INTEGRATED NUTRIENT MANAGEMENT FOR HYBRID BORO RICE

BY

MD. RAZIBUL HAQUE

REGISTRATION NO. 04-1453

A Thesis

Submitted to the Faculty of Agriculture, Dept. of Soil Science
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

IN

SOIL SCIENCE

SEMESTER: July - December, 2009

Approved by:

(Prof. Dr. Alok Kumar Paul)
Supervisor

(Assistant Prof. Jharna Rani Sarkar)
Co-supervisor

(Prof. Mst. Afrose Jahan)
Chairman
Department of Soil Science
Sher-e-Bangla Agricultural University

CERTIFICATE

This is to certify that the thesis entitled, ***"INTEGRATED NUTRIENT MANAGEMENT FOR HYBRID BORO RICE."*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE*** *in* ***SOIL SCIENCE,*** *embodies the result of a piece of bona fide research work carried out by* ***MD. RAZIBUL HAQUE,*** *Registration No.* ***04-1453*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated:

Place: Dhaka, Bangladesh

(Prof. Dr. Alok Kumar Paul)

Supervisor

DEDICATED TO MY BELOVED PARENTS

ACKNOWLEDGEMENTS

All praises are due to Omnipotent "Allah Rabbul Al-Amin" Who enabled me to pursue higher study and to complete the research work as well as to submit the thesis for the degree of Master of Science (M.S.) in Soil Science, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.

I would like to express my heartfelt respect, deepest sense of gratitude, profound appreciation and ever indebtedness to my supervisor, Professor ***Dr. Alok Kumar Paul****, Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka for his sincere guidance, scholastic supervision, constructive criticism, extending generous help and constant inspiration throughout the course and in preparation of the manuscript of thesis.*

I express my sincere respect to my Co-supervisor, Assistant Professor ***Jharna Rani Sarkar****, Department of Soil Science, Sher-e-Bangla Agricultural University, (SAU), Dhaka for his utmost co-operation, constructive suggestion to conduct the research work as well as preparation of the manuscript of thesis.*

I feel to express my sincere appreciation and indebtedness to my esteemed teachers Professor Dr. Md. Nurul Islam, Professor Dr. Asaduzzaman Khan, Professor Mst. Afrose Jahan, Assistant Professors Mohammad. Mosharraf Hossain, Mohammad. Issak, Md. Saiful islam Bhuiyan, Saikat Choudhury, , Dept. of Soil Science, Sher-e-Bangla Agricultural University, Dhaka for their valuable teaching, direct and indirect advice, encouragement and cooperation during the whole study period.

I express my unfathomable tributes, sincere gratitude and heartfelt indebtedness from my core of heart to my parents, and also pleasant to my brother, whose blessing, inspiration, sacrifice, and moral support opened the gate and paved to way of my higher study.

I feel much pleasure to convey the profound thanks to my friends, well wishers for their active encouragement and inspiration; personal acknowledgements are made to Arif,.

Place: Dhaka ***Md. Razibul Haque***

Dated: The December 2012

INTEGRATED NUTRIENT MANAGEMENT FOR HYBRID BORO RICE

ABSTRACT

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2010 to May 2011 to study integrated nutrient management for hybrid boro rice. The experimental treatments included T_1= No chemical fertilizer, no organic manure (Control), T_2=100% recommended N(120 kg nitrogen / ha) + recommended P,K,S; T_3=80 kg N from urea + 40 kg N substituted by vermicompost + recommended P,K,S; T_4=80 kg N from urea + 40 kg N substituted by cow dung + recommended P,K,S; T_5=60 kg N from urea + 60 kg N substituted by vermicompost + recommended P,K,S; T_6=60 kg N from urea + 60 kg N substituted by cow dung + recommended P,K,S; T_7=40 kg N from urea + 80 kg N substituted by vermicompost + recommended P,K,S; T_8=40 kg N from urea + 80 kg N substituted by cow dung + recommended P,K,S; T_9=80 kg N from urea + 40 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S; T_{10}=60 kg N from urea + 60 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S; T_{11}=40 kg N from urea + 80 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S; T_{12}=100% N substituted by equal portion of vermicompost and cow dung + recommended P,K,S. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Results showed that different nutrient management significantly differed in all growth and yield contributing characters. The maximum grain yield (7.16 t ha^{-1}) was produced from T_{10} (60 kg N from urea + 60 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S) treatment. The minimum grain yield (5.55 t ha^{-1}) was produced from control treatment. The maximum biological yield (16.73 t ha^{-1}) was produced from T_{10} (60 kg N from urea + 60 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S) treatment. The maximum harvest index (48.83%) was produced from control treatment. The minimum harvest index (42.19 %) was produced from T_{10} (60 kg N from urea + 60 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S) treatment. The higher grain yield was attributed mainly to the number of effective tillers $hill^{-1}$, filled grains $panicle^{-1}$ and 1000-grain weight. The highest N, P, K and S concentration in grain was recorded from 60 kg N from urea + 60 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S treatment. The highest N, P, K and S concentration in straw was recorded from 60 kg N from urea + 60 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S treatment.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

LIST OF ACRONYMS

AEZ	=	Agro- Ecological Zone
BARC	=	Bangladesh Agricultural Research Council
BBS	=	Bangladesh Bureau of Statistics
BINA	=	Bangladesh Institute of Nuclear Agriculture
BRRI	=	Bangladesh Rice Research Institute
cm	=	Centi-meter
cv.	=	Cultivar
DAT	=	Days after transplanting
^{0}C	=	Degree Centigrade
DF	=	Degree of freedom
EC	=	Emulsifiable Concentrate
et al.	=	and others
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram
HI	=	Harvest Index
HYV	=	High yielding variety
hr	=	hour
IRRI	=	International Rice Research Institute
Kg	=	kilogram
LV	=	Local variety
LYV	=	Low yielding varieties
LSD	=	Least significant difference
m	=	Meter
m^2	=	meter squares
MPCU	=	Mussorie phos-coated urea
MV	=	Modern variety
mm	=	Millimeter
viz.	=	namely
N	=	Nitrogen
ns	=	Non significant
%	=	Percent
CV %	=	Percentage of Coefficient of Variance
P	=	Phosphorus
K	=	Potassium
ppm	=	Parts per million
PU	=	Prilled urea
SAU	=	Sher-e- Bangla Agricultural University
S	=	Sulphur
SCU	=	Sulphur coated urea
t ha^{-1}	=	Tons per hectare
UNDP	=	United Nations Development Program
USG	=	Urea supergranules
Zn	=	Zinc

Chapter I

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important staple food crops, which supplies major source of calories for about 45 per cent of world population, particularly to the people of Asian countries. Rice stands second in the world after wheat in area and production. It occupies an area of 153.76 m. ha with an annual production of 598.85 m.t., with a productivity of 3895 kg per ha in the world (Anon, 2006). Asia produces and consumes 90 per cent of world's rice. Among the rice growing countries, India ranks first in area followed by China and Bangladesh. Rice is a major cereal crop of India occupied an area of 41.91 m. ha and production of 83.13 m.t. with average productivity of 9.84 t/ha (Anon, 2005). In Karnataka rice is cultivated in an area of 1.31 m. ha with an annual production of 2.70 m.t. with average productivity of 7.0 t/ha (Anon, 2006).

In Bangladesh total cultivable land is 90,98,460 hectare and near about 70 per cent of this land is occupied by Rice cultivation. In the year of 2011, total production of Rice is 3,35,41,099 metric ton. Hybrid rice varieties is cultivated in 6,53,000 hectare of land and total production is 28,82,000 metric ton in the year of 2010-2011. On the other hand, HYV(High Yielding Variety) is cultivated in 40,67,000 hectare land and the total production of rice is 156,32,000 metric ton. The average rice production of hybrid varieties is 4.41 metric ton and HYV varieties are 3.84 metric ton in the year of 2010 – 2011(BBS, 2011).

Intensive cultivation of rice has caused considerable damage to the environment and natural resources including build up of salinity or alkalinity, water logging, water pollution, depletion of groundwater and health hazards due to excessive use of agro chemicals and pesticides and release of higher methane gas to the environment. This has forced the farmers, scientists and policy makers to look at the integrated approach to nutrient management to rice.

Among the production factors affecting crop yield, nutrient is the single most important factor that plays a dominant role in yield increase if other production factors are not limiting. It is reported that chemical fertilizers today hold the key position to enhance crop production (BARC, 1997). Nutrient imbalance can be minimized by judicious application of different fertilizers. There is need to develop appropriate management technique to evaluate the performance and to assess the nutrient requirement for rice cultivation in the country. Among the fertilizers, nitrogen is essential for vegetative growth but excess nitrogen may cause excessive vegetative growth, prolong the growth duration and delay crop maturity with reduction in grain yield. Among the different elements nitrogen is universally needed for all crops. Many workers have reported a significant response of rice to nitrogen fertilizer in different soils (Bhuiya *et al.*, 1989; Hussain *et al.*, 1989).

Organic agriculture is one among the broad spectrum of production methods that are supportive of the environment. The demand for organic food is steadily increasing both in developed and developing countries with an annual growth rate of 20–25 per cent (Ramesh *et al.*, 2005). Organic cultivation which is responsible for material circulation in agricultural ecosystem and enhanced crop production with a minimal environmental load in keeping ecological balance contains the holistic approach for production and management system for enhancing health of agricultural ecosystem. Organic systems avoid the use of synthetic fertilizers, pesticides and growth regulators. Instead they relay on crop residues, animal manures, legumes, green manures, off – farm wastes, mechanical cultivation and biological pest control to maintain soil health, supply of plant nutrients and minimize insects, weeds and other inputs. Organic culture helps in improvement of crop quality and reduces environment pollution. It brightens the prospects of export of organic food items. Now there are signs of change across the agriculture landscape of the country towards organic farming. Rice produced by organic farming had higher grain quality (Mendoza, 2004).

Sustainability in crop yield and soil health could be achieved by the application of mineral fertilizers along with organic manures. Benefits of organic manures like cowdung, farm yard manure, green manures, poultry manure and vermicompost are well known but the availability is reducing day by day. These organic manures are not only good sources of nutrients but also improve the physical structure of the soil. Apart from containing NPK these also contain small amounts of trace elements especially boron, copper, iron, sulphur, zinc and with fair quantity of growth promoting substances. Integrated nutrient management involving both the organic and inorganic source is essential to realize higher yield potential. The information on the effect of integrated nutrient management on rice seed production and its seed quality is meager and scanty.

Keeping all the points in mind mentioned above, the present piece of research work was under taken with the following objectives.

i) To study and compare the potentiality of vermicompost and cow dung as supplement nitrogen for hybrid boro rice production.

ii) To find out the appropriate combination of inorganic N with different organic sources for high yield of hybrid boro rice.

iii) To evaluate the effect of integrated use of organic and inorganic fertilizers on organic carbon content in soil.

CHAPTER II

REVIEW OF LITERATURE

Yield and yield contributing characters of rice are considerably depended on manipulation of basic ingredients of crop production. The basic ingredients include variety, environment and agronomic practices (planting density, fertilizer, irrigation etc.). Among the factors nutrient mangement play key role for manipulation of the growth and yield of rice. High yielding varieties (HYV) are generally more adaptive to appropriate nutrient application. The available relevant reviews related to nutrient management in the recent past have been presented and discussed under the following headings:

2.1 Effect of nitrogen management

Among the factors that are responsible for growth, yield and yield contributing characters of rice, nitrogen management is very important for the production of modern varieties. Some information regarding effect of nitrogenous fertilizer and their application are reviewed under the following headings:

Mishra *et al.* (2000) carried out a field experiment in 1994-95 in Bhubaneswar, Orissa, India, and reported that rice cv. Lalate was given 76 kg N ha^{-1} as USG at 0, 7, 14 for 21 days after transplanting (DAT), and these treated control. N increased plant height, panicle length, N up take and consequently the grain and straw yields of lowland rice.

Prasad *et al.* (1999) conducted an experiment on growth of rice plants as influenced by the method of seeding, seed rate and split application of nitrogen and reported that plants were generally tallest with N applied 25% at 15 days after sowing, 50% at active tillering and 25% at panicle initiation stages.

Vijaya and Subbaiah (1997) showed that plant height, number of tillers, number and weight of panicles, N and P uptake, dry matter and grain yield of rice increased with the increasing USG size and were greater with the deep placement method of application both N and P compared with broadcasting.

Sharma (1995) reported in an experiment that split application of nitrogenous fertilizer increased the plant height significantly compare to the basal nitrogen application.

Reddy *et al.* (1990) reported a significant effect of nitrogen on plant height in rice with 120 kg N ha^{-1} in three split dressings at tillering, panicle initiation and booting stages.

Wagh and Thorat (1988) observed that (30+30+10+10) kg N ha^{-1} applied at 4 days after transplanting, maximum tillering, primordial initiation and flowering, respectively produced the longest plant, highest no. of total tiller, effective tiller/plant and grain yield

Singh and Singh (1986) reported that plant height increased significantly with the increase in the level of nitrogen from 27 to 87 kg ha^{-1}. Deep placement of USG resulted in the highest plant height than prilled urea (PU).

Akanda *et al.* (1986) at the Bangladesh Agricultural University, Mymensingh observed that applying nitrogen in three splits 20 kg at basal, 40 kg at active tillering and 20 kg at panicle initiation stage had no significant effect on plant height. He also found that the tallest plants, the highest no. of total tiller/ hill, effective tiller/ hill, and no. of grain/panicle were produced when 80 kg N ha^{-1} was applied in three splits (20 kg at basal, 40 kg at active tillering and 20 kg at maximum tillering).

Reddy *et al.* (1985) reported that 120 kg N ha^{-1} applied in three split dressings at transplanting (50%), tillering (25%) and panicle emergence stage (25%) gave longer plant and higher no. of total tiller/ hill in two equal split dressings at transplanting and tillering or in a single dressing at transplanting.

Geethadevi *et al.* (2000) conducted an experiment with four splits application of nitrogen and found that higher number of tillers, filled grains $panicle^{-1}$ and higher grain weight $hill^{-1}$ for split application of nitrogenous fertilizer at 120 kg N ha^{-1}.

Islam *et al.* (1996) reported that number of effective tillers $hill^{-1}$ increased with increasing nitrogen level upto 150 kg Nha^{-1} and split application was more effective compare to basal application during transplanting.

Shoo *et al.* (1989) reported that nitrogen application upto 120 kg ha^{-1} at transplanting or in two equal split dressing at transplanting and tillering stages increased the total number of tillers $hill^{-1}$.

Hussain *et al.* (1989) reported that 150 kg N ha^{-1} in split application increased the number of total tillers $hill^{-1}$. They also observed that nitrogen application date had significant effect on tiller production of aman rice.

Xie *et al.* (2007) reported that increased split application of nitrogen from control to 140 kg ha^{-1} increased dry matter accumulation (DMA) of different growth stages of Jinzao22 and Shanyou63 rice varieties and after that dose the DMA reduced due to the losses of nitrogen by volatilization.

Singh and Modgal (2005) noted that dry-matter accumulation (DMA) and concentration and uptake of nitrogen increased with increasing level of nitrogen at all the stages of crop growth. Split application of nitrogen with its heavier fractions (1/3+1/3+1/3) at tillering and panicle initiation stages resulted in higher dry-matter accumulation, and higher nitrogen concentration of rice. They also noted that the rice plants accumulated nearly 15% of the total absorbed nitrogen, up to tillering, 50% up to panicle initiation and 85–90% up to heading.

Bayan and Kandasamy (2002) noticed that the application of recommended rates of N in four splits at 10 days after sowing, active tillering, and panicle initiation and at heading stages effective tillers m^{-2}. Islam *et al.* (1996) reported that number of effective tillers $hill^{-1}$ increased with increasing nitrogen level and split application was more effective compare to basal application during transplanting.

Rao *et al.* (1997) showed that nitrogen application at 50 kg ha^{-1} at tillering, 25 kg ha^{-1} at panicle initiation and 25 kg ha^{-1} at booting stage produced the longest panicle.

Patel and Mishra (1994) carried out an experiment with rice cv. IR36 and was given 0, 30, 60 or 90 kg N ha^{-1} as Muossorie rock phosphate-coated urea, neem cake-coated urea, gypsum coated urea, USG or PU. The coated materials as incorporated before transplanting and USG as placed 5-10 deep a week after transplanting and urea as applied in 3 split doses. They showed that N rate had no significant effect on panicle lenght, percent sterility and harvest index.

Sen and Pandey (1990) reported that the application of USG or PU @ 38.32 kg N ha^{-1} gave higher yield than broadcast PU and there were no significant differences in panicle length.

Reddy *et al*. (1987) observed from an experiment that panicle length and total no. of spikelets/panicle increased with 120 kg N ha^{-1} in three split at tillering, panicle initiation and booting stages.

Latchanna and Yogeswara (1977) reported that the longest panicle was obtained when N was applied in three split dressings 1/3 at planting, 1/3 at tillering and 1/3 at panicle initiation.

Faraji and Mirlohi (1998) reported that plant height, number of tillers per unit area and days to heading and maturity increased with the increase of rate of N fertilizer application at 60, 90, 120 or 150 kg N ha^{-1}, were given before transplanting or in 2 or 3 splits while grain yield and panicle number increased with up to 120 kg N ha^{-1} but decreased were decreased with increasing N.

Kapre *et al.* (1996) reported that USG has favourable effects on rice. They also observed from a study with 8 slow releasing fertilizers that grain yield, straw production, panicle hill^{-1}, grains panicle^{-1} and 1000-grain weight increase significantly with USG and sulphur coated urea (SCU).

Surendra *et al.* (1995) conducted an experiment during rainy season with nitrogen level @ 0, 40, 80, 120 kg ha^{-1} and sources, of nitrogen, USG and urea dicyandiamide @ 80 kg ha-^{1}. They showed that USG and urea dicyandiamide produced more panicle hill^{-1}, filled grains panicle^{-1}, panicle weight and grain yield than PU @ 80 kg N ha^{-1}. Nassem et al. (1995) indicated that percent grains remained unchanged in response to different levels but a significantly lower 1000-grain weight was recorded in the control treatment than in the plots received nitrogen fertilizer.

Tantawi *et al.* (1991) stated that split application of nitrogen markedly increased yield and the highest yield obtained from the triple splits. They also observed that split application resulted in greater number of panicles, heavier grains and more grains panicle^{-1}.

Thakur (1991) reported that total spikelets panicle^{-1} was the highest when 40%, 30% and 20% nitrogen was applied as basal, at maximum tillering and panicle initiation stages, respectively. He also studied the influence of levels, forms of urea and method of application of nitrogen in rice during *Kharif* season. He observed that yield attributes attributes and grain yield differed significantly due to the levels and sources of nitrogen applied. Placement of nitrogen at 60 kg ha^{-1} through USG produced the highest number of panicle $unit^{-1}$.

Kamal *et al.* (1991) conducted a field experiment in *Kharif:* season of 1985 and 1986 on rice cv. Joya with different forms of urea and level of nitrogen @ 29.58, 87 kg ha^{-1}. They reported that total tiller varied significantly due to forms in 1995, but during 1996 there was no significant variation. PU was significantly inferior to the other forms. The highest number of tillers was produced in treatment where USG was applied.

Rama *et al.* (1989) observed that the number of grains $panicle^{-1}$ were significantly higher @ 40, 80 or 120 kg N ha^{-1} as USG applied as deep 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 Mashuri. They revealed that Mashuri had significantly higher yield, panicles m^{-2}, panicle length and weight, grains $panicle^{-1}$ and 1000-grain weight than Mashuri, probably due to Mashuri's long duration. All depths of USG placement resulted in higher yield characters than broadcast PU; however, differences except for panicle lengths were not significant.

Rama *et al.* (1989) mentioned form their earlier study that the Urea super granules (USG) significantly produced higher number grains $panicle^{-1}$ than split application of prilled urea.

Subhendu *et al.* (2003) conducted a field experiment during *kharif* season at Hyderabad, India. They found that the application of nitrogen (120 kg N ha^{-1}) as urea in equal splits during transplanting, tillering, panicle initiation and 50% flowering resulted in the highest 1000 grain weight (22.57 g).

Ali *et al.* (1992) reported from their earlier findings that 1000 grain weight was the highest when 100 kg N ha^{-1} was applied in three equal splits at basal, 30 and 60 days after transplanting.

At the Bangladesh Agricultural University, Mymensingh, Akanda *et al.* (1986) reported that the weight of 1000-grain was the highest when 80 kg N ha^{-1} was applied in three splits such as 20 kg ha^{-1} basal, 40 kg ha^{-1} at active tillering and 20 kg ha^{-1} at panicle initiation stages.

Bowen *et al.* (2005) conducted 531 on-farm trials during the *Boro* and *aman* seasons in 7 districts of Bangladesh from 2000-2004. The results showed that UDP (Deep placement of urea super granule) increased grain yield by 1120 kg ha^{-1} and 890 kg ha-1 during the *Boro* season and *aman* season, respectively.

Miah *et al.* (2004) carried out an experiment with transplanted rice cv. BINA dhan4. They found that the values of the parameters of urea. Rahman (2003) worked out an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh, during the aman season with three levels of USG viz. one, two and three USG/4 hills providing 40, 80 and 120 kg N ha^{-1}. He found that two USG/4 hills produced the higher grain and straw yield (5.22 and 6.09 t ha^{-1}, respectively).

Ikeda *et al.* (2003) stated the efficiency of the non-split fertilizer application to the rice variety 'Koshihikari' was evaluated in order to dispense with top dressing and improve the recovery rate of fertilizer in pneumatic direct sowing culture of rice on a submerged paddy field in Aichi Prefecture, Japan. The fertilizer used in this study, which was a combination of a linear-type coated urea and a sigmoidal-type coated urea, was found effective in this cultivation system. Results also showed that nitrogen recovery rate, yield rate and quality were improved with this system. The accumulative nitrogen release rates of the combined fertilizer were 40% at panicle formation stage, 80% at heading stage and 95% at maturity stage. Furthermore, the nitrogen release pattern was adapted for the growth phase of this cultivation system.

Jaiswal and Singh (2001) conducted an experiment with USG and PU both at 60 and 120 kg ha-1 under different planting methods. They found that transplanting method with urea super granules proved to be the best for maximum grain yield (4.53 t ha^{-1}).

Angayarkanni and Ravichandran (2001) conducted a field experiment at Tamill Naru from July to October, 1997 and found that split application of nitrogen for rice cv. IR20, treatment 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 yield e.g. 6189.4 kg ha^{-1}.

Ehsanullah *et al.* (2001) when work with split application of nitrogenous fertilizer and reported that nitrogen as split application at different growth stages significantly affected grain yield.

Ahmed *et al.* (2000) revealed that USG was more efficient than PU at all respective levels of nitrogen in producing all yield components and in turn, grain and straw yields. Placement of USG @ 160 kg N ha^{-1} produced the highest grain yield (4.32 t ha^{-1}) which was statistically identical to that obtained from 120 kg N ha^{-1} as USG and significantly superior to that obtained from any other level and source of nitrogen.

Geethadevi *et al.* (2000) showed that four split applications of 150 kg Nha^{-1} nitrogen in KRH-1 recorded the maximum yield, as well as increased growth and yield components.

Surekha *et al.* (1999) found that N application in four equal splits, the last at flowering improved the grain yield as well as nutrient uptake.

Asif *et al.* (1999) noticed that application of 60 : 67 : 67 or 180 : 90 : 90 kg NPK ha^{-1}, with N at transplanting and early tillering or a third each at transplanting, early tillering and panicle initiation resulted in higher grain yield with the higher NPK rates. Split application of N gave higher yields than a single application.

Thakur and Patel (1998) reported that the highest grain yield (3.84 t ha^{-1}) was recorded with the application of 80 kg N ha^{-1} in three split rates with 5 t FYM ha^{-1} and 60 kg N ha^{-1} in three split rates with 5 t FYM gave 3.81 t ha^{-1}.

Islam *et al.* (1996) reported that grain yield was increased with increasing nitrogen level and split application was more effective compare to basal application during transplanting.

Vaiyapuri *et al.* (1995) stated that application of 100 kg N ha^{-1} in three splits 25% basal + 50% tillering stage +25% panicle initiation gave the highest yield (5.88 t ha^{-1}).

Panda and Mphanty (1995) observed that grain yield was the highest with 60 $kgha^{-1}$ applied 30 kg at transplanting and 15 kg each at 21 and 75 days after transplanting.

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 applications of PU.

Channabasavanan and Setty (1994) found that rice yield was the highest when N was applied in different splits between sowing, tillering, panicle initiation and panicle emergence.

Rabinson (1992) reported that among 12 different split application treatments, grain yield ranged 4.2-5.9 t ha^{-1} and was the highest with application of three equal splits (Basal application, panicle initiation stages and heading stages).

Nair and Gautam (1992) found that grain yield was higher when 60 kg N was applied at initiation, or 50% at transplanting + at tillering + 25% at panicle initiation stages than when all was applied at transplanting or at tillering.

Mongia (1992) reported that grain yield was the highest with 60 kg N ha^{-1} with the application in three split application (50% basal + 25% at flowering + 25% at the flag leaf stage).

Roy and Peterson (1990) reported that application of 40 to 50 percent N at ten days after transplanting, 25-30% at 21 days after transplanting and the rest at the panicle initiation stage were desirable.

Park and Lee (1988) reported that brown rice yield of cv. Seomginbyeo increased significantly with up to 100 kg N and was the highest with 20% of N applied 25 days before heading.

Kim *et al*. (1987) stated that the highest rice grain yield was obtained from a basal application of 30 kg N ha^{-1}, three top dressing 32 and 15 days before heading and a final topdressing of 10 kg N ha^{-1} 10 days after heading.

Khander *et al*. (1987) stated that 90 kg N ha^{-1} as application in two split dressing and in a single dressing at transplanting gave yields of 5.47, 5.19 and 4.16 t ha^{-1}, respectively.

Paturde and Rahate (1986) observed that significant increase in grain yield and straw yield of rice was obtained due to split application of N as 40 kg N ha^{-1} at transplanting, 20 kg N ha^{-1} at panicle initiation and 20 kg N ha^{-1} at the heading stage.

Subhendu *et al.* (2003) conducted a field experiment during *kharif* season at Hyderabad, India. They found that the application of nitrogen (120 kg Nha^{-1}) as urea in equal split during transplanting, tillering, panicle initiation and 50% flowering resulted straw yield is 5322 kg kg ha^{-1}.

Ehsanullah *et al.* (2001) conducted an experiment with application of nitrogenous fertilizer as split at different growth stages and reported that split application significantly affected straw yield.

Hussain *et al.* (1989) stated from their study that straw yield was increased with split application of nitrogenous fertilizer in rice filed compare to basal application of nitrogen.

Salam *et al.* (1988) reported that straw yield was the highest with split application of nitrogen and also application of nitrogen at tillering stage it was more effective than basal application.

Mondal and Swamy (2003) found that application N (120 kg ha^{-1}) as urea in equal split during transplanting, tillering, panicle initiation and flowering resulted in the highest number of panicles, number of filled grain $panicle^{-1}$,1000-grain weight, straw yield and harvest index.

2.2 Organic Nutrients

Organic nutrition is one among the broad spectrum of production methods that are supportive of the environment. The demand for organic food is steadily increasing both in developed and developing countries with an annual average growth rate of 20- 25 per cent (Ramesh *et al.*, 2005). The term organic nutrition is not directly related to the type of inputs used. The concept of organic nutrition which comprises the soil minerals, organic matter, micro organisms, insects, plants, animals and human interact to create a coherent whole (Chaudhary *et al.*, 1981). Organic nutrition which is responsible for material circulation in agricultural ecosystem and enhances crop production with a minimal environmental load with keeping ecological balance contains the general meaning of holistic production and management system for enhancing health of agricultural ecosystem (Otto, 2003).

Organic systems avoid the use of synthetic fertilizers, pesticides and growth regulators. Instead they rely on crop rotations, crop residues, animal manures, legumes, green manures (GM), off farm wastes, mechanical cultivation and biological pest control to maintain soil health, supply of plant nutrients and minimize insects, weeds and other pests(Sullivan, 2003).

Among all organic sources, animal dung, crop residues, green manure, bio-fertilizers and bio-solids from agro-industries and food processing wastes are some of the potential sources of nutrients of organic nutrition. These manures have the capacity to fulfill the nutrient demand of crops adequately (Singh *et al.*, 2001). Maintaining soil fertility in organic cultivation typically involves more combination of crop rotation with green manure/cover crops, applying rock minerals, animal manures and composts and other approved organic amendments (Sullivan, 2003).

Rice growing countries indicated that application of nitrogen through organic sources or chemical fertilizers plays a dominant role in increasing the yield. To meet the current shortage of chemical fertilizers caused by energy crisis and socio economic constraints, it has become desirable to conserve crop residues and organic manure's and recycle them into the soil to increase the efficiency of soil nutrients. In general, integrated use of organic and inorganic nitrogen is the best combination of available nitrogen management techniques, which would facilitate achieving the required productivity and sustainability by efficient use of soil and applied nitrogen (Pushpanathan *et al.*, 2004).

Since no chemical fertilizers are allowed in organic nutrition, nutrients for the crop production are mostly supplied with organic fertilizers such as compost containing different organic materials. (Lee *et al.*, 2003). Agriculture wastes such as manures, plant materials and other organic materials containing beneficial nutrients can be used to fertilize or condition the soil (Mishra, 2003).

Organic nutrition helps in improvement of crop quality and reduces environmental pollution. It brightens the prospects of export of organic food items. (Jat and Kumar, 2004). An incorporation of green manure, daincha increased the optimum cooking time, total amylose content, crude protein and reduced the gruel loss (per cent) of rice grain (Murali and Setty, 2001).

Application of organic combination of nutrients increased the rice grain quality (Nakagawa *et al.*, 2000). Application of compost @ 10 t ha -1 recorded higher values of milling and kernel length after cooking in Pusa basmati rice (Singh *et* *al*., 2000). Application of vermicompost numerically increased the values of all quality parameters like hulling per cent, head rice recovery compared to no vermicompost application. (Hemalatha *et al.* 2000). Due to continued escalation of fertilizer prices, there is a great thrust either to supplement or replace mineral fertilizers with renewable and cheaper sources of nutrients like organic manures. In India, farmers use both urban and rural organic wastes wherever they are available. Organic materials were considered to be beneficial sources of plant nutrients in soil fertility management (Schoningh and Wichmann, 1990). Thus, incorporation of crop residues, farmyard manure, vermicompost, green manure are important in increasing soil nutrients status.

2.3 Vermicompost (VC)

The vermicompost is an aerobically degraded organic matter which has undergone chemical disintegration by the enzymic activity in the gut of earthworms and so also enzymes of the associated microbial population. It has been found that use of vermicompost in field crops, vegetables, flowering plants and fruit crops has increased the yield and improved the quality with less disease and pest incidence (Baphna, 1992).

Vermicompost is rich in both macronutrients (0.56% N, 1.48% P2O5 and 0.36% K2O) and micronutrients (Shinde *et al*., 1992), besides having plant growth promoting substances, humus forming microbes and nitrogen fixers (Bano and Kale, 1987) and Dhar and Mishra (1986) observed more available phosphorus, total nitrogen and nitrate nitrogen in worm cast than surrounding soil.

Kale *et al.* (1991) reported that application of vermicompost to summer paddy increased the uptake of nutrients and also increased the nitrogen and phosphorus contents of the soil. The application of vermicompost has long range influence on soil in improving chemical and biological properties.

Jadhav *et al.* (1993) reported that the water holding capacity and electrical conductivity of the soil were increased in the plots supplied with 5.0 t vermicompost per ha compared to control plots.

Hapse (1993) noticed that the organic carbon content of the soil increased by 0.27 per cent due to application of vermicompost compared to application of chemical fertilizer alone.

A field experiment was carried out during wet season of 1997 to study the response of scented rice (cv. Pusa basmati-1) to levels of NPK, vermicompost and growth regulator at ARS, Siraguppa. The results revealed that application of 150:75:75 NPK kg ha-1 has recorded significantly higher growth, yield attributes and yield (5261 kg ha-1) as compared to lower levels of NPK. Scented rice Pusa Basmati-1 responded significantly to the organic manure. Application of vermicompost @ 5 t ha-1 resulted in significantly higher yield (4889 kg ha-1) as compared to no vermicompost application. Significantly response was observed from spraying of triacontanol (GR) @ 500 ml ha-1 with respect to growth, yield attributes and yield (4861 kg ha-1) as compared to spraying @ 250 ml ha-1 and water spray (Murali and Setty, 2004).

Earthworms can live in decaying organic wastes and can degrade it into fine particulate materials, which are rich in nutrients. Vermicomposting is the application of earthworm in producing vermin-fertilizer, which helps in the maintenance of better environment and results in sustainable agriculture, earthworm make the soil porous and help in better aeration and water infiltration. Vermicompost can be prepared from different organic materials like sugarcane trash, coir pith, pressmud, weeds, cattle dung, bio digested slurry etc. Increased availability of nutrients in vermicompost compared to non-ingested soil resulted in significantly better growth and yield of rice has been reported by several workers (Sudhakar, *et al.*, 2002).

In a recent field experiment conducted at Kerala Agricultural University, vermicompost @ t t/ha was tried as an organic manure for short duration rice variety in Kanchana. It was found that vermicompost addition had a positive influence on growth and yield attributes of rice to result in a better grain yield of 4.54 t/ha and straw yield of 5.15 t/ha along with the NPK dose of 105: 52.5: 52.5 kg/ha supplied through inorganic sources. Apart from the improvement in fertilizer use efficiency, vermicompost ensured a steady supply of secondary nutrients like Mg as well as micronutrients throughout the growth period, which improved the chlorophyll content of leaves and reduced the chaff percentage. Unlike other organic manures, vermicompost addition has got the added advantage of quick nutrient absorption by plants, to result in better dry matter accumulation. The increase in panicle number m2 noted in the study was due to the promotion of tiller production with the supply of vermicompost (Sudha and Chandini, 2003).

Conjuctive use of vermicompost @ 2 t/ha along with 50 per cent N/ha enabled hybrid rice to produce grain yield on par that obtained by application of recommended dose of fertilizer along (Upendrarao and Srinivasulureddy, 2004).

Das and Patra (1979) reported that vermicast contained 0.47% N compared to 0.35% N in the surrounding soil. Nitrogen contribution from mucus, dead earthworm tissue and wormcasts amounted to 180 kg ha-1 year-1.

Kale *et al.* (1992) opined that vermicompost was like any other organic manure depending on the nature of wastes used as feed for worms. The nitrogen content varied between 0.5 to 2.0 per cent. Similar variation in respect of phosphorus and potassium content has also been reported. In the vermicompost production, the complex organic residues are bio-degraded by symbiotic association between earthworms and microbes. In the process of vermicompost, it helps to increase the density of microbes and also provides sufficient energy to remain active. Vermicasting will provide the vital macro nutrients *viz.*, N, P, K, Ca, Mg, and micronutrients such as Fe, Mo, Zn, Cu etc. Apart from this, it also contains plant growth promoting substances like NAA, cytokinins, gibberellins etc. the chemical analysis of vermicompost produced at Dharwad revealed the availability of N, P, and K content at 0.8, 1.1 and 0.5 per cent, respectively (Giraddi, 1993).

Gopal Reddy (1997) reported that vermicompost contains 1.98 per cent nitrogen 1.23 per cent phosphorus. 1.59 per cent potassium and 132, 70.5, 1440.2 and 317.5 mg per kg of total Zn, Cu, Fe and Mn, respectively.

Laboratory analysis showed that vermicompost contains 3.0 per cent nitrogen, 1.0 per cent phosphorus and 1.5 per cent potash. Jambhekar (1994) reported that vermicompost contains 2.0 to 2.5 per cent available nitrogen, 1.0 to 1.5 per cent available phosphorus and 1.0 to 1.5 per cent available potassium and also secondary nutrients like Ca, Mg and micronutrients like Fe, Cu, Zn, Mn and Mo in sample quantities. Further, it contains nzymes like phosphatases, invertase, chitinase etc. and also growth harmones like indole acetic acid and gibberellic acid. Microbial analysis confirms that vermicompost is rich in microbes *viz*., bacteria like *Azotobacter* and *Azospirillum* besides number of actinomycetes.

Vasanthi *et al*. (1995) reported that vermicompost application along with inorganic fertilizers increased the organic carbon content and available nitrogen status of soil by 87.7 and 42.9 per cent, respectively. In another study it was indicated that vermicomposting significantly increased the organic carbon by 17.88 per cent, available nitrogen by 20.93 per cent, available phosphorus by 6.82 per cent and available potassium by 15.93 per cent (Bangar and Jatgar, 1995).

Vermicomposting is the bioconversion of organic waste materials into nutritious compost by earthworm activity and is an important component of organic farming package. Meena (2003) reported multifarious effects of vermicompost on growth and yield of crops.

Senapathi *et al.* (1985) reported that paddy crop applied with vermicompost resulted in highest grain and straw production.

Application of vermicompost with fertilizer N and bio-fertilizer increased the rice yield by 16 per cent over the application of fertilizer N alone. Vermicompost applied with FYM recorded higher grain and straw yield of rice (Jeyabal and Kuppuswamy, 2001).

Application of vermicompost improved the chemical and physical structures of the soil. (Anitha and Prema, 2003). Application of vermicompost increased the infiltration and reduced run-off and thus increased soil water availability for plant growth (Longsdon and Linden, 1992). Vasanthi and Kumaraswamy (1999) found that the soil organic carbon content increased with the treatment receiving potato vermicompost over the control. Availability of nitrogen increased in earthworm cast application as compared to non-ingested soil.

In a field study, Kale and Bano (1986) observed that the vegetative parameters like shoot weight, root weight, root and shoot length in IR -20 rice variety were positively correlated with the application of wormcast than with chemical fertilizer alone. This was due to higher availability of nitrogen for plant growth. The improved growth was also attributed to the release of plant growth promoting compounds from wormcast. Although there was no significant difference in grain yield of rice between wormcast and chemical fertilizer treatment, it was felt that application of wormcast might be beneficial in long run due to its favourable influence on soil structure and on colonization of useful microbes such as N-fixers and actinomycetes.

Kale and Bano (1988) opined that fifty per cent of recommended NPK fertilizer could be saved with the application of 2.5 t ha-1 of vermicompost in upland and transplanted paddy. Studies conducted at Agricultural Research Station, Mugad under upland conditions have revealed that vermicompost application @ 2.5 t ha-1 was as good as application of 10 t ha-1 FYM and these could substitute 50% of recommended dose of fertilizer in rice (Anon., 1993).

Vasanthi and Kumaraswany (1996) reported that the seed yield of rice was significantly higher in the treatment that received vermicompost 5 t ha-1, along with recommended NPK application.

Ravi and Srivastava (1997) reported that combined application of vermicompost and inorganic fertilizers recorded significantly higher plant height, effective tillers per hill, seed and straw yield of rice, compared to application of inorganic fertilizer alone.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from December 2010 to April 2011 to study integrated nutrient management for hybrid boro rice. The details of the materials and methods have been presented below:

3.1 Description of the experimental site

3.1.1 Location

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

3.1.2 Soil

The soil belongs to "The Modhupur Tract", AEZ – 28 (FAO, 1988). Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and organic carbon content was 0.84%. The experimental area was flat having available irrigation and drainage system. The selected plot was medium high land. The details of experimental plot soil have been presented in Appendix-I.

3.1.3 Climate

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

3.2 Test crop and its characteristics

Hira dhan-2 was used as the test crop in this experiment. The grains are medium fine and white. It requires about 140 days in an average for completing its life cycle with an average grain yield of 4-7.5 t ha^{-1} (BBS, 2011).

3.3 Experimental details

3.3.1 Treatments

Treatment combinations:

T_1= No chemical fertilizer, no organic manure (Control)

T_2=100% recommended N(120 kg nitrogen / ha) + recommended P,K,S

T_3=80 kg N from urea + 40 kg N substituted by vermicompost + recommended P,K,S

T_4=80 kg N from urea + 40 kg N substituted by cow dung + recommended P,K,S

T_5=60 kg N from urea + 60 kg N substituted by vermicompost + recommended P,K,S

T_6=60 kg N from urea + 60 kg N substituted by cow dung + recommended P,K,S

T_7=40 kg N from urea + 80 kg N substituted by vermicompost + recommended P,K,S

T_8=40 kg N from urea + 80 kg N substituted by cow dung + recommended P,K,S

T_9=80 kg N from urea + 40 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S

T_{10}=60 kg N from urea + 60 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S

T_{11}=40 kg N from urea + 80 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S

T_{12}=100% N substituted by equal portion of vermicompost and cow dung + recommended P,K,S

3.3.2 Experimental design and layout

The experiment was laid out in one factors Randomized Complete Block Design with three replications. The layout of the experiment was prepared for distributing the combination of different combination of nutrient levels. Thus there were 36 unit plots each of 4 m × 3 m size. The 12 treatments of the experiment were assigned at random in 12 plots of each block, representing a replication.

3.4 Growing of crops

3.4.1 Raising seedlings

3.4.1.1 Seed collection

The seeds of the test crop i.e. Hira dhan 2 were collected from Bangladesh Rice Research Institute (BRRI), Joydevpur, Gazipur.

3.4.1.2 Seed sprouting

Healthy seeds were selected by specific gravity method, the seeds were immersed in water bucket for 24 hours and then they were kept tightly in gunny bags. After taking the bucket seeds started sprouting after 48 hours and were sown after 72 hours.

3.4.2 Preparation of the main field

The plot selected for the experiment was opened in the first week of December 2010 with a power tiller, and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed, and finally obtained a desirable tilth of soil for transplanting of seedlings.

3.4.3 Fertilizers and manure application

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

3.4.4 Uprooting of seedlings

The nursery bed was made wet by application of water one day before uprooting of the seedlings. The seedlings were uprooted on December 15, 2010 for transplant on the date of 16 January without causing much mechanical injury to the roots.

3.4.5 Transplanting of seedlings in the field

On the scheduled dates as per experiment the rice seedlings were transplanted in lines each having a line to line distance of 30 cm and plant to plant distance 25 cm in the well prepared plots.

3.4.6 After care

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of the rice seedlings.

3.4.6.1 Irrigation and drainage

Flood irrigation was provided to maintain a constant level of standing water upto 6 cm in the early stages to enhance tillering and 10-12 cm in the later stage to discourage late tillering and weed growth. The field was finally dried out at 15 days before harvesting.

3.4.6.2 Gap filling

First gap filling was done for all of the plots at 10 days after transplanting (DAT) by planting same aged seedlings.

3.4.6.3 Weeding

Weedings were done to keep the plots free from weeds, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully at tillering stage and at panicle initiation stage by mechanical means.

3.4.6.4 Top dressing

After basal dose, the remaining doses of urea were top-dressed in 2 equal installments and were applied on both sides of seedlings rows in the soil.

3.4.6.5 Plant protection

Furadan 57 EC was applied at the time of final land preparation and later on other insecticides were applied as and when necessary.

3.5 Harvesting, threshing and cleaning

The rice was harvested depending upon the maturity of plant and harvesting was done manually from each plot on 4th May, 2011. The harvested plants of each plot was bundled separately, properly tagged and brought to threshing floor. Enough care was taken during harvesting, threshing and cleaning of rice seed. Fresh weight of grain and straw were recorded plot wise. The grains were cleaned and finally the weight was adjusted to a moisture content of 14%. The straw was sun dried and the yields of grain and straw plot^{-1} were recorded and converted to t ha^{-1}.

3.6 Data recording

3.6.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 30, 50, 70, 90 DAT (Days after transplanting) and at harvest. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the tiller.

3.6.6 Total tillers hill^{-1}

The total tillers hill^{-1} was calculated by adding effective and non-effective tillers hill^{-1} and average value was recorded.

3.6.6 Dry matter plant^{-1}

Total dry matter plant^{-1} was recorded at harvest after oven drying of sample plants. Data were recorded as the average of 3 sample hill^{-1} selected at random from the inner rows of each plot and expressed in gram.

3.6.7 Length of panicle

The length of panicle was measured with a meter scale from 10 selected panicles and the average value was recorded.

3.6.8 Filled grain panicle^{-1}

The total number of filled grains was collected randomly from selected 5 plants of a plot on the basis of grain in the spikelet and then average number of filled grains panicle^{-1} was recorded.

3.6.9 Unfilled grains panicle^{-1}

The total number of unfilled grains was collected randomly from selected 5 plants of a plot on the basis of no grain in the spikelet and then average number of unfilled grains panicle^{-1} was recorded.

3.6.11 Weight of 1000 seeds

One thousand seeds were counted randomly from the total cleaned harvested seeds of each individual plot and then weighed in grams and recorded.

3.6.12 Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of central 1 m^2 area and five sample plants were added to the respective grain yield m^{-2} and converted to t ha^{-1}.

3.6.13 Straw yield

Straw obtained from each unit plot were sun-dried and weighed carefully. The dry weight of straw of central 1 m^2 area and five sample plants were added to the respective straw yield m^{-2} and finally converted to t ha^{-1}.

3.6.14 Biological yield

Grain yield and straw yield together were regarded as biological yield. The biological yield was calculated with the following formula:

Biological yield = Grain yield + Straw yield.

3.6.15 Harvest index

Harvest index was calculated from the grain and straw yield of rice for each plot and expressed in percentage.

$$HI = \frac{\text{Economic yield (grain weight)}}{\text{Biological yield (Total dry weight)}} \times 100$$

3.7.1 Collection and preparation of plant samples

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

3.7.2 Digestion of plant samples with sulphuric acid for N

For the determination of nitrogen an amount of 0.5 g oven dry, ground sample were taken in a micro kjeldahl flask. 1.1 g catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se in the ratio of 100: 10: 1), and 7 ml conc. H_2SO_4 were added. The flasks were heated at 160^0 C and added 2 ml 30% H_2O_2 then heating was continued at 360^0 C until the digests become clear and colorless. After cooling, the content was taken into a 50 ml volumetric flask and the volume was made up to the mark with de-ionized water. A reagent blank was prepared in a similar manner. Nitrogen in the digest was estimated by distilling the digest with 10 N NaOH followed by titration of the distillate trapped in H_3BO_3 indicator solution with 0.01N H_2SO_4.

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

A sub sample weighing 0.5 g was transferred into a dry, clean 100 ml digestion vessel. Ten ml of di-acid (HNO_3: $HClO_4$ in the ratio 2:1) mixture was added to the flask. After leaving for a while, the flasks were heated at a temperature slowly raised to 200^0C. Heating were stopped when the dense white fumes of $HClO_4$ occurred. The content of the flask were boiled until they were became clean and colorless. After cooling, the content was taken into a 50 ml volumetric flask and the volume was made up to the mark with de-ionized water. P, K and S were determined from this digest by using different standard methods.

3.8 Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatment means. The mean values of all the characters were calculated and analysis of variance was performed. The significant difference among the treatments means was estimated by the Duncan's Multiple Range Difference (DMRT) test at 5% level of probability (Gomez and Gomez, 1984).

Chapter IV

RESULTS AND DISCUSSION

The experiment was conducted to investigate the effects of integrated nutrient management for hybrid *Boro* rice. Data on different parameters were analyzed statistically. The result of the present study have been presented and discussed in this chapter under the following heading.

4.1. Plant height

The effects of nutrient management practices were evident at harvest recorded significantly influenced on plant height. The tallest plant (105.30 cm) was produced in T_{10} (60 kg N from urea + 60 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S). The lowest plant height (79.37cm) was produced under control treatment. The increase in plant height due to application of increased level of fertilizer and manure might be associated with stimulating effect of nitrogen on various physiological processes including cell division and cell elongation of the plant. In general, plant height increased with the increasing level of nitrogen with organic matter. The results are in agreement with those of Singh and Singh (1986) who reported a positive effect of USG level on plant height.

Table 1. Effect of integrated nutrient management on plant height, number of tiller per hill and total dry matter per hill of hybrid rice

Treatment	Plant Height (cm)	No. of tiller per hill	Total dry mater weight (g)
T_1	79.37 c	8.00 c	164.00 k
T_2	93.67 b	13.67 bc	268.30 i
T_3	99.33 ab	16.00 ab	369.60 d
T_4	99.67 ab	16.33 ab	395.00 c
T_5	94.76 b	10.33 bc	418.30 b
T_6	99.00 ab	15.33 ab	183.30 j
T_7	99.00 ab	13.00 bc	368.30 d
T_8	93.33 b	15.00 ab	353.30 e
T_9	99.77 ab	14.00 bc	305.00 h
T_{10}	105.30 a	20.67 a	497.00 a
T_{11}	95.73 b	14.67 ab	308.30 g
T_{12}	94.03 b	13.00 bc	332.60 f
LSD	5.85	5.46	2.94
CV (%)	7.89	12.75	8.53

T_1= No chemical fertilizer, no organic manure (Control)

T_2=100% recommended N (120 kg nitrogen / ha) + recommended P,K,S

T_3=80 kg N from urea + 40 kg N substituted by vermicompost + recommended P,K,S

T_4=80 kg N from urea + 40 kg N substituted by cow dung + recommended P,K,S

T_5=60 kg N from urea + 60 kg N substituted by vermicompost + recommended P,K,S

T_6=60 kg N from urea + 60 kg N substituted by cow dung + recommended P,K,S

T_7=40 kg N from urea + 80 kg N substituted by vermicompost + recommended P,K,S

T_8=40 kg N from urea + 80 kg N substituted by cow dung + recommended P,K,S

T_9=80 kg N from urea + 40 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S

T_{10}=60 kg N from urea + 60 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S

T_{11}=40 kg N from urea + 80 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S

T_{12}=100% N substituted by equal portion of vermicompost and cow dung + recommended P,K,S

4.2 Number of total tiller hill^{-1}

Total number of tiller per hill was statistically influenced by different levels of nutrient management (Table 1). The maximum total number of tiller hill^{-1} (20.67) was produced from T_{10}. Minimum total number of tiller hill^{-1} (8.00) was produced form T_o treatment. The progressive improvement in the formation of tillers with fertilizer was applied. Mirzeo and Reddy (1989) and Singh and Singh (1986), also reported similar results. On the other hand Peng *et al.* (1996) and Schnier *et al.* (1990) reported that N supply controlled the tiller production of rice plant unless other factors such as spacing or light became limiting.

4.3 Total dry matter production

Dry matter is the material which was dried to a constant weight. Total dry matter (TDM) production indicates the production potential of a crop. A high TDM production is the first perquisite for high yield. TDM of roots, leaves, leaf sheath + stem and or panicles of used varieties data were measured at harvest. The TDM production was affected significantly at harvest by the levels of nutrient management (Table 1). The maximum total dry matter (497.00 g) was produced from T_{10}. Minimum total dry matter (164.00 g) was produced form T_0 treatment. Rambabu *et al.* (1983) and Rao *et al.* (1986) from their study concluded that integrated nutrient management helps to produce high TDM in rice.

4.4 Panicle length

Panicle length was statistically affected by levels of different types of nutrient management (Table 2). Longest (28.24 cm) panicle was produced from T_{10} treatment. Lowest (21.90 cm) panicle length was produced form N_o treatment. A similar finding was reported by Hasan *et al.* (2002).

4.5 Number of filled grains panicle^{-1}

From the table 2 it was observed that there was a statistical variation in number of filled grains panicle^{-1} due to different fertilizer and manure management. Results showed that highest number of filled grains panicle^{-1} was obtained (156.00) from T_4 treatment. The shortest number of filled grains panicle^{-1} (78.03) was found from control treatment. Gradual adequate supply of nitrogen form vermicompost contributed to grain formation which probably increased number of grain panicle^{-1} with increasing nitrogen level. Rama *et al.* (1989) found significantly higher filled grains panicle^{-1} with 40, 80 or 120 kg N ha^{-1}. The present results supported those results.

4.6 Number of unfilled grains panicle^{-1}

Among the traits made, number of unfilled grains panicle^{-1} plays a vital role in yield reduction. Number of unfilled grains panicle^{-1} was statistically influenced from the different fertilizer and manure combination levels (Table 2). The highest number of unfilled grains panicle^{-1} was obtained (71.96) from control treatment. The lowest number of

Table 2. Effect of integrated nutrient management on yield contributing character of hybrid rice

Treatment	Panicle length (cm)	Filled grains	Unfilled grains	Thousand Seed weight (g)
T_1	21.90 l	78.03 k	71.96 a	13.76 h
T_2	26.87 d	108.20 i	58.16 b	15.68 f
T_3	25.74 g	100.90 j	53.60 c	15.54 fg
T_4	24.40 i	99.60 j	34.20 fg	20.00 d
T_5	27.74 b	151.10 b	33.80 fg	21.34 b
T_6	27.24 c	116.30 h	55.53 c	15.44 g
T_7	25.30 h	126.80 f	70.06 a	20.76 c
T_8	23.04 k	135.30 d	35.46 ef	15.87 e
T_9	25.84 f	146.00 c	49.10 d	15.47 g
T_{10}	28.24 a	156.00 a	30.62 h	21.91 a
T_{11}	24.04 j	133.80 e	32.66 gh	15.58 fg
T_{12}	25.94 e	124.30 g	37.13 e	20.64 c
$LSD_{(0.05)}$	0.054	1.47	2.58	0.17
CV (%)	5.25	6.71	7.32	5.83

T_1= No chemical fertilizer, no organic manure (Control)

T_2=100% recommended N (120 kg nitrogen / ha) + recommended P,K,S

T_3=80 kg N from urea + 40 kg N substituted by vermicompost + recommended P,K,S

T_4=80 kg N from urea + 40 kg N substituted by cow dung + recommended P,K,S

T_5=60 kg N from urea + 60 kg N substituted by vermicompost + recommended P,K,S

T_6=60 kg N from urea + 60 kg N substituted by cow dung + recommended P,K,S

T_7=40 kg N from urea + 80 kg N substituted by vermicompost + recommended P,K,S

T_8=40 kg N from urea + 80 kg N substituted by cow dung + recommended P,K,S

T_9=80 kg N from urea + 40 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S

T_{10}=60 kg N from urea + 60 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S

T_{11}=40 kg N from urea + 80 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S

T_{12}=100% N substituted by equal portion of vermicompost and cow dung + recommended P,K,S

unfilled grains panicle^{-1} (30.162) was found from T_{10} (60 kg N from urea + 60 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S) treatment. Hasan *et al.* (2002) also observed that unfilled grains panicle^{-1} was unaffected by the application of higher doses of nitrogen fertilizer.

4.7 1000-grain weight

There was significant variation in 1000-seed weight due to different levels of nutrient management (Table 2). The highest weight of thousand seed was obtained (21.91 g) from $T_{10.}$ The lowest thousand seed weight (13.76 g) was found from control treatment. The 1000-grain weight of rice is more or less a stable genetic character (Yoshida, 1981) and nutrient management strategy could increase the grain weight in this case.

4.8 Grain yield (kg/plot)

Grain yield is a function of interplay of various yield components such as number of productive tillers, grains panicle^{-1} and 1000-grain weight (Hassan *et al.*, 2003). Grain yield affected significantly due to the levels of different nutrient management (Table 3). The maximum grain yield (8.60 kg plot^{-1}) was produced from T_{10} treatment. The minimum grain yield (6.67 kg plot^{-1}) was produced from control treatment. Similar results were reported by Mishra *et al.* (2000) and Raju *et al.* (1987) who observed that among all the levels of N recorded the highest grain yield and proved significantly superior to other sources. Adequate amount of nitrogen application probably favoured to yield components i.e. number of tillers hill^{-1}, panicle length, number of grain and 1000 grain weight which ultimately gave higher grain yield.

Table 3. Effect of integrated nutrient management on yield and yield contributing character of hybrid rice

Treatment	Grain yield (kg plot^{-1})		Grain yield (t ha^{-1})		Straw yield (t ha^{-1})		Biological yield (t ha^{-1})		Harvest Index (%)	
T_1	6.67	c	5.55	c	6.11	d	11.66	c	47.63	ab
T_2	8.13	ab	6.78	ab	6.95	bcd	13.73	b	49.40	a
T_3	7.80	abc	6.50	abc	7.33	bcd	13.83	b	47.01	ab
T_4	7.42	abc	6.19	abc	7.17	bcd	13.35	b	46.35	ab
T_5	7.53	abc	6.28	abc	6.94	bcd	13.23	b	47.48	ab
T_6	7.47	abc	6.23	abc	7.55	bc	13.77	b	45.20	ab
T_7	7.50	abc	6.25	abc	7.39	bc	13.63	b	45.81	ab
T_8	7.67	abc	6.39	abc	6.61	cd	13.00	bc	49.12	a
T_9	7.87	abc	6.55	abc	7.55	bc	14.11	b	46.44	ab
T_{10}	8.60	a	7.16	a	9.55	a	16.73	a	42.81	b
T_{11}	7.67	abc	6.39	abc	7.89	b	14.28	b	44.72	ab
T_{12}	7.27	bc	6.05	bc	7.00	bcd	13.06	bc	46.36	ab
LSD	1.04		0.87		1.09		1.38		4.94	
CV (%)	8.08		8.06		8.80		5.96		6.31	

T_1= No chemical fertilizer, no organic manure (Control)

T_2=100% recommended N (120 kg nitrogen / ha) + recommended P,K,S

T_3=80 kg N from urea + 40 kg N substituted by vermicompost + recommended P,K,S

T_4=80 kg N from urea + 40 kg N substituted by cow dung + recommended P,K,S

T_5=60 kg N from urea + 60 kg N substituted by vermicompost + recommended P,K,S

T_6=60 kg N from urea + 60 kg N substituted by cow dung + recommended P,K,S

T_7=40 kg N from urea + 80 kg N substituted by vermicompost + recommended P,K,S

T_8=40 kg N from urea + 80 kg N substituted by cow dung + recommended P,K,S

T_9=80 kg N from urea + 40 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S

T_{10}=60 kg N from urea + 60 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S

T_{11}=40 kg N from urea + 80 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S

T_{12}=100% N substituted by equal portion of vermicompost and cow dung + recommended P,K,S

4.9 Grain yield (t/ha)

Grain yield affected significantly due to the levels of different nutrient management (Table 3). The maximum grain yield (7.16 t ha^{-1}) was produced from T_{10} treatment. The minimum grain yield (5.55 t ha^{-1}) was produced from control treatment. Similar results were reported by Mishra *et al.* (2000) and Raju *et al.* (1987) who observed that among all the levels of N recorded the highest grain yield and proved significantly superior to other sources. Adequate amount of nitrogen application probably favoured to yield components i.e. number of tillers $hill^{-1}$, panicle length, number of grain and 1000 grain weight which ultimately gave higher grain yield.

4.10 Straw yield

From the Table 3, it was found that straw yield was significantly affected due to the levels of different nutrient management. The maximum straw yield (9.55 t ha^{-1}) was produced from T_{10} treatment. The minimum straw yield (6.11 t ha^{-1}) was produce from control treatment.

4.11 Biological yield

It was evident from the results (Table 3) that biological yield was significantly affected by the levels of different levels of nutrient management. The maximum biological yield (16.73 t ha^{-1}) was produced from T_{10} treatment. The minimum biological yield (11.66 t ha^{-1}) was produce from control treatment.

4.12 Harvest Index

Levels of nitrogen fertilizer had exerted significant variation on harvest index (Table 3). The maximum harvest index (49.40%) was produced from T_2 treatment. The minimum harvest index (42.81 %) was produce from T_{10} treatment. Ali (2005) was reported that N management strategy did not influence HI. On the other hand Miah *et al.* (2004) also reported that levels of nitrogen fertilizer had exerted very little variation on harvest index.

4.13 NPKS concentration in grain

4.13.1 Effect of integrated nutrient management on N concentration in grain

Nitrogen concentrations in grain of rice showed statistically significant variation due to the application of integrated nutrient management are presented in Table 4. The nitrogen concentration in Boro rice grain significantly increased due to application of fertilizers and manure. The higher levels of grain N concentrations were recorded in the combined application of integrated nutrient management compare to the chemical fertilizer alone. The highest N concentration in grain (1.011%) was recorded from T_{10} which was statistically similar with T_5 and T_6. On the other hand, the lowest N concentration in grain (0.574%) was found from T_0 as control treatment which was closely followed (0.567%) by T_9. A significant increase in N content in rice grain due to the application of organic manure and fertilizers have been reported by investigators (Azim, 1999 and Hoque, 1999).

Table 4. Effect of integrated nutrient management on NPKS concentration in grain

	Concentration (%) in grain			
	N	P	K	S
T_1	0.5743 c	0.2063 e	0.3893 a	0.073 b
T_2	0.7003 bc	0.2603 bc	0.4463 a	0.109 a
T_3	0.6813 bc	0.2353 cd	0.4373 a	0.107 a
T_4	0.7283 b	0.2773 ab	0.4783 a	0.121 a
T_5	1.009 a	0.2923 a	0.4933 a	0.131 a
T_6	0.9093 a	0.2843 ab	0.4873 a	0.127 a
T_7	0.6703 bc	0.2163 de	0.4333 a	0.105 a
T_8	0.7093 b	0.2773 ab	0.4593 a	0.114 a
T_9	0.5673 c	0.2063 e	0.3923 a	0.075 b
T_{10}	1.011 a	0.2943 a	0.4953 a	0.132 a
T_{11}	0.6853 bc	0.2363 d	0.4373 a	0.108 a
T_{12}	0.7343 b	0.2773 ab	0.4773 a	0.121 a
$LSD_{(0.05)}$	0.1197	0.02395	0.1931	0.02933
CV (%)	4.23	3.32	5.78	2.33

T_1= No chemical fertilizer, no organic manure (Control)

T_2=100% recommended N (120 kg nitrogen / ha) + recommended P,K,S

T_3=80 kg N from urea + 40 kg N substituted by vermicompost + recommended P,K,S

T_4=80 kg N from urea + 40 kg N substituted by cow dung + recommended P,K,S

T_5=60 kg N from urea + 60 kg N substituted by vermicompost + recommended P,K,S

T_6=60 kg N from urea + 60 kg N substituted by cow dung + recommended P,K,S

T_7=40 kg N from urea + 80 kg N substituted by vermicompost + recommended P,K,S

T_8=40 kg N from urea + 80 kg N substituted by cow dung + recommended P,K,S

T_9=80 kg N from urea + 40 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S

T_{10}=60 kg N from urea + 60 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S

T_{11}=40 kg N from urea + 80 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S

T_{12}=100% N substituted by equal portion of vermicompost and cow dung + recommended P,K,S

4.13.2 Effects of integrated nutrient management on P concentration of boro rice grain

Phosphorous concentrations in grain of rice showed significant variation due to the application of integrated nutrient management are presented in Table 4. The highest P concentration in grain (0.294%) was recorded from T_{10} which was statistically similar with T_5. On the other hand, the lowest P concentration in grain (0.206%) was found from T_0 as control treatment which was statistically similar with T_9. Significant increase in P content in rice straw due to the application of organic manure and fertilizers has been reported by many investigators (Azim, 1999 and Hoque, 1999).

4.13.3 Effect of integrated nutrient management on K concentration in boro rice grain

Potassium concentrations in grain of rice showed insignificant variation due to the application of integrated nutrient management are presented in Table 4. The highest K concentration in grain (0.495%) was recorded from T_{10}. On the other hand, the lowest K concentration in grain (0.389%) was found from T_0 as control treatment. Singh *et al.* (2001) revealed that Potassium content in grain was increased due to combined application of organic manure and chemical fertilizers.

4.13.4 Effects of integrated nutrient management on S concentration in boro rice grain

Sulphur concentrations in grain of rice showed significant variation due to the application of integrated nutrient management are presented in Table 4. The highest S concentration in grain (0.132%) was recorded from T_{10}. On the other hand, the lowest S concentration in grain (0.073%) was found from T_0 as control treatment.

4.14.1 Effect of fertilizer on N concentration in boro rice straw

Nitrogen concentrations in straw of boro rice showed significant variation due to the application of integrated nutrient management are presented in Table 5. The N concentration of boro rice straw significantly increased due to the application of integrated nutrient management. The higher N concentrations were found in the treatments those received integrated nutrient management combined. The highest N concentration in straw (0.581%) was recorded from T_{10} which was statistically similar with T_5 and T_6. On the other hand, the lowest N concentration in straw (0.345%) was found from T_0 as control treatment.

4.14.2 Effect of different doses of integrated nutrient management on P concentration in straw

The application of different levels of integrated nutrient management increased the P concentration of Boro rice. Phosphorous concentrations in straw of rice showed significant variation due to the application of integrated nutrient management (Table 5). The highest P concentration in straw (0.0923%) was recorded from T_{10}. On the other hand, the lowest P concentration in straw (0.0493%) was found from T_0 as control treatment.

4.14.3 Effects different doses of integrated nutrient management on K concentration in boro rice straw

Potassium concentrations in straw of rice showed significant variation due to the application of integrated nutrient management (Table 5). The highest K concentration in straw (1.627%) was recorded from T_{10}. On the other hand, the lowest K concentration in straw (0.911%) was found from T_0 as control treatment. Singh *et al.* (2001) reported that Potassium content in grain was increased due to combined application of organic manure and chemical fertilizers.

4.14.4 Effect of integrated nutrient management on S concentration in straw of boro rice

Sulphur concentrations in straw of rice showed insignificant variation due to the application of integrated nutrient management (Table 5). The highest S concentration in straw (0.097%) was recorded from T_{10}. On the other hand, the lowest S concentration in straw (0.057%) was found from T_0 as control treatment. Azim (1999) and Hoque (1999) reported that application of sulphur from manure and fertilizers increased S content both in grain and straw.

Table 5. Effect of integrated nutrient management on NPKS concentration in straw

Treatment	Concentration (%) in straw			
	N	P	K	S
T_1	0.3453 c	0.0493 f	0.9113 d	0.057 a
T_2	0.4583 abc	0.0693 cde	1.252 abcd	0.067 a
T_3	0.4213 bc	0.0613 def	1.169 bcd	0.069 a
T_4	0.5183 ab	0.0803 abc	1.278 abcd	0.083 a
T_5	0.5783 a	0.0893 ab	1.613 ab	0.095 a
T_6	0.5713 a	0.0873 abc	1.533 abc	0.093 a
T_7	0.4143 bc	0.0723 bcd	1.119 cd	0.075 a
T_8	0.4963 ab	0.0573 def	1.259 abcd	0.064 a
T_9	0.3483 c	0.0513 ef	0.9083 d	0.055 a
T_{10}	0.5813 a	0.0923 a	1.627 a	0.097 a
T_{11}	0.4203 bc	0.0613 def	1.187 abcd	0.071 a
T_{12}	0.5173 ab	0.0723 bcd	1.227 abcd	0.082 a
$LSD_{(0.05)}$	0.1197	0.0169	0.3898	0.0536
CV (%)	5.86	4.12	4.78	7.88

T_1= No chemical fertilizer, no organic manure (Control)

T_2=100% recommended N (120 kg nitrogen / ha) + recommended P,K,S

T_3=80 kg N from urea + 40 kg N substituted by vermicompost + recommended P,K,S

T_4=80 kg N from urea + 40 kg N substituted by cow dung + recommended P,K,S

T_5=60 kg N from urea + 60 kg N substituted by vermicompost + recommended P,K,S

T_6=60 kg N from urea + 60 kg N substituted by cow dung + recommended P,K,S

T_7=40 kg N from urea + 80 kg N substituted by vermicompost + recommended P,K,S

T_8=40 kg N from urea + 80 kg N substituted by cow dung + recommended P,K,S

T_9=80 kg N from urea + 40 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S

T_{10}=60 kg N from urea + 60 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S

T_{11}=40 kg N from urea + 80 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S

T_{12}=100% N substituted by equal portion of vermicompost and cow dung + recommended P,K,S

CHAPTER V

SUMMERY AND CONCLUSIONS

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2010 to May 2011 to study integrated nutrient management for hybrid boro rice. The experimental treatments included T_1= No chemical fertilizer, no organic manure (Control), T_2=100% recommended N(120 kg nitrogen / ha) + recommended P,K,S, T_3=80 kg N from urea + 40 kg N substituted by vermicompost + recommended P,K,S; T_4=80 kg N from urea + 40 kg N substituted by cow dung + recommended P,K,S; T_5=60 kg N from urea + 60 kg N substituted by vermicompost + recommended P,K,S; T_6=60 kg N from urea + 60 kg N substituted by cow dung + recommended P,K,S; T_7=40 kg N from urea + 80 kg N substituted by vermicompost + recommended P,K,S; T_8=40 kg N from urea + 80 kg N substituted by cow dung + recommended P,K,S; T_9=80 kg N from urea + 40 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S; T_{10}=60 kg N from urea + 60 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S; T_{11}=40 kg N from urea + 80 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S; T_{12}=100% N substituted by equal portion of vermicompost and cow dung + recommended P,K,S. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The whole field was divided into three blocks each containing 12 plots. In total, there were 36 plots. The treatments were randomly assigned to each unit plot. The size of unit plot was 4 m ×3 m.

The effects of nutrient management practices were evident at harvest recorded significantly influenced on plant height. The tallest plant (105.30 cm) was produced in T_{10} (60 kg N from urea + 60 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S). Total number of tiller per hill was statistically influenced by levels of nutrient management. The maximum total number of tiller hill^{-1} (20.67) was produced from T_{10}. The TDM production was affected significantly at harvest by the levels of nutrient management. The maximum total dry matter (497.00 g) was produced from T_{10}. Panicle length was statistically affected by levels of different types of nutrient management. Longest (28.24 cm) panicle was produced from T_{10}. There was a statistical variation in number of filled grains panicle^{-1} due to form of different fertilizer management. Results showed that highest number of filled grains panicle^{-1} was obtained (156.00) from T_4 treatment. Number of unfilled grains panicle^{-1} was statistically influenced from the different nutrient levels. The highest number of unfilled grains panicle^{-1} was obtained (71.76) from control treatment. There was significant variation in 1000-seed weight due to different levels of nutrient management. The highest thousand seed weight was obtained (21.91 g) from T_{10}. Grain yield affected significantly due to the levels of different nutrient management. The maximum grain yield (7.16 t ha^{-1}) was produced from T_{10} treatment. The minimum grain yield (5.55 t ha^{-1})

was produced from control treatment. The straw yield was significantly affected due to the levels of different nutrient management. The maximum straw yield (9.55 t ha^{-1}) was produced from T_{10} treatment. The maximum biological yield (16.73 t ha^{-1}) was produced from T_{10} treatment. Levels of nitrogen fertilizer had exerted significant variation on harvest index. The maximum harvest index (49.40%) was produced from T_2 treatment. The minimum harvest index (42.81 %) was produce from T_{10} treatment.

The highest N (1.011%), P (0.294%), K (0.495%) and S (0.132%) concentration in grain was recorded from T_{10} (60 kg N from urea + 60 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S). The highest N (0.581%), P (0.0923%), K (1.627%) and S (0.097%) concentration in straw was recorded from T_{10} (60 kg N from urea + 60 kg N substituted by equal portion of vermicompost and cow dung + recommended P,K,S).

In conclusion it could be suggested that BRRI hybrid dhan 2 coupled with 60 kg N from urea + 60 kg N substituted by equal portion of vermicompost and cowdung + recommended P,K,S was found to be a promising practice for good yield. But suitable level of urea and organic maters particularly for modern variety and its laborious application method is considerable. However, to reach a specific conclusion and recommendation, more research work on variety, level of different nutrient management should be done over different Agro-ecological zones.

REFERENCES

Ahmed, M. H., Islam, M. A., Kader, M. A. and Anwar, M. P. (2000). Evaluation of USG as a source of nitrogen in T. aman rice. *Pakistan J. Biol. Sci.*, **25**(5): 735-737.

Akanda, M. R. U., Eunus, M., Islam, M. A. and Ali, M. I. (1986). Nitrogen application timing and performance of BR4 transplant aman rice. *Bangladesh J. Agril.* **11**(1): 39-43.

Ali, A. Karim, Hassan, M. A. G., Ali, A. S. S. and Majid, A. (1992). Rice grain quality as influenced by split application of nitrogenous fertilizer. *Intl. Rice. Res. Newsl.*, **17**(3): 7.

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

Anitha, S. And Prema, A. (2003). Vermicompost boosts crop production. *Indian Farming*, **53** (8):15-17.

Anonymous, (1993). Annual Report, Agricultural Research Station, Mugad Karnataka, pp. 87-91.

Anonymous, (2006). Rice in India, A Hand Book of Statistics, Director of Rice Development, Government of India, Hyderabad (A.P.).

Anonymuos (2005). Statistical Database, Food and Agricultural Organisation (FAO) of United Natinos, Rome, www.fao.org.

Asif, M., Chaudhary, F. M., and Saeed, M. (1999). Influence of NPK levels and split N application on grain filling and yield of fine rice. *Intl. Rice. Res. Notes.*, **24**(1):30-31.

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

Bangar, A.R. and Jatgar, H.S. (1995). Effect of vermicompost on the physical and chemical proper farming, Mahatma Phule Krishi Vidyapeeth, College of Agriculture, Pune, p. 30.

Baphna, P. D., (1992), Organic farming in sapota, *Proceedings of National Seminar on Organic Farming,* Mahatmapule Krishividyapeeth, College of Agriculture, Pune, **23** : 79-83.

Bayan, H. C. and Kandasamy, O. S. (2002). Effect of weed control methods and split application of nitrogen on weed and crop in direct seeded puddle rice. *Crop Res. Hisar.* **24**(2): 266-272.

BBS (Bangladesh Bureau of Statistics). (2011). Statistical Year Book of Bangladesh Bureau of Statistics. Bangladesh Rice Knowledge Bank (BRKB). Available at the following web site: http://www.knowledgebank-brri.org.

Bhuiyan, N. I., Miah, M. A. M. and Ishaque, M. (1989). Research on USG: Findings and Future Research Areas and Recommendation. Paper Presented at the National Workshop on urea super granules Technology, held at BARC, Dhaka, Bangladesh.

Bowen, W. T., Diamand, R. B., Singh, U. and Thompson, T. P. (2005). Urea deep placement increases yield and saves nitrogen fertilizer in farmers' field in Bangladesh. Rice in life: scientific perspectives for the 21st century proceeding of the World Rice Research Conference held in Tsukuba, Japan, 4-7 November, 2004. pp. 369-372.

BRAC (Bangladesh Agricultural Research Council). (1997). Fertilizer Guide. Bangladesh Agril. Res. Council, Farmgate, New Airport Road Dhaka-1215. pp.1-6.

Channabasavanan, A. S. and Setty, R. A. (1994). Response of broadcast rice (*Oryza sativa)* at two levels of nitrogen, phosphorus and potassium and time of N application. *Indian J. Agron.*, **39**(3): 457-459.

Chaudhary, M.L., Singh, J.P. and Naral, R.P. (1981), Effect of long term application of P, K and FYM on some oil chemical properties. *Journal of Indian Society of Soil Sciences*, **29** : 81-85.

Das, M. C. and Patra, U. C., (1979). Warm cast production and nitrogen contribution to soil by tropical earth worm population from a grassland site in Orissa. *Revone d, Ecologie et de Biologic du Sol.*, **6** (1) : 79-83.

Das, S. and Singh, T. A. (1994). Nitrogen use efficiency by rice and flood water parameters as affected by fertilizer placement techniques. *J. Indian Soc. Soil Sci.* **42**(l): 46-50.

Ehsanullah, A., Cheema, M. S. and Usman, M. (2001). Rice Basmati-385 response to single and split application of nitrogen at different growth stages. *Pakistan J. Agril. Sci.*, **38**(1-2): 84-86.

Faraji, A and Mirlohi, A. (1998). Effect of splitting and rate of nitrogen application on yield and yield components of rice (*Oryza sativa* L). in Isfahan. *J. Agril. Sci.*, **2**(3): 25-34.

Geethadevi, T., Gowada, A., Vidyachandra, B. and Babu, B. T. R. (2000). Studied on split application of nitrogen and their timings on growth and yield of rice genotypes. Current Res. *Univ. Agril. Sci.*, **29**(3-4): 42-4

Giraddi, R. S., (1993). Vermiculture and its role in Agriculture In : *Proceedings of Course on Use of Bio-fertilizers Training* for the Officers of State Department of Agricultural microbiology, University of Agricultural Sciences, Dharwad. pp. 50-54.

Gomez, K. A. and Gomez, A. A. (1984). Statistical Procedure for Agricultural Research (2^{nd} edn.). Int. Rice Res. Inst., A Willey Int. Sci., pp. 28-192.

Gopal, Reddy, B. (1997) Soil health under integrated nutrient management in maize soybean cropping system. *Ph.D. Thesis*, Acharya N. G. Ranga Agricultural University, Rajendranagar, Hyderabad.

Hapse, D. G. (1993). Organic farming in the light of reduction in use of chemical fertilizers. *Proceedings of 43rd Annual Deccan Sugar Technology Association,* Pune, Part **1**: SA37-SA51.

Hasan, M. S., Hossain, S. M. A., Salim, M., Anwar, M. P. and Azad, A. K. M. (2002). Response of Hybrid and Inbred rice Varieties to the Application Methods of Urea supergranules and Prilled Urea. *Pakistan J. Bio. Sci.* **5** (7): 746-748.

Hassan, G., Khan, N. U. and Khan, Q. N. (2003). Effect of transplanting date on the yield and yield components of different rice cultivars under high temperature of D.I. Khan. *Sci Khy.* **16**(2): 129-137.

Hemalatha, M., Thirumurugan, V. AND Balasubramanian R., 2000. Effect of organic sources nitrogen on productivity, quality of rice (*Oryza sativa*) and soil fertility in single crop wetlands. *Indian Journal of Agronomy*, **45** (3): 564-567.

Hoque, S. A. (1999). Nutrient requirements of wet land rice production. Proc. Int. Symp. On Paddy soils, September 15-19, Beijing, *China Academia Sinica*: 281-282.

Hussain, M. A., Salahuddin, A. B. M., Roy, S. K., Nasreen, S. and Ali, M. A. (1989). Effect of green manuring on the growth and yield of transplant aman rice. *Bangladesh J. Agril. Sci.* **16**(1): 25-33.

Ikeda, A., Yoshida, T., Shirota, M. and Takei, M. (2003). Method of the non-split application of fertilizer to ricr "Koshihikari" on pneumatic direct seeding culture on submerged paddy filed. *Research Bulletin of the Aichi ken Agricultural Redearch Center*. **35**: 23-29.

Islam, N., Inanagta, S., Chishaki, N. and Horiguchi, T. (1996). Effect of nitrogen top-dressing on dry matter and nitrogen distribution in *Indica rice. Japanese J. Trop. Agric.* **40**(2): 89-92.

Islam, N., Inanagta, S., Chishaki, N. and Horiguchi, T. (1996). Effect of nitrogen top-dressing on dry matter and nitrogen distribution in *Indica rice. Japanese J. Trop. Agric.* **40**(2): 89-92.

Jadhav, S. B., Jadhav, M. B., Joshi, V. A. and Jagatap, P. B., (1993). Organic farming in the light of reduction in use of chemical fertilizers. *Proceedings of 43rd Annual Deccan Sugar Technology Association*, Pune, Part **1**: SA53-SA65.

Jaiswal, V. P. and Singh, G. P. (2001). Performance of urea super granules and prilled urea under different planting methods in irrigated rice (*Oryza sativa*). *Indian J. Agril. Sci.*, **71**(3): 187-189.

Jambhekar, H. A., (1994). Bio-organic farming. In : *Proceedings of the seminar on Development of Agriculture* in Andhra Pradesh, 4-5 September, 1994 Acharya N. G. Ranga Agricultural University, Hyderabad, pp. 1-6.

Jat Ramavata and Kumar Dinesh, 2004, Need and opportunities of organic farming in India. *Intensive Agriculture*, 45 (5-6): 28-30.

Jeyabal and Kuppuswamy, (2001), Recycling of organic wastes for the production of vermicompost and its response in rice-legume cropping system and soil fertility. *European Journal Agronomy*,15 (3): 153-170.

Kale, R. D. and Bano, K. (1986) Field trials with vermicompost (vee comp. E. 83 UAS) on organic fertilizer. In: *Proceedings of National Seminar on Organic Waste Utilization.* Vermicompost Part B: Verms. and Vermicomposting (Eds.) Dash, M. C. Senapathi, B. K. and Mishra, P. C., pp.. 151-160.

Kale, R. D., Bano, K. and Satyavati, G. P. (1991). Influence of vermicompost application on growth and yield of cereals, vegetables and ornamental plants. Final report of KSCST Project No. 67-04/verm/34B (3478), Bangalore, pp. 87.

Kale, R. D., Mallesh, B. C., Bano, K. and Bagyaraj, D. J. (1992). Influence of vermicompost application on available micronutrients and selected microbial population in a paddy field. *Soil Biology and Biochemistry,* 24 (12) : 1317-1320.

Kale, R.D. and Bano, K., (1988) Earthworm cultivation and culturing techniques for production of Vee comp. (83 E, U.S.A. VCC meal 831, USA). *Mysore Journal of Agricultural Science*, **22** : 339-344.

Kamal, J., Tomy P. J. and Rajappan, N. (1991). Effect of sources and levels of nitrogen on the growth of wetland rice. *Indian J. Agron*., **36**(1): 40-43.

Kapre, M. M., Bisen, C. R. and Johar, M. S. (1996). Effect of slow release N fertilizers on rice under low land conditions. *Crop Res, Hisar.*, **11**:1, 17-23.

Khander, M. A., Reddi, M. R., Reddy, B. B. and Ramaiah, N. V. (1987). Studied on nitrogen management in wetland (flooded) rice. *Indian J. Agron.* **32**(1): 104-106.

Kim, C. K., Lee, S. Y., Kim, C. H., Lim, M. S. and Cho, C. I. (1987). Effect of nitrogen split application on the rice growth and yield production under machine transplanting in the rice *(Oryza sativa L.). Korean J. Crop Sci.* **32**(1): 48-54

Latchanna, A. and Yogeswara, R. Y. (1977). Effect of level and time of applicaton of nitrogen on rice varieties. *Andhre, J. Agric.*, **24**(6): 213-215.

Lee, Yonghawan Yun Geonglee Sangminlee, and Hoichoi, DU. (2003). Rice cultivation using organic farming system with organic input materials in Koera. www.niast.go.kr.

Logsdon, S.D. and Linden, D.R. (1992). Interactions of earthworms with soil physical condition influence plant growth. *Soil Sciences*, 154 :330-337.

Meena, K.C. (2003). Vermiculture in relation to organic farming. *Intensive Indian Farming*, 41(8): 11.

Mendoza, (2004). Organic/sustainable agriculture : case studies in the Philippines (Rice based farm system in Infanta, Queazon). www.organicrice.casestudy.html.

Miah, M. N. H., Sudarshan, T., Sarker, M. A. R. and Ansari, T. H. (2004). Effect of number of seedling hill^{-1} and urea super granules on growth and yield of the rice cv. BINA dhan 4. *J. Biol. Sci.*, **4**(2): 122-129.

Mirzeo, W. A. and Reddy, S. N. (1989). Performance of modified urea materials at graded levels of nitrogen under experimental and farmer's management conditions in low land rice (*Oryza sativa*). *Indian J. Agril. Sci.* **59**: 154-160.

Mishra, B. K., Mishra, S. Das, A. K. and Jean, D. (2000). Effect of time for urea super granule placement of low land rice. *Ann. Agric. Res.*, **20**: 4, 443-447.

Mishra, D. K., (2003. Management practice for field crops. *Agriculture Today*, 4 (1) 39- 41.

Mondal, S. and Swamy, S. N. (2003). Effect of time of N application on yield and yield attributes of rice (*Oryza sative L.)* cultivars. *Env. Ecol.* **21**(2): 411-413.

Mongia, A. D. (1992). Efficiency of nitrogen as affected by level and time of its application in wetland rice (*Oryza sativa). Indian J. Agron.*, **37**(3): 559-569.

Murali, M. K. and Setty, R. A., 2001, Growth, yield and nutrient uptake of scented rice (*Oryza sativa* L.) as influenced by levels of NPK, vermicompost and Triacontanol. *Mysore Journal of Agricultural Science*, 35: 1-4.

Murali, M.K. and Setty, R.A., (2004), Effect of fertilizer, vermicompost and triacontanol on growth and yield of scented rice. *Oryza*, **41** (1&2): 57-59.

Nair, A. K. and Gautam, R. C. (1992). Effect of rate and schedule of nitrogen on rice (*Oryza sativa)* yield of moderate fertility. *Indian J. Agron*. **37**(2): 349-350.

Nakagawa, S., Y. Tamara and Ogata, Y. 2000. Comparison of rice grain qualities as influences by organic and conventional farming system. *Japanese Journal Crop Sciences*, 69: 3-37.

Nassem, S. B., Mollah, M. I. U. and Ali, M. H. (1995). Yield response of upland rice to varying levels of weeding and nitrogen. *Bangladesh J. Sci. Res*., **30**(2-3): 65-71.

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

Otto, (2003), Codex alimentarious. In : The World of organic agriculture. Statistics and future prospects (Eds. Minon Yussefi and Helga willer), pp. 41-44.

Panda, M. M. and Mohanty, S. K. (1995). Time of application of low dose of nitrogen to rainy season rice (*Oryza sativa L.)* for increasing N use efficiency. *Indian J. Agric. Sci*. **65**(4): 283-285.

Park, J. S. and Lee, S. S. (1988). Performance of rice varieties at different levels and time of nitrogen application. *Korean J. Crop Sci.* **33**(3): 222-228.

Patel, S. R. and Mishra, V. N. (1994). Effect of different forms of urea and levels of nitrogen on the yield and nitrogen uptake of rice. *Advn. Pl. Sci.*, **7**(3): 297-401.

Paturde, J. T. and Rahate, V. T. (1986). Yield and yield attributory characters of paddy (*Oryza sativa*) variety IR20 as affected by split application of nitrogen at different growth stages under irrigated conditions. *Agric. Sci. Digest.* **61**(1):38-40.

Peng, S., Garcia, F. V., Gines, H. C., Laza, R. C., Samson, M. I., Sanico, A. L., Visperas, R. M. and Cassman, K. G. (1996). Nitrogen use efficiency of irrigated tropical rice established by broadcast wet-seeding and transplanting. *Fert. Res.* **45**: 29-96.

Prasad, M. K., Singh, S. B. Singh, J. M. and Shinha, R. P. (1999). Growth of rice plants as influenced by the method of seeding, seed rate and split application of nitrogen. *J. Applied Biol.* **9**(1): 52-54.

Pushpanathan, K. R. Vijaya Kumar, M. And Siddeswaran, K. (2004). Integrated use of various organic and inorganic nitrogen sources on growth, yield and quality of rice (*Orysa sativa* L). A review.

Rabinson, J. G. (1992). Dose and time of application of nitrogen for rice. *Madras J. Agric.* **79**(1): 47-48.

Rahman, M. A. (2003). Effect of levels of USG and depth of placement on the growth and yield of transplant *aman* rice. M.S. Thesis, Dept. Agron, Bangladesh Agril. Univ. Mymensingh. p. 100.

Raju, R. A., Hossain, M. M. and Nageeswariq, R. M. (1987). Relative efficiency of modified urea materials for low land rice. *Indian J. Agron.* **32**(4): 460-462.

Rama, S., Reddy, G. and Reddy, K. (1989). Effect of levels and source of nitrogen on rice. *Indian J. Agron.* **34**(3): 364-366.

Rambabu, P., Pillai, K. G. and Reddy, S. N. (1983). Effect of modified ureas materials and their methods of application on dry matter production, grain yield and nitrogen uptake in rice. *Oryza*. **20**: 86-90.

Ramesh, D., 1996, Studies on enhancement of seed germination and vigour in carrot (*Dacus carota* L.). *M.Sc. (Agri.) Thesis*, Tamil Nadu University, Coimbatore.

Ramesh, P., Mohan Singh and Subba Rao A., (2005). Organic farming; its relevance to the Indian context. *Current Science*, **88** (4): 561-567.

Rao, C. M., Ramaish, N. V., Reddy, S. N. and Reddy, G. V. (1986). Effect of urea and urea supergranules on dry matter accumulation yield and nutrient uptake in rice (*Oryza sativa*). *J. Res.* **14**:1-3.

Rao, R. V., Satyanarayana, V. and Reddy, G. H. S. (1997). Studies on the effect of time of nitrogen application on growth and yield of direct seeded sona rice under puded conditions. *Andhra Agric. J.* **24**(5): 181-186.

Ravi, R. and Srivastava, O.P. (1997) Vermicompost a potential supplement to nitrogenous fertilizers in rice cultures. *International Rice Research Newsletter*, **22** : 30-31.

Reddy, J. V., Balal, M. S. and Singh, J. I. V. (1990). Fertilizer management in broadcast rice under late transplanting. *Indian J. Agron.* **37**: 181-183.

Reddy, J. V., Singh, J. N. and Verma, A. K. (1985). Effect of time nitrogen on growth of rice (*Oryza sativa L.*). *Agril. Sci. Digest.* **7**(2): 83-85.

Reddy, T. M. M., Rangulh, A.V., Ramaiah, N. V. and Reddy, G. V. (1987). Effect of methods of planting and nitrogen levels on growth, yield attributes and yield of rice under late condition. *J. Res. Andhra-Pradesh Agril. Univ.* **15**(1): 56-58.

Roy, R. N. and Peterson, O. S. (1990). Nitrogen management of rice. *Intl. Rice Commn. Newsl.*, 39:118.

Salam, N. A., Tazuddin, E., Varghese, K., Hameed. S. M. S. and Thomas. Y. (1988). Effect of N source and application time on rice. Intl. *Rice Res. Newsl.* **13**(5):25.

Schnier, H. F., Dingkuhn, M., De Datta, S. K., Mengel, K., and Faronilo, J. E. (1990). Nitrogen fertilization of direct-seeded flooded vs. transplanted rice: I. nitrogen uptake, photosynthesis, growth and yield. *Crop Sci.* **30**: 1276-1284.

Schoningh, E. and Wichmann, W. (1990). Organic false promises. *Fertilizer News*, **26** (3): 29-30.

Sen, A. and Pandey, B. K. (1990). Effect on rice of placement depth of urea supergranules. *Intl. Rice Res. Newsl.*, **15**(4): 18, 51.

Senapathi, B. K., Dash, M.C., Rana, A.K., and panda, B. K. (1985). Observation on the effect of earthworm in the decomposition process in soil under laboratory conditions. *Company Physiology Ecology*, **5** :140-142.

Sharma, A. R. (1995). Effect of basal and post-flood nitrogen fertilization on performance of rice (*Oryza sativa*) under conditions intermediate deep water and simulated flush fooding. *Indian J. Agric. Sci.* **65**(6): 399-404.

Shinde, P.H., Naik, R. L., Nazirkar, R. B., Kadam, S. K. and Khaire, V. N. (1992). Evaluation of vermicompost. *Proceedings of the National Seminar or Organic Farming,* 18 – 19 April, 1992, Mahathmapule Krishi Vidyapeeth, College of Agriculture, Pune, pp. 83-85.

Shoo, N. C., Mishra, R. K. and Mohanty, J. P. (1989). Effect of single versus split application of nitrogen on growth and physiological growth parameters of rice. *Orissa J. Agril. Res.*, **2**(3-4): 194-195.

Singh, A.P., Tripathi, R. S. and Mittra, B. N., 2000. Effect of integration of organic and chemical sources nitrogen in rice wheat cropping system. *Oryza*, **37** (3): 205- 208.

Singh, B. K. and Singh, R. P. (1986). Effect of modified urea materials on rainfed low and transplanted rice and their residual effect on succeeding wheat crop. *Indian J. Agron.*, **31**(2): 198-200.

Singh, G., Wade, L. J., Singh, R. K. Nayak, R. Singh, B. B. and Singh, O. N., (2001). Nutrient management for rainfed lowland rice and its effect on succeeding lentil crop. *Oryza*, **38** (3) 123-126.

Singh, S. K. and Modgal, Y. P. (2005) Effect of nitrogen, copper and magnesium fertilization on yield and nutrition of rice. *Pakistan J. Sci. Ind. Res.* **45**(2): 102-107.

Subhendu. M., Swamy, S. N. and Mandal, S. (2003). Effect of time of nitrogen application on yield and yield attributes of rice (*Oryza sativa L.)* cultivars. *Environ. Ecol.*, **21**(2): 411-413.

Sudha B. and Chandini S. 2003. Vermicompost- a potential organic manure for rice. *Intensive Agriculture*, 40:1-2.

Sudhakar, G., Christopher, Lourduraj, A., Rangasamy, A., Subbian, P. and velayutham, A.. (2002). Effect of vermicompost application on the soil properties, nutrient availability, uptake and yield of rice- a review. *Agricultural Review*, **23** (2): 127-133.

Sullivan Prestan, (2003), Organic rice production. http:attar.ncat.org/ attrapub/pdf/ricepdf.

Surekha, K., Reddy, M. N., Kumar, R. M. and Kumar, C. H. M. V. (1999). Effect of nitrogen sources and timing on yield and nutrient uptake of hybrid rice. *Indian J. Agril. Sci.*, **69**(7): 477-481.

Surendra, S., Prasad, R. and Sharma, S. N. (1995). Effect of blue green algae, nitrogen levels and modified urea materials on yield attributes and yield of low land rice (*Oryza sativa*). *Indian J. Agron.*, **40**(4): 594-597.

Tantawi, B. A., Mahrous, F. N. and Balal, M. S. (1991). Fertilizer management in broadcast rice under late transplanting. *Indian J. Agron.*, **36**:281-282.

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

Thakur, R. B. (1991). Relative efficiency of prilled urea and modified urea fertilizer on rainfed low land rice. *Indian. J. Agron.*, **36**(1): 87-90.

Upendrarao, A. and Srinivasalureddy, D., (2004). Integrated nitrogen management in low land rice. *Journal of Research, Angrau*, 32 (2): 82-84.

Vaiyapuri, V., Karthikeyan, T. D. Ravichandran, M. and Sriramachandra, M. V. (1995). Effect of time of N application with graded levels of *sesbania species* on yield, N uptake and nitrogen use efficiency in rice. *Annl. Agril. Res.*, **16**(3): 286-288.

Vasanthi, D. and Kumaraswamy, K. (1999). Efficacy of vermicompost to improve soil fertility and rice yield. *Journal Indian Society Soil Science*, **2** : 268-272.

Vasanthi, D.A., Rajamannar, A. and Kumaraswamy, K. (1995). Influence of vermicompost on the yield and fertility status of the soil under rice-rice cropping systems. In : National Symposium on Organic Farming. Mahatma Phule Krishi Vidyapeeth, College of Agriculture, Pune, p.3.

Vijaya, D. and Subbaiah, S. V. (1997). Effect of methods of application of granular forms of fertilizers on growth, nutrient uptake and yield of paddy. *Ann. Agril. Res.*, **18**(3): 361-364.

Wagh, R. G. and Thorat, S. T. (1988). Response of rice (*Oryza sativa L.*) variety R24 to different times of application of nitrogen and plant densities in coastal soils. *J. Indian Soc. Coastal Agril. Res.*, **6**(2): 133-137.

Xie, P. P., Dubey, S. K. and Bisen, C.R. (2007). Response of rice to different fertility levels. *J. Soils Crops*. **13**(1): 120-122.

Yoshida, S. (1981). Physiological analysis of rice yield. **In**: Fundamentals of Rice Crop Science. IRRI, Los Banos, Philippines. pp. 1-41, 269.

APPENDIES

Appendix I: Soil characteristics of experimental farm of Sher-e-Bangla Agricultural University are analyzed by soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture garden, SAU, Dhaka
AEZ	Modhupur tract (28)
General soil type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	**N/A**

Source: SRDI

B. Physical and chemical properties of the initial soil

Characteristics	Value
Practical size analysis	
Sand (%)	16
Silt (%)	56
Clay (%)	28
Silt + Clay (%)	84
Textural class	Silty clay loam
pH	5.56
Organic matter (%)	0.25
Total N (%)	0.02
Available P (μgm/gm soil)	53.64
Available K (me/100g soil)	0.13
Available S (μgm/gm soil)	9.40
Available B (μgm/gm soil)	0.13
Available Zn (μgm/gm soil)	0.94
Available Cu (μgm/gm soil)	1.93
Available Fe (μgm/gm soil)	240.9
Available Mn (μgm/gm soil)	50.6

Source: SRDI

Appendix II. Monthly air temperature, Rainfall and Relative humidity of the experimental site during the study period (October, 2010 to April, 2011)

Year	Month	Air temperature (^0C)			Rainfall** (mm)	* Relative humidity (%)
		Max.	Min.	Mean		
2010	October	36.6	18.5	27.455	320	74.5
	November	30.8	15.8	24.3	14	68.0
	December	27.2	11.3	19.75	0.00	66.0
2011	January	28.0	12.8	19.75	0	17.5
	February	28.9	16.2	22.55	48	56
	March	34.4	23.3	28.85	22	59
	April	35.5	24.4	29.95	37	67

* Monthly average

** Monthly total

Source: The Meteorological Department (Weather division) of Bangladesh, Agargoan, Dhaka