EFFECT OF UREA AND NPK BRIQUETTE ON THE GROWTH AND YIELD OF T. AMAN RICE (BR 11)

MD. MAINUL ISLAM

DEPARTMENT OF SOIL SCIENCE
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

JUNE, 2016

EFFECT OF UREA AND NPK BRIQUETTE ON THE GROWTH AND YIELD OF T. AMAN RICE (BR 11)

BY

MD. MAINUL ISLAM

Registration No. 10-04186

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: January -June, 2016

Approved by:

____

(Prof. Dr. Md. Asaduzzaman Khan)
]
Department of Soil Science
Sher-e-Bangla Agricultural University
Supervisor

____

(Dr. Md. Ashraf

Principal Scientific Officer
Bangladesh Agricultural Research Institute
Co-supervisor

____

(Assoc. Prof. Dr. Mohammad Mosharraf Hossain)
Chairman
Department of Soil Science
Sher-e-Bangla Agricultural University

CERTIFICATE

This is to certify that the thesis entitled, *"EFFECT OF UREA AND NPK BRIQUETTE ON THE GROWTH AND YIELD OF T. AMAN RICE (BR 11)"* 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 SOIL SCIENCE,*** embodies the result of a piece of *bona fide* research work carried out by ***Md Mainul Islam*** Registration No. ***10-04186*** 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: June, 2016

Place: Dhaka, Bangladesh

(Prof. Dr. Md. Asaduzzaman Khan)

Department of Soil Science
Sher-e-Bangla Agricultural University
Dhaka-1207
Supervisor

ACKNOWLEDGEMENTS

All praises gratitude and thanks are due to "Almighty Allah" Who enabled the author to complete the work successfully.

*The author would like to express his most sincere and deepest sense of gratitude profound respect to his Supervisor, **Prof. Dr. Md. Asaduzzaman Khan**,Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka for his scholastic guidance, valuable suggestions, constructive criticisms, helpful comments and constant encouragement and supervision throughout the research work and in preparing this thesis.*

*The author express his gratitude, profound respect and indebtedness to his research Co-Supervisor, **Dr. Md. Ashraf Hossain,**Principal Scientific Officer, Bangladesh Agricultural Research Institute for his valuable suggestions, constructive criticisms and helpful advice during the period of research work and preparation of this thesis.*

*The author express his sincere respect to **Assoc.Prof.Dr.Mohammad Mosharraf Hossain,** Chairman,Department of Soil Science, Sher-e-BanglaAgricultural University.*

The author would also like to acknowledge the technical staff members of the Soil Science department of the Sher-e-Banngla Agricultural University, Dhaka, for the helpful instruction and cordial co-operation during the whole period of the experiment.

The author would like to acknowledge the Agriculturist Md Monir Hossain for his valuable suggestions and instruction during whole period of experiment .

The author is also highly indebted to his beloved parents and his siblings who always helped and inspired with their blessing to complete this study.

The Author

EFFECT OF UREA AND NPK BRIQUETTE ON THE GROWTH ANDYIELD OFT. AMAN RICE(BR 11)

ABSTRACT

The experiment was conducted at the Research Farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from July 2015 to November 2015 to determine the effectiveness of mixed NPK briquette fertilizer on the growth and yield of transplanted Aman rice (BR11). The experimental field belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28. The experiment was laid out in a randomized complete block design(RCBD) with four replications. The total numbers of plots were 20. The size of each plot was 6 m^2(3 m × 2 m). The five treatments were T_0: 0kg N/ha (control), T_1: 78kg N/ha as Prilled Urea (Recommended dose of FRG 2012), T_2: 52kg N/ha as Prilled Urea, T_3: 52kg N/ha as Urea Briquette (one 1.8 g briquette/4 hills of rice) and T_4: 52kg N/ha as NPK briquette (one 3.4g briquette/4hills of rice). The result of yield contributing characters such as the tallest plant height (122.68 cm) was found in treatment T_4 (One 3.4 g NPK briquette/4 hills of rice). The longest panicle length (25.90 cm) was recorded in the treatment T_4 (one 3.4 g NPK briquette/4 hills of rice). The maximum number of effective tillers/hill (13.55) was found from T_2 (52 kg N/ha as prilled urea) treatment and the maximum 1000 seed weight (25.25 gm) was recorded from treatment T_4 (one 3.4 gm NPK briquette/4 hills of rice). The highest number of filled grain (174.50) was found in the treatment T_2 (52 kg N/ha as Prilled urea) and the highest number of non effective tillers/hill (1.48) was found from the treatment (control) T_0 and the highest unfilled grain (12.85) was found from the treatment T4 (one 3.4g NPK briquette/4 hills of rice). The highest grain yield of (2.04 kg/plot) (3.38 t/h) was recorded from the treatment T_3 (52 Kg N/ha as one 1.8 g urea briquette/4 hills of rice) and the NPK briquette was represented almost similar grain yield (3.28 t/ha) at the treatment T_4 which had no statistical significant difference with the highest yield T_3 treatment. The highest straw weight (3.17 kg/plot) was recorded from the treatment T_4 (one 3.4gm NPK briquette/4 hills). However, Mixed NPK and USG showed better grain yield and straw yield compared to conventional broadcast prilled urea. USG and mixed NPK fertilizer showed better and almost similar performance to growth and yield of transplanted aman rice (BR11) compared to the prilled urea.

CONTENTS

CONTENTS (Cont.)

CONTENTS (Cont.)

List of Tables

CHAPTER 1

INTRODUCTION

Bangladesh is an excellent habitat for rice (*Oryza sativa*L.); a semi-aquatic annual grass plant belongs to Graminae family. Rice is the staple food for the people of Bangladesh intrinsically associated with their culture, rites and rituals. Bangladesh is the third largest (FAPRI, 2009) consumer and the fourth largest producer (FAOSTAT, 2012) of rice in the world and it alone provides 76% of calorie and 66% of total protein requirements of daily food intake (Bhuiyan *et al.,* 2002). So, rice occupies 11.42 M ha of land and produces about 33.6 M t (BBS, 2011) under the diverse ecosystems subject to irrigated, rainfed and deep water conditions in three distinct seasons in Bangladesh. Among them aman rice covers the largest area of 5.82 million hectares with a production of 12.897 million metric tons (BBS, 2012) of total rice production in Bangladesh. Therefore, emphasis should be given to increase the yield of rice through adoption of proper and intensive fertilizer management, modern varieties and other improved technologies of rice production.

In general, N, P, and K fertilizers are applied in the soil surface as conventional broadcast method for cultivation of rice. A large part of those applied fertilizers is getting lost because of volatilization, denitrification, run-off, leaching and fixation. Therefore, it reduced efficiency of applied nutrients as well as low crop yield. The nitrogen efficiency especially of urea fertilizer is very low (30-35%) in rice cultivation (IFDC, 2007). Khalil *et al.* (2006) demonstrated that the volatilization loss of prilled urea (PU) is very high and farmers lose a huge amount of money for N fertilizer and proposed that to control this loss and the deep placement of fertilizer might be a good option to minimize the production cost as well as to increase crop yield.

Deep placement is the best method of N fertilizers application into the anaerobic soil zone to reduce volatilization loss (Mikkelsen *et al*., 1978). The nitrate ion is subject to loss through denitrification and leaching. If the nitrification of ammonium into nitrate is delayed or reduced, denitrification loss will naturally be reduced. By using deep placement of urea fertilizer (Ding *et al.,* 2002) denitrification losses can be decreased.

Slow-release fertilizers like sulfur-coated urea can reduce denitrification losses considerably (Keeney, 1982; Keeney and Sahrawat, 1986). As an alkaline-hydrolyzing N fertilizer, urea influences nitrification through a transient rise in pH with subsequent denitrification leading to the formation and release of large amounts of N_2O (Khalil *et al.,* 2002b).

In the zone of USG placement, a high localized urea/NH_4^+ concentration develop followed by an increase in soil pH through enzyme-catalysed hydrolysis (Singh *et al.,* 1994). Both ammonium and nitrate forms of nitrogen are lost through leaching. The magnitude of fertilizer-N leaching varies depending on soil condition and the method of fertilizer application (Velu *et al.,* 2001, Xing and Zhu, 2000). By increasing water use efficiency, it may be possible to reduce the leaching loss of nitrate (Keeney, 1982). Nitrification inhibitors, use of slow release fertilizers and puddling of the rice fields are also ways of reducing leaching losses (Keeney and Sahrawat, 1986). Deep placement of USG (about 8-10 cm depth of soil) can save 30% nitrogen compared to PU. It increases absorption rate, improves soil health and ultimately increases rice yield (Savant *et al.*, 1991). 35 kg/ha N can save when applied USG as N fertilizer during the Aman season (Bowen *et al*., 2005). Deep placement of USG effectively increases N use efficiency compared to conventionally applied urea (Jaiswal and Singh, 2001).

Moreover, NPK briquette is primarily composed of three main elements: nitrogen (N), phosphorus (P), and potassium (K); each of these being essential in plant nutrition. Among other benefits, N helps to make plants greener, and helps them grow faster. P is a key player in the photosynthesis process. It encourages the growth of roots, and promotes blooming. K, the third essential nutrient plants demand, assists in photosynthesis, fruit quality, the building of protein, and the reduction of disease. Deep placement of NPK briquette may certainly help in reducing the loss of these nutrients. Farmers in Vietnam and Cambodia obtained 25% higher yields with deep placement of NPK briquette compared to the broadcasting of fertilizer (IFDC, 2007). Therefore, deep placement method of fertilizer application is environment-friendly and will not decrease the normal fertility of the land (BRRI, 2010).

However, through the developed strategies like proper timing, deep placement, proper dose, modified forms can increase the efficiency of applied fertilizers. Deep placement is the best effective method of fertilization to reduce loss of nutrient in the flood water or minimize losses through different processes. So, deep placement means placement of large granules or briquettes of fertilizers at 8-10 cm below the surface. Urea deep placement is a proven technology that reduces N losses by up to 50% when compared with the conventional broadcast application of urea (IFDC, 2007). The major N loss reduction results from negligible run-off loss as indicated by lower amounts of N in the flood water and lower ammonia volatilization loss.

From the above discussion it is clear that deep placement of NPK briquette and USG has great impact in increasing yield of rice. Therefore, the present study was conducted with the following objective:

1. To evaluate the effects of mixed NPK briquette and guti urea on the growth and yield of *T. Aman* rice and
2. To evaluate the effects of mixed NPK briquette on the growth and yield contributing characters of *T. Aman* rice compared to the effectiveness of USG (Urea Guti) and PU (Prilled Urea).

CHAPTER 2

REVIEW OF LITERATURE

2.1 Effect of PU (Prilled Urea) on yield contributing characters of rice plant

Das (2011) showed the highest grain yield (4.28 t ha^{-1}) in treatment U4 (240 kg PU) and the lowest grain yield (3.06 t ha^{-1}) in treatment U1 (no nitrogen application)**.** Razib (2010) observed that the tallest plant height (100.2cm) when 120 kg N ha^{-1} was applied. Vibhu Kapoor *et al.* (2007) stated that the amount of NH_4^++-N was higher under the farmer's practice where PU is broadcasted into the flood-water without any incorporation.

Mashkar and Thorat (2005) exhibited a field experiment during the 1994 kharif season in Konkan, Maharashtra, India, to study the effects of different nitrogen levels (0, 40, 80 and 120 kg N ha^{-1}) on the N, P and K uptake and grain yield of scented rice cultivars (Pula Basmati 1, Kasturi, Indrayani and Sugandha). The different levels of N had significant effect in augmenting the uptake of N, P and K nutrients, grains and straw yield of rice. Application of 120 kg N ha^{-1} recorded significantly higher N, P and K uptake in rice compared to the rest of the N levels.6 Every increment of 40 kg N ha^{-1} from 0 to 120 kg N ha^{-1} increased the total N uptake by 49.55, 34.30 and 27.17%, total P uptake by 40.33, 27.06 and 20.32%, and total K uptake by 32.43, 20.70 and 17.25%, respectively.

Rahman *et al.* (2005) experimented the different nitrogen level on rice and found that the grain yield of rice was increased with increasing nitrogen levels and the highest yield (4.19 t ha^{-1}) was attained with 150 kg N ha^{-1} while further increase in nitrogen level decreased the grain yield. It was estimated that the grain yield with 150 kg N ha^{-1} was 35.8, 18.9, 5.0 and 6.0% higher than those obtained with 0, 50,100 and 200 kg N ha^{-1} respectively. Salam *et al*. (2004) demonstrated an experiment to determine the level of nitrogen (0, 40, 80 and 120 kg ha^{-1}) and the highest grain yield was recorded from the application of 80 kg N ha^{-1}.

Sidhu *et al.* (2004) showed that nitrogen fertilizers substantially increased the mean grain yield of Basmati up to 40 kg N ha^{-1} in the fallow Basmati-wheat sequence while 60 kg N ha^{-1} reduced Basmati yield. The mean grain yield of Basmati was increased by 0.31 and 0.40 t ha^{-1} at doses of 20 and 40 kg N ha^{-1}, respectively. Singh and Shivay (2003) stated that the effective tillers $hill^{-1}$ was significantly affected by the level of nitrogen and increasing levels of nitrogen significantly increased the number of effective tillers $hill^{-1}$.

Dongarwar *et al.* (2003) demonstrated a field experiment in Shandara, Maharashtra. India to investigate the response of KJTRH-1, Jaya and Sawarna to 4 fertilizer rates i.e.75, 100, 125 and 150 kg N ha^{-1}. There was a significant increase in grain yield with successive increase in fertilizer rate. The highest grain yield (53.05 q ha^{-1}) was obtained with 150 kg N ha^{-1} and KJSTRH-1 produced a significant higher yield than Jaya (39.64 q ha^{-1}) and Sawarna (46.06 q ha^{-1}). Wopereis *et al.* (2002) found that rice yields increased significantly as a result of N application on two N dressing (applied at the onset of tillering and at panicle initiation) with a total of approximately 120 kg N ha^{-1} in farmer's fields.

Duhan and Singh (2002) observed that the rice yield and uptake of nutrient increased significantly with increasing N levels. Moreover, the application of N along with various green manures (GM) showed additive effects on the yield and uptake of micronutrients. Under all GM treatments the yield and nutrient uptake were always higher with 120 kg N ha^{-1} than with lower level of nitrogen. Angayarkanni and Ravichandran (2001) conducted a field experiment in Tamil Nadu, India from July to October 1997 to determine the best split application of 150 kg N ha^{-1} for rice cv. IR 20. They found that applying 16.66% of the recommended N as basal, followed by 33.33% N at 10 DAT, 25% N at 20 DAT and 25% N at 40 DAT recorded the highest grain (6189 kg ha^{-1}) and straw (8649 kg ha^{-1}) yields, response ratio (23.40) and agronomic efficiency (41.26).

Shoji *et al.* (2001) showed an experiment that controlled release of fertilizers and a nitrification inhibitor showed the highest potential to increased N use efficiency and reduced N fertilization rate. Chopra and Chopra (2000) reported that application of either 80 or 120 kg N ha^{-1} improved the entire yield attributes of rice compared to the control. Singh *et al.* (2000) stated that each increment dose of N significantly increased grain and straw yields of rice over its preceding dose. Consequently, the crop fertilized with 100 kg N ha^{-1} gave the maximum grain yield (2647 kg ha^{-1}).

2.2 Effect of USG (Urea Guti) on yield contributing characters of rice plant

Xiang *et al* (2013) demonstrated a field experiment to study the effect of deep placement of nitrogen fertilizer on growth, yield and nitrogen uptake of aerobic rice. They showed that urea and USG deep placement increased grain yield of aerobic rice by1.66 t ha^{-1} and the soil significantly reduced nitrogen loss by ammonia volatilization. Islam *et al*. (2013) concluded that, the highest grain yield (5.42 t ha^{-1}) and and straw yield (6.38 t ha^{-1}) were obtained by application two pellets of USG (1.8g)/4 hills and three pellets of USG (2.7g)/4 hills.

Hasanuzzaman *et al.* (2013) carried an experiment at Sher-e-Bangla Agricultural University, Dhaka during the period of November 2010 to May 2011 to study the influence of prilled urea and urea super granules on the growth and yield of hybrid rice Heera1. The treatments consisted of six prilled urea levels viz. 0, 80, 120, 160, 200 kg N ha^{-1} and urea super granule @ 75 kg N ha^{-1}). The effect of USG showed significant variation in respect of growth, yield contributing characters and yield. At harvest, the highest number of effective tillers $hill^{-1}$(13.63), filled grains $panicle^{-1}$ (154.67), 1000-grain weight (29.35 g), grain yield (9.42 t ha^{-1}) and straw yield (13.33 t ha^{-1}) were obtained from the application of USG showing 10% more grain yield than PU.

Miah *et al.* (2012) conducted a field experiment with ten treatment combinations consisting of two forms of urea viz., PU and USG and five levels of each form (0, 110, 180, 240 and 300 kg ha^{-1}). They found the highest grain yield (5.77 t ha^{-1}) in USG240 and straw yield (12.11 t ha^{-1}) was in USG300 and the lowest grain (4.12 t ha^{-1}) and straw yield (8.33 t ha^{-1}) were found in control. The highest protein and starch contents were observed in USG300 treatment and lowest were found in control. They also found a positive and significant correlation between grain yield and yield attributes in grain. They suggest that urea super granule @ 240 kg ha^{-1} may be suitable for better growth and yield of boro rice cv. BRRI dhan28 in the agro climatic condition of the study area.

Das *et al*. (2012) carried an experiment and showed that the higher grain yield (4.46 t ha^{-1}) was obtained from 20 cm × 20 cm spacing. They also found that rates of urea super granules significantly influenced all the yield contributing characters except weight of 1000-grain and length of panicle. The maximum effective tillers $hill^{-1}$ (14.60), grains $panicle^{-1}$(109.1), grain yield (5.80t ha^{-1}) and harvest index (44.90%) were obtained from 2.7g USG (68 kg N ha^{-1}). Xia *et al* (2011) carried a field experiment on super rice variety Xinliangyou 6 with four treatments of different rates of N fertilizer viz, no N fertilizer (N0), 189 kg ha^{-1} (N1), 270 kg ha^{-1} (N2), 351 kg ha^{-1} (N3). Result showed significant differences in the yield of rice treated N1, N2 and N3 were observed compare to N0. The highest yield was recorded with application of 270 kg ha^{-1} N (N2). These treatments also record the highest effective panicles, total grains, filled grains, 1000-grain weight and seed setting rate. According to results, the suitable rate of nitrogen fertilizer for the variety Xinliangyou 6 was 270 kg.

Das (2011) stated that the highest number of total tillers $hill^{-1}$ (13.14) was produced in treatment U3 (1.8 g USG $4hill^{-1}$) and the lowest number of total tillers (8.57) was produced in treatment U1 (no application of nitrogenous fertilizer). Tahura (2011) showed the highest grain yield (3.38 t ha^{-1}) in U3 (1.8 g USG 4 $hill^{-1}$) and the lowest grain yield (1.99 t ha^{-1}) in U1 (control). Haden *et al.* (2011) showed that urea-induced toxicities may be the main cause of poor growth when urea was applied on soil surface during the early growth stage in rice. Deep placement of urea super granule (USG) reduced the adverse effects of urea; this is because deep placement of urea can reduce nitrogen loss by ammonia volatilization and ammonia is known the main cause of urea induced toxicities. Kathrine (2011) carried out an experiment and found that urea super granule (USG) is designed to slowly release N into the soil. These fertilizers have been proved to increase crop N use efficiency, yield and protein levels, and to reduce unnecessary losses of applied N fertilizer in to the environment.

Rakib (2011) found the highest grain (4.64 t ha^{-1}) and straw (7.03 t ha^{-1}) yield in T4 (USG in three splits i.e. at 7 DAT). He also found the superior position in N uptake, N use efficiency and apparent N recovery by BRRI dhan29 in T4. Jun *et al*. (2011) demonstrated an experiment in a rice field with different crop rotation systems and nitrogen application rates, surface water nitrogen content, nitrogen loss via runoff, soil fertility and rice yield were determined. Based on the experiment, chemical nitrogen fertilizer application during rice season in alfalfa-rice or rye-rice rotation systems can be reduced, and not in wheat-rice rotation system in Yixing, Jiangsu Province. Alfalfa-rice and rye-rice rotation systems enhanced soil nitrogen content, promoted rice nitrogen absorption and significantly improved rice yield.

Hasanuzzaman *et al*. (2009) also observed that the application of USG @ 75 kg N ha^{-1} gave the highest thousand grain weight and straw yield. Similar results were found by Rahman (2003) and Alam (2002). According to Chien *et al*. (2009) in contrast to flooded rice, little study has been done on the use of USG for upland crops, presumably due to difficulty in deep placement of USG in upland soils. Slow-control release urea fertilizers are practically efficient under the growing conditions where soils are coarse, warm climate, high moisture content, high rainfall/irrigation, high potential volatilization and high leaching losses. Salahuddin *et al*. (2009) stated that plant height increased with the increasing rate of nitrogen up to 200 kg ha^{-1} and it was found significantly higher from the other levels of nitrogen.

Bowen (2008) reported that the use of deep-placed urea super granules has resulted in increased yield of rice grain (1120 kg/ha) and a decreased use of fertilizer (70 kg Nha^{1}) in the boro season. Jing Xiang et al. (2008) conducted three experiments (field micro-plot, two Pot and pot-diffusion incubations) in International Rice Research Institute (IRRI) farm. The field micro-plot experiment showed that urea and urea super granules (USG) deep placement increased grain yield of aerobic rice by 1.66 t ha^{-1} in continuous aerobic rice cultivation. Pot experiments studying the effects of different application methods of nitrogen indicated that N incorporation into soil and placement at a depth of 5-10cm in the soil increased the vegetative growth parameters, and plant growth parameters of aerobic rice under ammonium sulphate were significantly higher than urea at all applied treatments. In pot-diffusion incubations experiment, N placement at a depth of 5.0 cm in the soil significantly reduced nitrogen loss by ammonia volatilization

Hoque (2008) conducted an experiment and he found that deep placement of nitrogen fertilizer into the anaerobic soil zone is an effective method to reduce volatilization loss. Urea in the form of USG (Urea Super Granule) has been proved to be superior to granular urea in all aspects. It is applied in the rice field only for one time after 7 to 10 days of plantation of seedlings and it contributes for the whole growing period of rice. Instead of normal does of 247 kg of granular urea, only 160 kg ha-1 of USG is required (35% less) and it increases rice yield up to 20%.

Siddika (2007) conducted an experiment by using PU and USG and found that N use efficiency was higher from USG compared to PU. Hasan (2007) demonstrated an experiment during the aman season of 2006 and recorded the increased number of tillers hill^{-1} with increased nitrogen level as USG. He showed that different levels of USG did not have any significant effect on 1000- grain weight of three aman rice cultivars. Dhyan et al. (2007) carried out an experiment to see the economics, yield potential and soil health of rice (Oryza sativa)-wheat (*Triticum aestivum*) cropping system under long-term fertilizer experiment. Results showed that balancing of plant nutrients improved the nitrogen use efficiency and high cost: benefit ratio was obtained with the application of 100% N only.

Khalil *et al*. (2006) reported that high concentration gradients of NH^{+}_{4}, NO_2–, and pH developed in the USG placement zone through enzyme-catalyzed urea hydrolysis and thereby disperse slowly away from the granule under aerobic conditions. This results in the inhibition of both urease and nitrifier activity and little or no N immobilization initially and thus decreases N_2O emissions from coarse to medium-textured soils.

Bowen *et al.* (2005) demonstrated 531 on-farm trials during boro and aman seasons in 7 districts of Bangladesh from 2003-2004. The results showed that UDP (Deep Placement of USG) increased grain yields by 1120 kg ha^{-1} and 890 kg ha^{-1} during boro and aman season, respectively. Mazumder et al. (2005) stated that different level of nitrogen influenced grain yield and straw yield with the application of 100% RD of N (99.82 kg N ha^{-1}) which was statistically followed by other treatments in descending order. The highest grain yield (4.86 t ha^{-1}) was obtained with 100% RD of N and the lowest one (3.801 ha 1) from no application of nitrogen.

Kulkarni *et al*. (2005) conducted a field experiment at an agricultural college farm in Kolhapur, Maharashtra, India to investigate the utilization of prilled urea (PU) and urea super granules (USG) in single and split doses by deep placement at different crop growth stages. Grain yield was significantly increased by PU and USG application over control (no nitrogen). Treatments with 100 kg USG N, 80 kg USG N and 100 kg prilled urea N ha^{-1} in single and split doses were statistically at par. Rainfed rice showed good performance under N application through USG at 80 kg N ha^{-1} and 100 kg N ha^{-1} as full basal dose by deep placement.

Hossain *et al*. (2004) carried out an experiment at the farm of Bangladesh Institute of Nuclear Agriculture (BINA) to see the effect of four levels of seedling $hill^{-1}$ viz., 1, 2, 3 and 4 and two forms of nitrogen fertilizer- prilled urea (PU) and urea super granule (USG) on growth, yield and yield components of transplant aman rice cv. BINA Dhan4. The results showed that most of the growth parameters at all levels of seedling $hill^{-1}$ gave higher values with USG than those with PU. The highest grain yield (5.71 t ha^{-1}) and straw yield (8.20 t ha^{-1}) was obtained due to application USG.

Wang (2004) reported a field experiment in Taiwan to investigate the effect of deep placement of fertilizer and nitrogen top dressing on rice yield and to develop a simple method for diagnosing the level of nitrogen (N) top-dressing during panicle initiation stage. The deep placement of nitrogen fertilizer promoted nitrogen uptake, grain nitrogen and nitrogen harvest index, resulted in a higher dry matter production, harvest index and a higher grain yield of rice plant compared with conventional nitrogen application. Similarly, top-dressing of nitrogen at panicle initiation stage also increased nitrogen uptake, dry production, nitrogen harvest index, and harvest index and grain yield of rice plants.

Rahman (2003) reported that two USG per 4 hills produced the higher grain and straw yields (5.22 and 6.09 t ha^{-1}, respectively). Alam (2002) also showed that 1000- grain weight was not influenced by different levels of USG. Singh and Kumar (2003) conducted a field experiment and recorded the application and recorded the application of slow release fertilizers (USG), biogas slurry and blue green algae + drilled urea (PU) significantly increase grain and straw yield, nitrogen uptake, nitrogen use efficiency, and nitrogen recovery in rice. Tine highest grain yield, nitrogen recover was recorded with the application of USG.

Jena *et al*. (2003) revealed that deep placement of USG significantly increased N use efficiency of rice and reduced volatilization loss of ammonia relative to the PU application by improving grain and straw yields. Das and Singh (2003) reported that deep placement of 76 kg USG ha^{-1} at 5 cm soil depth produced significantly higher grain (43.1 q ha^{-1}) and straw (47.8 q ha^{-1}) yields with highest mean N use efficiency (24.13 kg gain kg-1 N applied). The study suggested that 76 kg N ha^{-1} is the optimum rate of N as USG.

Zaman *et al.* (2003) showed that deep placement of USG consistently higher grain and straw yields than application of PU and they also found that the total N recovery and agronomic efficiency of N were higher with USG than PU. Ding *et al*. (2002) stated that de-nitrification losses can also be decreased by deep placement of urea fertilizer. Li *et al*. (2002) showed that nitrogen loss by ammonia volatilization during the maize growing season was reduced from 30–48% to 11–18% of applied nitrogen when deep placement of USG instead of broadcasting urea on the soil surface.

Ahmed *et al.* (2000) showed that USG was more efficient than PU at all 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.

2.3 Effects of NPK briquette on yield contributing characters of rice plant

Shah *et al.* (2013) carried out twelve experiments at the Bangladesh Rice Research Institute (BRRI) farm, Gazipur, BRRI regional station Sagordi, Barisal and farmers' field in 2012 to evaluate the NPK briquette efficacy in rice production. Experimental results revealed that deep placement of NPK briquette (2 x 2.4g) increased rice yield about 10 percent and it saved 37 percent N, 30 percent P and 44 percent K than BRRI fertilizer recommended rate in boro season. Similarly, NPK briquette (1 x 3.4g) produced 28 percent and 18 percent more rice yield than BRRI fertilizer recommended rate for *T. aus* and *T. aman*, respectively. Thus, use of NPK briquette over NPK broadcast and incorporation was very much efficient for rice cultivation.

Shah *et al*. (2012) stated that deep placement of NPK briquette (2 × 2.4 g) increase rice yield about 10 percent and it saved 37 percent nitrogen than BRRI fertilizer recommended rate in Boro season. Similarly, NPK briquette (1 × 3.4 g) produced 28 percent and 18 percent more rice yield than BRRI fertilizer recommended rate for *T. Aus* and *T. Aman*, respectively and also resulted in savings of 26-39 percent nitrogen.

Azam *et al*. (2012) conducted a field experiment at the agronomy field of Shere-E-Bangla Agricultural University, Dhaka to find out the influence of variety and different urea fertilizer application method on growth and yield of boro rice. The experiment was carried out in split-plot design with three replications having three varieties. Result showed that variety and urea fertilizer application method had significant effect on plant height, tillers hill^{-1}, dry weight hill^{-1}, grains panicle^{-1}, leaf area index, 1000-grain weight, grain yield, straw yield and harvest index. Urea super granule treated plots showed better performance than that of prilled urea.

Islam *et al*. (2011) demonstrated an experiment on the effectiveness of NPK briquette on rice in tidal flooded soil condition. They found that NPK briquettes, USG and prilled urea (PU) treated plot produced statistically similar grain yield. N-treated plots (briquette, USG and PU) gave significantly higher grain yield than N control.

Choudhury *et al*. (2009) carried out a field experiment at Bangladesh Rice Research Institute to evaluate the effect of urea super granule (USG) deep point placement compared to conventional prilled urea (PU) broadcasting with respect to yield and nitrogen nutrition of wetland rice (Variety BR11). The result showed that USG treated plots gave higher grain and straw yields compared to PU treated plots within same dose of added N. In addition to that total N uptake by BR11, agronomic efficiency and apparent recovery of added N were also higher with USG compared to PU within the same N dose.

Kapoor *et al*. (2008) found that significantly higher grain yield was observed with deep placement of NPK briquette compared to broadcast application. Durguda *et al.* (2008) also showed that higher grain yield was observed in rice with DAP briquettes compared to urea. Bulbule *et al*. (2008) observed that grain yield of grain yield of rice significantly increased when the crop was fertilized through briquettes (100-50-30 kg NPK ha^{-1}) as compared to the application of conventional fertilizers (100-50-50 kg NPK ha^{-1}). Upendra Singh *et al.* (2008) stated that the deep-point placement of N, P and K briquettes significantly increased grain and straw yields, total N, P and K uptake, also N and P use efficiencies compared to broadcast incorporation of N, P and K in rice.

Vibhu Kapoor *et al.* (2008) found that deep placed N–P briquettes gave significantly higher grain yield, straw biomass, total P and K uptake, apparent P recovery, and agronomic N and P use efficiencies, when plant spacing was reduced from 20cm × 20 cm to 20 × 10 cm. Closer plant spacing led to better utilization of P and K and provided opportunities for deep placement of NP or NPK briquettes in soils with low available P. Combining site specific characteristics viz., high soil pH, low percolation rate, high rainfall and surface runoffs with plant spacing and NPK briquettes prepared based on site-specific nutrient requirements offered potential for higher yields, improved fertilizer use efficiency, balanced fertilization, and reduced nutrient losses.
IFDC (2007) showed that farmers in Vietnam and Cambodia obtained 25% higher yields with deep placement of NPK briquettes over the broadcasting of fertilizer. IFDC (2007) also found that deep placement of fertilizers had increased rice yield by 22 % over broadcasting and decreased urea use by 47 %. Peterson (2007) exhibited that placement of compound NPK fertilizer increased the grain yield and the quality parameters like grain size and the effect of fertilizer placement on grain yield and quality decreased in the order NPK> NP> N> P.

Siddika (2007) conducted an experiment by using PU and USG and found that N use efficiency was higher from USG in compared to PU. IFPRI (2004) stated that yield of rice was increased by 15-25 %, while expenditure on commercial fertilizer was decreased by 24-32 % when fertilizer briquettes were used as the source of plant nutrients. Deep placement of fertilizer briquettes also offered environmental and economic benefits in Bangladesh.

Neubauer *et al*.(2002) and Chandrajith *et al*. (2008) found that in tidal ecosystem, nutrient management strategies would be different from other ecosystem. Because, applied NPK fertilizers are washed-out from rice field during tidal flood. So, deep placement of all fertilizers would be effective rather than broadcasting. Kadam *et al.* (2001) reported that urea briquettes increased grain yield of rice over split application of urea and the additional yield increased from 5 to 83 %.

CHAPTER 3

MATERIALS AND METHODS

The research work was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from July to November 2015 to use of NPK Briquette and Guti Urea formulas as an alternative of prilled urea fertilizer on the growth and yield in T. *Aman* Rice (BR 11). 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).

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.

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.

3.2 Test crop and its characteristics

BR 11 was used as the test crop in this experiment.

3.3 Experimental details

The experiment was conducted with five treatments and four replications were used to achieve the desired objectives. The title of the experiments was as follows:

Use of NPK briquette and guti urea on the growth and yield of T. *Aman* rice.

3.3.1 Treatments

T_0= 0 kg N/ha (control)

T_1= 78 kg N/ha as Prilled Urea(Recommended dose as per FRG 2012)

T_2=52 kg N/ha as prilled Urea

T_3=52 kg N/ha as Urea briquette (One 1.8 g briquette/ 4 hills of rice)

T_4=52 kg N/ha as NPK briquette (One 3.4 g briquette/4 hills of rice)

Other fertilizer as blanket dose: P_{15} K_{50} S_{10} $Zn_{1.0}$

3.3.2 Experimental design and layout

The experiment was laid out in one factor Randomized Complete Block Design(RCBD) with four replications. The layout of the experiment was prepared for distributing the combination of different combination of nutrient levels. Thus there were 20 (5 treatments × 4 replication) unit plots (2 m × 3 m size) in each experiment. The five treatments of the experiment were assigned at random in 5 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 BR 11 were collected from Bangladesh Rice Research Institute, 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 july 2015 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 application

Treatment wise fertilizer was applied during the rice growing period. Total amount of TSP, MOP, gypsum were applied during final land preparation. Mixed NPK briquette, Guti urea and prilled urea was applied treatment wise in every plot after 7 days of seedling transferred.

3.4.4 Prilled urea

Urea is a chemical fertilizer. It contains 46% N. Prilled urea was applied during final land preparation in one installment and full dose of other fertilizers.

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. BR 11 was transplanted in 25th July 2015.

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 Guti urea application

Guti urea was applied after 7 days of transplant. One guti/ 4 hills had been applied in treatment wise plot.Guti urea was collected from IFDC.

3.4.7.2 NPK Briquette application

After 7 days of transplant NPK Briquette was applied. One briquette/ 4 hills had been applied in treatment wise plot.NPK briquette was collected from IFDC.

3.4.7.3 Prilled urea application as top dressing

Second dose of prilled urea was applied after 18 days of transplant and the third dose was applied before panicle come out. Prilled urea was collected from SAU farm.

3.4.8.1 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 5-6 cm in the later stage to discourage late tillering and weed growth. The field was finally dried out at 15 days before harvesting.

3.4.8.2 Gap filling

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

3.4.8.3 Weeding

Weeding was 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.

3.4.8.4 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, 2015. 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 riceseed. Ten hills of rice plant were selected randomly from the plants for measuring yield contributing characters. 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 plant.

3.6.2 Total effective tillers /hill

The total effective tillers hill was calculated by counting effective tillers /hill and average value was recorded.

3.6.3 Total non effective tillers /hill

The total non effective tillers /hill was calculated by counting non effective tillers /hill 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 ten sample plants were added to the respective straw yield unit plot.

3.7 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 4

RESULTS AND DISCUSSIONS

Different types of urea fertilizer and NPK briquettes were used in this experiment to find out the growth, yield and N uptake in T. *Aman* Rice (BR 11). Data on different parameters were analyzed statistically. The results of the experiment presented and discussed in this chapter under the below headings.

4.1 Plant Height

The effects of NPK briquette (One 3.4 g briquette/4 hills of rice) influenced the plant height significantly compare to the control treatment. The tallest plant height (122.68 cm) was found at treatment T_4 (One 3.4 g NPK briquette/4 hills of rice). The lowest plant height (116.50 cm) was recorded at treatment T_0 (control) (table-1). The main stimulating nutrient is nitrogen to elongation and cell division of plant cell and also different physiological process. Therefore, plant height was increased due to application of increased level of nitrogenous fertilizer. But, NPK briquette is a mixed fertilizer which was stimulated better plant physiological process such as plant height than the prilled urea or guti urea. Azam *et al*. (2012) reported similar result in their research. They found tallest plant height at the treatment of NPK briquette.

4.2 Panicle Length

The longest panicle length (25.90 cm) was recorded in the treatment T_4 (one 3.4 g NPK briquette/4 hills of rice) and the shortest panicle length (22.99 cm) was found in T_0 (control) treatment (table-1). Here, the panicle length of treatment T_4 was statistically significant compared to the (control) T_0 treatment but there were no significant difference with other treatments.Which was statistically similar to the treatments T_1, T_2 and T_3

4.3 Number of Effective Tillers/hill

The maximum number of effective tillers/hill (13.55) was found in T_2 (52 kg N/ha as prilled urea) treatment and the lowest number of effective tillers/hill (10.00) was recorded in T_0 (control) treatment (table-1). The treatment T_2 was statistically similar to all other treatments except T_0 treatment. Treatment T_2 has statistically significant difference compared to the treatment T_0 because N fertilizer influenced to produce tillers. Singh and Shivay (2003) stated that the effective tillers/hill was significantly affected by the level of nitrogen and increasing levels of nitrogen significantly increased the number of effective tillers/hill. Hasanuzzaman et al. (2013) also found similar result in their research by using guti urea.

Table-1: Effect of Mixed NPK Briquette and Guti Urea on the Yield Contributing Characters of T. *Aman* Rice.

Treatments		Plant height (cm)	Panicle length (cm)	No. of Effective tillers/hill
T_0	0 kg N/ha (Control)	116.50 b	22.99 b	10.00 b
T_1	78 kg N/ha as Prilled urea (Recommended dose as per FRG 2012)	118.76 ab	24.92 ab	12.90 a
T_2	52 kg N/ha as Prilled urea	119.90 ab	25.45 a	13.55 a
T_3	52 kg N/ha as Urea briquette (One 1.8 g briquette/ 4 hills of rice)	118.94 ab	24.86 ab	12.75 a
T_4	T_4=52 kg N/ha as NPK briquette (One 3.4 g briquette/4 hills of rice)	122.68 a	25.90 a	13.13 a
SE (±)		**1.09**	**0.45**	**0.36**
CV (%)		**2.04**	**4.07**	**6.41**

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

4.4 1000 Seed Weight (gm)

The maximum 1000 seed weight (25.25g) was recorded from treatment T_4(25.25) which was statistically similar to treatments T_1 (23.75g), T_2 (24.50g), T_3 (24.25g) and the lowest seed (21.75g) was found from T_0 treatment. . Hasanuzzaman *et al*. (2009) also recorded highest thousand grain seed weight by application of Urea Guti. Similar results were found by Rahman (2003) and Alam (2002). Deep placement of fertilizer has no chance of volatilization loss or run off loss. Rice plant can take slowly of these fertilizers and specially mixed NPK help to make more photosynthesis which is more effective to increase the thousand seed weight.

Table-2: Effect of Mixed NPK Briquette and Guti Urea on the Yield Contributing Characters of T. *Aman* Rice.

Treatments		1000 seed weight (gm)	No. of Filled grain	Number of non effective tillers/hill
T_0	0 kg N/ha (Control)	21.75 c	136.48 c	1.48 a
T_1	78 kg N/ha as Prilled urea (Recommended dose as per FRG 2012)	23.75 b	157.50 abc	0.10 b
T_2	52 kg N/ha as Prilled urea	24.50 ab	174.50 a	1.25 a
T_3	52 kg N/ha as Urea briquette (One 1.8 g briquette/ 4 hills of rice)	24.25 ab	148.95 bc	0.90 a
T_4	T_4=52 kg N/ha as NPK briquette (One 3.4 g briquette/4 hills of rice)	25.25 a	168.65 ab	1.00 a
SE (±)		**1.09**	**0.29**	**4.99**
CV (%)		**2.04**	**2.70**	**7.1**

(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.)

4.5 Number of Filled Grain/panicle

The highest number of filled grain (174.50) was found in the treatment T_2 (52 kg N/ha as Prilled urea) Which was statistically similar with T_1 and T_4 treatment and the lowest number of filled grain (136.48) was found in (control) T_0 treatment (Table-2). Treatment T_2 was shown statistically significant difference with treatment T_0 but not with all other treatments.

4.6 Number of Non-Effective Tillers/hill

The highest number of non effective tillers/hill (1.48) was found from the treatment (control) T_0 and the lowest number of non effective tillers/hill (0.100) was found from treatment T_1 (78 kg N/ha as Prilled urea) (Table-2). There was no significant difference among the treatments each other except treatment $T_{1.}$ and T_4 treatment was shown significant difference with all other treatments.

4.7 Number of Unfilled Grains per panicle

The highest unfilled grain (12.85) was found from the treatment T_4 (one 3.4g NPK briquette/4 hills of rice) and the lowest unfilled grains per panicle (11.00) was recorded from the treatment T_2 (52 kg N/ha as Prilled urea) (Table-3). There was no statistical significant difference among the treatments each other.

Table-3: Effect of Mixed NPK Briquette and Guti Urea on the Yield Contributing Characters of *T .Aman* Rice.

Treatments		No. of unfilled grain	Grain Yield (kg /plot)	Straw Yield (kg /plot)
T_0	0 kg N/ha (Control)	11.70	1.59 b	2.69 c
T_1	78 kg N/ha as Prilled urea (Recommended dose as per FRG 2012)	12.35	1.80 ab	3.02 ab
T_2	52 kg N/ha as Prilled urea	11.00	1.85 ab	2.99 ab
T_3	52 kg N/ha as Urea briquette (One 1.8 g briquette/ 4 hills of rice)	12.00	2.04(a)	2.85(bc)
T_4	T_4=52 kg N/ha as NPK briquette (One 3.4 g briquette/4 hills of rice)	12.85	1.97 a	3.17a
SE (±)		**.06**	**1.09**	**1.19**
CV (%)		**7.03**	**2.04**	**22.23**

(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.)

4.8 Grain Yield (kg/plot)

The highest grain yield 2.04 was recorded from the treatment T_3 (52 kg N/ha as one 1.8 g urea briquette/4 hills of rice) and the lowest grain yield 1.59 was found from the T_0 (control) treatment (Table-3). The treatment T_3 was shown statistically significant difference with the treatment T_0 but not with the other treatments. Here, NPK briquette was represented almost similar grain yield 1.97(3.28 t/ha) at the treatment T_4 which had no statistical significant difference with the highest yield T_3 treatment. Nitrogen fertilizer is the key nutrient element of growth and tillering of rice plant. So, the deep placement of Urea Guti or NPK briquette has less chance of losing nutrient than the conventional broadcasting system of prilled urea. Therefore, due to effective deep placement of Urea Guti and NPK briquette found better grain yield than the other treatments. Xiang *et al* (2013) demonstrated that USG deep placement increased grain yield and the soil significantly reduced nitrogen loss by ammonia volatilization. Islam *et al*. (2013) and Tahura (2011) also found highest grain yield by using one 1.8 g USG /4 hills.

4.9 Straw Yield (kg/plot)

The highest straw weight of 3.17 kg/plot(5.28t/ha) was recorded from the treatment T_4 (one 3.4gm NPK briquette/4 hills) which was statistically similar with the treatment T_1(3.02kg/plot) andT_2(3 kg/plot)treatment. Upendra Singh *et al*. (2008) and Vibhu Kapoor *et al.* (2008) also agreed that the deep placed NPK briquettes gave significantly higher grain yield and straw biomass.

CHAPTER 5

SUMMARY

The experiment was conducted at the Research Farm, Sher-e-Bangla Agricultural University, Dhaka during July 2015 to November 2015 to determine the effectiveness of mixed NPK briquette and guti urea fertilizer on the growth and yield of transplanted *Aman* rice (BR11). The experimental field belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28. The soil of the experimental field belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon soil series. The experiment was laid out randomized complete block design with four replications. The total numbers of unit plots were 20. The size of unit plot was 6 m^2 (3 m × 2 m).

The experiment consisted of one factor. The factor was Nitrogen Sources (5 levels); T_0: 0kg N/ha (control), T_1: 78kg/ha as Prilled Urea (Recommended dose of FRG 2012), T_2: 52kg/ha as Prilled Urea, T_3: 52kg/ha as Urea Briquette (one 1.8 g briquette/4 hills of rice) and T_4: 52kg/ha as NPK briquette (one 3.4g briquette/4hills of rice).

Results revealed that nitrogen sources, USG (Urea Guti) and NPK briquette had shown significant effects on growth and yield of transplanted*Aman* rice compared to the prilled urea doses. The result of yield contributing characters such as the tallest plant height (122.68 cm) was found in treatment T_4 (One 3.4 g NPK briquette/4 hills of rice). The longest panicle length (25.90 cm) was recorded in treatment T_4 (one 3.4 g NPK briquette/4 hills of rice). The maximum number of effective tillers/hill (13.55) was found in T_2 (52 kg N/ha as prilled urea) treatment and the maximum 1000 seed weight (25.25g) was recorded in treatment T_4 (one 3.4 gm NPK briquette/4 hills of rice). The highest number of filled grains per panicle (174.50) was found in the treatment T_2 (52 kg N/ha as Prilled urea) and the highest number of non effective tillers/hill (1.48) was found from the treatment (control) T_0 and the highest unfilled grain (12.85) was found from the treatment T4 (one 3.4g NPK briquette/4 hills of rice). The highest grain yield (2.04) was recorded from the treatment T_3 (52 kg N/ha as one 1.8 g urea briquette/4 hills of rice) and NPK briquette was represented almost similar grain yield (1.97) at the treatment T_4 which had no statistical significant difference with the highest yield T_3 treatment. The highest straw weight (3.17) was recorded from the treatment T_4 (one 3.4g NPK briquette/4 hills).

However, mixed NPK and USG showed better grain yield and straw yield compared to conventional broadcast prilled urea. USG and mixed NPK fertilizer showed significant effects to growth and yield of T. *Aman*rice (BR11).the highest grain yield of 2.04 kg/plot was obtained from T_3 treatment which was statistically similar with the treatment T_4(1.97 kg/plot).

CHAPTER 6

CONCLUSIONS

The conclusion of the results obtained from the experiment on the effects of PU, USG and NPK briquette on the growth and yield contributing characters of T. *Aman* rice (BR11) are as follows:

The highest grain yield was found from the treatment T_3 (52 Kg N/ha as one 1.8 g urea briquette/4 hills of rice) and NPK briquette was represented almost (staistically) similar grain yield (1.97) in the treatment T4.The highest straw weight (3.17) was recorded from the treatment T4 (one 3.4gm NPK briquette/4 hills). Nitrogen use efficiency by the rice plants was much higher when N was applied as USG and NPK briquette than those applied as PU because of reduce losses of deep placement technique. The application of NPK briquette fertilizers may be a better choice considering the less use of PU and more use of USG.

Therefore, treatment T_4(one 3.4g NPK briquette/4 hills) can be recommended for T. *Aman* rice BR11 orUrea Guti (52 kg N/ha as one 1.8 g urea briquette/4 hills of rice) can be recommended for farmers to use for BR11 rice . This is a short time research due to some barriers of research area; need further research in large scale. This is also a distinct year and location trial so more research is recommended in different agro–ecological zones (AEZ) of Bangladesh for regional adaptability and other performances.

REFERENCES

Ahmed MH, Islam MA, Kader MA, Anwar MP 2000: Evaluation of urea super granules as source of nitrogen in transplant aman rice. *Pakistan Journal of Biological Science.* **3(5)** 735-737.

Alam BMR, 2002: Effect of different level of urea super granule on the growth and yield of three varieties of *boro* rice, MS (Ag), Thesis, Department of Agronomy, Bangladesh Agricultural University, Mymensingh.

Angayarkanni A, Ravichandran M 2001: Judicious fertilizer N split for higher use efficiency in transplanted rice. *Indian Journal of Agricultural Research* **35(4**) 278-280.

Azam MT, Ali MH, Karim MF, Rahman A, Jalal MJ, Mamun AFM 2012: Growth and yield of boro rice as affected by different urea fertilizer application methods. *International Journal of Sustainable Agriculture* **4(3)**45-51.

Bhuiyan NI, Paul DNR, Jabber MA 2002: Feeding the extra millions by 2025– Challenges for rice research and extension in Bangladesh, National Workshop on Rice Research and Extension in Bangladesh, Bangladesh Rice Research Institute, Gazipur.

BBS 2011: Monthly Statistical Bulletin of Bangladesh. Statistical Division, Ministry of Planning, Government People's Republic Bangladesh.

BBS 2012: *Statistical* Yearbook of Bangladesh Bureau of Statistics, Ministry of Planning, Government People’s Republic Bangladesh, Dhaka. pp.136-140.

Bowen WT 2008: Urea deep placement for improving nitrogen use efficiency in rice based systems. pp. 29-31.

Bowen WT, Diamand RB, Singh U, Thompson TP 2005: Urea deep placement increases yield and saves nitrogen fertilizer in farmer's fields in Bangladesh. Rice in life: Scientific Perspectives for the 21st Century. In: Proc. World Rice Research Conference held in Tsukuba, Japan, 4-7 Nov.2004. pp. 369-372.

BRRI 2010: Annual Report of Soil and Fertilizer Management Programme. Bangladesh Rice Research Institute, Joydebpur, Gazipur. **2** 15-20.

Bulbule AV, Durgude AC, Patil VS, Kulkarni RV 2008: Fertilization of lowland transplanted rice through briquettes. *Journal of Crop Research* J **35** 1-5.

Chandrajith RK, Mahatantila HA, Jayasena H and Tobschall HJ 2008: Geochemical Cracteristics of sediments from areservoir (tank) ecosystem in Srilanka. Paddy Water Environment 6: 363-371.

Chien SH, Prochnow LI, Cantarella H 2009: Recent Developments of Fertilizer Production and Use to Improve Nutrient Efficiency and Minimize Environmental Impacts. Advances in Agronomy 102, 205-218.

Chopra NK, Chopra N 2000: Effect of row spacing and N level on growth, yield and seed quality of scented rice under transplanted conditions. *Indian Journal of Agronomy* **45(2)** 304-308.

Choudhury ATMA, Bhuiyan NI, Hashem NA, Matin MA 2009: Nitrogen fertilizers deep placement in wetland rice. *Bangladesh Research Publication Journal* **2(2)** 499-505.

Das KPB 2011: Effect of PM and nitrogenous fertilizer on the growth and yield of boro rice cv. BRRI dhan45, M.S. Thesis, Department of Agronomy,Bangladesh Agrilcultural University Mymensingh. pp. 31-45.

Das S, Singh TA 2003: Nitrogen use efficiency by rice flood water parameters as affected by fertilizer placement techniques, Adelaide, Australia. pp. 67-76.

Das S, Chaki AK, Sarker AR, Goswami PC Arshad HM 2012: Inflence of spacing of transplanting and rate of urea super granules on the yield of boro rice. *Bangladesh Journal of Progressive Science & Technology* **10(1)** 17-20.

Dhyani BP, Kumar V, Shahi UP, Vivek Sharma RD, Singh PS 2007: Economics, yield potential and soil health of rice (*Oryza sativa L.*) wheat (*Triticum aestivum*) cropping system under long-term fertilizer. *Indian Journal of Agricultural Science* **77(12)** 859-861.

Ding H, Guxin C, Yuesi W, Deli C 2002: Nitrification-denitrification loss and N2O emission from urea applied to crop-soil systems in North China Plain.

Ding H, Guxin C, Yuesi W, Deli C 2002: Nitrification-denitrification loss and N2O emission from urea applied to crop-soil systems in North China Plain. *Agricultural Science in China* **1** 184-188.

Dongarwar UR, Patankar MN and Pawar WS 2003: Response of rice to different fertility levels. *Journal of Soils Crops* **13(1)** 120-122.

Duhan BS, Singh M 2002: Effect of green manuring and nitrogen on the yield and uptake of micronutrients by rice. Journal of Indian Society of Soil Science 50(2) 178-180.

Durguda AG, Patil YJ, Bulbula AV, Patil VS 2008: Effect of fertilizer management through urea-DAP briquettes on lowland rice. *An Asian Journal of Soil Science* **3(1)** 1-3.

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

FAOSTAT 2012: Food and Agricultural Organisation of the United Nations, Production 11 Yearbook **46** FAO, Rome, Italy.

FAPRI 2009: The Agricultural Outlook 2009. World Rice.Food and Agricultural Policy Research Institute.

Gomez KA, Gomez AA 1984: Statistical Procedure for Agricultural Research (2nd edn.). Int. Rice Res. Inst., A Willey Int. Sci., pp. 28-192.

Haden VR, Xiang J, Peng SB, Bouman BAM, Visperas RM, Ketterings QM, Hobbs P, Duxbury MJ 2011: Relative effects of ammonia and nitrite on the germination and early growth of aerobic rice. *Journal Plant Nutrition and Soil Science* **174** 292-300.

Hasan SM 2007: Effect of levels of urea super granules on the performance of *T. aman* rice, M.S. Thesis, Department of Agronomy, Bangladesh Agricultural University, Mymensingh.

Hasanuzzaman M, Ali MH, Karim MF, Masum SM, Mahamud JA 2011: Influence of prilled urea and urea super granules on the growth and yield of hybrid rice. Bangladesh of *Bioscience Association* **4(1)**1-8.

Hasanuzzaman M, Nahar K, Alam MM, Hossain MZ , Islam MR 2009: Response of transplanted rice to different application methods of urea fertilizer. *International Journal of Sustainable Agriculture* **1(1)** 1-5.

Hoque N 2008: Saving of taka 250 crores and increasing yield by 20% by using Goti Urea (Bangla). The Daily Ittefaq. pp. 15-16.

Hossain MNM, Talukder S, Sarker MAR, Ansari TH 2004: Effect of number of seedling per hill and urea super granule on growth and yield of rice cv. BINA Dhan4. *Journal of Biological Sciences* **4(2)** 122-129.

IFDC 2007: Mitigating poverty and environmental degradation through nutrient management in *south* Asia, Report March-2007, International Fertilizer Development Centre.

IFPRI 2004: International Food Policy Research Institute, Annual Report, Production 2 Yearbook 74 IFPRI Wasington DC, United State of America.

Islam MM 2011: Response of urea super granules and urea mega granules with or without Nimin on boro rice (cv. BRRI dhan29), MS Thesis, Department of Soil Science, Bangladesh Agricultural University, Mymensingh.

Islam MU, Sarkar MAR, Paul SK2013: Effect of weeding regime and urea super granules on the yield of transplant *Aman* rice (cv. BRRI dhan51). *BangladeshJournal of Crop Science*, 42 (2): 3-4.

Jaiswal VP, Singh GR 2001: Performance of urea super granule and prilled urea under different planting methods in irrigated rice (*Oryza sativa*). *Indian Journal of Agricultural Science* **71** 187-189.

Jena D, Misra C, Bandyopadhyay KK 2003: Effect of prilled urea and urea super granules on dynamics of ammonia volatilization and N use efficiency of rice. *Journal of Indian Soceity of Soil Science* **51(3)** 257-261.

Jing X, Van RH, Shaobing P, Bouman AM, Jianliang H, Kehui C, Romeo MV, Defeng Z, Yuping Z, Huizhe C 2008: Effect of deep placement of nitrogen fertilizer on growth, yield and nitrogen uptake of aerobic rice. *Australian Journal of Crop Science* **7(6)** 870-877.

Jun Q, Mei YT, Feng X, Zhang YL, Ping L 2011: Reduction of nitrogen fertilizer application under different crop rotation systems in paddy fields of Taihu Area. *Zhongguo Shengtai Nongye Xuebao* / *Chinese Journal of Eco Agriculture* **19(1)** 24-31.

Kadam JR 2001: Efficient use of NPK fertilizer briquettes on the yield and quality of crops. *Indian Sugarcane* **51(2)** 115-118.

Kapoor V, Singh U, Patil SK, Magre H, Shrivastava LK, Mishra VN, Das RO Samadhiya VK, Sanabria J, Diamond R 2008: Rice Growth, Grain Yield and Floodwater Nutrient Dynamics as Affected by Nutrient Placement Method and Rate. *Agronomy Journal* **100(3)** 526-536.

Kathrine 2011: Increased efficiency of fertilizer nitrogen applied to rice through urea supergranules. *Indian Journal of Agricultural Science* **59(3)** 154-156.

Keeney DR 1982: Nitrogen management for maximum efficiency and minimum pollution. In: FJ Stevenson (Editor), Nitrogen in Agricultural Soils. *American Society of Agronomy*, Madison, Wisconsin. pp. 605-649.

Keeney DR, Sahrawat KL 1986: Nitrogen transformations in flooded rice soils. *Fertilizer Research* **9** 15-38.

Khalil MI, Rosenani AB, Van Cleemput O, Shamshuddin J, Fauziah CI 2002b: Nitrous oxide production from an ultisol treated with different nitrogen sources and moisture regimes. *Biological Fertilizer of Soils* **36** 59-65.

Khalil MI, Schmidhalter U, Gutser R 2006: N_2O, NH_3 and NOx emissions as a function of urea granule size and soil type under aerobic conditions. *Water and Air Soil Pollution* **175** 127–148.

Kulkarni RV, Marathe AB, Ingavale MT, Patil AP 2005: Effect of nitrogen application through prilled urea and urea super granules on drilled rainfed rice. *Journal of Soils and Crops* **15(1)** 102-104.

Li GT, Li BG, Chen DL 2002: Ammonia volatilization from large field planted with winter wheat and summer maize. *Acta Agriculture BoreallSinica* **17** 76–81.

Mashkar NV, Thorat ST 2005: Effect of nitrogen levels on NPK uptake and grain yield of scented rice varieties under Konkan condition. Nagpur, India: *Journal of Soils Crops* **15(1)** 206-209.

Mazumder MR, Bhuyia MSU, Hussain SMA 2005: Effect of N level and split application on the performance of transplanted aman rice cv. BRRI dhan31. *Bangladesh Journal of Agrilcultural Science* **31(2)** 183-188.

Miah I, Chowdhury MAH, Sultana R, Ahmed I, Saha BK 2012: Effects of prilled urea and urea super granule on growth, yield and quality of BRRI dhan28. *Journal Agroforestry Environment* **6(1)** 57-62.

Mikkelsen DS, De Datta SK, Obcemea WN 1978: Ammonia volatilization losses from flooded rice soils. *Soil Science Society of Annual Journal* **42** 725-730.

Neubauer SC, Anderson IC, Constantine JA, Kuehl SA 2002: Sediment Deposition and Accretion in a Mid-Atlantic (U.S.A) Tidal Freshwater Marsh Estuarine. *Coastal Shelf Science* **54** 713-727.

Peterson J 2007: Placement of Nitrogen, Phosphorus and Potassium fertilizers by drilling in spring barley grown for malt without use of pesticide. *Plant and Soil Science* **57 (1)** 53-64.

Rahman MA 2003: Effect of levels of urea super granules and depth of placement on the growth and yield of transplant aman rice, MS Thesis, Department of Agronomy, Bangladesh, Mymensingh.pp.1-100.

Rahman MA, Akanda MH, Rahman MM and Ali MY 2005: Effect of Urea Super Granule and prilled urea application on agro-economic performance of potato. *Journal of Agricultural Education Technology* **6(1&2)** 17-20.

Rakib 2011: Effects of prilled urea and urea super granule on growth, yield and quality of BRRI dhan28. MS thesis, Department of Agronomy, Bangladesh Agricultural University, Mymensingh. pp. 13-42.

Razib AH 2010: Performance of three varieties under different levels of nitrogen application, MS Thesis, Department of Agronomy, Bangladesh Agricultural University, Mymensingh. pp. 63 - 64.

Salahuddin KM, Parvin S 2009: Response of nitrogen and plant spacing of transplanted aman rice *Bangladesh Journal of Agricultural Resarch* 34(2): 279-285.

Salam MA, Forhad A, Anwar MP, Bhuiya MSU 2004: Effect of level of nitrogen and date of transplanting on the yield and yield attributes of transplant aman rice under SRI method. *Journal of Bangladesh Agricultural University* **2(1)** 31-36.

Savant NK, Ongkingco PS, Zarate IV, Torrizo FM, Stangel PJ 1991: Urea briquette applicator for transplanted rice. *Nutrient Cycling in Agroecosystems* **28(3)** 323-331.

Shah AL, Islam SMM, Sarker ABS, Mridha AJ 2012: Deep placement of NPK Briquette. Bangladesh Rice Research Institute. Research Paper.pp. 1-14.

Shah AL, Sarker ABS, Islam SMM, Mridha AJ 2013: Deep placement of NPK briquette: Environment friendly technology for rice production. Paper presented at the National Workshop on deep placement of NPK briquette, held at BARC, Dhaka on March 28, 2013 in collaboration with IFDC.

Shoji S, Delgado J, Mosier A, Miura Y 2001: Use of Controlled Release Fertilizers and Nitrification Inhibitors to Increase Nitrogen Use Efficiency and to Conserve Air and Water Quality. *Commun Soil Science and Annual Plant* **32** 1051–1070.

Siddika N 2007: Effect of nitrogen management with prilled urea, urea super granule and leaf color chart on the performance of transplant aman rice (cv. BR 14), MS Thesis, Department of Agronomy, Bangladesh Agricultural University, Mymensingh. pp. 35, 42-44.

Sidhu MS, Sikka R and Singh T 2004: Performance of transplanted Basmati rice in different cropping systems as affected by N application. *International Rice Research Notes* **29(1)** 63-65.

Singh CS, Kumar UN 2003: Effect of nitrogen and sulphur on growth and yield of rice cultivars. Res. on Crops 3 (3): 643-646.

Singh MK, Thakur R, Verma UN, Upasani RR, Pal SK 2000: Effect of planting time and nitrogen on production potential of Basmati rice cultivars in Bihar Plateau. *Indian Journal of Agronomy* **45(2)** 300-303.

Singh S, Shivay YS 2003: Coating of prilled urea with eco-friendly neem (*Azadirachta indica A. Juss*.). *Acta Agroninica, Hungarica* **51(1)** 53-59.

Singh Y, Malhi SS, Nyborg M, Beauchamp EG 1994: Large granules, nests or bands: Methods of increasing efficiency of fall-applied urea for small cereal grains in North America. *Fertilizer Research* **38** 61-87.

Tahura S 2011: Effect of PM and nitrogenous fertilizers on the growth and yield of transplant aman rice, MS Thesis, Department of Agronomy, Bangladesh Agricultural University, Mymensingh. pp. 37-66.

Upendra S, Patil KS, Vibhu K, Deborah H, Kovach S 2008: Improving Crop Yield and Fertilizer Use Efficiency with One-Time Nutrient Deep Placement. *Joint Annual meeting* **5 -9** 675 - 17.

Velu V, Ramanathan KM 2001: Nitrogen balance in wetland rice ecosystem as influenced by soil type. *Madras Agricultural Journal* **87** 21-25.

Vibhu Kapoor, Singh U, Patil SK, Magre H, Shrivastava LK, Mishra VN, Das RO, Samadhiya VK, Sanabria J, Diamond R 2008: Rice Growth, Grain Yield, and Floodwater Nutrient Dynamics as Affected by Nutrient Placement Method and Rate.

Wang CH 2004: Response of rice yield to deep placement of fertilizer and nitrogen top-dressing in panicle initiation stage and its diagnosis of fertilizer application. *Taiwanese Journal of Agricultural Chemistry Food Science* **42 (5)** 383-395.

Wopereis PMM, Watanable H, Moreira J, Wopereis WCS 2002: Effect of late nitrogen application on rice yield, grain quality and profitability in the Senegal River Valley. *European Journal of Agronomy* **17(3)** 191-198.

Xia LX, Xuan QK, Jie SF, Ping LT 2011: Effect of different rate of nitrogen application on yield of rice variety Xinliangyou 6. *Journal Southern Agric*. 42(5): 521-523.

Xiang J, Haden VR, Bouman AM, Zhu D 2013: Effect of deep placement of nitrogen fertilizer on growth, yield and nitrogen uptake of aerobic rice. *Australian Journal of Crop Science* **7(6)** 870-877.

Xing GX, Zhu ZL 2000: An assessment of N loss from agricultural fields to the environment in China. *Nutrient Cycling in Agroecosystems* **57** 67-73.

Zaman SK, Razzaque MA, Karim SMR, Ahmed AU 2003: Evaluation of prilled urea and urea super granules as nitrogen source for upland aus rice. pp.42-46.

APPENDICES

Appendix 1: Statistical analysis of Data

Title: Effect of NPK

Function: FACTOR

Experiment Model Number 7:

One Factor Randomized Complete Block Design

Data case no. 1 to 20.

Factorial ANOVA for the factors:

Replication (Rep) with values from 1 to 4

Factor A (Treat) with values from 1 to 5

Variable 3: 1000SW

Grand Mean = 23.900 Grand Sum = 478.000 Total Count = 20

T A B L E O F M E A N S

1	2	3	Total
1	*	24.200	121.000
2	*	24.000	120.000
3	*	23.800	119.000
4	*	23.600	118.000
*	1	21.750	87.000
*	2	23.750	95.000
*	3	24.500	98.000
*	4	24.250	97.000
*	5	25.250	101.000

A N A L Y S I S O F V A R I A N C E T A B L E

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	3	1.000	0.333	0.8000	
2	Factor A	4	27.800	6.950	16.6800	0.0001
-3	Error	12	5.000	0.417		
	Total	19	33.800			

Coefficient of Variation: 2.70%

s_ for means group 1: 0.2887 Number of Observations: 5
y
s_ for means group 2: 0.3227 Number of Observations: 4
y

===

Variable 4: ET

Grand Mean = 12.465 Grand Sum = 249.300 Total Count = 20

T A B L E O F M E A N S

1	2	4	Total
1	*	12.600	63.000
2	*	13.000	65.000
3	*	11.880	59.400
4	*	12.380	61.900
*	1	10.000	40.000
*	2	12.900	51.600
*	3	13.550	54.200
*	4	12.750	51.000
*	5	13.125	52.500

A N A L Y S I S O F V A R I A N C E T A B L E

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	3	3.270	1.090	1.7078	0.2183
2	Factor A	4	31.838	7.960	12.4724	0.0003

-3	Error	12	7.658	0.638

Total	19	42.766

Coefficient of Variation: 6.41%

s_ for means group 1: 0.3573 Number of Observations: 5

y

s_ for means group 2: 0.3994 Number of Observations: 4 y

===

Variable 5: FG

Grand Mean = 157.215 Grand Sum = 3144.300 Total Count = 20

T A B L E O F M E A N S

1	2	5	Total
1	*	153.480	767.400
2	*	160.400	802.000
3	*	154.060	770.300
4	*	160.920	804.600
*	1	136.475	545.900
*	2	157.500	630.000
*	3	174.500	698.000
*	4	148.950	595.800
*	5	168.650	674.600

A N A L Y S I S O F V A R I A N C E T A B L E

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	3	238.877	79.626	0.6394	
2	Factor A	4	3712.278	928.070	7.4519	0.0030
-3	Error	12	1494.490	124.541		
	Total	19	5445.646			

Coefficient of Variation: 7.10%

s_ for means group 1: 4.9908 Number of Observations: 5

y

s_ for means group 2: 5.5799 Number of Observations: 4y

==

Variable 6: GY

Grand Mean = 1848.650 Grand Sum = 36973.000 Total Count = 20

T A B L E O F M E A N S

1	2	6	Total
1	*	1971.600	9858.000
2	*	1877.000	9385.000
3	*	1764.000	8820.000
4	*	1782.000	8910.000
*	1	1588.250	6353.000
*	2	1801.500	7206.000
*	3	1847.500	7390.000
*	4	2039.000	8156.000
*	5	1967.000	7868.000

A N A L Y S I S O F V A R I A N C E T A B L E

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	3	137641.350	45880.450	2.7184	0.0912
2	Factor A	4	481089.800	120272.450	7.1262	0.0035
-3	Error	12	202529.400	16877.450		
	Total	19	821260.550			

Coefficient of Variation: 7.03%

s_ for means group 1: 58.0990 Number of Observations: 5

y

s_ for means group 2: 64.9566 Number of Observations: 4 y

===

Variable 7: NET

Grand Mean = 0.945 Grand Sum = 18.900 Total Count = 20

T A B L E O F M E A N S

1	2	7	Total
1	*	1.280	6.400
2	*	1.220	6.100
3	*	0.880	4.400
4	*	0.400	2.000
*	1	1.475	5.900
*	2	0.100	0.400
*	3	1.250	5.000
*	4	0.900	3.600
*	5	1.000	4.000

A N A L Y S I S O F V A R I A N C E T A B L E

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	3	2.446	0.815	5.5203	0.0129
2	Factor A	4	4.372	1.093	7.4018	0.0030
-3	Error	12	1.772	0.148		
	Total	19	8.590			

Coefficient of Variation: 40.66%

s_ for means group 1: 0.1719 Number of Observations: 5

y

s_ for means group 2: 0.1921 Number of Observations: 4 y

===

Variable 8: PL

Grand Mean = 24.823   Grand Sum = 496.460   Total Count = 20

T A B L E   O F   M E A N S

1	2	8	Total
1	*	24.224	121.120
2	*	24.972	124.860
3	*	25.092	125.460
4	*	25.004	125.020
*	1	22.985	91.940
*	2	24.920	99.680
*	3	25.450	101.800
*	4	24.860	99.440
*	5	25.900	103.600

A N A L Y S I S   O F   V A R I A N C E   T A B L E

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	3	2.431	0.810	0.7956	
2	Factor A	4	19.768	4.942	4.8529	0.0146
-3	Error	12	12.220	1.018		
	Total	19	34.419			

Coefficient of Variation: 4.07%

s_ for means group 1:   0.4513   Number of Observations: 5

y

s_ for means group 2:   0.5046   Number of Observations: 4 y

==

Variable 9: PH

Grand Mean = 119.348   Grand Sum = 2386.960   Total Count = 20

T A B L E   O F   M E A N S

1	2	9	Total
1	*	120.708	603.540
2	*	119.376	596.880
3	*	119.468	597.340
4	*	117.840	589.200
*	1	116.500	466.000
*	2	118.725	474.900
*	3	119.900	479.600
*	4	118.940	475.760
*	5	122.675	490.700

A N A L Y S I S   O F   V A R I A N C E   T A B L E

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	3	20.694	6.898	1.1592	0.3655
2	Factor A	4	80.157	20.039	3.3675	0.0456
-3	Error	12	71.409	5.951		
	Total	19	172.260			

Coefficient of Variation: 2.04%

s_ for means group 1: 1.0909 Number of Observations: 5 y

s_ for means group 2: 1.2197 Number of Observations: 4 y

==

Variable 10: SY

Grand Mean = 2944.650   Grand Sum = 58893.000   Total Count = 20

TABLE OF MEANS

1	2	10	Total
1	*	2973.600	14868.000
2	*	2913.000	14565.000
3	*	2922.400	14612.000
4	*	2969.600	14848.000
*	1	2685.500	10742.000
*	2	3023.500	12094.000
*	3	2998.000	11992.000
*	4	2845.000	11380.000
*	5	3171.250	12685.000

ANALYSIS OF VARIANCE TABLE

K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	3	14786.950	4928.983	0.3136	
2	Factor A	4	549999.800	137499.950	8.7484	0.0015
-3	Error	12	188605.800	15717.150		
	Total	19	753392.550			

Coefficient of Variation: 4.26%

s_ for means group 1: 56.0663 Number of Observations: 5 y

s_ for means group 2: 62.6840 Number of Observations: 4 y

==

Variable 11: UG

Grand Mean = 11.980 Grand Sum = 239.600 Total Count = 20

TABLE OF MEANS

1	2	11	Total
1	*	11.960	59.800

2	*	12.680	63.400
3	*	11.800	59.000
4	*	11.480	57.400

*	1	11.700	46.800
*	2	12.350	49.400
*	3	11.000	44.000
*	4	12.000	48.000
*	5	12.850	51.400

A N A L Y S I S O F V A R I A N C E T A B L E

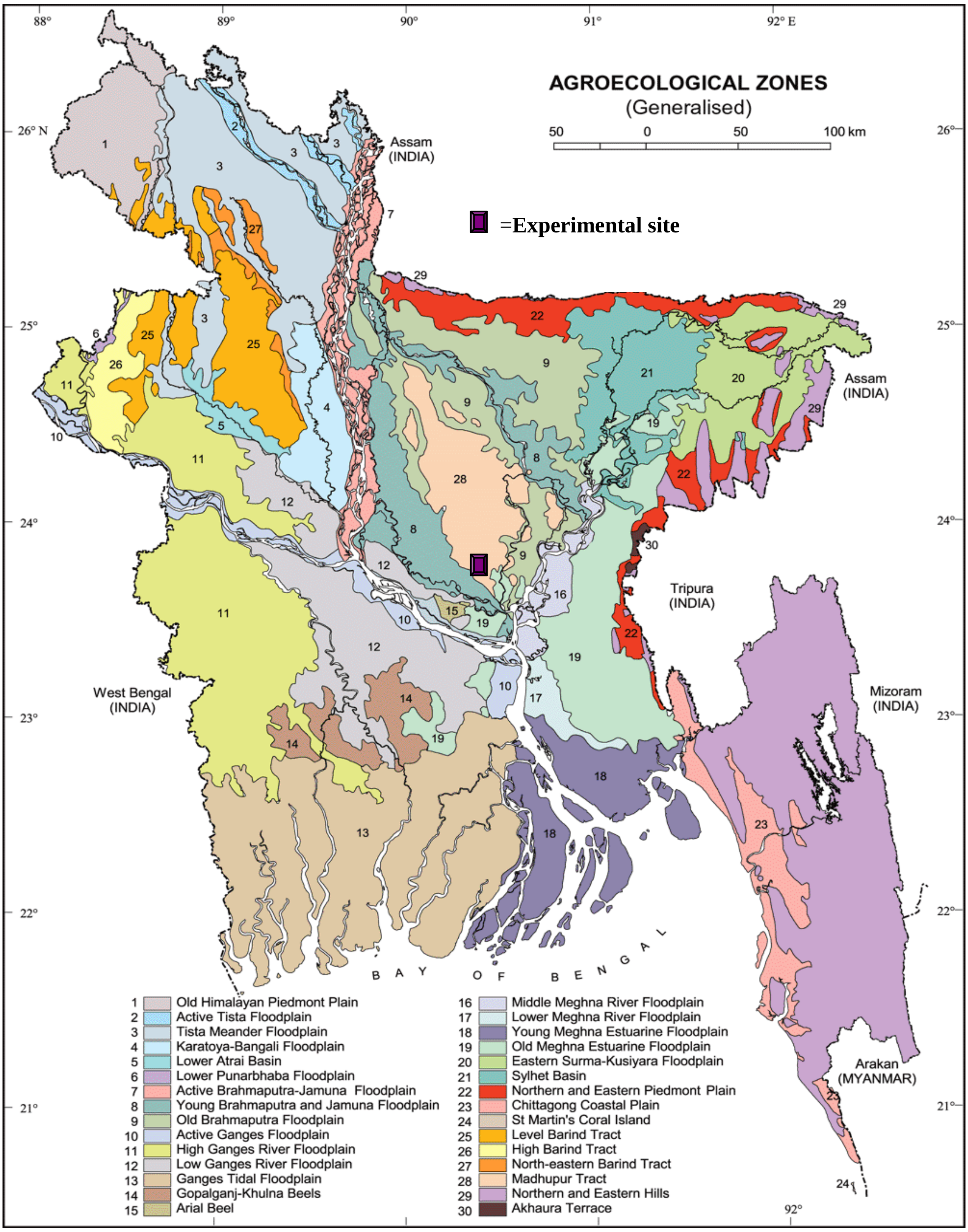
K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
1	Replication	3	3.864	1.288	0.1816	
2	Factor A	4	7.732	1.933	0.2725	
-3	Error	12	85.116	7.093		
	Total	19	96.712			

Coefficient of Variation: 22.23%

s_ for means group 1: 1.1910 Number of Observations: 5 y

s_ for means group 2: 1.3316 Number of Observations: 4 y

Appendix 2. Experimental location on the map of Agro-ecological Zones of Bangladesh



Appendix 3. The physical and chemical characteristics of soil of the experimental site as observed prior to experimentation 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 4. Monthly average temperature, relative humidity and total rainfall of the experimental site is below (during the period from June to November 2015).

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)