EFFECT OF FERTILIZER AND MANURE WITH LIME ON THE CHANGE OF pH AND NUTRIENT AVAILABILITY AND YIELD OF T. AMAN RICE IN TWO ACIDIC SOIL

ABDUR RAHMAN

DEPARTMENT OF SOIL SCIENCE
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

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ABDUR RAHMAN

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APPROVED BY:

Prof. Dr. Md. Asaduzzaman Khan
Supervisor
Department of Soil science
Sher-E-Bangla Agricultural University
Dhaka-1207

Prof. A.T.M. Shamsuddoha
Co-supervisor
Department of Soil science
Sher-E-Bangla Agricultural University
Dhaka-1207

Dr. Mohammad Issak
Chairman
Examination Committee
Department of Soil science
Sher-E-Bangla Agricultural University
Dhaka-1207

DEPARTMENT OF SOIL SCIENCE
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

This is to certify that the thesis entitled **‘Effect of Fertilizer and Manure with Lime on the Change of pH and Nutrient Availability and Yield of T. Aman Rice in two acidic Soil’** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science** in **Soil Science**, embodies the result of a piece of bonfire research work carried out by **Abdur Rahman**, Registration number: **06-01920** 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
Department of Soil Science
Sher-e-Bangla Agricultural University
Dhaka-1207

DEDICATED
TO MY
BELOVED PARENTS

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The Author

EFFECT OF FERTILIZER AND MANURE WITH LIME ON THE CHANGE OF pH AND NUTRIENT AVAILABILITY AND YIELD OF T. AMAN RICE IN TWO ACIDIC SOIL

ABSTRACT

The experiment was conducted on the net house at Soil Science Department of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from June to November 2014 in aman season to find out the effect of fertilizer, manure and lime 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 2 locations, S_1: Bhatgaon, S_2: Goari (collected from village Bhatgaon and Goari of Upazilla Bhaluka, Mymensingh) and Factor B: Different levels of fertilizers, manures and lime (9 levels)- T_0: Control condition i.e. no fertilizers and manures; T_1: $N_{150}P_{30}K_{70}S_{20}Zn_3$ (Recommended dose of chemical fertilizer), T_2: $N_{150}P_{30}K_{70}S_{20}Zn_3$ (RDCF)+ 1.0 g dolomite kg^{-1} soil, T_3: 50% NPKS + 5 ton cowdung ha^{-1} T_4: 50% NPKS + 5 ton cowdung ha^{-1} + 1.0 g dolomite kg^{-1}, T_5: 50% NPKS + 5 ton compost ha^{-1}, T_6: 50% NPKS + 5 ton compost ha^{-1} + 1.0 g dolomite kg^{-1}, T_7: 50% NPKS + 3.5 ton poultry manure ha^{-1} and T_8: 50% NPKS + 3.5 ton poultry manure ha^{-1}+ 1.0 g dolomite kg^{-1} soil. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Data were recorded on yield parameters, nutrient concentration in grain and straw, pore water and nutrient status of postharvest soil. Significant variation was observed for different treatment and their interaction effect. In case soil from different location, the highest grain yield pot^{-1} (58.71 g) was recorded from S_1 and the lowest grain yield pot^{-1} (48. 37 g) from S_2. The highest pore-water P (1.11 ppm) was found from S_2, while the lowest (0.95 ppm) from S_1. The highest N, P and K concentration in grain (1.08%, 0.240% and 0.193 %, respectively) was recorded from S_1, whereas the lowest (0.937%, 0.220% and 0.182%), respectively) was found from S_2. The highest organic matter (1.106%) was found from S_1, while the lowest (1.077%) from S_2. The highest pH (6.28) was observed from S_2, while the lowest pH (6.18) was recorded from S_1. The highest available P and K (24.12 ppm and 0.119 me 100 g $soil^{-1}$) was found from S_1. The highest total nitrogen (0.116%) was reported from S_2, while the lowest (0.113%) from S_1. For different fertilizers, manure & lime, the highest grain yield pot^{-1} (77.92 g) was found from T_8 while the lowest (4.18 g) from T_0. The highest pore-water P and K concentration (1.213 ppm and 2.50 ppm) was found in T_8 and T_2. The highest N, P, and K concentration in grain (1.124%, 0.263% and 0.212%) was recorded from (T_8, T_7 and T_6, respectively) while the lowest from T_0. The highest pH (6.53) was found from T_6 and the lowest pH (5.55) from T_0. The organic matter, available P, available K and total N in soil increased with (T_2, T_4, T_6 and $T_{8,}$ respectively) the application of fertilizers, manure & lime. Due to the interactive effect of soil with different levels of fertilizers, manures & lime, the highest grain yield pot^{-1} (79.40 g) was found from S_2T_8, whereas the lowest (3.67 g) was from S_1T_0. The highest N, P, and K concentration in grain (1.171%, 0.287% and 0.232%) was found from S_1T_8, S_1T_7 and S_1T_2, respectively, whereas the lowest (0.812%, 0.161% and 0.167%) from S_2T_0, S_2T_1 and S_1T_0. The highest pH (6.68) was found from S_2T_4 and the lowest pH (5.51) was recorded from S_2T_0. The organic matter, available P and total N in soil increased with the application of soil and fertilizers, manure & lime. Goari soil and 50% NPKS + 3.5 ton poultry manure ha^{-1}+ 1.0 g dolomite kg^{-1} performed better in relation to yield contributing characters and yield of BRRI dhan33. The level of pH was more increased in the post experiment soil by Goari with 50% NPKS + 5 ton cowdung ha^{-1} + 1.0 g dolomite kg^{-1} treatments. The level organic matter, available P and total N and K increased though application of inorganic fertilizers plus manure & lime soil.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

Agriculture in Bangladesh is predominantly rice based and Bangladesh is the fourth rice producing country in the world. Bangladesh lacks arable land to extend rice production. Besides, rice production is decreasing day by day due to high population pressure, continuing drought and flood in farming areas, and conversion of farmlands to grow cash crops instead of rice. Therefore, it is an urgent need of the time to increase rice yield in Bangladesh.

Rice is grown in three seasons namely Aus (mid-March to mid-August), Aman (mid-June to November) and Boro (Mid December to mid-June). The largest part of the total production of rice comes from Aman rice. Transplanted (T.) aman rice covers about 50.92% of the rice areas of Bangladesh of which modern T. aman varieties covers 60% (BBS, 2005). The second largest part of the total production of rice comes of Aman rice after Boro. Bangladesh earns about 19.0% of her gross domestic product (GDP) from agriculture (BBS, 2008) in which rice is the main crop. Agriculture in Bangladesh is characterized by intensive crop production with rice based cropping systems. Rice is also the principal commodity of trade in our internal agricultural business.

The depleted soil fertility is a major constraint to higher crop production in Bangladesh. The increasing land use intensity has resulted in a great exhaustion of nutrients in soils. The farmers of this country use on an average 102 kg nutrients/ha annually (70 kg N + 24 kg P + 6 kg K + 2 kg S and Zn) while the crop removal is about 200 kg/ha (Islam *et al.* 1994). In Bangladesh, most of the cultivated soils have less than 1.5% organic matter while a good agricultural soil should contain at least 2% organic matter. Moreover, this important component of soil is declining with time due to intensive cropping and use of higher dose of chemical fertilizers with little or no addition of organic manure in the farmer's field. Rice-rice system is the most important cropping system in Bangladesh. Continuous cultivation of this highly exhaustive cropping sequence in most of the irrigated fertile lands has resulted in the decline of soil physico-chemical condition in general and particularly soil organic matter (SOM) content. This has led to a reduction in the total factor productivity and raised questions on the sustainability of this cropping system. This implies increased use organic manures and of fertilizers, optimum adoption of pest management strategies and shifting from mono-to double-and triple cropping on the same piece of land year after year.

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

Rice grown in acidic soils pH<4.0 commonly encounter relatively severe mineral stresses. The H^+ associated with soil acidity has indirect effects on mineral elements in low pH soils so that deficiencies of P, Ca, Mg, K, and Zn and toxicities of Al and Mn commonly appear (Clark *et al.* 1999). Of the deficiencies/toxicities that plants may encounter when grown in acidic soil, Al toxicity is considered to be the major disorder (Foy, 1992). Aluminium is highly soluble at low pH and is toxic to plants at relatively low concentrations. It also interacts with other mineral nutrients essential to plant growth, especially P, Ca, and Mg, so that these essential nutrients often become more limiting. Not only is excess Al damaging to root growth and development (Foy, 1992), but Al as well as Fe oxides so prevalent in acidic soils (Manning and Goldberg, 1996) adsorb P and make it unavailable to plants. Poor fertility of acid soils is due to a combination of mineral toxicities (aluminum and manganese) and deficiencies (phosphorus, calcium, magnesium, and molybdenum). However, Al toxicity is the single most important factor, being a major constraint for crop production on 67% of the total acid soil area (Eswaran *et al.* 1997). In the tropical Africa and Asia most of the available land for rice expansion is that of acid sulphate soils. (Masulili and Utomo, 2010) reports that, these soils have a high iron sulfate mineral content of predominantly pyrite, and when the soil is drained it will release sulfuric acid, which in turn release Fe, Al, and other heavy metals that are dangerous for plants and other living organisms. Moormann (1961) found that when these soils are used for rice the most important constraints were: (i) acidity (which includes the combined effects of pH, Al toxicity, and P deficiency), and (ii) Fe stress (which is due to the combined effects of Fe toxicity and deficiencies of other divalent cation such as Ca). According to Shamshuddin (2010) when mismanaged acid sulfate soils can severely degrade the quality of coastal water via acidification, de-oxygenation, and metal toxicity. A commonly treatment to reduce the solubility of Al, Fe and other heavy metals in soil is to increase the soil pH. Acidity and Al toxicity in surface soil can be ameliorated through liming. A liming material is defined as a material whose Ca and Mg compounds are capable of neutralizing soil acidity (Barber and Adams, 1984). The bulk of agricultural lime comes from ground limestone, and can be calcite ($CaCO_3$), dolomite ($CaCO_3$, $MgCO_3$), or a mixture of the two. Other materials are used to neutralize soil acidity, including marl, slag from iron and steel making, flue dust from cement plants, and refuse from sugar beet factories, paper mills, calcium carbide plants, rock wool plants, and water softening plants (Thomas and Hargrove, 1984). However, total use of these materials is relatively small, and they are generally applied only in areas close to their source.

Therefore, the present research work has been undertaken with the following objectives:

i) To know the effects of acidic soil, fertilizers, manures and lime on the yield and quality of rice.

ii) To investigate the effects of fertilizer, manure and lime on the availability of N, P and K in pore-water of acidic paddy soils.

iii) To know the effect of fertilizer, manure and lime on the change of soil pH, OM and nutrient availability in acidic red soils.

CHAPTER II

REVIEW OF LITERATURE

The integrated use of inorganic fertilizer, organic manure with lime is the essential factor for sustainable soil fertility and crop productivity. Sole and combined use of inorganic fertilizer and cowdung, compost, poultry manure & lime increases plant growth and yield contributing characters. Experimental evidences that the use of nitrogen, phosphorus, potassium, sulphur and zinc with cowdung, compost, poultry manure & lime 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

Among 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.

Dwibedi (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. Geethadevi *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}.

Munnojan *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^{-1}. 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.

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 hadno 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.

2.3 Effect of lime

An experiment was conducted by Ayodele and Shittu during (2014) on the appropriate management practices with which to obtain high crop yields in these soils, characterized by high acidity, nutrient deficiencies and imbalances, should be developed. Surface layer (0-15 cm) samples of soils with extreme acidity (pH 4.0-4.6) formed on Coastal Plain Sands were collected from four locations in southern Nigeria and grown to maize (SUWAN 1-SR-Y) in pots for two cycles of six weeks each to measure the direct and residual effects of applied fertilizer (90 kg N+ 36 kg P+ 60 kg K.ha-1), 2.5 MT.ha-1 lime, 10 MT.ha-1 farm yard manure (FYM) compared to a control. The direct effect of FYM produced the highest dry matter yield while fertilizer and lime did not differ significantly from the control. The residual effects were significant in dry matter yield for FYM in all the soils and for lime in three soils. Lime and FYM increased soil pH and exchangeable bases, reduced iron, manganese and aluminium; fertilizer and FYM raised available P while only FYM increased soil organic matter contents. Application of lime, fertilizer and FYM in all possible combinations compared to the control in one soil showed that FYM + Fertilizer gave the highest maize dry matter yield, improved soil characteristics and would be the recommended nutrient management practice for these acid soils.

A study was done by Sadiq and Babagana during (2012) to review the importance of lime application to ameliorate acidity on paddy field. Emphasis is placed on acid sulfate commonly found in Southeast Asia and other related areas to which reference could be found. Most of the authors show that in acid sulfate soils, high content of Al caused adverse effect to rice growth. Application of lime precipitates Al and Fe in the soil and result in higher rice yield. The paper specifically covers the extent and types of acid sulfate soils, amelioration using lime and other combinations in rice cultivation and management.

A study was conducted by Azman et al. (2014) with the objective of increasing rice yields on these soils under rain-fed condition in Merbok, Kedah, Malaysia, using various lime sources. The acid sulphate soil was treated with ground magnesium limestone (GML), hydrated lime and liquid lime at specified rates. Paddy variety MR 219 was tested in a field experiment as this variety is the most common variety grown in Malaysia. Prior to treatments, the pH of water sample in the rice field was 3.7, while Al concentration was 878 µM. Thus, rice plants grown under these conditions would suffer from H^+ and Al^{3+} stress without amelioration, thus retard and/or minimize rice growth and yield. In the first season (1_{st} season) rice plants were affected by drought during the vegetative period, while in the subsequent season (2_{nd} season), they were infested with rice blast fungus (*Magnaporthe grisea*). In spite of that, however, the rice yield was 3.5 t ha^{-1} based on the application of 4 t GML ha^{-1}, which was almost equivalent to the average national yield of 3.8 t ha^{-1}. As a result, it was noted that the ameliorative effects of lime application in the 1_{st} season had continued to the 2_{nd} season. Liming at 4 t GML ha^{-1} incurs high cost to the farmers. However, the yield obtained is worth the effort and cost.

Fresh cattle manure and agricultural lime were compared for their effects on soil acidity and the production of canola (*Brassica napus* L.) and wheat (*Triticum aestivum* L.) in a greenhouse study by Whalen, during (2002). Canola and wheat yield, the nutrient content of grain and straw, and selected soil properties were determined on a Gray Luvisol (pH 4.8) from the Peace Region of Alberta. Soil pH increased with lime and manure applications, and canola and wheat yields were higher in limed and manureamended soils than unfertilized, unlimed soils. Macronutrient uptake by canola and wheat was generally improved by liming and manure applications, and micronutrient uptake was related to the effects of lime and manure on soil pH. An economic analysis compared the costs of using cattle manure and lime to increase soil pH to 6.0. The costs of applying lime and fresh cattle manure to increase soil pH were compared, based on the fees for purchasing and applying lime or loading, hauling and applying manure.

The nutrient value of manure was calculated based on the quantities of plant-available N, P and K in fresh manure. At distances less than 40 km, it is economical to substitute fresh cattle manure for agricultural lime to increase soil pH of acidic soils. However, good manure management practices should be followed to minimize the risk of nutrient transport and environmental pollution from agricultural land amended with cattle manure.

An experiment was conducted by Shaha et al. during (2012) to investigate the effect of lime and farmyard manure on the concentration of cadmium in water spinach. Water spinach (Ipomoea aquatica cv. Kankon) was grown in sandy loam soil spiked with 5mg Cd Kg^{-1} with lime (L) and farmyard manure (M) amendments. The treatments consisted of control, four levels of L (5, 10, 15, and 20 tha^{-1}), M (5, 10, 15, and 20 tha^{-1}), and their combinations (5 + 5, 10 + 10, 15 + 15, and

20 + 20 tha^{-1}). Growth parameters of water spinach increased significantly with the addition of lime and farmyard manure in the soil. Lime addition to soil decreased Cd concentration in both shoot and root of water spinach. In control (0 + 0), Cd concentration was 62.67$mgKg^{-1}$ in shoot, and 135.5$mgKg^{-1}$ in root. Cadmium concentration decreased by 72, 15, and 66% over the control in shoot and 82, 28, and 76% in the roots correspondingly with the highest rate of lime (20 tha^{-1}), manure (20tha^{-1}), and lime plus manure combinations (20 tha^{-1} + 20tha^{-1}). The results imply that 5 to 10 tha^{-1} lime could be used in Cd-contaminated soils to reduce Cd uptake by agricultural crops.

A study was conducted by Suswanto et al. during (2007) in a glasshouse to determine the effect of lime and fertiliser application in combination with water management on rice cultivated on an acid sulfate soil, using MR 219 rice variety as the test crop. The soil used was Typic Sulfosaprists. The results showed that soil pH increased from 4.27 to 4.93 by applying 4 t GML/ha, thereby reducing Al and/or Fe toxicity. In this treatment, exchangeable Ca increased from 1.28 to 3.13 cmolc/kg soil, which is above the rice Ca requirement. The increase in exchangeable Ca also reduced Al toxicity. Fertiliser or fertiliser in combination with lime affected rice production significantly. Rice yield was negatively correlated with acid-extractable Fe. Additionally, rice yield increased with increasing pH and Ca. The best yield of 14.15 t/ha was obtained for treatment with 4 t/ha lime together with 120 kg N/ha + 16 kg P/ha + 120 kg K/ha. This shows that liming together with prudent fertiliser management improves rice production on an acid sulfate soil.

A study was done by Serafim et al. (2013) to evaluate effects of manure application, liming and phosphorus application on soil properties and soybean performance. The study consisted of 8 treatments: manure (0, 5 and 10 t ha^{-1}), lime (0 and 2 t ha^{-1}) and P fertilizer (0, 30 and 60 kg P ha^{-1}). The experiment was laid out in a randomized complete block design (RCBD) with 4 replicates in plots of 4 m × 4.5 m. Manure and lime significantly reduced exchangeable acidity and increased soil pH. Application of manure alone or combined with lime or P fertilizer also increased Mg and K. Treatments that had sole lime, lime combined with manure and manure combined with P applied gave a significant increase in exchangeable Ca. Soybean responded well and significantly to application of manure either alone or combined with lime, P or both. These results showed the potential role of lime, manure and P fertilizer in improving soil fertility and soybean yields.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to find out effect of fertilizer, manure & lime on the change in soil pH, nutrient availability of soil and yield of T. Aman rice in 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 2014 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 experimental area is under the sub-tropical climate that is characterized by less rainfall associated with moderately low temperature during rabi season, (October-March) and high temperature, high humidity and heavy rainfall with occasional gusty winds during kharif season (April-September).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 acidic soils were collected from AEZ 28 by considering the difference of soil texture, pH and organic matter. The soil-1 and soil-2 of the experiment were collected from village Bhatgaon and Goari of Upazilla Bhaluka, Mymensingh belongs to the AEZ No. 28, Madhupur Tract, classified as Deep Red Brown Terrace Soils in Bangladesh soil classification system. There were used 54 earthen pots altogether and 14 kg soil was taken in each earthen pot. Some physicochemical properties of initial soils (0-15 cm) of Bhatgaon and Goari soils are shown in Table 3.1

Table 1. Physicochemical properties of initial soils (0-15 cm) of Bhatgaon **and** Goari **soils**

Characteristics	Bhatgaon	Goari
Textural class	Silt Loam	Clay loam
pH	5.4	5.5
Organic matter (%)	0.62%,	0.52%
Total N (%)	0.08%	0.08%
Available P(ppm)	3.6	1.10
Exchangeable K(me/100kg soil)	0.08	0.083

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 Amanseason 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 Treatments of the experiment

The experiment comprised of two factors

Factor A: Soils from different locations (soils from 2 locations)

i) S_1: Bhatgaon soil

ii) S_2: Goari soil

Factor B: Levels of fertilizers and manures (9 levels)

i) T_0: Control condition(no fertilizers, manures & lime)

ii) T_1: $N_{150}P_{30}K_{70}S_{20}Zn_3$ (Recommended dose of chemical fertilizers)

iii) T_2: $N_{150}P_{30}K_{70}S_{20}Zn_3$ (RDCF)+ 1.0 g dolomite kg^{-1} soil

iv) T_3: 50% NPKS + 5 ton cowdung ha^{-1}

v) T_4: 50% NPKS + 5 ton cowdung ha^{-1} + 1.0 g dolomite kg^{-1} soil

vi) T_5: 50% NPKS + 5 ton compost ha^{-1}

vii) T_6: 50% NPKS + 5 ton compost ha^{-1} + 1.0 g dolomite kg^{-1} soil

viii) T_7: 50% NPKS + 3.5 ton poultry manure ha^{-1}

ix) T_8: 50% NPKS + 3.5 ton poultry manure ha^{-1}+ 1.0 g dolomite kg^{-1} soil

There were in total 18 (2×9) treatment combinations such as S_1T_0, S_1T_1, S_1T_2, S_1T_3, S_1T_4, S_1T_5, S_1T_6, S_1T_7, S_1T_8, S_2T_0, S_2T_1, S_2T_2, S_2T_3, S_2T_4, S_2T_5, S_2T_6, S_2T_7 and S_2T_8

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 18 unit pots as treatments. Thus the total numbers of pots were 54.

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 14 kg soil was taken in each earthen pot in the second week of July 2014. Weeds and stubbles were removed. The experimental pot was partitioned in accordance with the experimental design. Organic, inorganic manures and lime as indicated below were mixed with the soil of each pot.

3.3.4 Fertilizers, manure and lime 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. 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. Three types of organic manure (cowdung, compost and poultry manure) were used in this rice experiment. The samples of manures were dried, powdered in a mill and analysed for pH, organic matter, total N, P and K contents following standard methods. Dolomite was applied @ 2 ton ha^{-1} during previous crop cultivation (Boro rice) whereas treatment-wise fertilizers and manures were applied in the experimental crop (T. aman rice)

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, 2014 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.

3.3.7 Irrigation

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

3.3.8 Weeding

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

3.3.9 Insect and pest control

There was no infection of diseases in the field but leaf roller (*Chaphalocrosis medinalis*) was observed in the field 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 Length of panicle

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

3.5.3 Effective tillers hill^{-1}

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

3.5.4 Non-Effective tillers hill^{-1}

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

3.5.5 Filled grains panicle^{-1}

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

3.5.6 Unfilled grains panicle^{-1}

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

3.5.7 Weight of 1000-grain

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

3.5.8 Grain yield plant^{-1}

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

3.5.9 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 and K.

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 and K concentrations as follows:

3.6.3 Digestion of plant samples with sulphuric acid and determination of 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 and K

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 and K were determined from this digest.

3.6.5 Determination of P and K 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 flame photometer.

3.7 Post harvest soil sampling

After harvest of crop soil samples were collected from each pot. Before T. Aman cultivation, Boro rice was cultivated in the same pots by using similar treatments. Soil samples of each pot 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 and K concentration. The soil samples were analyzed by the following standard methods as follows:

3.8.1 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 $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and conc. H_3PO_4 and to titrate the excess $K_2Cr_2O_7$ 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).

3.8.2 Soil pH

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

3.8.3 Available phosphorus

Available P was extracted from the soil with 0.5 M $NaHCO_3$ solutions, pH8.5. 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).

3.8.4 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).

3.8.5 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

3.6 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 effect of fertilizer, manure & lime 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. Yield parameters and yield of rice

4.1.1 Plant height (cm)

Crop production on acid soils can be improved greatly by adjusting the pH to near neutrality and soil acidity is commonly corrected by liming. Organic fertilizers and manures also have a healthy effect to neutralize soil acidity for better plant growth and yield.

Table 2. Effect of soil from different locations and fertilizer, manure with lime on Plant height, penicle length, effective and non-effective tiller number of BRRI Dhan33 T. Aman Rice

Treatments	Plant height (cm)	Panicle length (cm)	Effective tiller (No.)	Non-effective tiller (No.)
Soil from different locations				
S_I	79.38	20.53	36.15a	2.74
S_2	76.82	20.59	32.15b	2.82
SE(±)	NS	NS	1.03	NS
Fertilizer and manure				
T_0	53.80c	15.05c	6.67d	1.50c
T_1	79.12ab	20.37ab	36.50abc	2.83abc
T_2	73.85b	20.02b	33.50c	2.67abc
T_3	83.12a	21.73ab	34.50bc	2.50abc
T_4	83.08a	21.33ab	34.67bc	2.00c
T_5	78.07ab	21.20ab	36.50abc	2.33bc
T_6	82.78a	21.70ab	42.00ab	3.00abc

T_7	84.12a	21.48ab	42.50a	4.17a
T_8	84.98a	22.12a	40.50abc	4.00ab
SE(±)	2.25	0.50	2.18	0.49

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

In this experiment soil from different locations showed statistically non-significant effect on plant height of T. Aman rice (BRRI dhan33) (Table 2). The highest plant height (79.38 cm) was observed from the two red acidic soil, S_1 (Bhatgaon soil)and the lowest (76.82 cm) was observed from S_2 (Goari soil).

In this study different levels of fertilizers, manures & lime significantly influenced the plant height of BRRI dhan33 (Table 2). The tallest plant (84.98 cm) was observed from T_8 (75% NPKS + 3.5 ton poultry manure ha^{-1}+ 1.0 g dolomite kg^{-1}), which was statistically similar with T_1 ($N_{150}P_{30}K_{70}S_{20}Zn_3$ (Recommended dose of chemical fertilizer), T_3 (50% NPKS + 5 ton cowdung ha^{-1}), T_4 (50% NPKS + 5 ton cow dung ha^{-1} + 1.0 g dolomite kg^{-1} soil), T_5 (50% NPKS + 5 ton compost ha^{-1}), T_6 (50% NPKS + 5 ton compost ha^{-1} + 1.0 g dolomite kg^{-1} soil) and T_7 (50% NPKS + 3.5 ton poultry manure ha^{-1}), whereas the shortest plant (53.80 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 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.Ayodele and Shittu (2014) stated that liming reduces the extreme effect of acidity in soil to obtain favored growth and yield for rice.

The interaction effect of soil from different locations and different levels of fertilizers, manures & lime (Table 3) were statistically non-significant. The tallest plant (85.93 cm) was observed from S_2T_8(Bhatgaonsoil with 50% NPKS + 3.5 ton poultry manure ha^{-1}+ 1.0 g dolomite kg^{-1}). The shortest plant (53.03 cm) was recorded from S_1T_0 (Goari soil with T_0; control condition) treatment combination which was statistically comparable to S_2T_0 treatment combination. Many scientist; Suswanto*et al*. (2007), Serafim *et al*. (2013),Sadiq and Babagana (2012)showed that liming with organic fertilizers and manures improves rice production on acid soils.

4.1.2 Panicle length (cm)

Statistically non-significant variation was found for length of panicle of BRRI dhan33 due to soil from different locations (Table 2). The longest panicle (20.59 cm) was found from S_2 and the shortest panicle (20.53 cm) was observed from S_1.

Table 3. Interaction effect of soil from different locations and fertilizer, manure with lime on Plant height, penicle length, effective and non-effective tiller number of BRRI Dhan33

Treatment	Plant height (cm)	Panicle length (cm)	Effective tiller hill^{-1} (No.)	Non-effective tiller hill^{-1} (No.)
S_1T_0	53.03	14.50	7.00f	0.67d
S_1T_1	84.00	20.90	43.67ab	4.33a
S_1T_2	78.03	20.50	40.33abc	2.00a-d
S_1T_3	81.57	20.93	32.33cde	3.00a-d
S_1T_4	83.80	21.00	36.67a-e	1.67bcd
S_1T_5	80.10	21.70	38.00a-d	1.33cd
S_1T_6	85.33	21.93	44.00ab	3.33abc
S_1T_7	84.53	20.93	46.33a	4.33a
S_1T_8	84.03	22.33	37.00a-e	4.00ab
S_2T_0	54.57	15.60	6.33f	2.33a-d
S_2T_1	74.23	19.83	29.33de	1.33cd
S_2T_2	69.67	19.53	26.67e	3.33abc
S_2T_3	84.67	22.53	36.67a-e	2.00a-d
S_2T_4	82.37	21.67	32.67cde	2.33a-d
S_2T_5	76.03	20.70	35.00b-e	3.33abc
S_2T_6	80.23	21.47	40.00a-d	2.67a-d
S_2T_7	83.70	22.03	38.67a-d	4.00ab
S_2T_8	85.93	21.90	44.00ab	4.00ab
SE(±)	NS	NS	3.08	0.70

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

Length of panicle of BRRI dhan33 varied significantly for different levels of fertilizers & manures and lime (Table 2). The longest panicle (22.12 cm) was observed from T_8 (50% NPKS + 3.5 ton poultry manure ha^{-1}+ 1.0 g dolomite kg^{-1}) which was statistically identical withT_1(20.37 cm)T_3(21.73cm) ,T_4(21.33cm), T_5(21.20cm), T_6(21.70cm and T_7(21.48 cm). On the other hand, the shortest panicle (15.05 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 & lime showed non-significant variation on length of panicle (Table 3). The longest panicle (22.53 cm) was found from S_2T_3, while the shortest panicle (14.50 cm) was observed from S_1T_0. Suswanto *et al.* (2007), Serafim et al. (2013), Sadiq and Babagana during (2012)showed that liming improves rice production on an acidic soil.

4.1.3 Effective tiller (No.)

Soil from different locations showed significant variation 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} (36.15) was obtained from S_1, whereas the minimum number (32.15) was found from S_2.

Number of effective tillers hill^{-1} of BRRI dhan33 varied significantly for different levels of fertilizers, manures & lime (Table 2). The maximum number of effective tillers hill^{-1} (42.50) was recorded from T_7, which was statistically similar with T_1 (36.50), T_5 (36.50), T_6 (42.0) and T_8 (40.50), while the minimum number of effective tiller hill^{-1} (13.0) was found from T_0. Kant and Kumar (1994) reported that the increasing rates of amendments of chemical fertilizers with FYM significantly increased the number of effective tillers hill^{-1} and the maximum level of FYM (30 t ha^{-1}) increased the tillers hill^{-1}(48%)over the control .

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Interaction effect of soil from different location and levels of fertilizers, manures & lime showed significant variation on number of effective tillers hill^{-1} (Table 3). The maximum number of effective tillers hill^{-1} (46.33) was recorded from S_1T_7 which was statistically similar with the treatment combination of S_1T_6 and the minimum number (6.33) was found from S_2T_0.Ayodele and Shittu (2014) stated that liming reduces the extreme effect of acidity in soil to obtain favored growth and yield for rice.

4.1.4 Non-effective tiller (No.)

Statistically non-significant variation was recorded for number of non-effective tillers hill^{-1} of BRRI dhan33 due to soil from different location (Table 2). The maximum number of non-effective tillers hill^{-1} (2.82) was obtained from S_2, whereas the minimum number (2.74) was found from S_1.

Number of effective tillers hill^{-1} of BRRI dhan33 varied significantly for different levels of fertilizers, manures & lime (Table 2). The maximum number of non-effective tillers hill^{-1} (4.17) was recorded from T_7, which was statistically similar with T_1 (2.83), T_2 (2.67), T_3 (2.50), T_6 (3.0) and T_8 (4.0); while the minimum number (1.50) from T_0. Kant and Kumar (1994) reported that the increasing rates of amendments of chemical fertilizers with FYM increased the number of non-effective tillers hill^{-1} significantly and the maximum level of FYM (30 t ha^{-1}) the increased the tillers hill^{-1}(48%) over the control.

Interaction effect of soil from different locations and levels of fertilizers & manures showed significant variation on the number of non-effective tillers hill^{-1} (Table 3). The maximum number of non-effective tillers hill^{-1} (4.33) was recorded from S_1T_7 and the minimum number (0.67) was found from S_1T_0. Ayodele and Shittu (2014) stated that liming reduces the extreme effect of acidity in soil to obtain favored growth and yield for rice.

4.1.5 Filled grain panicle^{-1}

Statistically non-significant variation was found for number of filled grains panicle^{-1} of BRRI dhan33 due to soil from different locations (Table 4). The maximum number of filled grains panicle^{-1} (64.86) was observed from S_2, while the minimum number (64.21) was recorded from S_1.

Table 4. Effect of soil from different locations and fertilizer & manure on Filled grain/panicle, Unfilled grains/panicle, 1000 grain weight, Grain yield (g/pot) and Straw yield (g/pot of BRRI Dhan 33

Treatments	Filled grain/panicle (No)	Unfilled grains/panicle (No)	1000 grain weight (g)	Grain yield (g/pot)	Straw yield (g/pot
Soil from different locations					
S_I	64.21	12.79	20.78	58.71a	64.16a
S_2	64.86	10.98	20.89	48.37b	53.73b
SE(±)	NS	0.51	NS	1.82	1.92
Fertilizer, manure & lime					
T_0	27.50d	6.30c	18.17b	4.18f	4.63e
T_1	58.10bc	12.60ab	21.33a	49.72de	59.90cd
T_2	54.47c	14.83a	21.00a	42.72e	47.70d
T_3	76.13a	12.57ab	21.83a	58.48cd	64.48bc
T_4	75.10a	9.90b	21.33a	59.00cd	62.48c
T_5	62.03bc	12.70ab	21.00a	52.52cde	60.40cd
T_6	69.60ab	12.47ab	20.50a	63.98bc	70.08bc
T_7	77.00a	13.00ab	20.83a	73.35ab	84.07a
T_8	80.87a	12.57ab	21.50a	77.92a	76.73ab
SE(±)	3.72	1.09	0.55	3.97	4.07

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

Number of filled grains panicle^{-1} of BRRI dhan33 varied significantly for different levels of fertilizers, manures & lime (Table 4). The highest number of filled grains panicle^{-1} (80.87) was obtained from T_8, which was statistically identical with all other treatments except $T_{0,}$ $T_{1,}$ T_2 and $T_{5,}$ but the lowest number of filled grains panicle^{-1} (27.50) 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.

Table 5. Interacting effect of soil from different locations and fertilizer & manure on Filled grain/panicle, Unfilled grains/panicle, 1000 grain weight, Grain yield (g/pot) and Straw yield (g/pot of BRRI Dhan 33

Treatment	Filled grain Panicle^{-1}	Unfilled grains Panicle^{-1}	1000 grain weight(g)	Grain yield (g/pot)	Straw yield (g/pot)
S_1T_0	24.80g	6.00	18.67	3.67f	4.13f
S_1T_1	64.27b-f	12.67	21.33	69.20abc	80.13ab
S_1T_2	61.40c-f	13.47	21.33	53.13cd	55.30cde
S_1T_3	65.87b-f	15.20	21.67	57.80bcd	59.93b-e
S_1T_4	70.47a-e	10.00	20.67	64.83a-d	64.77bc
S_1T_5	71.00a-d	14.20	22.00	56.90bcd	64.03bc
S_1T_6	69.73a-e	14.07	20.67	70.53abc	80.13ab
S_1T_7	68.80a-e	14.93	20.33	75.87ab	94.70a
S_1T_8	81.53ab	14.53	20.33	76.43ab	74.30bc
S_2T_0	30.20g	6.60	17.67	4.70f	5.13f
S_2T_1	51.93ef	12.53	21.33	30.23e	39.67e
S_2T_2	47.53f	16.20	20.67	32.30e	40.10de
S_2T_3	86.40a	9.93	22.00	59.17bcd	69.03bc
S_2T_4	79.73abc	9.80	22.00	53.17cd	60.20bcd
S_2T_5	53.07def	11.20	20.00	48.13de	56.77cde
S_2T_6	69.47a-e	10.87	20.33	57.43bcd	60.03b-e
S_2T_7	85.20a	11.07	21.33	70.83abc	73.43bc
S_2T_8	80.20abc	10.60	22.67	79.40a	79.17ab
SE(±)	5.27	NS	NS	5.47	5.75

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

Number of filled grains panicle^{-1} showed significant variation due to the interaction effect of soil from different location and levels of fertilizers, manures & lime (Table 5). The maximum number of filled grains panicle^{-1} (86.40) was observed from S_2T_3 which was statistically similar with S_2T_4, S_2T_7 andS_2T_8; while the minimum number (24.80) was recorded from S_1T_0.

Many scientist; Suswanto *et al*. (2007), Serafim *et al*. (2013), Sadiq and Babagana (2012)showed that liming with organic fertilizers and manures improves rice production on acidic soils.

4.1.6 Unfilled grains/panicle

Statistically significant variation was found for number of unfilled grains panicle^{-1} of BRRI dhan33 due to soil from different location (Table 4). The maximum number of unfilled grains panicle^{-1} (12.79) was observed from S_1, while the minimum number (10.98) was recorded from S_1.

Number of unfilled grains panicle^{-1} of BRRI dhan33 varied significantly for different levels of fertilizers & manures (Table 4). The highest number of unfilled grains panicle^{-1} (14.83) was obtained from T_8, which was statistically identical with all other treatments except T_0 and T_4, but the lowest number of unfilled grains panicle^{-1} (6.30) 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 unfilled grains panicle^{-1} showed non-significant variation due to the interaction effect of soil from different location and levels of fertilizers, manures & lime (Table 5). The maximum number of unfilled grains panicle^{-1}(14.93) was observed from S_1T_7 and the minimum number (6.0) was recorded from S_1T_0. T. Suswanto *et al*. (2007), V. B. Serafim *et al*. (2013), A. A. Sadiq and U. Babagana (2012)showed that liming improves rice production on an acidic soil.

4.1.7 1000 grain weight

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 (20.89 g) was recorded from S_2, whereas the lowest weight (20.78 g) was recorded from S_1.

Weight of 1000-grains of BRRI dhan33 varied significantly for different levels of fertilizers, manures & lime (Table 4). The highest weight of 1000-grains (21.83 g) was found from T_3 and T_7, whereas the lowest weight (4.18 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 & lime showed non-significant variation on weight of 1000-grains (Table 5). The highest weight of 1000-grains (22.67 g) was obtained from S_2T_8 and the lowest weight (17.67 g) was found from S_2T_0. T. Suswanto *et al*. (2007),Serafim *et al*. (2013), Sadiq and Babagana (2012)showed that liming improves rice production on an acidic soil.

4.1.8 Grain yield pot^{-1}(g)

Soil from different location varied significantly in terms of grain yield pot^{-1} of BRRI dhan33 (Table 4). The highest grain yield pot^{-1} (58.71 g) was recorded from S_1 and the lowest grain yield pot^{-1} (48. 37 g) was observed from S_2.

Grain yield pot^{-1} of BRRI dhan33 varied significantly for different levels of fertilizers, manures & lime (Table 4). The highest grain yield pot^{-1} (77.92 g) was found from T_8 which was statistically similar with T_7, while the lowest grain yield pot^{-1} (4.18 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.

Statistically significant variation was recorded due to the interaction effect of soil from different location and levels of fertilizers, manures & lime in terms of grain yield pot^{-1} (Table 5). The highest grain yield pot^{-1} (79.40 g) was found from S_2T_8 which was statistically similar with S_1T_8, whereas the lowest grain yield pot^{-1} (3.67 g) was recorded from S_1T_0. Application of lime precipitates acidic molecule in the soil and result in higher rice yield. Many scientist; T. Suswanto *et al*. (2007), Serafim *et al.* (2013),Sadiq and Babagana (2012)showed that liming with organic fertilizers and manures improves rice production on acid soils.

4.1.9 Straw yield (g/pot)

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} (64.1 g) was found from S_1, while the lowest straw yield pot^{-1} (53.73 g) was recorded from S_2.Straw yield pot^{-1} of BRRI dhan33 varied significantly for different levels of fertilizers, manures & lime (Table 4). The highest straw yield pot^{-1} (84.70 g) was observed from T_7, whereas the lowest (4.63 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 & lime showed significant variation on straw yield pot^{-1} (Table 5). The highest straw yield pot^{-1} (94.70 g) was observed from S_1T_7 which was statistically similar with S_1T_6, S_2T_8 treatment combinationsand the lowest straw yield pot^{-1} (4.13 g) was recorded from S_1T_0. Many scientist; T. Suswanto *et al.* (2007), V. B. Serafim *et al.* (2013), A. A. Sadiq and U. Babagana (2012)showed be similar but not same in all cases.

4.2 The pore-water Phosphorus (P) and Potassium(K)

Table 6 : Effect of soil from different location and fertilizer, manure & lime on the pore-water Phosphorus (P) and Potassium(K) concentration

Treatment	P conc.(ppm) at 60DAT	K conc.(ppm) at 60DAT
Soil from different locations		
S_1	0.959b	2.237
S_2	1.112a	2.264
SE(±)	0.0274	NS
Fertilizer, manures & lime		
T_0	0.550c	1.775b
T_1	1.037ab	2.304a

T_2	1.027ab	2.500a
T_3	0.980b	2.205a
T_4	1.130ab	2.206a
T_5	1.039ab	2.157a
T_6	1.204a	2.255a
T_7	1.138ab	2.402a
T_8	1.213a	2.451a
SE(±)	0.058	0.1071

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

The pore-water P concentrations were significantly affected with the variations of soil. The higher level of pore-water P concentration (1.11 ppm) was found at 60 DAT in the soil-2(Goari Soil) compared to Bhatgaon soils (Soil-1) but the trend of pore-water K concentrations were almost similar in both the soils at 60DAT and showed statistically insignificant results (Table 6).The pore-water P and K concentrations were significantly affected with different fertilizer, manure and lime treatments (Table 6). Higher levels of P concentrations were found in the fertilizer treatments where fertilizer plus manure and lime were applied. At 60 DAT, the highest pore-water P concentration (1.213 ppm) was found in T_8 (50% NPKS + 3.5 ton poultry manure ha^{-1} + 1.0 g Dolomite kg^{-1} soil) treatment which was statistically and closely similar to the treatments T_4, T_6 where organic plus inorganic fertilizers were used and lime was applied in the previous crop. The lowest P concentration (0.55 ppm) was observed in T_0 treatment. The highest pore-water K concentration (2.50 ppm) was obtained from T_2 treatment which was closely similar to the treatments T_8 where lime was applied in the previous crop boro rice and lowest K concentration (1.775 ppm) was found in the treatment T_0.

Table 7:Interaction effect of soil and fertilizer, manure & lime on the pore-water Phosphorus (P) & K concentration.

Soil & Fertilizer treatment combination	P conc.(ppm) at 60DAT	K conc.(ppm) at 60DAT
S_1T_0	0.522	1.804
S_1T_1	1.053	2.255
S_1T_2	0.950	2.549
S_1T_3	0.874	1.959
S_1T_4	0.998	2.255
S_1T_5	0.888	2.059
S_1T_6	1.110	2.353
S_1T_7	1.121	2.451

S_1T_8	1.113	2.451
S_2T_0	0.577	1.745
S_2T_1	1.022	2.353
S_2T_2	1.103	2.451
S_2T_3	1.085	2.451
S_2T_4	1.262	2.157
S_2T_5	1.190	2.555
S_2T_6	1.298	2.157
S_2T_7	1.155	2.353
S_2T_8	1.312	2.451
SE(±)	NS	NS

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

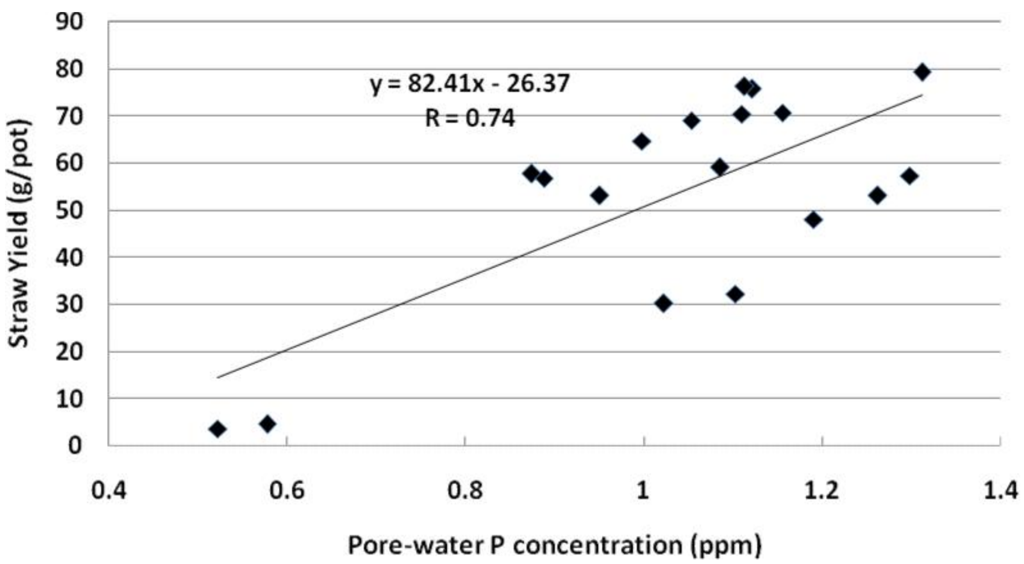

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Fig. 1. Correlation between pore-water P concentration and straw yield of T. Aman rice

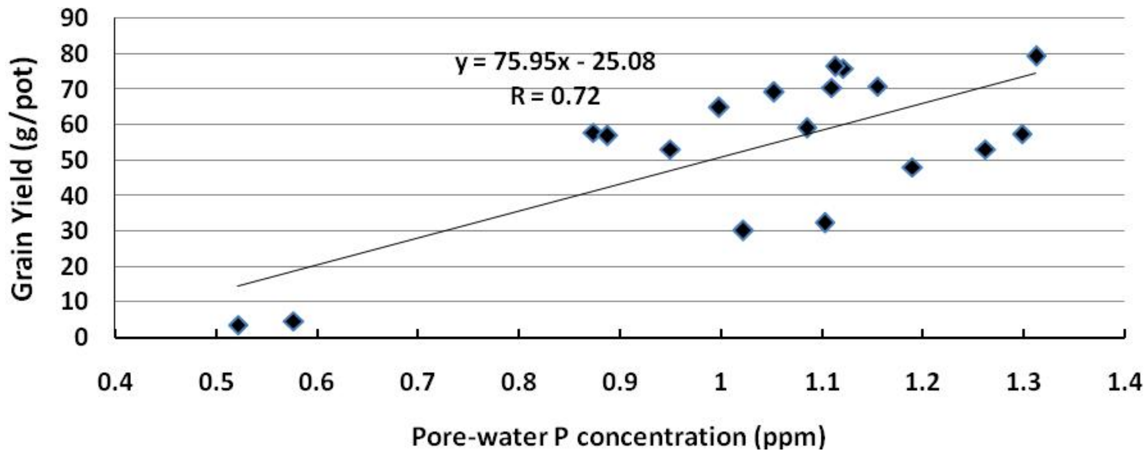

Fig. 2. Correlation between pore-water P concentration and grain yield of T. Aman rice

The interaction effect of soil and fertilizer on the pore-water phosphorus (P) and potassium (K) concentrations were not significantly different (Table 7). The higher levels of pore-water P concentrations were found in the combination of soil-2 and fertilizer treatments. The highest P concentration of 1.312 ppm was found in the S_2T_8 treatment combination which was closely similar to S_2T_4 (Soil-2 & 50% NPKS + 5 ton cowdung ha^{-1} + 1.0 g Dolomite kg^{-1} soil) and S_2T_6 (Soil-2 & 50% NPKS + 5 ton compost ha^{-1} + 1.0 g dolomite kg^{-1} soil) treatment combinations and the lowest P concentration was observed in S_2T_0 treatment combination (Table 7). The pore-water P concentrations were significantly correlated with the yields of rice (Figure 1 &2). The higher P concentrations were found in the Goari soil compared to Bhatgaon soil. The highest pore-water K concentration was found in S_2T_5 treatment which was closely similar to S_1T_2, S_1T_7, S_1T_8, S_2T_2 andS_2T_8 treatment combinations and the lowest was obtained in S_2T_0 treatment combination.

4.3 N, P, and K concentration in grain

Statistically significant variation was found for N, P, and K concentration in grain of BRRI dhan33 due to soil from different location (Table 8). The highest N, P, and K concentration in grain (1.08%, 0.240% and 0.193 %, respectively) was recorded from S_1, whereas the lowest N, P, and K concentration in grain (.937%, 0.220% and 0.182%) from S_2.

Table 8**:** Effect of soil and fertilizer, manure & lime on Nitrogen (N), Phosphorus (P), Potassium (K) concentration in T. Aman rice grain

Treatment	Grain nutrient concentration (%)		
	N	P	K
Soil from different locations			
S_1	1.086a	0.240a	0.193a
S_2	0.937b	0.220b	0.182b

SE(±)	0.0012	0.0002	0.0001
Fertilizer, manure & lime			
T_0	0.839i	0.193h	0.165i
T_1	0.908h	0.197g	0.198c
T_2	1.039d	0.222e	0.199b
T_3	1.004f	0.208f	0.190e
T_4	1.002g	0.241d	0.192d
T_5	1.030e	0.247c	0.168h
T_6	1.062c	0.249b	0.187f
T_7	1.095b	0.263a	0.212a
T_8	1.124a	0.249b	0.178g
SE(±)	0.0025	0.0004	0.0001

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

N, P, and K concentration in grainof BRRI dhan33 varied significantly for different levels of fertilizers, manures & lime (Table 8). The highest N, P, and K concentration in grain (1.124%, 0.263% and 0.212%) was recorded from (T_8, T_7 and T_6, respectively) while the lowest N, P, and K concentration in grain (0.839%, 0.193% and 0.165%) 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.

Table 9: Effect of soil and fertilizer on the grain Nitrogen (N), Phosphorus (P) and Potassium (K) concentration

Soil & Fertilizer	Grain nutrient concentration (%)		
	N	P	K
S_1T_0	0.865n	0.195m	0.167n
S_1T_1	0.954j	0.224k	0.199e
S_1T_2	1.165b	0.268b	0.232a
S_1T_3	1.056g	0.185n	0.203d
S_1T_4	1.137d	0.244f	0.192g
S_1T_5	1.123e	0.266c	0.170m
S_1T_6	1.139c	0.263d	0.189h
S_1T_7	1.165b	0.278a	0.214b
S_1T_8	1.171a	0.234h	0.174l
S_2T_0	0.812p	0.161p	0.163o
S_2T_1	0.863o	0.199 l	0.196f
S_2T_2	0.914m	0.176o	0.167n

S_2T_3	0.952k	0.230i	0.178k
S_2T_4	0.866n	0.238g	0.192g
S_2T_5	0.938l	0.227j	0.167n
S_2T_6	0.985i	0.234h	0.185i
S_2T_7	1.025h	0.249e	0.210c
S_2T_8	1.076f	0.263d	0.181j
SE(±)	0.0036	0.0005	0.0002

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

Interaction effect of soil from different location and levels of fertilizers, manures & lime showed significant variation on N, P, and K concentration in grain (Table 9). The highest N, P, and K concentration in grain (1.171%, 0.287% and 0.232%) was found from S_1T_8, S_1T_7 and S_1T_2, respectively, whereas the lowest N, P, and K concentration in grain (0.812%, 0.161% and 0.167%) was found from S_2T_0, S_2T_1 and S_1T_0.

4.4 Nutrient status of post harvest soil

4.4.1 Organic matter

Statistically non-significant variation was found for organic matter in postharvest soil of BRRI dhan33 due to soil from different location (Table 10). The highest organic matter (1.106%) was found from S_1, while the lowest (1.077%) was recorded from S_2. 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.

Table 10:Effects of soil and fertilizer, manure & lime on the chemical properties of post-experiment soils.

Treatments	Soil Organic Matter (%)	Soil pH	Soil Avail. P(ppm)	Soil Avail. K (meq/100g)	Soil Total N (%)
Soil from different locations					
S_I	1.106	6.18b	24.12a	0.119a	0.113b
S_2	1.077	6.28a	8.86b	0.109b	0.116a
SE(±)	NS	0.03	0.53	0.003	0.0004
Fertilizer, manure & lime					
T_0	0.503e	5.55d	2.76e	0.095e	0.092h
T_1	0.707de	5.99c	4.47e	0.112c	0.098f
T_2	0.813d	6.42a	5.57e	0.122b	0.102e
T_3	1.530a	6.16bc	19.37c	0.110c	0.111d
T_4	1.560a	6.50a	36.72a	0.112c	0.096g

T_5	1.248b	6.23b	15.29d	0.125b	0.135b
T_6	1.352ab	6.53a	18.74cd	0.132a	0.171a
T_7	0.967cd	6.19b	18.50cd	0.105d	0.113c
T_8	1.143bc	6.52a	26.99b	0.113c	0.112c
SE(±)	0.083	0.054	1.12	0.005	0.0008

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

Organic matter in post-harvest soil varied significantly for different levels of fertilizers, manures & lime (Table 10). The highest organic matter (1.560%) was observed from T_2, which was statistically identical with T_3 and T_6, whereas the lowest organic matter (0.503%) was found from T_0. Rahman (2001) reported that the integrated use of fertilizers with manure & lime (viz. cowdung) could be an efficient practice for ensuring higher crop yields without degradation of soil fertility. Farid *et al*. (1998) found that incorporation of compost or rice straw and subsequent decomposition increased and maintained organic matter level at 2.5% that was higher than that in traditionally managed rice soil.

Table 11: Interaction effects of soil and fertilizer on the physico-chemical properties post-harvest soil.

Soil and Fertilizer Treatment combination	Soil Organic Matter (%)	Soil pH	Soil Available P concentration (ppm)	Soil Available K concentration (meq/100g)	Soil Total N (%)
S_1T_0	0.550gh	5.58h	4.74fgh	0.100	0.081n
S_1T_1	0.747fgh	5.96g	7.82fg	0.113	0.092l
S_1T_2	0.950defg	6.31cde	8.75f	0.130	0.103j
S_1T_3	1.410abc	6.20defg	31.45bcd	0.110	0.103j
S_1T_4	1.617ab	6.32cde	40.72a	0.110	0.088m
S_1T_5	1.317abcd	6.36bcde	26.88d	0.120	0.133e
S_1T_6	1.500abc	6.42abcd	31.89bcd	0.140	0.151c
S_1T_7	0.997def	6.11efg	28.77cd	0.110	0.103j
S_1T_8	0.867efgh	6.43abcd	36.09ab	0.133	0.162b
S_2T_0	0.457h	5.51h	0.78h	0.090	0.092l
S_2T_1	0.667fgh	6.02fg	1.12h	0.110	0.107i
S_2T_2	0.667fgh	6.53abc	2.38gh	0.113	0.100k
S_2T_3	1.650a	6.12efg	7.29fg	0.110	0.118g
S_2T_4	1.503abc	6.68a	32.71bc	0.113	0.111h
S_2T_5	1.180cde	6.10efg	3.70fgh	0.130	0.136d
S_2T_6	1.203bcde	6.64a	5.60fgh	0.123	0.192a
S_2T_7	0.937defg	6.26cdef	8.23f	0.100	0.122f
S_2T_8	1.420abc	6.61ab	17.90e	0.093	0.103j
SE (±)	0.117	0.076	1.58	NS	0.001

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

Interaction effect of soil from different location and levels of fertilizers with manure & lime showed significant variation on organic matter (Table 11). The highest organic matter (1.650%) was observed from S_2T_3 and the lowest organic matter (0.457%) was recorded from S_2T_0. The organic matter content in post harvest soil increased more in the Goari soil in comparison to Bhatgaon 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.

4.4.2pH

Crop production on acid soils can be improved greatly by adjusting the pH to near neutrality and soil acidity is commonly corrected by liming. Organic fertilizers and manures also have a healthy effect to neutralize soil acidity for better plant growth and yield.

Statistically significant variation was found for pH in post harvest soil of different location (Table 10) due to dolomite application. The highest pH (6.28) was observed from S_2, while the lowest pH (6.18) was recorded from S_1.

The pH in post-harvest soil varied significantly for different levels of fertilizers with manure & lime (Table 10). The highest pH (6.53) was found from T_6, which was closely followed by T_2,T_4 and T_8. On the other hand, the lowest pH (5.55) was found from T_0. Ayodele and Shittu (2014) stated that liming reduces the extreme effect of acidity in soil as a result pH increased in acid soil. This results shows that application of lime the acidic soil pH.

Interaction effect of soil from different location and levels of fertilizers with manure & lime showed significant variation on pH (Table 11). The highest pH (6.68) was found from S_2T_4 which was closely similar to S_2T_8 and the lowest pH (5.51) was recorded from S_2T_0. Soil pH was increased more in S_2 soil due to the difference of physio-chemical properties of soil. Suswanto*et al.* (2007),Serafim*et al.* (2013), Sadiq and Babagana (2012) showed that liming with organic fertilizers and manures improves acidic soils and pH increased near to neutralization.

4.4.3 Available P

Statistically significant variation was found for available P in post experiment soil collected from different location (Table 10). The highest available P (24.12 ppm) was found from S_1 and the lowest (8.86 ppm) from S_2.

Available P in post harvest soil of BRRI dhan33 varied significantly for different levels of fertilizers with manures & lime (Table 10). The highest available P (36.72 ppm) was observed from T_4, while the lowest available P (2.76 ppm) was found from T_1 which was which was statistically similar (4.47 ppm and 5.57 ppm) with T_1 and T_2.

Interaction effect of soil from different location and levels of fertilizers with manure & lime showed non-significant variation on available P (Table 11). The highest available P (40.72 ppm) was observed from S_1T_4, while the lowest available P (0.78 ppm) was recorded from S_2T_0. Liming increased the available P in post-harvest soil.

4.4.4 Available K

Statistically significant variation was found for available K in post harvest soil of BRRI dhan33 due to soil from different location (Table 10). The highest available K (0.119 me/100 g soil) was recorded from S_1, while the lowest (0.109 me 100 g soil^{-1}) was observed from S_2.

Available K in post-harvest soil of BRRI dhan33 varied significantly for different levels of fertilizers with manure & lime (Table 10). The highest available K (0.132 me 100 g soil^{-1}) was found from T_6, whereas the lowest available K (0.095 me/100 g soil) was recorded from T_0.Interaction effect of soil from different location and levels of fertilizers with manure & lime showed non-significant variation on available K (Table 11). The highest available K (0.133 me/100 g soil) was found from S_1T_8 and the lowest available K (0.100 me 100g soil^{-1}) was recorded from S_1T_0. This results indicates that the availability of K was increased by lime application.

4.4.5 Total nitrogen

Statistically significant variation was found for total nitrogen in post-harvest soil of BRRI dhan33 due to soil from different location (Table 10). The highest total nitrogen (0.116%) was attained from S_2, while the lowest (0.113%) was recorded from S_1.

Total nitrogen in post-harvest soil of BRRI dhan33 varied significantly for different levels of fertilizers with manure & lime (Table 10). 6

Interaction effect of soil from different location and levels of fertilizers with manure & lime showed significant variation on total nitrogen (Table 11). The highest total nitrogen (0.192%) was found from S_2T_6 where lime was applied and the lowest total nitrogen (0.081%) was recorded from S_1T_0 treatment combination.

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 2014 in aman season to find out effect of fertilizer, manure & lime to the change of pH, 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: Bhatgaon soil, S_2: Goari soil (collected from village Bhatgaon and Goari of Upazilla Bhaluka, Mymensingh) and Factor B: Different levels of fertilizers, manures and lime (9 levels)- T_0: Control condition i.e. no fertilizers and manures; T_1: $N_{150}P_{30}K_{70}S_{20}Zn_3$ (Recommended dose of chemical fertilizer), T_2: $N_{150}P_{30}K_{70}S_{20}Zn_3$ (RDCF)+ 1.0 g dolomite kg^{-1} soil, T_3: 50% NPKS + 5 ton cowdung ha^{-1} T_4: 50% NPKS + 5 ton cowdung ha^{-1} + 1.0 g dolomite kg^{-1} soil and T_5: 50% NPKS + 5 ton compost ha^{-1}, T_6: 50% NPKS + 5 ton compost ha^{-1} + 1.0 g dolomite kg^{-1}, T_7: 50% NPKS + 3.5 ton poultry manure ha^{-1} and T_8: 50% NPKS + 3.5 ton poultry manure ha^{-1}+ 1.0 g dolomite kg^{-1} soil. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Data were recorded on yield parameters, nutrient concentration in pore water, grain and straw and nutrient status of post harvest soil. Significant variation was observed for different treatments and their interaction effect.

In case of soil from different location, at harvest, the tallest plant (79.38 cm) was found from S_1, while the shortest plant (76.82 cm) was recorded from S_2. Soil from different location showed no statistical variation for panicle length. The maximum number of effective tillers hill^{-1} (36.15) was obtained from S_1, whereas the minimum number (32.15) was found from S_2. Non-effective tillers hill^{-1} showed insignificant result in case of soil from different location. The maximum number of filled grains panicle^{-1} (64.86) was observed from S_2, while the minimum number (64.21) was recorded from S_1. The maximum number of unfilled grains panicle^{-1} (12.79) was observed from S_1, while the minimum number (10.98) was recorded from S_2. There was no significant variation in case 1000-grains by different soil. The highest grain yield pot^{-1} (58.71 g) was recorded from S_1 and the lowest grain yield pot^{-1} (48. 37 g) from S_2. The highest straw yield pot^{-1} (64.1 g) was found from S_1, while the lowest pot^{-1} (53.73 g) from S_2.

The highest pore-water P (1.11 ppm) was found from S_2, while the lowest (0.95 ppm) from S_1. The pore-water K concentrations showed statistically insignificant results. The highest N, P and K concentration in grain (1.08%, 0.240% and 0.193 %, respectively) was recorded from S_1, whereas the lowest N, P, K and S concentration in grain (0.937%, 0.220% and 0.182%), respectively) was found from S_2. The highest organic matter (1.106%) was found from S_1, while the lowest (1.077%) was recorded from S_2. The highest pH (6.28) was observed from S_2, while the lowest pH (6.18) was recorded from S_1. The highest available P (24.12 ppm) was found from S_1 and the lowest (8.86 ppm) was recorded from S_2. The highest available K (0.119 me/100 g soil) was recorded from S_1, while the lowest (0.109 me/100 g soil) was observed from S_2.The highest total nitrogen (0.116%) was attained from S_2, while the lowest (0.113%) was recorded from S_1.

For different fertilizers, manure & lime, at harvest, the tallest plant (84.98 cm) was found from T_8 (50% NPKS + 3.5 ton poultry manure ha^{-1}+ 1.0 g dolomite kg^{-1}), while the shortest plant (53.80 cm) was recorded from T_0 (Controled). The longest panicle (22.12 cm) was observed from T_8 and the shortest panicle (15.05 cm) was found from T_0. The maximum number of effective tillers hill^{-1} (42.50) was recorded from T_7, while the minimum number (6.67) from T_0. The maximum number of non-effective tillers hill^{-1} (4.17) was recorded from T_7, while the minimum number (1.50) from T_0. The highest number of filled grains panicle^{-1} (80.87) was obtained from T_8 but the lowest number of filled grains panicle^{-1} (27.50) was found in $T_{0.}$ The highest number of unfilled grains panicle^{-1} (14.83) was obtained from T_8 but the lowest number of unfilled grains panicle^{-1} (6.30) was found in T_0. The highest weight of 1000-grains (21.83 g) was found from T_3 and T_7, whereas the lowest weight (4.18 g) was found from T_0. The highest grain yield pot^{-1} (77.92 g) was found from T_8 while the lowest grain yield pot^{-1} (4.18 g) was obtained from T_0. The highest straw yield pot^{-1} (84.07 g) was observed from T_7, whereas the lowest (4.63 g) was found from T_0.

The highest pore-water P concentration (1.213 ppm) was found in T_8 and the lowest P concentration (0.55 ppm) was observed in T_0. The highest pore-water K concentration (2.50 ppm) was obtained from T_2 and the lowest (1.775 ppm) was found in the T_0. The highest N, P, and K concentration in grain (1.124%, 0.263% and 0.212%) was recorded from (T_8, T_7 and T_7, respectively) while the lowest N, P, and K concentration in grain (0.839%, 0.193% and 0.165%) was observed from T_0. The highest organic matter (1.560%) was observed from T_4, whereas the lowest organic matter (0.503%) was found from T_0. The highest pH (6.53) was found from T_6 and the lowest pH (5.55) was found from T_0. The highest available P (36.72 ppm) was observed from T_4, while the lowest available P (2.76 ppm) was found from T_1. The highest available K (0.132 me/100 g soil) was found from T_6, whereas the lowest available K (0.095 me/100 g soil) was recorded from T_0. The highest total nitrogen (0.171%) was observed from T_6, whereas the lowest total nitrogen (0.092%) was observed from T_0.

The interactive effect of soil with different levels of fertilizers, manures & lime were statistically non-significant for plant height and length of panicle. Interaction of soil with fertilizers, manures & lime showed significant variation on number of effective and non-effective tillers hill^{-1}. The maximum number of effective tillers hill^{-1} (46.33) was recorded from S_1T_7 and the minimum number (7.00) was found from S_1T_0. The maximum number of non-effective tillers hill^{-1} (4.33) was recorded from S_1T_7 and the minimum number (0.67) was found from S_1T_0. The maximum number of filled grains panicle^{-1} (86.40) was observed from S_2T_3 and the minimum number (24.80) was recorded from S_1T_0. Number of unfilled grains panicle^{-1} and 1000-grains showed non-significant variation. The highest grain yield pot^{-1} (79.40 g) was found from S_2T_8, whereas the lowest grain yield pot^{-1} (3.67 g) was recorded from S_1T_0. The highest straw yield pot^{-1} (94.70 g) was observed from S_1T_7 and the lowest straw yield pot^{-1} (4.13 g) was recorded from S_1T_0.

The interaction effect of soil with different levels of fertilizers, manures & lime on the pore-water phosphorus (P) and potassium (K) concentrations were not significant. Interaction effect of soil with fertilizers, manures & lime showed significant variation on N, P, and K concentration in grain. The highest N, P, and K concentration in grain (1.171%, 0.287% and 0.232%) was found from S_1T_8, S_1T_7 and S_1T_2, respectively, whereas the lowest N, P, and K concentration in grain (0.812%, 0.161% and 0.167%) was found from S_2T_0, S_2T_1 and S_1T_0 treatment combinations. The highest organic matter (1.650%) was observed from S_2T_3 and the lowest organic matter (0.457%) was recorded from S_2T_0. The highest pH (6.68) was found from S_2T_4 and the lowest pH (5.51) was recorded from S_2T_0. The highest available P (40.72 ppm) was observed from S_1T_4, while the lowest available P (0.78 ppm) was recorded from S_2T_0. The available K showed non-significant variation on this interaction. The highest total nitrogen (0.192%) was found from S_2T_6 and the lowest total nitrogen (0.081%) was recorded from S_1T_0. The postharvest soil nutrient availability increased more where lime was applied with manure.

Conclusion

It may be concluded that Goari soil and 50% NPKS + 3.5 ton poultry manure ha^{-1}+ 1.0 g dolomite kg^{-1}performed better in relation to yield contributing characters and yield of BRRI dhan33. The application of inorganic fertilizers plus manures& lime improved the chemical properties and nutrient levels of post experiment soils. The level of pH was more increased in the post experiment soil of Goariby applying inorganic fertilizers plus manures& lime (Goari with 50% NPKS + 5 ton cowdung ha^{-1} + 1.0 g dolomite kg^{-1}) treatments. The T. Aman rice yield increased more by applying fertilizers, manures and lime. The postharvest soil nutrient availability and plant nutrient accumulation were increased by liming in combination with manure. So dolomite can be applied in acidic red soils of AEZ 28 for increasing yield of rice and fertility of soil.

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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 2014

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*