GROWTH AND YIELD OF T. AMAN RICE AS AFFECTED BY NITROGEN MANAGEMENT FROM DIFFERENT SOURCES

A Thesis
By

MD. SAIFUL ISLAM

Registration No. 00804
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Submitted to the Department of Soil Science
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CERTIFICATE

This is to certify that the thesis entitled ***"GROWTH AND YIELD OF T. AMAN RICE AS AFFECTED BY NITROGEN MANAGEMENT FROM DIFFERENT SOURCES"*** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of ***MASTER OF SCIENCE IN SOIL SCIENCE,*** embodies the results of a piece of bona fide research work carried out by ***MD. SAIFUL ISLAM, REGISTRATION NO. 00804,*** under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma 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.

Prof. Dr. Alok Kumar Paul

Dated:

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Dedicated to

My Beloved Parents

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The Author

ABSTRACT

A field experiment was conducted at SAU farm, Dhaka from August to November 2007 to find the effects of different sources and management of N on that growth and yield of T. aman rice (cv. BR 11). The soil was silt loam having pH 5.4, organic matter 1.75%, available P 8.0 μg g^{-1}, available S 9.6 μg g^{-1} and K 0.11 meq/100g contents. There were nine treatments taking various doses of urea, USG and vermicompost viz. T_0: control, T_1: 120 kg N from urea, T_2: 100 kg N from urea+ 20 kg N from vermicompost, T_3: 80 kg N from urea + 40 kg N from vermicompost, T_4: 60 kg N from urea + 60 kg N from vermicompost, T_5: 120 kg N from USG, T_6: 103.5 kg N from USG + 16.5 N from vermicompost, T_7: 69 kg N from USG + 51 N from vermicompost and T_8: 45 kg N from USG + 75 N from vermicompost. The treatments were laid out in a randomized complete block design with four replications. Recommended doses of P, K, S and Zn were applied to all plots. The application of urea, USG and vermicompost had a significant positive effect on the plant height, panicle length and grains $panicle^{-1}$. The highest grain (4.85 t ha^{-1}) and straw (6.92 t ha^{-1}) yields of rice were recorded in the T_1 treatment. The T_0 (control) treatment gave the lowest grain (2.56 t ha^{-1}) and straw yields (3.97 t ha^{-1}). The application of urea, USG and vermicompost significantly increased the N, P, K and S contents as well as their uptake by the crop. Overall results indicate that the application of urea at a recommended rate i.e. 120 kg N ha^{-1} along with recommended rate of P, K, S and Zn is necessary for obtaining higher grain yield as well as straw yield of T. aman rice in SAU farm soil and also in the areas having similar climatic, land and soil characteristics.

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Introduction

CHAPTER I

INTRODUCTION

Rice is the most important food crop in the developing countries of Asia, where population densities are very high and overall dietary levels are not adequate. In south and Southeast Asia, rainfed and irrigated transplanted rice occupies nearly two thirds of the rice-growing area and produces more than 80% of the paddy rice.

The crop production in Bangladesh is dominated by intensive rice cropping covering about 80% of arable land and the most dominant cropping pattern is Boro -T. aman rice. Out of total rice production in this country, about 48%, 45% and 7% come from boro, aman and aus crops, respectively (BBS, 2000). Although, Bangladesh ranks 4th in the world both in acreage and production of rice, it ranks 39th in yield (IRRI, 1995). The average yield of rice is low (3.44 t ha^{-1}) compared to other leading rice producing countries such as China, Korea, Japan and USA where per hectare yield is 6.26, 6.23, 6.58 and 7.37 t ha^{-1}, respectively (FAO, 2003).

Soil fertility management has significant importance to increase crop productivity. Unfortunately fertility of this country's soils has deteriorated over the years which are responsible for stagnating or declining crop yields. Plant nutrients in soil, whether naturally endowed or artificially maintained, is a major determinant of the success or failure of a crop production system. The crop production system with high yield targets can not be sustainable unless nutrient inputs to soil are at least balanced against nutrient removal by crops (Bhuiyan *et al.,* 1991). In Bangladesh the use of chemical fertilizers as a supplemental source of nutrients has been increasing steadily, however they are not usually applied in balanced proportions (BARC, 1997). Hence, a pragmatic step needs to be taken for balanced application of fertilizer with organic manure wherever necessary.

The farmers of Bangladesh usually apply only about 172 kg nutrients ha^{-1} annually (132 kg N, 17 kg P, 17 kg K, 4 kg S and 2 kg Zn + B + others), while the crop removal is about 250 kg ha^{-1} (Islam, 2002). Consequently, in addition to N, P and K deficiencies, some other nutrients such as B, Zn and S deficiencies are being observed in many parts of the country.

In these areas, prilled urea (PU) conventionally applied by farmers is very inefficiently used for transplanted rice largely because of serious losses (up to 60% of applied N) via ammonia volatilization, denitrification, nitrate, leaching, and/or runoff. In order to minimize N loss, especially loss due to denitrification, historically the Japanese have used different ways of deep placing fertilizer N. In 1975, IFDC proposed use of super granules of urea (USG) in place of mudballs containing urea fertilizer to achieve the same agronomic benefits as achieved through the Japanese concept of deep point placement of fertilizer N in transplanted rice.

USG can be prepared by melt-type processes (pan granulation, falling curtain, and fluid bed) and briquette (a special type of compaction). The latter process seems to be the most cost-effective viable alternative. Small-scale briquette machines have been developed to produce urea briquettes (UB) at village level at a rate of 200-250 kg/day. Basically, USG are large, discrete particles of ordinary urea $[(NH_2)_2CO]$ containing 46% N as NH_2 (amide form); their weights may vary from 1 to 2 g per particle. USG from melt granulation process are nearly spherical with a relatively smooth surface, while UB from briquetting will be pillow-shaped with broken edges.

The production of degradable organic waste and its safe disposal becomes the current global problem. Meanwhile the rejuvenation of degraded soils by protecting topsoil and sustainability of productive soils is a major concern at the international level. Provision of a sustainable environment in the soil by amending with good quality organic soil additives enhances the water holding capacity and nutrient supplying capacity of soil and also the development of resistance in plants to pests and diseases. By reducing the time of humification process and by evolving the methods to minimize the loss of nutrients during the course of decomposition, the fantasy becomes fact. Earthworms can serve as tools to facilitate these functions. They serve as "nature's plowman" and form nature's gift to produce good humus, which is the most precious material to fulfill the nutritional needs of crops. The utilization of vermicompost results in several benefits to farmers, industries, environment and overall national economy.

Hence, the prevailing situation underscores the need for a research to investigate whether use of fertilizer viz. urea and urea super granules combined with manure like vermicompost increase the yield of rice and improve the soil health and decrease the loss of urea. The present investigation was therefore undertaken with the following objectives:

1. To evaluate the efficiency of nitrogen supplied by different sources on the growth and yield of T. aman rice.
2. To examine effects of different sources of nitrogen on the nutrient uptake by T. aman rice.

Chapter II
Review of Literature

CHAPTER II

REVIEW OF LITERATURE

An attempt has been made in this chapter to present a brief and pertinent review of the works in Bangladesh and also in the other parts of the world in relation to the effects of urea, urea super granules and vermicompost on the growth, yield and nutrient uptake by rice.

2.1 Effect of USG compared with urea on rice

Krishnappa *et al.*, (1987) found slow release fertilizer performed better than PU at all N levels and yield with SCU or USG at 38 kg or 75 kg ha^{-1} was similar to yield with PU at 113 kg N ha^{-1}, but yield declined with SCU or USG at 150 kg N ha^{-1}.

Raja *et al.* (1987) conducted an experiment with rice cv. Pravath and six different forms of nitrogen and mentioned that nitrogen as USG gave the highest average yield of 5.44 t ha^{-1} compared with 4.64-4.92 t ha^{-1} for nitrogen in five other forms and the USG at 75 kg N ha^{-1} gave the highest yield of 7.2 t ha^{-1}. Chakravorti *et al.*(1989) reported that application of N as USG @ 37.5, 75.0 and 112.5 kg N ha^{-1} gave rice yield of 3.85, 5.22 and 5.48 t ha^{-1}, respectively compared with 3.10, 4.29 and 4.97 t ha^{-1} respectively, with N as prilled urea and 1.95 t ha^{-1} without N.

Sen and Pandey (1990) carried out a field trial to study the effect of placement of USG (5, 10 or 15 cm deep) and broadcast PU on rice yields of tall long duration Mashuri and dwarf short duration Madhuri. They found that all depths of USG placement resulted in significantly higher yield characters except panicle length than broadcast PU. Narayanan and

Thangamuthu (1991) carried out field experiments on rice cv. Tk. M9 and IR 20 at Coimbatore, Tamil Nadu in 1984-85, N was applied at 30N 60 and 90 kg N ha^{-1} using USG placed at a depth of 10 cm in the main plot. They noted that maximum yields of grain and straw were gained from 90 kg N per ha, while the lowest was under the control treatment.

Reddy *et al.* (1991) carried out a field experiment in 1984 to study the effects of different N sources on rice cv. Jaya and Mangala. They found that the highest grain yield of 5863 kg ha^{-1} was found from cv. Jaya treated with 112 kg ha^{-1} of urea super granules (USG) placed in the root zone. Sarker and Bastia (1991) studied the effect of 80 kg N ha^{-1} at transplanting in 7 different N forms, or received no N. They observed that grain yield was 2.10 t ha^{-1} without N and among the N sources ranged from 2.66 t ha^{-1} with prilled urea to 3.89 t ha^{-1} with large granule urea (LGU). They also observed that N uptake was highest from LGU and urea super granules (USG), while relative agronomic efficiency was highest with USG.

Bhale and Salunke (1993) conducted a field trial to study the response of upland irrigated rice to nitrogen applied through urea and USG. They found that grain yield increased with up to 120 kg urea and 100 kg USG. Singh *et al.* (1993) revealed that grain yield and N uptake increased with increased rates of N application and was highest with deep placement of USG.

Bhardwaj and Singh (1993) observed that placement of 84 kg N as USG produced a grain yield of 6.8 t ha^{-1} which was similar to placement of 112 kg USG.

The highest mean grain yields of 6.68 and 6.59 t ha^{-1} were obtained with split application of 80 kg N ha^{-1} as PU + dicyandiamide and by basal application of 80 kg N ha^{-1} as USG, respectively (Tomar and Verma, 1993). Das and Singh (1994) reported that grain yield and N use efficiency by rice were greater for deep placed USG than for USG broadcast and incorporated or three split application of PU.

Bhuiyan *et al.* (1998) concluded that economic benefit due to USG relative to PU was very high during the boro season than the transplant aman season and the benefit was higher in a lower rate of USG application in both seasons. Mishra *et al.* (1999) observed that application of nitrogen increased plant height, panicle length, number of tillers $hill^{-1}$, N uptake and consequently the grain and straw yields of lowland rice and they also observed that 76 kg N ha^{-1} as urea super granules (USG) produced the best results. Want *et al.* (1999) conducted a field experiment on the efficiency of some slow-release or modified sources of urea at different N levels and found that urea super granule @ 120 kg N ha^{-1} was the best in producing the yield and yield attributes of rice.

Miah *et al.* (2004) conducted a field experiment in Bangladesh from July to November 1999 to determine the effects of planting rate (1, 2, 3 or 4 seedlings/hill) and 2 forms of nitrogen (urea and urea super granules) on the yield and yield components of transplanted rice cv. BINA Dhan4. Plant height and number of productive tillers per hill were highest with planting of one and 2 seedlings/hill, respectively. The total number of tillers, leaf area index and total dry matter were highest with planting of 4 seedlings of rice/hill. The values of the parameters measured were higher with application of urea super granules compared to application of urea.

2.2 Combined effect of manures and fertilizer on rice

Gupta *et al.*, (1995) conducted field trials on different organic manure in India and reported that the application of pig manure (10 t ha^{-1}) produced the highest grain yield (4.5 t ha^{-1}) followed by PM and FYM which produced yield of 4.1 and 3.9 t ha^{-1} of rice grain, respectively. Jeong *et al.* (1996) studied the effects of organic matter application on rice growth and grain quality and they reported that 5 t fermented poultry manure ha^{-1} in rice field increased N content in plants.

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

Gopalswamy *et al.*, (1997) stated from a trial at seven sites in the Laurvery delta in winter 1992 that application of 50 kg N ha^{-1} and inoculation of *Azolla* microphylla gave higher yield of rice than the application of 50 kg N ha^{-1} alone. Sanzo *et al.* (1997) yield generally increased with increasing rates of manure and better results were found in combination with NPK. They also reported that there was no significant difference in producing yield between 45 t ha^{-1} cattle manure and 200 kg N ha^{-1}. Sarma and Singh (1998) reported that substitution of urea N with composted *Azolla* increased the yield of rice by 34.5%.

Thakur and Patel (1998) stated that nitrogen increased yield attributes, yield, plant N content and N uptake of rice compared with no N or application of FYM alone. They also stated that the highest grain yield (3.84 t ha^{-1}) was recorded with the application of 80 kg N ha^{-1} in 3 split dose with 5 t FYM ha^{-1} during both the years 60 kg N in 3 split doses with 5 t FYM gave 3.81 t grain ha^{-1}.

Bahu *et al.*, (2000) observed that application of FYM, NPK fertilizers, poultry manure and FYM + N all resulted significantly higher grain and straw yields than the control and FYM + N produced the highest rice yield, longest and heaviest panicles, heaviest grain weight and highest net returns for both Rasi and KRH-I.

2.3 Combined effects of fertilizer and vermicompost on rice

Singh *et al.*, (2005) conducted an experiment during the rainy seasons of 1999 and 2000 in Imphal, Manipur, India to study the efficiency of urea in integration of Azolla and vermicompost in rain fed lowland rice (*Oryza sativa*) indicated that the integration of chemical fertilizer with Azolla improved the yield attributes and yield of rice. Effective substitution of the recommended N dose of rice could be done up to 33% by vermicompost. Combined application of inorganic and organic source had better up of soil organic C and available N, P and K after crop harvest.

Singh et al (2005) carried out a field experiment in India to study the effect of integrated management of N fertilizer, vermicompost and Azolla on grain and nutrient uptake of rice. The highest grain and straw yields were recorded with the application of 60 kg N/ha plus Azolla. The combined application of fertilizer N, vermicompost and Azolla sustained the productivity even at lower rate of N application. The height N, P and K uptake was also recorded with the application of 60 kg N/ha plus Azolla treatment.

Sing *et al.,* (2005) conducted a pot culture study to evaluate the effect of vermicompost in comparison to biodigested slurry and farmyard manure (FYM) on an equal N basis with and without biofertilizer in rice. The study showed that the integrated application of vermicompost, fertilizer N and biofertilizers viz., *Azospirillum* and phosphobacteria increased rice yield by 15.9% over application with fertilizer N alone.

Jeyabal and Kuppuswamy (2001) conducted a field experiment to study the direct and residual effect of different sources of organic N with fertilizer N and biofertilizers in rice–legume crop sequence. The integrated application of 50% N through vermicompost, 50% via fertilizer N and biofertilizers recorded a grain yield of 6.25 and 0.51 t ha^{-1} in the rice and legume, respectively. These yields were 12.2 and 19.9% higher than those obtained with 100% fertilizer N alone. On average, integrated application increased the N, P and K uptake by 15.3, 10.7 and 9.4%, respectively in rice over fertilizer N alone. Organic carbon content in the residual soil after rice was not depleted due to integrated application. After the legume, organic carbon content increased by 4.55 to 6.82% due to integrated nutrition compared to fertilizer alone.

Sreenivas *et al.,* (2000) studied the integrated effect of application of fertilizer and vermicompost on soil available nitrogen (N) and uptake of ridge gourd (*Luffa acutangula*) at Rajendranagar, Andhra Pradesh, India. Soil available N increased significantly with increasing levels of vermicompost and highest N uptake was obtained at 50% of the recommended fertilizer rate plus 10 t ha^{-1} vermicompost. Similarly, the uptake of N, phosphorus (P), potassium (K) and magnesium (Mg) by rice (*Oryza sativa*) plant was highest when fertilizer was applied in combination with vermicompost (Jadhav *et al.*, 1997).

Soil available N increased significantly with increasing levels of vermicompost and highest N uptake was obtained at 50% of the recommended fertilizer rate plus 10 t ha^{-1} vermicompost. Similarly, the uptake of N, phosphorus (P), potassium (K) and magnesium (Mg) by rice (*Oryza sativa*) plant was highest when fertilizer was applied in combination with vermicompost (Jadhav *et al.* 1997).

2.4 Vermicomposting

Vermicomposting is a simple biotechnological process of composting, in which certain species of earthworms are used to enhance the process of waste conversion and produce a better end product. Vermicomposting differs from composting in several ways (Gandhi *et al.* 1997).

2.5 Nutrient status of vermicompost

Importance of vermicompost Source of plant nutrients Earthworms consume various organic wastes and reduce the volume by 40–60%. Each earthworm weighs about 0.5 to 0.6 g, eats waste equivalent to its body weight and produces cast equivalent to about 50% of the waste it consumes a day. These worm castings have been analyzed for chemical and biological properties. The moisture content of castings ranges between 32 and 66% and the pH is around 7.0. The worm castings contain higher percentage (nearly twofold) of both macro and micronutrients than the garden compost (Table 1).

Table 1. Nutrient composition of vermicompost and garden compost.

Nutrient element	Vermicompost Percentage (%)	Garden compost Percentage (%)
Organic carbon	9.8	13.412
Nitrogen	0.51	1.610
Phosphorus	0.19	1.020
Potassium	0.15	0.730
Calcium	1.18	7.612
Magnesium	0.093	0.568
Sodium	0.058	0.158
Zinc	0.004	0.110
Copper	0.002	0.004
Iron	0.205	1.331
Manganese	0.010	0.203

From earlier studies also it is evident that vermicompost provides all nutrients in readily available form and also enhances uptake of nutrients by plants.

2.6 Vermicompost improved crop growth and yields

Vermicompost plays a major role in improving growth and yield of different field crops, vegetables, flowers and fruit crops. The application of vermicompost gave higher germination (93%) of mungbean (*Vigna radiata*) compared to the control (84%). Further, the growth and yield of mung bean was also significantly higher with vermicompost application. Likewise, in another pot experiment, the fresh and dry matter yields of cowpea (Vigna unguiculata) were higher when soil was amended with vermicompost than with biodigested slurry (Karmegam *et al.* 1999, Karmegam and Daniel 2000).

Reddy *et al* (2004) reported that application of vermicompost at 5 t ha^{-1} significantly increased yield of tomato (*Lycopersicon esculentum*) (5.8t ha^{-1}) in farmers' fields in Adarsha watershed, Kothapally, Andhra Pradesh compared to control (3.5 t ha^{-1}). Similarly, greenhouse studies at Ohio State University in Columbus, Ohio, USA have indicated that vermicompost enhances transplant growth rate of vegetables. Amendment of vermicompost with a transplant grown without vermicompost had the highest amount of red marketable fruit at harvest. In addition, there were no symptoms of early blight lesions on the fruit at harvest. The yield of pea (Pisumsativum) was also higher with the application of vermicompost (10 t ha^{-1}) along with recommended N, P and K than with these fertilizers alone.

Sreenivas *et al.* (2000) studied the integrated effect of application of fertilizer and vermicompost on soil available nitrogen (N) and uptake of ridge gourd (*Luffa acutangula*) at Rajendranagar, Andhra Pradesh, India. Soil available N increased significantly with increasing levels of vermicompost and highest N uptake was obtained at 50% of the recommended fertilizer rate plus 10 t ha^{-1} vermicompost. Similarly, the uptake of N, phosphorus (P), potassium (K) and magnesium (Mg) by rice (*Oryza sativa*) plant was highest when fertilizer was applied in combination with vermicompost (Jadhav *et al.* 1997).

An experiment was conducted to study the effect of vermicompost and NPKS fertilizers on growth and yield of potato (cv. Cardinal) in Level Barind Tract (AEZ-25) soils of Bangladesh. The organic matter of the experimental field soil was very low and N, P, K and S were also low. 1

The land was medium fertile and P was 5.4. There were 12 treatments *viz.* control (T), vermicompost H 2 3 4 5 (VC) 2.5 t/ha (T), VC 5.0 t/ha (T), VC 10.0 t/ha (T), VC 2.5 t/ha+50% NPKS (T), VC 5 t/ha+50% 6 7 8 9 NPKS (T), VC 10 t/ha+50% NPKS (T), VC 2.5 t/ha+100% NPKS (T), VC 5 t/ha+100% NPKS (T), 10 11 12 VC 10 t/ha+100% NPKS (T), 50% NPKS (T) and 100% NPKS (T). The experiment was laid out in RCBD with three replications. The doses of N-P-K-S were 90-40-100-18 kg/ha for potato. Application of 10 vermicompost and NPKS significantly influenced the growth and yield of potato. The treatment T produced the highest (25.56 t/ha) tuber yield of potato. The lowest yield and yield contributing parameters 1 recorded in control (T). Application of various amounts of vermicompost (2.5, 5, 10 t/ha) with NPKS ers (50% and 100%) increased the vegetative growth and yield potato. Vermicompost at 2.5 5 and 10 t/ha with 50% of NPKS increased tuber yield over control by 78.3, 96.9 and 119.5 t/ha respectively. And vermicompost at 2.5, 5 and 10 t/ha with 100% of NPKS increased tuber yield by 146.8, 163.1 and 197.9 %, respectively. The results indicated that vermicompost (10 t/ha) with NPKS (100%) produced the highest growth and yield of potato. The correlation matrix showed that tuber yield of potato had significant and positive correlation with plant height (r = 0.953**), number of main stem/hill (r = 0.732*), weight of haulm (r = 0.948**), yield of haulm (r = 0.935**), dry weight of haulm (r = 0.935**), number of tubers/hill (r = 0.909**), percentage of dry matter of tubers (r = 0.948**), weight of tubers/hill (r = 1.00***) and dry weight of tuber (r = 0.985**). It is suggested that 100% inorganic fertilizers with 5-10 t/ha of vermicompost is suitable for better production of potato but 10 t/ha of vermicompost may not economically profitable.

A field experiment was conducted in a Rhodic Haplustox during 1997-98 to study the effect of enriched vermicompost on the yield and uptake of nutrients by cowpea. Among the different treatments tried, enriched vermicompost showed its superiority over other treatments for yield and uptake of major nutrients like N, P, K, Ca and Mg. But the micronutrient uptake was not significantly influenced by any of the treatment.

Reddy and Ohkura (2004) reported the nutrient content of vermicomposts of rice straw produced by 3 earthworm species (*Perionyx excavatus, Octochaetona phillotti* and *Octonochaeta rosea*). The nutrient contents of the rice straw vermicomposts and their effects on sorghum (*Sorghum bicolor*) growth were compared with those of the normal compost (without earthworms), chemical fertilizers (urea and single super-phosphate applied at 40 kg ha^{-1}), and soil without any amendments. The vermicompost produced by the 3 species of earthworms differed in their nutrient concentrations, and showed higher concentrations of total N and Ca than the normal compost. The vermicompost produced by *P. excavatus* showed higher concentrations of total N, and available P, K, Ca and Na than the compost produced by *O. rosea*. The growth of sorghum (in terms of plant height, shoot biomass, root length, root length, root biomass, leaf number and area) in a mixture of 75% of vermicompost produced by *P. excavatus* and 25% soil was significantly higher than the plants grown in a mixture of vermicompost produced by *O. phillotti* and *O. rosea* and soil, normal compost, soil mixed with chemical fertilizers and soil alone.

2.7 Soil properties and vermicompost

The influence of different fertilizer applications on soil biological and physical properties was studied in a field experiment in Tuscia, Italy.

Vermicompost from biological sludge, stabilized daily manure of mineral nitrogen fertilizer (NH_4NO_3) were applied to a maize crop at 200 kg N ha^{-1}. Soil enzyme activity (acid phosphates, dehydrogenase and protease) and CO_2 production were measured as indices of soil biological activity. These measures of metabolic activity were correlated to soil physical properties.

The soluble fractions of C and N were taken as indicators of fertilizer effects on soil fertility. There were positive correlation between soil porosity, enzymatic activity and CO_2 production in organic and mineral treatments. The addition of organic fertilizers improved soil physical and biological properties. The increase in macrospores, ranging from 50-100 µm, in soil treated with organic fertilizers was mainly due to an increase in elongated pores, which are considered very important both in soil-water-plant relationships and in maintaining a good soil structure. Organic treatments stimulated soil biological activity probably due to an enrichment of soil organic matter. Mineral fertilizer enhanced soil porosity by increasing regular and irregular pores and caused a priming effect of native soil organic matter (Marinari *et al.*, 2000).

Vermicompost increased macrospore space ranging from 50 to 500 µm, resulting in improved air-water relationship in the soil which favorably affect plant growth (Marinara et al. 2000). The application of organic matter including vermicompost favorably affects soil pH, microbial population and soil enzyme activities (Maheswarappa et al. 1999). It also reduces the proportion of water-soluble chemical species, which cause possible environmental contamination (Mitchell and Edwards 1997).

Chapter III
Materials and Methods

CHAPTER III

MATERIALS AND METHODS

This chapter describes the experimental aspects of the study. The experiment was conducted at Sher-e-Bangla Agricultural University Farm, with Aman rice (cv. BR 11) under some selected treatments. Chemical analysis of soil and plant (grain and straw) was carried out in the laboratory. This section for convenience of presentation has been divided into various sub-sections such as site and soil, climate, crop and variety, land preparation, experimental design, treatments, fertilizer application, sowing and transplanting, intercultural operations, harvesting and threshing, data collection, soil analysis, plant analysis and statistical analysis.

3.1 Site and soil

The experiment was conducted at Sher-e-Bangla Agricultural University (SAU) Farm, Dhaka during May to November 2007. It's a medium high land. The farm belongs to the Madhupur Tract agro ecological zone (AEZ 28). The soil falls into the Tejgaon soil series. General characteristics of the soil are presented in Table 1 and Table 2.

Table: 1 Morphological characteristics of the experimental field

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

Table: 2 Physical and chemical characteristics of the initial soil

Characteristics	Value
Mechanical fractions: % Sand (0.2-0.02 mm) % Silt (0.02-0.002 mm) % Clay (<0.002 mm)	 29.0% 41.8% 29.2%
Textural class	Clay Loam
Consistency	Granular and friable when dry.
pH (1: 2.5 soil- water)	5.8
CEC (cmol kg^{-1})	17.9
Organic C (%)	0.686
Organic Matter (%)	1.187
Total N (%)	0.032
Exchangeable K (cmol kg^{-1})	0.12
Available P (mg kg^{-1})	19.85
Available S (mg kg^{-1})	14.40

3.2 Climate

The experimental area has a sub-tropical climate, which is characterized by high temperature, high humidity and high rainfall with occasional gusty winds in the kharif season (April-September) and low rainfall associated with moderately low temperature during rabi season (October-March). Weather information regarding air temperature, relative humidity, rainfall and sunshine hours that prevailed at the experimental site during the cropping season is presented Appendix.

3.3 Crop and variety

The crop under study was T. Aman rice (cv. BR 11). The variety has been developed by the Bangladesh Rice Research Institute (BRRI), Gazipur and was released in 1991. This is a modern variety with high yield potential. Life cycle of this variety ranges from 110 to 120 days. The plant attains a height of 100-120 cm and it gives up to 7.5 t ha^{-1} grain yield (BRRI, 1999). This is a popular variety recommended for cultivation in Boro and Aman season in Bangladesh. It is somewhat resistant to many diseases with a particular resistant to blast disease. Insect and pest attacks are comparatively less in this variety.

3.4 Experimental season

The field experiment was conducted during Aman season of 2007. The experimental period was August 01 to November 25, 2007.

3.5 Land preparation

Land preparation was started in the 1st week of August 2007. The land was prepared by repeated ploughing and cross-ploughing with a power tiller. Every ploughing was followed by laddering to have a good tilth. Weeds and stubbles of the previous crop were collected and removed from the field. After leveling, the experimental plots were laid out as per treatments and design.

3.6 Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD). There were seven treatments, each replicated four times. Each treatment was spited into several plots for the T. Aman rice. The unit plot size was 2.4 m × 2.1 m. The plots were separated from each other by 0.3 m bunds. There were 1m drains between the blocks. The treatments were randomly distributed to each block. The layout of the experiment is presented in the appendix.

3.7 Treatments

There were eight treatments with various combinations of urea, USG and vermicompost including control. The treatments were shown as follows:

T_0 : Control

T_1 : 120 kg N from urea

T_2 : 100 kg N from urea + 20 kg N supplied by vermicompost

T_3 : 80 kg N from urea + 40 kg N supplied by vermicompost

T_4 : 60 kg N from urea + 60 kg N s supplied by vermicompost

T_5 : 120 kg N supplied from USG

T_6 : 103.5 kg N from USG + 16.5 kg N supplied by vermicompost

T_7 : 69 kg N from USG + 51 kg N supplied by vermicompost

T_8 : 45 kg N from USG + 75 kg N supplied by vermicompost

* USG= urea super granules

Table: 3 Nutrient elements, their sources and doses used in the experiment

Nutrient element	Source	Rate ha^{-1}
Phosphorus	TSP (20% P)	25 kg P ha^{-1}
Potassium	MoP (50% K)	65 kg K ha^{-1}
Sulphur	Gypsum (18% S)	10 kg S ha^{-1}
Zinc	ZnO (78% Zn)	15 kg Zn ha^{-1}

3.8 Fertilizer application

Well decomposed vermicompost was incorporated to the plots as per treatment at 6 days before transplantation of rice. The sources of N, P, K, S and Zn were urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum and zinc oxide respectively. Urea was applied to the plots as per treatments, One-third of which and the entire amount of other fertilizers were applied to the individual plots during final land preparation. Urea super granules were placed into the soil at 5 cm to 8 cm deep at 7 days after transplantation. The fertilizers were incorporated into soil by spading. As the amount of ZnO for a unit plot was small, the fertilizer was mixed with ground dry soil before application and then applied to the plot. The second split of urea was applied at 30 days after transplanting i.e. at maximum tillering stage and the remaining split at 55 days after transplanting i.e. at panicle initiation stage.

3.9 Sowing and transplanting

A well-puddle land was selected for the raising of seedlings. The sprouted seeds of Aman rice were sown in the seedbed on 20 June 2007, respectively and covered with a thin layer of fine earth. Adequate care of the seedling was taken. The seedlings were uprooted carefully from the seedbed in the morning and transplanted on the same day. After satisfactory land preparation followed by layout of the experimental field, the rice seedling were transplanted in the plots on 08 August, 2007. Forty eight days old, healthy seedlings were uprooted carefully from the seedbed and three seedlings were placed in each hill with a spacing of 20 cm × 15 cm.

3.10 Intercultural operations

During growing period of the crop, all necessary cares were done for ensuring and maintaining the normal growth and development of the crop. The following intercultural operations were done.

3.10.1 Irrigation

The experiment was conducted during wet season and so, irrigation was not needed frequently. The plots were irrigated times to time from the deep tube well so as to maintain the requisite soil moisture for optimum growth of the plants. About 5-6 cm water height was maintained in the plots up to the milk stage of rice plant. Excess water was drained out when the grains reached hard dough stage.

3.10.2 Weeding

The experimental plots were infested with some common weeds, which were removed twice by uprooting.

3.10.3 Insect control

The field was infested by rice stem borer, which was controlled by applying Furadan 3G on 26 September 2007.

3.11 Harvesting

After attaining full maturity, the crop was harvested on 25 November 2007. The harvested crop from each plot was bundled separately and brought to threshing floor. The crops were threshed, cleaned and processed.

3.12 Data collection

Data on the yield components were recorded on 10- hills $plot^{-1}$ and the yield data were on individual plots.

3.12.1 Plant height

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

3.12.2 Tillering

Tillers per hill were counted. It includes both productive and unproductive tillers.

3.12.3 Effective tillers

Effective tillers were counted per hill.

3.12.4 Panicle length

Panicle length in cm was measured from basal node of the rachis to apex.

3.12.5 Number of grains panicle^{-1}

The number of grains panicle^{-1} of all fertile tillers was counted.

3.12.6 1000-grain weight

Thousand rice grains from each plot were counted and weighed. It was expressed in (g).

3.12.7 Grain yield

After harvesting of the crop, grain yield from each unit plot was dried and weighed. The result was expressed as kg ha^{-1} on 14% moisture basis.

3.12.8 Straw yield

After harvesting of the crop, straw yield from each unit plot was dried and weighed. The result was expressed as kg ha^{-1}.

3.13 Soil analysis

The initial soil sample was analyzed for soil texture, consistency, pH, and organic matter, total N, available P, S, K and CEC. The results are presented in Table 2.

3.13.1 Collection and preparation of soil samples

Soil samples from the experimental field before the start of the experiment were collected from 10 different random spots from a depth of 0-15 cm. The soil samples were mixed thoroughly to make a composite sample and the unwanted materials such as stubbles, stones, weeds etc. were removed from soil. The soil samples were air-dried, ground, and sieved through a 2-mm (10 meshes) sieve. The composite sample was stored in a clean container for physical and chemical analysis.

3.13.2 Analysis of soil sample

Mechanical analysis

Mechanical analysis was done by hydrometer method (Buoyoucos, 1927). The textural class was determined following Marshall's triangular coordinate using USDA system.

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 (1962).

Organic matter content

Organic carbon content of soil was determined following wet oxidation method (Page *et al.,* 1982). The amount of organic matter was calculated by multiplying the percent organic carbon with the van Bemmelen factor, 1.73 (Piper, 1950).

Total nitrogen

Total N content in soil was determined by Kjeldahi method. The soil was digested with 30% H_2O_2, conc. H_2SO_4 and catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$: Se = 10:1:0.1). Nitrogen in the digest was determined by distillation with 40% NaOH followed by titration of the distillate trapped in H_3BO_3 with 0.01 N H_2SO_4 (Page *et al.*, 1982).

Available phosphorus

Available P content was extracted from soil with 0.5M $NaHCO_3$ solution at a pH 8.5 (Olsen *et al.*, 1954). The P in the extract was then determined by developing blue colour with $SnCl_2$ reduction of phosphomolybdate complex and measuring the colour by spectrophotometer at 660 nm wavelength (Page *et al.*, 1982).

Exchangeable potassium, calcium and magnesium

Exchangeable K was determined by extraction with 1M NH_4OAc, pH 7.0 solution followed by measurement of extractable K by flame photometer (Page *et al.*, 1982).

Available sulphur

Available S content was determined by extracting soil sample with $CaCl_2$ (0.15%) solution as described by Page *et al.* (1982). The S content in the extact was determined turbidimeterically and the turbid was measured by spcterophotometer at 420 nm wavelength.

3.14 Plant analysis

3.14.1 Preparation of plant sample

The plant samples were dried in an oven at 60^0C for about 48 hours and then ground by a grinding machine to pass through a 20-meash sieve. The ground plant materials (grain and straw) were stored in paper bags in a desiccator. The grain and straw samples were analyzed for determination of N, S and Zn concentration. The methods were as follows:

3.14.2 Digestion of plant samples with nitric-perchloric acid

A sub-sample weighing 0.5 g was transferred into a dry clean 100 ml Kjeldahl flask. A 10ml of diacid mixture (HNO_3: $HClO_4$ in the ratio 2:1) was added. After leaving for while, the flask was heated at a temperature slowly raised to 200^0 C. heating was momentarily stopped when the dense white fumes of $HClO_4$ occurred. The contents of the flask were boiled until they became clean and colorless. Elements like P, K, S and Zn were determined from the digest.

3.14.3 Digestion of plant samples with sulphuric acid

An amount of 100 mg oven dry, ground samples was taken in a 100 ml Kjeldahl flask. Into the flask, 1.1 g catalyst mixture (K_2SO_4:$CuSO_4.5H_2$-O:Se = 10:1:0.1), 2 ml 30% H_2O_2 and 3 ml conc. H_2SO_4 were added. The flask was swirled and allowed to stand for about 10 minutes, followed by heating at 200^0C. Heating was continued until the digest was clear and colourless. After cooling, the contents were taken into a 100 ml volumetic flask and the volume was made with distilled water. This digestion was performed for N determination exclusively.

3.14.4 Determination of elements

Nitrogen content

The N concentration in the digest was determined by distillation with 40% NaOH followed by titration of the distillate trapped in H_3BO_3 with 0.01 N H_2SO_4 (Page *et al.*, 1982).

Sulphur content

The S concentration in the digest was estimated turbid metrically by a spectrophotometer using 420 nm wave lengths.

3.15 Statistical analysis

The analysis of variance for various crop characters and also for nutrient concentration and uptake were done following the principle of F-statistics. Mean comparisons of the treatments were adjudged by the Duncan's Multiple Range Test (Gomez and Gomez, 1984). Correlation statistics was performed to examine the interrelationship among the plant characters under study.

Chapter IV
Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was carried out at SAU farm to evaluate the effect of different rates of urea and USG combined with vermicompost application on different yield contributing characters and yield of BR 11 rice. The data have been shown in various tables and figures. Results are discussed below under different sub-heads.

4.1 Effects of urea and USG combined with vermicompost on the yield parameters of rice

4.1.1 Plant height

Plant height of Boro rice was significantly affected due to application of various rates of urea and USG combined with vermicompost (Table 4). The highest plant height was observed in T_1 treatment the recommended dose of N (BARC 2005) which is statistically similar to the treatment T_5. The lowest plant height observed in T_0 (control) treatment. Plant height due to different treatments varied from 91.6 to 120.7 cm.

4.1.2 Panicle length

Panicle length is an important parameter for rice which is directly related to grain yield. (Table 4). The highest panicle length was observed in the treatment containing 100% of the recommended dose of N produced the highest result (24.5 cm) and the control treatment had the lowest (21.2 cm). Panicle length was statistically similar between treatments except the control. The present study is in agreement with the results reported by Balakrishnar and Natarajaratnam (1986).

4.1.3 Filled grains panicle^{-1}

Like other parameters, there was a significant effect of different sources of N on the number of grains panicle^{-1} (Table 4). The number of filled grains panicle^{-1} was found to vary from 64.4 to 120.3 across the treatments. The number of filled grains panicle^{-1} varied significantly with the treatments except the control. The highest number of grains panicle^{-1} was observed in T_1 treatment and the lowest in T_0 (control). The treatment T_1 and T_5 were statistically identical.

4.1.4 Unfilled grain panicle^{-1}

There was a significant effect of urea, USG and combined with vermicompost on the number of unfilled grains panicle^{-1} (Table 4). The number of unfilled grains panicle^{-1} was found to vary from 22.6 to 37.4 across the treatments. The number of unfilled grains panicle^{-1} varied significantly with the treatments except the control. The highest number of unfilled grains panicle^{-1} was observed in control (T_0) treatment and the lowest in T_3 treatment. Treatments T_1, T_2, T_3, T_4 and T_7 were statistically similar.

4.1.5 Thousand grain weight

The weight of 1000 grains did not vary significantly with the treatments. The 1000 grain weight followed the order of $T_1 > T_4 > T_5 > T_6 > T_8 > T_7 > T_2 > T_3 > T_0$ (Table 4). The 1000 grain weight ranged from 21.9 to 22.5 g over the treatments. Islam (1978) reported a significant increase of 1000 grain weight of rice due to N application. Hossain *et al.* (1997) reported that micronutrient deficiency might limit the grain yield of rice by reducing tillering and grain formation, but not affecting the 1000 grain weight.

Table: 4 Effects of urea and USG combined with vermicompost on grain and on the growth and yield components of T. Aman rice (cv. BR 11)

Treatment	Plant height (cm)	Panicle length (cm)	Filled grain panicle^{-1}	Unfilled grains panicle^{-1} (no.)	1000 grain weight (g)
T_0	91.6 c	18.6 bc	63.4 d	37.4 a	21.9
T_1	120.7 a	25.7 a	120.3 a	25.1 b	22.5
T_2	115.1 b	24.4 b	112.6 b	22.8 b	22.3
T_3	119.4 b	24.6 b	101.4 bc	22.6 b	22.2
T_4	117.0 b	23.1 b	100.8 bc	27.3 b	22.5
T_5	119.7 a	24.0 a	115.4 a	30.1 ab	22.1
T_6	117.9 b	23.6 b	99.7 bc	32.5 ab	22.4
T_7	117.6 b	23.5 b	98.8 bc	26.8 b	22.2
T_8	112.3 b	23.0 b	87.9 c	32.8 ab	22.3
SE (±)	8.36	5.74	6.77	13.6	NS
CV (%)	5.47	4.26	8.78	3.18	2.31

Figures having common letter in a column are not significantly different by DMRT at 5% level. SE = Standard error of means, CV = Co-efficient of variation, T_0: Control, T_1: 120 kg N from urea, T_2: 100 kg N from urea+ 20 kg N supplied by vermicompost, T_3: 80 kg N from urea + 40 kg N supplied by vermicompost, T_4: 60 kg N from urea + 60 kg N supplied by vermicompost, T_5: 120 kg N supplied by USG, T_6: 103.5 kg N from USG + 16.5 kg N supplied by vermicompost, T_7: 69 kg N from USG + 51 kg N supplied by vermicompost, T_8: 34.5 kg N from USG + 75 kg N supplied by vermicompost, * USG= urea super granules.

4.2 Effects of urea, USG and vermicompost on grain and straw yields of rice

4.2.1 Grain yield

Grain yield was the most important parameter of this study. The grain yield was significantly affected due to application of urea, USG then combination with vermicompost (Table 5 and Fig. 1). The grain yield varied from 2.56 to 4.85 t ha^{-1}. The highest grain yield was obtained in T_1 (120 kg N ha^{-1} from urea) treatment. Again treatments T_2 (100 kg N from urea + 20 kg N from vermicompost) T_3 (80 kg N from urea +40 kg N from vermicompost) and T_5 (120 kg N from USG) producing yields of 4.51, 4.41 and 4.82 t ha^{-1} respectively were not significantly different. The lowest yield was observed in the treatment T_0 (control). The yields of treatments T_4, T_6 and T_7 were statistically similar. Grain yield was higher in T_1 treatment and T_5 compared to other treatments due to higher production of effective tillers hill^{-1} and increased number of grains panicle^{-1}. Positive impact of N fertilization on rice yield is evidenced by many other scientists (Idris and Jahiruddin, 1982, Islam *et al.,* 1986 and Sahu *et al.,* 1997). A number of researchers also reported that S and N application had significantly higher grain yield over control (Choudhury and Hore, 1989; Hoque *et al.,* 1994; Akter *et al.,* 1994; Mandol *et al.,* 1998).

4.2.2 Straw yield

Like grain yield, there was a significant and positive effect of different sources of nitrogen on straw yield of T. aman rice (Table 5 and Fig 2). The straw yield varied between 3.97 and 6.92 t ha^{-1} with the highest yield in T_1 treatment, the second highest in T_5 treatment and the lowest in T_0 treatment. These results are in close agreement with the findings of Choudhury and Hore (1989). Treatments T_3, T_4, T_7, and T_8 were gave the statistically similar yields (viz. 5.32, 5.25, 5.27, 4.92 and 4.91 t ha^{-1}). The highest % yield increase was observed in treatment T_1. The trends of straw yield were T_1>T_5>T_2>T_3>T_4>T_6>T_7>T_8.

Table No: 5 Effects of urea and USG combined with vermicompost on grain and straw yields of T. aman rice (cv. BR 11)

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	% yield increase over control	
			Grain	Straw
T_0	2.56 d	3.97 c	-	-
T_1	4.85 a	6.92 a	89.5	74.3
T_2	4.51 a	5.92 ab	76.2	49.1
T_3	4.41ab	5.32 bc	72.3	34.0
T_4	3.59 c	5.25 bc	40.2	32.2
T_5	4.82 a	6.84 a	88.3	72.3
T_6	3.55 c	5.27 bc	38.7	32.7
T_7	3.52 c	4.92 bc	37.5	23.9
T_8	3.87 bc	4.91 bc	51.2	23.7
SE (±)	0.183	133.22	-	-
CV (%)	8.22	7.61	-	-

Figures having common letter in a column are not significantly different by DMRT at 5% level. SE = Standard error of means, CV = Co-efficient of variation, T_0: Control, T_1: 120 kg N from urea, T_2: 100 kg N from urea + 20 kg N supplied by vermicompost, T_3: 80 kg N from urea + 40 kg N supplied by vermicompost, T_4: 60 kg N from urea + 60 kg N supplied by vermicompost, T_5: 120 kg N supplied by USG, T_6: 103.5 kg N from USG + 16.5 kg N supplied by vermicompost, T_7: 69 kg N from USG + 51 kg N supplied by vermicompost, T_8: 45kg N from USG + 75 kg N supplied by vermicompost, * USG= urea super granules.

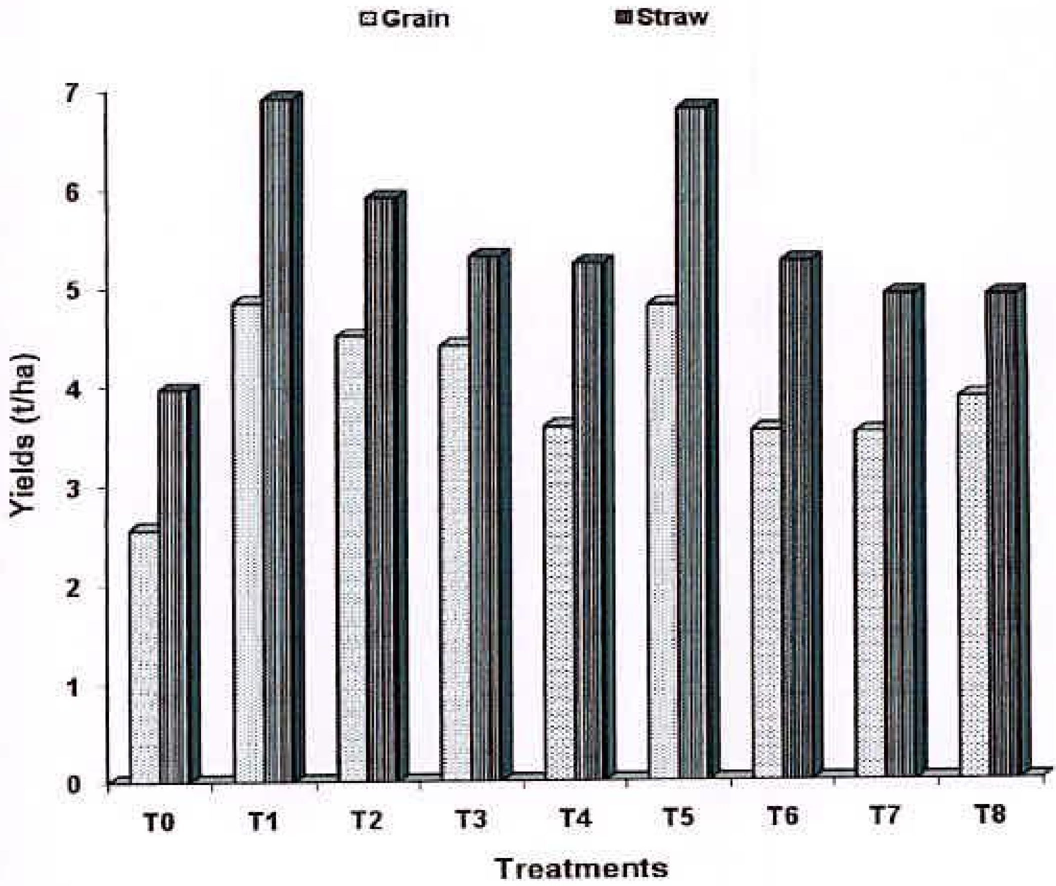

Fig. 1 Effects of urea, USG and combined with vermicompost on grain and straw yields of T. aman rice (BR 11)

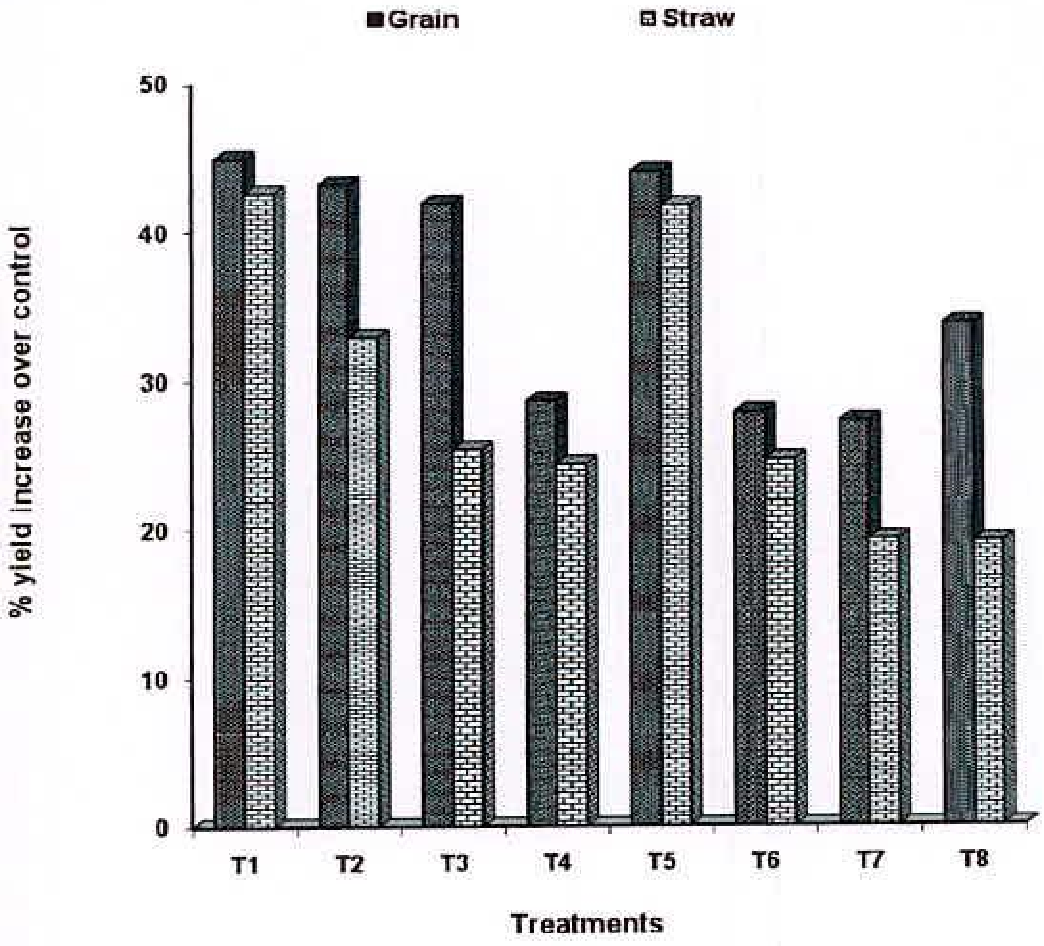

Fig. 2 Effects of urea, USG and combined with vermicompost on % yield increase over control BR 11 rice.

4.3 Effects of urea, USG and vermicompost on nutrient content in rice

4.3.1 Nitrogen content

Application of different sources of nitrogen increased the N content in both grain and straw (Table 6). The grain N content ranged from 0.997% to 1.41%. The N content of grain was found maximum in treatment T_5. The second highest value (1.40%) of N content was found in treatment T_1 and the third highest value (1.35%) was in T_2 treatment. In case of N content of straw the result varied from 0.515 to 0.670%, the highest value being obtained in T_1 and the lowest in control treatment. The findings of the present study are in conformity with the report of Mandata *et al.* (1994) indicating that concentration of N in rice plant increased with increasing rates of N application.

4.3.2 Phosphorus content

Phosphorus concentrations in grain and straw of BR 11 have been shown in (Table 6). It appeared that the P content in grain varied from 0.245 to 0.329% The highest P content was obtained in T_1 treatment which was closely followed by the treatment T_5 (0.326%) with no significant difference between these two treatments. The lowest value was found in control treatment. All the treatments responded to P application compared to control. In case of straw, the P content ranged from 0.072 to 0.112%. Again, the highest P content was observed in T_1 treatment. It also showed that all the treatments responded significantly over control.

Table: 6 Effects of urea and USG combined with vermicompost on N and P contents in grain and straw of T. aman rice (cv. BR 11)

Treatment	N Concentration (%)		P Concentration (%)	
	Gain	Straw	Grain	Straw
T_0	0.997d	0.515	0.245	0.072d
T_1	1.40 a	0.670	0.329	0.112 a
T_2	1.35 b	0.662	0.324	0.107b
T_3	1.32 b	0.656	0.301	0.103b
T_4	1.33 b	0.655	0.272	0.100b
T_5	1.41a	0.661	0.326	0.111a
T_6	1.18 bc	0.625	0.256	0.094c
T_7	1.13 c	0.651	0.254	0.093c
T_8	1.15 c	0.622	0.268	0.096c
SE (±)	0.017	NS	NS	0.045
CV (%)	5.69	4.65	8.96	11.23

Figures having common letter in a column are not significantly different by DMRT at 5% level. SE = Standard error of means, CV = Co-efficient of variation, $T_{0:}$ Control, $T_{1:}$ 120 kg N from urea, $T_{2:}$ 100 kg N from urea + 20 kg N supplied by vermicompost, $T_{3:}$ 80 kg N from urea + 40 kg N supplied by vermicompost, $T_{4:}$ 60 kg N from urea + 60 kg N supplied by vermicompost, $T_{5:}$ 120 kg N supplied by USG, $T_{6:}$ 103.5 kg N from USG + 16.5 kg N supplied by vermicompost, $T_{7:}$ 69 kg N from USG + 51 kg N supplied by vermicompost, $T_{8:}$ 45kg N from USG + 75 kg N supplied by vermicompost, * USG= urea super granules.

4.3.3 Potassium content

Application of N from different sources of fertilizer and manure significantly increased the K content in both grain and straw (Table 7). The K content in grain ranged from 0.194% to 0.249%. The K content in grain was found maximum in treatment T_5 which was more of less similar to the treatment T_1. The second highest value (0.245%) of K content was found in treatment T_1 and the third highest value (0.240%) was in T_3. In case of straw K content, the result varied from 0.760 to 1.51%, the highest value being obtained in T_5 and T_1 treatments and the lowest in control. The findings of the present study are in conformity with the report of Mandata *et al.* (1994) indicating that concentration of N in rice plant increased with increasing rates of N application.

4.3.4 Sulphur content

Sulphur concentrations in grain and straw of BR 11 have been shown in (Table 7). It appeared that the S content in grain varied from 0.094 to 0.110%, the highest S content was obtained in T_5 treatment which was closely followed by the treatment T_1 (0.130%) with no significant difference between these two treatments. The lowest value was found in control T_0 treatment. All the treatments responded to S application compared to control. In case of straw, the S content ranged from 0.120 to 0.140%. Again, the highest S content was observed in T_1 and T_2 treatments. It also showed that all the treatments responded significantly over control. The trend of S content in rice straw were T1>T2>T3>T4>T5>T6>T7>T8>T0.

Table: 7 Effects of urea, USG combined vermicompost on K and S contents in grain and straw of T. aman rice (cv. BR 11)

Treatment	K concentration (%)		S concentration (%)	
	Gain	Straw	Grain	Straw
T_0	0.194	0.760c	0.094	0.120
T_1	0.249	1.42 a	0.130	0.168
T_2	0.241	1.32 b	0.116	0.168
T_3	0.240	1.19 bc	0.125	0.162
T_4	0.231	1.27 b	0.116	0.150
T_5	0.245	1.51 a	0.133	0.145
T_6	0.214	1.16 bc	0.108	0.142
T_7	0.224	1.19 bc	0.102	0.134
T_8	0.215	1.18 bc	0.110	0.140
SE (±)	NS	0.125	NS	NS
CV (%)	3.65	3.55	4.66	6.54

Figures having common letter in a column are not significantly different by DMRT at 5% level. SE = Standard error of means, CV = Co-efficient of variation, T_0: Control, T_1: 120 kg N from urea, T_2: 100 kg N from urea + 20 kg N supplied by vermicompost, T_3: 80 kg N from urea + 40 kg N supplied by vermicompost, T_4: 60 kg N from urea + 60 kg N supplied by vermicompost, T_5: 120 kg N supplied by USG, T_6: 103.5 kg N from USG + 16.5 kg N supplied by vermicompost, T_7: 69 kg N from USG + 51 kg N supplied by vermicompost, T_8: 45kg N from USG + 75 kg N supplied by vermicompost, * USG= urea super granules.

4.4 Effects of urea, USG and vermicompost on nutrient uptake by rice

4.4.1 Nitrogen uptake

The uptake of N by both grain and straw due to different treatments was significantly influenced by the treatments. It appeared from Table 8. Treatment T_1 recorded the highest N uptake by grain and straw and treatment T_0 (control) did the lowest. The grain N uptake ranged between 25.5 to 67.8 and straw N uptake ranged from 20.4 to 46.3 kg ha^{-1}. The highest total N uptake was observed in treatments T_1 which was statistically identical of the treatment T_5. Poongothai *et al.* (1999) reported that application of N significantly increased S uptake by rice.

4.4.2 Phosphorus uptake

There was a significant variation in K uptake by both grain and straw due to different rates of sources of N application (Table 8). The P uptake by rice grain was considerably higher compared to rice straw. Concerning P uptake by the crop, the maximum P uptake was due to the application of full dose of recommended N and the minimum was due to no use. Such result was equally true for grain and straw. The total P uptake was found to vary from 9.17 to 23.4kg ha^{-1} due to control and T_5 treatments. The total P uptake by rice treatments T_1 and treatment T_5 gave the same results.

Table: 8 Effects of urea and USG combined with vermicompost on N and P uptake by grain and straw of T. aman rice (cv. BR 11)

Treatment	N uptake (kg/ha)			P uptake (kg/ha)		
	Gain	Straw	Total	Grain	Straw	Total
T_0	25.5 c	20.4c	45.9c	6.31d	2.86d	9.17d
T_1	67.9 a	46.3a	114.2a	15.9a	7.75a	23.04a
T_2	60.7 b	39.1ab	100.0ab	14.6ab	6.33ab	20.9ab
T_3	58.2 b	34.9b	93.1b	13.3b	5.48bc	19.1b
T_4	47.8 c	34.4b	82.2c	9.77c	5.25bc	15.2c
T_5	67.8 a	45.1a	112.9a	15.7a	7.57a	23.4a
T_6	41.9 cd	32.9d	74.8c	9.09c	4.95bc	14.1c
T_7	39.9 d	32.0d	71.9c	8.94c	4.58c	13.5c
T_8	44.5 cd	30.5d	75.0c	10.4c	4.71c	15.1c
SE (±)	0.989	1.86	4.07	0.621	0.483	0.125
CV (%)	7.89	14.2	8.54	9.74	15.6	8.11

Figures having common letter in a column are not significantly different by DMRT at 5% level. SE = Standard error of means, CV = Co-efficient of variation, T_0: Control, T_1: 120 kg N from urea, T_2: 100 kg N from urea + 20 kg N supplied by vermicompost, T_3: 80 kg N from urea + 40 kg N supplied by vermicompost, T_4: 60 kg N from urea + 60 kg N supplied by vermicompost, T_5: 120 kg N supplied by USG, T_6: 103.5 kg N from USG + 16.5 kg N supplied by vermicompost, T_7: 69 kg N from USG + 51 kg N supplied by vermicompost, T_8: 45kg N from USG + 75 kg N supplied by vermicompost, * USG= urea super granules.

4.4.3 Potassium uptake

The uptake of K by both grain and straw due to different treatments was significantly influenced by the treatments. It appeared from Table 9. the highest K uptake by grain was observed in treatment T_1 (12.1 kg ha^{-1}) and the lowest observed in treatment T_0 (4.97 kg ha^{-1}). Like grain K uptake straw K uptake were significantly influenced due to the different treatments. The highest S uptake recorded T_5 treatment and treatment T_0 (control) did the lowest. The total S uptake ranged between 35.1 and 114.8 kg ha^{-1}. This result corroborates well with the findings of Manchanda *et al.* (1993) who observed a significant P uptake by rice plant due to N application.

4.4.4 **Sulphur uptake**

There was a significant variation in S uptake by both grain and straw due to different sources of N application. The S uptake by rice straw was considerably higher compared to rice grain. Concerning s uptake by the crop, the maximum S uptake was due to the application of full dose of recommended N dose from urea and minimum was due to no use of N (Table 9). Such result was equally true for grain and straw. The total S uptake was found to vary from 7.17 to 17.9 kg ha^{-1} due to different treatments. The highest was observed in T_1 treatments and the lowest in control treatments.

Table: 9 Effects of urea and USG combined with vermicompost on K and S uptake by grain and straw of T. aman rice (cv. BR 11)

Treatment	K uptake (kg/ha)			S uptake (kg/ha)		
	Gain	Straw	Total	Grain	Straw	Total
T_0	4.97e	30.2d	35.1d	2.41d	4.76d	7.17e
T_1	12.1a	98.3a	110.4a	6.31a	11.63a	17.9a
T_2	10.9bc	78.2b	89.1b	5.23b	9.95ab	15.8b
T_3	10.6c	63.3bc	73.9bc	5.51b	8.62bc	14.1bc
T_4	8.29d	66.3bc	74.9bc	4.16bc	7.88bc	12.0cd
T_5	11.8ab	102.1a	114.8a	6.40ab	9.89ab	16.3ab
T_6	7.60d	61.1bc	68.7c	3.83c	7.48c	11.3d
T_7	7.88d	58.6c	66.4c	3.59cd	6.59cd	10.2d
T_8	8.32d	57.9c	66.3c	4.26cd	6.87cd	11.1d
SE (±)	0.245	1.31	4.23	0.387	0.342	0.616
CV (%)	8.46	5.81	8.01	4.88	10.2	5.74

Figures having common letter in a column are not significantly different by DMRT at 5% level. SE = Standard error of means, CV = Co-efficient of variation, $T_{0:}$ Control, $T_{1:}$ 120 kg N from urea, $T_{2:}$ 100 kg N from urea + 20 kg N supplied by vermicompost, $T_{3:}$ 80 kg N from urea + 40 kg N supplied by vermicompost, $T_{4:}$ 60 kg N from urea + 60 kg N supplied by vermicompost, $T_{5:}$ 120 kg N supplied by USG, $T_{6:}$ 103.5 kg N from USG + 16.5 kg N supplied by vermicompost, $T_{7:}$ 69 kg N from USG + 51 kg N supplied by vermicompost, $T_{8:}$ 45kg N from USG + 75 kg N supplied by vermicompost, * USG= urea super granules.

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 an insignificant decreasing effect on the pH of the post harvest soil (Table 10). All the treatment slightly decreased the soil pH as compared to initial soil. The pH value of post harvest soils ranged from 5.75 to 6.150 against pH value of 6.2 of the initial soil sample. The decreasing effect was more where no fertilizer was applied. The lowest value of pH (5.75) was observed in the treatment T_0 (Control). And the highest value (6.150) was recorded in T_5 : 120 kg N substituted by USG. A decreasing trend in the pH values of the post harvest soils might be due to the organic acids released from the decomposition of organic manure, crop residue and the acidic effect of sulphur fertilizers. Bharadwaj and Tyagi (1994) reported that the soil pH reduce due to the application of FYM plus pressmud. Similar results were also observed by Islam (1997), Khan (1998) and Swarup and Singh (1994).

4.5.2 Organic matter content

Table 10 reveals that the organic matter content of the post harvest soils ranged from 1.245 to 1.412%. The organic matter of initial soil was 1.187%. It was observed that organic matter content tended to increase in the soils treated with organic manure while the soils treated with chemical fertilizers caused a decreasing effect but the effect was statistically insignificant. Application of organic manure resulted in an increased organic matter content of post harvest soils as compared to the initial soil. The increasing organic matter content might be due to the addition of biomass through manuring. The highest value of 1.412% organic matter content in soil was observed in the treatment T_6 : 103.5 kg

N from USG + 16.5 N substituted by vermicompost and the lowest value was obtained in the treatment T_0 (Control). Zhang *et al.* (1996) showed that the combined application of organic manure and chemical fertilizers increased organic matter content in soil. Organic carbon also increased due to application of organic manure as reported by Haque *et al.* (2001); Mathew and Nair (1997); Azim (1999) and Hoque (1999).

4.5.3 Total Nitrogen

The total N contents of the post-harvest soils varied considerably by different treatments (Table 10). The total N content of the post-harvest soils ranged from 0.023 to 0.053 % as compared to the value of 0.032% of the initial soil. The highest value (0.053%) was observed in the treatment T_6 : 103.5 kg N from USG + 16.5 N substituted by vermicompost and lowest value was found in the treatment T_0 (Control). The result indicates that application of organic manure exerted an increasing effect on the total N content of the post harvest soils although the increase was insignificant. Rice cultivation with chemical fertilizers tended a decreasing effect on the organic matter and total N content of the soil. Gao and Chang (1996) and Mathew and Nair (1997) reported that the application of organic manure increased the total N content in soil. Several workers reported that organic manure had a positive influenced on total and available N content of soil. Similar were also observed by Razzaque (1996); Hoque (1999) and Azim (1999).

4.5.4 Available Phosphorous

Available phosphorous contents of the post-harvest soils varied considerably by the application of organic manure and chemical fertilizers (Table 10). Available phosphorous content in soil ranged from 18.92 to 24.14 ppm against the P value of 19.85 ppm in the initial soil. The highest P content (24.14 ppm) was recorded in the treatment T_5: 120 kg N substituted by USG and in the treatment T_0 (Control) having lowest P content (18.92 ppm). There was a little decrease in available P content in the soil treated with chemical fertilizers. Gupta *et al*., (1996) reported that organic carbon and available P content in the post harvest soil were increased by poultry manure application. Similar results were also found by Zhang *et al.,* (1996); Mathew and Nair (1997); Hoque (1999) and Azim (1999).

4.5.5 Exchangeable Potassium

Exchangeable potassium content of the post-harvest soils varied considerably due to the application of organic manure and chemical fertilizers (Table 10). The exchangeable K content in post-harvest soils ranged from 0.095 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_7 : 69 kg N from USG + 51 N substituted by vermicompost and the lowest (0.095 m. eq. per 100 g) was observed in the treatment T_0 (Control). Zhang *et al*. (1996) reported that the combined application of poultry manure with chemical fertilizer increased exchangeable K content in soil. Mathew and Nair (1997) observed that application of cattle manure increased the exchangeable K content in soil. Similar results were also reported by Sharma and Sharma (1994); Hoque (1999) and Azim (1999).

4.5.6 Available sulphur

Available sulphur content of the post-harvest soil also varied considerably due to different treatments (Table 10). The available sulphur content of the initial soil was 14.4 ppm and values in the post-harvest soils ranged from 11.338 to 19.575 ppm. The highest available S content (19.575 ppm) was observed in the treatment T_5 : 120 kg N substituted by USG and lowest value was observed in the treatment T_0 (Control). The S content of the post-harvest soils was higher in soils treated with organic manure compared to the soils treated with the chemical fertilizers. Hossain (1996) found that the combined use of the organic manure with NPKS improved the S status in soil. Shahidduzaman (1997) also found that the application of organic manure increase available S content in soil compared to application of chemicals fertilizers. Similar results were obtained by Hoque (1999) and Azim (1999).

Table 10. Effect of different treatment by the use of vermicompost and chemical fertilizers on the post-harvest soils

Treatments	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (m. eq. per 100g)	Available S (ppm)
T_0 : Control	5.75	1.245	0.023 f	18.92 b	0.095 f	11.338 g
T_1 : 120 kg N from urea	5.857	1.234	0.050 ab	19.31 c	0.134 e	18.188 c
T_2 : 100 kg N from urea + 20 kg N substituted by vermicompost	5.825	1.180	0.036 c	24.35 a	0.135 de	16.650 f
T_3 : 80 kg N from urea + 40 kg N substituted by vermicompost	5.675	1.199	0.046 bc	17.60 d	0.140 cd	17.750 d
T_4 : 60 kg N from urea + 60 kg N substituted by vermicompost	5.70	1.190	0.039 dc	17.43 d	0.147 b	17.550 c
T_5 : 120 kg N substituted by USG	6.150	1.303	0.043 cd	24.14 a	0.148 b	19.575 a
T_6 : 103.5 kg N from USG + 16.5 N substituted by vermicompost	5.750	1.412	0.053 a	19.95 b	0.141 c	17.775 d
T_7 : 69 kg N from USG + 51 N substituted by vermicompost	5.80	1.329	0.050 ab	18.83 c	0.156 a	18.400 b
T_8 : 45 kg N from USG + 75 N substituted by vermicompost	5.95	1.372	0.047 ab	20.43 b	0.149 b	18.54 b
SE (±)	NS	NS	17.89	2.01	2.11	0.54
CV (%)	3.13	0.0182	0.0027	0.1436	0.001	0.033
Initial Soil (Composite Sample)	6.2	1.187	0.032	19.85	0.12	14.4

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

SE (±) = Standard error of means

CV (%) = Coefficient of variation

PU = Prilled Urea

USG = Urea Super Granule

Chapter V

Summary and Conclusions

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at SAU farm during T. aman'07 season. The objective was to study growth and yield of T. aman rice as affected by nitrogen management of different sources. The experimental site belongs to Tejgaon soil series under the AEZ 28 (Madhupur Trace). There were nine treatments taking various doses of urea, USG and vermicompost viz. T_0: Control, T_1: 120 kg N from urea, T_2: 100 kg N from urea + 20 kg N from vermicompost, T_3: 80 kg N from urea + 40 kg N from vermicompost, T_4: 60 kg N from urea + 60 kg N from vermicompost, T_5: 120 kg N from USG, T_6: 103.5 kg N from USG + 16.5 N from vermicompost, T_7: 69 kg N from USG + 51 N from vermicompost and T_8: 45 kg N from USG + 75 N from vermicompost. The treatments were laid out in a randomized completely block design with four replications. All plots received a flat dose of P, K, S and Zn in order to support normal crop growth. Nutrients P, K, S and Zn were applied in the form of TSP, MoP, gypsum and ZnO, respectively. Intercultural operations were done as and when necessary.

Among the parameters the grain yield was the most important parameter in this study. The grain yield of rice was significantly influenced due to urea and USG fertilization. The grain yield varied from 2.56 to 4.85 t ha^{-1} where the highest yield observed in the T_1 treatment (100% recommended dose) and the lowest yield in the control T_0. Treatment T_1 recording the highest grain yield was not significantly different from treatment T_5. (120 kg N from USG)Like grain yield, the straw yield of rice responded markedly to the N sources of urea and USG applications. The straw yield ranged from 3.97 to 6.92 t ha^{-1} over the treatments. Except 1000 grain weight, all other growth and yield parameters of rice i.e. plant height, panicle length and grains $panicle^{-1}$ was significantly influenced by the different treatments. In all cases treatment T_1 and T_5 showed significantly higher results compared to other treatments.

The BR 11 rice responded positively to the different sources of N treatments in terms of nutrient content. The highest grain N, P, K, S content were observed in the treatment containing recommended dose of urea and USG. The straw N, P, K, S content was also highest in the treatment having 100% recommended dose of urea and USG. There was consistency between the treatments over grain and straw N contents.

There was a significant effect of the treatments on N uptake by rice. The highest N uptake was observed in treatment receiving 100% of the recommended dose and the lowest N uptake was obtained in the control. The total N uptake by the crop (grain + straw) ranged from 45.9 to 112.9 kg ha^{-1}.

Like N uptake there was a significant effect of the treatments on P uptake by rice. The highest P uptake was observed in treatment T_5 which was statistically identical of the treatment T_1. Lowest N uptake was obtained in the control. The total N uptake by the crop (grain + straw) ranged from 9.17 to 23.4 kg ha^{-1}.

There was a significant effect of the treatments on K uptake by rice. The highest K uptake was observed in treatment receiving 100% of the recommended dose of urea and USG (treatment $T_1$and T_5) the lowest K uptake was obtained in the control. The total K uptake by the crop (grain + straw) ranged from 35.1 to 114.8 kg ha^{-1}.

Like N, P and K uptake by grain and straw, there was a good variation in S uptake between grain and straw. The S uptake by straw was much higher than that by grain. However, the highest K uptake by both grain and straw was found in treatment $T_1$and T_5 and the lowest uptake in T_0 (control). The total S uptake (grain + straw) varied from 7.71 to 17.9 kg ha^{-1}.

Overall results indicate that application of nitrogen (100%) as prilled urea or USG performed better than their combination with vermicompost. Substitution of N by vermicompost had no positive effect on yield of rice or nutrient status of post harvest soil. Further experimention is required to substantiate the role of vermicompost in rice production.

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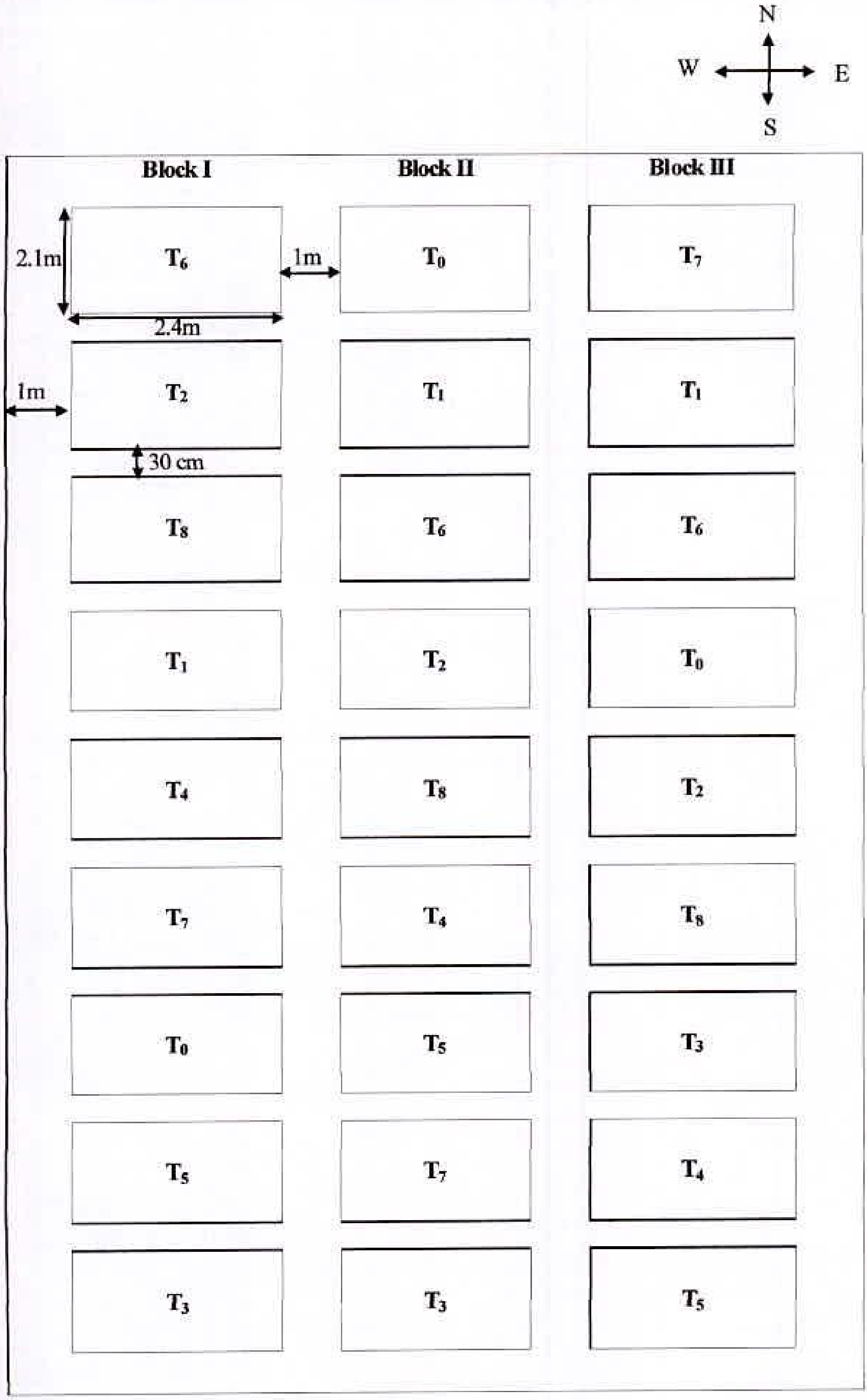
Appendices

APPENDICES

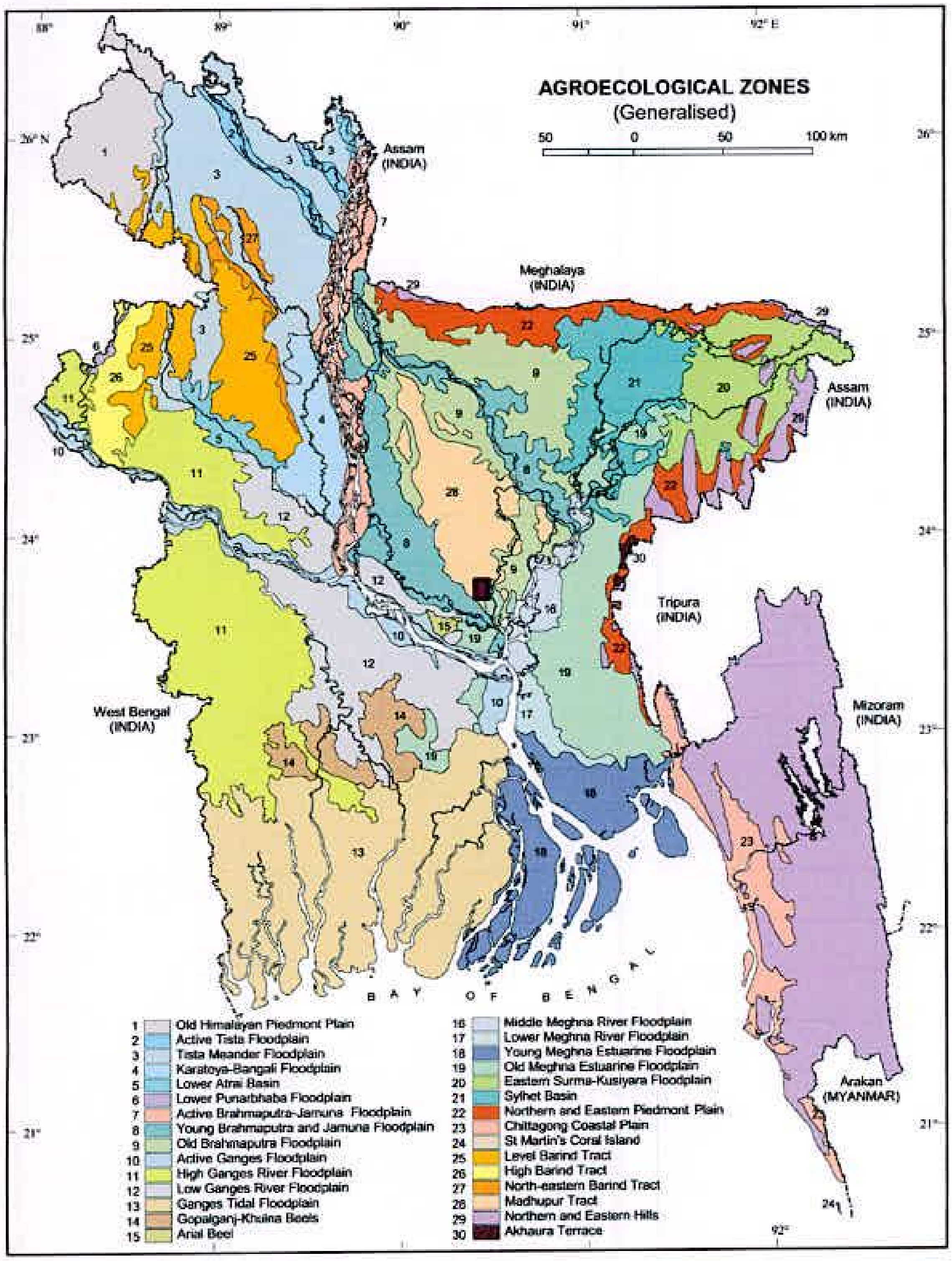
Monthly Temperature, Total Rainfall, Relative Humidity And Sunshine Data during June to December 2007 of experiment Site (Dhaka).

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

Source: Bangladesh Metrological Society, Climate Division, Dhaka.



Layout of the experimental plot



Map showing the experimental site under study

ABBREVIATIONS

AEZ	:	Agro-Ecological Zone
ANOVA	:	Analysis of Variance
APP	:	Ammonium Polyphosphate
BARC	:	Bangladesh Agricultural Research Council
BARI	:	Bangladesh Agricultural Research Institute
BAU	:	Bangladesh Agricultural University
BBS	:	Bangladesh Bureau of Statistics
BRRI	:	Bangladesh Rice Research Institute
CV	:	Coefficient of Variation
DMRT	:	Duncan's Multiple Range Test
FAO	:	Food and Agriculture Organization
FRG	:	Fertilizer Recommendation Guide
FYM	:	Farm Yard Manure
IRRI	:	International Rice Research Institute
MoP	:	Muriate of Potash
PU	:	Prilled Urea
RCBD	:	Randomized Complete Block Design
SAU	:	Sher-e-Bangla Agricultural University
SE	:	Standard error of means
T. Aman	:	Transplanted Aman
t ha^{-1}	:	Ton per Hectare
TSP	:	Triple Superphosphate
USDA	:	United States Department of Agriculture
USG	:	Urea Super Granules

Some photo of the experiment

Photo: 1

Photo: 2

Photo: 3

Photo: 4