EFFECT OF NEB FORMULAS ON THE GROWTH, YIELD AND N CONTENT OF T. AMAN RICE

(BRRI DHAN 32)

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This is to certify that the thesis entitled, ***"EFFECT OF NEB FORMULAS ON THE GROWTH, YIELD AND N CONTENT OF T. AMAN RICE (BRRI DHAN 32)"*** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfilment of the requirements for the degree of ***MASTER OF SCIENCE IN AGRICULTURAL CHEMISTRY,*** embodies the result of a piece of *bona fide* research work carried out by ***SELIM,*** Registration No. ***06-02018*** 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.

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The Author

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ABSTRACT

Two experiments were conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from June to December 2012 to effect of NEB formulas on the growth, yield and N content in T. Aman Rice (BRRI dhan 32). Two different experiments each with eight treatments with three replications were conducted to achieve the desired objectives. The first experimental treatments included viz. T_1= Control, T_2= $N_{50}P_{46}K_{50}S_{18}$ (50% urea), T_3= $N_{100}P_{46}K_{50}S_{18}$ (Recommended dose of fertilizer kg ha^{-1}); T_4= $N_{50}P_{46}K_{50}S_{18}$ + standard NEB-1XT; T_5= $N_{50}P_{46}K_{50}S_{18}$ + standard NEB-300; T_6= $N_{50}P_{46}K_{50}S_{18}$ + NEB-301; T_7= $N_{50}P_{46}K_{50}S_{18}$ + standard NEB-302; T_8= $N_{50}P_{46}K_{50}S_{18}$ + standard NEB-303 + NEB powder and the second experimental treatments included viz. T_1= Control, T_2= $N_{70}P_{46}K_{50}S_{18}$ (70% urea), T_3= $N_{100}P_{46}K_{50}S_{18}$ (Recommended dose of fertilizer kg ha^{-1}); T_4= $N_{70}P_{46}K_{50}S_{18}$ + standard NEB-1XT; T_5= $N_{70}P_{46}K_{50}S_{18}$ + standard NEB-300; T_6= $N_{70}P_{46}K_{50}S_{18}$ + NEB-301; T_7= $N_{70}P_{46}K_{50}S_{18}$ + standard NEB-302; T_8= $N_{70}P_{46}K_{50}S_{18}$ + standard NEB-303 + NEB powder. The experiments were laid out in Randomized Complete Block Design (RCBD) with three replications. The application of 50% nitrogenous fertilizers plus different NEB formulas was significantly increased the plant height, panicle length, grain and straw yield. The tallest plant was produced in $N_{50}P_{46}K_{50}S_{18}$ + standard NEB-300. The maximum number of effective tiller $hill^{-1}$, longest panicle, grain and straw yields were produced from $N_{50}P_{46}K_{50}S_{18}$ + standard NEB-300. The highest grain yield of 5.08 t ha^{-1} was recorded in $N_{50}P_{46}K_{50}S_{18}$ + standard NEB-300. In second experiment, the application of 70% nitrogenous fertilizers plus different NEB formulas was significantly influenced the plant height, grain and straw yield. The tallest plant was produced in $N_{70}P_{46}K_{50}S_{18}$ + standard NEB-300. The maximum number of effective tiller $hill^{-1}$ and longest panicle was produced from $N_{70}P_{46}K_{50}S_{18}$ + standard NEB-300. Similarly, the same treatment gave the highest grain and straw yield. In each experiment, highest yield increased was obtained from 50% or 70% urea plus NEB treatment. So NEB can be used as an alternative of 30 or 50% nitrogenous fertilizer.

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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
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 the most important food crop of the world and the staple food of more than 3 billion people or more than half of the world's population. Rice is grown in more than a hundred countries with a total harvested area of nearly 160 million hectares, producing more than 700 million tons every year (IRRI, 2010). Rice grain is rich in nutrients and contains a number of vitamins and minerals. Rice provides 21% of global human per capita energy and 15% of per capita protein (IRRI, 2010).

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).

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. 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).

Proper fertilization is an important management practice which can increase the yield of hybrid rice. Judicious and proper use of fertilizers can markedly increase the yield and improve the quality of rice (Youshida, 1981). Nitrogen is the top most important nutrient and it is a key input for rice production in the rice growing countries as well in Bangladesh (Hasan, 2002). Nitrogen is required in adequate amount at early, at midtillering, and panicle initiation stage for better grain development (Ahmed *et al*. 2005). According to Crasswell and De datta (1980) broadcast application of urea on the surface soil causes losses up to 50% but point placement of urea supergranules (USG) in 10 cm depth results negligible loss. USG is a fertilizer that can be applied in the root zone at 8-10 cm depth of soil (reduced zone of rice soil) which can save 30% nitrogen than prilled urea, increase absorption rate, improve soil health and ultimately increase the rice yield (Savant *et al*., 1991).

The information on the effect of integrated nutrient management on rice production and its seed quality is meager and scanty. The worldwide demand for urea is growing stronger. Thus new technologies that allow a more efficient use of urea represent a major opportunity. NEB unlocks the trapped nitrogen doubling the available N to the plant. NEB functions by increasing microbial populations which increases the amount of N that is immobilized. The result is more total N available to the plant. Immobilization stores nitrogen that would otherwise be lost to leaching or denitrification. In addition, the nitrogen is released slowly over time, further benefiting the plant.

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

i) To know the effectiveness of NEB application in T. aman rice yield for reducing the application of urea fertilizer.

ii) Effect of NEB appliction on the N concentration of T. Aman rice.

iii) To know the effectiveness of NEB application as an alternative of 30 or 50% of urea.

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:

Salem (2006) reported that the nitrogen levels had a positive and significant effect on growth parameters of rice plants. Increasing nitrogen levels up to 70 kg ha^{-1} significantly increased plant height. The highest plant height was recorded about 92.81 cm with 70 kg N ha^{-1}.

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 compared 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 with increasing N.

Awan *et al*. (2011) conducted an experiment to study the effect of different nitrogen levels (110, 133 and 156 kg N ha^{-1}) in combination with different row spacing (15 cm, 22.5 cm and 30 cm). They noted that maximum level of N (156 kg N ha^{-1}) produced maximum effective tillers irrespective of spacing.

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 $ha\text{-}^{1}$. 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 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.

Hasanuzzaman *et al.* (2009) conducted an experiment to study the economic and effective method of urea application in rice crop. They noted that urea supergranules produced longest panicle (22.3 cm).

Islam *et al.* (2008) conducted an experiment to study the effect of nitrogen and number of seedlings per hill on the yield and yield components of T. *aman* rice (BRRI dhan 33). They noted that panicle length, number of grain panicle^{-1} increased with the application rate of N up to 100 kg ha^{-1} and then declined.

Singh and Shivay (2003) found that increasing levels of nitrogen significantly increased the panicle length.

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.

Masum *et al.* (2010) reported that placement of N fertilizer in the form of USG @ 58 kg N ha^{-1} produced the highest number of effective tillers $hill^{-1}$, filled grains $panicle^{-1}$ which ultimately gave the higher grain yield than split application of 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.

BRRI (2009) conducted an experiment on study of N release pattern from USG and prilled urea under field condition and its effect on grain yield and N nutrition of rice with three doses of N namely 50, 100 and 150 kg N $ha^{-1}$from two types of urea e.g. prilled (PU) and urea super granules (USG) were tested as treatment. Result showed that the highest grain yield was recorded when N applied @ 100 kg N ha^{-1} both from USG and PU and the highest straw yield was obtained in PU @ 150 kg N ha^{-1}.

BRRI (2008) conducted an experiment on the title of response of MVs and hybrid entries to added N in a rice cropping pattern. Six N doses 0, 40, 80, 120, 160 and 120 kg N ha^{-1} were tested and resulted that grain yield of hybrid responded up to 120 kg N ha^{-1}.

Kabir *et al.* (2009) conducted an experiment to find out the effect of urea super granules (USG), prilled urea (PU) and poultry manure (PM) on the yield and yield contributes of transplant *aman* rice. They observed that the highest grain yield (5.17 t ha^{-1}), straw yield (6.13 t ha^{-1}) and harvest index (46.78%) were found from full dose of USG.

Lin *et al.* (2008) conducted an experiment to find out the effect of plant density and nitrogen fertilizer rates (120, 150, 180 and 210156 kg N ha^{-1}) on grain yield and nitrogen uptake of hybrid rice. They observed that there was a better response to N fertilization, as increasing N application from 120 to 180 kg N ha^{-1} (by 50%) raised yield by 17%. Raising the application rate to 210 kg N ha^{-1} (by 75%) boosted yield by 24.1%.

Field experiments were conducted by Wan *et al.* (2007) in China to study the effects of different nitrogen (N) fertilizer application regimes (basal and panicle applications) on the yield, quality and N use efficiency of super japonica hybrid rice cv. Changyou 1. They indicated that yield was significantly influenced by the different N fertilizer application regimes. The regime with the highest yield was at the basal to panicle application ratio of 58.34:41.66 and equal split panicle applications at the fourth and second leaf age from the top.

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.

NEB in an organic, non-toxic feeding stimulant produced by Agmor, USA that has been tested and proved to be effective on many crops and vegetables in USA. In order to introduce the product into China, Hena Agricultural Academy undertook tests on the effectiveness of NEB pm crops in different soil conditions in 1997. Yields of wheat, maize, cotton and sesame were increased significantly with the application of NEB-26 and NEB-33. In cotton and sesame applied with NEB, the occurrence of Fusarium wilt showed a marked decline. For different soils, the effects on loam and clay loam soils were much better than sandy loam (Haiyang, 1997).

NEB-26 was tested seriously, replicated in many times (especially for the rice plant harvests in 3 years 2006-2008) all provided the similar results and prove in a firm way that NEB-26 brings back high economical effectveness for the farmers especially confirming the fact of reducing 50% urea fertilizer. We propose to bring NEB-26 into serving agricultural production in Vietnam, the sooner the beeter (Trung Thu, 2008).

CHAPTER III

MATERIALS AND METHODS

The experiments were conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from June to December 2012 to use of NEB formulas as an alternative of nitrogenous fertilizer on the growth, yield and N concentration in T. Aman Rice (BRRI dhan 32). 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 (Apendix I).

3.1.2 Soil

The soil belongs to "The Modhupur Tract", AEZ – 28 (FAO, 1988). Top soil was silty loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.9 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-II.

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 III.

3.2 Test crop and its characteristics

BRRI dhan 32 was used as the test crop in this experiment.

3.3 Experimental details

Two different experiments each with eight treatments with three replications were conducted to achieve the desired objectives. The experiments were as follows:

Experiment 1: use of NEB as an alternative of 50% nitrogenous fertilizer on the growth, yield and N concentration in T. Aman rice.

3.3.1 Treatments

Treatment combinations:

i) T_1= Control

ii) T_2= $N_{50}P_{46}K_{50}S_{18}$ (50% urea)

iii) T_3= $N_{100}P_{46}K_{50}S_{18}$ (Recommended dose of fertilizer kg ha^{-1})

iv) $T_4 = N_{50}P_{46}K_{50}S_{18}$ + standard NEB-1XT

v) $T_5 = N_{50}P_{46}K_{50}S_{18}$ + standard NEB-300

vi) $T_6 = N_{50}P_{46}K_{50}S_{18}$ + NEB-301

vii) $T_7 = N_{50}P_{46}K_{50}S_{18}$ + standard NEB-302

viii) $T_8 = N_{50}P_{46}K_{50}S_{18}$ + standard NEB-303 + NEB powder.

Experiment 2: Use of NEB as an alternative of 70% nitrogenous fertilizer on the growth, yield and N concentration in T. Aman rice.

3.3.2 Treatments

There were eight fertilizer treatments.

i) T_1 = Control

ii) $T_2 = N_{70}P_{46}K_{50}S_{18}$ (70% urea)

iii) $T_3 = N_{100}P_{46}K_{50}S_{18}$ (Recommended dose of fertilizer kg ha^{-1})

iv) $T_4 = N_{70}P_{46}K_{50}S_{18}$ + standard NEB-1XT

v) $T_5 = N_{70}P_{46}K_{50}S_{18}$ + standard NEB-300

vi) $T_6 = N_{70}P_{46}K_{50}S_{18}$ + NEB-301

vii) $T_7 = N_{70}P_{46}K_{50}S_{18}$ + standard NEB-302

viii) $T_8 = N_{70}P_{46}K_{50}S_{18}$ + standard NEB-303 + NEB powder.

3.3.3 Experimental design and layout

The experiment was laid out in one factor 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 24 (8 treatments × 3 replication) unit plots (4 m × 3 m size) in each experiment. The 8 treatments of the experiment were assigned at random in 8 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. BRRI dhan 32 were collected from Bangladesh Agricultural Development Corporation (BADC), Dhaka.

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 july 2012 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

Treatment wise fertilizer was applied during the rice growing period. Total amount of TSP, MP, gypsum and 1/3rd of urea/NEB fertilizers were applied during final land preparation. The 2nd and 3rd application dates of Urea and NEB fertilizers were 16th August and 3rd September, respectively.

3.4.4 NEB

NEB is an organic fertilizer additive. The active ingredients are naturally derived carbohydates. NEB is organic, non-toxic and non-hazardous. NEB functions by increasing beneficial soil microbes, making more nitrogen available to the plant. As a result, only 50% of the normal recommended rate of urea is needed for the plant to thrive and produce a full yield.

3.4.5 Uprooting of seedlings

The nursery bed was made wet by application of water one day before uprooting of the seedlings.

3.4.6 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 20 cm and plant to plant distance 20 cm in the well prepared plots. BRRI dhan 32 was transplanted in 25^{th} July.

3.4.7 Intercultural management

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

3.4.7.1 Irrigation and drainage

Flood irrigation was provided to maintain a constant level of standing water upto 3.-4 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.

3.4.7.2 Gap filling

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

3.4.7.3 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.

3.4.7.4 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.

3.4.7.5 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 November, 2012. 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. Ten hills of rice plant were selected randomly from the plants for measuring yield contriuting charaxters. The dry 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 harvest. Data were recorded as the average of 10 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.

3.6.2 Total effective tillers hill^{-1}

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

3.6.3 Total non effective tillers hill^{-1}

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

3.6.4 Length of panicle

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

3.6.5 Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of central unit plot area and ten sample plants were added to the respective grain yield unit plot.

3.6.6 Straw yield

Straw obtained from each unit plot were sun-dried and weighed carefully. The dry weight of straw of central unit plot area and five sample plants were added to the respective straw yield unit plot.

3.7 Collection and preparation of plant samples

Grain samples were collected after threshing for N 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. The grain samples were analyzed for determination of N concentrations. The methods were as follows:

3.8 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 into 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.

3.9 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 use of NEB formulas as an alternative of nitrogenous fertilizer on the growth, yield and N uptake in T. Aman Rice (BRRI dhan 32). Data on different parameters were analyzed statistically. The result of the present two studies have been presented and discussed in this chapter under the following heading.

Experiment 1: Use of NEB as an alternative of 50% nitrogenous fertilizer on the growth, yield and N concentration in T. Aman rice

4.1.1 Plant height

The effects of 50% nitrogenous fertilizers plus different NEB formulas significantly influenced the plant height. The tallest plant (107.40 cm) was produced in T_5 ($N_{50}P_{46}K_{50}S_{18}$ + standard NEB-300) treatment. The lowest plant height (91.22cm) was produced under control treatment. The increase in plant height due to application of increased level of fertilizer might be associated with stimulating effect of nitrogen availability 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 Urea and NEB on the yield contributing character of T. Aman rice

Treatments		Plant height (cm)	Number of effective tillers $hill^{-1}$	Number of non-effective tillers $hill^{-1}$
T_1	Control	91.22c	8.07	4.83a
T_2	$N_{50}P_{46}K_{50}S_{18}$ (50% urea)	100.98ab	8.40	3.57ab
T_3	$N_{100}P_{46}K_{50}S_{18}$ (Recommended dose of fertilizer kg ha^{-1})	100.56ab	8.47	3.53ab
T_4	$N_{50}P_{46}K_{50}S_{18}$ + standard NEB-1XT	96.72bc	8.13	4.20a
T_5	$N_{50}P_{46}K_{50}S_{18}$ + standard NEB-300	107.40a	9.60	2.33b
T_6	$N_{50}P_{46}K_{50}S_{18}$ + NEB-301	99.73abc	8.60	3.47ab
T_7	$N_{50}P_{46}K_{50}S_{18}$ + standard NEB-302	99.63abc	8.47	4.20a
T_8	$N_{50}P_{46}K_{50}S_{18}$ + standard NEB-303 + NEB powder	101.64ab	8.73	3.47ab
SE (±)		**1.54**	**NS**	**0.26**
CV (%)		**4.38**	**12.60**	**19.56**

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

4.1.2 Number of effective tiller hill^{-1}

Number of effective tiller per hill was not statistically influenced by 50% nitrogenous fertilizers plus different NEB formulas (Table 1). The maximum number of effective tiller hill^{-1} (9.60) was produced from T_5 ($N_{50}P_{46}K_{50}S_{18}$ + standard NEB-300). Minimum number of effective tiller hill^{-1} (8.07) was produced from T_0 treatment. The progressive improvement in the formation of tillers with fertilizer was found. 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.

4.1.3 Number of noneffective tiller hill^{-1}

Number of effective tiller per hill was statistically influenced by 50% nitrogenous fertilizers plus different NEB formulas (Table 1). The maximum number of non effective tiller hill^{-1} (4.83) was produced from T_0 (control). Minimum number of non effective tiller hill^{-1} (2.33) was produced form T_5 ($N_{50}P_{46}K_{50}S_{18}$ + standard NEB-300) treatment.

4.1.4 Panicle length

Panicle length was statistically affected by 50% nitrogenous fertilizers plus different NEB formulas (Table 2). Longest (23.70 cm) panicle was produced from T_5 treatment which was statistically similar to all other treatment except T_0. Lowest (20.32 cm) panicle length was produced form T_0 treatment.

Table 2. Effect of Urea and NEB on the yield of T. Aman rice

Treatments		Panicle length (cm)	Straw Yield (kg $plot^{-1}$)	Grain Yield (kg $plot^{-1}$)
T_1	Control	20.32b	4.23c	3.36c
T_2	$N_{50}P_{46}K_{50}S_{18}$ (50% urea)	22.69a	4.98bc	3.85bc
T_3	$N_{100}P_{46}K_{50}S_{18}$ (Recommended dose of fertilizer kg ha^{-1})	22.54a	5.98ab	5.03a
T_4	$N_{50}P_{46}K_{50}S_{18}$ + standard NEB-1XT	22.84a	6.14ab	4.40ab
T_5	$N_{50}P_{46}K_{50}S_{18}$ + standard NEB-300	23.70a	6.51a	5.08a
T_6	$N_{50}P_{46}K_{50}S_{18}$ + NEB-301	22.58a	6.18ab	4.21b
T_7	$N_{50}P_{46}K_{50}S_{18}$ + standard NEB-302	22.83a	5.79ab	4.47ab
T_8	$N_{50}P_{46}K_{50}S_{18}$ + standard NEB-303 + NEB powder	23.40a	6.48a	4.19b
SE (±)		**0.31**	**0.24**	**0.14**
CV (%)		**3.83**	**14.68**	**8.85**

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

4.1.5 Grain yield

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 50% nitrogenous fertilizers plus different NEB formulas (Table 2). The maximum grain yield (5.08 kg plot^{-1}) was produced from T_5 ($N_{50}P_{46}K_{50}S_{18}$ + standard NEB-300) treatment, which was statisticaly similar to the treatments T_3 ($N_{100}P_{46}K_{50}S_{18}$), T_7 ($N_{50}P_{46}K_{50}S_{18}$ + standard NEB-302) and T_4 ($N_{50}P_{46}K_{50}S_{18}$ + standard NEB-1XT). The use NEB increased the yield as an alternative of 50% urea.The minimum grain yield (3.36 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, and number of grain and 1000 grain weight which ultimately gave higher grain yield.

4.1.6 Straw yield

From the Table 2, it was found that straw yield was significantly affected due to the application of 50% nitrogenous fertilizers plus different NEB formulas. The maximum straw yield (6.51 kg plot^{-1}) was produced from T_5 ($N_{50}P_{46}K_{50}S_{18}$ + standard NEB-300) treatment, which was statisically comparable to the treatments of T_8 ($N_{50}P_{46}K_{50}S_{18}$ + standard NEB-303 + NEB powder), T_6 ($N_{50}P_{46}K_{50}S_{18}$ + NEB-301), T_4 ($N_{50}P_{46}K_{50}S_{18}$ + standard NEB-1XT), T_3 ($N_{100}P_{46}K_{50}S_{18}$) and T_7 ($N_{50}P_{46}K_{50}S_{18}$ + standard NEB-302) treatments. From this finding it proves that

NEB application is a substitute of 50% urea. The strong correlation was found between the straw and grain yield of T. Aman rice. The minimum straw yield (4.23 kg $plot^{-1}$) was produced from control treatment.

4.1.7 N content in grain of T. Aman rice

Nitrogen concentrations in grain of rice showed statistically significant variation due to the application of 50% nitrogenous fertilizers plus different NEB formulas are presented in Table 3. The nitrogen concentration in T. aman rice grain significantly increased due to application of 50% nitrogenous fertilizers plus different NEB formulas. The highest levels of grain N concentration (1.39%) were recorded in the combined application of $N_{50}P_{46}K_{50}S_{18}$ + standard NEB-303 + NEB powder (T_8), which was statisically similar to the treatments of T_3 ($N_{100}P_{46}K_{50}S_{18}$) where 100% recommended dose of N was used. On the other hand, the lowest N concentration in grain (0.99%) was found from T_0 as control treatment. A significant increase in N content in rice grain due to the application of manure and fertilizers have been reported by investigators (Azim, 1999 and Hoque, 1999).

Table 3. Effect of Urea and NEB on N concentration in grain

Treatments	N Concentration (%) in grain
T_1	0.99 d
T_2	1.14 c
T_3	1.37 ab
T_4	1.25 bc
T_5	1.19 c
T_6	1.24 bc
T_7	1.24 bc
T_8	1.39 a
SE (±)	0.041
CV (%)	5.81

Experiment 2: Use of NEB as an alternative of 70% reduction nitrogenous of fertilizer on the growth, yield and N concentration in T. Aman rice

The application of 70% nitrogenous fertilizer plus NEB affected the yield parameters and yield of T. aman rice and the results are presented in this chapter:

4.2.1 Number of effective tiller hill^{-1}

Number of effective tiller per hill was not statistically influenced by 70% nitrogenous fertilizers plus different NEB formulas (Table 3). The maximum number of effective tiller hill^{-1} (7.60) was produced from T_5 ($N_{70}P_{46}K_{50}S_{18}$ + standard NEB-300). Minimum number of effective tiller hill^{-1} (5.33) was produced form T_0 treatment. The progressive improvement in the formation of tillers with fertilizer was observed. 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.

4.2.2 Plant height

The effects of 70% nitrogenous fertilizers plus different NEB formulas significantly influenced the plant height (table 4). The tallest plant (102.98 cm) was produced in T_5 ($N_{70}P_{46}K_{50}S_{18}$ + standard NEB-300), which was closely similar to the treatment T_3 ($N_{100}P_{46}K_{50}S_{18}$) and T_7 ($N_{70}P_{46}K_{50}S_{18}$ + standard NEB-302). This result indicates that NEB increased plant height as an alternative of 30% urea. The lowest plant height (87.62cm) was produced under control treatment. The increase in plant height due to application of increased

Table 4. Effect of Urea and NEB on the yield contributing characters of T. Aman rice

Treatments		Number of effective tillers $hill^{-1}$	Number of non-effective tillers $hill^{-1}$	Plant height (cm)
T_1	Control	5.53	3.70	87.62b
T_2	$N_{70}P_{46}K_{50}S_{18}$	7.33	3.03	93.46ab
T_3	$N_{100}P_{46}K_{50}S_{18}$	6.73	3.27	102.64a
T_4	$N_{70}P_{46}K_{50}S_{18}$ + standard NEB-1XT	6.87	2.87	96.59ab
T_5	$N_{70}P_{46}K_{50}S_{18}$ + standard NEB-300	7.60	2.67	102.98a
T_6	$N_{70}P_{46}K_{50}S_{18}$ + NEB-301	7.20	3.20	99.81a
T_7	$N_{70}P_{46}K_{50}S_{18}$ + standard NEB-302	7.07	2.73	100.07a
T_8	$N_{70}P_{46}K_{50}S_{18}$ + standard NEB-303 + NEB powder	6.00	2.73	99.27a
SE (±)		**NS**	**NS**	**1.85**
CV(%)		**14.30**	**19.56**	**4.88**

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

level of fertilizer 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 and increasing level of available N from organic matter.

4.2.3 Number of noneffective tiller hill^{-1}

Number of non effective tiller per hill was not statistically influenced by 70% nitrogenous fertilizers plus different NEB formulas (Table 3). The maximum number of non effective tiller hill^{-1} (3.70) was produced from T_0 (control) treatment. Minimum number of effective tiller hill^{-1} (2.67) was produced form T_5 ($N_{50}P_{46}K_{50}S_{18}$ + standard NEB-300) treatment.

4.2.4 Panicle length

Panicle length was not statistically affected by 70% nitrogenous fertilizers plus different NEB formulas (Table 5). Longest (25.22 cm) panicle was produced from T_5 ($N_{70}P_{46}K_{50}S_{18}$ + standard NEB-300) treatment. Lowest (22.94 cm) panicle length was produced form T_o (control) treatment.

Table 5. Effect of Urea and NEB on the yield and yield parameters of T. Aman rice

Treatments		Panicle length (cm)	Straw Yield (kg $plot^{-1}$)	Grain Yield (kg $plot^{-1}$)
T_1	Control	22.94	4.12c	3.02d
T_2	$N_{70}P_{46}K_{50}S_{18}$	23.16	5.46b	3.42c
T_3	$N_{100}P_{46}K_{50}S_{18}$	23.88	5.37b	4.29b
T_4	$N_{70}P_{46}K_{50}S_{18}$ + standard NEB-1XT	24.29	5.74ab	4.33b
T_5	$N_{70}P_{46}K_{50}S_{18}$ + standard NEB-300	25.22	6.43a	4.81a
T_6	$N_{70}P_{46}K_{50}S_{18}$ + NEB-301	24.83	5.79ab	4.17b
T_7	$N_{70}P_{46}K_{50}S_{18}$ + standard NEB-302	23.46	5.53b	4.27b
T_8	$N_{70}P_{46}K_{50}S_{18}$ + standard NEB-303 + NEB powder	24.27	5.36b	4.14b
SE (±)		NS	0.12	0.06
CV (%)		17.43	6.39	5.21

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

4.2.5 Grain yield

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 70% nitrogenous fertilizers plus different NEB formulas (Table 5). The maximum grain yield (4.81 kg plot^{-1}) was produced from T_5 ($N_{70}P_{46}K_{50}S_{18}$ + standard NEB-300) treatment. The minimum grain yield (3.02 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.

4.2.6 Straw yield

From the Table 5, it was found that straw yield was significantly affected due to the levels of 70% nitrogenous fertilizers plus different NEB formulas. The maximum straw yield (6.43 kg plot^{-1}) was produced from T_5 ($N_{70}P_{46}K_{50}S_{18}$ + standard NEB-300) treatment, which was statistically similer with T_4 ($N_{70}P_{46}K_{50}S_{18}$ + standard NEB-1XT) and T_6 ($N_{70}P_{46}K_{50}S_{18}$ + NEB-301) treatments. The minimum straw yield (4.12 kg plot^{-1}) was produce from control treatment.

4.2.7 Effect of 70% nitrogenous fertilizers plus different NEB formulas on N content in grain

Nitrogen concentrations in grain of rice showed statistically significant variation due to the application of 70% nitrogenous fertilizers plus different NEB formulas in Table 6. The nitrogen concentration in T. aman rice grain significantly increased due to application of fertilizers. The higher levels of grain N concentrations were recorded in the combined application of 70% nitrogenous fertilizers plus different NEB formulas. The highest N concentration in grain (1.32%) was recorded from T_3. On the other hand, the lowest N concentration in grain (0.93%) was found from T_0 as control treatment. 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 6. Effect of Urea and NEB on N concentration in grain

Treatment	N Concentration (%) in grain
T_1	0.93 E
T_2	1.10 Cd
T_3	1.32 A
T_4	1.16 Bc
T_5	1.20 B
T_6	1.07 Cd
T_7	1.14 Bc
T_8	1.021 D
SE (±)	0.017
CV (%)	4.18

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

4.3 Comparative study of two experiments:

The higher yield increase was found in the first experiment where 50% nitrogenous fertlilizer plus NEB was used. In the first experment, the highest grain yield (5.08 kg plot^{-1}) was obtained from T_5 ($N_{50}P_{46}K_{50}S_{18}$ + standard NEB-300) treatment where 51% yield increased. The use of recommended dose of urea increased 50% yield compared to control. The second experiment was conducted in separate plot with NEB as an alternative of 30% urea. In this experiment vegetative growth of the plant was higher and slightly lower yield was obtained in all the treatments. The highest grain yield (4.81 kg plot^{-1}) was produced from T_5 ($N_{70}P_{46}K_{50}S_{18}$ + standard NEB-300) treatment where 59% yield increased where as 42% yield was increased in T_3 treatment where 100% recommended dose of nitrogenous fertilizer was used. So, NEB can be used as an alternative of 30% or 50% nitrogenous fertilizer.

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 June to December 2012 to know the application of NEB formulas as an alternative of nitrogenous fertilizer on the growth, yield and N concentration in T. Aman Rice (BRRI dhan 32). Two experiments were completed in SAU farm. The first experimental treatments included viz. T_1= Control, T_2= $N_{50}P_{46}K_{50}S_{18}$ (50% urea), T_3= $N_{100}P_{46}K_{50}S_{18}$ (Recommended dose of fertilizer kg ha^{-1}); T_4= $N_{50}P_{46}K_{50}S_{18}$ + standard NEB-1XT; T_5= $N_{50}P_{46}K_{50}S_{18}$ + standard NEB-300; T_6= $N_{50}P_{46}K_{50}S_{18}$ + NEB-301; T_7= $N_{50}P_{46}K_{50}S_{18}$ + standard NEB-302; T_8= $N_{50}P_{46}K_{50}S_{18}$ + standard NEB-303 + NEB powder. The second experimental treatments included viz. T_1= Control, T_2= $N_{70}P_{46}K_{50}S_{18}$ (50% urea), T_3= $N_{100}P_{46}K_{50}S_{18}$ (Recommended dose of fertilizer kg ha^{-1}); T_4= $N_{70}P_{46}K_{50}S_{18}$ + standard NEB-1XT; T_5= $N_{70}P_{46}K_{50}S_{18}$ + standard NEB-300; T_6= $N_{70}P_{46}K_{50}S_{18}$ + NEB-301; T_7= $N_{70}P_{46}K_{50}S_{18}$ + standard NEB-302; T_8= $N_{70}P_{46}K_{50}S_{18}$ + standard NEB-303 + NEB powder. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared by distributing the treatments into a block. Thus there were 24 (8 treatments × 3 replicartion) unit plots (4 m × 3 m size) were maintained in each experiment. The 8 treatments of the experiment were assigned at random in 8 plots of each block, representing a replication.

First experiment application of 50% nitrogenous fertilizers plus different NEB formulas were evident at harvest recorded, significantly influenced the plant height. The number of effective tillers hill^{-1} was not significantly influenced by urea and NEB application. The numbers of non-effective tillers hill^{-1}, plant height, panicle length, straw and grain yields were significantly influenced by the application of urea and different NEB. The tallest plant (107.40 cm) was produced in T_5 ($N_{50}P_{46}K_{50}S_{18}$ + standard NEB-300). The maximum number of effective tiller hill^{-1} (9.60) was produced from T_5 ($N_{50}P_{46}K_{50}S_{18}$ + standard NEB-300). Minimum number of non effective tiller hill^{-1} (2.33) was produced form T_5 ($N_{50}P_{46}K_{50}S_{18}$ + standard NEB-300) treatment. Longest (23.70 cm) panicle was produced from T_5 treatment. The highest straw yield (6.43 kg plot^{-1}) was obtained in T_5 treatment where $N_{50}P_{46}K_{50}S_{18}$ + standard NEB-300 was used and lowest was found in T_1 where fertilizer was not used. The highest grain yield of 5.08 kg plot^{-1} was recorded in T_5 treatment ($N_{50}P_{46}K_{50}S_{18}$ + standard NEB-300) and lowest in T_1 treatment. Nitrogen concentrations in grain of rice showed statistically significant variation due to the application of 50% nitrogenous fertilizers plus different NEB formulas. The highest N concentration in grain (1.39%) was recorded from T_8 treatment ($N_{50}P_{46}K_{50}S_{18}$ + standard NEB-303 + NEB powder) and lowest in T_1 treatment.

In second experiment, the application of 70% nitrogenous fertilizers plus different NEB formulas significantly influenced the plant height. The numbers of effective tillers hill^{-1}, panicle length, of T. aman rice were not significantly influenced by urea and NEB application. The plant height was significantly influenced by urea/NEB application. The tallest plant (102.98 cm) was produced in T_5 ($N_{70}P_{46}K_{50}S_{18}$ + standard NEB-300) treatment. The maximum number of effective tiller $hill^{-1}$ (7.60) was produced from T_5 ($N_{70}P_{46}K_{50}S_{18}$ + standard NEB-300) treatment. Minimum number of effective tiller $hill^{-1}$ (2.67) was produced form T_5. Longest (25.22 cm) panicle was produced from T_5 treatment. The highest grain yield of 4.81 kg $plot^{-1}$ was recorded in T_5 treatment ($N_{70}P_{46}K_{50}S_{18}$ + standard NEB-300) and lowest grain yield was obtained in T_1 treatment where fertilizer was not used. The maximum straw yield (6.43 kg $plot^{-1}$) was produced from T_5 treatment. Nitrogen concentrations in grain of rice showed statistically significant variation due to the application of 70% nitrogenous fertilizers plus different NEB formulas. The highest N concentration in grain (1.32%) was recorded from T_3.

In the first experiment, application of 50% nitrogenous fertilizers plus different NEB formulas shows that the maximum grain yield (5.08 kg $plot^{-1}$) where maximum 51% yield increased. In second experiment, application of 70% nitrogenous fertilizers plus different NEB formulas shows that the maximum grain yield (4.81 kg $plot^{-1}$) where 59% yield increased compared to control. The higher yield was found in 50% nitrogenous fertilizer plus NEB and the lower yield was found in 70% nitrogenous fertilizer plus NEB. So, 50% nitrogenous ferilizer was more effective in the production T aman rice.

Application of NEB increased the yield of T. Aman rice where NEB was applied instead of 50% urea. Some NEB treatments with urea (50% urea plus NEB) gave higher yield of rice which was statistically similar to the recommended dose of fertilizer treatments where 100% Urea was applied. Some NEB treatment (70% urea plus NEB) gave the higher yield compared to 100% urea and maximum NEB treatments (70% urea plus NEB) gave statistically similar rice yields with the recommended dose of nitrogenous fertilizer treatment. So NEB can be used for reducing the 30% pr 50% nitrogenous fertilizer in T. Aman rice cropping. 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. (2005). 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-

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.

Awan, T.H., Ali, R.I., Manzoor, Z., Ahmed, M. and Akhtar, M. (2011). Effect of different nitrogen levels and row spacing on the performance of newly evolted medium grain rice variety, KSK-133. *J. Animal and Plant Sci.* **21**(2): 231-234.

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.

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). Agriculture crop cutting. Estimation of boro rice 2009-2010. Government of the People's Republic of Bangladesh. Web site: http://www. bbs. gov.bd.

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.

BRRI (Bangladesh Rice Research Institute). (2008). Annual Report for 2007-2008. Bangladesh Rice Research Institute, Gazipur-1701.

BRRI (Bangladesh Rice Research Institute). (2009). BRRI Annual Internal Review 2007-2008. Soil Science Division. Bangladesh Rice Research Institute, Gazipur-1701.

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.

Craswell, E. T. and De Datta, S. K. (1980). Recent developments in research on nitrogen fertilizers for rice. *Indian J. Agron.* **31**(4): 387-389.

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.

FAO (Food and Agricultural Organization) and UNDP (United Nations Development Programme). (1988). Land Resources Appraisal of Bangladesh for Agricultural Development. Report 2, Agro-eco. Reg. Bangladesh. pp. 472-496.

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

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.

Haiyang, Z. 1997. Test report on NEB at Hena Provice of China.Agricultural Academy Henan Porvice.

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.

Hasanuzzaman, M. Nahar, K. Alam, M.M., Hossain, M.Z. and Islam, M.R. (2009). Response of transplanted rice to different application methods of urea fertilizer. *Intl. J. Sustain. Agric.* **1**(1):1-5.

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.

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.

IRRI (International Rice Research Institute). (2010). http:// www.irri.org/about rice/ rice facts/what is rice.

Islam M. S., Howlader M. I. A., Rafiquzzaman S., Bashar H. M. K. and Al-Mamun M. H. (2008). Yield Response of Chili and T. Aman Rice to NPK Fertilizers in Ganges Tidal Floodplain. *J. Soil. Nature*. **2**(1): 07-13

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.

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.

Kabir, M. H., Sarkar, M. A. R., and Chowdhury, A. K. M. S. H. (2009). Effect of urea super granules, prilled urea and poultry manure on the yield of transplant aman rice varieties. *J. Bangladesh Agril. Univ*. **7**(2): 259-263.

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.

Lin, X. Q., Zhu, D. F., Chen, H. Z., Cheng, S. H and Uphoff, N. (2008). Effect of plant density and nitrogen rates on grain yield and nitrogrh uptake of hybrid rice (*Oryza sativa* L.). *J. Agric. Biote. and Sustain. Develop.* **1**(2): 44-53.

Masum, S. M., Ali, M. H., and Ullah, M. J. (2010). Performance of seedling rate and urea supergranules on the yield of T. *aman* rice varieties. *J. Sher-e-Bangla Agric. Univ.* **4**(1):1-5.

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.

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.

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.

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.

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.

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

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.

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.

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.

Salem, A. K. M. (2006). Effect of nitrogen levels, plant spacing and time of farmyard manure application on the productivity of rice. *J. Appl. Sci. Res.* **2**(11): 980-987.

Savant, N. K., Crasewar, E. T. and Diamond, R. B. (1991). Use of urea supergranules for wetland rice: a review Fert. News. **28**(8): 27-35.

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.

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

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.

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, 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, 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.

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.

Trung Thu, D. 2008. NEB-26 is effective to attract the interest of industry. Ministry of Agriculure and Rural Development, Vietnam. Research report.

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.

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.

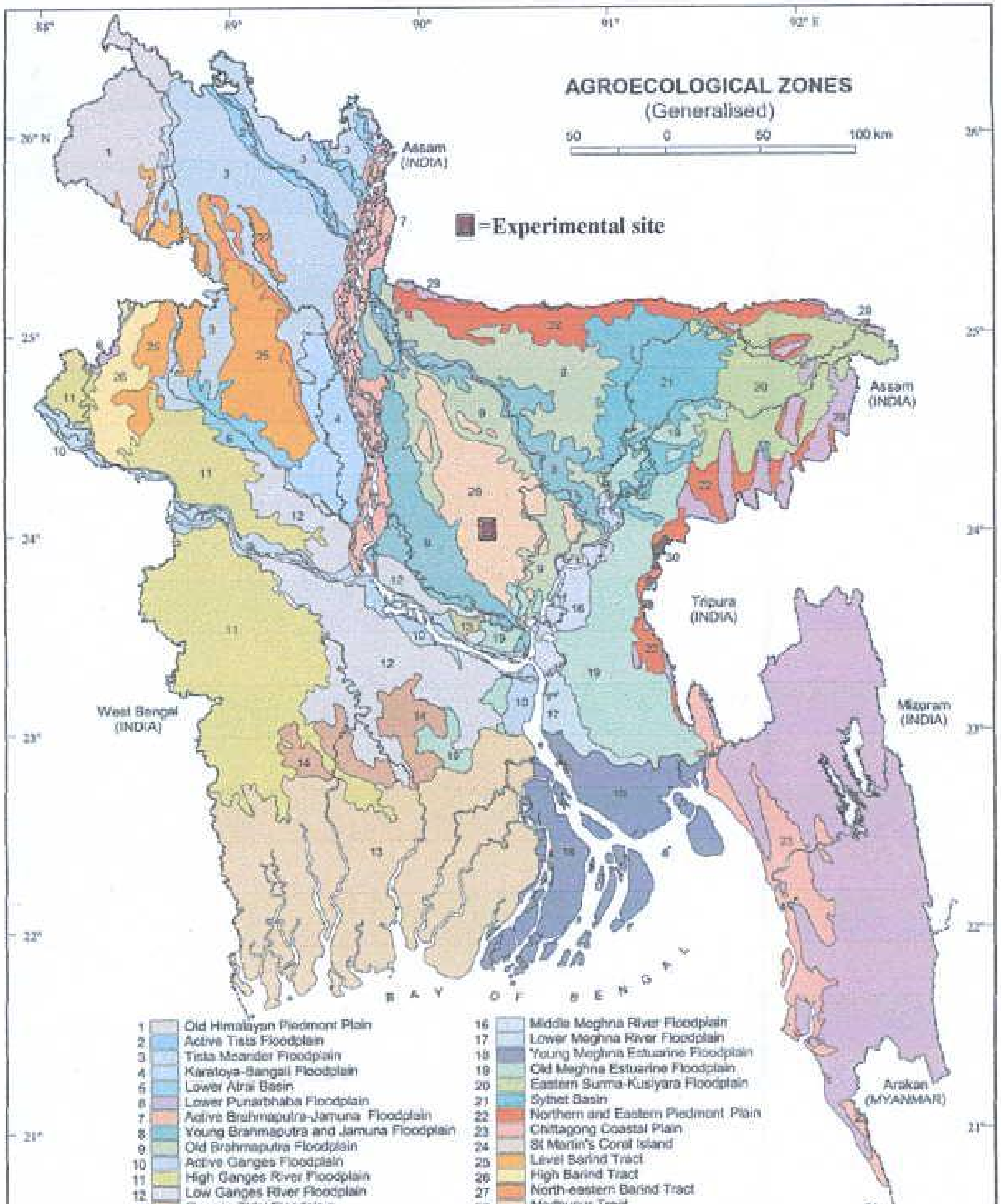
Wan, L. J., Zhang, H. C., Huo, Z.Y., Lin, Z. C.; Dai, Q. G., Xu, K. and Zhang, J. (2007). Effects of nitrogen application regimes on yield, quality, and nitrogen use efficiency of super japonica hybrid rice. *Acta-Agronomica-Sinica.* **33**(2): 175-182.

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**: Fundamental of Rice Crop Science. IRRI, Los Banos, Philippines. pp. 91-98, 269.

APPENDICES

Appendix I. Experimental location on the map of Agro-ecological Zones of Bangladesh



Appendix II. The physical and chemical characteristics of soil of the experimental site as observed prior to experimentation (0- 15 cm depth)

Constituents	Percent
Sand	26
Silt	45
Clay	29
Textural class	Silty clay

Chemical composition:

Soil characters	Value
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.07
Phosphorus	22.08 µg/g soil
Sulphur	25.98 µg/g soil
Magnesium	1.00 meq/100 g soil
Boron	0.48 µg/g soil
Copper	3.54 µg/g soil
Zinc	3.32 µg/g soil
Potassium	0.30 µg/g soil

Source: Soil Resources Development Institute (SRDI), Khamarbari, Dhaka

Appendix III. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from June to November 2012

Month	Air temperature (^{0}C)			RH (%)	Total rainfall (mm)
	Maximum	Minimum	Mean		
June	33.25	25.07	29.18	79.58	310
July	33.00	26.72	29.86	77.00	167
August	34.00	27.05	30.53	78.55	350
September	32.85	26.15	29.50	79.05	165
October	33.20	25.50	29.35	75.5	170
November	30.00	20.90	25.45	69.30	0

Source: Metrological Centre, Agargaon, Dhaka (Climate Division)