RESPONSE OF MANURE AND GREEN MANURE AS A COMPONENT OF INTEGRATED NUTRIENT MANAGEMENT (INM) IN T. AMAN RICE (BRRI dhan 40)

A Thesis

By

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CERTIFICATE

This is to certify that the thesis entitled, " **Response of Manure & Green Manure as a Component of Integrated Nutrient Management (INM) in Transplanted Aman Rice (BRRI dhan 40)"**submitted to the Faculty of Agriculture,, Sher-e-Bangla Agricultural University, Dhaka 1207, in partial fulfillment of the requirementsfor the degree of **MASTER OF SCIENCE (M. S.) IN SOIL SCIENCE,** embodies the result of a piece of bona fide research work conducted by **Mst. ShamsunNaher**bearing**Registration No.10-04215**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.

Dated: **Professor Dr. Alok Kumar Paul**

Dhaka,Bangladesh **Research Supervisor**

DEDICATED TO MY

BELOVED PARENTS

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MST. SHAMSUN NAHER

ABSTRACT

RESPONSE OF T. AMAN RICE (BRRI dhan 40) TO MANURE AND GREEN MANURE AS A COMPONENT OF INTEGRATED NUTRIENT MANAGEMENT (INM)

A field experiment was carried out at Sher-e-Bangla Agricultural University (SAU) Farm during the kharif period from July, 2011 to November 2011 to evaluate the response of BRRI dhan 40 to green manure & cowdung as a component of Integrated Nutrient Management . The field experiment was conducted in combination with inorganic fertilizer and organic manure. The Red Brown Terrace Soil of Tejgoan series was silty loam in texture having pH 5.6 .The experiment was conducted in a Randomized Complete Block Design (RCBD) with 11 treatments and 3 replications. The treatments were T_0 (Control), T_1 (N_{120} $P_{15}K_{45}S_{20}$, Recommended dose), T_2 (80% NPKS + 2 t ha^{-1} DH), T_3 (80% NPKS + 4 t ha^{-1}CD), T_4 (80% NPKS + 1 t ha^{-1} DH + 2 t ha^{-1} CD), T_5 (70% NPKS + 4 t ha^{-1} DH), T_6 (70% NPKS + 8 t ha^{-1} CD), T_7 (70% NPKS + 2 t ha^{-1} DH + 4 t ha^{-1} CD), T_8 (50% NPKS + 6 t ha^{-1} DH), T_9 (50% NPKS + 12 t ha^{-1} CD), T_{10} (50% NPKS + 3 t ha^{-1} DH + 6 t ha^{-1} CD). The result demonstrated that the yield contributing characters, grain and straw yields were significantly influenced by the added fertilizers and manure. Application of 70 % NPKS fertilizers + 4 t ha^{-1} dhaincha produced the highest grain yield (5.9 t ha^{-1}) and the second highest grain yield (5.85 t ha^{-1}) was obtained from T_2 (80% NPKS + 2 t ha^{-1} DH) treatment. In straw yield, the treatment T_3 (80% NPKS + 4 t ha^{-1} CD) produced the highest yield (8.59 t ha^{-1}) and the second highest straw yield (8.08 t ha^{-1}) was obtained from T_1 (N_{120} P_{15} K_{45} S_{20} , Recommended dose) treatment. The grain yield increases over control and ranges between. 31.18 to 86.31 %.The treatments T_1 and T_2 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 dhaincha and cowdung were applied in combination with NPKS fertilizers. Grain yield of T. Aman rice was positively correlated with number of effective tiller, plant height, panicle length, filled grain per panicle and straw yield. The combined application of fertilizer and organic manure increased the % organic carbon (OC), organic matter (OM) %, total N, available P and available S in post harvest soils. The overall findings of the study indicate that the integrated use of inorganic fertilizer and organic 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.)

CONTENTS (Contd.)

LIST OF TABLE

LIST OF FIGURE

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

CHAPTER 1

INTRODUCTION

Rice (*Oryza sativa*) is one of the most important cereal crops of the world. There are one hundred eleven rice growing countries in the world that occupies about 146.5 million hectares more than 90% is in Asia. It is the staple food for more than two billion people in Asia and many millions in Africa and Latin America. About 95% of the world rice is consumed in Asia. About 40% of the world population consume rice as a major source of calories (Banik, 1999). Agriculture in Bangladesh is predominately rice based and Bangladesh is the fourth rice producing country in the world (BRRI, 2006). It is grown in 10.5 million hectares of land with a total production of 26.5 million tons in the year 2005-2006. Rice is grown in three seasons namely Aus (mid march to mid august), Aman (mid june to November) and Boro (Mid december to mid june). Out of these aman cover the largest area (about 5.75 million hectare) and the high production of about 11.50 million metric tons of rice (BBS, 2004).

Plants require 16 essential elements. Carbon, hydrogen, and oxygen are derived from the atmosphere and soil water. The remaining 13 essential elements (nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, zinc, manganese, copper, boron, molybdenum, and chlorine) are supplied either from soil minerals and soil organic matter or by organic or inorganic fertilizers. For plants to utilize these nutrients efficiently, light, heat, and water must be adequately supplied. Cultural practices and control of diseases and insects also play important roles in crop production. Each type of plant is unique and has an optimum nutrient range as well as a minimum requirement level. Below this minimum level, plants start to show nutrient deficiency symptoms. Excessive nutrient uptake can also cause poor growth because of toxicity. Therefore, the proper amount of application and the placement of nutrients is important for normal functioning and growth. A plant's sufficiency range is defined as the range of nutrient necessary to meet the plant's nutritional needs and maximize growth (Figure 1). Nutrient deficiency occurs when an essential nutrient is not available in sufficient quantity to meet the requirements of a growing plant. Toxicity occurs when a nutrient is in excess of plant needs and decreases plant growth or quality. Integrated nutrient management (INM) or integrated nutrient supply (INS) system aims at achieving efficient use of chemical fertilizers in conjunction with organic manures. Long term fertilizer experiments involving intensive cereal based cropping systems reveal a declining trend in productivity even with the application of recommended levels of N, P and K fertilizers (Mahajan *et al.*, 2002; Mahajan and Sharma, 2005). The crop productivity increases from the combined application of chemical fertilizers and organic manures. Such combination contributed to the improvement of physical, chemical and biological properties and soil organic matter and nutrient status. The basic concept of INM system is the maintenance of plant nutrients supply to achieve a given level of crop production by optimizing the benefits from all possible sources of plant nutrients in an integrated manner, appropriate to each cropping system and farming situation (Mahajan and Sharma, 2005; Subba Rao, A. and Sammi Reddy, A. 2005). If the soil fertility has already eroded to a high degree by inappropriate management practices, one major task of INM system will be to at least stop the ongoing loss of surface or top soil nutrients (Mahajan and Sharma, 2005).

Soil fertility deterioration is a major constraint for higher yield of rice in Bangladesh. The increasing land use intensity without adequate and balanced use of chemical fertilizers and with little or no use of organic manure have caused severe fertility deterioration of our soils resulting in stagnating or even declining of crop productivity. The farmers of this country use, on an average, 172 kg nutrients/ha annually (132 kg N + 27 kg P + 17 kg K + 4 kg S, and 2 kg Zn), while the crop removal is about 250 kg/ha (Islam, 2002). Since fertile soil is the fundamental resource for higher crop production, its maintenance is a prerequisite for long- term sustainable crop productivity. 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 amount of micronutrients. In Bangladesh, most of the cultivated soils have less than 1.5% organic matter, while a good agricultural soil should contain at least 2% organic matter. Moreover, this important component of soils is declining with time due to intensive cropping and use of higher doses of nitrogenous fertilizers with little or no addition of organic manure. Consequently, Zn and B deficiencies are frequently reported on some soils and crops (Jahiruddin *et al.*, 1995 and Mondal *et al.*, 1992). Rice *(Oryza sativa* L.) is intensively cultivated in Bangladesh covering about 80% of arable land. Unfortunately, the yield of rice in this country is low (3.4 t/ha) compared to other rice growing countries like South Korea and Japan where the average yield is 6.00 and 5.6 t/ha, respectively (FAO, 2003). 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 source of nutrients is necessary for sustainable agriculture that can ensure food production with high quality (Reganold *et al.*, 1990). Nambiar (1991) viewed 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. Thus, it is necessary to use fertilizer and manure 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 to investigate the effect of combined use of chemical fertilizers and organic manures in T. aman (BRRI dhan 40) production. The message conveyed through this paper is that soil health needs to be cared for by adopting the sustainable soil nutrient management practices outlined in this paper for the sustenance of human life.

Considering the above facts ,the present research was under taken with the following objectives:

- To develop a suitable combination of inorganic fertilizers, organic manure and green manure on the growth and yield of T.Aman rice.
- To evaluate the efficacy of organic manure and green manure as a component of integrated nutrient management on the yield and quality of T. Aman rice.
- To study the effect of integrated nutrient management on soil health.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Soil organic manure and inorganic fertilizer is the essential factor for sustainable soil fertility and crop productivity because is the store house of plant nutrients. Sole and combined use of cowdung, green manure and inorganic fertilizer acts as a source of essential plant nutrients. Experimental evidences in the use of cowdung, green manure (dhaincha) and nitrogen, phosphorus, potassium and sulphur showed and intimate effects on the yield and yield attributes of rice. Yield and yield contributing characters of rice are considerably influenced by different doses of NPKS fertilizer and cowdung and green manure and their combined application. Some literature related to the "Response of manure and green manure as a component of integrated nutrient management on T. Aman rice cv. BRRI dhan 40" are reviewed below:

2.1 Effect on organic manure on the yield of rice

Organic matter is considered as the life of the soil and is the store house of plant nutrients. Organic matter is the principle source of NPKS and other nutrient elements, increases the soil buffering capacity, protect soil erosion and maintain healthy community of soil organisms.

Organic matter content of particular soil is an indicator of its productivity. It helps binding the soil particles into aggregates thereby improving drainage and reducing erosion, reduced leaching loss of nutrients through enhanced action exchanged activity, increase water holding capacity, support the activities of micro organisms, increase the benefits from chemical fertilizer and promote the production of beneficial plant hormones (BRAC, 1997).

2.1.1 Effect of manure (cowdung) on yield of rice

Indulker and malewar (1991) stated that application of 10 ton/ha FYM alone produced grain yield of 2.19 t/ha and the untreated control gave 2.06 t/ha. 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 of FYM of a rice based cropping system. Rajput and Warsi (1991) conducted a field experiment and reported that rice yield was increased to 34.44 kg/ha with the application at FYM of 10 t/ha.

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

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

Kant and Kumar (1994) reported that the increasing rates of amendments with FYM increased the number of effective tillers per hill significantly, number of grain per panicle, weight of 1000 grains also increased over the control. At maximum level of FYM (30 t/ha) the increase of 48% tillers per hill, 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) resulted 22% increased in grain yield over the untreated plots.

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 on growth, yield and N uptake by rice with and without 5 ton FYM/ha and proposed that both N rates increased yield attributes, yield, plant N content and N uptake 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) was recorded with the application of 80 kg N/ha in three split doses with 5 t/ha FYM during both the years, 60 kg N in 3 split doses with 5 t/ha FYM gave 3.85 ton grain/ha.

Mehla *et al.* (1998) conducted field experiment in India from 1990-1996 on a Vertic Ustochrept soil using paddy cv. HKR 120 with 4 manure treatments. The manures increased the mean grain yield which was 6.98, 6.74, 6.16 and 5.43 t/ha in GM, FYM, ash and control treatments respectively.

Gupta *et al.* (1999) conducted a field experiment on clay loam soil in 1993 in Jammu 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 receive a basal dressing of N, K and Zn. Grain yield was also height with 100 kg P_2O_5 + FYM (5.20 t/ha).

Mannan *et al.* (2000) reported that manuring with cowdung up to 10 t/ha in addition to recommended inorganic fertilizers with late Nitrogen application improved grain and straw yield 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 decreased in the number of panicle. Yearly application of manure increased the total carbon and nitrogen content in soil.

Aga *et al.* (2004) assessed the effect of compost on the growth and yield of rice. Plant growth characters such as plant height were highest with application of 15 ton compost/ha. Grain yield increased significantly with the graded level of compost application @ 10 ton/ha but the response decreased with the increase of compose from 10 to 15 ton/ha.

2.1.2 Effect of green manure on the yield of rice

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

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 height dhaincha plots followed by sun hemp.

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

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

Keeling *et al.* (2003) determined the green waste compost and provider with additional fertilizer and showed consistency that the response of wheat rape to green matter compost and fertilizer together was greater than responses to the individual additives, but only when very stable compost was used (>10 months processing). Experiments with 15_N labeled fertilizer showed that wheat was able to utilize the applied N more efficiently when cultivated in the stable green manure compost.

2.2 Effect of inorganic fertilizer on the yield of rice

2.2.1 Effect of nitrogen

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

BRRI (1992) reported that both grain and straw yield of rice were increased significantly up to 80 kg N/ha. Application of nitrogen from 120 to 160 kg N/ha significantly reduced the yield which was assumed to be due to excessive vegetative growth follower by lodging after flowering.

Ahmed and Hossain (1992) observe that plant height of wheat were 79.39, 82.30 and 84.40 cm with 45, 90 and 135 kg N/ha, respectively. Plant height increased with increasing Nitrogen doses. Chandra *et al.* (1992) carried out an experiment during 1979-1980 at Varanasi, Uttar Pradesh (India) and reported that plant height and dry matter increased with increasing the rate of nitrogen up to 120 kg/ha. Further increment of 3 kg N/ha decreased this parameter.

Awasthi and Bhan (1993) reported that increasing levels of nitrogen up to 60 kg/ha influenced LAI and dry matter production of rice. Patel and Upadhaya (1993) found that plant height of rice increased significantly with increasing rate of nitrogen up to 150 kg/ha.

Kumar *et al.* (1995) observed a field experiment with 4 levels of nitrogen (0, 60, 120 and 180 kg N/ha) and reported that productive tillers increased significantly with the increased of nitrogen doses from 0 – 120 kg N/ha, but differences in productive tillers between 120 and 180 kg N/ha were not significant.

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

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

Adhikary and Rahman (1996) reported that rice grain yield per ha in various treatments of N show significant effect. The highest yield was obtained from 100% kg N/ha (4.52 t/ha) follow by 120 kg N/ha (4.46 t/ha) and 80 kg N/ha (4.40 t/ha). Khanda and Dixit (1996) reported that the increased levels of applied N significantly influenced the grain yield. They found that maximum grain and straw yields of 4.58 and 6.21 ton/ha were obtained from 90 kg N/ha respectively.

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 height (4.47 t/ha) when 100 kg N/ha was applied 30% basally, 40% at tillering and 30% at panicle initiation stage. Andrade and Amorim Neto (1996) observed that increasing level of applied N increased plant height, panicle/m^2, grains/panicle and grain yield significantly.

Islam and Bhuiya (1997) studied the effect of N and P on the growth, yield and nutrient update of deep-water rice. They observed that N and P fertilization significantly increased the number of fertile tiller per m^2 and also that of grains per panicle, which in turn resulted in significantly increase in grain yield. The application of 60 kg N/ha alone gave 22% yield benefit over control.

BRRI, (1997) reported during Boro and T. Aman to determine rice seed yield. The experiment was laid out with four N levels 0, 50, 100 and 150 kg/ha and noted that seed yield increased gradually with the gradual increase of N. Dwibvedi, (1997) noticed that application of N significantly increased in growth, yield and yield components, grain yield, straw yield as well as harvest index with 60 kg N/ha.

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). They observe that the varieties responded linearly to the applied N level up to 120 kg/ha.

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

Castro and Sarker (2000) conduct field experiment to see the effects of N applications as basal (80, 60 and 45 kg N/ha) and top dressing (10, 30 and 45 kg/ha) 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 (basal) and 45 kg N/ha (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 gave maximum grain yield (2647 kg/ha).

BRRI, (2000) reported that the grain yield was linearly increased with increasing N rates. Chopra and Chopra, (2000) cited that seed yield increased linearly up to 80 kg N/ha. Bellido et al. (2000) evaluate a field experiment with 4 levels of N (0, 50, 100 and 150 kg N/ha) and reported that the amount of total dry matter was significantly greater at the N fertilizer rates of 100 and 150 kg N/ha.

Pullly *et al.* (2000) observed that increased yield associated with application of N in various stage, although booting stage N application had no effect on shoot growth or N uptake. These preliminary results suggested a single application of N is sufficient to maintain healthy rice growth, alleviating the need for additional N application after flooding. Rice may be responded to N applied as late as booting, but only when the rice is N limited and not severely N stressed.

Shrirame *et al.* (2000) conducted an experiment during the kharif 1996 in Nagpur, Maharastra, india on rice cv. TNRH-10, TNRH-13 and TNRH-18 were grown at 1, 2 and 3 seedlings/hill. One seedling/hill showed significantly higher harvest index.

Geethdevi *et al.* (2000) found that 120 kg N/ha in the form of urea, 50 % N was applied in four splits resulted in higher number of tillers, filled grains/panicle and higher grain weight/hill. Singh et al. (2000) claimed each incremental dose of N gave significantly higher straw yield.

Munnujan *et al.* (2001) treated 4 levels of N fertilizers (0, 40, 80 and 160 kg/ha) application at three levels in each planting density (20, 40 and 80 hill/m^2) and conducted that the highest grain yield (3.8 t/ha) was obtained with 180 kg N/ha, which was similar to the yield obtained at 80 kg N/ha (3.81 t/ha).

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

Slaton *et al.* (2001) showed that the highest yield was obtained lower N rates when applied in a single pre-flood (SPF) application but with intermediate and high N rates when applied in splits application. The total number of kernel/panicle, lodging and harvest grain moisture generally increased with higher N rates. Total milled rice percentage was very affected by N rates or method of application in this trial.

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 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) and straw (8649.6 kg/ha) 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 than with lower level of N.

Bayan and Kandasamy (2002) noticed that the application of recommended doses of N in four splits at 10 days after sowing, active tillering, panicle initiation and at heading stages recorded significantly lower dry weight of weeds and increased crop growth viz. effective tillers/m^2.

Mondal and Swamy (2003) found that application of N (120 kg/ha) as urea in equal splits during transplanting, tillering, panicle initiation and flowering resulted in the highest number of panicle, number of grains/panicle, 1000-grain weight, straw yield and harvest index.

2.2.2 Phosphorus

Hasan *et al.* (1993) carried out and experiment and observed the yield response of Bashmati385 rice to 0, 33, 66 and 99 kg/ha P. All treatments received 128-62-4.2 kg NKZn /ha. They observed that yield increased significantly up to 33 kg P/ha for all soil P test values, but significantly response to the next higher dose was observed only when test values were less than or equal to 11 mg P/kg.

Subba Rao *et al.* (1995) reported that P applied @50 mg P/kg soil as SSP increased the grain and straw yields significantly.

Chen Lizuan 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 and 60, 150, 200 kg P/ha and found that application of Zn and P significantly increased yield especially in Hexi-35 amd Yungeng-34.

Ghosal *et al.* (1998) conducted a field experiment in Bihar on rice cv. Pankaj with 10-40 kg P/ha as triple super phosphate (TSP), Highly Reactive Morocco Rock Phosphate (HRMRP), Florida Rock Phosphate (FRP) and stated that yield increase with increasing P rates of 4 sources. They further proposed that grain yield was the highest with TSP followed by PARP, HRMRP and FRP.

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

Sahrawat *et al.* (2001) conducted a field experiment for 6 years (1993-1998) to determine the response of four promising upland rice cultivars with 0, 45, 90, 135 & 180 kg/ha as triple super Phosphate (TSP). Only once used in 1993 and its residual value in 1994, 1995, 1996, 1997 & 1998 stated that grain yields of the rice cultivars were significantly increased by fertilizer P in 1993 & 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 to 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 without fertilizers to 4.59 t/ha 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, K uptake increased with increasing level of Potash application. K uptake by different cropping sequence was in order: rice-wheat (221 kg/ha), sorghum-mustard (205 kg/ha), groundnut-oats (204 kg/ha) and ragi-lentil (181 kg/ha) respectively.

Chowdhury *et al.* (1994) conducted a field experiment during dry and wet seasons with cv. BR 3 and BR 11 and observe that application of N, P, K & S from urea, TSP, MOP & gypsum respectively gave similar grain yields of 5.6-5.7 t/ha in the wet season.

Channadasppa *et al.* (1998) reported from a field experiment in 1993-1994 in Karnakata with rice cv. IR 64 that the split application of P and K did not significantly affect grain yield.

Saleque *et al.* (1998) conducted on six farm trials on K deficient Barind soil of Bangladesh to evaluate the response of rice to K fertilizers & observed that application of 30 kg/ha significantly increased grain yield at all the test locations. K application increase 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 & K did not significantly affect grain yield.

Salton *et al.* (1999) reported that rice yield varied with soil test levels of P & K but not significantly affected by P & K fertilizers.

2.2.4 Sulphur

Rashid *et al.* (1992) reported that elemental S and produced rice yield of 18, 9.2 & 5.8% more when applied at transplanting, 15 & 30 days after transplanting, respectively. Kaunt & Kumar (1992) reported that the application of 4 soil amendments (gypsum, pyrite, pressmud & FYM) 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 FYM.

Islam & Hossain (1993) reported that the application of 20 kg S/ha with NPK significantly increased the grain yield of BR 11 rice.

Haque & Jahiruddin (1994) studied the effect of single and multiple application S & Zn in a continuous rice cropping system and noted that crop yield were increased by S (20 kg/ha as gypsum) & not generally by Zn. They also observe that although added gypsum had residual effect up to third crop in every crop produced comparatively higher grain yield of rice.

Akther *et al.* (1994) carried out field experiment on silty and sandy loam soils of farmer's field at 4 sites in Bangladesh. At one site S application increased grain yield and another site of S application decreased grain yields. There was no yield response to Zn application. At one site, 50 kg S + 5 kg Zn/ha gave the highest grain yield (5.98 t/ha) compared to control yield of (4.61 t/ha) while at another site 25kg S + 10 kg Zn/ha decreased grain yield.

Chowdhury *et al.*(1996) stated that application of Zn single or in combination with S increased the straw and grain yield 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 in Zn_0S_0 treatment to 6.6 t/ha in $Zn_{12}S_{45}$ treatment.

Viayapuri, Sriramach and Rasekharan (2001) conducted and experiment on integrated use of green manure (12.5 t/ha) with graded level of S (0, 20 and 40 kg/ha) applied through 3 different sources in rice cv. ADT 37. They reported that the highest rice yield (5.3 t/ha) was obtained when green manure was applied along with pyrite 20 kg S/ha, which was comparable with pyrite applied at 40 kg/ha in the absence of green manure.

Peng *et al.* (2002) conducted a field experiment where 116 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 to of rice plant. The increasing rate of rice was 2.9-15.5%. A residual effect was also observed.

Sing and Sing (2002) carried out a field experiment to see the effect of different S levels (0, 20 and 40 kg/ha 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 per panicle were significantly increased with increasing levels of S up to 40 kg/ha. Sen *et al.* (2002) reported that rice yield significantly with application of S @ 30 kg/ha.

Sarfaraz *et al.* (2002) conducted a field experiment to determine the effect of different S fertilizer at 20 kg/ha 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 significantly increased with the application of NPK and S fertilizers compared to the control. They also found that NPK concentrations and they are uptake in grain and straw significantly increased with the application of NPK + S fertilizers compared to the control.

2.3 Combined effects of organic manure and chemical fertilizers 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) and cowdung (CD) as alternative or supplementary sources of nutrients. In Bangladesh, only limited attempts have been made in this perspective.

Maskina *et al.* (1986) conducted and experiment with different organic manure as a N source in rice-wheat rotation. They observed that yield with FYM and 80 kg N fertilizer/ha were equal to 120 kg N/ha fertilizer alone. They also reported that application of any one of the manure added to rice had residual effect equivalent to 30 kg N 11 kg N/ha in wheat.

Maskina *et al.* (1986) studied the effect of N application on wet land rice in a loamy sandy soil amended with cowdung (60 kg N/ha). The absence of urea cowdung/cattle manure increases the rice grain yield by 37%. Rice yield increased linearly with N rates whether or not the soil was amended with organic manure. Urea/N equivalent to cowdung and PM varied from 21-53 kg/ha and 50 to 123 kg/ha respectively.

Ali (1994) carried out several experimental 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 increased 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 followed by Aman rice with only 100% chemical fertilizer.

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.

Gupta (1995) conducted field trial on different organic manure in India and reported that the application of field manure (10 t/ha) produced the highest grain yield (4.5 t/ha) followed by Poultry Manure (PM) and FYM which produced yield of 4.1 and 3.9 t/ha of rice grain respectively. The increase in rice yield with organic manure was 34-55% higher over control and 5-22% higher over NPK fertilizers.

Islam (1995) found a significant yield increased with N fertilizer + cowdung compared to N fertilizer alone in T. Aman rice. In the following Boro rice yields with N fertilizer + residual effect of cowdung were higher than the N fertilizer alone.

Gupta (1995) conducted field trial on different organic manure in India and reported that the application of the field manure (10 t/ha) produced the highest grain yield (4.5 t/ha) followed by Poultry Manure (PM) and FYM which produced yields of 4.1 and 3.9 t/ha of rice grain respectively. The increase in rice yield with organic manure was 34-55% higher over control and 5-22% higher over NPK fertilizers.

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 trial (1987-1993) to develop a system for integrated nutrient supply for a rice-rice cropping sequence. Application of 45:45:45 kg NPK/ha as mineral fertilizers and 45 kg N/ha as FYM in the kharif seasons followed by 90:45:45 kg mineral NPK/ha in the rabi seasons gave the highest yields in all years except 1993.When application of half of the N in the kharif season or crop residues or green manure gave the highest yield.

Goshal *et al.* (1998) in an experiment with rice found increased grain and dry matter yield when inorganic N fertilizer (50 kg N/ha) was applied alone or when a combination of organic (10 t FYM/ha) and inorganic N fertilizer (25 kg N/ha) were applied as compared with organic sources (20 t FYM/ha) alone.

Mondal and Chettri (1998) conducted field experiment during 1991-1993 in West Bengal, 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 situ and FYM to rice only. They showed maximum grain yields of rice (4.96 and 5.77 t/ha) in the wet and dry seasons respectively.

Yadav (1998) conducted long term fertilizer experiment 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 1990-1991 to 1992-1993 at Bari Bhag, Uttar Pradesh, India using recommended dose of N, P, K and Zn (120, 60, 40 and 20 kg/ha respectively, or 10 t/ha of FYM or rice straw 25 or 50% recommended rates (R>R) : N=RPK, K and Zn. Rice yield was highest with FYM + S50 RRN, followed by RRN, P, K and Zn.

Abedin Miah and Mosleahuddain (1999), conducted a long term fertility trial in Shonatala silt-loam soil at Bangladesh Agricultural University farm, Mymensingh to evaluate the effect of continued fertilization and manuring 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 yield in Amam 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

FYM 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 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 balanced study showed a severe loss most of the nutrients through soil degradation.

Rahnam (2002) reported that in rice-rice cropping pattern, the highest grain yield of Boro rice was reported in the soil test basis (STB) NPKS and Zn fertilizer treatment while in T. Aman rice the 75% or 100% of NPKS Zn (STB) fertilizers plus GM with or without cowdung gave the highest or a comparable yield. The mean yearly N, P, K, S and Zn uptake by rice (Boro + T Aman) increased with increasing supply of nutrient. Application of cowdung along with NPKSZn (STB) resulted in markedly higher uptake of nutrient 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 soil increased slightly due to manuring. The whole results suggested that the integrated use of fertilizer with manure (VIZ. *Sesbania,* cowdung) could be and efficient and practice for ensuring higher crop yields without degradation of soil fertility.

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

Soil organic matter improves the physiochemical properties of the soil and ultimately promotes crop production. Organic materials are widely used to maintain soil fertility and improve soil properties in intensive cropping systems specially in traditional agriculture.

Studies at IRRI showed that the total N, exchangeable K and available P in soil increased by green manuring. The application of FYM increased organic C, total N, available P, exchangeable 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% N and P treatment (Singh and Nambiar, 1984).

Bair (1990) stated that sustainable production of crop can't 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.

Prasad and Kerketta (1991) conducted and experiment to asses 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 compost applied to the crops. There was an overall increases in organic carbon, 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 on their combined use with organic manure increased the organic C status in 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 from their initial values. 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.

Evidences from different AEZ's of the country have been shown a decrease in the content of organic matter by the range of 15-30 % over the last 20 years (Miah,1994).

More (1994) reported from three years study that application of 25 t/ha FYM + 20 t/ha press mud decreased the soil pH and increased organic matter content and available N, P and K in soil.

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.

Medhi *et al.* (1996) reported that incorporation of organic and inorganic source 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.

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

Sarker and Singh (1997) reported that organic fertilizers when applied alone of 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. Mathew and Nair (1997) reported that cattle manure when applied alone or in combination with chemical fertilizer (NPK) increased the organic carbon content, total N, available P and K in rice soils. Xu *et al.* (1997) observed that application of organic matters affect soil pH value as well as nutrient level.

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.

Ravanker *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 & METHODS

CHAPTER III

MATERIALS AND METHODS

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

The study was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from July 2011 to November 2011 to determination of the response of T. Aman rice to green manure and manure as a component of integrated nutrient management .

3.1 Experimental site and location

The research work relating to the study of the response of green manure and manure as a component of integrated nutrient management on T. Aman rice was conducted at the Sher-e-Bangla Agricultural University (SAU) Farm, Dhaka - 1207 during the Kharif-2 season of 2011.

3.1.1 Geographical Location

The experimental area was situated at 23°77'N latitude and 90°33'E longitude at an altitude of 8.6 meter above the sea level (Anon., 2007).

3.1.2 Agro-Ecological Region

The experimental field belongs to the Agro-ecological zone of "The Madhupur Tract", AEZ-28 (Anon., 2003a). This was a region of complex relief and soils developed over the Madhupur clay, where floodplain sediments buried the dissected edges of the Madhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain (Anon., 2003b). The experimental site was shown in the map of AEZ of Bangladesh in Fig.3.1.

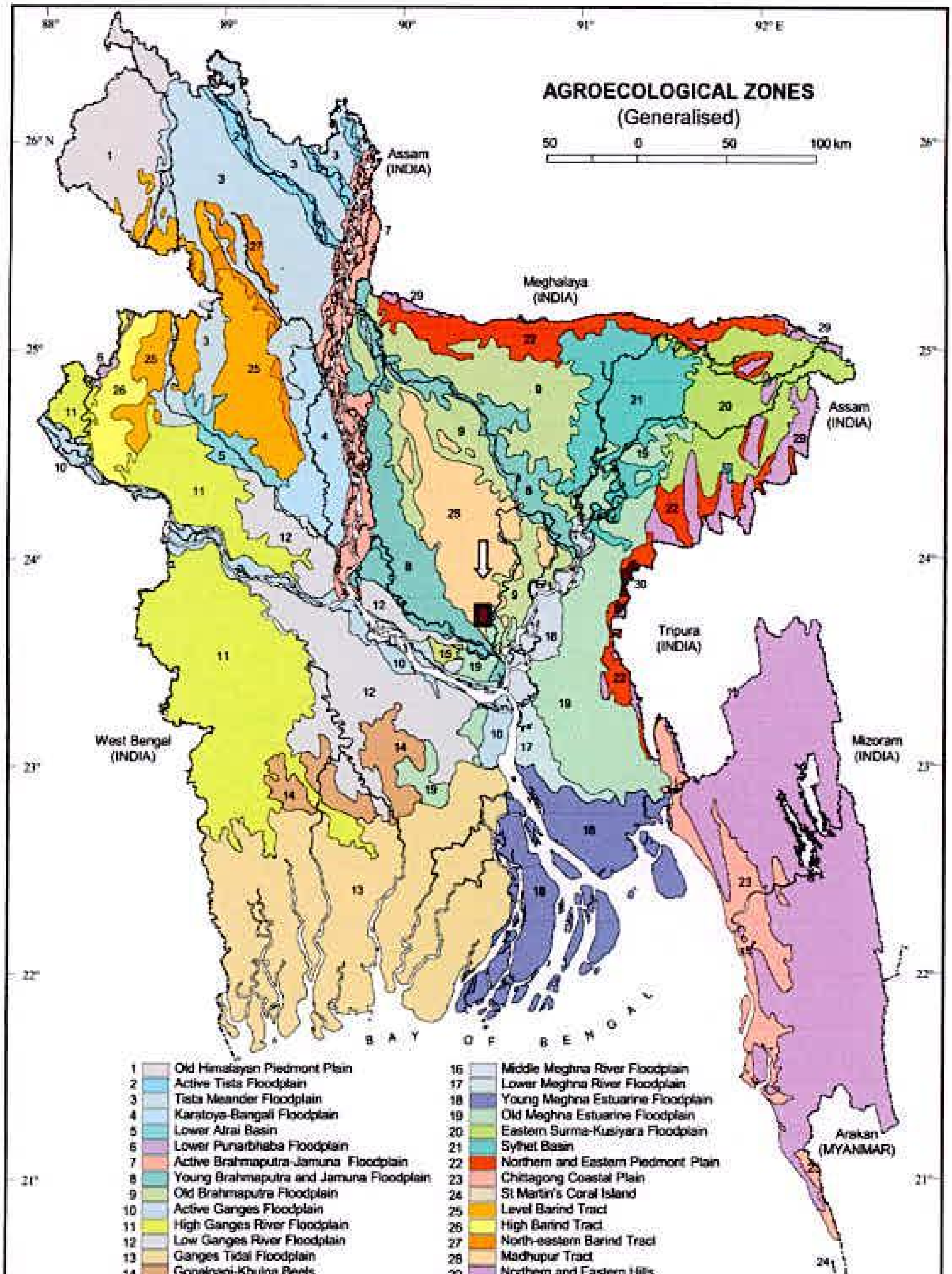


Fig. 3.1. Map showing the experimental site under study

3.1.3 Climate

The area has subtropical climate, characterized by high temperature, high relative humidity and heavy rainfall with occasional gusty winds in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during the Rabi season (October-March). Weather information regarding temperature, relative humidity, rainfall and sunshine hours prevailed at the experimental site during the study period, July-November, 2011 was presented in Appendix I.

3.2 Characteristics of soil

The soil of the experimental site belongs to the General Soil Type, Deep Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH ranged from 5.8 – 6.0 and had organic matter1.19%. The experimental area was flat having available irrigation and drainage system and above flood level. Composite soil samples from 0-15 cm depths were collected from experimental field. The analyses were done at SRDI Laboratory and Sher-e-Bangla Agricultural University (SAU) Laboratory, Dhaka. The physicochemical properties of the soil are presented in Table 3.1.

Table 3.1 Initial physical and chemical properties of the experimental soil

Soil properties	Value
A. Physical properties	
1. Particle size analysis of soil.	
% Sand	29.14
% Silt	41.76
% Clay	29.10
2. Soil texture	Clay loam
B. Chemical properties	
1. Soil pH	5.8
2. Organic carbon (%)	0.69
3. Organic matter (%)	1.19
4. Total N (%)	0.045
5. Available P (ppm)	16.0
6. Exchangeable K (me/100 g soil)	0.12
7. Available S (ppm)	14.4
8. CEC (me/100 g soil)	17.9

3.3 Description of soil

The soil of the experimental field belongs to the Tejgaon series under the Agro ecological Zone, Madhupur Tract (AEZ- 28) and the General Soil Type is Deep Red Brown Terrace Soils. A composite sample was made by collecting soil from several spots of the field at a depth of 0-15 cm before the initiation of the experiment. The collected soil was air-dried, ground and passed through 2 mm sieve and analyzed for some important physical and chemical parameters. Morphological characteristics of the soil are shown in table 3.2.

Table 3.2 Morphological characteristics of experimental field

Morphological features	**Characteristics**
Location	Sher-e-Bangla Agricultural University Farm, Dhaka
AEZ No. and name	AEZ-28, Madhupur Tract
General Soil Type	Deep Red Brown Terrace Soil
Soil Series	Tejgaon
Topography	Fairly leveled
Depth of Inundation	Above flood level
Drainage condition	Well drained
Land type	High land

3.4 Description of the Rice cultivar

BRRI dhan 40 is a high yielding and most popular variety of T. Aman rice was used as the test crop in this experiment. This variety was released by Bangladesh Rice Research Institute, Joydebpur, Gazipur in 2001. Life cycle of this variety is 145 days. Heights of mature plants are 110 cm and the variety is resistant to diseases, insects and pest attack. The average grain yield of this variety generally lies between 4.5 – 5 tha^{-1}.

3.5 Land preparation

The field selected for the experiment was opened by power tiller on the 28th July 2011, afterwards the land was ploughed and cross-ploughed several times followed by laddering to obtain a good tilth . Weeds and stubbles were removed, and the large clods were broken into smaller pieces to obtain a desirable tilth of soil for sowing of seeds. Then the land was leveled and the experimental field was partitioned into the unit plots in accordance with the experimental design. Finally each plot was prepared by puddling.

3.6 Layout of the experiment

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The total numbers of plots were 33, each measuring 3 m × 2m ($6m^2$). The treatment combination of the experiment was assigned at random into 11 plots of each at 3 replications. The blocks were separated from one another by 1 m drain and distance maintained between two plots was 50 cm. Treatments were randomly distributed within the blocks. The layout of the experiment is presented in the following figure.

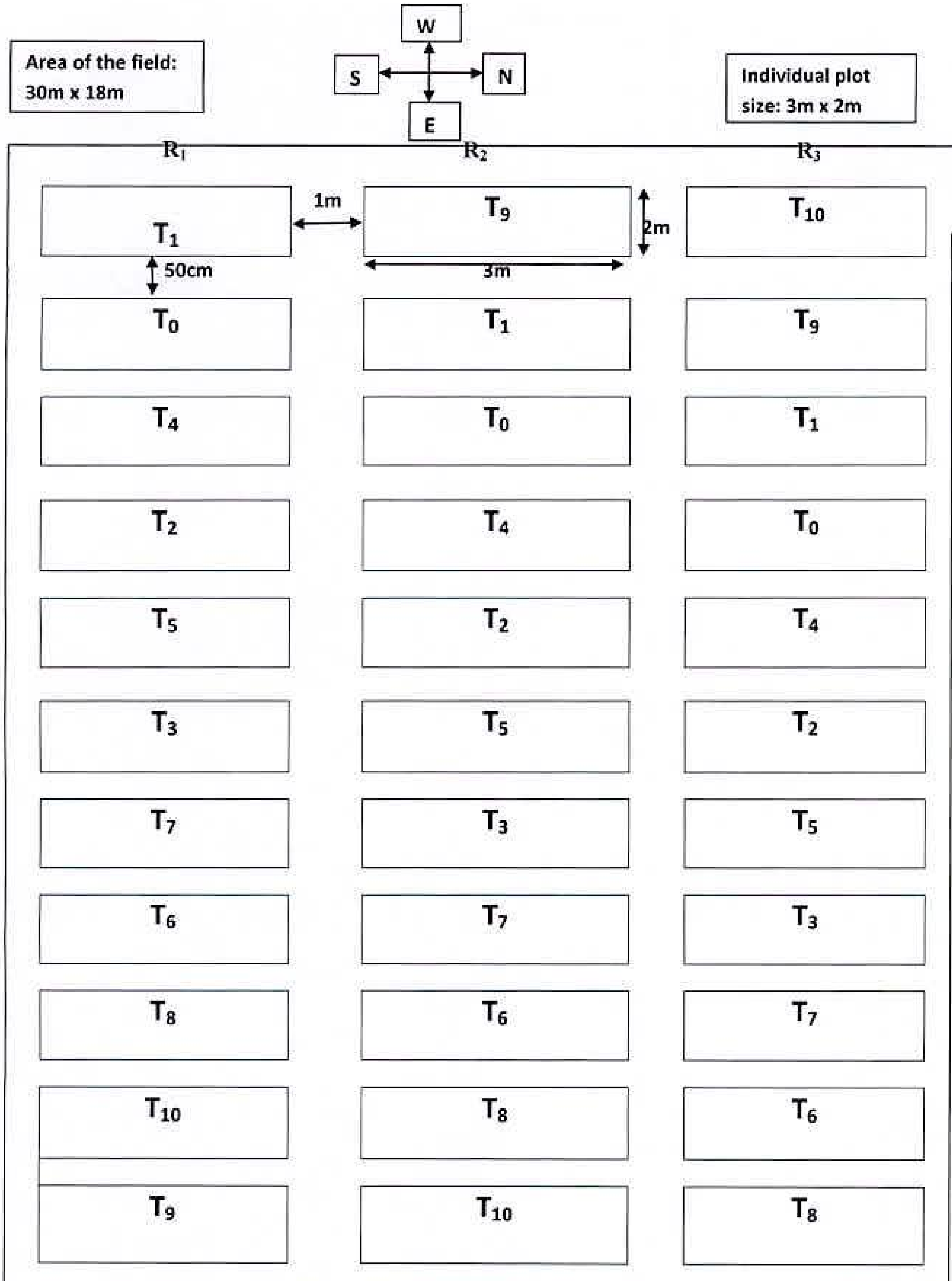


Fig. 3.2. Layout of the experiment in RCBD

Fig. 3.3. View of the experimental field

3.7 Initial soil sampling

Before land preparation, initial soil samples at 0-15 cm depth were collected from different spots on the experimental field. The composite soil sample were air-dried, crushed and sieved through a 2 mm (10 mesh) sieve. After sieving, the soil samples were kept in a plastic container for physical and chemical analysis of the soil.

3.8 Treatments

The fertilizer treatments used in the experiment was based on Fertilizer Recommendation Guide, 2005. Two different types of organic manure (dhaincha and cowdung) were used in this study. The experiment consisted of 11 treatments, control, 100% recommended dose of NPKS and 50%, 30% or 20% reduction of NPKS dose plus dhaincha (DH) and cowdung (CD). The treatments were as follows:

T_0: Control

T_1: N_{120} P_{15} K_{45} S_{20} (Recommended dose)

T_2: 80%NPKS + 2 t ha^{-1}DH

T_3: 80%NPKS + 4 t ha^{-1} CD

T_4: 80%NPKS + 1 t ha^{-1}DH + 2 t ha^{-1} CD

T_5: 70% NPKS + 4 t ha^{-1}DH

T_6: 70% NPKS + 8 t ha^{-1} CD

T_7: 70% NPKS + 2 t ha^{-1}DH + 4 t ha^{-1} CD

T_8: 50% NPKS + 6 t ha^{-1}DH

T_9: 50% NPKS + 12 t ha^{-1} CD

T_{10}: 50% NPKS + 3 t ha^{-1}DH + 6 t ha^{-1} CD

3.9 Fertilizers application

The amounts of N, P, K and s fertilizers required per plot were calculated as per treatments. Full amount of TSP, MOP 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 in active tillering stage (30 DAT) and the remaining one third was applied at 5 days before panicle initiation stage (55DAT).

3.10 Organic manure incorporation

Two different types of organic manure viz. green manure (GM) and cowdung (CD) were used. The rate of manure required per plot were calculated as per the treatments respectively. GM were applied before 2 weeks of transplanting. CD were applied before one week of transplanting. Chemical compositions of the used manures have been presented in Table 3.3.

Table 3.3 Chemical compositions of the cowdung and green manure (oven dry basis)

Sources of organic manure	Nutrient content					
	C (%)	N (%)	P (%)	K (%)	S (%)	C:N
Cowdung	36	0.50	1.00	0.75	0.21	24
Green manure	46	1.00	0.26	1.56	0.24	15

3.11 Raising of seedling

The seedlings of rice variety BRRI dhan 40 were raised by wet bed method. Seeds (95 % germination) @ 5 kg/ha were soaked and incubated for 48 hours and sown on a well prepared seedbed. During seedling growing, no fertilizers were used. Proper water and pest management practices were followed whenever required.

3.12 Transplanting

Thirty days (30) old seedlings of BRRI dhan 40 were carefully uprooted from the seedling nursery and transplanted on 14 August, 2011 in well puddled plot. Two seedling per hill were used following a spacing of 20 cm x 15 cm. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings whenever required.

3.13 Intercultural operations

Various intercultural operations were done to ensure normal growth of the crops. Plant protection measures were followed as and when required. The following intercultural operations were done.

3.13.1 Irrigation

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

3.13.2 Weeding

The plots were infested with some common weeds, which were removed by uprooting them from the field 3 times during the period of cropping season.

3.13.3 Insect and pest control

At the very early growth stage (after 10 days of emergence of seedlings in seed bed) the plants were attacked by Aphids, which was removed by applying Malathion. In case of leaf roller (*Chaphalocrosis medinalis*, Pyralidae, Lepidoptera) was observed in the field which can also be removed by applying Malathion @1.12 L/ha.

3.14 Crop harvest

The crop was harvested at full maturity when 80-90 % of the grains were turned into straw colored on 26 November, 2011. The crop was cut at the ground level. The harvested crop of each individual plot was bundled separately and brought to the threshing floor.

3.15 Yield components

Ten representative plant hills from each plot were selected randomly for recording the yield contributing character. After harvesting the following data were recorded from the experiment,

i. Plant Height (cm)
ii. Tillering Number/hill
iii. Effective Tiller Number/hill
iv. Panicle Length (cm)
v. Grain Number Per Panicle
vi. Number of Filled Grain Per Panicle
vii. Number of Empty Grain Per Panicle
viii. 1000-grain wt.(g)
ix. Grain and straw Yield (t/ha)

3.15.1 Plant height

The plant height was measured from the ground level to the top of the panicle. Plants of 5 hills were randomly measured from each plot and averaged. It was done at the ripening stage of the crop.

3.15.2 Panicle Length (cm)

The measurement of panicle length was taken from basal node of the rachis to the apex of each panicle. Panicle lengths were measured randomly and counted from ten plants and then averaged. This was taken at the ripening stage.

3.15.3Tillering Number / hill

The tillering number was counted randomly from 10 hills separately and then averaged.

3.15.4 Effective Tiller Number/hill

The effective tiller number was counted from the same 10 hills separately and then averaged.

3.15.5 Grain Number Per Panicle

At the time of harvest, randomly 10 panicles were selected from each plot .The total grain number was counted from 10 panicles separately and then averaged.

3.15.6 Number of Filled Grain Per Panicle

From the same10 panicles, the filled grain number was counted separately and then averaged.

3.15.7 Number of Empty Grain Per Panicle

From the same10 panicles, the empty grain number was counted separately and then averaged.

3.15.8 1000- grain wt.(g)

Thousand seed of rice were counted randomly and then weighed plot wise and the weight was recorded in an electrical balance after sun drying.

3.15.9 Grain and straw yield (t/ha)

The harvested crops were threshed, cleaned, dried and weighed carefully. Grain and straw yields were adjusted to 12 % moisture content and expressed as t/ha.

3.16 Initial and Post harvest soil Sampling

The initial soil samples were collected randomly from 3different spots from each plot selected for the experiment at 0-15 cm depth after harvesting the crops and mixed thoroughly to make a composite sample for analysis. Post harvest soil samples were collected from each plot at 0-15 cm depth on 30^{th} November, 2011. The samples were air -dried, ground and sieved through a 2 mm (10 mesh) sieve and kept in a plastic container for physical and chemical analysis of the soil.

3.17 Soil analysis

Soil samples were analyzed for both physical and chemical characteristics viz. organic C, 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 :

3.17.1 Textural class

Mechanical analysis of soil was 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 using USDA system.

3.17.2 Soil pH:

Soil pH was measured with the help of a glass electrode pH meter, the soil water ratio being **1:2.5** as described by Jackson (1973).

3.17.3 Organic carbon

Soil organic carbon was determined by Walkley and Black's wet oxidation method as outlined by Jackson (1973) from the samples collected before sowing and also after harvesting the crop. The underlying principle was used to oxidize the organic matter with an excess of 1N $K_2Cr_2O_7$in presence of conc. $H_2SO_4$and conc.$H_3PO_4$and to titrate the excess $K_2Cr_2O_7$solution with 1N $FeSO_4$.

3.17.4 Organic matter

The organic matter content was calculated by multiplying the percent organic carbon with Van Bemmelen factor 1.73 and the results were expressed in % (Page et al. 1982).

3.17.5 Total nitrogen

Total nitrogen of soil samples were estimated following by Micro-Kjeldahl method. 1g oven dry ground soil sample was taken into micro kjeldhal flask to which 1.1 gm catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Selenium powder in the ratio 100:10:1 respectively), and 6 ml $H_2SO_4$was added. The flask were swirled and heated at 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 in 100 ml volumetric flask and the volume was made up to the mark with distilled water. A blank reagent was prepared in a similar manner. These digests were used for N determination (Page et al. 1982).

Then 20 ml digest solution was transferred into the distillation flask. Then10 ml of H_3BO_3indicator 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 be washing the delivery outlet of the distillation apparatus with distilled water. Finally the distillates were titrated with standard 0.01 N H_2SO_4until the color changes from green to pink. The amount of N was calculated by using the following formula:

% N = (T-B) x N x 0.014 x 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 gm

3.17.6 Available phosphorous

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

3.17.7 Exchangeable potassium

Exchangeable potassium in the soil sample was determined by 1N neutral ammonium acetate (NH_4OAc, pH 7) extraction methods and the potassium content was determined by flame photometer with a standard curve (Page et al. 1982).

3.17.8 Available sulphur

Available sulphur was determined by extracting the soil with $CaCl_2$ (0.15 %) solution as described by (Page et al. 1982). The extractable sulphur was determined by developing turbidity by adding acid seed solution (20 ppm S as K_2SO4 in 6N HCl) and $BaCl_2$ crystals. The intensity of turbidity was measured by spectrophotometer at 420 nm wavelengths.

3.18 Chemical analysis of plant samples

3.18.1 Collection of plant samples

Grain and straw samples are 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 analysis of N, P, K and S.

3.18.2 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 of N, P, K and S concentrations. The methods were as follows:

3.18.3 Digestion of plant samples with H_2SO_4 for N

For the determination of N an amount of 0.2 gm oven dry, ground sample were taken in a micro kjeldahl flask to which 1.1 gm catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Selenium powder in the ratio 100:10:1 respectively), and 5 ml conc. H_2SO_4were added. The flask were heating at 120^{0}C and added 2.5 ml 30 % H_2O_2 and then heating at 180^{0}C was continued until the digest was clear and colorless. After cooling the content was taken in a 100 ml volumetric flask and the volume was made up to the mark with de-ionized water. A blank reagent was prepared in a similar manner. N 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 standard 0.01 N H_2SO_4.

3.18.4 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 flask were heated at a temperature slowly raised to 200 ^{0}C . Heating were stop when the dense white fumes of $HClO_4$ occurred. The content of the flask were boiled until they were become clean and colorless. After cooling, the content was taken in 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 the digest.

3.18.5 Determination of P, K & S from plant samples

3.18.5.1 Phosphorus

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

3.18.5.2 Potassium

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

3.18.5.3 Sulphur

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

3.19 Nutrient uptake

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

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

3.20 Statistical analysis

The data obtained from the experiment were analyzed statistically to find out the significance of the difference among the treatments. The mean values of all the characters were evaluated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the differences among pairs of treatment means was estimated by the least significant difference (LSD) test at 5% and 1% level of probability (Gomez and Gomez, 1984). The mean comparisons of the treatment were evaluated by DMRT (Duncan's Multiple Range Test).

CHAPTER IV

RESULTS & DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

An attempt has been made to present a brief and pertinent 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 based cropping sequence.

4.1 Growth and yield contributing parameters

4.1.1 Plant height

The plant height of BRRI dhan 40 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 132.66 cm to 140.67 cm and highest value (140.67 cm) was noted in the treatment T_5 (70% NPKS + 4 t ha^{-1} DH) . The lowest plant height (132.66 cm) was obtained in the treatment T_0 where no fertilizers were used. The treatments T_1, T_4, T_6 and T_{10} produced statistically similar plant height. The combined application of fertilizers with manure increased the plant height compared to single application of chemical fertilizer or manure. Rajani Rani *et al.* (2001) observed that the plant height was significantly influenced by the application of organic manure and chemical fertilizers. Hossain *et al.* (1997), Sharma and Mitra (1991), Babu *et al.* (2001) and Singh *et al.* (1999) also observed the similar results.

4.1.2 Panicle length

The panicle length of BRRI dhan 40 varied significantly by different treatments (Table 4.1). The panicle ranged from 23.23 to 27.73 cm. The highest panicle length of 27.73 cm was observed in the treatment T_5 (70% NPKS + 4 t ha^{-1} DH). The lowest panicle length (23.23cm) was recorded in the treatment T_0 (control). The treatments were T_6, T_8 and T_9 produced statistically similar panicle length. The more increase of panicle length was observed in the single application of chemical fertilizer or organic manure as compared to combined application of chemical fertilizers with cowdung or Dhaincha. BRRI dhan 40 responded significantly better in combined application of 50% chemical fertilizers with organic manure. Babu *et al.* (2001), Haque (1999) noted a significant increase in panicle length due to combined application of organic manure and chemical fertilizers. Azim (1999), Apostol (1989), Ahmed and Rahman (1991) also reported similar results.

4.1.3 Number of grains panicle^{-1}

The number of grains panicle^{-1} varied significantly due to different treatment under study and the result showed in the table 4.1. The number of grains panicle^{-1} ranged from 93 to 122.7 and the highest value (122.7) was observed in the treatment T_5 (70% NPKS + 4 t ha^{-1} DH). The treatment T_3 and T_4 was statistically similar and T_9 was statistically identical with T_{10}. The lowest value (93.0) was obtained in the treatment T_0 (control). Dhaincha manure applied in combination with NPKS fertilizer increased the number of grains panicle^{-1} of BRRI dhan40 considerably compared to cowdung in combination with NPK fertilizers. The effect of measure on increasing the number of grain panicle^{-1} was more pronounced as compared to fertilizers. This might be due to more availability of nutrient from the green manure (dhaincha). Grain panicle^{-1} significantly increased due to the application of organic measures 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 40 significantly varied due to application of organic manure and chemical fertilizers. The number of effective tillers hill^{-1} due to different treatments ranged from 11.20-17.70 (Table 4.1). The treatment T_1 (N_{120} P_{15} K_{45} S_{20}), gave the highest number of effective tiller hill^{-1} where chemical fertilizers were applied at the recommended doses. The treatment T_2 and T_3 was statistically similar and T_4 was statistically identical with T_7. The lowest number of effective tillers hill^{-1} was observed in the treatment T_0 (control). The superior effect of Dhaincha in increasing the number of effective tiller hill^{-1} of BRRI dhan 40 over cowdung was noted. BRRI dhan 40 responded significantly better to chemical fertilizers when applied at the recommended doses than the manure when applied singly or combined application of manure and chemical fertilizers. Chandar 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 40. The 1000-grain weight varied significantly due to different treatments. The 1000-grain weight ranged from 23.08 gm to 23.44 gm. The highest thousand grain weight of 23.44 gm was obtain in T_7 (70% NPKS + 2 t ha^{-1} DH + 4 t ha^{-1} CD) treatment which was statistically identical with all other treatments except T_0. The lowest thousand-grain weight was recorded in T_0 (Control) 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 40)s

Treatment	Plant Height (cm)	Tiller number/ hill	Effective tiller number/ hill	Panicle length (cm)	Grain number/ panicle	Number of filled Grain/ panicle	1000 grain wt.(g)
T_0(Control)	132.66g	13.00g	11.20h	23.23i	93.00i	78.5i	23.08b
T_1(N_{120} P_{15} K_{45} S_{20} , Recommended dose)	136.75e	18.70a	17.70a	24.13h	106.57e	97.57e	23.35ab
T_2(80% NPKS + 2 t ha^{-1} DH)	140.02b	17.00c	15.93c	25.80f	108.8d	100.3d	23.35ab
T_3(80% NPKS + 4 t ha^{-1} CD)	139.72c	16.50d	15.93c	25.37g	111.47c	103.00c	23.29ab
T_4(80% NPKS + 1 t ha^{-1} DH + 2 t ha^{-1} CD)	137.33e	18.50a	17.15b	27.27b	110.9c	104.9b	23.41a
T_5 (70% NPKS + 4 t ha^{-1} DH)	140.67a	15.00e	14.2e	27.73a	122.7a	113.2a	23.34ab
T_6 (70% NPKS + 8 t ha^{-1} CD)	137.00e	13.9f	13.9f	26.33d	102.8g	91.80g	23.26ab
T_7 (70% NPKS + 2 t ha^{-1} DH + 4 t ha^{-1} CD)	138.90c	17.60b	17.05b	26.73c	103.7f	93.70f	23.44a
T_8(50% NPKS + 6 t ha^{-1} DH)	138.05d	16.20d	15.15d	26.13de	114.2b	102.7c	23.41a
T_9(50% NPKS + 12 t ha^{-1} CD)	134.67f	15.00e	13.85f	25.97ef	98.6h	87.6h	23.30ab
T_{10}(50% NPKS + 3 t ha^{-1} DH + 6 t ha^{-1} CD)	137.00e	14.00f	12.90g	25.23g	99.00h	87.0h	23.40a
Significance Level	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CV (%)	0.24	1.42	0.79	0.73	0.37	0.42	0.68

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

CV (%) = Coefficient of variation

CD = Cowdung, DH = Dhaincha

Table 4.2 Effect of organic manure and chemical fertilizer on the grain and straw yield of T. Aman rice (cv. BRRI dhan 40)

Treatments	Grain		Straw	
	Yield (t ha^{-1})	Increase over control (%)	Yield (t ha^{-1})	Increase over control (%)
T_0(Control)	3.63h	-	4.66e	-
T_1(N_{120} P_{15} K_{45} S_{20} , Recommended dose)	5.62d	75.66	8.08ab	65.5
T_2(80% NPKS + 2 t ha^{-1} DH)	5.85ab	84.41	8.00abc	75.6
T_3(80% NPKS + 4 t ha^{-1} CD)	5.82b	83.27	8.59a	87.2
T_4(80% NPKS + 1 t ha^{-1} DH + 2 t ha^{-1} CD)	5.75c	80.61	7.82bc	86.5
T_5 (70% NPKS + 4 t ha^{-1} DH)	5.90a	86.31	7.47bc	72.51
T_6 (70% NPKS + 8 t ha^{-1} CD)	5.18e	58.93	7.34c	65.9
T_7 (70% NPKS + 2 t ha^{-1} DH + 4 t ha^{-1} CD)	5.20e	59.69	7.37bc	63.69
T_8(50% NPKS + 6 t ha^{-1} DH)	4.53f	34.22	6.24d	30.22
T_9(50% NPKS + 12 t ha^{-1} CD)	4.45g	31.18	6.06d	35.18
T_{10}(50% NPKS + 3 t ha^{-1} DH + 6 t ha^{-1} CD)	4.52f	33.84	6.16d	37.84
Significance Level	0.01	--	0.01	--
CV (%)	0.87	--	5.34	--

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

CV (%) = Coefficient of variation , CD = Cowdung, DH = Dhaincha

4.2 Grain and straw yield of rice

4.2.1 Grain yield

The grain yield of BRRI dhan 40 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 3.63 ton to 5.90 t ha^{-1} . The highest grain yield (5.90 t ha^{-1}) was observed in the treatment T_5 (70% NPKS + 4 t ha^{-1} DH), and the lowest value (3.63 t ha^{-1}) was recorded in the treatment T_0 (control). The next higher grain yield 5.85 t/ha was observed in the treatment T_2 (80% NPKS + 2 t ha^{-1} DH), which was statistically identical with T_3 and T_5 treatments. The treatment may be ranked in order of $T_5 > T_2 > T_3 > T_4 > T_1 > T_7 > T_6 > T_8 > T_{10} > T_9 > T_0$ in term of grain yields. The percent increase in grain yield over control ranged from 86.31-31.18 %. Dhaincha manure when applied in combination with NPKS fertilizer exerted marked effect in increasing the grain yield of BRRI dhan 40 as compared to cowdung. Haque *et al.* 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 Calendacion *et al.* (1990), Ahmed and Rahman (1991), Laxminarayan (2000), Dwivedi and Thakur (2000) and Rajni Rani *et al.* (2001).

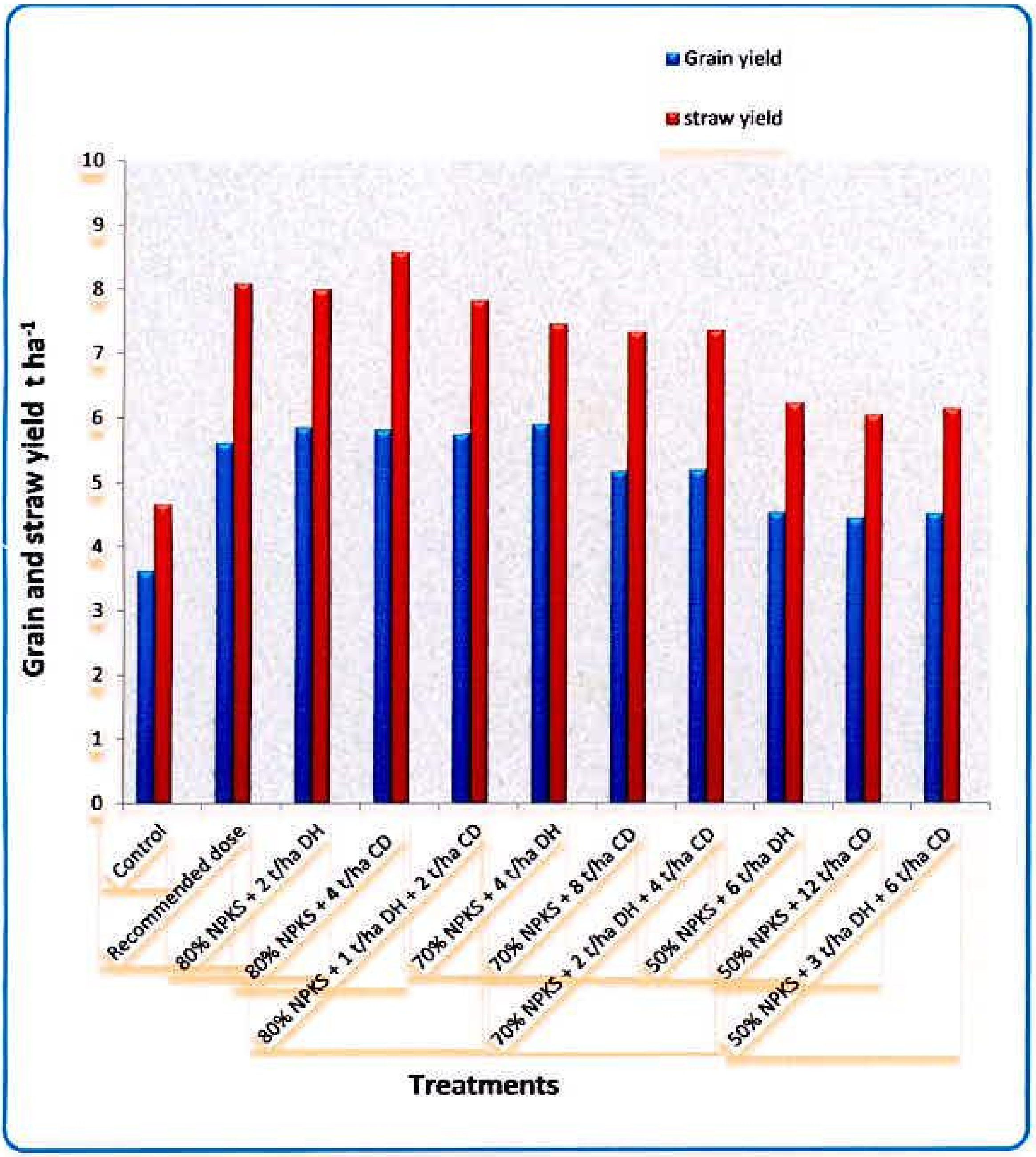


Fig. 4.1 Integrated use of manure and fertilizers on grain and straw yield of T. Aman rice (cv. BRRI dhan 40).

4.2.2 Straw yield

Straw yield of BRRI dhan 40 also varied significantly by different treatments under study. The yields of straw ranged from 4.66 ton to 8.59 t/ha. The highest straw yields (8.59 t/ha) was obtained in the treatment T_3 (80% NPKS + 4 t ha^{-1} CD)and the lowest value (4.63 t/ha) was noted in the treatment T_0 (control). The next highest straw yield (8.08 t/ha) was observed in the treatment T_1 (N_{120} P_{15} K_{45} S_{20} , Recommended dose), which was statistically identical with treatments T_2, T3, T4, T_5, T_6 and T_7 respectively. The treatment may be ranked in order of T_3> T_1> T_2> T_4> T_5> T_7> T_6> T_8> T_{10}> T_9> T_0in terms of straw yield. The percent increase in straw yield range from 23.22 to 87.2 % in different treatments over the control. Cowdung exerted comparatively better effect in producing higher straw yield as compared to dhaincha. Ahmed and Rahman (1991) reported that the application of organic manure and chemical fertilizers increased the straw yield of rice. These findings are well corroborated with the work of Khan (1998) and Islam (1997). It is clear that organic manure in combination with inorganic fertilizers encouraged vegetative growth of plants and thereby increasing straw yield.

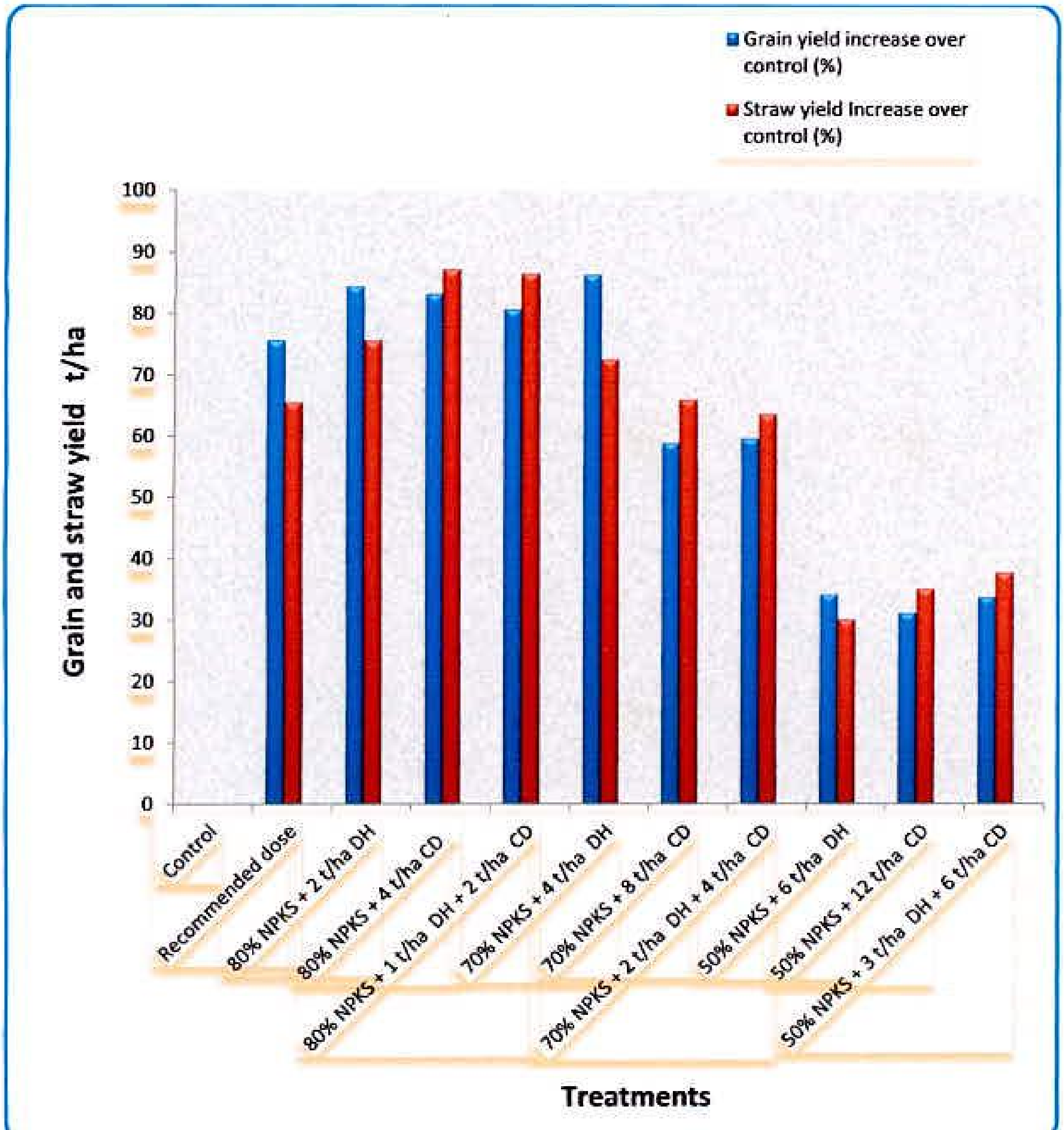


Fig. 4.2 Grain and straw yields of T. Aman rice (cv. BRRI dhan 40) increase over control by different treatment.

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 correlative with number of effective tiller, plant height, panicle length and filled grains panicle^{-1}. Similarly straw yield was positively correlated with plant height and panicle length and number of tiller per hill.

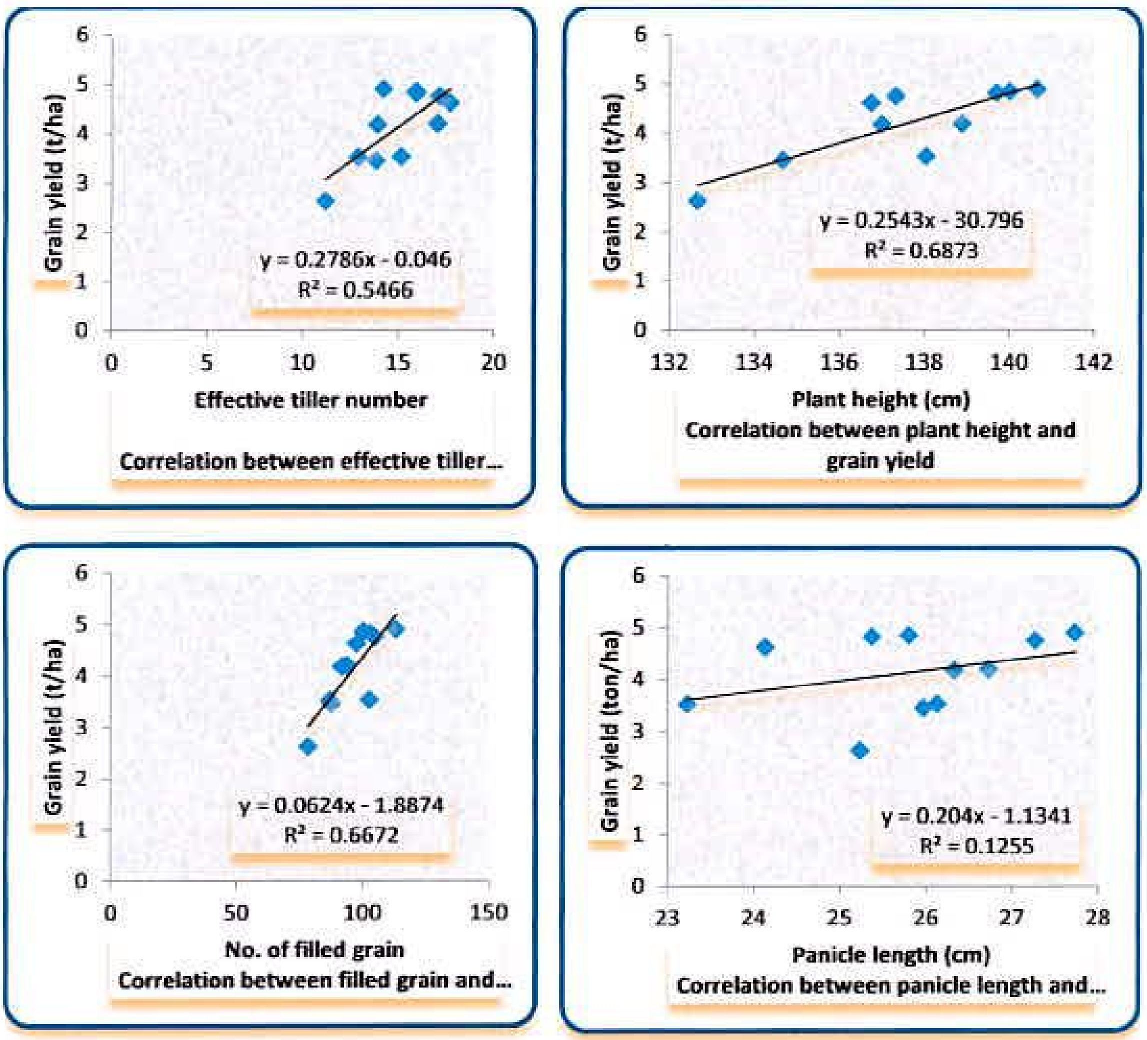
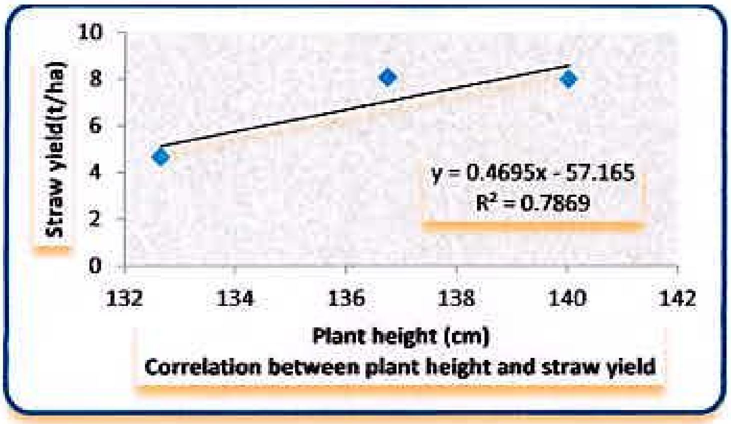
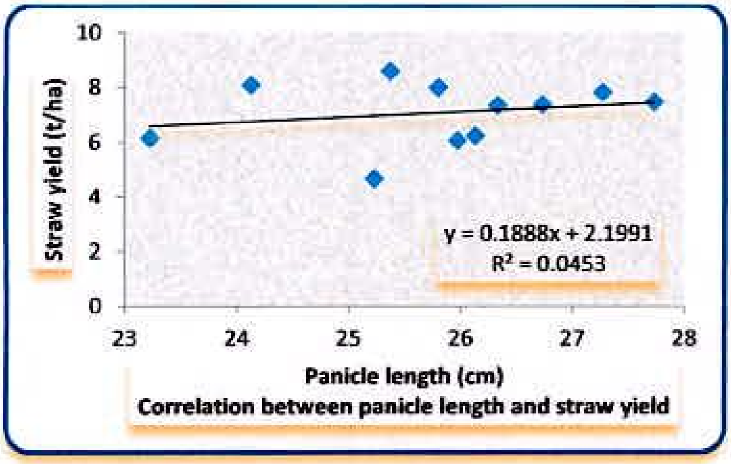


Fig. 4.3 Correlation between grains yield with yield components of rice.





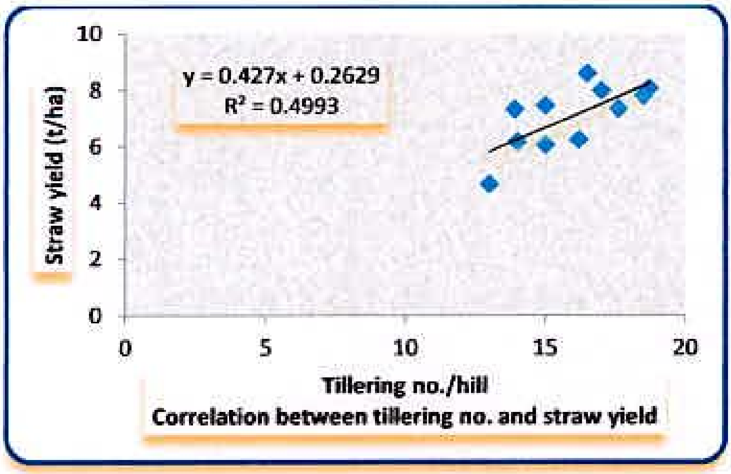


Fig. 4.4 Correlation between straw yield with yield components of rice.

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 different treatments (Table 4.3). The nitrogen contents in rice grain ranged from 1.14 to 1.28 %. The highest nitrogen contents (1.28%) in rice grain was observed in the treatment T_1 (N_{120} P_{15} K_{45} S_{20}), due to application of recommended doses of chemical fertilizers and lowest nitrogen content in grain (1.14%) was noted in T_0 (control) treatment . The effect of 4 t/ha dhaincha manure application in combination with 70% NPKS fertilizers (T_5 treatment) was more pronounced in increasing the nitrogen content in rice grain of BRRI dhan 40 as compared to cowdung which was the next height grain nitrogen concentration and statistically identical with treatment T_2 (80% NPKS + 2 t ha^{-1} DH) and T_3 (80% NPKS + 4 t ha^{-1} CD) and statistically comparable with all other higher treatments. Application of chemical fertilizers increased the nitrogen content in rice grain markedly.

The nitrogen content in rice straw varied significantly due to different treatments (Table 4.3). The nitrogen contents in rice straw range from 0.710 to 0.862 %. The highest nitrogen contents (0.862 %) in rice straw was observed in the treatment T_1 (N_{120} P_{15} K_{45} S_{20}), due to application of recommended doses of chemical fertilizers and lowest nitrogen content in straw (0.710 %) was noted in T_0(control) treatment. The next height nitrogen concentration in straw of BRRI dhan 40 was observed at 4 t/ha cowdung application in combination with 80 % NPKS fertilizers (T_3) treatments which was more as compared to green manure and was statistically identical with all other treatment except T_0 (control) treatment.

BRRI dhan 40 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 nitrogen content in rice grain was higher than that of straw. A significant increase in nitrogen content in rice grain and straw due to the application of organic manure and fertilizers have been reported by many investigators (Azim, 1999; Verma, 1991; Hoque, 1999 and Jeong *et al.* 1996).

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 0.200 to 0.292%. The highest phosphorus content (0.292%) in grain was observed in the treatment T_2 (80% NPKS + 2 t ha^{-1} DH) 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_5 (70% NPKS + 4 t ha^{-1} DH) which was statistically identical with all other treatment except T_0 (control) treatment. Lower grain P content was observed in the treatment those received NPKS fertilizers with cowdung compared to those obtained with 100% NPKS and NPKS fertilizers with dhaincha.

In rice straw the P content varied significantly due to different treatments (Table 4.3). The P content in straw ranged from 0.051 to 0.081 %. The highest P content (0.081 %) in rice straw was recorded in the treatment T_2 (80% NPKS + 2 t ha^{-1} DH) 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_2 (80% NPKS + 2 t ha^{-1} DH) which is statistically identical to T_3, T_6 and T_9.

Application of GM in combination with NPKS fertilizers cost pronounced effect in increasing P content in rice grain and straw as compared to cowdung. Verma 1991 reported that incorporation of organic manure significantly increased the concentration of P in rice grain and 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 significantly increased the concentration of P in rice grain and straw.

Table 4.3 Effect of different treatments on N, P, K and S concentrations in grain and straw of T. Aman rice (cv. BRRI dhan 40).

Treatments	Concentration (%)							
	Grain				Straw			
	N	P	K	S	N	P	K	S
T_0(Control)	1.14d	0.200b	0.258b	0.090c	0.710c	0.051d	1.573de	0.055c
T_1($N_{120}P_{15}K_{45}S_{20}$, Recommended dose)	1.280a	0.280a	0.324a	0.114ab	0.862a	0.065bc	2.120ab	0.073ab
T_2(80% NPKS + 2 t ha^{-1} DH)	1.209bc	0.292a	0.336a	0.114ab	0.770bc	0.081a	2.152ab	0.083a
T_3(80% NPKS + 4 t ha^{-1} CD)	1.150cd	0.273a	0.317ab	0.094c	0.787b	0.076a	1.960abc	0.070b
T_4(80% NPKS + 1 t ha^{-1} DH + 2 t ha^{-1} CD)	1.146d	0.280a	0.330a	0.102b	0.768bc	0.058c	2.052ab	0.078a
T_5(70% NPKS + 4 t ha^{-1} DH)	1.260ab	0.289a	0.341a	0.116a	0.778b	0.056c	2.250a	0.086a
T_6(70% NPKS + 8 t ha^{-1} CD)	1.164cd	0.285a	0.315ab	0.096bc	0.750bc	0.079ab	1.910bc	0.071b
T_7(70% NPKS + 2 t ha^{-1} DH + 4 t ha^{-1} CD)	1.182cd	0.282a	0.323a	0.099bc	0.761bc	0.063bc	1.385e	0.077ab
T_8(50% NPKS + 6 t ha^{-1} DH)	1.157cd	0.279a	0.312ab	0.113ab	0.779b	0.077b	2.150ab	0.079ab
T_9(50% NPKS + 12 t ha^{-1} CD)	1.160cd	0.255ab	0.298ab	0.106b	0.754bc	0.079ab	1.722cd	0.070b
T_{10}(50% NPKS + 3 t ha^{-1} DH + 6 t ha^{-1} CD)	1.150cd	0.251ab	0.290ab	0.096bc	0.752bc	0.055c	1.690cde	0.073ab
CV (%)	2.14	3.52	1.10	3.97	0.83	2.34	9.17	1.20

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

CV (%) = Coefficient of variation, CD = Cowdung, DH = Dhaincha

4.3.3 Potassium content

The potassium content in rice grain varied significantly due to different treatments (Table 4.3). Potassium content in rice grain ranged from 0.258 to 0.341%. The highest potassium content (0.341%) in grain was observed in the treatment T_5 (70% NPKS + 4 t ha^{-1} DH)that was significantly higher than the rest of the treatments and the lowest K concentration was noted in the treatment T_0 (control). The next highest K content in rice grain was found in the treatments T_1 (Recommended dose) and T_2 (80% NPKS + 2 t ha^{-1} DH). Lower grain K content was observed in the treatment those received NPKS fertilizers along with cowdung compared to NPKS fertilizers with dhaincha.

In rice straw the K content varied significantly due to different treatments (Table 4.3). The K content in straw ranged from 1.573 to 2.250%. The highest K content (2.250%) in rice straw was recorded in the treatment T_5 (70% NPKS + 4 t ha^{-1} DH) and the lowest K concentration was noted in the treatment T_0 (control). The next highest K content in rice straw was found in the treatment T_2 (80% NPKS + 2 t ha^{-1} DH).

The increasing K content in both grain and straw was more pronounced by green manure compared to cowdung. From the results it was observed that the K content in rice straw was higher than those in grain in all the treatments K contents both in grain and straw of rice increased due to combined application of organic manure and chemical fertilizers (Islam, 1997 and Khan, 1998). Singh *et al.* (2001) also revealed that K 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 different treatments (Table 4.3). Sulphur content in rice grain ranged from 0.09 to 0.116%. The highest S content (0.116%) in grain was observed in the treatment T_5 (70% NPKS + 4 t ha^{-1} DH)that was significantly higher than the rest of the treatments and the lowest S concentration was noted in the treatment T_0 (control). The next highest S content in rice grain was found in the treatment T_2 (80% NPKS + 2 t ha^{-1} DH), that was statistically identical with T_1 (recommended dose) and T5 (70%NPKS + 2.4 t/ha PM) respectively. Lower grain S content was observed in the treatment those received NPKS fertilizers with cowdung compared to NPKS fertilizers with dhaincha.

In rice straw the S content varied significantly due to different treatments (Table 4.3). The S content in straw ranged from 0.055 to 0.086 %. The highest S content (0.086 %) in rice straw was recorded in the treatment T_5 (70% NPKS + 4 t ha^{-1} DH)and the lowest S concentration was noted in the treatment T_0 (control). The next highest S content in rice straw was found in the treatment T_2 (80% NPKS + 2 t ha^{-1} DH).

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

4.3.5 Correlation between 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**).

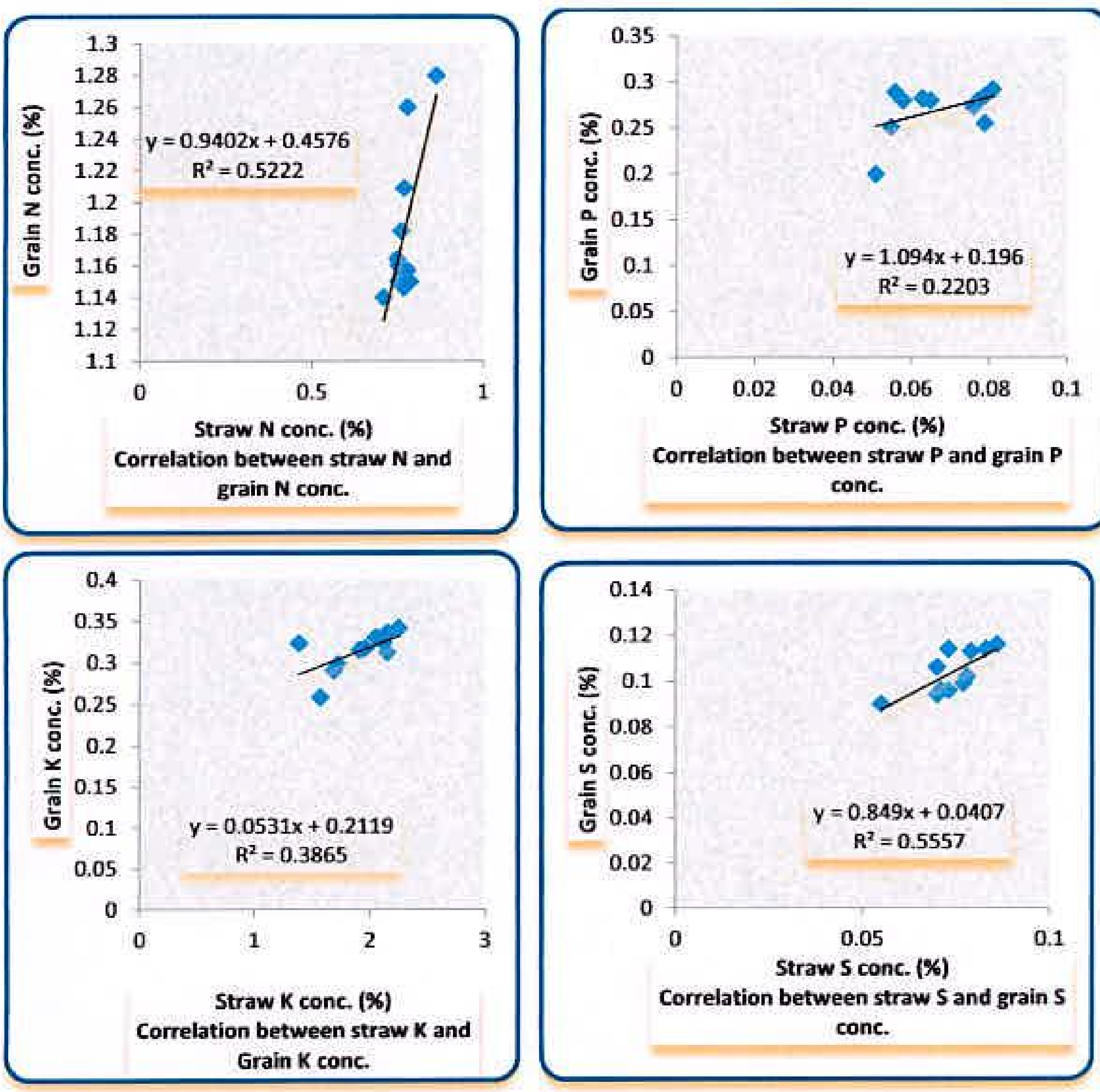


Fig. 4.5 Relationship between straw nutrient and grain nutrient conc. (%)

4.4 Nutrient uptake by grain and straw of rice

The uptake of N, P, K and S ware calculated from the yields (kg/ha) and nutrient concentration (%) of grain and straw. The results of N, P, K and S uptake by grain and straw of BRRI dhan 40 are presented and discussed below:

4.4.1 Nitrogen uptake

Table 4.4 indicate that the results of nitrogen uptake by both rice grain and straw of BRRI dhan 40 varied significantly due to application of organic manure and chemical fertilizers. The nitrogen uptake by rice grain ranged from 41.38 to 71.94 kg/ha and straw ranged from 33.08 to 69.65 kg/ha. The highest N uptake by grain 71.94 kg/ha and by straw (69.65 kg/ha) were recorded in the treatment T_1 (Recommended dose). The lowest N uptake in rice grain (41.38 kg/ha) and straw (33.08 kg/ha) were recorded in the treatment T_0. 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 N uptake ranged from 74.46 to 141.9 kg/ha (Table 4.4 and figure 4.5). The highest total N uptake (141.9 kg/ha) was recorded in the treatment T_1 (Recommended dose) and the lowest value (74.46 kg/ha) was observed in the treatment T_0. This results shows that the total N uptake by grain and straw were more influenced due to combined application of green manure (GM) 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. Duhan *et al.* (2002); Rahman (2001); Hoque (1999) and Azim (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 by both rice grain and straw of BRRI dhan 40 varied significantly due to application of organic manure and chemical fertilizers. The P uptake by rice grain ranged from 7.26 to 17.08 kg/ha and straw ranged from 2.38 to 6.53 kg/ha. The highest P uptake by grain (17.08 kg/ha) and by straw (6.53 kg/ha) were recorded in the treatment T_5 (70% NPKS + 4 t ha^{-1} DH) and T_3 (80% NPKS + 4 t ha^{-1} CD) respectively. The lowest P uptake in rice grain (7.26 kg/ha) and straw (2.38 kg/ha) were recorded in the treatment T_0 (control).

The total P uptake (Table 4.4) both by rice grain and straw varied significantly with different treatments. The total P uptake ranged from 9.64 to 23.40 kg/ha (Table 4.4 and figure 4.5). The highest total P uptake (23.40 kg/ha) was recorded in the treatment T_2 (80% NPKS + 2 t ha^{-1} DH), and the lowest value (9.64 kg/ha) was observed in the treatment T_0 (control). This results shows that the total P uptake by grain and straw were more influenced due to combined application of green manure (GM) with chemical fertilizers. Sengar *et al.* (2000) reported that the P uptake by rice grain and straw increased significantly with the combined application of organic manure and chemical 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 40) 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)	41.38 e	33.08 e	74.46f	7.26 f	2.38 g	9.64 i
T_1(N_{120} P_{15} K_{45} S_{20} , Recommended dose)	71.94 a	69.65 a	141.59a	15.74 b	5.25 c	20.99cd
T_2(80% NPKS + 2 t ha^{-1} DH)	70.73 a	61.40 b	132.13bc	17.05 a	6.32 a	23.40 a
T_3(80% NPKS + 4 t ha^{-1} CD)	70.30 b	67.60 a	138.9ab	15.89 b	6.53 a	22.42 b
T_4(80% NPKS + 1 t ha^{-1} DH + 2 t ha^{-1} CD)	65.90 b	60.06 bc	125.96c	16.10 b	4.53 d	20.63 d
T_5(70% NPKS + 4 t ha^{-1} DH)	69.85 a	58.10 bc	132.44bc	17.08 a	4.16 e	21.15 c
T_6(70% NPKS + 8 t ha^{-1} CD)	60.30 c	55.05 c	115.35d	14.76 c	5.95 b	20.71 cd
T_7(70% NPKS + 2 t ha^{-1} DH + 4 t ha^{-1} CD)	61.46 c	56.09 c	117.55d	14.67 c	4.64 d	19.31 e
T_8(50% NPKS + 6 t ha^{-1} DH)	52.41 d	48.61 d	101.02e	12.64d	4.80 d	17.44 f
T_9(50% NPKS + 12 t ha^{-1} CD)	51.62 d	45.69 d	97.31e	11.35 e	4.79 d	16.14 g
T_{10}(50% NPKS + 3 t ha^{-1} DH + 6 t ha^{-1} CD)	51.98 d	46.32 d	98.3e	11.35 e	3.39 f	14.74 h
CV (%)	3.73	5.24	3.36	3.79	4.30	2.29

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

CV (%) = Coefficient of variation, CD = Cowdung, DH = Dhaincha

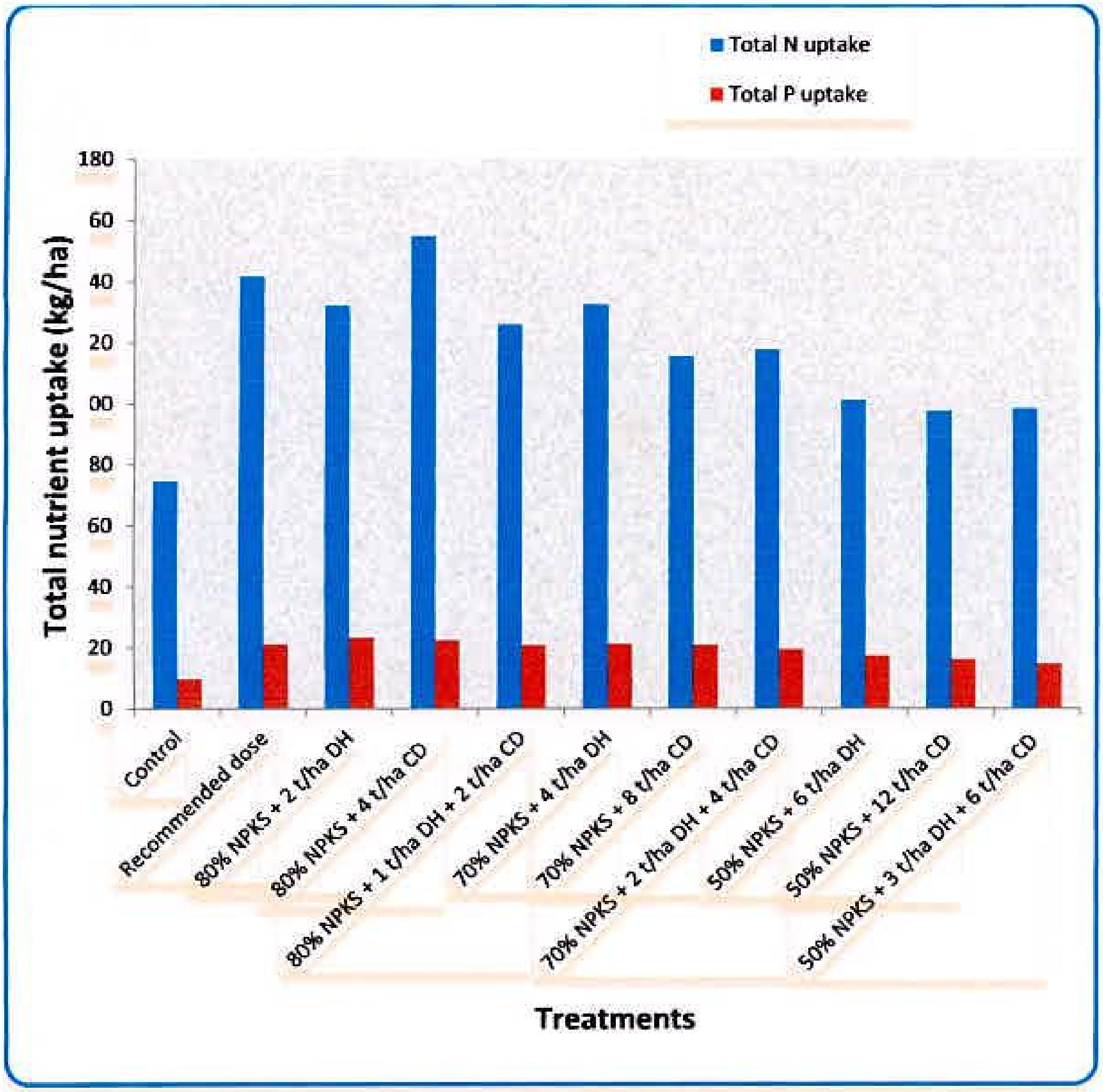


Fig. 4.6 Total N and P uptake by grain and straw of T. Aman rice (cv. BRRI dhan 40) as influenced by combined use of fertilizers and manure

4.4.3 Potassium uptake

Table 4.5 indicate that the results of K uptake by both rice grain and straw of BRRI dhan 40 varied significantly due to application of organic manure and chemical fertilizers. The K uptake by rice grain ranged from 9.37 to 20.12 kg/ha and in straw ranged from 73.32 to 172.15 kg/ha. The highest K uptake by grain (20.12 kg/ha) and by straw (172.15 kg/ha) were recorded in the treatment T_5 (70% NPKS + 4 t ha^{-1} DH) and T_2 (80% NPKS + 2 t ha^{-1} DH), respectively. The lowest P uptake in rice grain (9.37 kg/ha) and straw (73.32 kg/ha) were recorded in the treatment T_0 (control).

The total K uptake (Table 4.5) both by rice grain and straw varied significantly with different treatments. The total K uptake ranged from 82.69 to 191.81 kg/ha (Table 4.5 and figure 4.6). The highest total K uptake (191.81 kg/ha) was recorded in the treatment T_2 (80% NPKS + 2 t ha^{-1} DH), and the lowest value (82.69 kg/ha) was observed in the treatment T_0 (control). This results shows that the total K uptake by grain and straw were more influenced due to combined application of green manure (GM) with chemical fertilizers. Sengar *et al.* (2000) reported that the K uptake by rice grain and straw increased significantly with the combined application of organic manure and chemical fertilizers. Similar results were also obtained 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 by both rice grain and straw of BRRI dhan 40 varied significantly due to application of organic manure and chemical fertilizers. The S uptake by rice grain ranged from 3.27 to 6.84 kg/ha and in straw ranged from 2.57 to 6.64 kg/ha. The highest S uptake by grain (6.84 kg/ha) and by straw (6.64 kg/ha) were recorded in the treatment T_5 (70% NPKS + 4 t ha^{-1} DH) and T_2 (80% NPKS + 2 t ha^{-1} DH), respectively. The lowest S uptake in rice grain (3.27 kg/ha) and straw (2.57 kg/ha) were recorded by the treatment T_0 (control).

The total S uptake (Table 4.5) both by rice grain and straw varied significantly with different treatments. The total S uptake ranged from 5.84 to 13.31 kg/ha (Table 4.5 and figure 4.6). The highest total S uptake (13.31 kg/ha) was recorded in the treatment T_2 (80% NPKS + 2 t ha^{-1} DH) and the lowest value (5.84s kg/ha) was observed in the treatment T_0 (control). This results shows that the total S uptake by grain and straw were more influenced due to combined application of green manure (GM) with chemical fertilizers. GM provides better in increasing the S uptake by BRRI dhan 40 as compared to cowdung. Poongothai *et al.* (1999) observed that application of S enhanced significantly S uptake by rice. Sengar *et al.* (2000) and Rahman (2001) reported the similar results. Azim (1999) and Hoque (1999) recorded the higher uptake of S with the application of manure and fertilizers either alone or in combinations.

Table 4.5 Potassium and Sulphur uptake by grain and straw of T. Aman rice (cv. BRRI dhan 40) 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)	9.37 f	73.32 e	82.69 d	3.27 h	2.57 h	5.84g
T_1(N_{120} P_{15} K_{45} S_{20} , Recommended dose)	18.21c	171.29 a	189.5 a	6.41 b	5.90 bc	12.31 b
T_2(80% NPKS + 2 t ha^{-1} DH)	19.66 ab	172.15 a	191.81 a	6.67 ab	6.64 a	13.31 a
T_3(80% NPKS + 4 t ha^{-1} CD)	18.45 bc	168.38 a	186.83 a	5.47 d	6.01 bc	11.48 c
T_4(80% NPKS + 1 t ha^{-1} DH + 2 t ha^{-1} CD)	18.98abc	160.46 ab	179.44ab	5.87 c	6.10 abc	11.97 bc
T_5 (70% NPKS + 4 t ha^{-1} DH)	20.12 a	168.01 a	188.13 a	6.84 a	6.42 ab	13.26 a
T_6 (70% NPKS + 8 t ha^{-1} CD)	16.32 d	148.51 abc	164.83 ab	4.97 e	5.21 de	10.18e
T_7 (70% NPKS + 2 t ha^{-1} DH + 4 t ha^{-1} CD)	16.80 d	123.55 cd	140.3 bc	5.15 e	5.67 cd	10.82d
T_8(50% NPKS + 6 t ha^{-1} DH)	14.13 e	132.13 bcd	146.27 b	5.12 e	4.93 ef	10.05 e
T_9(50% NPKS + 12 t ha^{-1} CD)	13.26 e	104.35 d	117.61 c	4.72 f	4.24 g	8.96 f
T_{10}(50% NPKS + 3 t ha^{-1} DH + 6 t ha^{-1} CD)	13.11 e	104.11 d	117.22 c	4.34 g	4.50 fg	8.84 f
CV (%)	5.17	11.69	10.44	3.59	5.85	3.52

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

CV (%) = Coefficient of variation, CD = Cowdung, DH = Dhaincha

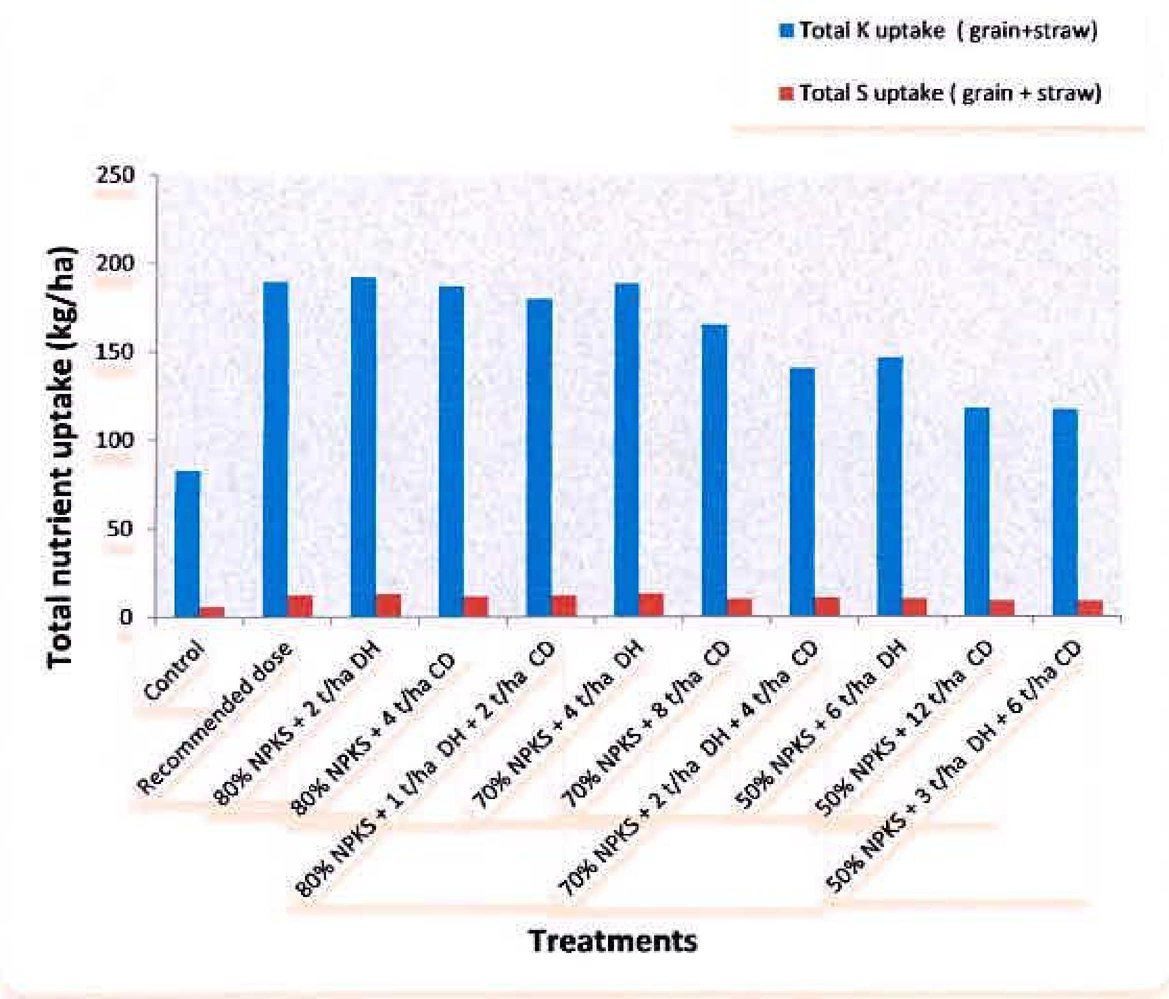


Fig. 4.7 : Total K and S uptake by grain and straw of T. Aman rice (cv. BRRI dhan 40) as influenced by use of organic manure and chemical fertilizers at different treatments.

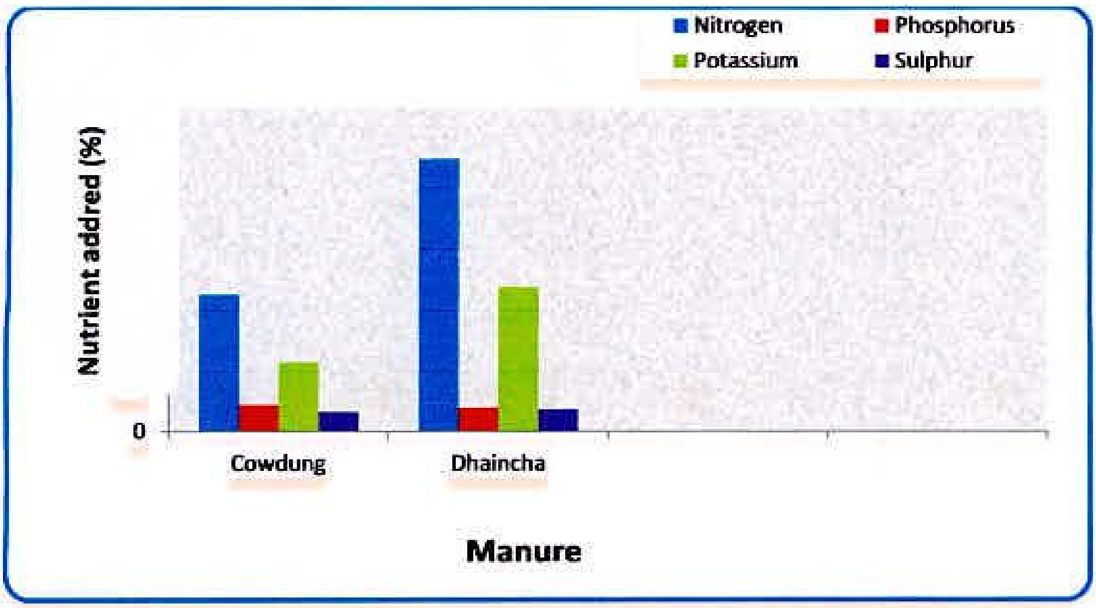


Fig. 4.8 Amount of nutrient (%) added to soil from various manures

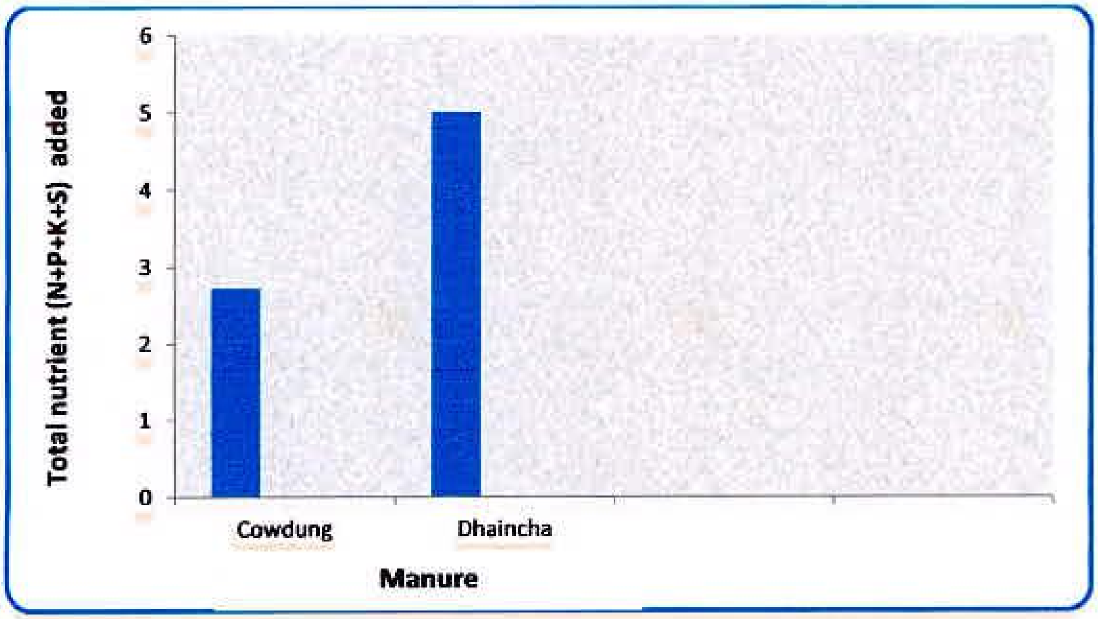


Fig. 4.9 Total amounts of nutrients % of (N+P+K+S) added to soil from various manures

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 range from 5.78 to 6.0 against pH value of 6.15 of the initial soil sample. The decreasing effect was more where no chemical fertilizers were applied. The lowest value of pH (5.78) was observed in the treatment T_0 and the highest value (6.0) was recorded in treatment T_3 (80% NPKS + 4 t ha^{-1} CD) and treatment T_{10} (50% NPKS + 3 t ha^{-1} DH + 6 t ha^{-1} CD).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 acidic effect of S fertilizers. Swarup and Singh (1994) reported that the soil pH reduce due to the application organic manure with chemical fertilizers . Similar results were also observed by Islam (1997) Bharadwaj and Tyagi (1994) and Khan (1998).

4.5.2 Organic matter content

Table 4.6 reveals that the organic matter content of the post harvest soils ranged from 1.28 to 1.42%. The organic matter of initial soil was 1.19%. It was observed that organic matter content tended to increased 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 value of 1.42 % organic matter content in soil was observed in the treatment T_5 (70% NPKS + 4 t ha^{-1} DH) and lowest value was obtained in the treatment T_0 (control). Zhang *et al.* (1996) showed that the combined application of organic manure and chemical fertilizer 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); Hoque (1999) and Azim (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 contents of the post-harvest soils ranged from 0.065 to 0.097% as compared to the value of 0.035 % of the initial soil. The highest value (0.097%) was observed in the treatment T_5 (70% NPKS + 4 t ha^{-1} DH),and lowest value (0.065 %) 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 contents of the post-harvest soils ranged from 17.48 to 23.98 ppm as compared to the P value of 13.40 ppm of the initial soil. The highest P content (23.98 ppm) was observed in the treatment T_6 (70% NPKS + 8 t ha^{-1} CD) and treatment T_0 (control) having lowest P content (17.48 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 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 soils were increased due to application of organic manure in soil compared to application of chemical fertilizers. Similar were also observed by hang *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 0.099 to 0.156 m. eq. per 100 g 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_5 (70% NPKS + 4 t ha^{-1} DH) and the lowest (0.099 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 inorganic fertilizers. Zhang *et al.* (1996) reported that the combined application of dhaincha 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 soils varied considerably due to the application of organic manure and chemical fertilizers (Table 4.6). The available sulphur content in post-harvest soils ranged from 11.02 to 19.665 ppm against the S value of 14.4 ppm in the initial soil. The highest value of available sulphur content (19.665 ppm) was noted in the treatment T_2 (80% NPKS + 2 t ha^{-1} DH) and the lowest (11.02 ppm) was observed in the treatment T_0 (control). Results in table 4.6 also indicate that available sulphur content was higher in soils treated with organic manure than those treated with inorganic fertilizers. Hossain (1996) found that the combined use of organic manure with NPKS improved the S status in soil. Shahiduzzaman (1997) also found that the application of organic manure increase available S content in soil compared to application of chemical fertilizers. Similar result was obtained by Azim (1999).

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

Treatment	Soil pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me/ 100 g of soil)	Available S (ppm)
T_0(Control)	5.92ab	1.28 c	0.065a	17.48j	0.099e	11.02c
T_1(N_{120} P_{15} K_{45} S_{20} , Recommended dose)	5.98a	1.39 ab	0.095a	19.45d	0.135c	18.168a
T_2(80% NPKS + 2 t ha^{-1} DH)	5.80bc	1.34 b	0.089a	19.09f	0.147ab	19.665a
T_3(80% NPKS + 4 t ha^{-1} CD)	6.00a	1.36ab	0.090a	19.31e	0.134c	16.450ab
T_4(80% NPKS + 1 t ha^{-1} DH + 2 t ha^{-1} CD)	5.78c	1.36ab	0.092a	18.56i	0.148ab	17.752a
T_5 (70% NPKS + 4 t ha^{-1} DH)	5.86bc	1.42a	0.097a	19.95c	0.156a	18.280a
T_6 (70% NPKS + 8 t ha^{-1} CD)	5.82bc	1.38ab	0.088a	23.98a	0.150a	16.225ab
T_7 (70% NPKS + 2 t ha^{-1} DH + 4 t ha^{-1} CD)	5.88abc	1.36ab	0.089a	20.12b	0.140a	17.558a
T_8(50% NPKS + 6 t ha^{-1} DH)	5.90abc	1.38ab	0.090a	18.96g	0.142bc	17.770a
T_9(50% NPKS + 12 t ha^{-1} CD)	5.84bc	1.38ab	0.082a	18.80h	0.112d	12.520bc
T_{10}(50% NPKS + 3 t ha^{-1} DH + 6 t ha^{-1} CD)	6.00a	1.35b	0.079a	18.66i	0.141bc	16.665ab
Significant level	0.01	0.01	ns	0.01	0.01	0.01
CV (%)	1.08	1.16	2.18	0.33	17.05	15.77

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

CV (%) = Coefficient of variation

CHAPTER V

SUMMARY & 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 2011 to evaluate the effects of chemical fertilizers and organic manure in T. Aman rice (cv. BRRI dhan 40). The soil belongs to the Tejgoan soil series under the AEZ of Madhupur Tract (AZE-28) . The soil texture was silt loam having pH 5.8, 0.045 % total N, 16 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 eleven treatments and laid out in Randomized Complete Block Design (RCBD) with three replications. The unit plot size was 3m × 2m and the total number of plots ware 33. The treatments were T_0 (Control), T_1 (N_{120} P_{15} K_{45} S_{20} , Recommended dose), T_2 (80% NPKS + 2 t ha^{-1} DH), T_3 (80% NPKS + 4 t ha^{-1} CD), T_4 (80% NPKS + 1 t ha^{-1} DH + 2 t ha^{-1} CD), T_5 (70% NPKS + 4 t ha^{-1} DH), T_6 (70% NPKS + 8 t ha^{-1} CD), T_7 (70% NPKS + 2 t ha^{-1} DH + 4 t ha^{-1} CD), T_8 (50% NPKS + 6 t ha^{-1} DH), T_9 (50% NPKS + 12 t ha^{-1} CD), T_{10} (50% NPKS + 3 t ha^{-1} DH + 6 t ha^{-1} CD). Dhaincha were applied before two weeks of final land preparation by following irrigation and well decomposed cowdung were incorporated into the plots 7 days before transplanting of rice seedling. Nitrogen, Phosphorus, Potassium and Sulphur were applied in different rates from Urea, TSP, MOP and Gypsum, respectively. The seedling of 30 days old were transplanted in the experimental plots on 14 August, 2011. The intercultural operations were done as and when required required. The crop was harvested on 26 November, 2011 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 12 % 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 content. 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 revealed that all the yield contributing characters except 1000-grain weight of BRRI dhan 40 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 tiller per hill and 1000-grain weight were recorded in the treatment T_3,T_5, T_5, T_1 and T_7 respectively and the lowest were found in the control treatment T_0. The highest grain (5.9 tha^{-1}) and straw (8.59 t ha^{-1}) yields were obtained in the treatment T_5 (70% NPKS + 4 t ha^{-1} DH) and T_3 (80% NPKS + 4 t ha^{-1} CD) respectively and the lowest grain yield (3.63 t ha^{-1}) and straw yields (4.66 t 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 $T_5 > T_2 > T_3 > T_4 > T_1 > T_7 > T_6 > T_8 > T_{10} > T_9 > T_0$ and $T_3 > T_1 > T_2 > T_4 > T_5 > T_7 > T_6 > T_8 > T_{10} > T_9 > T_0$ respectively.

The highest nitrogen content in grain (1.28%) and straw (0.862 %) were recorded in treatment T1 (recommended dose) treated plot and the lowest nitrogen content in grain (1.14 %) and straw (0.71 %) were found in the T_0 treated plot. The highest P content in grain (0.292 %) and straw (0.081%) were observed in the treatment T_2 (80% NPKS + 2 t ha^{-1} DH) and the lowest P content in grain (0.200 %) and straw (0.051%) were found in the treatment T_0 (control). K 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 GM) and T_5 (70% NPKS + 2.4 t/ha PM) treatments, respectively. The lowest K contents in grain (0.256%) and straw (1.580%) were found in the treatment T_0. 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. S 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 found in the treatment T_5 (70% NPKS + 2.4 t/ha) and T_7 (70% NPKS + 6 t/ha DH), respectively. The lowest S contents in grain (0.063%) and straw (0.052) were found in the treatment T_0.

Nitrogen, phosphorus, Potassium and Sulphur uptake by rice (BRRI dhan 40) grain and straw were also affected significantly due to the various treatments. The highest total N uptake by grain (71.94 kg/ha) and straw (69.65 kg/ha) were found in the treatment T_1 (Recommended dose) . The lowest value of N uptake in grain (41.38 kg/ha) and straw (33.08 kg/ha) were observed in the treatment T_0.

The highest total P uptake by grain (17.08 kg/ha) and straw (6.53 kg/ha) were found in the treatment T_5 (70% NPKS + 4 t/ha PM). The lowest value of P uptake in grain (7.26 kg/ha) and straw (2.38 kg/ha) were observed in the treatment T_0.

The highest total K uptake by grain (20.12 kg/ha) and straw (172.15 kg/ha) were found in the treatment T_5 (70% NPKS + 4 t/ha GM) and T_2 (80% NPKS + 2 t ha^{-1} DH), respectively. The lowest value of K uptake in grain (9.37 kg/ha) and straw (73.32 kg/ha) were observed in the treatment T_0.

The highest total S uptake by grain (6.84 kg/ha) and straw (6.64 kg/ha) were found in the treatment T_5 (70% NPKS + 4 t/ha GM) and T_2 (80% NPKS + 2 t ha^{-1} DH), respectivelyThe lowest value of S uptake in grain (3.27 kg/ha) and straw (2.57 kg/ha) were observed in the treatment T_0.

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 (6.0). 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 40 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 GM 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 40 can be cultivated profitably in the Tejgoan silt loam soil by using combined application of 70% NPKS fertilizers with 4 t/ha GM. 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.

CONCLUSION AND RECOMMENDATIONS

Conclusions

- Combined application of 70% NPKS as the source of urea along with 4 ton ha^{-1} green manure performed the best in recording yield and yield contributing characters of BRRI dhan 40.
- Among the organic sources, green manure performed the best in recording yield and yield attributing characters as well as NPK content and uptake by BRRI dhan 40.
- Green manure and cowdung alone or with the combination of nitrogenous fertilizer slightly decreased soil pH than in initial soil.
- Organic manuring slightly increased total N, available P, exchangeable K and available S in post harvest soil compared to initial soil.

Recmmendations

- In farmer's field 70 % NPKS as the source of inorganic fertilizer along with 4 t ha^{-1} from green manure may be recommended for higher yield of BRRI dhan 40.
- Similar study should be done to evaluate the integrated nutrient management to get maximum yield of BRRI dhan 40 in other places of Bangladesh.

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APPENDICES

Appendix I. Monthly average of air temperature, relative humidity and total rainfall of the experimental site during the period from July 2011 to November 2011

Month	Year	Monthly average air temperature (^{0}C)			Average relative humidity (%)	Total rainfall (mm)	Normal rainy day	Average sunshine hours per day
		Maximum	Minimum	Mean				
July	2011	31.4	26.2	28.8	72	373.1	17	2
August	2011	31.6	26.3	28.95	74	316.5	16	2
September	2011	31.8	25.9	28.85	71	300.4	13	3
October	2011	31.6	23.8	27.4	65	172.3	7	6
November	2011	29.6	19.2	24.4	53	34.4	2	8

Source: Bangladesh Meteorological Department, Agargaon, Dhaka

APPENDICES

ABBREVIATIONS

SL. NO.	TERM	ABBREVIATIONS
1.	AEZ	Agro-ecological Zone
2.	BRAC	Bangladesh Agriculture Research Council
3.	BARI	Bangladesh Agriculture Research Institute
4.	BAU	Bangladesh Agricultural University
5.	BNF	Biological Nitrogen Fixation
6.	BRRI	Bangladesh Rice Research Institute
7.	Cmol kg^{-1}	Centimole Per Kilogram
8.	CD	Cowdung
9.	CV	Coefficient of Variation
10.	DAT	Day After Transplanting
11.	DH	Dhaincha
12.	DMRT	Duncan's Multiple Range Test
13.	FAO	Food and Agricultural Organization
14.	GM	Green Manure
15.	HYV	High Yielding Variety
16.	IPNS	Integrated Plant Nutrient System
17.	IRRI	International Rice Research Institute
18.	LSD	Least Significant Difference
19.	meq/100gm	Milli Equivalent per One Hundred Gram
20.	mg kg^{-1}	Milli Gram per Kilogram
21.	SAU	Sher-e-Bangla Agricultural University
22.	STB	Soil Test Basis
23.	t ha^{-1}	Ton per Hectare
24.	T. Aman	Transplanted Aman
25.	TSP	Triple Super Phosphate
26.	USDA	United States Department of Agriculture

ABBREVIATIONS

SL. NO.	TERM	ABBREVIATIONS
1.	AEZ	Agro-ecological Zone
2.	BRAC	Bangladesh Agriculture Research Council
3.	BARI	Bangladesh Agriculture Research Institute
4.	BAU	Bangladesh Agricultural University
5.	BNF	Biological Nitrogen Fixation
6.	BRRI	Bangladesh Rice Research Institute
7.	Cmol kg^{-1}	Centimole Per Kilogram
8.	CD	Cowdung
9.	CV	Coefficient of Variation
10.	DAT	Day After Transplanting
11.	DH	Dhaincha
12.	DMRT	Duncan's Multiple Range Test
13.	FAO	Food and Agricultural Organization
14.	GM	Green Manure
15.	HYV	High Yielding Variety
16.	IPNS	Integrated Plant Nutrient System
17.	IRRI	International Rice Research Institute
18.	LSD	Least Significant Difference
19.	meq/100gm	Milli Equivalent per One Hundred Gram
20.	mg kg^{-1}	Milli Gram per Kilogram
21.	SAU	Sher-e-Bangla Agricultural University
22.	STB	Soil Test Basis
23.	t ha^{-1}	Ton per Hectare
24.	T. Aman	Transplanted Aman
25.	TSP	Triple Super Phosphate
26.	USDA	United States Department of Agriculture