EFFECT OF FERTILIZER AND MANURE ON THE NUTRIENT AVAILABILITY AND YIELD OF T. AMAN RICE IN TWO DIFFERENT SOIL

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CERTIFICATE

This is to certify that the thesis entitled **'Effect of Fertilizer and Manure on the Nutrient Availability and Yield of T. Aman Rice in Two Different Soil'** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **Master of Science** in **Soil Science**, embodies the result of a piece of bonafide research work carried out by **Md. Abdur Rouf**, Registration number: **07-02497** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:

Dhaka, Bangladesh

Prof. Dr. Md. Asaduzzaman Khan

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DEDICATED

TO

MY BELOVED PARENTS

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ABSTRACT

The experiment was conducted in a net house of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from June to November 2013 in aman season to find out effect of fertilizer and manure on the nutrient availability and yield of T. Aman rice in different soil. BRRI dhan33 was used as the test crop in this experiment. The experiment comprised of two factors- Factors A: Soils from two different locations, S_1: SAU soil, S_2: Shingair soil (collected from Shingair Manikgonj) and Factor B: Levels of fertilizers and manures T_0: Control condition i.e. no fertilizers and manures; T_1: Recommended dose of fertilizer ($N_{120}P_{25}K_{60}S_{20}Zn_2$), T_2: 50% NPKSZn + 5 ton cow dung ha^{-1}, T_3: 50% NPKSZn + 5 ton compost ha^{-1} and T_4: 50% NPKSZn + 3.5 ton poultry manure ha^{-1}. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Data were recorded on different growth, yield parameters, nutrient concentration in grain and straw and nutrient status of post harvest soil. Significant variation was observed for different treatment and their interaction effect. For soil from different location, the highest grain yield (101.13 g pot^{-1}) was recorded from S_2 and the lowest grain yield (76.21 g pot^{-1}) from S_1. The highest N, P, K and S concentration in grain (1.378%, 0.249%, 0.225% and 0.071%, respectively) was recorded from S_2, whereas the lowest was found from S_1. The highest organic matter (2.45%) was found from S_2, while the lowest (1.30%) was recorded from S_1. For different fertilizers and manure, the highest grain yield (123.65 g pot^{-1}) was found from T_4, while the lowest grain yield (33.70 g pot^{-1}) was obtained from T_0. The highest N, P, K and S concentration in grain (1.536%, 0.279%, 0.252% and 0.077%, respectively) was recorded from T_4, while the lowest was observed from T_0. The highest organic matter (2.11%) was observed from T_4, whereas the lowest organic matter (1.61%) was found from T_0. The highest post experiment soil. Due to the interaction of soil from different location and fertilizers and manure, the highest grain yield (134.97 g pot^{-1}) was found from S_2T_4, whereas the lowest grain yield (32.03 g pot^{-1}) was recorded from S_1T_0. The highest N, P, K and S concentration in grain (1.651%, 0.286%, 0.262% and 0.081%, respectively) was recorded from S_2T_4 and the lowest was found from S_1T_0. The highest organic matter (2.56%) was observed from S_2T_2 and the lowest organic matter (0.99%) was recorded from S_1T_0. Shingair soil and 50% NPKSZn + 3.5 ton poultry manure ha^{-1} performed better in relation to yield contributing characters and yield of BRRI dhan33.The level of pH, total N, available P and S of the post experiment soil increased more in the SAU soil with 50% inorganic fertilizer plus 3.5 t poultry manure ha^{-1}. The level of OM increased more in SAU soil the lower container soil than Shingair soil.

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CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important and staple food not only in Bangladesh but also in South Asia and widely grown in tropical and subtropical regions (Singh *et al*., 2012). It provides 21% and 15% per capita of dietary energy and protein, respectively (Maclean *et al*., 2002). The slogan 'Rice is life' is most appropriate for Bangladesh and this crop plays a vital role in food security and livelihood for millions of rural people. However, at present the national average rice yield in Bangladesh (4.2 t ha^{-1}) is very low compared to other rice growing countries, like China (6.30 t ha^{-1}), Japan (6.60 t ha^{-1}) and Korea (6.30 t ha^{-1}) (FAO, 2009). Rice yields are either decelerating/stagnating/declining in post green revolution era mainly due to imbalance in fertilizer use, soil degradation, type of cropping system practiced, lack of suitable rice genotypes/variety for low moisture adaptability and disease resistance (Prakash, 2010).

Among the production factors affecting crop yield, essential nutrient is the single most important factor that plays a dominant role in yield increase if other production factors are not limiting. It is reported that chemical fertilizers today hold the key to success of production systems of Bangladesh agriculture being responsible for about 50% of the total crop production (BARC, 1997). Nutrient imbalance can be minimized by judicious application of different fertilizers. In Bangladesh, there is tendency to use indiscriminate amount of nitrogenous fertilizers and very limited amount of other nutrients (Rahman *et al*., 2008). Due to intensification of crop and rapid adoption of improved cultivars has not only increased yield but also have significantly increased the output of nutrients and, where there has been an imbalance between outputs and inputs, has resulted in declining soil fertility and an increase in the incidence of deficiencies of certain plant nutrients. On an average to produce one ton of grain of high yielding varieties of rice, remove about 22 kg N, 7 kg P_2O_5, 32 kg K_2O, 5 kg MgO, 4 kg CaO, 1 kg S and 40 g Zn from the soil (Chaudhary *et al*., 2007).

Depleted soil fertility is a major constrain to higher crop production in Bangladesh. The increasing land use intensity has resulted in a great exhaustion of nutrient in soils. The farmers of our country use on an average 102 kg nutrients ha^{-1} annually (70 kg N + 24 kg P + 6 kg K + 2 kg S and Zn) while the crop removal is about 200 kg ha^{-1} (Islam *et al*., 1994). In Bangladesh, most of the cultivated soils have less then 1.5% organic matter while a good agricultural soil should contain at least 2% organic matter (Ali, 1994). 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. Unless due attention is paid to the improvement and maintenance of soil organic matter it may not be possible the goal to increase and sustained productivity of crop.

Among the fertilizers, nitrogen (N) is essential for vegetative growth but excess N may cause excessive vegetative growth, prolong the growth duration and delay crop maturity with reduction in grain yield. Many research works revealed a significant response of rice to N fertilizer in different soils (Hussain *et al*., 1989). Inadequate and improper applications of N are now considered one of the major reasons for low yield of rice in Bangladesh. Phosphorus is also one of the important essential macro elements for the normal growth and development of plant. It is a major component in ATP, the molecule that provides 'energy' to that plant for such processes as photosynthesis, protein synthesis, nutrient translocation, nutrient uptake and respiration (Li *et al*., 2007). Potassium plays a vital role in proper growth and development and also increased growth parameters and also yield of rice (Krishnappa *et al*., 2006). Sulphur requirement of rice varies according to the nitrogen supply and it is required early in the growth of rice plants. If it is limiting during early growth, then tiller number and therefore final yield will be reduced (Blair and Lefroy, 1987). Zinc deficiency is the most widespread micronutrient disorder in lowland rice and application of Zinc increases the grain yield dramatically in most cases (Chaudhary *et al*., 2007; Muthukumararaja and Sriramachandrasekharan, 2012).

Soil organic matter improves the physicochemical properties of the soil and ultimately promotes crop production. Evidences from different AEZ of the country have shown a decrease in the content of organic matter by the range of 15 to 30% over the last 20 years (Miah, 1994). Therefore, it would not be wise to depend only on inherent potentials of soils for higher crop production. More recently, attention is focused on the global environmental problems; utilization of organic wastes, vermicompost and poultry manures as the most effective measure for the purpose. The application of different fertilizers and manures also positively correlated with soil porosity and enzymatic activity. Organic fertilizer enhances soil porosity by increasing regular and irregular pores and causes a priming effect of native soil organic matter. Application of both chemical and organic fertilizers needs to be applied for the improvement of soil physical properties and supply of essential plant nutrients for higher yield.

A suitable combination of organic and inorganic sources of nutrients is necessary for sustainable agriculture that can ensure quality food production. The long-term research of BARI revealed that the application of cowdung @ 5 t ha^{-1} $year^{-1}$ improved rice productivity as well as prevented the soil resources from degradation (Bhuiyan, 1994). A marked higher incidence of micro and macro nutrient deficiency is found in crop due to intensive cropping, loss of fertile top soil and losses of nutrient through leaching (Rahman *et al*., 2008; Somani, 2008 and Singh *et al*., 2011). Keeping in the view of the importance of rice and role of organic and inorganic nutrient in crop physiology, therefore, the present research work has been undertaken with the following objectives:

- Effects of fertilizer and manure with different soils on the nutrient availability in soil with rice culture,
- Effects of fertilizer, manure and soil on the yield and quality of T. Aman rice, and
- To know the effects of fertilizer and manure on the fertility improvement in soil.

CHAPTER II

REVIEW OF LITERATURE

Integrated use of organic manure and nitrogen fertilizer is the essential factor for sustainable soil fertility and crop productivity. Sole and combined use of inorganic fertilizer and cowdung, compost, poultry manure increases plant growth and yield contributing characters. Experimental evidences that the use of nitrogen, phosphorus, potassium, sulphur and zinc with cowdung, compost and poultry manure have an intimate effect on the yield and yield attributes of rice. The available relevant review that was presented below stated that the relation and the effect of various organic manure and inorganic fertilizer on yield and yield attributes of rice.

2.1 Effect of inorganic fertilizer

2.1.1 Nitrogen on yield contributing characters and yield of rice

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

Kumar *et al.* (1995) conducted a field experiment with four levels of nitrogen (0, 60, 120 and 180 kg N ha^{-1}) and reported that productive tillers increased significantly with the increase of N doses from 0-120 kg N ha^{-1}, but differences in productive tillers between 120 and 180 kg N ha^{-1} and they were not statistically significant.

Effective tillers m^{-2} responded significantly to the application of N fertilizer (Behera, 1995). Effective tillers increased significantly with increase the level of N fertilizer up to 80 kg N ha^{-1}. Patel and Upadhyay (1993) conducted an experiment with 3 levels of N (90, 120 and 150 kg ha^{-1}) and reported that total and effective tillers m^{-2} increased significantly with increasing rates of N up to 120 kg ha^{-1}.

Andrade and Amorim (1996) observed that increasing level of applied N increased plant height, panicle m^{-2}, grains panicle^{-1} and grain yield significantly. Palm *et al.* (1996) conducted a field trial at Waraseoni in the 1989-90 rainy season and observed that yield of rice cv. R. 269 was the highest (4.47 t ha^{-1}) when 100 kg N ha^{-1} was applied 30% basally, 40% at tillering and 30% at panicle initiation stage.

Khanda and Dixit (1996) reported that the increased levels of applied nitrogen significantly influenced the grain yields. They found that maximum grain and straw yields of 4.58 and 6.21 t ha^{-1} were obtained from 90 kg N ha^{-1}, respectively.

Adhikary and Rhaman (1996) reported that rice grain yield ha^{-1} in various treatments of N showed significant effect. The highest yield was obtained from 100 kg N ha^{-1} (4.52 t ha^{-1}) followed by 120 kg N ha^{-1} (4.46 t ha^{-1}) and 80 kg N ha^{-1} (4.40 t ha^{-1}).

Verma and Achraya (1996) observed that LAI increased significantly at maximum tillering and flowering stages with increasing levels of nitrogen. BINA (1996) stated that the effect of different levels of nitrogen was significant only for number of tillers hill^{-1}, effective tillers hill^{-1}, straw yield and crop duration. The highest number of total and productive tillers hill^{-1} was obtained from the highest level (120 kg ha^{-1}) of N application.

Dwibvedi (1997) noticed that application of nitrogen significantly increased in growth, yield and yield components, grain yield, straw yield as well as harvest index with 60 kg N ha^{-1}. BRRI (1997) reported during *boro* and transplant *aman* to determined rice seed yield. The experiment was laid out with four nitrogen levels 0, 50, 100 and 150 kg ha^{-1} and noted that seed yield increased gradually with the gradual increase of nitrogen.

Islam and Bhuiya (1997) studied the effect of nitrogen and phosphorus on the growth, yield and nutrient uptake of deep-water rice and observed that nitrogen and phosphorus fertilization significantly increased the number of fertile tiller m^{-2} and also that of grains panicle^{-1}, which in turned in grain yield. The application of 60 kg N ha^{-1} alone gave 22% yield benefit over control.

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

Kumar and Sharma (1999) conducted a field experiment with 4 levels of nitrogen (0, 40, 80 and 120 kg N ha^{-1}) and observed that dry matter accumulation in rice increased from 0-40 kg N ha^{-1} at 40 DAS, 0-120 kg N ha^{-1} at 60 DAS, 0-80 kg ha^{-1} at 80 DAS. Nitrogen application also hastened the growth and resulted in higher percentage of total dry matter accumulation in early stage of crop growth.

Bellido *et al*. (2000) evaluate a field experiment with 4 levels of nitrogen (0, 50, 100 and 150 kg N ha^{-1}) and reported that the amount of total dry matter was significantly greater at the N fertilizer rates of 100 and 150 kg nitrogen ha^{-1}.

BRRI (2000) reported that the grain yield was linearly increased with increasing nitrogen rates. Chopra and Chopra (2000) cited that seed yield increased linearly up to 80 kg N ha^{-1}. Castro and Sarker (2000) conducted field experiment to see the effects of N applications as basal (80, 60, and 45kg N ha^{-1}) and top dressing (10, 30 and 45 kg ha^{-1}) on the yield and yield components of Japonica rice and obtained high effective tiller, percentage of ripened grains and high grain yields from 45 kg N ha^{-1} (basal) and 45 kg N ha^{-1} (top dressing). Singh *et al.* (2000) stated that each increment dose of N significantly increased grain and straw yields of rice over its preceding dose. Consequently the crop fertilized with 100 kg N ha^{-1} gave maximum grain yield (2647 kg ha^{-1}).

Pully *et al*. (2000) observed that increased yield associated with application of nitrogen stage, although booting stage nitrogen application had no effect or shoot growth or nitrogen uptake. Geethdevi *et al*. (2000) found that 120 kg N ha^{-1} in the form of urea, 50% nitrogen was applied in four splits resulted in higher number of tillers, filled grains panicle^{-1} and higher grain weight hill^{-1}.

Munnujan *et al*. (2001) treated 4 levels of nitrogen fertilizer (0, 40, 80, and 160 kg ha^{-1}) application at three levels each planting density (20, 40 and 80 hill m^{-1}) and conducted that the highest grain yield (3.8 t ha^{-1}) was obtained with 180 kg N ha^{-1}, which was similar to the yield obtained at 80 kg N ha^{-1} (3.81 t ha^{-1}).

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 significant.

Angayarkanni and Ravichandran (2001) conducted a field experiment in Tamil Nadu, India from July to October to determine the best split application of 150 kg N ha^{-1} for rice cv. IR20. Data revealed that that applying 16.66% of the recommended N as basal, followed by 33.33% N at 10 DAT, 25% N at 20 DAT and 25% N at 40 DAT recorded the highest grain (6189.4 kg ha^{-1}) and straw (8649.6 kg ha^{-1}) yields, response ratio (23.40) and agronomic efficiency (41.26).

Duhan and Singh (2002) conducted a field experiment and reported that the rice yield and uptake of nutrients increased significantly with increasing N levels. Mondal and Swamy (2003) found that application of N (120 kg ha^{-1}) as urea in resulted in the highest number of panicle, number of grains panicle^{-1}, 1000-grain weight, straw yield and harvest index.

2.1.2 Phosphorus on yield contributing characters and yield of rice

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

Subba *et al.* (1995) reported that phosphorus applied @50 mg P/kg soil as SSP increased the grain and straw yields significantly. Ghosal *et al*. (1998) conducted a field experiment in Bihar on rice cv. Pankaj with 10–40 kg P/ha as triple super phosphate (TSP), highly reactive Morocco Rock Phosphate (HRMRP), Florida Rock Phosphate (FRP) and stated that yield increased with increasing P rates of four sources. They further proposed that grain yield was the highest with TSP followed by PAPR, HRMRP and FRP.

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

Nair and Rajasree (2004) conducted a field experiment to assess comparative efficiency of super phosphate and PR (34/74) at different levels in the yield characters and composition of rice. The treatments were 30 and 45 kg P_2O_5 ha^{-1} in the form of superphosphate and PR (34/74) with and without organic matter (6 t ha^{-1}), green manure (10 t ha^{-1}) and iron pyrites (10% by weight). The results showed that high grade phosphate rock (M, 34/74) with organic manure performed well and were followed by PR (34/74) with iron pyrites and green manure. Thus, PR (34/74) performed well with organic matter, FeS_2 and green manure in deciding growth and yield of rice. Higher contents of N, P, K, Ca and Mg of grain and straw were obtained at higher levels of 45 kg P_2O_5 ha^{-1} treatment.

Moula (2005) conducted an experiment on T. aman rice with different phosphorus rates. He found that when four treatments (P_0, 60 kg ha^{-1} phosphate rock, 60 kg ha^{-1} TSP and 210 kg ha^{-1} phosphate rock) were applied, 210 kg phosphate rock (PR) showed better performance on yield contributing characters and nutrient content as well as nutrient uptake by rice over other treatments.

Das and Sinha (2006) conducted a field experiment on sandy loam soil during the kharif season to study the effects of the integrated use of organic manures and various rates of N (urea) on the growth and yield of rice cv. IR 68. Among the different sources of organic amendments, farmyard manure (FYM; 10 t ha^{-1}) was superior, followed by the incorporation of wheat straw (5 t ha^{-1}) along with the combined application of phosphates rock (40 kg P_2O_5 ha^{-1}) and N. Grain and straw yields were highest when FYM was applied with 90 kg N ha^{-1}, although this treatment was comparable with combined application of wheat straw, phosphate rock and 90 kg N ha^{-1}.

Islam *et al*. (2010) conducted a field experiment with five phosphorus rates (0, 5, 10, 20 and 30 kg P ha^{-1}) with four rice genotypes in Boro and T. Aman season. Phosphorus rates did not influence grain yield irrespective of varieties in T. aman season while in Boro season P response was observed among the P rates. Application of P @ 10 kg ha^{-1} significantly increased the grain yield. But when P was applied @ 20 and 30 kg P ha^{-1}, the grain yield difference was not significant. The optimum and economic rate of P for T. Aman was 20 kg P ha^{-1} but in Boro rice the optimum and economic doses of P were 22 and 30 kg ha^{-1}, respectively. Hybrid entries (EH_1 and EH_2) used P more efficiently than inbred varieties. A negative P balance was observed up to 10 kg P ha^{-1}.

Tang *et al*. (2011) conducted a field experiment on winter wheat (*Triticum aestivum* L.) and rice (*Oryza sativa* L.) crop rotations in Southwest China to investigate phosphorus (P) fertilizer utilization efficiency, including the partial factor productivity (PFP), agronomic efficiency (AE), internal efficiency (IE), partial P balance (PPB), recovery efficiency (RE) and the mass (input–output) balance. This study suggests that, in order to achieve higher crop yields, the P fertilizer utilization efficiency should be considered when making P fertilizer recommendations in wheat–rice cropping systems.

2.1.3 Potassium on yield contributing characters and yield of rice

Singh *et al.* (2000) evaluated the effect of levels of K application on rice at different places. Results indicated that K application significant enhanced the growth and yield of rice over no application. The highest grain and straw yields of rice was obtained at 90 kg K_2O ha^{-1} all the cropping seasons.

Sarkar and Singh (2002) conducted a field experiment to determine the effect of potassium and sulphur. They applied 110 kg N: 90 kg P: 70 kg K: 20 Kg S ha^{-1}. They observed that the number of tillers m^{-2}, 1000-grain weight, paddy and straw yield significantly increased with the application of N, P, K and S.

Shen *et al*. (2003) studied the effects of N and K fertilizer on the yield and quality of rice. Potassium fertilizer significantly improved all quality parameters and yield at 150 kg N ha^{-1} and equal amounts of K fertilizer applied to rice fields are optimum to obtain high yield.

Natarajan *et al*. (2005) conducted an experiment during 2002-2003 with two rice hybrids, KRH2 and DRRHI in main plots and three levels of potassium (0, 40, and 80 kg ha^{-1}) in subplots to study the performance of rice hybrids with different K levels. The results clearly indicated that hybrid KRH2 performed superior with different levels of K.

Krishnappa *et al.* (2006) reported that increasing K rates increased paddy yields. Potassium applied in split dressings were more effective than when applied at transplanting time. Application of potassium fertilizer with organic manure increased soil K availability, K content and the number of grains $panicle^{-1}$.

Muangsri *et al*. (2008) reported that the effect of rice straw and rice hull in combination with nitrogen, phosphorus and potassium fertilizer on yield of rice grown on Phimai soil series. The treatments consisted of the control (without fertilizer) NPK fertilizer, rice straw at the rate of 0.75, 1.5 and 3.0 g kg^{-1} soil in combination with NPK fertilizer, and rice hull at the rate of 0.75, 1.5, 3.0 and 4.5 g kg^{-1} soil in combination with NPK fertilizer. The results showed that the growth, yield and nutrient uptake of rice plant grown on Phimai soil series without fertilizer were the lowest. Yield of rice plant grown on the soil amended with rice straw in combination with NPK fertilizer tended to be higher than that of rice plant grown on the soil amended with only NPK fertilizer.

Mostofa *et al*. (2009) conducted a pot experiment in the net house at the Department of Soil Science, Bangladesh agricultural University, Mymensingh. Four levels of potassium (0, 100, 200, and 300 kg ha^{-1}) were applied. They observed that the yield contributing characters like plant height, tiller number, and dry matter yield were the highest in 100 kg ha^{-1} of K.

Wan *et al*. (2010) conducted an experiment to evaluate the effects of application of fertilizer, pig manure (PM), and rice straw (RS) on rice yield, uptake, and usage efficiency of potassium, soil K pools, and the non-exchangeable K release under the double rice cropping system. The field treatments included control (no fertilizer applied), NP, NK, NPK, and NK + PM, NP + RS, NPK + RS. The application of K fertilizer (NPK) increased grain yield by 56.7 kg ha^{-1} over that obtained with no K application (NP).

Wang *et al*. (2011) carried out a field experiment to study the effects of N, P and K fertilizer application on grain yield, grain quality as well as nutrient uptake and utilization of rice to elucidate the interactive effects among N, P and K in a field experiment with four levels of nitrogen (N), phosphorus (P) and potassium (K) fertilizers. The results showed that the application of N, P and K fertilizer significantly increased grain yield, and the highest yield was found under the combined application of N, P and K fertilizer.

2.1.4 Sulphur on yield contributing characters and yield of rice

Raju and Reddy (2001) conducted field investigations to study the response of both hybrid and conventional rice to sulphur (20 kg ha^{-1}) and zinc applications and reported significant improvement in grain yield was observed due to sulphur application.

Vaiyapuri and Sriramachandrasekharan (2001) conducted an experiment on integrated use of green manure with graded levels of sulphur (0, 20, and 40 kg ha^{-1}) applied through three different sources in rice cv. ADT 37. It appeared that the maximum nutrient uptake (115.5, 27.6, 220.2 and 24.8 kg ha^{-1} for N, P, K and S, respectively), rice yield (5.07 t kg ha^{-1}) and soil available nutrients (199.5, 13.4, 299.1 and 22.8 kg ha^{-1} for N, P, K and S, respectively) were noticed with 40 kg sulphur ha^{-1}.

Peng *et al*. (2002) carried out a field experiment where the average content of available S in these soil samples was 21.7 mg kg^{-1}. The soil with available S content was lower than the critical value of 16 mg kg^{-1} accounted for 57.8%. Field experiments showed that there was a different yield-increasing efficiency by applying S at the doses of 20-60 kg ha^{-1} to rice plant.

Singh and Singh (2002) carried out a field experiment to see the effect of different nitrogen levels and 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} row length, dry matter production, panicle length and grains panicle $^{-1}$ were significant with increasing levels of S up to 40 kg S ha^{-1}. They also found that total N uptake, grain, straw and grain protein yields significantly improved with the increasing level S application being the maximum at 40 kg S ha^{-1} respectively.

Basumatary and Talukdar (2007) conducted a field experiment at the University, Jorhat, Assam, India to find out the direct effect of sulphur alone and in combination with graded doses of farmyard manure on rapeseed and its residual effects on rice with respect to yield, uptake and protein content. The N:S ratio in both crops progressively decreased with increasing sulphur levels up to 45 kg ha^{-1}. The lowest N:S ratio was observed upon treatment with 45 kg S ha^{-1} alone with 3.0 tonnes farmyard manure per hectare.

Bhuvaneswari *et al.* (2007) conducted a field experiment during kharif season, to study the effect of sulphur (S) at varying rates, i.e. 0, 20, 40 and 60 kg ha^{-1}, with different organics, i.e. green manure, farmyard manure, sulfitation press mud and lignite fly ash, each applied at 12.5 t ha^{-1}, on yield, S use efficiency and S optimization of rice cv. ADT 43. The results revealed that rice responded significantly to the application of S and organics compared to the control. The highest grain (5065 kg ha^{-1}) and straw yields (7524 kg ha^{-1}) was obtained with 40 kg S ha^{-1}.

Mrinal and Sharma (2008) conducted a field trials during the rainy (kharif) season to study the relative efficiency of different sources (gypsum, elemental sulphur and cosavet) and varying levels of sulphur (0, 10, 20, 30 and 40 kg S ha^{-1}) in rice. The growth and yield attributing characters of rice increased with the sulphur application. The grain and straw yields of rice increased significantly with increasing levels of sulphur up to 30 kg S ha^{-1}. The difference between sulphur sources was generally not significant.

An experiment was conducted by Rahman *et al.* (2009) to know the effect of different levels of sulphur on growth and yield of BRRI dhan41 at soil science Laboratory of Bangladesh Agricultural University, Mymensingh during T. Aman season. There were eight treatments and they were T_0 (without S), T_1 (50% RFD of S), T_2 (75% RFD of S), T_3 (100% RFD of S), T_4 (125% RFD of S), T_5 (150% RFD of S), T_6 (175% RFD of S) and T_7 (200% RFD of S). All yield contributing characters like effective tillers $hill^{-1}$, filled grain $panicle^{-1}$, grain yield, straw yield, biological yield and 1000-grain weight except plant height and panicle length of BRRI dhan41 significantly responded to different levels of S. Generally treatment T_6 performed the best result and T_0 did the worst.

A field experiment was conducted by Jawahar and Vaiyapuri (2011) at Experimental Farm, Annamalai University, Annamalai Nagar, Tamil Nadu, India to study the effect of sulphur and silicon fertilization on yield, nutrient uptake and economics of rice. The treatments comprised four levels of sulphur (0, 15, 30 and 45 kg ha^{-1}) and silicon and were laid out in factorial randomized block design with three replications. Among the different levels of sulphur, sulphur at 45 kg ha^{-1} recorded higher values for yield (grain and straw) and nutrient uptake (NPKS) of rice, respectively.

A field experiment was conducted by Dixit *et al*. (2012) to study the effect of sulphur and zinc on yield, quality and nutrient uptake by hybrid rice grown in sodic soil and found that application of 40 kg S ha^{-1} recorded significantly high grain and straw yield, protein content and sulphur uptake.

2.1.5 Zinc on yield contributing characters and yield of rice

Binod *et al*. (1998) conducted an experiment on rice (cv. Sita) was given soil application of 0, 12.5 and 25 kg $ZnSO_4$ ha^{-1}. After transplanting, plants were given soil applications of 0, 12.5 and 25 kg $ZnSO_4$ ha^{-1} and they obtained best results with application of 25 kg $ZnSO_4$ ha^{-1} to transplanted plants

Raju and Reddy (2001) conducted field investigations to study the response of both hybrid and conventional rice to sulphur and zinc (10 kg ha^{-1}) applications and reported that zinc application failed to improve the yield markedly.

A field experiment was conducted by Ullah *et al*. (2001) in Mymensingh, Bangladesh, to study the effect of zinc sulfate (0, 10, and 20 kg ha^{-1}) on rice cv. BR30. Zinc sulfate, along with 60 kg P_2O_5 and 40 kg K_2O ha^{-1}, was incorporated during land preparation. 80 kg N ha^{-1} was applied by 3 equal installments during land preparation, and at 25 and 60 days after transplanting. Plant height; tiller number; 1000-grain weight; grain and straw yields; and grain, straw, and soil Zn contents increased with zinc sulfate application. The tallest plants (75.67 cm) and the highest number of tillers (10.60 $hill^{-1}$), 1000-grain weight (28.70 g), and the concentration of Zn in straw (101.93 ppm) and grain (73.33 ppm) were obtained with 20 kg zinc sulfate ha^{-1}.

A study was carried out by Cheema *et al*. (2006) to evaluate the effect of four zinc levels on the growth and yield of coarse rice cv. IR-6 at Faisalabad, Pakistan. Four zinc levels viz., 2.5, 5.0, 7.5 and 10.kg $ZnSO_4$ ha^{-1} caused increase in yield and yield component as compared with control. Final plant height, number of tillers $hill^{-1}$, panicle bearing tillers, number of primary and secondary spikelets, panicle size, 1000 grain weight, paddy and straw yield and harvest index showed positive correlation with the increase in $ZnSO_4$ levels from 2.5 to 10 kg ha^{-1}.

A pot experiment was conducted by Khan *et al*. (2007) at Faculty of Agriculture Gomal University, Pakistan to evaluate the effect of different levels of zinc application on the yield and growth components of rice at eight different soil series. Zn as $ZnSO_4.7H_2O$ (21%) was applied @ 0, 5, 10 and 15kg ha^{-1} along with the basal doses of 120 kg N, 90 kg P_2O_5 and 60 kg K_2O ha^{-1}. Thirty days old four seedlings of rice cv. IRRI-6 were grown. The increasing levels of Zn in these soil series significantly influenced yield and yield components of rice. Application of 10 kg Zn ha^{-1} appeared to be an optimum dose for rice crop in these soil series.

The study was conducted by Mustafa *et al*. (2011) at agronomic research area, University of Agriculture, Faisalabad, to evaluate the effect of different methods and timing of zinc application on growth and yield of rice. Experiment was comprised of eight treatments viz., control, rice nursery root dipping in 0.5% Zn solution, $ZnSO_4$ application at the rate of 25 kg ha^{-1} as basal dose, foliar application of 0.5% Zn solution at 15, 30, 45, 60 and 75 days after transplanting. Maximum productive tillers per m^2 (249.80) were noted with basal application at the rate 25 kg ha^{-1} 21% $ZnSO_4$ and minimum (220.28) were recorded with foliar application at 60 DAT @ 0.5% Zn solution. Zinc application methods and timing had significantly pronounced effect on paddy yield. Maximum paddy yield (5.21 t ha^{-1}) was achieved in treatment Zn_2 (Basal application at the rate of 25 kg ha^{-1}

21% $ZnSO_4$) and minimum paddy yield (4.17 t ha^{-1}) was noted in Zn_7 (foliar application at 75 DAT @ 0.5% Zn solution).

Muthukumararaja and Sriramachandrasekhara (2012) reported that Zinc deficiency in flooded soil is impediment to obtain higher rice yield. Zinc deficiency is corrected by application of suitable zinc fertilizer. The results revealed that rice responded significantly to graded dose of zinc applied. The highest grain (37.53 g pot^{-1}) and straw yield (48.54 g pot^{-1}) was noticed at 5 mg Zn kg^{-1} which was about 100% and 86% greater than control (no zinc) respectively. The highest zinc concentration and uptake in grain and straw and DTPA-Zn at all stages was noticed at 7.5 mg Zn kg^{-1}. The linear regression analysis showed grain zinc concentration and grain Zn uptake caused 89.64 and 89.01% variation in rice yield. Similarly, the linear regression analysis of DTPA-Zn caused 98.31, 96.34 and 93.12% variation in yield of rice at tillering, panicle initiation and harvest stages respectively. The agronomic, physiological and agrophysiological apparent recovery and utilization efficiencies was highest at lower level of zinc application and decreased with Zn doses.

An experiment was carried out by Yadi *et al.* (2012) at Sari, Mazandaran, Iran. Zinc fertilizer application was chosen as main plots (0, 20 and 40 kg ha^{-1}) and genotypes as sub plots. The results showed that the most panicle number m^{-2} and harvest index had observed in 40 kg Zn ha^{-1} and the least of those was obtained in control treatment. The highest zinc content in grain, zinc uptake in grain and straw, and nitrogen uptake in grain were observed in 40 kg Zn ha^{-1}, as the most zinc content in straw, nitrogen, potassium, phosphorus and sulphur content in grain and straw, and nitrogen uptake in straw were observed highest with application of 40 and 20 kg Zn ha^{-1}.

A field experiment was conducted by Dixit *et al.* (2012) to study the effect of sulphur and zinc on yield, quality and nutrient uptake by hybrid rice grown in sodic soil and that positive response of hybrid rice to zinc application was noticed significantly up to the zinc dose @ 10 kg ha^{-1}.

2.2 Effect of organic fertilizer

2.2.1 Cowdung on yield contributing characters and yield of rice

Rajput and Warsi (1991) conducted a field experiment and reported that rice yield was increased to 34.44 kg ha^{-1} with the application at FYM of 10 t ha^{-1}. Sharma and Mitra (1991) reported a significant increase in N, P and K content and also the nutritional status of soil with 5 t ha^{-1} of FYM of rice based cropping system.

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

Miah (1994) stated that only the first crop following the application recovered one-fifth to one-half of the nutrient supplied by animal manure, reminder was held as humus to very slow decomposition, 2.4% element being released per annum.

Islam *et al*. (1994) found a significant yield increase with fertilizers with cowdung compared to fertilizer-N alone in T. Aman rice. In the following rice, the yields with fertilizer-N + residual of cowdung were higher than fertilizer-N alone.

Kant and Kumar (1994) reported that the increasing rates of amendments of chemical fertilizers with FYM increased the number of effective tillers $hill^{-1}$ significantly, number of grain $panicle^{-1}$, weight of 1000-grain also increased over the control. At the maximum level of FYM (30 t ha^{-1}) the increase of 48% tillers $hill^{-1}$, 14% number of grain $panicle^{-1}$ and 4.5% weight of 1000-grain over the control were recorded. They also reported that higher rate of FYM (30 t ha^{-1}) resulted 22.00% increase in grain yield over the untreated plots.

Thakur and Patel (1998) conducted field experiments during *kharif* season to study the effect of split application of 60 or 80 kg N ha^{-1} on growth, yield and nitrogen uptake by rice with and without 5 t FYM ha^{-1} and proposed that both N rates increased yields attributes, yield, plant N content and N uptakes of rice compared with N or application of FYM alone. N rates and use of split doses had no effect. The highest grain yield (3.84 t ha^{-1}) was recorded with the application of 80 kg N ha^{-1} in three split doses with 5 t ha^{-1} FYM during both the years, 60 kg N in three split doses with 5 t ha^{-1} FYM gave seed grain 3.85 t ha^{-1}.

A field experiment was conducted by Gupta *et al.* (1999) on clay loam soil in 1993 in Jummu and Kasmir using rice cv. PC-19 as test crop with 0-100 kg P_2O_5 ha^{-1} and 0 or 10 t FYM. The crop also received a basal dressing of N, K and Zn. Grain yield was highest with 100 kg P_2O_5 + FYM (5.20 t ha^{-1}).

A field experiment was conducted by Mannan *et al.* (2000) at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh, during August to December 1995 to study the effect of manuring and fertilizer application on growth, yield and quality of transplanted aman rice. Four varieties, namely, BR10, BR11, BR22, and BR23, and five fertilizer application treatments, namely, F_1 = inorganic fertilizers (IF), F_2 = IF + cowdung 5 t ha^{-1}, F_3 = IF + cowdung 10 t ha^{-1}, F_4=IF with late N application + cowdung 5 t ha^{-1}, and F_5 = IF with late N application + cow dung 10 t ha^{-1}. The doses of inorganic fertilizers were 150 kg urea, 90 kg triple superphosphate, 40 kg muriate of potash, 60 kg gypsum and 10 kg zinc sulfate $hectare^{-1}$. In F_4 and F_5 treatments, urea top dressing was delayed at second and third applications by one and two weeks, respectively. Among the fertilizer application treatments, F_5 and F_3 produced the highest and F_1 the lowest grain and straw yields. Grain protein content was higher in F_5, F_4 and F_3 treatments receiving 5 or 10 t ha^{-1} cowdung and late N application. 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 fertilizers 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.

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

An experiment was conducted by Ali *et al*. (2003) at Bangladesh Agricultural University, Mymensingh during the aman season to study the combined effect of cowdung with urea super granule (USG) on the yield and nutrient uptake by BRRI Dhan30. The experiment was laid out in a randomized complete block design with three replications. There were six treatments such as T_1= Control (no fertilizer), T_2= USG at 29 kg N ha^{-1}, T_3= cowdung @ 1.3 t ha^{-1} plus USG at 29 kg N ha^{-1}, T_4=USG at 58 kg N ha^{-1}, T_5= cowdung @ 1.3 t ha^{-1} plus USG at 58 kg N ha^{-1} and T_6 = USG at 87 kg N ha^{-1}. Phosphorus @ 15 kg ha^{-1}, potassium @ 50 kg ha^{-1} and sulphur @ 15 kg ha^{-1} were applied as basal dose to all the experimental plots. Cowdung @ 1.3 t ha^{-1} was applied before 6 days of transplanting. The highest grain yield was recorded with the incorporation of cowdung @ 1.3 t ha^{-1} combined with USG at 58 kg N ha^{-1} (T_5) which was statistically different from all other treatments. The NPKS contents of grain and straw as well as total NPKS uptake by the crop increased due to application of cowdung in combination with urea super granule. The study clearly indicated a great prospect of cowdung combined with USG at 58 kg N ha^{-1} application of rice cultivation.

A 7 year long field trial was conducted by Saha *et al*. (2007) on integrated nutrient management for dry season rice (Boro) green manure wet season rice (T. Aman) cropping system at the Bangladesh Rice Research Institute Farm, Gazipur. Five packages of inorganic fertilizers, cowdung, and green manure dhaincha (*Sesbania aculeata*) were evaluated for immediate and residual effect on crop productivity, nutrient uptake, soil-nutrient balance sheet, and soil-fertility status. Plant height, active tiller production, and grain and straw yields were significantly increased as a result of the application of inorganic fertilizer and organic manure. Application of cowdung at the rate of 5 t ha^{-1} once a year at the time of Boro transplanting supplemented 50% of the fertilizer nutrients other than nitrogen (N) in the subsequent crop of the cropping pattern. A positive effect of green manure on the yield of T. Aman rice was observed. The comparable yield of T. Aman was also observed with reduced fertilizer dose in cowdung treated plots. The total P, K, and S uptake (k $ha^{-1}yr^{-1}$) in the unfertilized plot under an irrigated rice system gradually decreased over the years. This study showed that the addition of organic manure cowdung gave more positive balances.

The literature review discussed above indicates that cowdung 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.

2.2.2 Compost on yield contributing characters and yield of rice

Anzai *et al*. (1989) found out the effect of successive application of rice straw compost on the growth and yield of rice with low and high soil nitrogen levels, respectively. The growth rice in the soil supplemented with rice straw compost was retarded initially and restored after the panicle formation stage. The yield was lower than that in the soil supplied with chemical fertilizer due to decrease in the percentage of ripened grains. Successive applications of 30 ton compost ha^{-1} produced more number of grain m^{-2} but a lower percentage of ripened grains and yield than that where chemical fertilizer was applied.

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

A study in typical clayey rice soil (Aeric Albaquept) of Bangladesh was conducted by Farid *et al*. (1998) incorporation of compost or rice straw and subsequent decomposition increased and maintained organic matter level at 2.5% that was higher than that in traditionally managed rice soil (<2%).

Application of composted coir pith improves the soil available K status and increase the uptake of K by grain and straw yield of rice. Application of 50 kg N with green leaf manure gave the highest grain and straw yield in both season, followed composted coir pith (Chittra and Janaki, 1999).

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

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

Keeling *et al*. (2003) determined the green waste composts and provider with additional fertilizer and showed consistently that the response of wheat rape to compost and fertilizer applied together was greater than responses to the individual additives, but only when very stable compost was used. Experiments with 15 N labeled fertilizer showed that wheat was able to utilize the applied N more efficiently when cultivated in the stable compost.

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

Aga *et al*. (2004) assessed the effect of compost on the growth and yield of rice. Plant growth characters such as plant height were highest with application of 15 t compost ha^{-1}. Grain yield increased significantly with the graded levels of compost application @ 10 t ha^{-1} but the response decreased with the increase of compost from 10 to 15 t ha^{-1}.

2.2.3 Poultry manure on yield contributing characters and yield of rice

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

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

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

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

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

Although there was increased yield following application, the result of this study indicated a possible risk of trace elements export to the environment with in a year, if high levels of manures are applied. Xu *et al*. (1997) observed that application of organic matter affected soil pH value as well as nutrient level. They also observed that pig manure was high influencing soil methane production when was followed by chicken manure. Cattle manure was the least in influencing were not significant in influencing soil methane production.

Channbasavana and Biradar (2001) reported that the application of poultry manure @ 3 t/ha gave 26% and 19% higher grain yield than that of the control 1998 and 1999, respectively. Eneji *et al*., (2001) observed that average across the soils, the level of extractable Fe increased by 5% in chicken manure and 71% in cattle manure; Mn by 61% in chicken manure and 172% in swine manure and Cu by 327% in chicken manure and 978% in swine manure. Mixing these manures before application reduce the level of extractable trace elements.

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

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to find out effect of fertilizer and manure on the change of soil nutrient availability and yield of T. Aman rice in two different soil. The details of the materials and methods has been presented below under the following headings:

3.1 Description of the experimental site

3.1.1 Experimental period

The experiment was conducted during the period from June to November 2013 in aman season.

3.1.2 Site description

The present piece of research work was conducted in the experimental area of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is $23^{0}74^{/}$N latitude and $90^{0}35^{/}$E longitude with an elevation of 8.2 meter from sea level.

3.1.3 Climatic condition

The geographical location of the experimental site was under the subtropical climate and its climatic conditions is characterized by three distinct seasons, namely winter season from the month of November to February and the pre-monsoon period or hot season from the month of March to April and monsoon period from the month of May to October. Details of the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e-Bangla Nagar, Dhaka and details has been presented in Appendix I.

3.1.4 Soil characteristics of the experimental pot

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

Table 1. Physicochemical properties of initial soils (0-15 cm) of SAU and Shingair soils

Characteristics	SAU Soil	Shingair Soil
Textural class	Silt Loam	Clay loam
pH	6.4	6.5
Organic matter (%)	1.12%	2.12%
Total N (%)	0.07%	0.08%
Available P(ppm)	7.6	5.72
Exchangeable K (ppm)	18.6	28.6
Available S (ppm)	7.20	8.0

3.2 Experimental details

3.2.1 Planting material

BRRI dhan33 was used as the test crop in this experiment. This variety was developed at the Bangladesh Rice Research Institute. It is recommended for Aman season and average plant height of the variety is 100 cm. It requires about 118 days completing its life cycle with an average yield is 4.5 t ha^{-1} (BRRI, 2012).

3.2.2 Treatment of the experiment

The experiment comprised of two factors

Factors A: Soils from different location (soil from 2 locations)

i) S_1: SAU soil

ii) S_2: Shingair soil (collected from Shingair Manikgonj)

Factor B: Levels of fertilizers and manures (5 levels)

i) T_0: Control condition i.e. no fertilizers and manures

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

iii) T_2: 50% NPKSZn + 5 ton cow dung ha^{-1}

iv) T_3: 50% NPKSZn + 5 ton compost ha^{-1}

iv) T_4: 50% NPKSZn + 3.5 ton poultry manure ha^{-1}

There were in total 10 (2×5) treatment combinations such as S_1T_0, S_1T_1, S_1T_2, S_1T_3, S_1T_4, S_2T_0, S_2T_1, S_2T_2, S_2T_3 and S_2T_4.

3.2.3 Experimental design and layout

The experiment was laid out in a randomized complete block design (RCBD) with three replications. Each block was divided into 10 unit pots as treatments. Thus the total numbers of pots were 30.

3.3 Growing of crops

3.3.1 Seed collection and sprouting

Seeds were collected from BRRI (Bangladesh Rice Research Institute), Gazipur just 25 days ahead of the sowing of seeds in seed bed. Seeds were immersed in water in a bucket for 24 hours. These were then taken out of water and kept in gunny bags. The seeds started sprouting after 48 hours which were suitable for sowing in 72 hours.

3.3.2 Raising of seedlings

The nursery bed was prepared by puddling with repeated ploughing followed by laddering. The sprouted seeds were sown as uniformly as possible. Irrigation was gently provided to the bed as and when needed. No fertilizer was used in the nursery bed.

3.3.3 Pot preparation

The pot selected for conducting the experiment was filled up with 14 kg soil in the second week of July 2013. Weeds and stubbles were removed. The experimental pot was partitioned in accordance with the experimental design. Organic and inorganic manures as indicated below were mixed with the soil of each pot.

3.3.4 Fertilizers and manure application

The fertilizers N, P, K, S and Zn in the form of urea, TSP, MoP, Gypsum and zinc sulphate, respectively were applied as per treatment. As a manure cowdung, compost and poultry manure also applied as per treatment. The one third amount of urea and entire amount of TSP, MOP, gypsum and zinc sulphate were applied during the final preparation of pot. Rest urea was applied in two equal installments at tillering and panicle initiation stages.

3.3.5 Transplanting of seedling

Twenty five days old seedlings of BRRI dhan33 were carefully uprooted from the seedling nursery and transplanted on 22 July, 2013 in well prepared pots. Two seedling pot^{-1} were used. After one week of transplanting all pots were checked for any missing hill, which was filled up with extra seedlings whenever required.

3.3.6 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.

3.3.6.1 Irrigation

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

3.3.6.2 Weeding

The plots were infested with some common weeds, which were removed by uprooting them from the pot three times during the cropping season.

3.3.6.3 Insect and pest control

There was no infection of diseases in the pot but leaf roller (*Chaphalocrosis medinalis*) was observed in the pot and used Malathion @ 1.12 L ha^{-1}.

3.4 Harvesting, threshing and cleaning

The crop was harvested at full maturity at 28 November when 80-90% of the grains were turned into straw colored. The harvested crop was bundled separately, properly tagged and brought to threshing floor. Enough care was taken during threshing and cleaning period of rice grain. Fresh weight of rice grain and straw were recorded pot wise. The grains were dried, cleaned and weighed for individual pot. The weight was adjusted to a moisture content of 14%.

3.5 Data collection on yield components and yield

3.5.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of after harvest. The height was measured from the ground level to the tip of the panicle/flag leaf.

3.5.2 Effective tillers hill^{-1}

The total number of effective tiller hill^{-1} was counted as the number of panicle bearing tiller during harvesting.

3.5.3 Length of panicle

The length of panicle was measured with a meter scale as per plant.

3.5.4 Filled grains panicle^{-1}

The total numbers of filled grain was collected and then numbers of filled grains panicle^{-1} was recorded.

3.5.5 Weight of 1000-grain

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

3.5.6 Grain yield plant^{-1}

Grains obtained from each plant were sun-dried and weighed carefully and recorded.

3.5.7 Straw yield plant^{-1}

Straw obtained from each unit plant were sun-dried and weighed carefully recorded.

3.6 Chemical analysis of samples

3.6.1 Collection of plant samples

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

3.6.2 Preparation of samples

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

3.6.3 Digestion of plant samples with sulphuric acid for N

For the determination of nitrogen an amount of 0.2 g oven dry, ground sample were taken in a micro kjeldahl flask. 1.1 g catalyst mixture (K_2SO_4: $CuSO_4.$ $5H_2O$: Se in the ratio of 100: 10: 1), and 5 ml conc. H_2SO_4 were added. The flasks were heated at 120^0C and added 2.5 ml 30% H_2O_2 then heating was continued at 180^0C until the digests became clear and colorless. After cooling, the content was taken into a 100 ml volumetric flask and the volume was made up to the mark with de-ionized water. A reagent blank was prepared in a similar manner. Nitrogen in the digest was estimated by distilling the digest with 10 N NaOH followed by titration of the distillate trapped in H_3BO_3 indicator solution with 0.01N H_2SO_4.

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

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

3.6.5 Determination of P, K and S from plant samples

3.6.5.1 Phosphorus

Phosphorus in the digest was determined by using 1 ml for grain sample and 2 ml for straw sample from 100 ml extract was then determined by developing blue color with reduction of phosphomolybdate complex and the color intensity were measured colorimetrically at 660 nm wavelength and readings were calibrated with the standard P curve (Page *et al*., 1982).

3.6.5.2 Potassium

Five milli-liter of digest sample for the grain and 10 ml for the straw were taken and diluted 50 ml volume to make desired concentration so that the absorbance of sample were measured within the range of standard solutions. The absorbance was measured by atomic absorption flame photometer.

3.6.5.3 Sulphur

Sulphur content was determined from the digest of the plant samples (grain and straw) with $CaCl_2$ (0.15%) solution as described by (Page *et al*., 1982). The digested S was determined by developing turbidity by adding acid seed solution (20 ppm S as K_2SO_4 in 6N HCl) and $BaCl_2$ crystals. The intensity of turbidity was measured by spectrophotometer at 420 nm wavelengths (Hunter, 1984).

3.7 Post harvest soil sampling

After harvest of crop soil samples were collected from each plot at a depth of 0 to 15 cm. Before T. Aman cultivation, Boro rice was cultivated in the same pots by using similar treatments. Soil samples of each plot was air-dried, crushed and passed through a two mm (10 meshes) sieve. The soil samples were kept in plastic container to determine the physical and chemical properties of soil.

3.8 Soil analysis

Post experiment soil samples were analyzed for pH, organic matter, total N, available P, K and S concentration. The soil samples were analyzed by the following standard methods as follows:

3.8.1 Soil pH

Soil pH was measured with the help of a glass electrode pH meter, the soil water ratio being maintained at 1: 2.5 as described by Page *et al*., 1982.

3.8.2 Organic matter

Organic carbon in soil sample was determined by wet oxidation method. The underlying principle was used to oxidize the organic matter with an excess of 1N $K_2Cr_20_7$ in presence of conc. H_2SO_4 and conc. H_3PO_4 and to titrate the excess $K_2Cr_20_7$ solution with 1N $FeSO_4$. To obtain the content of organic matter was calculated by multiplying the percent organic carbon by 1.73 (Van Bemmelen factor) and the results were expressed in percentage (Page *et al.*, 1982).

3.8.3 Total nitrogen

Total N content of soil were determined followed by the Micro Kjeldahl method. One gram of oven dry ground soil sample was taken into micro kjeldahl flask to which 1.1 gm catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se in the ratio of 100:10:1), and 6 ml H_2SO_4 were added. The flasks were swirled and heated 200^0C and added 3 ml H_2O_2 and then heating at 360^0C was continued until the digest was clear and colorless. After cooling, the content was taken into 100 ml volumetric flask and the volume was made up to the mark with distilled water. A reagent blank was prepared in a similar manner. These digests were used for nitrogen determination (Page *et al*., 1982).

Then 20 ml digest solution was transferred into the distillation flask, Then 10 ml of H_3BO_3 indicator solution was taken into a 250 ml conical flask which is marked to indicate a volume of 50 ml and placed the flask under the condenser outlet of the distillation apparatus so that the delivery end dipped in the acid. Add sufficient amount of 10N-NaOH solutions in the container connecting with distillation apparatus. Water runs through the condenser of distillation apparatus was checked. Operating switch of the distillation apparatus collected the distillate. The conical flask was removed by washing the delivery outlet of the distillation apparatus with distilled water. Finally the distillates were titrated with standard 0.01 N H_2SO_4 until the color changes from green to pink. The amount of N was calculated using the following formula:

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

Where,

T = Sample titration (ml) value of standard H_2SO_4

B = Blank titration (ml) value of standard H_2SO_4

N = Strength of H_2SO_4

S = Sample weight in gram

3.8.4 Available phosphorus

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

3.8.5 Exchangeable potassium

Exchangeable K was determined by 1N NH_4OAc (pH 7) extraction methods and by using flame photometer and calibrated with a standard curve (Page *et al.*, 1982).

3.8.6 Available sulphur

Available S content was determined by extracting the soil with $CaCl_2$ (0.15%) solution as described by Page *et al.*, 1982. The extractable S was determined by developing turbidity by adding acid solution (20 ppm S as K_2SO_4 in 6N HCl) and $BaCl_2$ crystals. The intensity of turbidity was measured by spectrophotometer at 420 nm wavelengths.

3.9 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference of fertilizer and manure on the change of nutrient availability and yield of T. Aman rice in different soil. The mean values of all the characters were calculated and analysis of variance was performed by Mstat-C. The significance of the differences among the treatment means were estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to find out the effect of fertilizer and manure on the nutrient availability and yield of T. Aman rice in different soil. The analyses of variance of the data on different growth, yield parameters, yield nutrient concentration in grain and straw and nutrient status of post harvest soil are presented in this chapter. The results have been presented and discusses with the help of table and graphs and possible interpretations given under the following headings:

4.1 Yield contributing characters and yield of rice

4.1.1 Plant height

Plant height of BRRI dhan33 showed statistically non-significant variation due to soil from different location at harvest (Table 2). The tallest plant (102.7 cm) was found from S_2 (Shingair soil), while the shortest plant (100.3 cm) was recorded from S_1 (SAU soil).

Different levels of fertilizers & manures varied significantly for at harvest in terms of plant height of BRRI dhan33 (Table 2). The tallest plant (105.9 cm) was observed from T_3 (50% NPKSZn + 5 ton compost ha^{-1}), which was statistically identical (104.0 cm, 103.1 cm and 102.5 cm) with T_1 (Recommended dose of fertilizer: $N_{120}P_{25}K_{60}S_{20}Zn_2$), T_4 (50% NPKSZn + 3.5 ton poultry manure ha^{-1}) and T_2 (50% NPKSZn + 5 ton cowdung ha^{-1}), whereas the shortest plant (92.0 cm) from T_0 (control condition). Plant height was significantly influenced by the integrated effect of organic and inorganic fertilizers. Gurung and Sherchan (1993) reported that the application of cowdung with chemical fertilizers produced significantly plant than that of chemical fertilizers alone. Rini and Srivastava (1997) reported that one-third or one-quarter of N as vermicompost increased plant height yield components of rice.

Table 2. Effect of soil from different locations and fertilizer & manure on plant height, effective tiller hill^{-1}, panicle length and grains panicle^{-1} of BRRI dhan33

Treatment	Plant height (cm)	Number of effective tiller hill^{-1}	Panicle length (cm)	Number of filled grain panicle^{-1}
Soil from different locations				
S_1	100.3	24.13	24.28	138.9
S_2	102.7	28.87	24.59	155.3
SE(±)	NS	NS	NS	NS
Fertilizer & manure				
T_0	92.0b	13.0c	21.97b	111.5b
T_1	104.0a	29.0ab	25.27a	158.2a
T_2	102.5a	28.0b	24.51a	152.2a
T_3	105.9a	29.7ab	25.79a	165.0a
T_4	103.1a	32.8a	24.64a	148.6ab
SE(±)	1.93	1.16	0.478	9.7

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

S_1: SAU soil

S_2: Shingair soil

T_0: Control condition

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

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

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

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

Statistically non-significant variation was recorded due to the interaction effect of soil from different location and levels of fertilizers & manures (Table 3). The tallest plant (106.7 cm) was observed from S_2T_2 (Shingair soil with 50% NPKSZn + 5 ton cowdung ha^{-1}) which was similar to S_1T_1, S_1T_3, S_1T_4, S_2T_1, S_2T_2 and S_2T_3 treatment combination. The shortest plant (89.8 cm) was recorded from S_1T_0 (SAU soil in control condition) treatment combination which was statistically comparable to S_2T_0 treatment combination.

4.1.2 Number of effective tillers hill^{-1}

Statistically non-significant variation was recorded for number of effective tillers hill^{-1} of BRRI dhan33 due to soil from different location (Table 2). The maximum number of effective tillers hill^{-1} (28.87) was obtained from S_2, whereas the minimum number (24.13) was found from S_1.

Number of effective tillers hill^{-1} of BRRI dhan33 varied significantly for different levels of fertilizers & manures (Table 2). The maximum number of effective tillers hill^{-1} (32.8) was recorded from T_4, which was statistically similar (29.7 and 29.0) with T_3 and T_1 and closely followed (28.0) T_2, while the minimum number (13.0) from T_0. Kant and Kumar (1994) reported that the increasing rates of amendments of chemical fertilizers with FYM increased the number of effective tillers hill^{-1} significantly and at the maximum level of FYM (30 t ha^{-1}) the increase of 48% tillers hill^{-1} over the control were recorded.

Interaction effect of soil from different location and levels of fertilizers & manures showed non-significant variation on number of effective tillers hill^{-1} (Table 3). The maximum number of effective tillers hill^{-1} (35.33) was recorded from S_2T_4 and the minimum number (12.67) was found from S_1T_0.

4.1.3 Length of panicle

Statistically non-significant variation was found for length of panicle of BRRI dhan33 due to soil from different location (Table 2). The longest panicle (24.59 cm) was found from S_2 and the shortest panicle (24.28 cm) was observed from S_1.

Table 3. Interaction effect of soil from different locations and fertilizer & manure on plant height, effective tiller hill^{-1}, panicle length and grains panicle^{-1} of BRRI dhan33

Treatment	Plant height (cm)	Number of effective tiller hill^{-1}	Panicle length (cm)	Number of filled grain panicle^{-1}
S_1T_0	89.8	12.66	21.66	99.5
S_1T_1	106.4	26.33	25.51	163.0
S_1T_2	98.3	23.66	23.98	130.3
S_1T_3	105.8	27.66	25.91	158.6
S_1T_4	101.3	30.33	24.33	143.2
S_2T_0	94.1	13.33	22.28	123.4
S_2T_1	101.7	31.66	25.02	153.4
S_2T_2	106.7	32.33	25.04	174.1
S_2T_3	105.9	31.66	25.66	171.5
S_2T_4	104.9	35.33	24.94	154.0
SE(±)	NS	1.64	NS	NS

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

S_1: SAU soil

S_2: Shingair soil

T_0: Control condition

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

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

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

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

Length of panicle of BRRI dhan33 varied significantly for different levels of fertilizers & manures (Table 2). The longest panicle (25.79 cm) was observed from T_3, which was statistically identical (25.27 cm, 24.64 cm and 24.51 cm) with T_1, T_4 and T_2. On the other hand, the shortest panicle (21.97 cm) was found from T_0. Rini and Srivastava (1997) reported that one-third or one-quarter of N as vermicompost increased yield components of rice.

Interaction effect of soil from different location and levels of fertilizers & manures showed non-significant variation on length of panicle (Table 3). The longest panicle (25.91 cm) was found from S_1T_3, while the shortest panicle (21.66 cm) was observed from S_1T_0.

4.1.4 Number of filled grains panicle^{-1}

Statistically non-significant variation was found for number of filled grains panicle^{-1} of BRRI dhan33 due to soil from different location (Table 2). The maximum number of filled grains panicle^{-1} (155.3) was observed from S_2, while the minimum number (138.9) was recorded from S_1.

Number of filled grains panicle^{-1} of BRRI dhan33 varied significantly for different levels of fertilizers & manures (Table 2). The highest number of filled grains panicle^{-1} (165.0) was obtained from T_3, which was statistically identical with all other treatments except T_0 and the lowest number of filled grains panicle^{-1} was found in T_0 treatment. Kant and Kumar (1994) reported that the increasing rates of amendments of chemical fertilizers with FYM increased the number of grain panicle^{-1} increased over the control and at the maximum level of FYM (30 t ha^{-1}) the increase of 14% number of grain panicle^{-1} over the control were recorded.

Number of filled grains panicle^{-1} showed non-significant variation due to the interaction effect of soil from different location and levels of fertilizers & manures (Table 3). The maximum number of filled grains panicle^{-1} (174.1) was observed from S_2T_2 and the minimum number (99.5) was recorded from S_1T_0.

4.1.5 Weight of 1000-grain

Statistically non-significant variation was found for weight of 1000-grains of BRRI dhan33 due to soil from different location (Table 4). The highest weight of 1000-grains (20.77 g) was recorded from S_2, whereas the lowest weight (20.53 g) was recorded from S_1.

Weight of 1000-grains of BRRI dhan33 varied non-significantly for different levels of fertilizers & manures (Table 4). The highest weight of 1000-grains (21.25 g) was found from T_4, whereas the lowest weight (19.75 g) was found from T_0. Kant and Kumar (1994) reported that the increasing rates of amendments of chemical fertilizers with FYM increased weight of 1000-grain also increased over the control and 4.5% weight of 1000-grain over the control were recorded.

Interaction effect of soil from different location and levels of fertilizers & manures showed non-significant variation on weight of 1000-grains (Table 5). The highest weight of 1000-grains (21.33 g) was obtained from S_2T_4 and the lowest weight (19.67 g) was found from S_2T_0.

4.1.6 Grain yield pot^{-1}

Soil from different location varied significantly in terms of grain yield pot^{-1} of BRRI dhan33 (Table 4). The highest grain yield pot^{-1} (101.13 g) was recorded from S_2 and the lowest grain yield pot^{-1} (76.21 g) was observed from S_1.

Grain yield pot^{-1} of BRRI dhan33 varied significantly for different levels of fertilizers & manures (Table 4). The highest grain yield pot^{-1} (123.65 g) was found from T_4, while the lowest grain yield pot^{-1} (33.70 g) was obtained from T_0. Gurung and Sherchan (1993) reported that the application of cowdung with chemical fertilizers produced significantly higher grain yield than that of chemical fertilizers alone. Rahman (2001) reported that in rice-rice cropping pattern, the highest grain yield of Boro rice was recorded in the soil test basis (STB) N P K S Zn fertilizers treatment while in T. Aman rice the 75% or 100% of N P K S Zn (STB) fertilizers plus green manure (GM) with or without cowdung gave the highest or a comparable yield.

Table 4. Effect of soil from different locations and fertilizer & manure on weight of 1000 grains and grain and straw yield $plant^{-1}$ of BRRI dhan33

Treatment	Weight of 1000 grains (g)	Grain yield (g pot^{-1})	Straw yield (g pot^{-1})
Soil from different locations			
S_1	20.53	76.21a	70.83a
S_2	20.77	101.13b	83.53b
SE(±)	NS	2.40	1.74
Fertilizer & manure			
T_0	19.75	33.70c	34.62c
T_1	20.58	96.22b	85.32b
T_2	21.00	92.72b	84.17b
T_3	20.67	97.05b	80.47b
T_4	21.25	123.65a	101.35a
SE(±)	0.14	3.80	2.76

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

S_1: SAU soil

S_2: Shingair soil

T_0: Control condition

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

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

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

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

Statistically significant variation was recorded due to the interaction effect of soil from different location and levels of fertilizers & manures in terms of grain yield pot^{-1} (Table 5). The highest grain yield pot^{-1} (134.97 g) was found from S_2T_4, whereas the lowest grain yield pot^{-1} (32.03 g) was recorded from S_1T_0.

4.1.7 Straw yield pot^{-1}

Statistically significant variation was found for straw yield pot^{-1} of BRRI dhan33 due to soil from different location (Table 4). The highest straw yield pot^{-1} (83.53 g) was found from S_2, while the lowest straw yield pot^{-1} (70.83 g) was recorded from S_1.

Straw yield pot^{-1} of BRRI dhan33 varied significantly for different levels of fertilizers & manures (Table 4). The highest straw yield pot^{-1} (101.35 g) was observed from T_4, whereas the lowest (34.62 g) was found from T_0. Chittra and Janaki (1999) reported that application of 50 kg N with green leaf manure gave the highest straw yield.

Interaction effect of soil from different location and levels of fertilizers & manures showed significant variation on straw yield pot^{-1} (Table 5). The highest straw yield pot^{-1} (110.07 g) was observed from S_2T_4 and the lowest straw yield pot^{-1} (32.93 g) was recorded from S_1T_0.

Table 5. Interaction effect of soil from different locations and fertilizer & manure on weight of 1000 grains and grain and straw yield plant^{-1} of BRRI dhan33

Treatment	Weight of 1000 grains (g)	Grain yield (g pot^{-1})	Straw yield (g pot^{-1})
S_1T_0	19.83	32.03d	32.93
S_1T_1	20.33	84.33c	80.87
S_1T_2	21.00	74.10c	77.07
S_1T_3	20.33	78.23c	70.67
S_1T_4	21.17	112.33b	92.63
S_2T_0	19.67	35.37d	36.30
S_2T_1	20.83	108.10b	89.77
S_2T_2	21.00	111.33b	91.27
S_2T_3	21.00	115.87ab	90.27
S_2T_4	21.33	134.97a	110.07
SE(±)	NS	5.37	NS

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

S_1: SAU soil

S_2: Shingair soil

T_0: Control condition

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

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

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

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

4.2 N, P, K and S concentration in grain

Statistically significant variation was found for N, P, K and S concentration in grain of BRRI dhan33 due to soil from different location (Table 6). The highest N, P, K and S concentration in grain (1.378%, 0.249%, 0.225% and 0.071%, respectively) was recorded from S_2, whereas the lowest N, P, K and S concentration in grain (1.280%, 0.238%, 0.213%, and 0.066%) from S_1.

N, P, K and S concentration in grain of BRRI dhan33 varied significantly for different levels of fertilizers & manures (Table 6). The highest N, P, K and S concentration in grain (1.536%, 0.279%, 0.252% and 0.077%) was recorded from T_4, while the lowest N, P, K and S concentration in grain (1.023%, 0.167%, 0.131% and 0.050%) was observed from T_0. Sharma and Mitra (1991) reported a significant increase in N, P and K content and also the nutritional status of soil with 5 t ha^{-1} of FYM of rice based cropping system.

Interaction effect of soil from different location and levels of fertilizers & manures showed significant variation on N, P, K and S concentration in grain (Table 7). The highest N, P, K and S concentration in grain (1.651%, 0.286%, 0.262% and 0.081%) was recorded from S_2T_4 and the lowest N, P, K and S concentration in grain (1.007%, 0.164%, 0.126% and 0.048%) was found from S_1T_0.

4.3 Nutrient status of post harvest soil

4.3.1 pH

Statistically non-significant variation was found for pH in post harvest soil of BRRI dhan33 due to soil from different location (Figure 1). The highest pH (6.7) was observed from S_2, while the lowest pH (6.3) was recorded from S_1.

The pH in post harvest soil varied significantly for different levels of fertilizers & manures (Figure 2). The highest pH (7.3) was found from T_4, which was closely followed (6.5) by T_3. On the other hand, the lowest pH (6.1) was found from T_1.

Table 6. Effect of soil from different locations and fertilizer & manure on N, P, K and S concentrations in grain of BRRI dhan33

Treatment	Concentration (%) in grain			
	N	P	K	S
Soil from different locations				
S_1	1.280 b	0.238 b	0.213 b	0.066 a
S_2	1.378 a	0.249 a	0.225 a	0.071 a
SE(±)	0.064	0.008	0.008	0.008
Fertilizer & manure				
T_0	1.023 d	0.167 b	0.131 d	0.050 b
T_1	1.405 b	0.256 b	0.239 bc	0.073 a
T_2	1.248 c	0.249 a	0.227 c	0.065 a
T_3	1.434 b	0.268 a	0.247 ab	0.076 a
T_4	1.536 a	0.279 a	0.252 a	0.077 a
SE(±)	0.102	0.012	0.012	0.012

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

S_1: SAU soil
S_2: Shingair soil

T_0: Control condition
T_1: Recommended dose of fertilizer ($N_{120}P_{25}K_{60}S_{20}Zn_2$)
T_2: 50% NPKSZn + 5 ton cow dung ha^{-1}
T_3: 50% NPKSZn + 5 ton compost ha^{-1}
T_4: 50% NPKSZn + 3.5 ton poultry manure ha^{-1}

Table 7. Interaction effect of soil from different locations and fertilizer & manure on N, P, K and S concentrations in grain of BRRI dhan33

Treatment	Concentration (%) in grain			
	N	P	K	S
S_1T_0	1.007 e	0.164 d	0.126 d	0.048 c
S_1T_1	1.410 bc	0.254 bc	0.246 ab	0.076 a
S_1T_2	1.301 bcd	0.244 c	0.207 c	0.054 bc
S_1T_3	1.261 cd	0.258 bc	0.247 ab	0.076 a
S_1T_4	1.422 b	0.271 ab	0.242 b	0.074 a
S_2T_0	1.039 e	0.169 d	0.136 d	0.052 c
S_2T_1	1.401 bc	0.259 bc	0.232 b	0.070 ab
S_2T_2	1.195 d	0.254 bc	0.248 ab	0.076 a
S_2T_3	1.606 a	0.278 a	0.248 ab	0.076 a
S_2T_4	1.651 a	0.286 a	0.262 a	0.081 a
SE(±)	0.144	0.017	0.017	0.017

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

S_1: SAU soil

S_2: Shingair soil

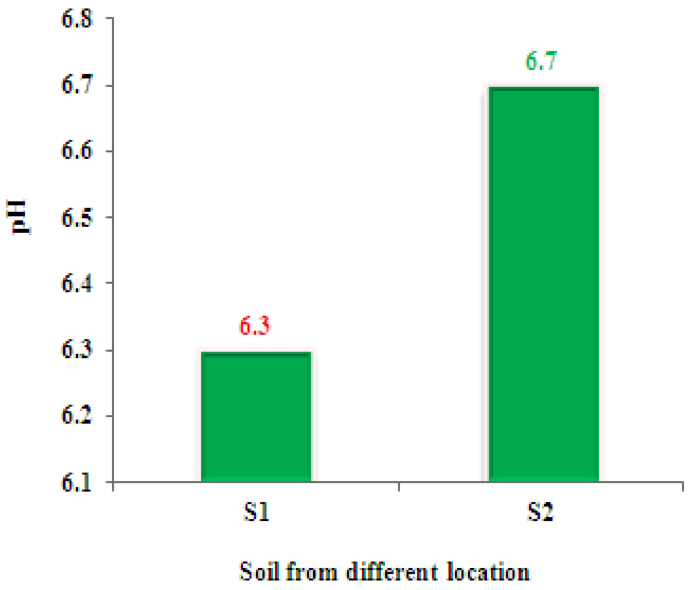
T_0: Control condition

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

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

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

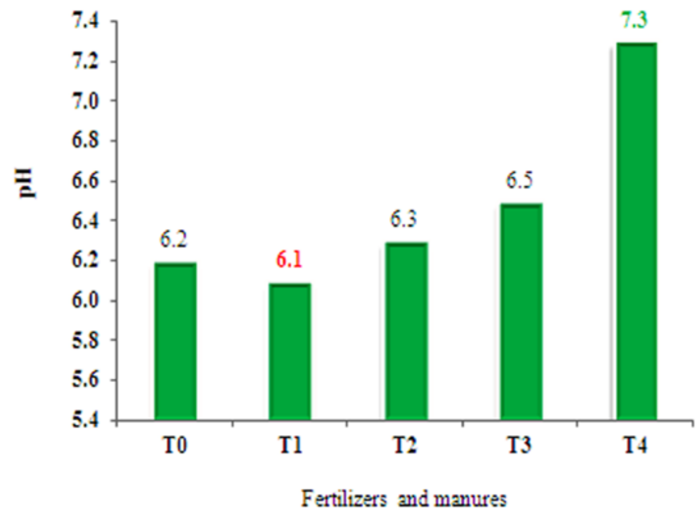
T_4: 50% NPKSZn + 3.5 ton poultry manure ha^{-1}



S_1: SAU soil

S_2: Shingair soil

Figure 1. Effect of soil from different locations on pH of post harvest soil of BRRI dhan33.



T_0: Control condition, T_1: Recommended dose of fertilize ($N_{120}P_{25}K_{60}S_{20}Zn_2$)

T_2: 50% NPKSZn + 5 ton cow dung ha^{-1} T_3: 50% NPKSZn + 5 ton compost ha^{-1}

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

Figure 2. Effect of different fertilizers and manures on pH in post harvest soil of BRRI dhan33.

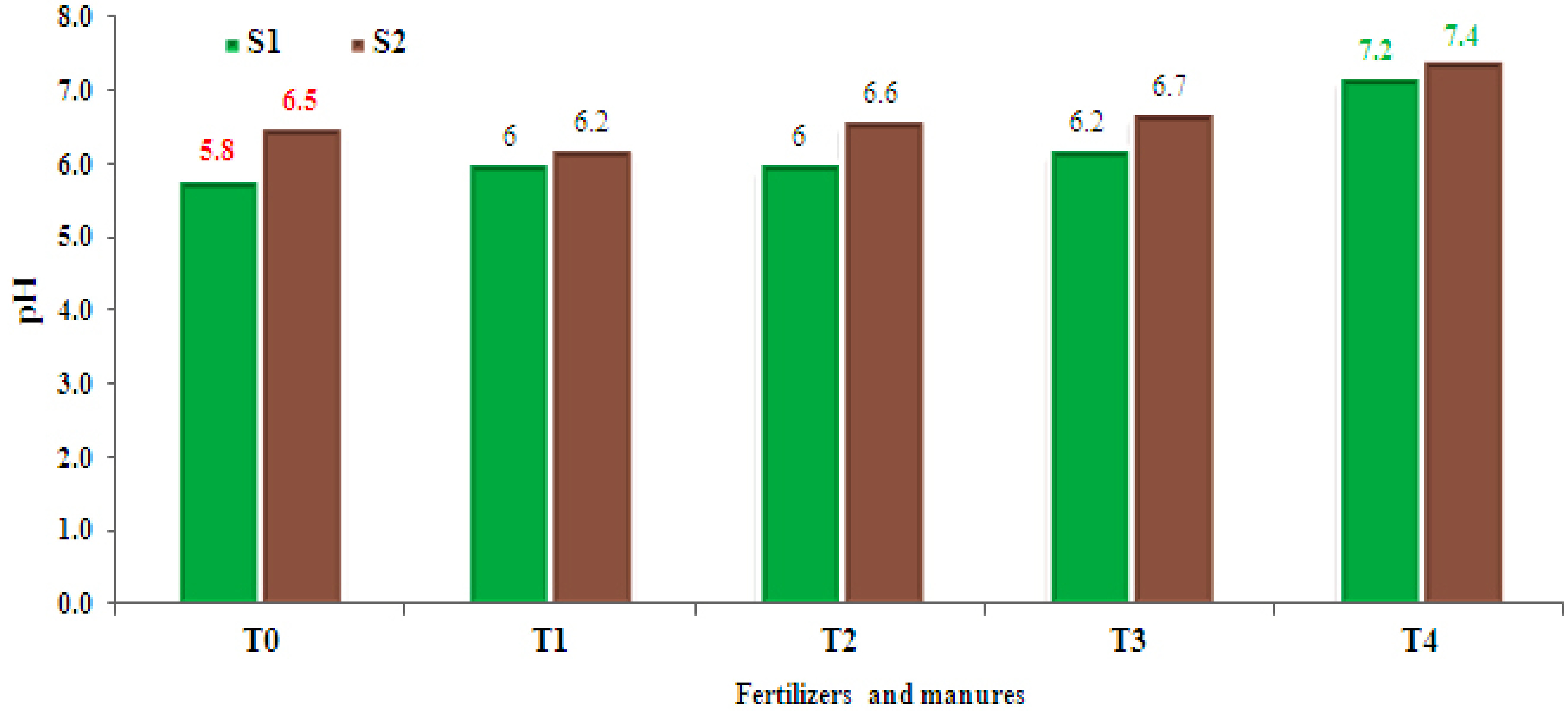
Interaction effect of soil from different location and levels of fertilizers & manures showed significant variation on pH (Figure 3). The highest pH (7.4) was found from S_2T_4 and the lowest pH (5.8) was recorded from S_1T_0.

4.3.2 Organic matter

Statistically significant variation was found for organic matter in post harvest soil of BRRI dhan33 due to soil from different location (Figure 4). The highest organic matter (2.45%) was found from S_2, while the lowest (1.30%) was recorded from S_1. Sharma and Mitra (1991) reported a significant increase in N, P and K content and also the nutritional status of soil with 5 t ha^{-1} of FYM of rice based cropping system.

Organic matter in post harvest soil of BRRI dhan33 varied significantly for different levels of fertilizers & manures (Figure 5). The highest organic matter (2.11%) was observed from T_2, which was statistically identical (1.98%) with T_4 and closely followed (1.89%) by T_3, whereas the lowest organic matter (1.61%) was found from T_0. Rahman (2001) reported that the integrated use of fertilizers with manure (viz. cowdung) could be an efficient practice for ensuring higher crop yields without degradation of soil fertility. Farid *et al*. (1998) incorporation of compost or rice straw and subsequent decomposition increased and maintained organic matter level at 2.5% that was higher than that in traditionally managed rice soil.

Interaction effect of soil from different location and levels of fertilizers & manures showed significant variation on organic matter (Figure 6). The highest organic matter (2.56%) was observed from S_2T_2 and the lowest organic matter (0.99%) was recorded from S_1T_0. The organic matter content in post harvest soil increased more in the SAU soil in comparison to Shingair soil. The higher increase of organic matter level was observed in the organic plus inorganic fertilizer treatments. The application of cowdung performed better for increasing the level of organic matter in comparision to poultry manure and compost.



S_1: SAU soil

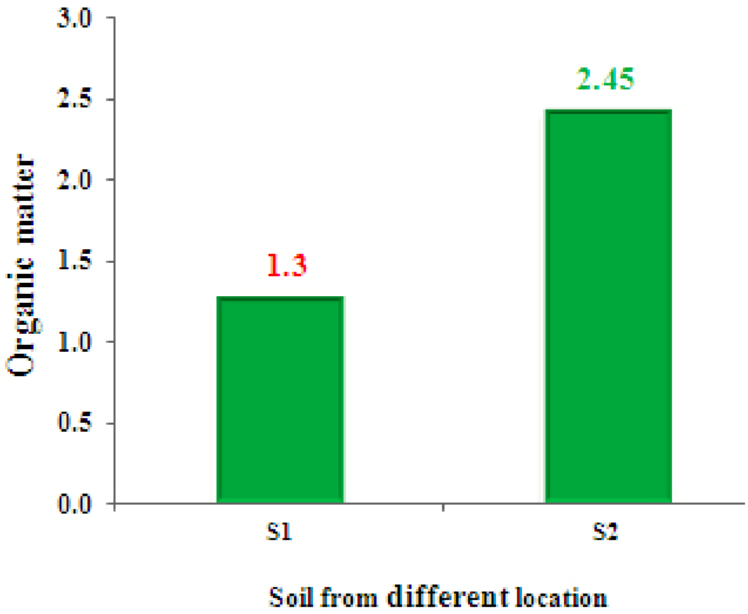
S_2: Shingair soil

T_0: Control condition, T_1: Recommended dose of fertilizer ($N_{120}P_{25}K_{60}S_{20}Zn_2$)

T_2: 50% NPKSZn + 5 ton cow dung ha^{-1} T_3: 50% NPKSZn + 5 ton compost ha^{-1}

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

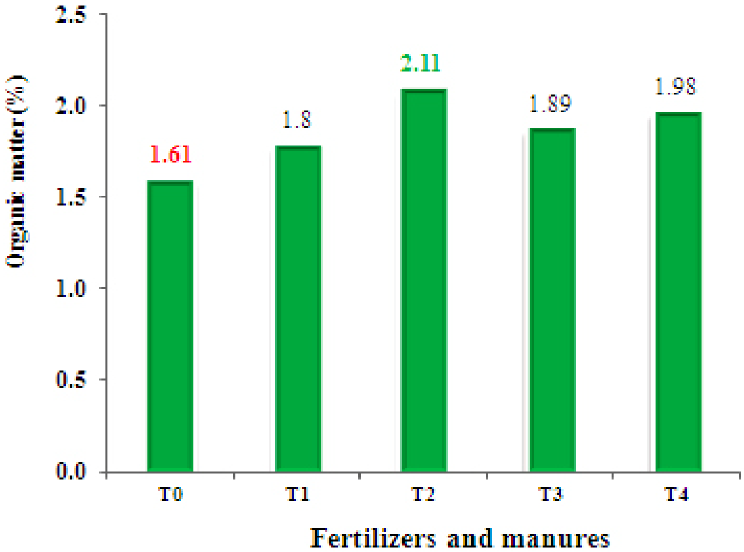
Figure 3. Interaction effect of soil from different location and different fertilizers and manures on pH in post harvest soil of BRRI dhan33.



S_1: SAU soil

S_2: Shingair soil

Figure 4. Effect of soil from different locations on organic matter content in post harvest soil of BRRI dhan33.

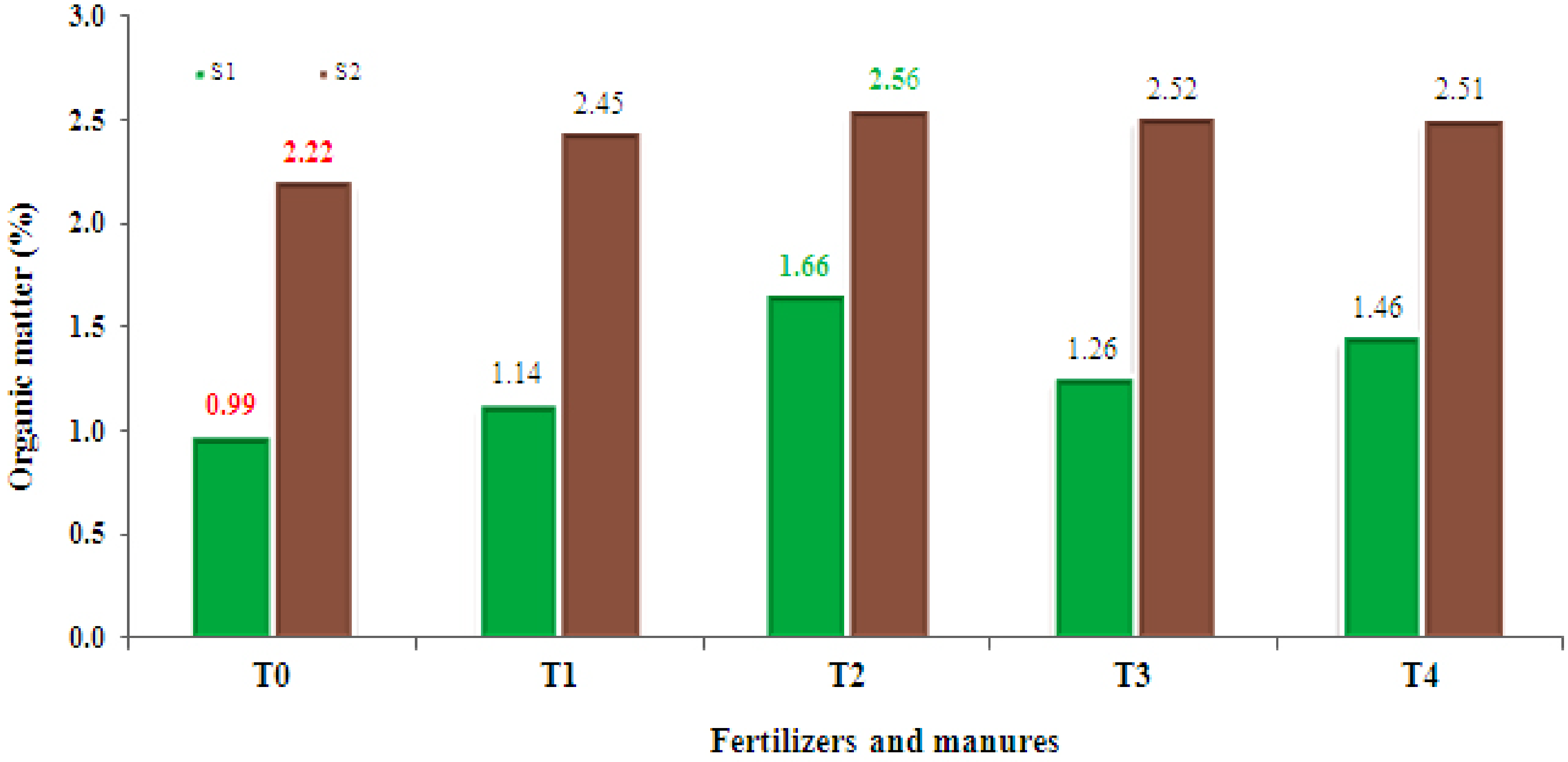


T_0: Control condition T_1: Recommended dose of fertilizer ($N_{120}P_{25}K_{40}S_{20}Zn_2$)

T_2: 50% NPKSZn + 5 ton cow dung ha^{-1} T_3: 50% NPKSZn + 5 ton compost ha^{-1}

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

Figure 5. Effect of different fertilizers and manures on organic matter content in post harvest soil of BRRI dhan33.



S_1: SAU soil

S_2: Shingair soil

T_0: Control condition T_1: Recommended dose of fertilizer ($N_{120}P_{25}K_{40}S_{20}Zn_2$)

T_2: 50% NPKSZn + 5 ton cow dung ha^{-1} T_3: 50% NPKSZn + 5 ton compost ha^{-1}

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

Figure 6. Interaction effect of soil from different location and different fertilizers and manures on organic matter content in post harvest soil of BRRI dhan33.

4.3.3 Total nitrogen

Statistically significant variation was found for total nitrogen in post harvest soil of BRRI dhan33 due to soil from different location (Table 8). The highest total nitrogen (0.087%) was attained from S_2, while the lowest (0.072%) was recorded from S_1.

Total nitrogen in post harvest soil of BRRI dhan33 varied significantly for different levels of fertilizers & manures (Table 8). The highest total nitrogen (0.101%) was observed from T_4, which was statistically identical (0.090%) with T_3 and closely followed (0.079%) by T_1, whereas the lowest total nitrogen (0.060%) was observed from T_0 which was statistically similar (0.066%) with T_2.

Interaction effect of soil from different location and levels of fertilizers & manures showed significant variation on total nitrogen (Table 9). The highest total nitrogen (0.115%) was found from S_2T_4 and the lowest total nitrogen (0.051%) was recorded from S_1T_0.

4.3.4 Available P

Statistically significant variation was found for available P in post experiment soil collected from different location (Table 8). The highest available P (8.91 ppm) was found from S_1 and the lowest (6.46 ppm) from S_2.

Available P in post harvest soil of BRRI dhan33 varied significantly for different levels of fertilizers & manures (Table 8). The highest available P (11.67 ppm) was observed from T_4, while the lowest available P (6.32 ppm) was found from T_1 which was which was statistically similar (6.66 ppm, 6.86 ppm and 6.93 ppm) with T_1, T_2 and T_3.

Interaction effect of soil from different location and levels of fertilizers & manures showed non-significant variation on available P (Table 9). The highest available P (12.96 ppm) was observed from S_1T_4, while the lowest available P (5.51 ppm) was recorded from S_2T_0.

Table 8. Effect of soil from different locations and fertilizer & manure on total N, available P, exchangeable K and available S BRRI dhan33

Treatment	Total N (%)	Available P (ppm)	Exchangeable K (me %)	Available S (ppm)
Soil from different locations				
S_1	0.072 b	8.91 a	0.034	8.11 b
S_2	0.087 a	6.46 b	0.041	9.67 a
SE(±)	0.008	0.23	0.001	0.775
Fertilizer & manure				
T_0	0.060 c	6.66 b	0.029 d	6.09 c
T_1	0.079 b	6.32 b	0.045 a	9.57 ab
T_2	0.070 b	6.86 b	0.035 b	8.51 b
T_3	0.090 ab	6.93 b	0.032 c	9.68 ab
T_4	0.101 a	11.67 a	0.030d	10.58 a
SE(±)	0.012	0.37	0.002	1.226

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

S_1: SAU soil
S_2: Shingair soil

T_0: Control condition
T_1: Recommended dose of fertilizer ($N_{120}P_{25}K_{60}S_{20}Zn_2$)
T_2: 50% NPKSZn + 5 ton cow dung ha^{-1}
T_3: 50% NPKSZn + 5 ton compost ha^{-1}
T_4: 50% NPKSZn + 3.5 ton poultry manure ha^{-1}

Table 9. Interaction effect of soil from different locations and fertilizer & manure on total N, available P, exchangeable K and available S of BRRI dhan33

Treatment	Total N (%)	Available P (ppm)	Exchangeable K (me %)	Available S (ppm)
S_1T_0	0.051 d	7.81	0.026	5.22 c
S_1T_1	0.078 bc	7.06	0.043	10.17 ab
S_1T_2	0.076 c	8.83	0.030	6.60 c
S_1T_3	0.085 bc	7.89	0.030	9.01 b
S_1T_4	0.088 bc	12.96	0.027	9.54 b
S_2T_0	0.069 cd	5.51	0.032	6.96 c
S_2T_1	0.079 bc	5.58	0.047	8.98 b
S_2T_2	0.085 bc	5.89	0.040	10.43 ab
S_2T_3	0.096 b	5.96	0.033	10.35 ab
S_2T_4	0.115 a	10.38	0.033	11.62 a
SE(±)	0.017	NS	NS	1.733

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

S_1: SAU soil

S_2: Shingair soil

T_0: Control condition

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

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

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

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

4.3.5 Available K

Statistically significant variation was found for available K in post harvest soil of BRRI dhan33 due to soil from different location (Table 8). The highest available K (0.041 me/100 g soil) was recorded from S_2, while the lowest (0.034 me/100 g soil) was observed from S_1.

Available K in post harvest soil of BRRI dhan33 varied significantly for different levels of fertilizers & manures (Table 8). The highest available K (0.045 me/100 g soil) was found from T_1, which was closely followed (0.035 me/100 g soil) by T_2, whereas the lowest available K (0.029 me/100 g soil) was recorded from T_4 which was followed (0.030 me/100 g soil) by T_4.

Interaction effect of soil from different location and levels of fertilizers & manures showed non-significant variation on available K (Table 9). The highest available K (0.047 me/100 g soil) was found from S_2T_1 and the lowest available K (0.026 me/100 g soil) was recorded from S_1T_0.

4.3.6 Available sulphur

Statistically significant variation was found for available S in post harvest soil of BRRI dhan33 due to soil from different location (Table 8). The highest available S (9.67 ppm) was found from S_2, whereas the lowest (8.11 ppm) from S_1.

Available S in post harvest soil of BRRI dhan33 varied significantly for different levels of fertilizers & manures (Table 8). The highest available S (10.58 ppm) was recorded from T_4, which was statistically similar (9.68 ppm and 9.57 ppm) with T_3 and T_1, while the lowest available S (6.09 ppm) was found from T_0 which was followed (8.51 ppm) by T_2.

Interaction effect of soil from different location and levels of fertilizers & manures showed significant variation on available S (Table 9). The highest available S (11.62 ppm) was recorded from S_2T_4 and the lowest available S (5.22 ppm) was recorded from S_1T_0.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the experimental area of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from June to November 2013 in aman season to find out effect of fertilizer and manure to the change of nutrient availability and yield of T. Aman rice in different soil. BRRI dhan33 was used as the test crop in this experiment. The experiment comprised of two factors- Factors A: Soils from different location (soil from 2 locations), S_1: SAU soil, S_2: Shingair soil (collected from Shingair Manikgonj) an Factor B: Levels of fertilizers and manures (5 levels)- T_0: Control condition i.e. no fertilizers and manures; T_1: Recommended dose of fertilizer ($N_{120}P_{25}K_{60}S_{20}Zn_2$), T_2: 50% NPKSZn + 5 ton cow dung ha^{-1}, T_3: 50% NPKSZn + 5 ton compost ha^{-1} andT_4: 50% NPKSZn + 3.5 ton poultry manure ha^{-1}. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Data were recorded on different growth, yield parameters, yield nutrient concentration in grain and straw and nutrient status of post harvest soil and significant variation was observed for different treatment and their interaction effect.

In case soil from different location, at harvest, the tallest plant (102.7 cm) was found from S_2, while the shortest plant (100.3 cm) was recorded from S_1. The maximum number of effective tillers $hill^{-1}$ (28.87) was obtained from S_2, whereas the minimum number (24.13) was found from S_1. The longest panicle (24.59 cm) was found from S_2 and the shortest panicle (24.28 cm) was observed from S_1. The maximum number of filled grains $panicle^{-1}$ (155.3) was observed from S_2, while the minimum number (138.9) was recorded from S_1. The highest weight of 1000-grains (20.77 g) was recorded from S_2, whereas the lowest weight (20.53 g) was recorded from S_1. The highest grain yield (101.13 g pot^{-1}) was recorded from S_2 and the lowest grain yield (76.21 g pot^{-1}) from S_1. The highest straw yield (83.53 g pot^{-1}) was found from S_2, while the lowest (70.83 g pot^{-1}) from S_1.

The highest N, P, K and S concentration in grain (1.378%, 0.249%, 0.225% and 0.071%, respectively) was recorded from S_2, whereas the lowest N, P, K and S concentration in grain (1.280%, 0.238%, 0.213% and 0.066%, respectively) was found from S_1. The highest pH (6.7) was observed from S_2, while the lowest pH (6.3) was recorded from S_1. The highest organic matter (2.45%) was found from S_2, while the lowest (1.30%) was recorded from S_1. The highest total nitrogen (0.087%) was attained from S_2, while the lowest (0.072%) was recorded from S_1. The highest available P (22.17 ppm) was found from S_2 and the lowest (18.11 ppm) was recorded from S_1. The highest available P (8.91 ppm) was found from S_1 and the lowest (6.46 ppm) from S_2. The highest available K (0.041 me/100 g soil) was recorded from S_2, while the lowest (0.034 me/100 g soil) was observed from S_1. The highest available S (9.67 ppm) was found from S_2, whereas the lowest (8.11 ppm) from S_1.

For different fertilizers and manure, at harvest, the tallest plant (105.9 cm) was observed from T_3, whereas the shortest plant (92.0 cm) was found from T_0. The maximum number of effective tillers hill^{-1} (32.8) was recorded from T_4, while the minimum number (13.0) was observed from T_0. The longest panicle (25.79 cm) was observed from T_3 and the shortest panicle (21.97 cm) was found from T_0.The maximum number of filled grains panicle^{-1} (165.0) was found from T_4, whereas the minimum number (111.5) was obtained from T_0. The highest weight of 1000-grains (21.25 g) was found from T_4, and, the lowest weight (19.75 g) was found from T_0. The highest grain yield (123.65 g pot^{-1}) was found from T_4, while the lowest grain yield (33.70 g pot^{-1}) was obtained from T_0. The highest straw yield (101.35 g pot^{-1}) was observed from T_4, whereas the lowest straw yield (34.62 g pot^{-1}) was found from T_0.

The highest N, P, K and S concentration in grain (1.536%, 0.279%, 0.252% and 0.077%, respectively) was recorded from T_4, while the lowest N, P, K and S concentration in grain (1.023%, 0.167%, 0.131% and 0.050%, respectively) was observed from T_0. The highest pH (7.3) was found from T_4 and the lowest pH (6.1) was recorded from T_1. The highest organic matter (2.11%) was observed from T_2, whereas the lowest organic matter (1.61%) was found from T_0. The highest total nitrogen (0.101%) was observed from T_4, whereas the lowest total nitrogen (0.060%) was observed from T_0. The highest available P (11.67 ppm) was observed from T_4, while the lowest available P (6.32 ppm) was found from T_0. The highest available K (0.045 me/100 g soil) was found from T_1, whereas the lowest available K (0.029 me/100 g soil) was recorded from T_4. The highest available S (10.58 ppm) was recorded from T_4, while the lowest available S (6.09 ppm) was found from T_0.

Due to the interaction of soil from different location and fertilizers and manure, at harvest, the tallest plant (106.7 cm) was observed from S_2T_2 and the shortest plant (89.8 cm) was recorded from S_1T_0. The maximum number of effective tillers hill^{-1} (35.33) was recorded from S_2T_4 and the minimum number (12.67) was found from S_1T_0. The longest panicle (25.91 cm) was found from S_2T_3, while the shortest panicle (21.66 cm) was observed from S_1T_0. The maximum number of filled grains panicle^{-1} (174.1) was observed from S_2T_2 and the minimum number (99.5) was recorded from S_1T_0. The highest weight of 1000-grains (21.33 g) was obtained from S_2T_4 and the lowest weight (19.67 g) was found from S_2T_0. The highest grain yield (134.97 g pot^{-1}) was found from S_2T_4, whereas the lowest grain yield (32.03 g pot^{-1}) was recorded from S_1T_0. The highest straw yield (110.07 g pot^{-1}) was observed from S_2T_4 and the lowest straw yield (32.93 g pot^{-1}) was recorded from S_1T_0.

The highest N, P, K and S concentration in grain (1.651%, 0.286%, 0.262% and 0.081%, respectively) was recorded from S_2T_4 and the lowest N, P, K and S concentration in grain (1.007%, 0.164%, 0.126% and 0.048%, respectively) was found from S_1T_0. The highest pH (7.4) was found from S_2T_4 and the lowest pH (5.8) was recorded from S_1T_0. The highest organic matter (2.56%) was observed from S_2T_2 and the lowest organic matter (1.14%) was recorded from S_1T_0. The highest total nitrogen (0.115%) was found from S_2T_4 and the lowest total nitrogen (0.051%) was recorded from S_1T_0. The highest available P (12.96 ppm) was observed from S_1T_4, while the lowest available P (5.51 ppm) was recorded from

S_2T_2. The highest available K (0.047 me/100 g soil) was found from S_2T_1 and the lowest available K (0.026 me/100 g soil) was recorded from S_1T_0. The highest available S (11.62 ppm) was recorded from S_2T_4 and the lowest available S (5.22 ppm) was recorded from S_1T_0.

Conclusion

It may be concluded that Shingair soil and 50% NPKSZn + 3.5 ton poultry manure ha^{-1} performed better in relation to yield contributing characters and yield of BRRI dhan33. The application of inorganic fertilizer plus manure improved the chemical properties and nutrient level of post experiment soil. The level of organic matter was more increased in the lower organic matter containing post experiment soil of SAU by applying organic plus inorganic fertilizer treatments.

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APPENDICES

Appendix I. Monthly record of air temperature, relative humidity, rainfall, and sunshine (average) of the experimental site during the period from June to November 2013

Month (2013)	Air temperature (^{0}c)		Relative humidity (%)	Rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
June	35.7	23.2	78	312	5.4
July	36.0	24.6	83	563	5.1
August	36.0	23.6	81	319	5.0
September	34.8	24.4	81	279	4.4
October	26.5	19.4	81	22	6.9
November	25.8	16.0	78	00	6.8

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