer and 3.5 ton poultry manure ha^{-1}) which was closely and statistically similar to the treatment combination S_1T_1 (SAU soil + RDCF) S_1T_2 (SAU soil plus 50% inorganic fertilizer and 5 ton cowdung ha^{-1}), S_1T_3 (SAU soil + 50% inorganic fertilizer and 5 ton compost ha^{-1}) and S_2T_1 (Shingair soil + RDCF) treatment combinations. The lowest grain yield (60 g pot^{-1}) was obtained in S_1T_0 treatment combination which was closely similar to the treatment combinations S_2T_0 (Shingair soil+ control treatment) and S_2T_4 (Shingair soil+50% NPKS+ 3.5 ton poultry manure ha^{-1}). The higher level of organic matter present in the Shingair soil, so combined application of fertilizer and manure was not so effective for increasing rice yield in comparison 100% inorganic fertilizer (T_1) treatment.

4.1.7 Straw yield

4.1.7.1 Effect of soils on the straw yield of Boro rice (BRRI dhan29)

The effects of soils on the straw yield of rice are presented in Table 4.1. Insignificant variation was observed in the straw yield of rice grown in two different soils. Between these two soils, S_1 (SAU soil) showed the higher straw yield (71.65 g pot^{-1}) and S_2 (Shingair soil) showed lower straw yield (69.19 g pot^{-1}).

4.1.7.2 Effects of different doses of fertilizer and manure on the straw yield of Boro rice (BRRI dhan29)

The straw yield of rice showed statistically significant variation due to the application of different doses of fertilizer treatments (Table 4.2). Among the different treatments of fertilizer, T_1 (RDCF) showed the highest straw yield pot^{-1} (85.2 g pot^{-1}). On the contrary, the lowest grain yield pot^{-1} (54.53 g pot^{-1}) was observed with T_0 where no fertilizer was applied.

4.1.7.3 Interaction effects of fertilizer, manure and soils on the straw yield of Boro rice

The combined effect of different doses of fertilizer, manure and soils on the straw yield of rice was insignificant (Table 4.3). The higher straw yield of rice (87.67 g pot^{-1}) was recorded with the treatment combination S_1T_1 (SAU soil + RDCF).On the other hand, the lowest straw yield (49.93 g pot^{-1}) was found in S_1T_0 (SAU soil + control) treatment combination.

4.2 NPKS concentration in grains

4.2.1 Effect of soils on N concentration in grain

The effect of soils on N concentration in grain of rice is presented in Table 4.4. The grain N concentration was not significantly affected by different soils. Between these two soils, S_2 (Shingair Soil) showed the higher N concentration in grain (1.201%) and S_1 (SAU Soil) showed lower N concentration in grain (1.195%).

Table 4.4. Effect of soil on the grain nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) concentration

Soil	Grain nutrient concentration (%)			
	N	P	K	S
S_1	1.195	0.268	0.215	0.076
S_2	1.201	0.258	0.224	0.074
SE(±)	NS	NS	NS	NS

In a column figures having similar letter(s) do not differ significantly at 5% level of significance whereas figures with dissimilar letter(s) differ significantly as per DMRT.

4.2.2 Effect of different doses of fertilizer and manure on N concentration in grain of Boro rice BRRI dhan29

Nitrogen concentrations in grains of rice showed significant variation due to the application of different doses of fertilizer and manure are presented in Table 4.5. The nitrogen concentration in Boro rice grains significantly increased due to application of fertilizers and manure. The higher levels of grains N concentrations were recorded in the combined application of fertilizer and manure compared to the chemical fertilizer alone. The highest N concentration in grains (1.290%) was recorded from T_3 (50% NPKS + 5 ton compost ha^{-1}) treatment which was closely similar to all other treatments except control. On the other hand, the lowest N concentration in grains (0.987%) was found from T_0 where no fertilizer was used. A significant increase in N content in rice grains due to the application of organic manure and fertilizers have been reported by investigators (Azim, 1999 and Hoque, 1999).

Table 4.5. Effect of fertilizer and manure on the grain nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) concentration

Fertilizer	Grain nutrient concentration (%)			
	N	P	K	S
T_0	0.987 b	0.208 c	0.176 b	0.045 d
T_1	1.237 a	0.310 a	0.216 b	0.069 c
T_2	1.213 a	0.276 abc	0.215 b	0.094 a
T_3	1.290 a	0.231 bc	0.216 b	0.082 b
T_4	1.263 a	0.289 ab	0.274 a	0.084 b
SE(±)	0.044	0.017	0.012	0.008

In a column figures having similar letter(s) do not differ significantly at 5% level of significance whereas figures with dissimilar letter(s) differ significantly as per DMRT.

4.2.3 Interaction effect of fertilizer, manure and soils on N concentration in grain of Boro rice BRRI dhan29

The combined effects of different doses of fertilizer, manure and soils did not significantly affect the accumulation of grain N concentration. The higher N concentrations were found in the treatment combinations where organic plus inorganic fertilizers were applied. The highest N concentration (1.293%) was obtained from the S_1T_4 (SAU soil + 50% inorganic fertilizer and 3.5 ton poultry manure ha^{-1}) as well as S_2T_3 (Shingair soil +50% NPKS and 5 ton compost ha^{-1}) treatment combinations and the lowest (0.980%) from S_1T_0 (SAU soil + control treatment) treatment combination (Table 4.6).

Table 4.6. Effect of soils and fertilizer on the grain nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) concentration

Soil and Fertilizer	Grain nutrient concentration (%)			
	N	P	K	S
S_1T_0	0.980	0.227	0.174	0.046
S_1T_1	1.220	0.341	0.214	0.069
S_1T_2	1.193	0.268	0.204	0.089
S_1T_3	1.287	0.225	0.215	0.091
S_1T_4	1.293	0.277	0.265	0.085
S_2T_0	0.993	0.189	0.177	0.045
S_2T_1	1.253	0.279	0.219	0.070
S_2T_2	1.233	0.285	0.225	0.098
S_2T_3	1.293	0.238	0.217	0.073
S_2T_4	1.233	0.300	0.283	0.082
SE(±)	NS	NS	NS	NS

In a column figures having similar letter(s) do not differ significantly at 5% level of significance whereas figures with dissimilar letter(s) differ significantly as per DMRT.

4.2.4 Effect of soils on P concentration in grain of Boro rice BRRI dhan29

The effect of soils on P concentration in grain of rice is presented in Table 4.4. The grain P concentration was not significantly affected by different soils. Between these two soils, S_1 (SAU soil) showed the higher P concentration in grain (0.268%) and S_2 (Shingair soil) showed lower P concentration in grain (0.258%).

4.2.5 Effect of different doses of fertilizer and manure on P concentration in grain of Boro rice BRRI dhan29

Phosphorous concentrations in grains of rice showed significant variation due to the application of different fertilizer and manure treatments are presented in Table 4.5. The P concentration in Boro rice grains significantly increased due to application of fertilizers and manure. The higher levels of grains P concentrations were recorded in the combined application of fertilizer and manure compared to the chemical fertilizer alone. The highest P concentration in grains (0.310 %) was recorded from T_1 (RDCF) which was closely similar to T_4 (50% NPKS+ 3.5 ton poultry manure ha^{-1}) and T_3 (50% NPKS + 5 ton compost ha^{-1}) treatment. On the other hand, the lowest P concentration in grains (0.208 %) was found from T_0 where no fertilizer was used. A significant increase in P content in rice straw due to the application of organic manure and fertilizers has been reported by investigators (Azim, 1999 and Hoque, 1999).

4.2.6 Interaction effect of fertilizer, manure and soils on P concentration in grain of Boro rice BRRI dhan29

The combined effects of different doses of fertilizer and soils did not significantly affect the accumulation of grain P concentration. The higher P concentrations were found in the treatment combinations where inorganic fertilizer was applied. The highest P concentration (0.341%) was obtained from the S_1T_1 (SAU soil + RDCF) treatment combination and lowest (0.189%) from S_2T_0 (Shingair soil + control treatment) treatment combination (Table 4.6).

4.2.7 Effect of soils on K concentration in grain of Boro rice BRRI dhan29

The effect of soils on K concentration in grain of rice is presented in Table 4.4. The grain K concentration was not significantly affected by different soils. Between these two soils, S_2 (Shingair soil) showed the higher K concentration in grain (0.224%) and S_1 (SAU soil) showed lower K concentration in grain (0.215%).

4.2.8 Effect of different doses of fertilizer and manure on K concentration in grain of Boro rice BRRI dhan29

Potassium concentrations in grains of rice showed significant variation due to the application of different fertilizer and manure treatments are presented in Table 4.5. The K concentration in Boro rice grains significantly increased due to application of fertilizers and manure. The higher levels of grains K concentration was recorded in the combined application of fertilizer and manure compared to the chemical fertilizer alone. The highest K concentration in grains (0.274%) was recorded from T_4 (50% NPKS + 3.5 ton poultry manure ha^{-1}) treatment. On the other hand, all other treatments showed all most similar result including control treatment. Singh *et al.* (2003) revealed that potassium content in grain was increased due to combined application of organic manure and chemical fertilizers.

4.2.9 Interaction effect of fertilizer, manure and soils on K concentration in grain of Boro rice BRRI dhan29

The combined effects of different doses of fertilizer and soils did not significantly affect the accumulation of grain K concentration (Table 4.6). The higher K concentrations were found in the treatment combinations where organic plus inorganic fertilizers were applied. The highest K concentration (0.283%) was obtained from the S_2T_4 (Shingair soil + 50% NPKS and 3.5 ton poultry manureha^{-1}) treatment combinations and lowest (0.174%) from S_1T_0 (SAU soil + control treatment) treatment combination.

4.2.10 Effect of soils on S concentration in grain of Boro rice BRRI dhan29

The effects of soils on grain S concentration of rice are presented in Table 4.4. The grain S concentration was not significantly affected by different soils. Similar grain S concentrations were found in SAU and Shingair soils.

4.2.11 Effects of different doses of fertilizer and manure on S concentration in grain of Boro rice BRRI dhan29

Sulphur concentrations in grain of rice showed statistically significant variation due to the application of different fertilizer treatments are presented in Table 4.5. The highest (0.094 %) grain S concentration was recorded from T_2 (50% NPKS + 5 ton cow dung ha^{-1}). On the other hand, the lowest (0.045 %) S concentration in grain was found from T_0 as control treatment.

4.2.12 Interaction effect of fertilizer, manure and soils on S concentration in grain of Boro rice BRRI dhan29

The combined effect of different doses of fertilizer and soils on S concentration of grain was insignificant (Table 4.6). The highest (0.098%) grain S concentration was recorded in the treatment combination S_2T_2 (Shingair soil + 50% NPKS and 5 ton cow dung ha^{-1}). On the other hand, the lowest (0.045%) S concentration in grain of rice was found in S_2T_0 (Shingair soil + control treatment) as well as (0.046%) in S_1T_0 (SAU soil + control treatment) treatment combinations.

4.3 NPKS concentration in straw

4.3.1 Effect of soils on N concentration in straw of Boro rice BRRI dhan29

The effect of soils on N concentration in straw of rice is presented in Table 4.7. The straw N concentration was significantly affected by different soils. Between these two soils, S_1 (SAU soil) showed the higher N concentration in straw (0.515 %) and S_2 (Shingair soil) showed lower N concentration in straw (0.480 %).

Table 4.7. Effect of soil on the straw nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) concentration

Soil	Straw nutrient concentration (%)			
	N	P	K	S
S_1	0.515 a	0.059	1.481 b	0.050
S_2	0.480 b	0.061	1.618 a	0.056
SE(±)	0.010	NS	0.041	NS

In a column figures having similar letter(s) do not differ significantly at 5% level of significance whereas figures with dissimilar letter(s) differ significantly as per DMRT.

4.3.2 Effect of different doses of fertilizer and manure on N concentration in straw of Boro rice BRRI dhan29

Nitrogen concentrations in straw of rice showed significant variation due to the application of different doses of fertilizer and manure are presented in Table 4.8. The nitrogen concentration in Boro rice straw significantly increased due to application of fertilizers and manure. The higher levels of straw N concentrations were recorded in the combined application of fertilizer and manure compared to the chemical fertilizer alone. The highest N concentration in straw (0.547%) was recorded from T_4 (50% NPKS and 3.5 ton poultry manure ha^{-1}) treatment which was closely similar to all other treatments except control. On the other hand, the lowest N concentration in straw (0.410 %) was found from T_0 where no fertilizer was used.

Table 4.8. Effect of fertilizer and manure on the straw nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) concentration

Fertilizer	Straw nutrient concentration (%)			
	N	P	K	S
T_0	0.410 b	0.046 d	1.271 b	0.036 c
T_1	0.420 a	0.072 a	1.644 a	0.062 a
T_2	0.513 a	0.058 c	1.679 a	0.047 b
T_3	0.497 a	0.065 b	1.485 ab	0.059 a
T_4	0.547 a	0.058 c	1.668 a	0.063 a
SE(±)	0.016	0.004	0.065	0.003

In a column figures having similar letter(s) do not differ significantly at 5% level of significance whereas figures with dissimilar letter(s) differ significantly as per DMRT.

4.3.3 Interaction effect of fertilizer, manure and soils on N concentration in straw of Boro rice BRRI dhan29

The combined effects of different doses of fertilizer, manure and soils did not significantly affect the straw N concentration. The higher N concentrations were found in the treatment combinations where organic plus inorganic fertilizers were applied. The highest N concentration (0.560%) was obtained from the S_1T_4 (SAU Soil + 50% inorganic fertilizer and 3.5 ton poultry manure/ha) treatment combination and lowest (0.393%) from S_2T_0 (Shingair soil + control) treatment combination (Table 4.9).

Table 4.9. Effect of soils and fertilizer on the straw nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) concentration

Soil and fertilizer	Straw nutrient concentration (%)			
	N	P	K	S
S_1T_0	0.427	0.043	1.258	0.036 e
S_1T_1	0.513	0.072	1.695	0.064 b
S_1T_2	0.520	0.056	1.628	0.046 d
S_1T_3	0.553	0.066	1.347	0.057 bc
S_1T_4	0.560	0.057	1.475	0.050 cd
S_2T_0	0.393	0.049	1.283	0.035 e
S_2T_1	0.527	0.073	1.594	0.059 b
S_2T_2	0.507	0.060	1.731	0.049 cd
S_2T_3	0.440	0.065	1.622	0.061 b
S_2T_4	0.533	0.059	1.861	0.076 a
SE(±)	NS	NS	NS	0.004

In a column figures having similar letter(s) do not differ significantly at 5% level of significance whereas figures with dissimilar letter(s) differ significantly as per DMRT.

4.3.4 Effect of soils on P concentration in straw of Boro rice BRRI dhan29

The effect of soils on P concentration in straw of rice is presented in Table 4.7. The straw P concentration was not significantly affected by different soils. Similar straw P concentrations were found in SAU and Shingair soils.

4.3.5 Effect of different doses of fertilizer and manure on P concentration in straw of Boro rice BRRI dhan29

Phosphorous concentrations in straw of rice showed significant variation due to the application of different fertilizer and manure treatments are presented in Table 4.8. The P concentration in Boro rice straw significantly increased due to application of fertilizers and manure. The highest P concentration in straw (0.072%) was recorded from T_1 (RDCF) treatment. On the other hand, the lowest P concentration in straw (0.046%) was found from T_0 where no fertilizer was used.

4.3.6 Interaction effect of fertilizer, manure and soils on P concentration in straw of Boro rice BRRI dhan29

The combined effects of different doses of fertilizer, manure and soils did not significantly affect the straw P concentration. The higher P concentrations were found in the treatment combinations where inorganic fertilizers were applied. The higher P concentration (0.073%) was obtained from the S_2T_1 (Shingair Soil + RDCF) and (0.072%) from the S_1T_1 (SAU Soil + RDCF) treatment combinations and lowest (0.043%) from S_1T_0 (SAU Soil + control treatment) treatment combination (Table 4.9).

4.3.7 Effect of soils on K concentration in straw of Boro rice BRRI dhan29

The effect of soils on K concentration in straw of rice is presented in Table 4.7. The straw K concentration was significantly affected by different soils. Between these two soils, S_2 (Shingair Soil) showed the higher K concentration in straw (1.618 %) and S_1 (SAU Soil) showed lower K concentration in straw (1.481 %).

4.3.8 Effect of different fertilizer and manure on K concentration in straw of Boro rice BRRI dhan29

Potassium concentrations in straw of rice showed significant variation due to the application of different fertilizer and manure treatments are presented in Table 4.8. The K concentration in Boro rice straw significantly increased due to application of fertilizers and manure. The higher levels of straw K concentrations were recorded in the combined application of fertilizer and manure compared to the chemical fertilizer alone. The highest K concentration in straw (1.679%) was recorded from T_2 (50% NPKS + 5 ton cow dung ha^{-1}) treatment which was closely similar to T_4 (50% NPKS+ 3.5 ton poultry manure ha^{-1}) and T_1 (RDCF) treatments. On the other hand, the lowest K concentration in straw (1.271%) was found from T_0 where no fertilizer was used which was closely similar to T_3 (50% NPKS + 5 ton compost ha^{-1}) treatment.

4.3.9 Interaction effect of fertilizer, manure and soils on K concentration in straw of Boro rice BRRI dhan29

The combined effects of different doses of fertilizer, manure and soils did not significantly affect the straw K concentration. The higher K concentrations were found in the treatment combinations where inorganic fertilizers were applied. The highest K concentration (1.861%) was obtained from the S_2T_4 (Shingair Soil + 50% NPKS and 3.5 ton poultry manure ha^{-1})

treatment combination and lowest (0.393%) from S_1T_0 (SAU Soil + control treatment) treatment combination (Table 4.9).

4.3.10 Effect of soils on S concentration in straw of Boro rice BRRI dhan29

The effect of soils on S concentration in straw of rice is presented in Table 4.7. The straw S concentration was not significantly affected by different soils. Between these two soils, S_2 (Shingair Soil) showed the higher S concentration in straw (0.056%) and S_1 (SAU Soil) showed lower S concentration in straw (0.050%).

4.3.11 Effect of different fertilizer and manure treatments on S concentration in straw of Boro rice BRRI dhan29

Sulphur concentrations in straw of rice showed significant variation due to the application of different fertilizer and manure treatments are presented in Table 4.8. The S concentration in Boro rice straw significantly increased due to application of fertilizers and manure. The higher levels of straw S concentrations were recorded in the combined application of fertilizer and manure compared to the chemical fertilizer alone. The highest S concentration in straw (0.063 %) was recorded from T_4 (50% NPKS and 3.5 ton poultry manure ha^{-1}) which was closely similar to T_1 (RDCF) and T_3 (50% NPKS + 5 ton compost ha^{-1}) treatments. On the other hand, the lowest S concentration in straw (0.036 %) was found from T_0 where no fertilizer was used.

4.3.12 Interaction effect of fertilizer, manure and soils on S concentration in straw of Boro rice BRRI dhan29

The combined effect of soils and different fertilizer and manure treatments on S concentration in straw of rice was significant (Table 4.9). The highest S concentration in straw of rice (0.076 %) was recorded with the treatment combination S_2T_4 (Shingair Soil + 50% NPKS and 3.5 ton poultry manure ha^{-1}). On the other hand, the lowest S concentration in straw of rice (0.035 %) was found in S_2T_0 (Shingair Soil+ control treatment) which was closely similar to S_1T_0 (SAU Soil + control) treatment combination.

4.4 NPKS concentrations of pore-water

4.4.1 Effect of soils on the pore-water Nitrogen concentration during Boro rice (BRRI dhan29) growing season

The pore-water N concentrations were significantly affected with the variations of soil (Table 4.10). The higher levels of pore-water N concentrations were found at 20 and 40 DAT in the SAU soil (S_1) compared to Shingair soil (S_2). At 20 DAT the highest pore-water N concentration (7.88 ppm) was found in SAU soil (S_1) and the lowest pore-water N concentration (4.69 ppm) was found in Shingair soil (S_2). At 40 DAT there was no significant difference in pore-water N concentration between the two soils. At 60 DAT the highest pore-water N concentration (6.55 ppm) was found in SAU soil (S_1) and the lowest pore-water N concentration (5.34 ppm) was found in Shingair soil (S_2).

Table 4.10. Effect of soil on the pore-water nitrogen (N) and phosphorus (P) concentration

Soil	N (ppm)			P (ppm)		
	20DAT	40DAT	60DAT	20DAT	40DAT	60DAT
S_1	7.88 a	7.56	6.55 a	0.288 b	0.343	0.157 b
S_2	4.69 b	6.77	5.34 b	1.44 a	0.407	0.269 a
SE(±)	0.27	NS	0.12	0.02	NS	0.009

In a column figures having similar letter(s) do not differ significantly at 5% level of significance whereas figures with dissimilar letter(s) differ significantly as per DMRT.

4.4.2 Effect of fertilizer and manure on the pore-water nitrogen concentration during Boro rice growing period

The pore-water N concentrations were significantly affected with different fertilizer treatments (Table 4.11). Higher levels of N concentrations were found in T_4 (50% NPKS+ 3.5 ton poultry manure ha^{-1}) treatment at 20, 40 and 60 DAT. Among them at 40 DAT, T_4 showed the highest (8.93 ppm) N concentration which was similar to T_3 (50% NPKS + 5 ton compost ha^{-1}) and T_2 (50% NPKS + 5 ton cow dung ha^{-1}) treatment. On the other hand lowest level of N concentration was found in T_0 (control) treatment at 20, 40 and 60 DAT. Among them at 20 DAT, T_0 (control) showed the lowest (3.30 ppm) amount of N concentration.

Table 4.11. Effect of fertilizer and manure on the pore-water nitrogen (N) and phosphorus (P) concentration

Fertilizer	N (ppm)			P (ppm)		
	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
T_0	3.30d	4.33c	4.77c	0.69c	0.235 b	0.148 b
T_1	7.20ab	6.87b	6.18ab	0.80bc	0.363 ab	0.223 a
T_2	5.33c	7.30ab	5.80b	1.03a	0.471 a	0.241 a
T_3	6.93bc	8.40ab	6.27ab	0.89ab	0.471 a	0.216 a
T_4	8.67a	8.93a	6.70a	0.92ab	0.334 ab	0.235 a
SE(±)	0.42	0.46	0.18	0.04	0.04	0.014

In a column figures having similar letter(s) do not differ significantly at 5% level of significance whereas figures with dissimilar letter(s) differ significantly as per DMRT.

4.4.3 Interaction effects of soil and fertilizer on the pore-water nitrogen concentration during Boro rice (BRRI dhan29) growing period

The interaction effect of soil and fertilizer on the pore-water Nitrogen concentrations was significantly different (Table 4.12). The higher levels of pore-water N concentrations were found in the combination of SAU soil and fertilizer treatments. At 20 and 40DAT S_1T_4 (SAU soil + 50% inorganic fertilizer and 3.5 ton poultry manure ha^{-1}) showed the highest (12.13 and 10.53 ppm) N concentrations respectively. But at 60 DAT S_2T_4 (Shingair soil + 50% NPKS and 3.5 ton poultry manure ha^{-1}) showed the highest (7.93 ppm) N concentrations. On the other hand the lower levels of pore-water N concentrations were found in the combination of both SAU soil and Shingair Soil with control fertilizer treatment.

Table 4.12. Interaction effect of soil and fertilizer on the pore-water nitrogen (N) and phosphorus (P) concentration

Soil and Fertilizer	N (ppm)			P (ppm)		
	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
S_1T_0	4.00 cd	3.73e	4.53e	0.139 e	0.223 c	0.207 bcd
S_1T_1	8.40 b	6.27cde	5.50de	0.175 de	0.312 bc	0.316a
S_1T_2	5.73 c	7.93bc	5.67d	0.527 c	0.313 bc	0.296a
S_1T_3	9.13 b	9.33ab	5.53de	0.365 cd	0.524 ab	0.266ab
S_1T_4	12.13a	10.53a	5.47de	0.234 de	0.342 bc	0.260abc
S_2T_0	2.60d	4.93de	5.00de	1.246 b	0.247c	0.090f
S_2T_1	6.00c	7.47bcd	6.87bc	1.425 ab	0.415abc	0.130ef
S_2T_2	4.93cd	6.67cd	5.93cd	1.523 a	0.630 a	0.187cde
S_2T_3	4.73cd	7.47bcd	7.00ab	1.406 ab	0.418 abc	0.167de
S_2T_4	5.20c	7.33bcd	7.93a	1.614 a	0.326 bc	0.209bcd
SE(±)	0.596	0.644	0.258	0.054	0.057	0.020

In a column figures having similar letter(s) do not differ significantly at 5% level of significance whereas figures with dissimilar letter(s) differ significantly as per DMRT

4.4.4 Effect of soils on the pore-water Phosphorous concentration during Boro rice (BRRI dhan29) growing period

The pore-water Phosphorous concentrations were significantly affected with the variations of soil (Table 4.10). The higher levels of pore-water P were found at 20 and 40 DAT in the Shingair soil (S_2) compared to SAU soil (S_1). At 20 DAT the highest pore-water P concentration (1.44 ppm) was found in S_2 (Shingair soil) and the lowest pore-water P concentration (0.288 ppm) was found in S_1 (SAU soil). At 40 DAT there was no significant difference in pore-water P concentration between the two soils. But at 60 DAT S_1 (SAU soil) showed higher pore-water P concentration compared to S_2 (Shingair soil) which was significantly different.

4.4.5 Effect of fertilizer and manure on the pore-water phosphorous concentration during Boro rice (BRRI dhan29) growing period

The pore-water P concentrations were significantly affected with different fertilizer and manure treatments (Table 4.11). Different fertilizer and manure treatments showed different concentration during the different days after transplantation of boro rice. At 20 DAT the highest pore-water P concentration (1.03 ppm) was found in the T_2 (50% NPKS + 5 ton cow dung ha^{-1}) treatment which was closely similar to T_3 (50% NPKS + 5 ton compost ha^{-1}) and T_4 (50% NPKS+ 3.5 ton poultry manure ha^{-1}) and the lowest pore-water P concentration (0.69 ppm) showed in the T_0 (control) treatment. At 40 DAT both T_2 (50% NPKS + 5 ton cow dung ha^{-1}) and T_3 (50% NPKS + 5 ton compost ha^{-1}) treatment showed the highest pore-water P concentration (0.471 ppm) which was closely similar to T_4 (50% NPKS+ 3.5 ton poultry manure ha^{-1}) and T_1 (RDCF) and the lowest pore-water P concentration (0.235 ppm) showed the T_0 (control) treatment. Again at 60 DAT all the treatments showed the lower level of pore water P concentration and the results were similar in different fertilizer treatments except control.

4.4.6 Interaction effects of soil and fertilizer on the pore-water phosphorous concentrations during Boro rice (BRRI dhan29) growing period

The Interaction effects of soil and fertilizer on the pore-water phosphorus concentrations were significantly different (Table 4.12). The higher P concentrations were found in the Shingair soils compared to SAU soil. The pore-water P concentration decreased with increasing days after transplantation. At 20 DAT the highest pore-water P concentration (1.614 ppm) was found in S_2T_4 (Shingair soil + 50% NPKS + 3.5 ton poultry manure ha^{-1}) and (1.523 ppm) in S_2T_2 (Shingair soil + 50% NPKS + 5 ton cow dung ha^{-1}) treatments which were closely similar to S_2T_1 (Shingair soil + RCDF) and S_2T_3 (Shingair soil + 50% NPKS + 5 ton compost ha^{-1}). At 40 DAT, the highest pore-water P concentration (0.630 ppm) was found in S_2T_2 (Shingair soil + 50% NPKS + 5 ton cow dung ha^{-1}) treatment which was closely similar to S_1T_3 (SAU soil + 50% NPKS + 5 ton compost ha^{-1}) treatment and the lowest was found in both soils with control treatments. Again at 60 DAT, the highest pore-water P concentration (0.316ppm) was found in S_1T_1 (SAU soil + RDCF) treatment which was closely similar to S_1T_2 (SAU soil + 50% NPKS + 5 ton cow dung ha^{-1}) treatment and the lowest (0.090 ppm) was found in S_2T_0 (Shingair soil + control) treatment which was closely similar to S_2T_1 (Shingair soil + RDCF) treatment comination.

4.4.7 Effect of soils on the pore-water potassium concentration during Boro rice (BRRI dhan29) growing period

The effect of soils on the pore-water K concentration was not significantly different (Table 4.13). Similar concentrations of K were found in the SAU and Shingair soils. At 60 DAT S_2 (Shingair soil) showed higher pore-water K concentration compared to S_1 (SAU soil) which was significantly different.

Table 4.13. Effect of soils on the pore-water potassium (K) and sulphur (S) concentration

Soil	K (ppm)			S (ppm)		
	20DAT	40DAT	60DAT	20DAT	40DAT	60DAT
S_1	3.444	2.072	2.431 b	2.176	2.202	2.555
S_2	3.693	1.773	3.123 a	2.046	2.389	2.347
SE(±)	NS	NS	0.132	NS	NS	NS

In a column figures having similar letter(s) do not differ significantly at 5% level of significance whereas figures with dissimilar letter(s) differ significantly as per DMRT.

4.4.8 Effect of fertilizer and manure on the pore-water potassium concentration during Boro rice (BRRI dhan29) growing period

The pore-water K concentration was significantly affected by application of fertilizer and manure (Table 4.14).Higher levels of pore-water K concentrations were found in the treatments where fertilizer and manures were applied combinedly. Pore-water K concentrations decreased with increasing time. At 20 DAT, the highest pore-water K concentration (4.64 ppm) was found in T_4 (50% inorganic fertilizer + 3.5 ton ha^{-1}) treatment and lowest concentration was found in the T_0 (control) treatment (Table 4.14). Similar results were obtained in the samples of 40 and 60 DAT.

Table 4.14. Effect of fertilizer on the pore-water potassium (K) and sulphur (S) concentration

Fertilizer	K (ppm)			S (ppm)		
	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
T_0	2.625 c	1.272 b	2.094 b	1.274 b	1.626 b	1.420 b
T_1	3.818 ab	1.897 ab	2.905 ab	2.703 a	2.351 a	2.566 a
T_2	3.024 bc	1.959 a	2.833 ab	2.208 a	2.428 a	2.423 ab
T_3	3.735 ab	1.987 a	2.715 ab	2.090 a	2.528 a	2.432 ab
T_4	4.642 a	2.5 a	3.337 a	2.279 a	2.544 a	3.415 a
SE(±)	0.248	0.169	0.209	0.175	0.116	0.259

In a column figures having similar letter(s) do not differ significantly at 5% level of significance whereas figures with dissimilar letter(s) differ significantly as per DMRT.

4.4.9 Interaction effects of soils and fertilizer on the pore-water potassium concentration during Boro rice (BRRI dhan29) growing period

The interaction effects of soils and fertilizer on the pore-water potassium concentrations were not significantly different (Table 4.15). At 20 DAT, S_2T_4 (Shingair soil + 50% NPKS+ 3.5 ton poultry manure ha^{-1}) showed the highest pore-water Potassium concentration (5.520 ppm) which was statistically different from all other treatments and lowest pore water K concentration (2.470 ppm) was found in S_2T_0 (Shingair soil + RDCF) combination.

Table 4.15. Interaction effects of soils and fertilizer on the pore-water potassium (K) and sulphur (S) concentration during Boro rice growing period

Soil and Fertilizer	K (ppm)			S (ppm)		
	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
S_1T_0	2.779 bc	1.387	2.049	1.213	1.422	1.299
S_1T_1	3.766 bc	2.050	2.477	3.209	2.185	2.654
S_1T_2	2.961 bc	2.181	2.477	2.304	2.441	2.371
S_1T_3	3.950 b	2.307	2.383	1.999	2.357	2.343
S_1T_4	3.763 bc	2.437	2.770	2.153	2.604	4.107
S_2T_0	2.470 c	1.157	2.140	1.336	1.829	1.541
S_2T_1	3.870 bc	1.743	3.333	2.196	2.518	2.478
S_2T_2	3.087 bc	1.737	3.190	2.112	2.416	2.475
S_2T_3	3.520 bc	1.667	3.047	2.181	2.699	2.521
S_2T_4	5.520 a	2.563	3.903	2.405	2.484	2.722
SE(±)	0.351	NS	NS	NS	NS	NS

In a column figures having similar letter(s) do not differ significantly at 5% level of significance whereas figures with dissimilar letter(s) differ significantly as per DMRT.

4.4.10 Effect of soils on the pore-water sulphur concentration during Boro rice (BRRI dhan29) growing period

The effect of soils on the pore-water S concentration was not significantly different (Table 4.13). Similar concentrations of S were found in the SAU and Shingair soils.

4.4.11 Effect of fertilizer and manure on the pore-water sulphur concentration during Boro rice (BRRI dhan29) growing period

The pore-water S concentration was significantly affected by application of fertilizer and manure (Table 4.14). Higher levels of pore-water S concentrations were found in the treatments where fertilizer and manures were applied combinedly. Pore-water S concentrations increased with increasing time. At 20, 40 and 60 DAT, the highest pore-water S concentration was found in T_4 (50% inorganic fertilizer + 3.5 ton ha^{-1}) treatment which was statistically similar to all other treatments except control.

4.4.12 Interaction effects of soils and fertilizer on the pore-water sulphur concentration during Boro rice (BRRI dhan29) growing period

The interaction effects of soils and fertilizer on the pore-water sulphur concentrations were not significantly different (Table 4.15). At different DAT the pore-water sulphur concentrations were not affected by the combined effects of soils and fertilizer and manure application.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the net house of Soil Science Department of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2012 to May 2013 to study the effect of fertilizer and manure application on yield and yield components of rice and availability of nutrients in soil pore water. The BRRI dhan29 was used as the test crop in this experiment. The experiment consists of 2 factors i. e. soils and fertilizer plus manure. Two soils (S_1 = SAU soil and S_2 = Shingair soil) were used with 5 levels of fertilizer plus manure, as T_0: Control, T_1: 100% Recommended dose of fertilizer ($N_{120}P_{25}K_{60}S_{20}Zn_2$), T_2: 50% NPKS + 5 ton cow dung ha^{-1}, T_3: 50% NPKS + 5 ton compost ha^{-1} and T_4: 50% NPKS+ 3.5 ton poultry manure ha^{-1}. There were 10 treatment combination as S_1T_0 (SAU soil + Control), S_1T_1 (SAU soil + 100% Recommended dose of fertilizer ($N_{120}P_{25}K_{60}S_{20}Zn_2$), S_1T_2 (SAU soil + 50% NPKS + 5 ton cow dung ha^{-1}), S_1T_3 (SAU soil + 50% NPKS + 5 ton compost ha^{-1}), S_1T_4 (SAU Soil + 50% NPKS+ 3.5 ton poultry manure ha^{-1}),S_2T_0 (Shingair soil + Control), S_2T_1 (Shingair soil + 100% Recommended dose of fertilizer ($N_{120}P_{25}K_{60}S_{20}Zn_2$), S_2T_2 (Shingair soil + 50% NPKS + 5 ton cow dung ha^{-1}), S_2T_3 (Shingair soil + 50% NPKS + 5 ton compost ha^{-1}), S_2T_4 (Shingair soil + 50% NPKS+ 3.5 ton poultry manure ha^{-1}) and 3 replications.

The rice yield parameters and yields were significantly influenced with the variation of soils. The higher plant height, panicle length, filled grains panicle^{-1}, 1000 grain weight, grain yield and straw yield (g pot^{-1}) were found in the SAU soil (S_1) and lower values of the following yield parameters and yields were found in the Shingair soil (S_2).

The yield parameters and yields were significantly affected by fertilizer and manure treatments. The T_4 treatment gave highest plant height (79.43 cm), panicle length (25.95 cm), number of filled grains panicle^{-1}(166.65) and lowest was obtained from T_0 (control) treatment. The highest grain yield (94.22 g pot^{-1}) was found in T_1 (RCDF) which was statistically similar to all other treatments of fertilizer plus manure except control treatment. Similarly, the highest straw yield was obtained from the same T_1 (RCDF) treatment which was statistically similar to all other treatments except T_0 (control).

The plant height, panicle length, filled grains panicle^{-1}, unfilled grain panicle^{-1}, 1000 grain weight, grain yields were significantly influenced by interaction of soil and fertilizer plus manure treatments. Higher plant height, panicle length, filled grains panicle^{-1}, grain and straw yields were found in SAU soil with all the fertilizer plus manure treatments and lower in the Shingair soil (S_2). The rice yield was more increased in organic plus inorganic fertilizer treatments in SAU soils because the level of organic matter is very low, so integrated plant nutrient system was more effective in SAU soil (S_1) soil in comparison to Shingair soil (S_2) soil. The highest plant height (83.14 cm) was found in S_1T_2(SAU soil + 50% NPKS + 5 ton cow dung ha^{-1}), panicle length (26.98 cm) and filled grains panicle^{-1} (204.81) was found in S_1T_4 (SAU soil + 50% NPKS+ 3.5 ton poultry manure ha^{-1}) and 1000 grains weight (24.17g) was found in S_1T_1 (SAU soil + RCDF) treatment combination. The highest grain yield of 97.40 g pot^{-1} was obtained from S_1T_4 (SAU soil + 50% NPKS+ 3.5 ton poultry manure ha^{-1}) which was closely similar to the treatment combinations S_1T_1 (SAU soil + RDCF), S_1T_3 (SAU soil + 50% NPKS + 5 ton compost ha^{-1}) and S_2T_1 (Shingair soil + RDCF). The lowest grain yield (60 g pot^{-1}) was obtained in S_1T_0 (SAU soil + Control) treatment combination. The straw yield was not significantly influenced by combined application of soil and fertilizer plus manure. The highest straw yield of 87.67g pot^{-1} was obtained from S_1T_1 (SAU soil + RCDF) treatment combination and the lowest straw yield (49.93g pot^{-1}) was obtained from S_1T_0 (SAU soil + Control) treatment combination.

The grain N, P, K and S concentrations were not significantly influenced with the variation of soils and almost similar concentrations of N, P, K and S in the grains were found in both the soils. The grain N, P, K and S concentrations were significantly influenced by different fertilizer treatments. Except control, the similar concentrations of grain N, P, K and S were obtained from different fertilizer treatments. The highest concentrations of N (1.290%) and S (0.094%) were obtained from T_3 (50% NPKS + 5 ton compost ha^{-1}) and T_2 (50% NPKS + 5 ton cow dung ha^{-1}) treatments respectively. The same treatment T_4 (50% NPKS+ 3.5 ton poultry manure ha^{-1}) gave the highest grain P (0.289%) and K (0.274%) concentration. In all cases lowest concentration was obtained from T_0 (control) treatment where fertilizer was not used.

The interaction effects of soil and fertilizer did not significantly affect the accumulation of grain N, P, K and S. The higher N and S concentrations were found in the treatment combinations where organic plus inorganic fertilizers were applied. The highest N concentration of 1.293% was obtained from the S_1T_4 (SAU soil + 50% NPKS+ 3.5 ton poultry manure ha^{-1}) and S_2T_3 (Shingair Soil + 50% NPKS + 5 ton compost ha^{-1}) treatment combinations and lowest from S_1T_0 (SAU soil + Control) treatment combination. Similarly, the highest S concentration was obtained from S_2T_2 (Shingair soil + 50% NPKS and 5 ton cowdung ha^{-1}) which was closely similar to S_1T_3 (SAU soil + 50% NPKS+ 5 ton compost ha^{-1}) treatment combination and lowest in S_1T_0 (SAU soil + Control) treatment combination. The highest P concentration was found in S_1T_1 (SAU soil + RDCF) treatment combination which was almost similar to the treatment combination of S_2T_4 (Shingair soil + 50% NPKS+ 3.5 ton poultry manure ha^{-1}) treatment combination. The T_4 (50% NPKS + 3.5 ton poultry manure ha^{-1}) treatment increased the accumulation of K in both the soils and higher levels of K were found in the S_2T_4 (Shingair soil + 50% NPKS+ 3.5 ton poultry manure ha^{-1}) and S_1T_4 (SAU soil + 50% NPKS+ 3.5 ton poultry manure ha^{-1}) treatment combination and lowest was observed in S_1T_0 (SAU soil + Control) treatment combination.

The straw P and S concentrations were not significantly influenced with the variation of soils but N and K were significantly affected with the variation of soils. The higher N concentration was found in the straw of S_1 (SAU soil) and higher levels of K were obtained from S_2 (Shingair Soil). The straw N, P, K and S concentrations were significantly influenced by different fertilizer treatments. Except control, the similar concentrations of straw N and K were obtained from different fertilizer treatments. The highest concentrations of N (0.547%) and S (0.063%) were obtained from the same treatment T_4 (50% NPKS+ 3.5 ton poultry manure ha^{-1}) and lowest from T_0 (Control) treatment. The highest concentrations of P (0.072) and K (1.679) were obtained from T_1 (RCDF) and T_2 (50% NPKS + 5 ton cow dung ha^{-1}) treatments respectively and lowest from T_0 (Control) treatment.

The interaction effects of soil and fertilizer did not significantly affect the accumulation of straw N, P and K but significantly affected the straw S concentration. The higher N concentrations were found in the treatment combinations where organic plus inorganic fertilizers were applied. The highest N concentration of 0.560% was obtained from the S_1T_4 (SAU soil + 50% NPKS+ 3.5 ton poultry manure ha^{-1}) and lowest from S_1T_0 (SAU soil + Control) treatment combinations. Similarly, the highest S concentration (0.076%) was obtained from S_2T_4 (Shingair soil + 50% NPKS + 3.5 ton poultry manure ha^{-1}) treatment combination and lowest in S_1T_0 (SAU soil + Control) treatment combination. The highest P concentration was found in S_2T_1 (Shingair soil + RCDF) treatment combination which was almost similar to the treatment combination of S_1T_1 (SAU soil + RDCF) treatment combination. The T_4 (50%

NPKS + 3.5 ton poultry manure ha^{-1}) treatment increased the accumulation of K in Shingair soil compared to SAU soil and highest level of straw K concentration (1.861%) was found in the S_2T_4 (Shingair soil + 50% NPKS+ 3.5 ton poultry manure ha^{-1}) treatment combination and lowest was observed in S_1T_0 (SAU soil + Control) treatment combination.

The pore-water N concentrations were significantly affected with the variations of soil. The higher levels of pore-water N were found at 20 and 40 DAT in the S_1 (SAU soil) compared to S_2 (Shingair soil) but the trend of P concentrations were opposite and the highest level of 1.44ppm P was found in the Shingair soil (S_2) at 20DAT. The pore-water P level decreased sharply in Shingair soil with increasing time but almost similar levels of P were found in the samples of SAU soil with different dates of collection. The pore-water N and P concentrations were significantly affected with different fertilizer treatments. Higher levels of N were found in the T_4 treatment where 50% NPKS+ 3.5 ton poultry manure ha^{-1} was applied and higher rice yield was found in this treatment. The higher levels of P concentrations were found in fertilizer treatments where organic plus inorganic fertilizers were used.

The interaction effect of soil and fertilizer on the pore-water nitrogen (N) and phosphorus concentrations were significantly different. The higher levels of pore-water N were found in the combination of SAU soil and fertilizer treatments. The highest concentration of 12.13 ppm at 20 DAT and 10.53 ppm at 40 DAT were found in the S_1T_4 treatment combinations and lowest in S_2T_0 treatment combinations. The pore-water N concentrations were significantly correlated with the yields of rice. The higher P concentrations were found in the Shingair soil compared to SAU soil. The pore-water P concentration decreased with increasing days after transplantation.

The pore-water K and S concentrations were significantly affected by application of fertilizer and manure. Higher levels of pore-water K concentrations were found in the treatments where fertilizer and manures were applied combinedly. Pore-water K concentrations decreased with increasing time. At 20 DAT, the highest concentration of 4.64 ppm K was found in T_4 treatment where 50% inorganic fertilizer plus 3.5 ton/ha was used and lowest concentration was found in the T_0 treatment. Similar results were obtained in the samples of 40 and 60 DAT. The levels of S in the pore-water of different dates were almost similar. In each DAT samples, the similar and higher concentrations of S were found in all the fertilizer treatments except control. At 60 DAT, the highest concentration of pore-water S was found in the T_4 treatment and lowest in control treatment.

The pore-water K and S concentrations were significantly influenced by interaction effects of soil and fertilizer. The higher levels of K concentrations were found in the both soils where poultry manure was used. The pore-water K concentration decreased with increasing time. The highest concentration of 5.520 ppm K was found in the S_2T_4 treatment during 20 DAT which was statistically dissimilar with all other treatment combinations.

From the above discussion it can be concluded that S_1 (SAU soil) had significant effect on yield and yield contributing characters compared to S_2 (Shiingair soil) with the application of fertilizer plus manure. Application of organic plus inorganic fertilizer is most favorable for improving yield and yield contributing characters in Boro rice (BRRI dhan29). The nutrient availability in pore water was higher in the treatments where combinedly applied fertilizer and manure compared to chemical fertilizer treatment. There was a positive correlation between pore water nutrient concentration and yield of rice. Higher grain nutrient concentrations were obtained where higher levels of pore water nutrients were found. The nutrient concentrations in straw were also significantly affected by the combined application of fertilizer and manure with the combination of both soils (SAU soil and Shingair soil).

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

1. Such study can be followed by using the soils of different agro-ecological zones (AEZ) of Bangladesh.
2. Another combination of NPKS and others organic manures with different fertilizer management may be included for further study.

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APPENDIX

Appendix I. Monthly record of air temperature, rainfall, relative humidity, soil temperature and Sunshine of the experimental site during the period from October 2012 to May 2013

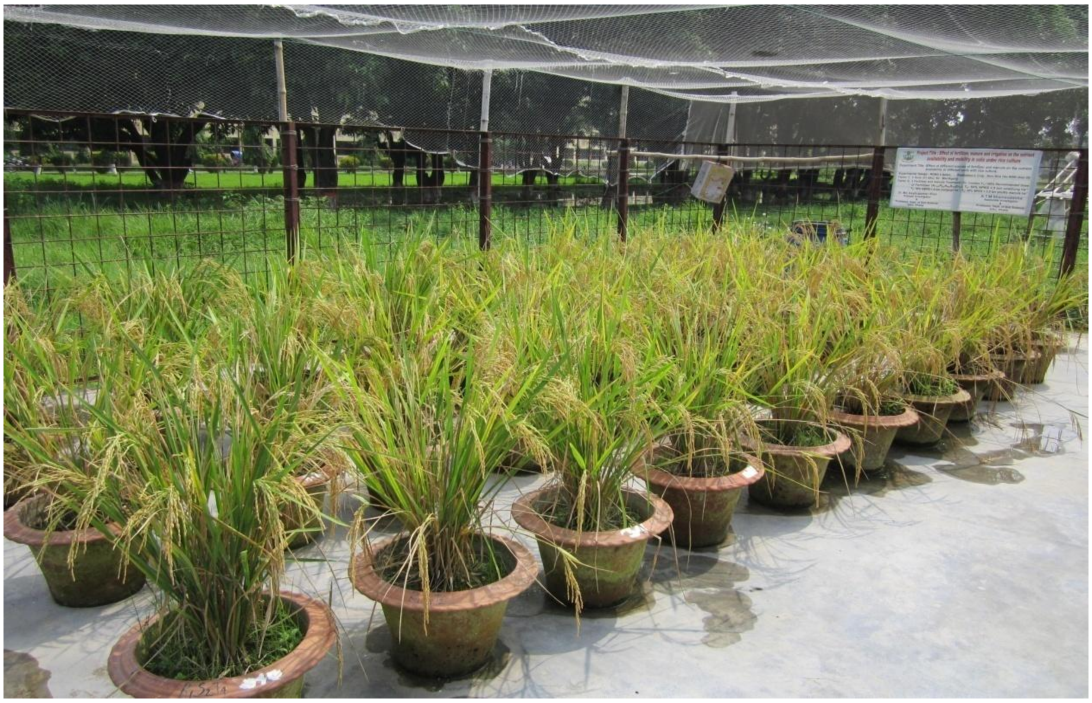
Year	Month	*Air temperature (ºc)		*Relative humidity (%)	*Rain fall (mm) (total)	*Sunshine (hr)
		Maximum	Minimum			
2012	October	36.2	17.5	74.9	320	5.9
	November	31.	15.6	67.3	0.00	5.8
	December	25.5	15.2	68	13.6	5.7
2013	January	24.8	14.2	66	6.6	5.8
	February	27.7	16.1	67	27.8	5.5
	March	33.5	21.9	65	64.7	5.6
	April	49.5	27.5	69	165.9	4.8
	May	31.5	19.2	73	34.4	5.1

* Monthly average,

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

Picture 1. Experiment in the net house

Picture 2. Pore water collection in the net house



Picture 3. Harvesting day in the net house