INTEGRATED USE OF FERTILIZERS AND MANURE IN T.AMAN RICE

A Thesis
By

SHAHIDUL ISLAM

Registration No. 00715
Semester: July-December 2006

Submitted to the Department of Soil Science
Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka
In partial fulfillment of the requirements
For the degree of

MASTER OF SCIENCE (M.S.)
IN
SOIL SCIENCE

DEPERTMENT OF SOIL SCIENCE
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA

JUNE, 2008

INTEGRATED USE OF FERTILIZERS AND MANURE IN T. AMAN RICE

A Thesis
By

SHAHIDUL ISLAM

Registration No. 00715
Semester: July-December 2006

Approved as to the style and content by

A Saduzzaman

(Dr. Md. Asaduzzaman Khan)
Supervisor

(Prof. Dr. Alok Kumar Paul)
Co-supervisor

A.T. M. Shamsuddoha
Chairman
Department of Soil Science
Sher-e-Bangla Agricultural University, Dhaka-1207

JUNE, 2008

CERTIFICATE

This is to certify that the thesis entitled ***"INTEGRATED USE OF FERTILIZER AND MANURE IN T. AMAN RICE"*** 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 results of a piece of bona fide research work carried out by ***SHAHIDUL ISLAM, REGISTRATION NO. 00715,*** under my supervision and guidance. No part of this thesis has been submitted for any other degree in any other institutions.

I further certify that any help or sources of information received during the course of this investigation have been duly acknowledged.

Asaduzzaman

Dr. Md. Asaduzzaman Khan

Supervisor

Dated:

Dhaka, Bangladesh

DEDICATED

TO

MY DEPARTED FATHER

Acknowledgement

All praise is due to the Almighty Allah Who has enabled the author to pursue higher education and to complete the thesis for the degree of M.S. in Soil Science.

The author deems it a proud privilege to extend his indebtedness and sincere appreciation to his reverend supervisor Dr. Md. Asaduzzaman Khan, Associate professor, Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka for his keen interest, scholastic guisance, valuable suggestions, grnerous help, constant encouragement, outstanding assistance and constructive criticism from the beginning to the successful completion of the research work as well as preparation of this thesis.

The author also acknowledges to his deep sense of gratitude and indebtedness to his honorable co- supervisor Dr. Alok Kumar Paul, professor, Department of Soil Science, Sher-e- Bangla Agricultural University, Dhaka for his rendering help, valuable advice, technical suggestions and encouragement from the beginning to the end of the preparing the thesis.

The author express his profound appreciation,thankfulness and gratitude to A.T.M. Shamsuddoha, Head, Department of Soil Scinece, Sher-e-Bangla Agricultural University, Dhaka for his co-operation and providing all facilities to carry out the research and preparing the thesis.

The author is deeply indebted to Dr.Nurul Islam, professor, Md. Mosharraf Hossain, Assistant professor, and other respected teachers of the department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka for their encouragement, visiting the experimental site, valuable advice to complete this research and preparing the thesis.

The author is thankful to especially Haidar Ali and other staffs of the Department of Soil Science, Sher-e-Bangla Agricultural University.

The author also acknowledges and expresses cordial thanks to all friends especially Zahid, Ferdous, Tushi, Tewel, Saiful, Iqbal, Homayon, Kabir, Rabiul, *Tapu & Kakon for their moral support, encouragement and co-operation during the entire research work.*

The author respectfully remembers his departed father Zaker Hossain, who sacrificed his everything to pave the way for his education.

Finally, the author is proud to remember his beloved mother, grandfather, grandmother, uncle Sayed Hossain,Mobarak Hossain, Sadek Hossain, aunt, brother Mostak and bhabi and wish to express his deepest gratityude to his sister Kajol and brother Robel for their immeasurable sacrifice, blessing, continuous inspiration and moral support.

The Author

ABSTRACT

The study was performed at Sher-e-Bangla Agricultural University (SAU) Farm on integrated use of fertilizers and manure in T. Aman rice (Var. BRRI dhan 33) during July to Nov. 2007. A Field experiment was conducted in combination with inorganic fertilizers and manure. The experiment was laid out in a randomized complete block design with eight treatments and four replications. The treatments were T_0 (control), T_1($N_{100}P_{15}K_{45}S_{20}$ (Recommended dose), T_2(50% NPKS + 5 t ha^{-1} CD), T_3(70% NPKS + 3 t ha^{-1} CD), T_4(50% NPKS + 4 t ha^{-1} PM), T_5(70% NPKS + 2.4 t ha^{-1} PM), T_6(50% NPKS + 10 t ha^{-1} DH) and T_7(70% NPKS + 6 t ha^{-1} DH). The result demonstrated that the yield contributing characters, grain and straw yields were significantly influenced by the added fertilizers and manure. Application of 50% of NPKS fertilizers plus 10 t ha^{-1} dhaincha produced the highest grain yield (5085 kg ha^{-1}) which was identical to that obtained with 70% of NPKS with 6 t ha^{-1} dhaincha. In case of straw yield, the treatment T_7 (70% NPKS + 6 t ha^{-1} DH) produced the highest yield (5470 kg ha^{-1}) and the second highest straw yield (5250 kg ha^{-1}) was obtained from T_6 (50% NPKS + 10 t ha^{-1} DH) treatment. The grain yield increases over control and ranges between 15 to 76%. The treatments T_6 and T_7 resulted in higher nutrient use efficiency along with higher N, P, K and S uptake by the T. Aman rice. The application of inorganic fertilizer with manure influenced the nutrient concentration in rice grain and straw. The higher grain N, P, K and S concentrations were observed in the treatments where poultry manure and dhaincha were applied in combination with N P K fertilizers. Grain yield of T. Aman rice was positively correlated with number of effective tiller, plant height, panicle length, filled grains $panicle^{-1}$ and straw yield. The combined use of fertilizer and manure resulted in considerable improvement in soil fertility. The combined application of fertilizer and manure increased the % OC, total N, available P and available S in post harvest soils. The overall findings of this study indicate that the integrated use of fertilizer and manure should be encouraged to address the deteriorating soil fertility and increased crop yield of T. Aman rice.

CONTENTS

CONTENTS (Contd.)

CONTENTS (Contd.)

CONTENTS (Contd.)

LIST OF TABLE

LIST OF FIGURE

LIST OF APPENDICES

Chapter I
Introduction

CHAPTER I

INTRODUCTION

Depleted soil fertility is a major constrain to higher crop production in Bangladesh. The increasing land use intensity has resulted in a great exhaustion of nutrient in soils. The farmers of this country use on an average 102 kg nutrients ha^{-1} annually (70 kg N + 24 kg P + 6 kg K + 2 kg S and Zn) while the crop removal is about 200 kg ha^{-1} (Islam *et al.* 1994). Since fertile soil is the fundamental resource for higher crop production, its maintenance is a prerequisite for long-term sustainable crop production.

Soil organic matter is a key factor for sustainable soil fertility and crop productivity. Organic matter undergoes mineralization with the release of substantial quantities of N, P, and S and smaller amounts of micronutrients.

In Bangladesh, most of the cultivated soils have less then 1.5% organic matter while a good agricultural soil should contain at least 2% organic matter. 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 addition, rapid mineralization of soil organic matter occurs due to humid tropic climatic conditions of Bangladesh. Cycling of organic matter in soil is a pre–requisite for efficient cycling of nutrients. Unless due attention is paid to the improvement and maintenance of soil organic matter it may not be possible the goal to increase and sustained productivity of crop.

Soil organic matter improves the physicochemical properties of the soil and ultimately promotes crop production. Evidences from different AEZ,s of the country have shown a decrease in the content of organic matter by the range of 15 to 30% over the last 20 years (Miah, 1994). Therefore, it would not be wise to depend only on inherent potentials of soils for higher crop production. More recently, attention is focused on the global environmental problems; utilization of organic wastes, FYM, compost, vermicompost and poultry manures as the most effective measure for the purpose.

The application of different fertilizers and manures influences the physical and chemical properties of soil and enhance the biological activities of soil. The organic and chemical fertilizers are also positively correlated with soil porosity, enzymatic activity and CO_2 production. Organic matter stimulates soil biological activity. Organic fertilizer enhances soil porosity by increasing regular and irregular pores and causes a priming effect of native soil organic matter (Marinari, *et al.*, 2000).

Rice (*Oryza sativa* L.) intensively cultivated in Bangladesh covering about 80% of arable land. Unfortunately, the yield of rice in the countries like South Korea and Japan where the average yield is 7.00 and 6.22 t ha $^{-1}$, respectively (FAO, 1999). On the other hand, the demand for increasing rice production is mounting up to feed the ever-increasing population.

A suitable combination of organic and inorganic sources of nutrients is necessary for sustainable agriculture that can ensure food production with high quality. Nambiar (1991) views that integrated use of organic manure and chemical fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining better soil fertility. The long-term research of BARI revealed that the application of cowdung @ 5 t ha^{-1} year^{-1} improved rice productivity as well as prevented the soil resources from degradation (Bhuiyan, 1994). Poultry manure is another good source of nutrients in soil. Meelu and Singh (1991) showed that 4 t ha^{-1} poultry manure along with 60 kg N ha^{-1} as urea produce grain yield of crop similar to that with 120 kg N ha^{-1} as urea alone. Organic manure can supply a good amount of plant nutrients thus can contribute to crop yields. Thus, it is necessary to use fertilizer and manure in an integrated way in order to obtain sustainable crop yield without affecting soil fertility.

The integrated approach by using the organic and inorganic sources of nutrients helps improve the efficiency of nutrients. Mineralization and immobilization are biochemical in nature and are mediated through the activities of microorganisms. The rate and extent of mineralization determines crop availability of nutrients. The transformation of N, P and S in soil depends on the quality and quantity of organic matter as well as soil fertility and microbial activity.

Combined applications of both chemical and organic fertilizers need to be applied for the improvement of soil physical properties and supply of essential plant nutrients for high yield. Thus, it is necessary to carry out studies by using fertilizers and manures in an integrated way in order to obtain sustainable crop yield without affecting soil fertility.

Based on the soil fertility problem as discussed above, the present study was undertaken with the following objectives:

i) To develop a suitable combination of inorganic fertilizers and organic manures for T. Aman rice.

ii) To see any improvement in soil fertility due to use of organic manure and chemical fertilizers.

iii) To evaluate the effects different levels of inorganic fertilizers and organic manures on the yield and quality of T. Aman rice.

Chapter II
Review of Literature

CHAPTER II

REVIEW OF LITERATURE

An attempt has been made to present a brief and pertinent review of literature in this chapter. A better understanding of the effects of the nutrients supplied from manure and fertilizers on rice in our soils will obviously facilitate the development of some agronomic practice for production of crops. While reviewing the earlier work in the world, particularly attention has been paid to the integrated use of organic manure with chemical fertilizers for maintenance of soil fertility, yield, nutrient uptake and crop productivity in rice.

2.1 EFFECTS OF ORGANIC MANURE ON RICE

2.1.1 Farmyard manure (cowdung)

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}. Indulker and Malewar (1991) stated that application of 10 t ha^{-1} FYM alone produced grain yield of 2.19 t ha^{-1} and the untreated control gave 2.06 t ha^{-1}. Sharma and Mitra (1991) reported a significant increase in N, P and K uptake and also the nutritional status of soil with 5 t ha^{-1} of FYM of a rice based cropping system.

Kuppuswamy *et al.* (1992) conducted a field trial in 1998 at Annamalainagar, Tamil Nadu with rice cv. Subarea at transplanting and 10 kg N ha^{-1} at the tillering and panicle initiating stage gave the highest yield (2.90 t) among fertilizer treatments.

Kant and Kumar (1994) reported that the increasing rates of amendments with FYM increased the number o effective tillers per hill significantly, number of grain $panicle^{-1}$, weight of 1000 grains 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 per panicle and 4.5% weight of 1000 grains 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.

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

Thakur and Patel (1998) conducted field experiments during *kharif* season of 1993 and 1994 to study the effect of split application of 60 or 80 kg N ha^{-1} on growth, yield and nitrogen uptake by rice with and without 5 t FYM ha^{-1} and proposed that both N rates increased yields attributes, yield, plant N content and N uptakes of rice compared with N or application of FYM alone. N rates and use of split doses had no effect .The highest grain yield (3.84 t ha^{-1}) was recorded with the application of 80 kg N ha^{-1} in three split doses with 5 t ha^{-1} FYM during both the years, 60 kg N in three split doses with 5 t ha^{1} FYM gave 3.85 t grain ha^{-1}.

Mehla *et a*l. (1998) conducted field experiment in India from 1990-1996 on a Vertic Ustochrept soil using paddy cv. HKR 120 with four manure treatments. The manures increased the mean grain yield which was 6.98, 6.74, 6.16 and 5.43 t ha^{-1} in GM, FYM ash and control treatments respectively.

Gupta *et al.* (1999) conducted a field experiment 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}).

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

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

2.1.2 Poultry Manure

Calendacion *et al.* (1990) observed that the highest total yield was produced by rice following 220-70-70 kg NPK + 12 t poultry manure ha^{-1}. They concluded that rice and potatoes could be profitably grown in rotation. Application of poultry manure to potatoes improved soil fertility for the following rice crop.

Budhar *et al.* (1990) reported the effect of farm wastes on low land rice. They found that grain yield of IR-60 was the highest with application of poultry manure (6.63 t ha^{-1}) followed by *Sesbania rostrata* (6.64 t ha^{-1}) and the lowest with no manure application (5.17 t ha^{-1}). They also found that the plant height was significantly increased by the basal incorporation of farm wastes.

Govindasamy *et al.* (1994) reported that the use of poultry litter was more economical at high target yields of rice than 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 PM application on rice growth and grain yield quality. They reported that 5 ton fermented chicken manure ha^{-1} in rice field increased N content in rice.

Singh *et al.* (1996) carried out a field experiment in India where irrigated rice was given 60, 120 and 180 kg N ha^{-1} as poultry manure, urea and poultry manure + urea. In first year, poultry manure did not perform better then urea but in the third year, 120 and 150kg N as poultry manure produced significantly higher grain yields than the same rates as urea and poultry manure sustained the grain yield during the three years while the yield decreased with urea.

Laxmainarayana (2000) cited that application of 100% NPK + poultry manure @5 t ha^{-1} gave the highest grain (5.44 t ha^{-1}) and straw (13.19 t ha^{-1}) yields among the treatments and the lowest grain yield was in 100% N treated plot. Channabasavanna and Birandar (2001a) observed that the grain yield increased with each increment of poultry manure application and was maximum in 3-ton poultry manure ha^{-1}, which was 26 and 19% higher than that of the control during 1998 and 1999, respectively, and the increase was significant up to 2-ton poultry manure ha^{-1}.

Channabasavanna and Birandar (2001b) conducted a field experiment with four sources of organic manure (FYM 7 t ha^{-1}, rice husk 5 t ha^{-1}, poultry manure 2 t ha^{-1} and press mud 2 t ha^{-1}) with one control and 3 levels of Zn (0, 25 and 50 kg $ZnSO_4$ ha^{-1}). Application of poultry manure with 25 kg $ZnSO_4$ ha^{-1} recorded significantly higher yield over rest of the treatments. The residual effect was more prominent when rice husk was applied. They also cited that organic manure increased panicle $hill^{-1}$ and seeds $panicle^{-1}$.

2.1.3 Dhaincha

Anand Swarup *et al.*(2000) conducted field experiments in Haryana, India, and showed that continuous use of fertilizers N and P significantly enhanced the yield of rice. The maximum yield was obtained with 100% NPK + GM (*Sesbania aculeata*) followed by 150% and 100% NPK +FYM.

Zaman *et al.* (1995 b) reported that the application of *Sesbania* @ of 5 t ha^{-1} (oven dry basis) once a year, prior to wet season planting, along with 140 kg urea N/ha/yr (80 kg for dry season and 60 kg for wet season) and recommended doses of P, K and S gave a yield of about 11t ha^{-1} yr^{-1} in a rice-rice cropping pattern on a moderate fertile soils. This practice allowed saving of 150 kg urea $ha^{-1}yr^{-1}$.

Hundal *et al.* (1992) stated that the contribution of GM to P nutrition of rice showed that fertilizer P addition increased dry matter production and P uptake by GM. Grain yield and P uptake by rice were highest in dhaincha plots followed by sun hemp.

Goswami *et al.* (1988) reported that manuring with *Sesbania aculeata* increased rice yield by 5 t ha^{-1}. They found 35.4% recovery of applied N from the rate of 60 kg N ha^{-1} as *Sesbania*. Green manuring increased rice yield by 1.00 t ha^{-1} in dry season and 0.5 t ha^{-1} in wet season as reported by Balasubramaniyan et al. (1989)

2.2 EFFECTS OF CHEMICAL FERTILIZERS ON RICE CROP

2.2.1 Nitrogen:

Andrade and Amorim Neto (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 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}).

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.

Islam and Bhuiya (1997) studied the effect of nitrogen and phosphorus on the growth, yield and nutrient uptake of deep-water rice. They observed that nitrogen and phosphorus fertilization significantly increased the number of fertile tiller m^{-2} and also that of grains $panicle^{-1}$, which in turn resulted in significant increase 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}.

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}).

Angayarkanni and Ravichandran (2001) conducted a field experiment in Tamil Nadu, India from July to October 1997 to determine the best split application of 150 kg N ha^{-1} for rice cv. IR20.They found that applying 16.66% of the recommended N as basal, followed by 33.33% N at 10 DAT, 25% N at 20 DAT and 25% N at 40 DAT recorded the highest grain (6189.4 kg ha^{-1}) and straw (8649.6 kg ha^{-1}) yields, response ratio (23.40) and agronomic efficiency (41.26).

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

2.2.2 Phosphorus

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} P. All treatments received 128-62-4.2 kg NKZn ha^{-1}. They observed that yield increased significantly up to 33 kg P ha^{-1} 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^{-1}.

Subba Rao *et al.* (1995) reported that phosphorus applied @50 mg P kg^{-1} soil as SSP increased the grain and straw yields significantly.

Chen Lijuan and Fan Xingming (1997) conducted a field experiment at Rice Research Institute of Yannan Agricultural University, Kunming on soils low in P and Zn using rice cultivars Xunza – 29, Hexi – 35 and Yungeng – 34 as test crop with 0, or 5 kg Zn ha^{-1} and 60, 150, or 200 kg P ha^{-1} and found that application of Zn and P significantly increased yield especially in Hexi – 35 and Yungeng – 34.

Ghosal *et al.* (1998) conducted a field experiment in Bihar on rice cv. Pankaj with 10–40 kg P ha^{-1} 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.

Sarkunan *et al.* (1998) conducted a pot experiment to find out the effect of P and S on yield of rice under flooded condition, on a P and S deficient sandy loam soil. They found increased yield with increasing level of P from 16.9 to 42.5 g pot^{-1}. Sulphur addition at 25 mg kg^{-1} resulted in 9% increase in grain yield. The treatment combination of 100 mg P and 10 mg S kg^{-1} soil gave significantly higher grain yield than other treatments.

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^{-1} 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.

2.2.3 Potassium

Haque (1992) worked with rice cv. BR 11 during August – December of 1988 without fertilizers, one with NPKS and Zn, fertilizers and one with each individual nutrient missing and proposed that grain yield ranged from 2.27 t ha^{-1} without fertilizers to 4.59 t ha^{-1} with all nutrients.

Prasad (1993) conducted a field experiment in Bihar, India and state that all crops responded significantly to K application in a K deficient calcareous soil. The magnitude of the response was higher in kharif crops particularly rice, groundnut and ragi (*Eleusine coracana*) than in *rabi* crops. Potassium uptake increased with increasing levels of potash application. Potassium uptake by different cropping sequence was in order: rice–wheat (221 kg ha^{-1}), sorghum–mustard (205 kg ha^{-1}), groundnut-oats (204 kg ha^{-1}) and ragi-lentil (181 kg ha^{-1}), respectively.

Chowdhury *et al.* (1994) conducted field experiment during dry and wet seasons with cv. BR 3 and BR 11 and observed that application of N, P, K and S from urea, TSP, MP and Gypsum, respectively gave similar grain yields of 5.6-5.7 t ha^{-1} in the wet season. Saleque *et al.* (1998) conducted six on farm trials on K deficient Barind soil of Bangladesh to evaluate the response of rice to K fertilizers and observed that application of 30 kg K ha^{-1}significantly increased grain yield at all the test locations. Potassium application increased K content only in the straw but not the grain.

Channadasppa *et al.* (1998) reported from a field experiment in 1993-1994 in Karnataka with rice cv. IR 64 that the split application of P and K did not significantly affect grain yield. Salton *et al.* (1999) reported that rice yield varied with soil test levels of P and K but not significantly affected by P and K fertilizers.

2.2.4 Sulphur

Rashid *et al.* (1992) reported that elemental S, produced rice yield o f 18, 9.2 and 5.8% more when applied at transplanting, 15 or 30days after transplanting, respectively. Kaunt and Kumar (1992) reported that the application of four soil amendments (gypsum, pyrite, pressmud and farmyard manure) significantly increased rice grain yield (11-26%) compared with control plots. The plots treated with gypsum gave significantly higher yields than those treated with pyrite followed by pressmud and farmyard manure. Islam and Hossain (1993) reported that the application of 20 kg S ha^{-1} with NPK significantly increased the grain yield of BR11 rice.

Hoque and Jahiruddin (1994) studied the effect of single and multiple applications of S and Zn in a continuous rice cropping system and noted that crop yields were increased by S (20 kg ha^{-1} as gypsum) and not generally by Zn. They also observed that although added gypsum had residual effect up to 3rd crop application in every crop produced comparatively higher grain yield of rice.

Akther *et al.* (1994) carried out field experiments on silty and sandy loam soils of farmer's field at four sites in Bangladesh. At one site S application increased grain yields and another site of S application decreased grain yields. There was no yield response to Zn application. At one site, 50 kg S + 5kg Zn ha^{-1} gave the highest grain yield (5.98 t ha^{-1}) compared to control yield of (4.61 t ha^{-1}) while at another site 25 kg S +10 kg Zn decreased grain yield.

Chowdhury *et al.* (1996) stated that application of Zn single or in combination with S increased the straw and grain yields of rice. They further reported the highest yield showing 33.6% increased over control which was obtained from the treatments, $Zn_{12}S_{45}$, Zn_8S_{45} and $Zn_{12}S_{30}$. Straw yield ranges from 5.1 t ha^{-1} in Zn_0S_0 treatment to 6.6 t ha^{-1} in $Zn_{12}S_{45}$ treatment.

Vaiyapuri and Sriramachandrasekharan (2001) conducted an experiment on integrated use of green manure (12.5 t ha^{-1}) with graded level of sulphur (0, 20, and 40 kg ha^{-1}) applied through three different sources in rice cv. ADT 37. They reported that the highest rice yield (5.3 t ha^{-1}) was obtained when green manure was applied along with pyrite 20 kg S ha^{-1}, which was comparable with pyrite applied at 40 kg ha^{-1} in the absence of green manure.

Peng *et al.* (2002) conducted a field experiment where one hundred and sixteen soil samples were collected from cultivated soils in Southeast Fujian, China. Field experiment showed that there were a different yield increasing efficiency by applying S at the doses of 20 - 60 kg ha^{-1} to of rice plant. The increasing rate of rice was 2.9-15.5%. A residual effect was also observed.

Sarfaraz *et al.* (2002) conducted a field experiment to determine the effect of different S fertilizer at 20 kg ha^{-1} on crop yield and composition of rice cv. Shaheen Basmati in Pakistan. They found that the number of tillers m^{-2}, 1000-grain weight, grain and straw yields were significantly increased with the application of NPK and S fertilizers compared to the control. They also found that NPK concentrations and their uptake in grain and straw significantly increased with the application of NPK + S fertilizers compared to the control.

Sen *et al.* (2002) reported that rice yield significantly increased with application of sulphur @30 kg ha^{-1}. Singh and Singh (2002) carried out a field experiment to see the effect of different S levels (0, 20 and 40 kg ha^{-1}) on rice cv. Swarna and PR-108 in Varanasi, Utter Pradesh, India. They reported that plant height, tillers m^{-2}, dry matter production, panicle length and grains $panicle^{-1}$ were significantly increased with increasing levels of S up to 40 kg ha^{-1}.

2.3 COMBINED EFFECTS OF ORGANIC MANURE AND CHEMICAL FRTILIZERS ON RICE

The concept of integrated nutrient management is the continuous improvement of soil productivity through appropriate use of fertilizers and organic manure including green manure. Considerable work has been done in India, China, Thailand, Philippines and other countries of the world with respect to the use of green manure (GM), poultry manure (PM) and farmyard manure (FYM) as alternative or supplementary sources of nutrients. In Bangladesh, only limited attempts have been made in this perspective.

Maskina *et al*. (1986) studied the effect of N application on wetland rice in a loamy sand soil amended with cattle manure (60 kg N ha^{-1}) or PM (80 kg N ha^{-1}). The absence of urea–N: PM increases the rice grain yield by 98%, which was 2.6 times higher than cattle manure (37%). Rice yield increased linearly with N rates whether or not the soil was amended with organic manure. Urea-N equivalent to cattle and PM varied from 21 to 53 kg ha^{-1} and 50 to 123 kg ha^{-1} respectively. Apparent recovery 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, organic manure like poultry manure is another good source of nutrient of soil. Experiments on the use and agronomic efficiency of poultry manure showed that 4 t ha^{-1} poultry manure along with 60 kg N ha^{-1} as urea produced grain yield of rice similar to that with 120 kg N ha^{-1} as urea alone (Meelu and Singh. 1991).

Maskina *et al*. (1986) conducted an experiment with different organic manure as a nitrogen source in rice wheat rotation. They observed that yield with poultry manure and 80 kg urea–N ha^{-1} were high as those were with 160 kg urea-N ha^{-1} alone. Yield with farmyard manure or pig manure and 80 kg fertilizers N ha^{-1} were equal to 120 kg N ha^{-1} fertilizer alone. They also reported that application of any one of the manure added to rice had residual effect equivalent to 30 kg N and 11 kg ha^{-1} in wheat.

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 (1995) 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. Flynn *et al.* (1995) studied the residual effect of broiler litter as a supplemental of mineral N and concluded that broiler litter applied in autumn at the rate of 9 t ha^{-1} reduced the mineral N from 44 kg to 22 kg ha^{-1}.

Gupta (1995) conducted field trial on different organic manure in India and reported that the application of field manure (10 t ha^{-1}) produced the highest grain yield (4.5 t ha^{-1}) followed by PM and FYM which produced yields of 4.1 and 3.9 t ha^{-1} of rice grain respectively. The increase in rice yield with organic manure was 34 to 55% higher over control and 5 to 22% higher over NPK fertilizers. Gupta *et al.* (1996) concluded that the rate of application of poultry manure could be reduced by 80 kg per ha of soil with the application of 1% poultry manure (PM). Organic C and available P contents of soil after harvest were increased with PM applications.

Singh *et al.* (1996) carried out a field experiment in India where irrigated rice was given 60, 80 or 120 kg N per ha per year as poultry manure, urea, poultry manure + urea respectively. In the first year, PM did not perform better than urea but in the fourth year, 120 g and 150 kg N as PM produced significantly higher grain yield than the same rate as urea. The PM help to sustain the grain yield of rice during the 3 years while the yield decreased with urea application

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 GM with or without cow dung 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 CD showed higher N, P, K, S, Zn uptake than that of NPKS (FRG) and NPK (FP) 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. *Sesbania*, cow dung) could be an efficient practice for ensuring higher crop yields without degradation of soil fertility.

Ali (1994) carried out several experiments on integrated nutrient management at different places of Bangladesh. They reported that when Boro rice received total chemical fertilizers followed by Aman rice receiving the same, the combined yield increase over the control was 96 and 86% for grain and straw, respectively. But these figures were 125 and 102% when Boro rice crop was fertilized with 100% chemical fertilizers + 5 t FYM ha^{-1} followed by Aman rice with only 100% chemical fertilizer.

Goshal *et al.* (1998) in an experiment with rice found increased grain and dry matter yield when inorganic N fertilizer (50 kg N ha^{-1}) was applied alone or when a combination of organic (10 t FYM ha^{-1}) and inorganic N fertilizer (25 kg N ha^{-1}) were applied as compared with organic sources (20 t FYM ha^{-1}) alone. Islam (1995) found a significant yield increased with fertilizer N + cowdung compared to fertilizer-N alone in T-Aman rice. In the following Boro rice yields with fertilizer-N + residual effect of cowdung were higher than the fertilizer N alone.

Hossain *et al.* (1997) conducted a field experiment to evaluate the effect of integrated nutrient management on rice cropping in Old Brahmaputra Floodplain soil and found that the grain yield of BR 11 rice increased significantly due to the application of fertilizer alone or in combination with manures over control.

Devi *et al.* (1997) conducted a field trail (1987-93) to develop a system for integrated nutrient supply for a rice-rice cropping sequence. Application of 45:45:45 kg NPK ha^{-1} as mineral fertilizers and 45 kg N ha^{-1} as FYM in the kharif seasons followed by 90:45:45 kg mineral NPK ha^{-1} in the rabi seasons gave the highest yields in all years expect 1993. When application of half of the N in the *kharif* season or crop residues or green manure gave the highest yield.

Mondal and Chettri (1998) conducted field experiment during 1991-93 in West Bangal, India to study integrated nutrient management for high productivity and fertility building under a rice based cropping system with application of S as ammonium sulfate along with green manure in suit and farmyard manure to rice only. The result showed maximum grain yields of rice (4.96 and 5.77 t ha^{-1}) in the wet and dry seasons, respectively.

Yadav (1998) conducted long-term fertilizer experiments on a rice-wheat cropping system at four locations in India. Long-term rice-wheat cropping system resulted in depletion of soil organic carbon and available N and P at two locations but increased in organic carbon, available N and K at the third location. The available P and K content of the soil also increased at the fourth location.

Singh *et al.* (1999) conducted field experiment during the rainy and winter seasons of 1990-91 to 1992-93 at Bari Bhag, Uttar Pradesh, India using recommended rates of N, P, K and Zn (120, 60, 40, 20 kg ha^{-1}) respectively, or 10 t ha^{-1} of FYM or rice straw 25 or 50% recommended rates (R.R) : N+RRP, K and Zn. Rice yield was the highest with FYM + S50 RRN, followed by the RRN, P, K and Zn.

Abedin Miah and Mosleahuddain (1999), conducted a long term fertility trail in Sonatala silt-loam soil at Bangladesh Agricultural University farm, Mymensingh to evaluate the effects of continued fertilization and manureing on soil properties and yield of crops. Grain yield of rice increased due to N, P, K and S application but the rate of increase varied in different seasons. Residual S showed remarkable decrease in the yield in Aman season. The yield of Aman showed a decreasing trend over the years but the yield of Aus remained almost static. The NPKSZn treatment maintained its superiority both in T-Aman and Aus rice although the performance of NFYM was very close to NPKSZn treatment. In general, the response of T-Aman to S containing treatments showed a decreasing trend over the years. The availability of P, S and Zn increased in soil due to long continued application. P fertilization also improved the micronutrient status of soil. No considerable changes in K status were noted due to K application. Nutrient balance study showed a severe loss of most of the nutrients through soil degradation.

Rajni Rani *et al.* (2001) conducted a pot experiment in a glass house of Varanasi, Utter Pradesh, India during *kharif* season to assess the response of rice to different combinations of vermicompost (VC), poultry manure (PM) and nitrogen fertilizers. Results showed that at integrated treatments significant increase in plant height, number of effective panicle over the treatment having full nitrogen dose through urea.

2.4 CHANGES IN SOIL FERTILITY AND PROPERTIES DUE TO INTIGRATED USE OF FERTILIZERS WITH MANURE

Organic materials are widely used to maintain soil fertility and improve soil properties in intensive cropping systems especially in traditional agriculture.

Studies at IRRI showed that the total N, exch. K and available P in soil increased by green manuring. The application of FYM increased organic C, total N, available P, Exch, K and CEC than GM (IRRI, 1979). Application of NPK at 100-150% based on the initial soil test showed appreciable improvement in available soil N, P, and K. Organic C content was maximum under FYM treatment. Depletion of P was highest under 100% treatment and K under 100% N and P treatment (Singh and Nambiar. 1984)

Prasad and Kerketta (1991) conducted an experiment to assess the soil fertility, crop production and nutrient removal under different cropping sequences in the presence of recommended doses of fertilizers and cultural practices along with 5 t ha $^{-1}$ compost applied to the crops. There was an overall increases in organic C, increase in total N, (83.9%), available N (69.9%), available P (117.3%) and CEC (37.7%).

Bhandari *et al.* (1992) reported that an application of fertilizers or their combined use with organic manure increased the organic C status of soil. The NPK fertilizers at 100% level and their combined use with organic N sources also increased the available N and P by 5.22 kg and 0.8-3.8 kg ha^{-1} from their initial values. Bair (1990) stated that sustainable production of crop can not be maintained by using chemical fertilizers only and similarly it is not possible to obtain higher crop yield by using organic manure alone. Sustainable crop production might be possible through the integrated use of organic manure and chemical fertilizers.

Nimbiar (1997 a) views that integrated use of organic manure and chemical fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining healthy soil fertility status.

Intensive crop production systems have witnessed serious problems associated with loss of soil fertility as a result of excessive soil mining of plant nutrients and consequently reduction in productivity. Application of external source of plant nutrients is a key element in optimal management of soil organic matter, crop residues and manure for ensuring the bio-availability, the cycling and the balance of nutrients in the soil - plant systems (Nambiar, 1997 b).

Meelu *et al.* (1992) reported that organic C and total N increased significantly when *sesbania* and *crotolaria* were applied in the preceded rice crop for two wet seasons. Nahar *et al.* (1995) had examined the soil condition after one crop cycle (rice-wheat). Addition of organic matter during the rice crop doubled the organic C content compared to its original status. Total and available N contents were also significantly improved by addition of organic matter, but had less impact on soil exchangeable cations.

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

More (1994) reported from 3-years study that application of 25 t ha^{-1} FYM + 20 t ha^{-1} press mud decreased the soil pH and increased organic matter content and available N, P and K in soil. Medhi *et al.* (1996) reported that incorporation of organic and inorganic sources of N increased soil solution NH_4-N to a peak and then declined to very low levels.

Palm *et al.* (1996) stated that organic materials influence nutrient availability nutrients added through mineralization – immobilization pattern as an energy sources for microbial activities and as precursors to soil organic matter and by reducing P sorption of the soil.

Mathew and Nair (1997) reported that cattle manure when applied alone or in combination with chemical fertilizer (NPK) increased the organic C content, total N, available P and K in rice soils. Sarker and Singh (1997) reported that organic fertilizers when applied alone or in combination with inorganic fertilizers increase the level of organic carbon in soil as well as the total N, P and K contents of soil.

Xu *et al.* (1997) observed that application of organic matters affect soil pH value as well as nutrient level. Ravankar *et al.* (1999) reported that organic carbon, total N and available P_2O_5, K_2O, S and Zn in the soil were higher in the plots where nutrients were applied through organics than the inorganic sources.

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

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

Chapter III

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

This chapter describes materials and methods of the experiment followed in the field and laboratory. This chapter presents a brief description on the location, climate, soil, crop, experimental design, treatments, cultural operation, collection of soil and plant samples and the methods followed for chemical and statistical analysis.

The experiment was carried out at the Sher-e-Bangla Agricultural University, Dhaka during the period from July to November 2007. The study was conducted to evaluate the effects of chemical fertilizers and organic manures on the yield and quality of BRRI dhan 33. The physical and chemical analysis of soil and chemical analysis of grain and straw were done in the Soil Science Laboratory, SAU and DU. The materials used and methods followed for the experiment have been described under the following section.

3.1 Experimental site and soil

The experiment was conducted in typical rice growing silt loam soil at the Sher-e-Bangla Agricultural University (SAU) farm, Sher-e-Bangla Nagar, Dhaka during the T. Aman season of 2007. The morphological, physical and chemical characteristics of the soil are shown in the Table 3.1 and 3.2.

3.2 Climate

The climate of the experimental area is characterized by high temperature, high humidity and medium rainfall with occasional gusty winds during the *kharif* season (March-September) and a scanty rainfall associated with moderately low temperature in the *rabi* season (October-February). The weather information regarding temperature, rainfall, relative humidity and sunshine hours prevailed at the experimental site during the cropping season July-November, 2007 have been presented in Appendices.

Table 3.1 Morphological characteristics of the experimental field

Morphology	Characteristics
Locality	SAU farm, Dhaka.
Agro-ecological zone (FAO and UNDP, 1988)	Madhupur Tract (AEZ 28)
General Soil Type	Deep Red Brown Terrace Soil
Parent material	Madhupur Terrace.
Topography	Fairly level
Drainage	Well drained
Flood level	Above flood level

Table 3.2 Initial physical and chemical characteristics of the soil

Characteristics	Value
Mechanical fractions: % Sand (0.2-0.02 mm) % Silt (0.02-0.002 mm) % Clay (<0.002 mm)	 22.26 56.72 20.75
Textural class	Silt Loam
Consistency	Granular and friable when dry.
pH (1: 2.5 soil- water)	6.2
CEC (cmol kg^{-1})	17.9
Organic C (%)	0.686
Organic Matter (%)	1.187
Total N (%)	0.032
Exchangeable K (cmol kg^{-1})	0.12
Available P (mg kg^{-1})	19.85
Available S (mg kg^{-1})	14.40

3.3 Planting material

BRRI dhan 33, a high yielding, most popular and recent variety of T. Aman rice was used in this experiment as the test crop. Bangladesh Rice Research Institute (BRRI) developed this variety in 1997. Genetic serial no. of this variety is BG 850-2, and life cycle ranges from 105-115 days. Heights of mature plants are 100 cm and do not lodge. The average grain yield of this variety generally lies between 5-5.5 t ha^{-1}.

3.4 Land preparation

The land was first opened on July 19, 2007 by a tractor and prepared thoroughly by ploughing and cross ploughing with a power tiller followed by country plough. Laddering helped breaking the clods and leveling the land followed every ploughing. Before transplanting each unit of plot was cleaned by removing the weeds, stubbles and crop residues. Finally each plot was prepared by puddling.

3.5 Experimental design and layout

The experiment was laid out in a randomized complete block design (RCBD), where the experimental area was divided into four blocks representing the replications to reduce soil heterogenetic effects. Each block was divided into eight unit plots as treatments with raised bunds around. Thus the total number of unit plot size was 2 m x 2 m and ailes separated plots from each other. The blocks were separated from one another by one-meter drain. Treatments were randomly distributed within the blocks. The layout of the experiment is presented in the Figure 3.1.

3.6 Initial soil sampling

Before land preparation, initial soil samples at 0-15 cm depth were collected from different spots of the experimental field. The composite soil sample were air-dried, crushed and passed through a 2-mm (8 meshes) sieve. After sieving, the soil samples were kept in a plastic container for physical and chemical analysis of the soil.

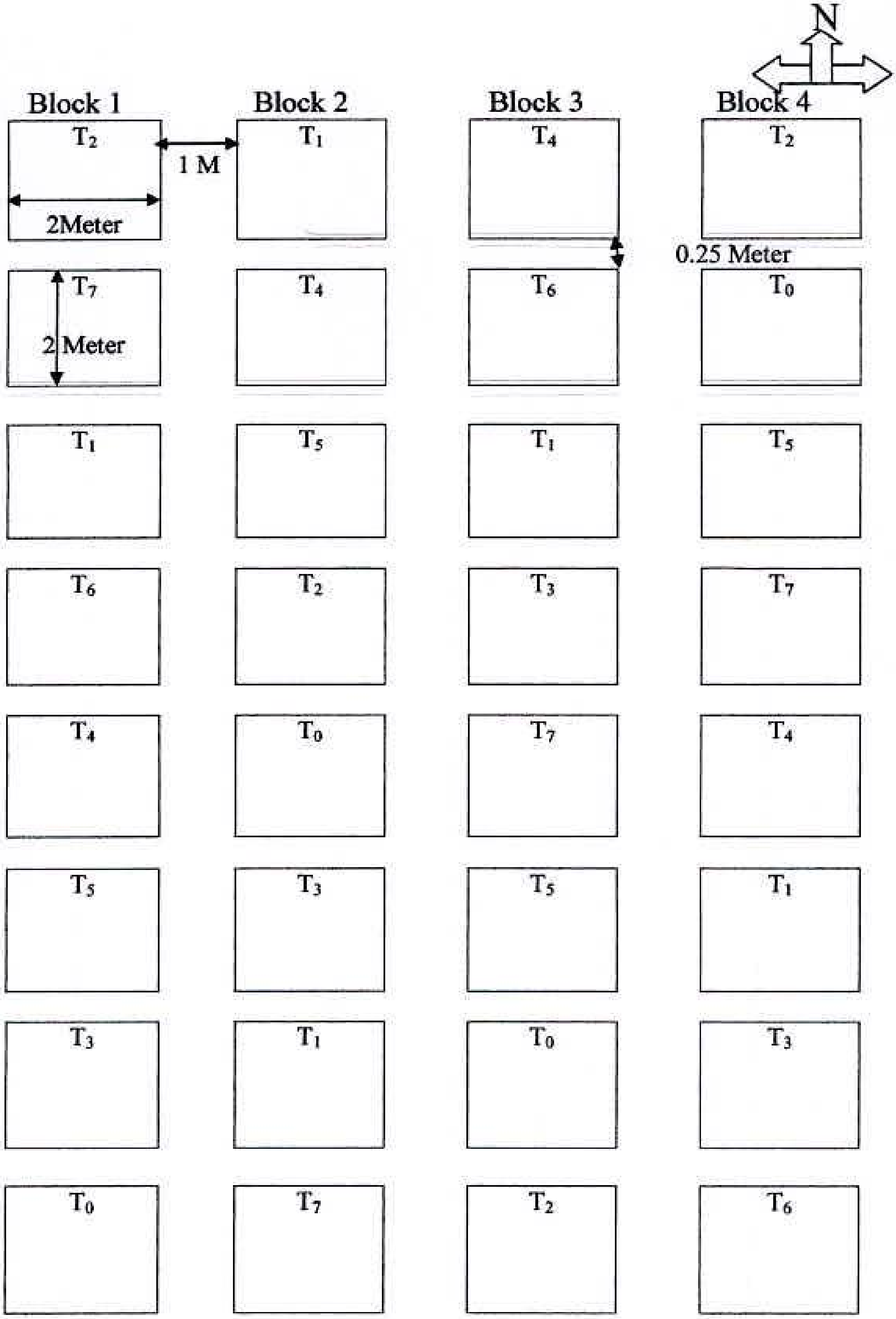


Figure 3.1: LAY OUT OF THE EXPERIMENT

3.7 Treatments

The fertilizer treatments used in the experiment was based on BARC Fertilizer Recommendation Guide, 2005. Three different types of organic manure (dhaincha, cowdung and poultry manure) were used in this study. The experiment consisted of 8 treatments, viz. control. 100% recommended dose of NPKS and 50% or 30% reduction of NPKS dose plus dhaincha (DH), cowdung (CD) and poultry manure (PM). The treatments were as follows:

T_0: Control

T_1: $N_{100}P_{15}K_{45}S_{20}$ (Recommended dose)

T_2: 50% NPKS + 5 t ha^{-1} CD

T_3: 70% NPKS + 3 t ha^{-1} CD

T_4: 50% NPKS + 4 t ha^{-1} PM

T_5: 70% NPKS + 2.4 t ha^{-1} PM

T_6: 50% NPKS + 10 t ha^{-1} DH

T_7: 70% NPKS + 6 t ha^{-1} DH

3.8 Fertilizer application

The amounts of N, P, K and S fertilizers required per plot were calculated as per the treatments. Full amounts of TSP, MP and gypsum were applied as basal dose before transplanting of rice seedlings. Urea were applied in 3 equal splits: one third was applied at basal before transplanting, one third at active tillering stage (30 DAT) and the remaining one third was applied at 5 days before panicle initiation stage (55 DAT).

3.9 Organic manure incorporation

Three different types of organic manure viz. dhaincha (DH), cowdung (CD) and poultry manure (PM) were used. The rates of manure were 10, 5 and 4 ton per ha for DH, CD and PM required per plot were calculated as per the treatments respectively. Dhaincha were applied before one week of final land preparation. Cowdung and poultry manures were applied before four days of final land preparation. Chemical compositions of the manures used have been presented in Table 3.3.

Table 3.3 Chemical compositions of the cowdung, poultry manure and dhaincha (Oven dry basis)

Sources of organic manure	Nutrient content					
	C (%)	N (%)	P (%)	K (%)	S (%)	C: N
Cowdung	36	1.48	0.29	0.75	0.21	24
Poultry manure	29	2.19	1.98	0.81	0.34	8
Dhaincha	46	2.95	0.26	1.56	0.24	15

3.10 Raising of seedlings

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

3.11 Transplanting

Forty days old seedlings of BRRI dhan 33 were carefully uprooted from the seedling nursery and transplanted on 31 July 2007 in well puddled plot. Two seedlings per hill were used following a spacing of 20 cm x 20 cm. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings whenever required.

3.12 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.

3.12.1 Irrigation

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

3.12.2 Weeding

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

3.12.3 Insect and pest control

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

3.13 Crop harvest

The crop was harvested at full maturity when 80-90% of the grains were turned into straw colored on 14 November 2007. The crop was cut at the ground level and plot wise crop was bundled separately and brought to the threshing floor.

3.14 Yield components

Ten representative plant hills from each plot were selected randomly for recording the yield contributing character. After harvest the following yield components were recorded:

- Plant height (cm)
- Panicle length (cm)
- Number of effective tiller $hill^{-1}$
- Number of filled grains $panicle^{-1}$
- 1000-grains weight (gm)
- Grain and straw yield (kg ha^{-1})

3.14.1 Plant height

The plant height was measured from the ground level to the top of the panicle. From each plot, plants of 10 hills were measured and averaged.

3.14.2 Panicle length

The measurement of panicle length was taken from basal node of the rachis to the apex of each panicle. Each observation was an average of 10 hills.

3.14.3 Number of effective tiller hill^{-1}

Ten hills were taken randomly from each plot and total numbers of effective tillers hill^{-1} were recorded.

3.14.4 Number of filled grains panicle^{-1}

Filled and unfilled grains per panicle were counted and averaged from the panicles of ten hills.

3.14.5 1000-grain weight

1000 grains were taken from the collected samples plot wise and the weight was recorded in an electrical balance after sun drying.

3.14.6 Grain and straw yields

The harvested crops was threshed, cleaned, dried and weighed carefully. Grain and straw yields were adjusted to 14% moisture content and expressed as kg ha^{-1}.

3.15 Post harvest soil sampling:

After harvest of crop soil samples were collected from each plot at a depth of 0 to 15 cm. Soil sample of each plot were 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.

3.16 Soil analysis

Soil samples were analyzed for both physical and chemical characteristics viz. organic matter, pH, total N and available P, K, and S contents. These results have been shown in the Table 4.6. The soil samples were analyzed by the following standard methods as follows:

3.16.1 Textural class

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

3.16.2 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 (Jackson, 1962).

3.16.3 Organic matter

Organic carbon in soil sample was determined by wet oxidation method of Walkley and Black (1935). The underlying principle was used to oxidize the organic matter with an excess of 1N $K_2Cr_20_7$ in presence of conc. H_2SO_4 and conc. H_3PO_4 and to titrate the excess $K_2Cr_20_7$ solution with 1N $FeSO_4$. To obtain the content of organic matter was calculated by multiplying the percent organic carbon by 1.73 (Van Bemmelen factor) and the results were expressed in percentage (Page *et al.* 1982).

3.16.4 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: $CuSO_4$. $5H_20$: Se in the ratio of 100: 10: 1), and 6 ml H_2SO_4 were added. The flasks were swirled and heated 200 ^{0}C and added 3 ml H_2O_2 and then heating at 360 ^{0}C 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) × N × 0.014 × 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

3.16.5 Available phosphorus

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

3.16.6 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).

3.16.7 Available sulphur

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

3.17 Chemical analysis of plant samples

3.17.1 Collection of plant samples

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

3.17.2 Preparation of plant samples

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

3.17.3 Digestion of plant samples with sulphuric acid for N

For the determination of nitrogen an amount of 0.2 g oven dry, ground sample were taken in a micro kjeldahl flask. 1.1 g catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se in the ratio of 100: 10: 1), and 5 ml conc. H_2SO_4 were added. The flasks were heating at 120 ^{0}C and added 2.5 ml 30% H_2O_2 then heated was continued at 180 ^{0}C 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 .

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

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

3.17.5 Determination of P, K and S from plant samples

3.17.5.1 Phosphorus

Phosphorus was digested from the plant sample (grain and straw) with 0.5 M $NaHCO_3$ solutions, pH 8.5 (Olsen *et al.*, 1954). 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).

3.17.5.2 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 absorbances were measured by atomic absorption flame photometer.

3.17.5.3 Sulphur

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

3.18 Nutrient Uptake

After chemical analysis of straw and grain samples the nutrient contents were calculated and from the value of nutrient contents, nutrient uptakes were also calculated by following formula:

Nutrient uptake = Nutrient content (%) x Yield (kg ha^{-1}) / 100

3.19 Statistical analysis

The data for every crop parameters and also for the nutrient concentration and nutrient uptake by the plant (grain and straw) were analyzed statistically by F-test to examine whether the treatment effects were significant or non-significant (Gomez and Gomez, 1984). The mean comparisons of the treatment were evaluated by DMRT (Duncan's Multiple Range Test).

Chapter IV
Results and Discussion

CHAPTER IV
RESULTS AND DISCUSSION

An attempt has been made to present a brief and pertinent review of literature in this chapter. A better understanding of the effects of the nutrients supplied from manure and fertilizers on rice in our soils will obviously facilitate the development of some agronomic practice for production of crops. While reviewing the earlier work in the world, particularly attention has been paid to the integrated use of organic manure with chemical fertilizers for maintenance of soil fertility, yield, and nutrient uptake and crop productivity in rice based cropping sequence.

4.1 Growth and yield contributing parameters

4.1.1 Plant height

The plant height of BRRI dhan 33 varied significantly in different treatments due to application of organic manure and chemical fertilizers (Table 4.1). It was revealed that all the treatments produced significantly taller plants compared to the control treatment. The plant height ranged from 98.50 to 104.88 cm and the highest value (104.88 cm) was noted in the treatment T_4 (50% NPKS + 4 t ha^{-1} poultry manure), which was statistically similar to those found in treatments T_2, T_3, T_6 and T_7 respectively. The lowest plant height (98.50 cm) was obtained in the treatment T_0 where no fertilizers were used. The combined application of fertilizers with manure increased the plant height compared to single application of recommended dose of fertilizers. Babu *et al.* (2001) observed that the plant height was significantly influenced by the application of organic manure and chemical fertilizers. Rajani Rani *et al.* (2001), Singh *et al.* (1999), Hossain *et al.* (1997) and Sharma and Mitra (1991) also observed similar results.

4.1.2 Panicle length

The panicle length of BRRI dhan 33 varied significantly by different treatments (Table 4.1). The panicle length ranged from 23.19 to 24.41 cm. The highest panicle length of 24.41 cm was observed in the treatment T_4 (50% NPKS+4 t ha^{-1} poultry manure). The lowest panicle length (23.19 cm) was recorded in the treatment T_0 where no fertilizer was used. The treatments of T_1, T_5, T_6 and T_7 produced statistically similar panicle length. The more increase of panicle length was observed in the single application of NPK fertilizers as compared to combined application of chemical fertilizers with cowdung or dhonicha. BRRI dhan 33 responded significantly better-combined application of 50% chemical fertilizers with organic manure. Haque (1999) and Azim (1999) noted a significant increase in panicle length due to the application of organic manure and chemical fertilizers. Babu *et al.* (2001), Ahmed and Rahman (1991) and Apostol (1989) also reported similar results.

4.1.3 Number of grains panicle^{-1}

The number of grains panicle^{-1} varied significantly due to different treatments under study that result shows in the table 4.1. The number of grains panicle^{-1} ranged from 84.2 to 106.1 and the highest value (106.1) was observed in the treatment T_7 (70% NPKS+ 6 t ha^{-1} dhaincha). It was observed that the number of grains panicle^{-1} did not vary significantly among the treatments T_0, T_1, T_3 and T_4. The lowest value (84.17) was obtained in the treatment T_2 where 5 t ha^{-1} cowdung was applied along with 50% NPKS fertilizers. Dhaincha manure applied in combination with NPKS fertilizer increased the number of grains panicle^{-1} of BRRI dhan 33 considerably compared to poultry manure and cowdung. The effect of manure on increasing the number of grains panicle^{-1} was more pronounced as compared to fertilizers. This might be due to more availability of nutrient from the manure. Grains panicle^{-1} significantly increased due to the application of organic manures and chemical fertilizers (Razzaque, 1996). These results are also in agreement with Hoque (1999) and Azim (1996).

4.1.4 Number of effective tillers hill^{-1}

The number of effective tillers hill^{-1} of BRRI dhan 33 significantly varied due to application of organic manure and chemical fertilizers. The number of effective tillers hill^{-1} due to different treatments ranged from 12.70 to 19.50 (Table 4.1). The treatment T_1 ($N_{100}P_{20}K_{45}S_{15}$) gave the highest number of effective tillers hill^{-1} where chemical fertilizers were applied at the recommended doses. The treatment T_6 and T_0 was statistically similar and T_7 was statistically identical with T_2. The lowest number of effective tillers hill^{-1} (12.7) was observed in the treatment T_3 (70% NPKS+3 t ha^{-1} cowdung). The lower number of effective tillers hill^{-1} also observed in the treatment T_4 (50% NPKS + 4 t ha^{-1} poultry manure) and T_5 (70% NPKS+2.4 t ha^{-1} PM). The superior effect of dhaincha in increasing the number of effective tillers hill^{-1} of BRRI dhan 33 over cowdung and poultry manure was noted. BRRI dhan 33 responded significantly better to chemical fertilizers when applied at the recommended doses than the manure when applied singly or combined application of 50% of manure and chemical fertilizers. Chander and Pandey (1996) reported a significant increase in effective tillers hill^{-1} due to application of higher doses of nitrogen.

4.1.5 1000-grain weight

Table 4.1 shows the effect of organic manure and chemical fertilizers on 1000-grain weight of BRRI dhan 33. The 1000-grain weight varied significantly due to different treatments. The 1000-grain weight ranged from 22.5 to 23.03 gm. The highest thousand grain weight of 23.03 gm was obtain in T_1 (Recommended dose) treatment which was statistically identical with all other treatments except T_0 and T_4. The lowest thousand-grain weight was recorded in T_0 (Control) treatment, which was statistically identical with T_4 treatment. Abedin *et al.* (1999) reported that the combined application of organic manure and chemical fertilizers increased the 1000-grain weight of rice. Apostol (1989) observed that application of organic manure and chemical fertilizer increased 1000-grain weight of rice. Hoque (1999) also recorded that

1000-grain weight were increased by the application of organic manure. Statistically similar thousand-grain-weight was observed in maximum treatments.

Table 4.1 Effect of organic manures and chemical fertilizers on different growth parameter of T. Aman rice (cv. BRRI dhan 33)

Treatments	Plant height (cm.)	Panicle length (cm.)	Number of grains panical^{-1}	Number of effective tiller hill^{-1}	1000-grain weight (gm.)
T_0 (Control)	98.50 c	23.19 b	89.2 cde	18.85 ab	22.57 b
T_1 (Recommended dose)	101.61 b	24.00 ab	92.3 bcd	19.50 a	23.04 a
T_2 (50%NPKS + 5 t ha^{-1} CD)	102.26 ab	23.13 b	84.9 e	17.70 bc	23.03 a
T_3 (70%NPKS + 3 t ha^{-1} CD)	103.11 ab	23.40 b	93.3 bc	12.70 e	23.00 a
T_4 (50%NPKS + 4 t ha^{-1} PM)	104.88 a	24.41 a	93.4 bc	14.70 d	22.62 b
T_5 (70% NPKS+2.4 t ha^{-1} PM)	101.79 b	23.58 ab	86.1 de	16.25 c	23.02 a
T_6 (50%NPKS +10 t ha^{-1} DH)	103.48 ab	23.66 ab	96.8 b	18.95 ab	23.01 a
T_7 (70%NPKS + 6 t ha^{-1} DH)	104.23 ab	23.96 ab	106.1 a	17.75 bc	23.00 a
SE (±)	0.6090	0.1867	1.5525	0.3615	0.0474
CV (%)	1.68	2.24	4.73	6.00	0.59

Means followed by the same latter (s) in the column are not statistically significant at 5% level in DMRT.

SE (±) = Standard error of mean

CV (%) = Coefficient of variation

CD = cowdung, PM = poultry manure, DH = dhaincha

Table 4.2 Effect of organic manure and chemical fertilizers on the grain and straw yield of T. Aman rice (cv. BRRI dhan 33)

Treatments	Grain		Straw	
	Yield (Kg ha^{-1})	Increase over control (%)	Yield (Kgha^{-1})	Increase over control (%)
T_0 (Control)	2895 d		3221d	
T_1 (Recommended dose)	4685 a	61.83	4777cd	48.30
T_2 (50%NPKS + 5 t ha^{-1} CD)	4105 b	41.80	5009 bc	55.52
T_3 (70%NPKS + 3 t ha^{-1} CD)	3325 c	14.85	4407 abc	36.82
T_4 (50%NPK + 4 t ha^{-1} PM)	3700 bc	27.81	4482 ab	39.15
T_5 (70%NPKS + 2.4 t ha^{-1} PM)	3850 b	33	4519 ab	40.30
T_6 (50%NPKS + 10 t ha^{-1} DH)	5085 a	75.65	5250 ab	63
T_7 (70%NPKS + 6 t ha^{-1} DH)	5080 a	75.47	5470 a	69.82
SE (±)	95.75	–	82.05	–
CV (%)	6.62	–	5.00	–

Means followed by the same latter (s) in the column are not statistically significant at 5% level in DMRT.

SE (±) = Standard error of mean

CV (%) = Coefficient of variation

CD = cowdung, PM = poultry manure, DH = dhaincha

4.2 Grain and straw yield of rice

4.2.1 Grain yield

The grain yield of BRRI dhan 33 varied significantly due to application of organic manure and chemical fertilizers (Table 4.2). All the treatments gave significantly higher grain yield over the control. The grain yield ranged from 2.89 ton to 5.08-ton ha^{-1}. The highest grain yield (5.09 ton ha^{-1}) was observed in the treatment T_6 (70% NPKS + 6 t ha^{-1} dhaincha) and the lowest value (2.89 ton ha^{-1}) was recorded in the treatment T_0 (control). The next higher grain yield (5.08 ton ha^{-1}) was observed in the treatment T_7 (70% NPKS+ 10 t ha^{-1} dhaincha) which was statistically identical with T_1 (Recommended dose). The treatment may be ranked in order of $T_6 > T_7 > T_1 > T_2 > T_5 > T_4 > T_3 > T_0$ in term of grain yields. The percent increase in grain yield over control ranged from 75.65 to 14.85%. Dhaicha manure when applied in combination with fertilizer NPKS exerted marked effect in increasing the grain yield of BRRI dhan 33 as compared to poultry manure and cowdung. It is noticed here that treatment T_3 (70% NPKS+3 t ha^{-1} cowdung) failed to produce the highest grain yield due to lodging. Dwivedi and Thakur (2000) reported the grain yield was significantly increased due to application of organic manure and chemical fertilizers. This is also in agreement with the findings of Rajni Rani *et al.* (2001), Haque *et al.* (2001), Ahmed and Rhaman (1991), Calendacion *et al.* (1990) and Laxminarayan (2000).

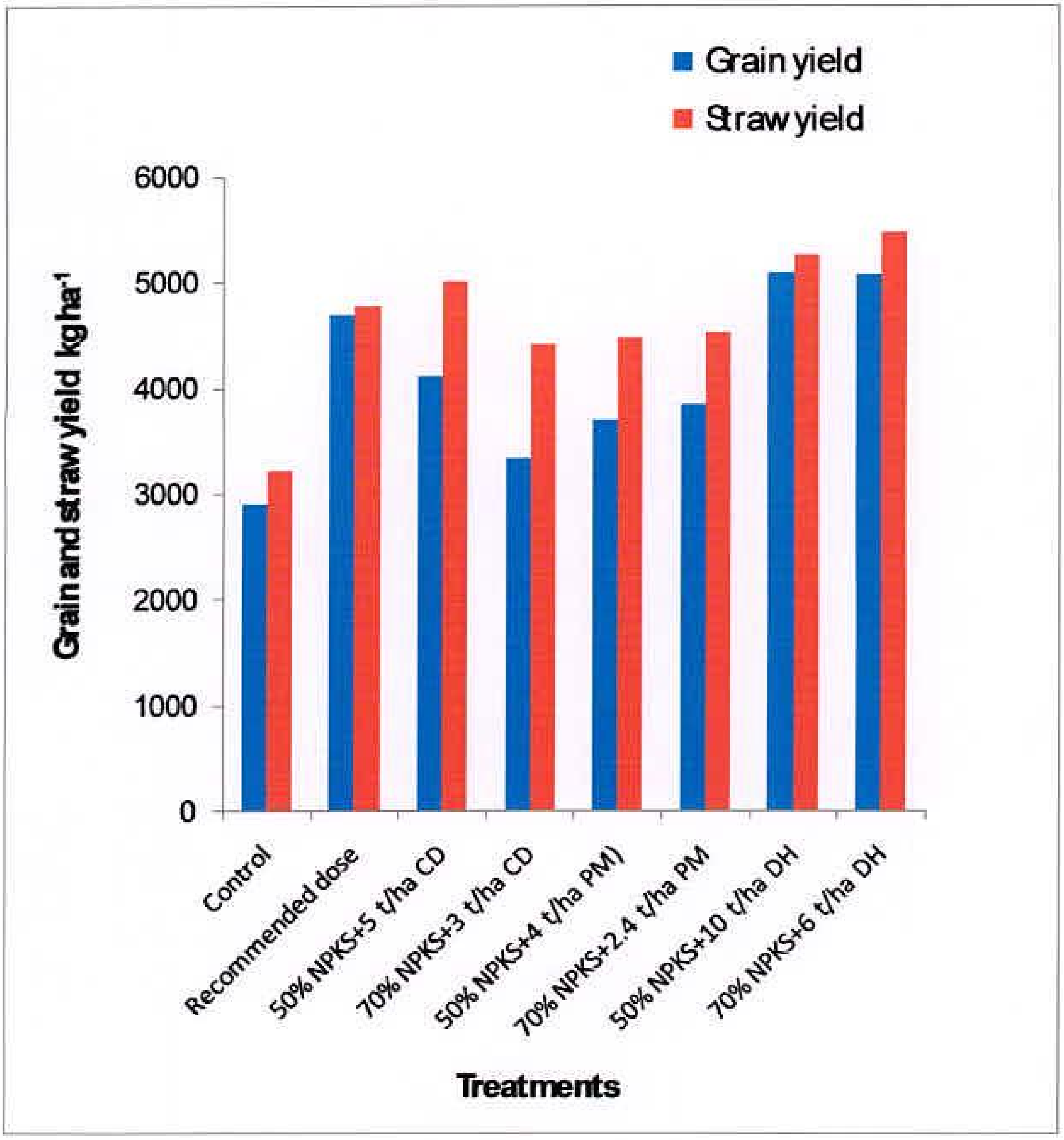


Figure 4.1: Integrated use of manure and fertilizers on grain and straw yield of T. Aamn rice (cv. BRRI dhan 33)

4.2.2 Straw yield

Straw yield of BRRI dhan 33 also varied significantly by different treatments under study. The yields of straw ranged from 3221 kg to 5470 kg ha^{-1}. The highest straw yield (5470 kg ha^{-1}) was obtained in the treatment T_7 (70% NPKS+ 6 t ha^{-1} dhaincha) and the lowest value (3221 kg ha^{-1}) was noted in the treatment T_0 (Control). The next highest straw yield (5250 kg ha^{-1}) was observed in the combined use of 50% NPKS fertilizers and 10 t ha^{-1} dhaincha manure treatment T_6, which was statistically comparable with treatments T_5 and T_4 respectively. The treatments may be ranked in order of $T_7>T_6>T_2>T_1>T_5>T_4>T_3>T_0$ in terms of straw yield. The percent increase in straw yield range from 69.82 to 36.82 % in different treatments over the control. Dhaincha and poultry manure exerted comparatively better effect in producing higher straw yields as compared to cowdung and poultry manure. Ahmed and Rahman (1991) reported that the application of organic manure and chemical fertilizers increased the straw yields of rice. These findings are well corroborated with the work of Islam (1997) and Khan (1998). It is clear that organic manure in combination with inorganic fertilizers encouraged vegetative growth of plants and thereby increasing straw yield.

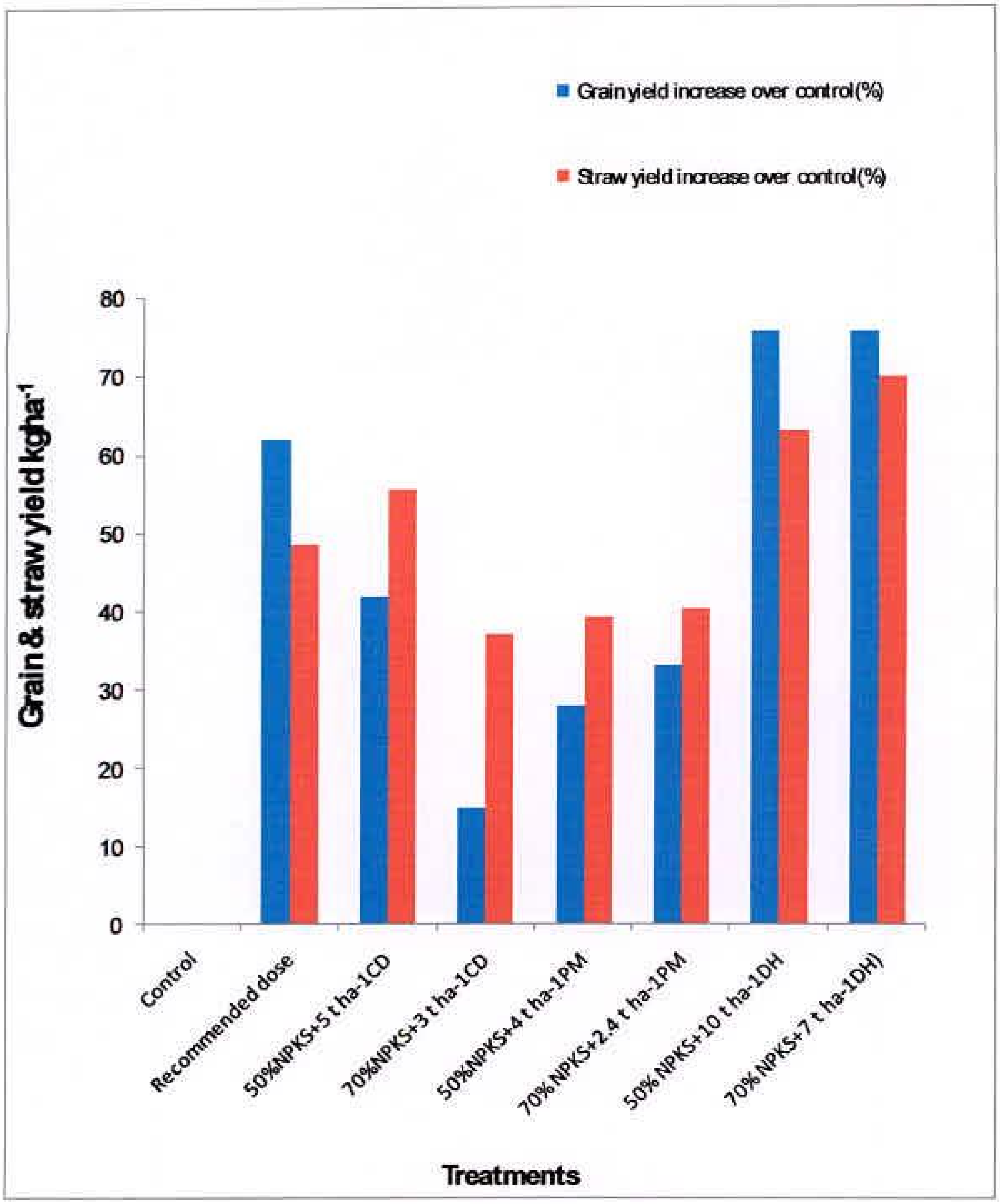


Figure 4.2 Grain and Straw yields of T. Aman rice (cv.BRRI dhan 33) increase over control by different treatment

4.2.3 Correlation of yield components with grain and straw yields

Grain yield of a crop is a complex character, which results from interactions of many characters. Grain yield was positively correlated with number of effective tillers, plant height, panicle length and filled grains panicle^{-1}. Similarly straw yield was positively correlated with plant height (r=0.86 **) and panicle length(r=0.42).

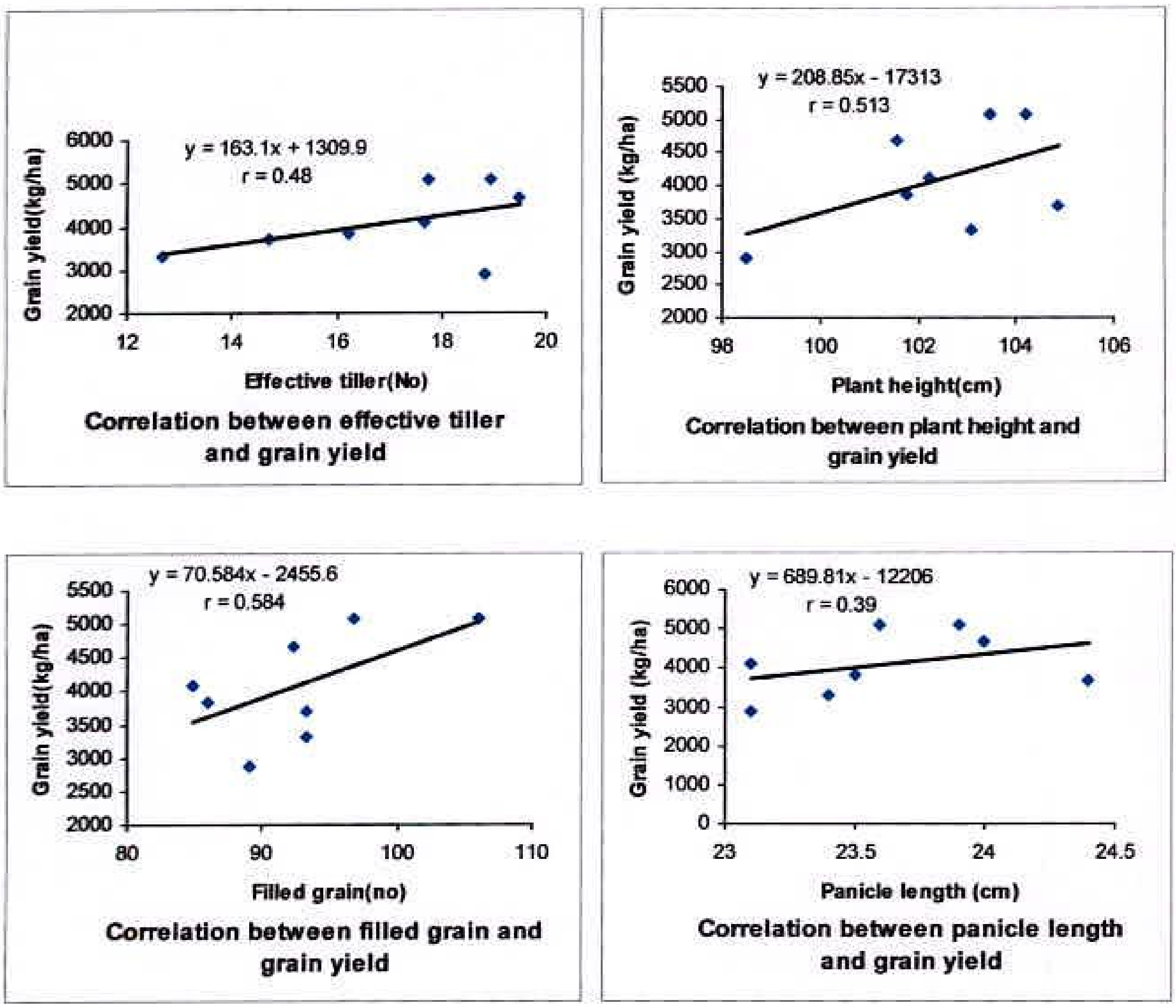


Figure 4.3 Correlation between grains yields with yield components of rice

4.3 Nutrient concentration in rice grain and straw of rice

The grain and straw sample of rice were analyzed for estimating N, P, K and S contents. The results of N, P, K and S contents of grain and straw have been discussed under the following sub section.

4.3.1 Nitrogen content

The nitrogen content in rice grain varied significantly by the deferent treatments (Table 4.3). The N content in rice grain ranged from 1.12 to 1.26%. The highest N content (1.26%) in rice grain was observed in the treatment T_1 ($N_{120}P_{20}K_{45}S_{15}$) due to application of recommended doses of chemical fertilizers and the lowest N content in grain (1.12%) was noted in T_5 treatment where 2.4 t ha^{-1} poultry manure and 70% NPKS fertilizers was applied. The effect of 10 t ha^{-1} dhaincha manure application in combination with 50% NPKS fertilizers (T_6 treatment) was more pronounced in increasing the N content in rice grain of BRRI dhan 33 as compared to cowdung and poultry manure which was the next highest grain N concentration and statistically identical with treatment T_7 (70% NPKS+ 6 t ha^{-1} dhaincha) and statistically comparable with all other higher treatments. Application of chemical fertilizers increased the N content in rice grain markedly.

In rice straw the N content varied significantly due to different treatments (Table 4.3). The N content in rice straw ranged from 0.665 to 0.849%. The highest N content (0.849%) in rice grain was observed in the treatment T_1 ($N_{120}P_{20}K_{45}S_{15}$) due to application of chemical fertilizers at the recommended doses and the lowest N content in grain (0.665%) was noted in treatment T_0 (Control). The next highest N concentration in straw of BRRI dhan 33 was observed at 3 t ha^{-1} cowdung application in combination with 70% NPKS fertilizers (T_3 treatment) which was more pronounced as compared to poultry manure and was statistically comparable with all other treatment T_7 (70% NPKS+ 6 t ha^{-1} dhaincha) except T_0 and T_2.

BRRI dhan 33 responded significantly better when organic manure was added in combination with chemical fertilizers and organic manure then applied singly chemical fertilizers. The results revealed that N content in rice grain was higher than that of straw. A significant increase in N content in rice grain and straw due to the application of organic manure and fertilizers have been reported by many investigators (Verma, 1991; Jeong *et al.* (1996); Azim, 1999 and Hoque, 1999).

4.3.2 Phosphorus content

The phosphorus content in rice grain varied significantly due to the different treatments (Table 4.3). Phosphorus content in rice grain ranged from 0.202 to 0.290%. The highest P content (0.290%) in grain was observed in the treatment T_5 (70% NPKS+2.4 t ha^{-1} poultry manure) and the lowest P concentration was noted in the treatment T_0 (Control). The next highest P content in rice grain was found in the treatment T_4 (50%NPKS+ 4 t ha^{-1} poultry manure). Lower grain P content was observed in the treatments those received NPKS fertilizers with cowdung compared to those obtained with 100% NPKS and NPKS fertilizers with poultry manure and dhaincha.

In rice straw the P content varied significantly due to different treatments (Table 4.3). The P content in rice straw ranged from 0.053 to 0.078%. The highest P content (0.078%) in rice straw was recorded in the treatment T_5(70%NPKS+2.4 t ha^{-1} poultry manure) and the lowest P concentration was noted in the treatment T_0(Control). The next highest P content in rice straw was found in the treatment T_4 (50%NPKS+ 4 t ha^{-1} poultry manure).

Application of poultry manure in combination with NPKS fertilizers caused pronounced effect in increasing the P content in rice grain and straw as compared to cowdung and dhaincha manure. Gupta *et al.* (1995) stated that the concentration of P in rice tissue at different stages increased with the application of P and/or poultry manure. An increase in P contents both in rice grain and straw due to the application of poultry manure and chemical fertilizers was reported by many investigators (Razzaque, 1996; Azim, 1999 and Hoque, 1999). Verma (1991) also reported that incorporation of organic manure significantly increased the concentration of P in rice grain and straw.

Table 4.3: Effects of different treatments on N, P, K and S concentrations in grain and straw of T-Aman rice (BRRI dhan 33)

Treatments	Concentration (%)							
	Grain				Straw			
	N	P	K	S	N	P	K	S
T_0 (Control)	1.120 b	0.202 g	0.256 g	0.063 f	0.665 c	0.053 e	1.580 g	0.052 e
$T_1(N_{100}P_{20}K_{45}S_{15})$	1.260 a	0.280 d	0.323 c	0.114 b	0.849 a	0.058 d	2.120 d	0.072 cd
T_2 (50%NPKS+5 t ha^{-1} CD)	1.146 b	0.253 f	0.315 e	0.084 e	0.726b c	0.065 c	1.960 f	0.073 cd
T_3 (70%NPKS+3 t ha^{-1} CD)	1.164 b	0.255 f	0.303 f	0.092 d	0.787 ab	0.073 b	2.052 e	0.076 bcd
T_4 (50%NPKS+4 t ha^{-1} PM)	1.138 b	0.285 b	0.314 e	0.113 b	0.761 b	0.075 ab	2.230 b	0.072 d
T_5 (70%NPKS+2.4 t ha^{-1} PM)	1.120 b	0.290 a	0.336 b	0.116 a	0.770 b	0.078 a	2.250 a	0.077 bc
T_6 (50%NPKS+10 t ha^{-1} DH)	1.208 ab	0.271 e	0.317 d	0.115 b	0.779 b	0.057 dc	2.052 e	0.079 ab
T_7 (70%NPKS+6 t ha^{-1} DH)	1.190 ab	0.282 c	0.341 a	0.105 c	0.779 b	0.063 c	2.145 c	0.083 a
SE (±)	0.0200	0.0006	0.0006	0.0062	0.0148	0.0006	0.0060	0.0003
CV (%)	4.48	0.66	0.58	17.59	5.46	2.62	0.82	0.002

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

SE (±) = Standard error of means

CV (%) = Coefficient of variation

CD = Cowdung, PM = Poultry manure, DH = Dhaincha

4.3.3 Potassium content

The Potassium content in rice grain varied significantly due to the different treatments (Table 4.3). Potassium content in rice grain ranged from 0.256 to 0.341%. The highest Potassium content (0.341 %) in grain was observed in the treatment T_7 (70%NPKS+6t ha^{-1} dhaincha manure) that was significantly higher than the rest of the treatments and the lowest Potassium concentration was noted in the treatment T_0 (Control). The next highest Potassium content in rice grain was found in the treatment T_5 (70%NPKS+2.4 t ha^{-1} poultry manure).

In rice straw the Potassium content varied significantly due to different treatments (Table 4.3). The K content in rice straw ranged from 1.580 to 2.250%. The highest K content (2.250%) in rice straw was recorded in the treatment T_5 (70%NPKS+2.4 t ha^{-1} poultry manure) and the lowest K concentration was noted in the treatment T_0 (Control). The next highest Potassium content in rice straw was found in the treatment T_4 (50%NPKS+ 4 t ha^{-1} poultry manure).

The increasing Potassium content in both grain and straw was more pronounced by poultry manure and dhaincha compared to cowdung. From the results, it was observed that the Potassium content in rice straw was higher than those in grain in all the treatments. Potassium contents both in grain and straw of rice increased due to application of organic and chemical fertilizers (Islam, 1997 and Khan, 1998). Sing *et al.* (2001) also revealed that Potassium content in grain and straw were increased due to combined application of organic manure and chemical fertilizers.

4.3.4 Sulphur content

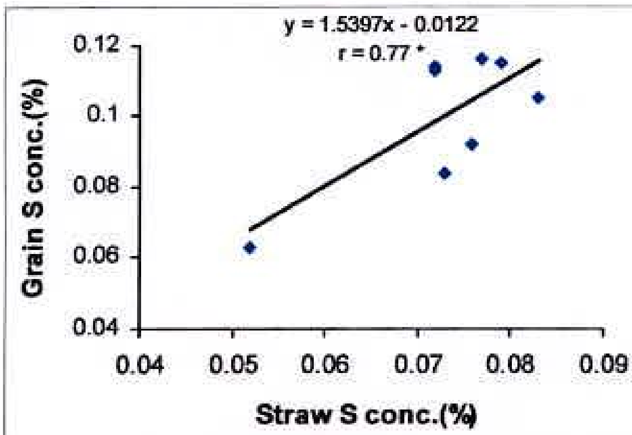
The sulphur content in rice grain varied significantly due to the different treatments (Table 4.3). Sulphur content in rice grain ranged from 0.063 to 0.116%. The highest sulphur content (0.116 %) in grain was observed in the treatment T_5 (70%NPKS+2.4 t ha^{-1} poultry manure), and the lowest S concentration was noted in the treatment T_0 (Control). The next highest sulphur content in rice grain was found in the treatment T_6 (50% NPKS+10 t ha^{-1} dhaincha) that was statistically identical with T_1 ($N_{100}P_{20}K_{45}S_{15}$) and T_5 (70%NPKS+2.4 t ha^{-1} PM) respectively.

In rice straw the sulphur content varied significantly due to different treatments (Table 4.3). The S content in rice straw ranged from 0.052 to 0.083%. The highest sulphur content (0.083%) in rice straw was recorded in the treatment T_7 (70%NPKS+6 t ha^{-1} dhaincha manure) and the lowest sulphur concentration was noted in the treatment T_0 (Control). The next highest S content in rice straw was found in the treatment T_6 (50% NPKS+10 t ha^{-1} dhincha).

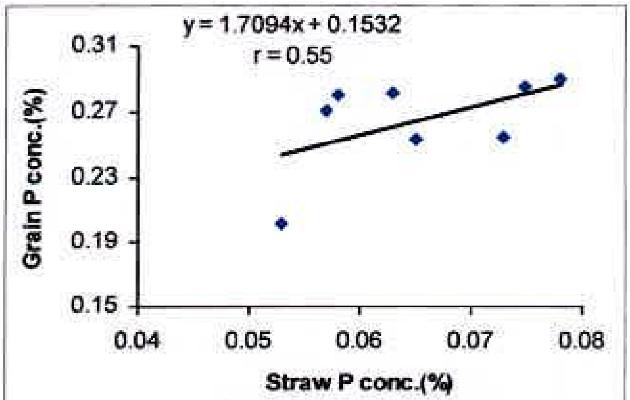
Sulphur content in grain was slightly higher than that of straw. Poultry manure and dhaincha influenced greatly in increasing the S content in rice grain compared to cowdung when applied with chemical fertilizers. The straw sulphur concentration was more increased in poultry manure with chemical fertilizer treatment compared to single chemical fertilizer and other combined application of organic and inorganic fertilizer treatments. Azim (1999) and Hoque (1999) reported that application of sulphur from manure and fertilizers increased S content both in grain and straw. Hossain (1996) also reported the similar results.

4.3.5 Correlation of straw nutrient and grain nutrient.

There was a strong correlation observed between straw S vs grain S and straw P vs grain P. Similar significant relationship was observed between straw K and grain K (r=0.89 **).



Correlation between straw S and grain S conc.



Correlation between straw P and grain P conc.

Figure 4.4 Relationship between straw nutrient and grain nutrient

4.4 Nutrient uptake by grain and straw of rice

The uptake of N, P, K and S were calculated from the yields (kg ha^{-1}) and nutrient concentration (%) of grain and straw. The results of N, P, K and S uptake by grain and straw of BRRI dhan 33 are presented and discussed below:

4.4.1 Nitrogen uptake

Table 4.4 indicate that the results of nitrogen uptake both by rice grain and straw of BRRI dhan 33 varied significantly due to application of organic manure and chemical fertilizers. The N uptake by rice grain ranged from 32.07 to 64.79 kg ha^{-1} and in straw ranged from 21.74 to 43.14 kg ha^{-1}. The highest Nitrogen uptake by grain (64.82 kg ha^{-1}) and by straw (44.80kg ha^{-1}) were recorded both in the treatment T_1 (Recommended dose) which was statistically comparable with treatments T_6(50% NPKS+10 t ha^{-1} dhaincha) and T_7(70%NPKS+6t ha^{-1} dhaincha manure). The lowest N uptake in rice grain (32.07 kg ha^{-1}) and straw (21.74 kg ha^{-1}) were recorded in the treatment T_0 (Control). The reason for the higher N uptake was mainly due to the higher grain and straw yields of rice.

The total N uptake (Table 4.4) both by rice grain and straw varied significantly with different treatments. The total nitrogen uptake ranged from 53.85 to 109.62 kg ha^{-1} (Table 4.4 and Fig 4.5). The highest total N uptake (109.62 kg ha^{-1}) was recorded in the treatment T_1 and the lowest value (53.81 kg ha^{-1}) was observed in the treatment T_0 (Control). This result shows that the total N uptake by grain and straw were more influenced due to combined application of dhaincha manure with chemical fertilizers. Sengar *et al.* (2000) reported that the N uptake by rice grain and straw increased significantly with the combined application of organic manure and chemical fertilizers. Rahman (2001); Duhan *et al.* (2002); Azim (1999) and Hoque (1999) also reported similar results. A linear relationship between grain yield and N uptake was obtained which have been presented in Figure 4.5.

4.4.2 Phosphorus uptake

Table 4.4 indicate that the results of P uptake both by rice grain and straw of BRRI dhan 33 varied significantly due to application of organic manure and chemical fertilizers. The P uptake by rice grain ranged from 5.86 to 15.05 kg ha^{-1} and in straw ranged from 1.67 to 3.58 kg ha^{-1}. The highest phosphorus uptake by grain (15.05 kg ha^{-1}) and by straw (3.58 kg ha^{-1}) were recorded in the treatment T_7 (70%NPKS + 6t ha^{-1} dhaincha manure) and T_5 (70%NPKS + 2.4 t ha^{-1}PM) respectively. The lowest P uptake by rice grain (5.86 kg ha^{-1}) and straw (1.67 kg ha^{-1}) were recorded in the treatment T_0 (Control).

The total P uptake both by rice grain and straw varied significantly with different treatments. The total phosphorus uptake ranged from 7.53 to 18.46 kg ha^{-1} (Table 4.4 and Fig 4.5). The highest total P uptake (18.46 kg ha^{-1}) was recorded in the treatment T_7 (70%NPKS + 6 t ha^{-1} dhaincha manure) and the lowest value (7.53 kg ha^{-1}) was observed in the treatment T_0 (Control). This result shows that the total P uptake by grain and straw were more influenced due to application of organic manure with chemical fertilizers. Sengar *et al.* (2000) observed that the highest P uptake by rice grain was recorded with the combined application of organic manure and phosphatic fertilizers. Similar results were also obtained by Gupta *et al.* (1995).

Table 4.4 Nitrogen and Phosphorus uptake by grain and straw of T.Aman rice (cv. BRRI dhan 33) as influenced by use of organic manure and chemical fertilizers at different treatments

Treatments	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})		
	Grain	Straw	Total	Grain	Straw	Total
T_0 (Control)	32.07 d	21.78 d	53.85 d	5.86 f	1.67 e	7.53 f
T_1 (Recommended dose)	64.82 a	44.80 a	109.62 a	13.98 b	2.83 d	16.81 b
T_2 (50%NPKS + 5 t ha^{-1} CD)	47.05 b	39 bc	86.05 b	10.24 d	3.29 abc	13.53 d
T_3 (70%NPKS + 3 t ha^{-1} CD)	41.92 c	35.14 c	77.06 c	8.54 e	3.16 bc	11.70 e
T_4 (50% NPKS + 4 t ha^{-1} PM)	42.61 bc	35.48 c	78.09 c	10.45 d	3.28 abc	13.73 d
T_5 (70%NPKS + 2.4 t ha^{-1}PM)	44.94 bc	37.19 c	82.13 bc	11.40 c	3.58 a	14.98 d
T_6 (50% NPKS + 10t ha^{-1} DH)	64.79 a	41.82 ab	106.61 a	14.20 ab	3.04 cd	17.24 b
T_7 (70% NPKS + 6 t ha^{-1} DH)	61.49 a	43.14 a	104.6 a	15.05 a	3.41 ab	18.64 a
SE (±)	1.033	0.944	1.514	0.224	0.066	0.282
CV (%)	5.85	7.16	4.91	5.65	6.23	5.61

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

SE (±) = Standard error of means

CV (%) = Coefficient of variation

CD = cowdung, PM = poultry manure, DH = dhaincha

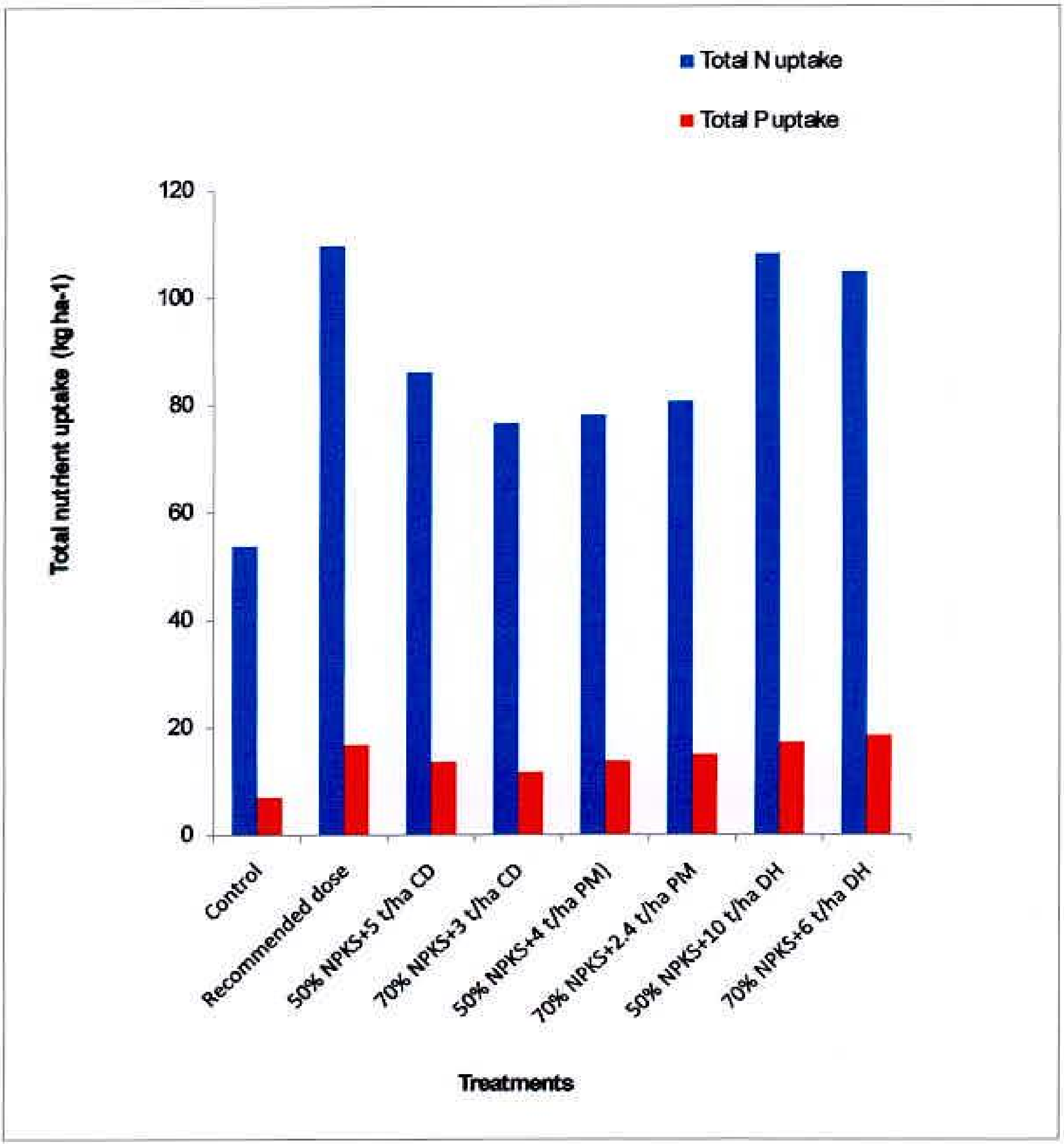


Figure 4.5 Total N and P uptake by grain and straw of T. Aman rice (cv. BRRI dhan 33) as influenced by the combined use of fertilizers and manure.

4.4.3 Potassium uptake

Table 4.5 indicate that the results of K uptake both by rice grain and straw of BRRI dhan 33 varied significantly due to application of organic manure and chemical fertilizers. The K uptake by rice grain ranged from 7.46 to 18.17 kg ha^{-1} and in straw ranged from 50.37 to 115.93 kg ha^{-1}. The highest Potassium uptake by grain (18.17 kg ha^{-1}) and by straw (115.93 kg ha^{-1}) was recorded in the treatment T_7 (70%NPKS + 6t ha^{-1} dhaincha manure). The lowest K uptake in rice grain (7.46 kg ha^{-1}) and straw (50.37 kg ha^{-1}) were recorded in the treatment T_0 (Control).

The total K uptake both by rice grain and straw varied significantly with different treatments. The total K ranged from 57.83 to 134.10 kg ha^{-1} (Table 4.5 and Fig 4.6-). The highest total K uptake (134.10 kg ha^{-1}) was recorded in the treatment T_7 (70%NPKS + 6 t ha^{-1} dhaincha manure) and the lowest value (57.83 kg ha^{-1}) was observed in the treatment T_0 (Control). This result shows that the total K uptake by grain and straw were more influenced due to application of organic manure in combination with chemical fertilizers. Sengar *et al.* (2000) reported that application of chemical fertilizer and organic manure significantly increased the K uptake by rice. Similar results were also found by Sharma and Mitra (1991), Cassman (1995), Azim (1996) and Hoque (1999).

4.4.4 Sulphur uptake

Table 4.5 indicate that the results of S uptake both by rice grain and straw of BRRI dhan 33 varied significantly due to application of organic manure and chemical fertilizers. The S uptake by rice grain ranged from 1.84 to 7.38 kg ha^{-1} and in straw ranged from 1.65 to 4.46 kg ha^{-1}. The highest S uptake by grain (7.38 kg ha^{-1}) and by straw (4.46 kg ha^{-1}) was recorded in the treatment T_6 (50% NPKS + 10 t ha^{-1} dhincha) and T_7 (70%NPKS + 6t ha^{-1} dhaincha manure) respectively. The lowest S uptake in rice grain (1.84 kg ha^{-1}) and straw (1.65 kg ha^{-1}) were recorded by the treatment T_0 (Control).

The total S uptake both by rice grain and straw varied significantly with different treatments. The total S ranged from 3.49 to 11.58 kg ha^{-1} (Table 4.5 and Fig. 4.6). The highest total S uptake (11.58 kg ha^{-1}) was recorded in the treatment T_6 (50% NPKS + 10 t ha^{-1} dhincha) and the lowest value (3.49 kg ha^{-1}) was observed in the treatment T_0 (Control). This result shows that the total S uptake by grain and straw were more influenced due to application of dhaincha manure with chemical fertilizers. Dhaincha manure provides better effect in increasing the S uptake by BRRI dhan 33 as compared to cowdung and poultry manure. Poongothai *et al.* (1999) observed that application of sulphur enhanced significantly S uptake by rice. Azim (1999) and Hoque (1999) recorded the higher uptake of S with the application of manure and fertilizers either alone or in combinations. Similar results were also reported by Sengar *et al.* (2000) and Rahman (2001).

Table 4.5 Potassium and Sulphur uptake by grain and straw of T.Aaman rice (cv. BRRI dhan 33) as influenced by use of organic manure and chemical fertilizers at different treatments

Treatments	K uptake (kg ha^{-1})			S uptake (kg ha^{-1})		
	Grain	Straw	Total	Grain	Straw	Total
T_0 (Control)	7.46 f	50.37 e	57.83 f	1.84 d	1.65 e	3.49 e
T_1 (Recommended dose)	16.63 b	103.09 bc	119.72 bc	5.76 ab	3.48 bc	9.24 bc
T_2 (50%NPKS+5 t ha^{-1} CD)	12.74 cd	99.01 c	111.75 cd	3.44 cd	3.71 b	7.15 d
T_3 (70%NPKS+3 t ha^{-1} CD)	10.17 e	88.76 d	98.93 e	3.11 cd	3.27 cd	6.38 d
T_4 (50% NPKS+4 t ha^{-1} PM)	11.51 d	97.43 c	108.94 d	4.15 bc	3.12 d	7.27 d
T_5 (70%NPKS+2.4 t ha^{-1}PM)	13.08 c	102.84 bc	115.92 cd	4.60 bc	3.51 bc	8.11 cd
T_6 (50% NPKS+10t ha^{-1} DH)	16.65 b	109.07 ab	125.72 b	7.38 a	4.20 a	11.58 a
T_7 (70% NPKS+6 t ha^{-1} DH)	18.17 a	115.93 a	134.10 a	5.51 b	4.46 a	9.97 ab
SE (±)	0.296	2.52	1.94	0.405	0.065	0.422
CV (%)	6.13	5.27	5.04	25.65	5.37	15.13

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

SE (±) = Standard error of means

CV (%) = Coefficient of variation

CD = cowdung, PM = poultry manure, DH = dhaincha

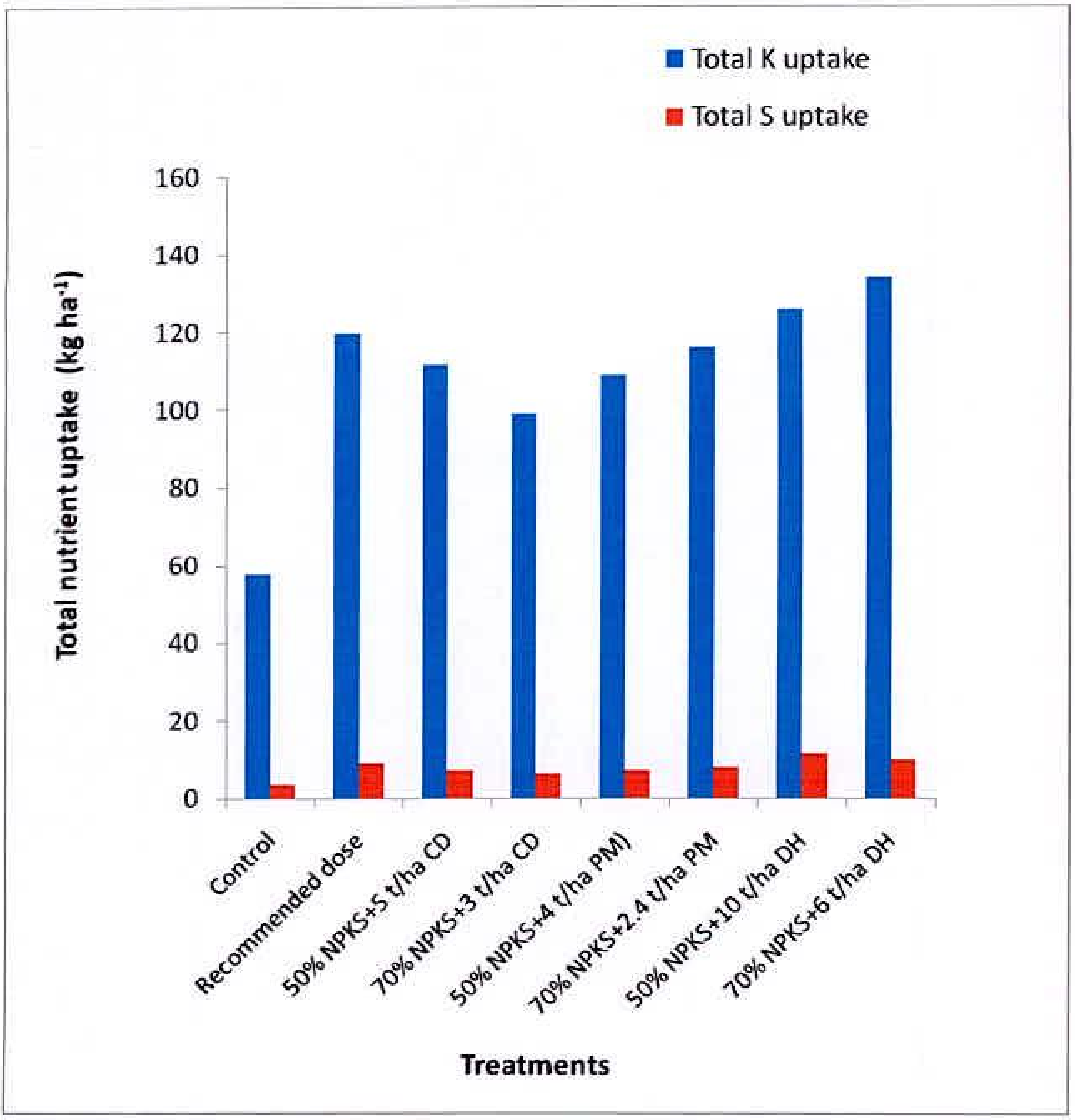


Figure 4.6 Total K and S uptake by grain and straw of T. Aman rice (cv. BRRI dhan 33) as influenced by the combined use of fertilizers and manure.

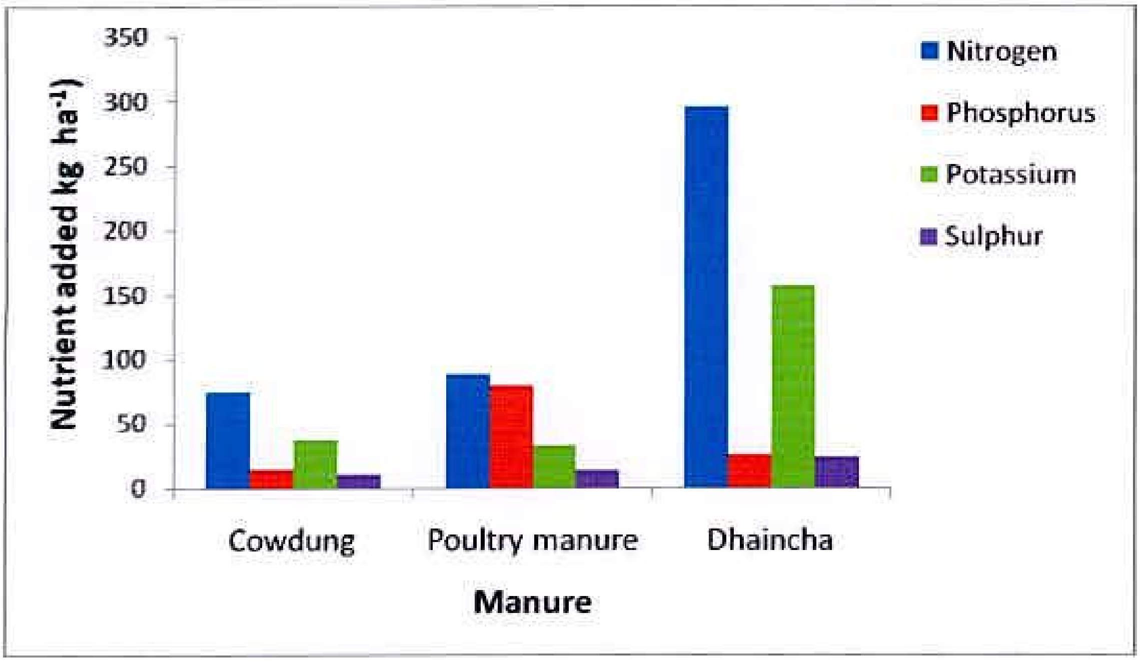


Figure 4.7 Amount of nutrients added to soil from various manures

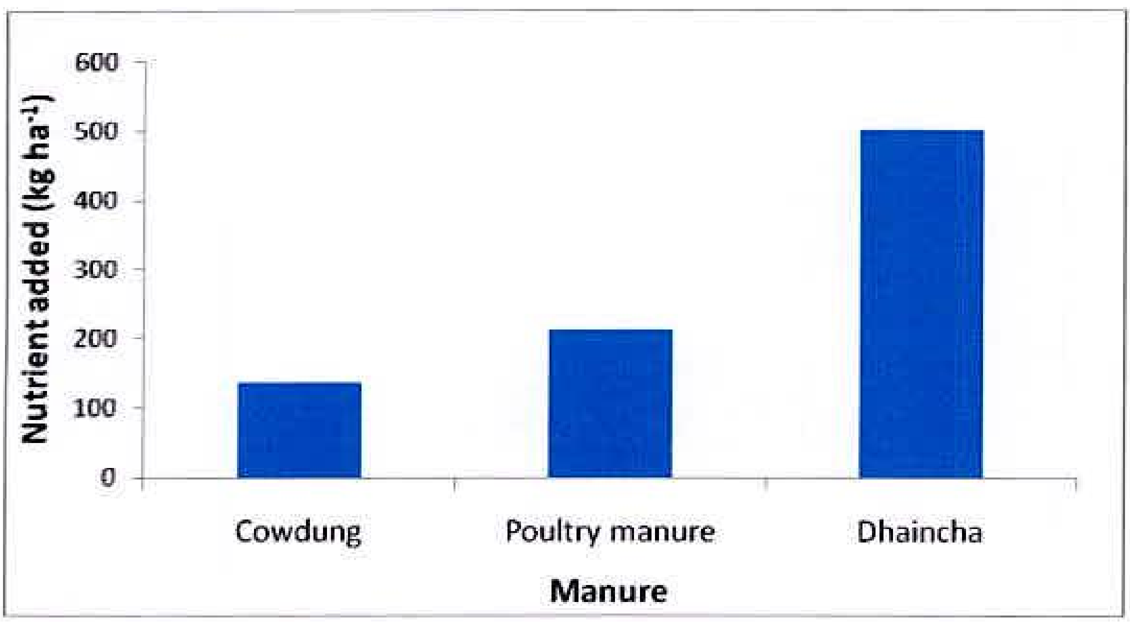


Figure 4.8 Total amounts of nutrients (N+P+K+S) added to soil from various manures

4.5 Effects of organic manure and chemical fertilizers on soil properties

4.5.1 Soil pH

Application of organic manure and chemical fertilizers caused a decreasing effect on the pH of the post harvest soil (Table 4.6). All the treatment slightly decreased the soil pH as compared to initial soil. The pH value of post harvest soils ranged from 5.7 to 6.1 against pH value of 6.2 of the initial soil sample. The decreasing effect was more where no fertilizer was applied. The lowest value of pH (5.70) was observed in the treatment T_0 (Control), and the highest value (6.05) was recorded in T_4 (50%NPKS+4 t ha^{-1} poultry manure). A decreasing trend in the pH values of the post harvest soils might be due to the organic acids released from the decomposition of organic manure, crop residue and the acidic effect of sulphur fertilizers. Bharadwaj and Tyagi (1994) reported that the soil pH reduce due to the application of FYM plus pressmud. Similar results were also observed by Islam (1997), Khan (1998) and Swarup and Singh (1994).

4.5.2 Organic matter content

Table 4.6 reveals that the organic matter content of the post harvest soils ranged from 1.180 to 1.449%. The organic matter of initial soil was 1.187%. It was observed that organic matter content tended to increase in the soils treated with organic manure while the soils treated with chemical fertilizers caused a decreasing effect. Application of organic manure resulted in an increased organic matter content of post harvest soils as compared to the initial soil. The increasing organic matter content might be due to the addition of biomass through manuring. The highest value of 1.449% organic matter content in soil was observed in the treatment T_5 (70% NPKS+2.4 t ha^{-1} poultry manure) and the lowest value was obtained in the treatment T_2 (50% NPKS+5 t ha^{-1} cowdung). Zhang *et al.* (1996) showed that the combined application of organic manure and chemical fertilizers increased organic matter content in soil. Organic carbon also increased due to application of organic manure as reported by Haque *et al.* (2001); Mathew and Nair (1997); Azim (1999) and Hoque (1999).

4.5.3 Total Nitrogen

The total N contents of the post-harvest soils varied considerably by different treatments (Table 4.6). The total N content of the post-harvest soils ranged from 0.025 to 0.053% as compared to the value of 0.032% of the initial soil. The highest value (0.053%) was observed in the treatment T_6 (50% NPKS+10 t ha^{-1}dhaincha) and lowest value was found in the treatment T_0 (Control). The result indicates that application of organic manure exerted an increasing effect on the total N content of the post harvest soils although the increase was insignificant. Rice cultivation with chemical fertilizers tended a decreasing effect on the organic matter and total N content of the soil. Gao and Chang (1996) and Mathew and Nair (1997) reported that the application of organic manure increased the total N content in soil. Several workers reported that organic manure had a positive influenced on total and available N content of soil. Similar were also observed by Razzaque (1996); Hoque (1999) and Azim (1999).

4.5.4 Available Phosphorous

Available phosphorous contents of the post-harvest soils varied considerably by the application of organic manure and chemical fertilizers (Table 4.6). Available phosphorous content in soil ranged from 17.43 to 24.35 ppm against the P value of 19.85 ppm in the initial soil. The highest P content (24.348ppm) were recorded in the treatment T_2 (50% NPKS + 5 t ha^{-1} cowdung) and treatments T_3 (70% NPKS + 3 t ha^{-1} cowdung) having lowest P content (17.43 ppm). There was a little decrease in available P content in the soil treated with chemical fertilizers. The release of more available P from the decomposition of poultry manure and cowdung might be the cause of higher values in soil treated with organic manure than that of chemical fertilizers. Gupta *et al.* (1996) reported that organic carbon and available P content in the post harvest soil were increased by poultry manure application. Similar results were also found by Zhang *et al.* (1996); Mathew and Nair (1997); Hoque (1999) and Azim (1999).

4.5.5 Exchangeable Potassium

Exchangeable potassium content of the post-harvest soils varied considerably due to the application of organic manure and chemical fertilizers (Table 4.6). The exchangeable K content in post-harvest soils ranged from 0.097 to 0.156 m. eq. per 100g against the K value of 0.12 m.eq.per 100g in the initial soil. The highest value of exchangeable K was noted in the treatment T_7 (70% NPKS + 6 t ha^{-1} dhaincha) and the lowest (0.097 m. eq. per 100g) was observed in the treatment T_0 (Control). Results in table 4.6 also indicate that exchangeable K content was higher in soils treated with organic manure than those treated with organic fertilizers. Zhang *et al.* (1996) reported that the combined application of poultry manure with chemical fertilizer increased exchangeable K content in soil. Mathew and Nair (1997) observed that application of cattle manure increased the exchangeable K content in soil. Similar results were also reported by Sharma and Sharma (1999); Hoque (1999) and Azim (1999).

4.5.6 Available sulphur

Available sulphur content of the post-harvest soil also varied considerably due to different treatments (Table 4.6). The available sulphur content of the initial soil was 14.4 ppm and values in the post-harvest soils ranged from 12.338 to 19.575 ppm. The highest available S content (19.575 ppm) was observed in the treatment T_5 (70% NPKS + 2.4 t ha^{-1}poultry manure) and lowest value was observed in the treatment T_0 (Control). The S content of the post-harvest soils was higher in soils treated with organic manure compared to the soils treated with the chemical fertilizers.

Hossain (1996) found that the combined use of the organic manure with NPKS improved the S status in soil. Shahidduzaman (1997) also found that the application of organic manure increase available S content in soil compared to application of chemicals fertilizers. Similar results were obtained by Hoque (1999) and Azim (1999).

Table 4.6 Effect of integrated use of organic manure and chemical fertilizers in the post-harvest soils

Treatments	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me %)	Available S (ppm)
T_0 (Control)	5.7 de	1.288 bc	0.025 f	19.92 b	0.097 f	12.338 g
T_1 (Recommended dose)	5.857 b	1.234 cd	0.050 ab	19.31 c	0.134 e	18.188 c
T_2 (50%NPKS+5 t ha^{-1} CD)	5.825 c	1.180 d	0.036 c	24.35 a	0.135 de	16.650 f
T_3 (70%NPKS+3 t ha^{-1} CD)	5.675 e	1.199 d	0.046 bc	17.60 d	0.140 cd	17.750 d
T_4 (50% NPKS+4 t ha^{-1} PM)	6.050 a	1.190 d	0.039 dc	17.43 d	0.147 b	17.550 c
T_5 (70%NPKS+2.4 t ha^{-1}PM)	5.70 de	1.449 a	0.043 cd	24.14 a	0.148 b	19.575 a
T_6 (50% NPKS+10t ha^{-1} DH)	5.750 d	1.303 bc	0.053 a	19.95b	0.141 c	17.775 d
T_7 (70% NPKS+6 t ha^{-1} DH)	5.80 c	1.329 b	0.050 ab	18.83 c	0.156 a	18.400 b
SE (±)	0.1294	4.04	17.89	2.01	2.11	0.54
CV (%)	3.13	0.0182	0.0027	0.1436	0.001	0.033
Initial Soil (Composite Sample)	6.2	1.187	0.032	19.85	0.12	14.4

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

SE (±) = Standard error of means

CV (%) = Coefficient of variation

CD = cowdung, PM = poultry manure, DH = dhaincha

Chapter V

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The study was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka during the Aman season (July-November) of 2007 to evaluate the effects of chemical fertilizers and organic manure in T.Aman rice (cv. BRRI dhan 33). The soil belongs to the Tejgaon soil series under the AEZ of Madhupur Tract (AEZ – 28). The soil texture was silt loam having pH 6.2, 0.032% total N, 19.9 ppm available P, 0.12 m. eq. per 100g exchangeable K, 14.4 ppm available S, 1.19% organic matter and CEC 17.9 m.e. per 100 g soil. The experiment was designed with eight treatments and laid out in Randomized Complete Block Design (RCBD) with four replications. The unit plot size was 2m × 2m and the total number of plots were 32. The treatments were T_0 (Control), T_1 (Recommended dose-$N_{100}P_{20}K_{45}S_{15}$), T_2 (50% NPKS + 5 t ha^{-1} CD), T_3 (70% NPKS+3 t ha^{-1} CD), T_4 (50% NPKS + 4 t ha^{-1} PM), T_5 (70% NPKS+2.4 t ha^{-1} PM), T_6 (50% NPKS+ 10 t ha^{-1} DH) and T_7 (70% NPKS + 6 t ha^{-1} DH). Dhaincha were applied before one week of final land preparation and well decomposed poultry manure and cowdung were incorporated into the plots four days before transplanting of rice seedling. Nitrogen, Phosphorus, Potassium and Sulphur were applied in different rates from Urea, TSP, MP and Gypsum, respectively. The seedlings of 40 days old were transplanted in the experimental plots on July 31, 2007. The intercultural operations were done as required. The crop was harvested on November 14, 2007 at full maturity. Ten hills were selected randomly from each plot to record the yield contributing characters. The grain and straw yields were recorded plot wise and expressed on 14% moisture basis. Grain and straw samples were analyzed for N, P, K and S contents. The post harvest soil samples were also analyzed to see the soil pH, organic matter, total N, available P, exchangeable K and available S contents. The data were analyzed statistically by

F-test to examine whether the treatment effects were significant and the mean comparisons of the treatments were evaluated by DMRT at p 5 ≤ %.

The study reveled that all the yield contributing characters except 1000-grain weight of BRRI dhan 33 were significantly influenced by the integrated use of chemical fertilizers and organic manure. The highest plant height, panicle length, number of grain panicle^{-1}, number of effective tillers hill^{-1} and 1000-grain weight were recorded in the treatment T_4, T_4, T_7, T_1 and T_1, respectively and the lowest was found in the control treatment. The grain and straw yields varied significantly due to the different treatments. The highest grain (5085 kg ha^{-1}) and straw (5470 kg ha^{-1}) yields were obtained in the treatments T_6 (50%NPKS+ 10 t ha^{-1} DH) and T_7 (70%NPKS+6 t ha^{-1} DH) respectively and the lowest grain yield (2895 kg ha^{-1}) and straw yields (3221 kg ha^{-1}) were observed in the treatment T_0. The grain yield was positively correlated with the number of effective tiller, plant height, panicle length and filled grains panicle^{-1} and 1000 grain weight. The grain and straw yields due to different treatments ranked in order of T_6>T_7 >T_1 >T_2 T_5>T_4>T_3>T_0 and T_7>T_5>T_6>T_4>T_3>T_2>T_1>T_0 respectively.

The highest N content in grain (1.26%) and straw (0.85%) were recorded in treatment T_1 (Recommended dose) treated plot and the lowest N content in grain (1.12%) and straw (0.665%) were found in the treatment T_5 (70%NPKS + 2.4 t ha^{-1} PM) and T_0 (Control) treated plot, respectively. The highest P content in grain (0.290%) and straw (0.078%) were observed in the treatment T_5 (70%NPKS + 2.4 t ha^{-1} PM) and the lowest P contents in grain (0.202%) and straw (0.053%) were found in the treatment T_0 (Control). Potassium content in grain and straw also significantly varied due to different treatments. The highest K contents in grain (0.341%) and straw (2.250%) were obtained in the treatments T_7 (70%NPKS + 6 t ha^{-1} DH) and T_5 (70%NPKS + 2.4 t ha^{-1} PM) treatments, respectively. The lowest K contents in grain (0.256%) and straw (1.580%) were found in the treatment T_0 (Control). It was found that K content in straw was higher than that in grain.

Organic manure performed better in increasing the K content both in grain and straw as compared to chemical fertilizers. Sulphur content both in rice grain and straw differed significantly by different treatments. The highest S contents in grain (0.116%) and straw (0.083%) were obtained in the treatment T_5 (70%NPKS + 2.4 t ha^{-1} PM) and T_7 (70%NPKS + 6 t ha^{-1} DH), respectively. The lowest S contents in grain (0.063%) and straw (0.052%) were found in the treatment T_0 (Control).

Nitrogen, phosphorus, potassium and sulphur uptake by rice (BRRI dhan 33) grain and straw were also affected significantly due to the various treatments. The highest total N uptake by grain (64.82 kg ha^{-1}) and straw (43.14 kg ha^{-1}) were found in the treatment T_1 (Recommended dose) and T_7 (70%NPKS + 6 t ha^{-1} DH), respectively. The lowest value of N uptake in grain (32.07 kg ha^{-1}) and straw (21.74 kg ha^{-1}) were observed in the treatment T_0 (Control). The highest total P uptake by grain (15.05 kg ha^{-1}) and straw (3.58 kg ha^{-1}) were found in the treatment T_7 (70%NPKS + 6 t ha^{-1} DH) and T_5 (70%NPKS+2.4 t ha^{-1} PM), respectively. The lowest value of P uptake in grain (5.86 kg ha^{-1}) and straw (1.67 kg ha^{-1}) were found in the treatment T_0 (Control). Potassium and sulphur uptake by BRRI dhan 33 was affected significantly due to the application of organic manure and chemical fertilizers. The highest total K uptake by grain (18.17 kg ha^{-1}) and straw (115.93 kg ha^{-1}) were found in the treatment T_7 (70%NPKS + 6 t ha^{-1} DH). The lowest value of K uptake in grain (7.46 kg ha^{-1}) and straw (50.37 kg ha^{-1}) were recorded in the treatment T_0 (Control). The highest total S uptake by grain (7.38 kg ha^{-1}) and straw (4.46 kg ha^{-1}) were found in the treatment T_6 (50%NPKS + 10 t ha^{-1} DH) and T_7 (70%NPKS + 6 t ha^{-1} DH) respectively. The lowest value of S uptake by grain (1.84 kg ha^{-1}) and straw (1.65 kg ha^{-1}) were recorded in the treatment T_0 (Control).

Application of organic manure and chemical fertilizers resulted in considerable influence on the properties of the post harvest soils. All the treatments slightly decreased the pH value as compared to the initial value (6.2).

Organic manuring increased the organic matter content, total N, available P, exchangeable K and available S in the post harvest soils.

From the present study it may be concluded that BRRI dhan 33 responded better to the nutrient supplied from the organic manure in producing grain and straw yields. The study clearly demonstrates that the benefit of using dhaincha as green manure can reduce the N, P, K and S fertilizers for T. Aman rice, giving good economic yield and also markedly increased the soil organic matter content particularly when the fertilizers were applied on soil test basis (STB). The higher nutrient concentrations were observed in grain and straw where chemical fertilizers were applied in combination with organic manure. BRRI dhan 33 can be cultivated profitably in the Tejgaon silt loam soil by using combined application of 50% NPKS fertilizers with 10 t ha^{-1} dhaincha.The overall findings of this study indicate that the combined use of fertilizer and manure in T. Aman rice should be encouraged for maintaining rice yield, quality and soil fertility.

References

REFERENCES

Abedin Miah , M.J. and Moshleuddin, A.Z.M. 1999. Soil Fertility Changes Under Different Cropping Pattern in Long-term Fertility Trials. BRRI-IRRI joint workshop on long-term experiments on Soil Fertility in Rice based Cropping Systems. Bangladesh Rice Researches Institute.8-11, March,1999.

Abedin, M.J., Rouf, M.A., Rashid, M.H. and Eaqub, M. 1999. Residual effects of TSP and Farmyard manure under renewed application of urea on the yield of crop and some chemical properties of soil. Bangladesh J. Agril. Sci. 10 (2): 100-109.

Adhikary, R.C. and Rahman, H. 1996. Effect of different doses of nitrogen on the yield of BR 11 variety of rice. In: Variety, Fertilizer and Weedicide Trial of some Field crops. Rural Development Academy, Bogra, 15-20.

Ahmed, M. and Rahman, S. 1991. Influence of organic matter on the yield and mineral nutrition of modern rice and soil properties. Bangladesh Rice J. 2(1-2): 107-112.

Akter, S., Ali, M.I., Jahiruddin, M., Ahmed, S. and Rahman, L. 1994. Main and interaction effects of sulphur and zinc on rice, Crop Res. India. 7(1): 1-7.

Alam, M.P., Singh, R.S. and Prasad, k. 1994. Integrated nutrient management in rice-wheat cropping sequence. J. Res. Birsa Agril. Univ. 6(2): 165-166.

Ali, M.I. 1994. Nutrient balance for sustainable Agriculture. Paper presented at the workshop on Integrated Nutrient Management for sustainable agriculture held at SRDI, Dhaka.

Anand Swarup, Yaduvanshi, N.P.S. and Swarup, A. 2000. Effect of integrated nutrient management on soil properties and yield of rice in alkali soils. J. Indian Soil Sci. 48(2): 279-282.

Andrade, W.E. and Amorim Neyo, S. 1996. Effect of nitrogen fertilizer application on yield and other characteristics of two cultivars of irrigated rice in the Northern region of Rio de Janeiro. Ciencia-e-Agrolecnologoa. 20(3): 293-300.

Angayarkanni, A. and Ravichandran, M. 2001. Judicious fertilizer N split for higher use efficiency in transplanted rice. Indian. J. Agric. Res. 35(4): 278-280.

Apostol, E.D.F. 1989. Influence of mirasoil organic and x-rice liquid fertilizer in combination with inorganic fertilizer on IR 66 and Bpiri 12 rice varieties. Malabon, Metro Manila, Philippines: 73.

Azim, S.M.A. 1996. Effect of sulphur, zinc and boron supplied from manure and fertilizers on BRRI 29. M.S. Thesis, Dept. Soil Sci., (Jan-June, 1999. Sem.), BAU, Mymensingh.

Babu, S., Marimuthu, R., Manivanna, V, and Ramesh-Kumer, S. 2001. Effect of organic and inorganic manures on growth and yield of rice. Agric. Sci. Digest. 21(4): 232-234.

Bair,W. 1990. Characterization of the environment for sustainable agriculture in semi arid tropic. In Proc.: Sustainable Agriculture : Issue. Perspective and prospect in Semiarid tropics. Singh .R.D.Ed, Hydrabad India. Indian Soc. Agron. 1: 90-128.

Balasubramaniyam, P., Palaniappan, S. P. and Francis, H. J. 1989. Effect of green manure and inorganic N in rice-rice cropping system. Intl. Rice Res. Newslett. 14(4).

Banerjee, R. M., Ali Kary, S. and Bagchi, D.K. 1992. Effect of different cultural practices on long duration Aman rice (*Orayza sativa*) in Bihar plateau. Indian J. Agron. 37(2): 346-347.

BARC (Bangladesh Agriculture Research Council). 1997. Fertilizer Recommendation Guide. Pub. No. 41. Bangladesh Agriculture Research Council, Dhaka, Bangladesh.

Bhardwaj, V. amd Tyagi, V.V. 1994.Impact of continuous manuring on rice crop yields and uptake of nitrogen, phosphorus and potassium. J. Potassium Res. 10(3): 290-293.

Bhandari, A.L., Sood, A., Sharma, K.N. and Rana, D.S., 1992. Integrated Nutrient Management in Rice-Wheat System. J. Indian Soc. Soil Sci.40: 742-747.

Bhattaria, S., Maskey, S.L.V. and Geller, K.E. 1992. Effect of different sources of GM on the yield of rice. In: Proc. 17th Natl. Crop Workshop. Held in 29-31. January. 1992.

Bhuiyan, N.I. 1994. Crop production trends and need of sustainability in agriculture. Paper presented at the workshop. Integrated Nutrient Management for Sustainable Agriculture held at SRDI, Dhaka, Bangladesh in June 26-28. 1994.

BINA (Bangladesh Institute of Nuclear Agriculture), 1996. Annul Report for 1993-94. BINA. P.O. Box No. 4, Mymensingh: 175.

Bouyoucos, G.J. 1926. Hydrometer method improved for making particle size analysis of soils. Agron. J. 54: 4661-4665.

Budhar, M.N., Palaniapan, S.P. and Rangasamy, A. 1991. Effect of farm wastes and green manures on low land rice. Indian J. Agron. 36(2): 251-252.

Calendacion, A.N., Garrity, D.P., Batusal, P.A., De-Datta, S.K and Datta, S.K. 1990. Increased productivity through a potato-wet seeded rice rotation cropping system. Philippines J. Crop. Sci. 15(2): 85-98.

Cassman, K.G. 1995. The influence of moisture regime, organic matter and root eco-physiology on the availability of potassium implication for tropical low land rice. Cited from Field Crop Abst. 1996. 49(7-10): 728.

Castro, R. and Sarker, A.B.S. 2000. Rice growth response to different proportions of applied nitrogen fertilizer. Cultiva.Tropicales, 21(4): 57-62.

Chander, S. and Pandey, J. 1996. Effect of herbicide and nitrogen on yield of scented rice (*Oryza sativa*) under different rice cultures. Indian J. Agron. 41(2): 209-214.

Channabasavanna, A.S. and Barinder, D.P. 2001a. Response of irrigated rice to the application of poultry manure and inorganic fertilizers N, P and K in Karnataka, India. Int. Rice Res. Newsl. 26(2): 64-65.

Channabasavanna, A.S. and Barinder, D.P. 2001b. Yield and yield attributes of transplanted summer rice as influenced by organic manures and zinc levels. J. Maharastra Agric. Univ. 26(2): 170-172.

Channadasppa, S.K., Kumar, M.D., Reddy, B.S.M.Manj, J.H., and Hebbar, M. 1998. Effect of split application of phosphorus and potassium on growth and yield of rice. Karnakata.J. Agril. Sci: 11(1: 1-3)

Chen Lijuan and Fan Xingming, 1997. Grain quality response to phosphorus and zinc fertilizer in rice genotype. CRRN, Chinese Rice Res. Newsl. 5(3): 9-10.

Chowdhury, A.T.M.A., Zaman, S.K. and Bhuiyan, N.I. 1994. Evaluation of mixed and complex fertilizers for wet land rice. Pakistan J. Sci. Ind.Res. 37(9): 378-381.

Chowdhury, M.A.H.,Talukder, N.M., Samanta, S.C., Chowdhury, A.K. and Islam, M.A. 1996. Effect of S and Zn on BR 11 rice in calcareous soil. Bangladesh J. Agric. Sci. 23(1): 125-128.

David, M.S. and Biswas, D.R. 1996. Effect of phosphorus, poultry manure, biogas slurry, and farmyard manure on dry matter yield and utilization of applied P by wheat. J. Nuclear Agric. Biol. 25(2): 89-93.

Devi, S.K., Sharmr, R.S, and Vishwakarmr, S.K. 1997. Integrated nutrient management for sustainable productivity of important cropping systems in Madhya Pradesh. Indian J. Agron. 42(1): 13-17.

Devivedi, D. K. and Thakur, S. S. 2000. Effect of organic and inorganic fertilizers levels on productivity of rice (*Oryza sativa*) crop. Indian . Agron. 45(3): 568-574.

Duhan, B.S. and Singh, M. 2002.Effect of green manuring and nitrogen on the yield and nutrient uptake of micronutrient by rice. J. Indian Soc. Soil Sci. 50(2): 178-180.

FAO (Food and Agricultural Organization) 1999. Yearbook of Production, FAO Statistics Division. 605-607.

Flynn, R.P., Wood, C.W. and Touchton, J.T. 1995. Nitrogen recovery from broiler litter in a wheat millet production system. Bio-res. Tech. 44(2): 165-173.

Gao, G. and Chang, C. 1996. Changes in CEC and particle size distribution of soils associate with long-term annual application of cattle feed lot manure. Soil Sci. 161(2):115-120.

Ghosal, P.K., Chunya, B. and Baych, D.K. 1998. Direct and residual effect of rock phosphatic fertilizers on rice grown on lateric land in Eastern India. Indian J. Agric. Sci. 68(4):235-237.

Ghosh, B.C., Gosh, R., Mittra, B.N.A. and Jana, M.K. 1994. Influence of organic and inorganic fertilization on the growth and nutrition of rice and fish in dual culture system. J. Agric. Sci. 122(1): 41-45.

Gomez, K.A. and Gomez, A.A., 1984. Statistical procedures for Agricultural Research. Jhon Wiley and Sons, New York.

Govindasamy, R., Cochran, M.J., Miller, D.M. and Norman, R.J. 1994. Economies of trade off between urea nitrogen and poultry litter for rice production. J. Agril. Appl.. Econ. 26(2): 552-564.

Goswami, N.N., Prashad. R., Sarker, M.C. and Singh, S. 1988. Studies on the effect of green manuring in N economy in a rice-wheat rotation using a N^{15} technique J. Agric. Sci. 111: 413-417.

Gupta, A.P., Neve, H.J. and Singh, V.P. 1995. Increasing productivity through phosphatic fertilizer and poultry manure application in acid upland. Annals Biol. 11(2): 151-157.

Gupta, J.P., Surishta, D., Pradeep, W., and Devis, W.P. 1999. Influence of FYM and P levels on yield and its uptakes in rice. India Annals of Biology-Zudhiana. 15(1): 55-57.

Gupta, A.P., Neve, H.J. and Singh, V.P. 1995. Increasing productivity through phosphatic fertilizer and poultry manure application in acid upland. Annals Biol. 11(2): 151-157.

Gupta, P., Shakya, S.K., Kumar D. and Singh, J. 1996. Effect o f different doses of gypsum on soil properties and crop yield under drained conditions. Annals of Biol. Ludhiana. 12(1): 157-162.

Gupta, A.P., Anil, R.S. and Narwal, R.P. 1996. Effect of various organic manures and fertilizer nitrogen on the performance of wheat. Annals Biol. 12(2): 188-194.

Gupta, S.K. 1995. Effect of organic manure on rice yield and moisture retention in Alfisol soil. J. Hill Res.8 (2): 169-173.

Gurung, G.B. and Sherchan, D.P. 1993. Study on the effect of long tem application of compost and chemical fertilizers on crop yields and physiochemical properties of soil in a rice-wheat cropping pattern. Pakhribas Agril. Centre, Kathmandu, Nepal. PAC working paper No. 87: 6.

Haque, M.Q., Rahman, M.H., Fokrul, I., Jan, Rijmpa,and Kadir, M.M. 2001. Integrated nutrient management in relation of soil fertility and yield sustainability under Wheat- Mung-T. aman cropping pattern. On Line J. Biol. Sci. 1(8): 731-734.

Haque, M.S. and Jahiruddin, M. 1994. Effect of single and multiple application of sulphur and zinc in a continuous rice cropping pattern. Indian J. Agril. Res. 28: 9-14.

Haque, S.A. 1992. Nutrient requirements of wet land rice production. Proc. Int. Symp. On Paddy soils, September 15-19, Beijing, China Academia Sinica: 281-282.

Hassan, G., Chaudhory,F.H., Mian, S.M., Gill, K.H. and Sheikh, A.A. 1993. Yield response of Basmati rice to applied P at different soil P values. Int. Rice Res. Newsl. 18(4): 25.

Hemalatha, M., Thirumurugan, V., Joseph, M. and Balasubramanian, R. 200Accelaration of decomposition of paddy straw through bacteria, fertilizer, amendments and its influence on growth and yield of rice. J. Maharashtra Agril. Univ. 25(3): 267-269.

Hoque, M.A. 1999. Response of BRRI dhan 29 to sulpher, zinc and boron supplied from manure and fertilizers, M.S. Thesis, Dept. Soil Sci. (January- June, 1999, Sem.) BAU, Mymensingh.

Hossain, M.B. 1996. Integrated nutrient management for BR 11 rice. M.S. Thesis, Dept. Soil Sci. (July-Dec, 1996, Sem.), BAU, Mymensingh.

Hossain, M.B., Islam, M.R., Rhaman, M.M. and Jahiruddin, M. 1997. Effect of integrated nutrient management on rice yield and components of BR 11 rice.Progress. Agric. 8(1&2): 83-86.

Hundal, H.S., Dhillon, N.S. and Dev, G. 1992. Contribution of different green manures to P nutrition of rice. J. Indian Soc. Soil. 40: 76-81.

Hunter, A.H. 1984. Soil Fertility Analytical Service in Bangladesh. Consultancy Report BARC, Dhaka.

Indulkar, B.S. and Malewar, G.U. 1991. Response of rice to different zinc sources and their residual effects on succeeding chickpea, (*Cicer arietinum*) Indian J. Agron. 36(Supplement): 5-9.

International Rice Research Institute (IRRI). 1979. Annual Report for 1978 Los Banos. Manila, Philippines.

Islam, M.R. and Bhuiya, Z.H. 1997. Effect of nitrogen and phosphorus on the growth, yield and nutrient uptake of deep-water rice. Bangladesh J. Agril. Sci. 24(2): 93-96.

Islam, M.M. 1997. Response of BRRI dhan 30 rice to cowdung and urea- N in the boro season. M.S. Thesis, Dept. Soil Sci. (January-June, 1997, Sem.), BAU, Mymensingh.

Islam, A. 1995. Review of Soil Fertility Research in Bangladesh. Proceeding of the Inter-Congress Conference of Commission IV. December 1-3, 1992 Dhaka. Improving Soil Management for Intensive Cropping in the Tropic and Sub-tropics. BARC. Pub. No. 37: 1-18.

Islam. M.S., Amin. M.S. and Anwar, M.N., 1994. Integrated soil fertility management in Bangladesh. Paper presented at the Workshop on Integrated Nutrient Management for Sustainable Agriculture held at Soil Resour. Dev. Inst., Dhaka in June 26-28, 1994.

Islam, M.R. and Hossain, A. 1993. Influence of additive nutrients on the yields of BR 11 rice. Thai. J. Agric. Sci.26: 195-199.

Jackson, M.L. 1962. Soil Chemical Analysis. Constable and Co. Ltd London, First Print.

Jeong, E., Shin, Y., Choi, I., Shin, Y., jeong, E.K., Shin, Y.B., Choi, I.H. and Shin, Y.S. 1996. Effect of organic matter application on rice growth and grain quality. J. Agric. Res. 38(1): 17-26.

Kant, S. and Kumar, R. 1994. A comparative study on the effect of four soil amendments on the uptake of Fe, Mn and yield of rice in salt affected soil. Indian J. Agric. Chem. 27(283): 59-70.

Kaunt, S. and Kumar, R. 1994. Effect of gypsum, pyrite, pressmud and farmyard manure on soil properties and rice (*Oryza sativa*) Indian J. Agril. Sci. 62(3): 191-195.

Khan, M.M.R. 1998. Effect of cowdun, poultry manure and urea-N on the growth and yield of BRRI dhan 29. M.S. Thesis, Dept. Soil Sci. (July- December, 1998, Sem.), BAU, Mymensingh.

Khanda, C.M. and Dixit, L. 1996. Effect of zinc and nitrogen fertilization on yield and nutrient uptake of summer rice (*Oryza sativa*) Indian J. Agril. Sci. 40(4): 368-372.

Knudsen, D., Petterson, G.A. and Pratt, P.F. 1982. Lithium, Sodium and Potassium. *In* Methods of Soil Analysis. Part 2. 2nd Ed., Page, A.L., Miller, R.H. and keeney, D.R. 1982. Amer. Soc. Agron. Inc., Madi., Wis., USA. pp. 225-245.

Kuppuswamy, G., Jeyahal, A. and Lakshmanan, A.R. 1992. Effect of enriched bio-digested slury and FYM on growth and yield of rice. Hort. Sci. Digest(Kerala). 15(2): 104 [Cited from soil and Fert. 1991, 57(8): 865].

Laxminarayana, K. 200. Effect of integrated use of organic and inorganic manures on yield of low land paddy. J. Hill Res. 13(2): 125-127.

Mannan, M.A., Kamal, A.M.A. and Islam, R. 2000. Effect of manure and fertilizer on growth, yield and protein content of transplant aman rice .Bangladesh J. Train. Dev. 13(1-2): 203-210.

Mathew, T. and Nair, S.S. 1997. Physical and chemical properties of rice soils as influenced by organic and inorganic sources of nutrients. Indian J. Agril. Res. 31(4): 257-261.

Medhi, B.D., Barthakur, H.P. and Barthakur, S.N. 1996. Effect of organic and inorganic source of N on the nutrient in soil and soil solution and growth of rice. J. Indian Soc. Soil Sci. 44(2): 263-266.

Mehla, D.S., Sagwal, K.K., dabas, D.S., Dhaliwal, G.S., Aroka, R(ed). Randhawa, N.S. and Dhawan, A.K. 1998. CCS Haryana Agricultural University. Rice Reseaceh Station, Kaul-136021, India: 596-603.

Meelu, O.P. and Yadvinder Singh 1991. Integrated use of fertilizers and organic manure for higher returns. Prog. Fmg. Punjab Agric. Univ. 27: 3-4.

Mondal, S.S. and Chettri, M. 1998. Integrated Nutrient Management for sustaining productivity and fertility under rice (*Oryza sativa*) based cropping system. Indian J. Agric. SCI. 68(7): 337-340.

More, S.D. 1994. Effect of farm waste and organic manure on soil properties, nutrient availability and yield of rice wheat sequence grown on sodic vertisol. Indian J. Soc. Soil Sci. 42(2): 253-256.

Maskina, M.S., Khind, C.S., Meelu, O.P. 1986. Organic manure as N source in a rice-wheat rotation. IRRI Newl. 11(5): 44.

Meelu, O.P. and Yadvinder-Singh. 1991. Integrated use of fertilizers and organic manures for higher returns. Prog. Fmg. Punjab Agric. Univ.27: 3-4.

Meelu, O.P., Morris, R.A., Furoc, R.E., and Dizon, M.A.1992. Grain yield response in rice to eight tropical green manure. Trop. Agric. (Trinidad)68: 133-136.

Miah, M.M.U. 1994. Prospects and problems of organic farming in Bangladesh. Paper presented at the workshop on Integrated Nutrient Management for Sustainable Agriculture. Soil Resource Dev. Inst., Dhaka, June 26-28, 1994.

Nahar, K.,Haider,J. and Karim, A.J.M.S. 1995. Residual effect of organic manure and influence of nitrogen fertilizer on soil properties and performance of wheat. Annals Bangladesh Agric. 5(2): 73-78.

Nambiar, K.K.M. 1997a. Nutrient management for soil fertility restoration and sustaining cropping system productivity. In Nutrient Management Practices in Crops and Cropping System. Ghonsikar, C.P. and V.S. Shinde. V.S. eds., Sci. Pub., India. pp. 213-250.

Nambiar, K.K.M.1997b. Soil health and organic matter-Changing scenario. Proc. Nat. ACAD. Sci. India Special Issue. pp. 141-160.

Nambiar, K.K.M. 1991. Long-term fertility effects on wheat productivity. In wheat for the Non-traditional Warm areas, Saunders D.A. ed., CIMMYT.pp 516-521.

Olsen, S.R., Cole, C. V., Watanabe, F.S. and Dean, L.A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate, U.S. Dept. Agric. Circ., p. 929.

Palm, C.A., Myers, R.J.K. and Nandwa, S.M. 1996. Combined use of organic and inorganic sources for soil fertility maintenance and replenishment. In: Replenishing soil fertility in Africa. Proc. Int. Symp. Indianapolis, USA, 6th Nov. 1996. [Cited from CAB Abst. 1998, 61(7): 7551.

Page, A.L., Miller, R.H. and Keeney, D.R. (ed). 1982. Methods of analysis part 2, Chemical and Microbiological Properties, Second Edition American

Society of Agronomy, Inc., Soil Science Society of American Inc. Madson, Wisconsin, USA. p p. 403-430.

Paraye, P.M., Kandalkar, V.S. and Paliwal, A.K. 1996. Effect of split application of Nitrogen and plant spacing on low land bunded rice (Oryza sativa). Indian J. Agron. 41(3): 490 - 492

Peng, J.G., Zhang, M.Q., Lin, Q., Yang, J. and Zhang, Q.F. 2002. Effect of sulpher on the main cereal and oil seed crops ands cultivated soil available S status in southeast Fujian. Fujian J. Agric. Sci. 17(1): 52.

Poongothai, S., Savithri, R.K. and Bijujoseph. 1999. Influence of gypsum and green leaf manure application on rice. J. Indian Soc. Soil Sci. 47(1): 96-99.

Prasad, B. 1993. Effect of continuous application of potassium on crop yields and potassium availability under different cropping sequences in calcareous soil. J. Potassium Res., 9(1): 48-54.

Prasad, N.K. and Kerketta, R. 1991. Soil fertility as influence by different cropping sequences. Indian Agric. Sci. 61:16-19.

Rahman. M.A. 2001. Integrated use of fertilizer and manure for crop production in wheat-rice and rice-rice cropping patterns Ph.D. Thesis. Dept. Soil Sci., Bangladesh Agril. Univ., Mymensingh.

Rajni Rani, Srivastava, O.P. and Rani, R. 2001. Effect of integration of organics with fertilizer N on rice and N uptake. Fertilizer News. 46(9): 63-65.

Rajput, A.L. and Warsi, A.S. 1991. Contribution organic materials to nitrogen economy in rice (*Oryza sativa*) production. Indian J. Agron. 36(3):455-456.

Rashid, M., Bajwa, M.I., Hussain, R., Nasem-Ud-Din, M. and Rhaman, F. 1992. Rice response to sulpher in Pakistan. Sulpher in Agriculture No. 16: 35.

Ravanker, H.N.,Deore, R.s. and Deshmukh, P.W.. 1999. Effect of nutrient management through organic and inorganic source on soybean yield and soil fertility. PKV Res. J. 23(1): 47-50

Razzaque, M.M.A. 1996.Comparative study on the effect of rice straw, farmyard manure and fertilizer nitrogen on the growth and yields of BR 11 rice. M.S. Thesis, Dept. Soil Sci. (January-June, 1996, Sem.), BAU, Mymensingh.

Shahiduzzaman, M.1997. Effect of inorganic and organic source of nitrogen and potassium on BGA population and on growth and yield of BR-11 rice, M.S Thesis, Dept. of Soil Sci. (Jan-June 1997), BAU, Mymensing.

Sahrawat, K.L., Jones, M.P., Diatta, S. and Adam, A. 2001. Response of upland rice to fertilizer phosphorus and its residual value in an ultisol. Communication in Soil Sci. and Plant Analysis. 32(15-16): 2457-2468.

Saitoh, K., Kuroda,T. and Kumano, S. 2001. Effect of organic fertilization and pesticide application on growth and yield of field- grown rice for 10 years. Japanese J. Sci. 70(4): 530-540.

Saleque, M.A., Saha, P.K., Panaullah, G.M. and Bhuiyan, N.I. 1998. Response of wet land rice to potassium in farmer's field of the Barind tract, Bangladesh. J. Plant Nutrition. 21(1): 39-47.

Salton, N.A., Wilson, C.E., Jr. Sabbe, W.E., Ntamatungiro, S., Frizzell, D. and Norman, R.J. 1999. Rice Response to phosphorus and potassium fertilization at different soil test levels. Research Series-Arkansas-Agricultural-Experiment-Station. No.463: 52-56.

Santhi, F., Velusamy, M.S., Murugappan, V.M. and Selvi, D. 1999. Effect of inorganic fertilizers and fertilizer manure combination of soil physic-chemical properties and dynamics of microbial biomass in an inceptisol. J. Indian Soc. Soil Sci. 47(3): 479-482.

Sarfaraz, M., Mehdi, S.M., Sadiq,M. and Hassan, G. 2002. Effect of sulphur on yield and chemical composition of rice. Sarhad J. Agric. 18(4): 411-414.

Sarkar,S. and Singh, S.R. 1997. Integrated nutrient management in relation to soil fertility and yield sustainability under dry land farming. Indian J. Agric. Sci. 67(9): 431-433.

Sarkunan, V., Misra, A.K. and Mohapatra, A.R. 1998. Effect of P and S on yield and uptake of P and S by rice. J. Indian Soc. Soil Sci. 46(3): 476-477.

Sen, P., Roy, P. and Bhattacharya, B. 2002. Effect of sulpher application on yield and nutrient uptake in rice-mustard cropping system. Fertilizer Marketing News. 36(6): 9-15.

Sengar, S.S., Wade, L.J., Baghel, S.S., Singh, R.K. and Singh, G. 2000. Effect of nutrient management on rice (Oryza sativa) in rain fed low land of Southeast Madhya Pradesh. Indian J. Agron. 45(2): 315-322.

Sharma, A.R. and Mitra, B.N. 1991. Direct and residual effect of organic materials and phosphorus fertilizers in rice (*Oryza sativa*) based cropping system. Indian J. Agron. 36(3): 299-303.

Sharma, G.D. and Sharma, H.L. 1999. Utilization of wed plants as organic manure under different methods of rice (*Oryza sativa* L.) establishment. Indian J. Agric. Sci. 64(3): 164-186.

Singh, A.K., Nongkynrith, P. and Khan, S.K. 1999. Critical limit of zinc deficiency for predicting response of rice to zinc application on wet land rice soil of Meghalaya. J. Indian Soc. Soil Sci. 36(2): 171-172.

Singh, A.K., Thakur, S.K. and Singh, S.S. 1996. Effect of N with and without FYM and Zn on yield, uptake and economics of rice. J. Res. Birsa Agril. Univ. 8(2): 175-176.

Singh, C.S. and Singh, U.N. 2002. Effect of nitrogen and sulphur nutrition on growth and yield of rice (*Oryza sativa* L.)cultivars. Research on crops. 3(3): 645-646.

Singh, M.K., Takur, R., Verma, U.N., Upasani, R.R. and Pal, S.K. 2000. Effect of planting time and nitrogen on production potential of Basmati rice cultivars in Bihar Plateau. Indian J. Agron. 45(2): 300-303.

Singh, R., Singh, S. and Prasad, K. 2001. Effect of fertilizer, FYM and row spacing on transplanted rice. Crop Res. (Hisar). 22(2): 295-296.

Singh, S.P., Devil,B.S. and Subbiah, S.V. 1998. Effect on nitrogen levels and lime of application on grain of hybrid rice. Int. Rice Res. (Hisar). 23(1): 25.

Singh, G.B. and Nambiar, K.K.M. 1984. Crop productivity and fertility under intensive use of chemical fertilizers in long-term field experiments. Indian J. Agron.31(2):115-127.

Singh, J.P. and Vinodumar. 1996. Nitrogen mineralization of legume residue in soil in relation to their chemical composition. J. Indian Soc. Soil Sci. 44:219-223.

Son,D.Chen, E.F., Xu, X.C., Zhank, J.H. and Li, H.Z.1994. Effect of organic manure application on physical properties and humas characteristics of paddy soil pedosphere. 4(2):127-135.

Subba Rao, A., Ganeshamurthy, A.N., Sammi Reddy, K. and Tukkar, P.N. 1995. Evaluation of some phosphate carriers for their efficiency in vertic ustochrept to sustain high productivity of wheat and rice. J. Indian Soc. Soil Sci. 43(3): 386-391.

Swarup, A. and Singh, K.N. 1994. Effect of gypsum, farmyard manure and N on amelioration highly sodic soil and yields of rice and wheat. Int. Rice Res. Notes (Philippines). 9(3): 22-23.

Thakur, D.S. and Patel, S.R. 1998. Response of split application of nitrogen on rice with and without farmyard manure in inceptisols. Environ. Ecol. 16(2): 310-313.

Vaiyapuri, V. and Sriramachandrasekharan, M.V. 2001. Integrated use of green manure and sulpher on nutrient uptake and rice yield. J. Ecobiol. 13(3): 223-227.

Verma, T.S. 1991. Influence of *Lantana euoatroium* and farmyard manure on paddy crop. The association of research workers. India. 28(2): 177-182.

Walkley, A. and Black, D. R. 1935. An examination of the digestion method for determining soil organic matter and proposed modification of the chronic acid titration method. Soil Sci. 37: 29-38.

Xu, y., Wang, Z., li, Z., Guo, Y. and Wang, B.J. 1997. Methane productivity of two rice soils as affected by application of fertilizer. Acta Agron. Sinica. 232(2): 137-143.

Yadav, R.L. 1998. Factor productivity trends in a rice-wheat cropping system under long- term use of chemical fertilizers. Experimental Agriculture. 34(1): 1-8.

Zaman, S., Hashem, M.A., Miah, M.H., Mallik, S.A. and Shamsuddoha, A.T.M. 2000. Effect of organic and inorganic sources of nitrogen and potassium on physical and chemical properties of soil under rice cropping. Bangladesh J. Agril. Sci. 27(1): 71-76.

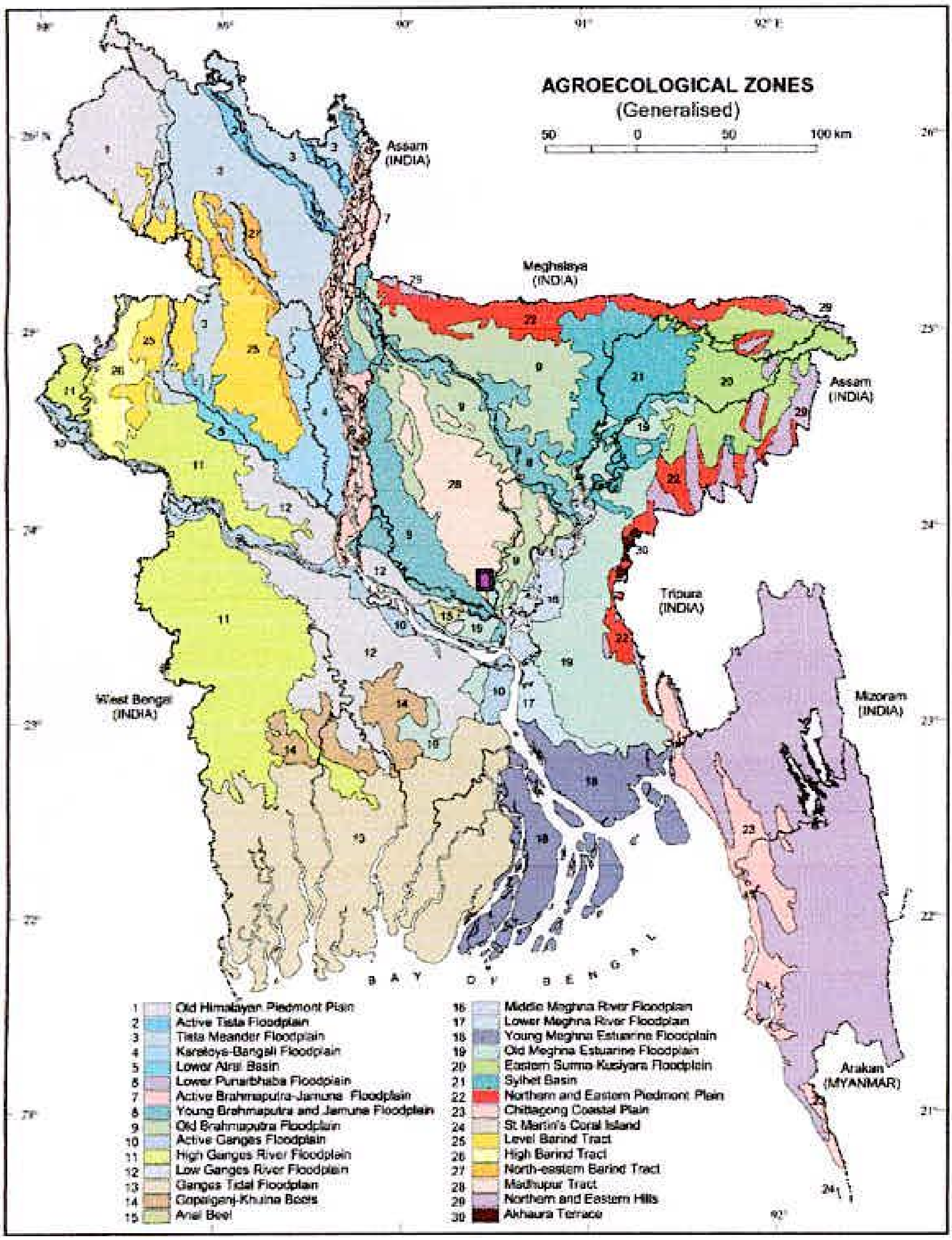
Zaman, S.K. Bhuiyan, N.I., Panaullah, G.M. and Saha, A.L. 1995b. A long term study on the integrated use of organic residues and chemical fertilizers for wet land rice. Thai J. Agric. Sci. 28: 183-194.

Zhang, M. Gu, H. and Peng, P. 1996. Study on the combined application of organic and inorganic fertilizer in dry and poor red paddy soils. Res. Agric. Modernizational. 17(10): 41-44. [Cited from Rice Abst. 1997, 20(1): 32.]

Appendices

ABBREVIATIONS

AEZ	Agro-ecological zone.
BRAC	Bangladesh Agriculture Research Council.
BARI	Bangladesh Agriculture Research Institute.
BAU	Bangladesh Agriculture University.
BNF	Biological Nitrogen Fixation
BRRI	Bangladesh Rice Research Institute
Cmol kg^{-1}	Centimole per Kilogram
CD	Cowdung
CV	Coefficient of Variation
DAT	Day After Transplanting
DH	Dhaincha
DMRT	Duncan's Multiple Range Test
FAO	Food and Agricultural Organization
GM	Green Manure
HYV	High Yielding Variety
IPNS	Integrated Plant Nutrient System
IRRI	International Rice Research Institute
LSD	Least Significant Difference
meq/100gm	Milli Equivalent per One Hundred Gram
mg kg^{-1}	Milli Gram per Kilogram
PM	Poultry Manure
SAU	Sher-e-Bangla Agricultural University
STB	Soil Test Basis
t ha^{-1}	Ton per Hectare
T. Aman	Transplanted Aman
TSP	Triple Super Phosphate
USDA	United States Department of Agriculture


AGROECOLOGICAL ZONES
(Generalised)
50 0 50 100 km
Assam (INDIA)
Meghalaya (INDIA)
Assam (INDIA)
Tripura (INDIA)
West Bengal (INDIA)
Mizoram (INDIA)
Arakan (MYANMAR)
BAY OF BENGAL
1 Old Himalayan Piedmont Plain
2 Active Tista Floodplain
3 Tista Meander Floodplain
4 Karatoya-Bangali Floodplain
5 Lower Atrai Basin
6 Lower Punarbhaba Floodplain
7 Active Brahmaputra-Jamuna Floodplain
8 Young Brahmaputra and Jamuna Floodplain
9 Old Brahmaputra Floodplain
10 Active Ganges Floodplain
11 High Ganges River Floodplain
12 Low Ganges River Floodplain
13 Ganges Tidal Floodplain
14 Gopalganj-Khulna Beels
15 Arial Beel
16 Middle Meghna River Floodplain
17 Lower Meghna River Floodplain
18 Young Meghna Estuarine Floodplain
19 Old Meghna Estuarine Floodplain
20 Eastern Surma-Kusiyara Floodplain
21 Sylhet Basin
22 Northern and Eastern Piedmont Plain
23 Chittagong Coastal Plain
24 St Martin's Coral Island
25 Level Barind Tract
26 High Barind Tract
27 North-eastern Barind Tract
28 Madhupur Tract
29 Northern and Eastern Hills
30 Akhaura Terrace

APPENDICES

Monthly Temperature, Total Rainfall, Relative Humidity and Sunshine Data During June to December 2007 of experiment Site (Dhaka).

Month	Air temperature ^{0}C			Total rainfall (mm)	Relative humidity (%)	**Average sunshine (Hrs./day)**
	Maximum	Minimum	Average			
JUNE	32.4	25.5	28.95	628	81	4.7
JULY	31.4	25.7	28.55	753	84	3.3
AUGUST	32.5	26.4	29.45	505	80	4.9
SEPTEMBER	32.0	26.4	29.45	189	80	3.0
OCTOBER	31.4	23.8	27.6	320	78	5.2
NOVEMBER	29.0	19.9	24.45	111	77	5.7
DECEMBER	25.8	15.0	20.4	10	69	5.4

Source: Bangladesh Metrological Society, Climate Division, Dhaka.