EFFECT OF NPK BRIQUETTE FERTILIZATION ON THE GROWTH AND YIELD OF T. AMAN RICE VARIETY BRRI dhan75

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CERTIFICATE

This is to certify that the thesis entitled '**Effect of NPK Briquette Fertilization on the Growth and Yield of T. Aman Rice Variety BRRI dhan75**' submitted to the Department 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**, embodies the results of a piece of bona fide research work carried out by **FARIHA TILAT**, Registration No. **16-07555** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated: December, 2017
Dhaka, Bangladesh

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TO

MY BELOVED PARENTS

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ABSTRACT

The experiment was conducted in the Soil Science Farm of Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh during the period from July to November, 2017 to study the effect of NPK briquette fertilization on the growth and yield of T. Aman rice variety BRRI dhan75. The experiment comprised of 7 treatments as- T_0: Control, T_1: 100% RFD, T_2: 120% RFD, T_3: 80% RFD, T_4: 1 NPK briquette within 4 hills, T_5: 2 briquette within 4 hills and T_6: 80% RFD + 1 briquette within 4 hills. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data on different yield attributes, yield and characteristics of post-harvest soil was recorded and statistically significant variation was observed for different treatment under the study. The longest plant (115.87 cm) was found from T_6 treated plot, whereas the shortest plant (95.96 cm) from T_0 treatment at harvest. The maximum number of total tillers hill^{-1} (16.67) was found from T_6 treatment, whereas the minimum number (13.33) from T_0 treatment. The longest panicle (24.85 cm) was found from T_6 treatment, whereas the shortest panicle (20.55 cm) from T_0 treated plot. The maximum number of total grains panicle^{-1} (97.33) was recorded from T_6 treatment, while the minimum number (66.00) from T_0 treatment. The highest grain yield (4.47 t ha^{-1}) was found from T_6 treatment, while the lowest grain yield (2.81 t ha^{-1}) from T_0 treatment. The highest total N (0.073%) was recorded from T_6 treatment and the lowest soil total N (0.031%) was found from T_0 treatment. The highest available P (29.58 ppm) was recorded from T_6 treatment and the lowest available P (18.76 ppm) from T_0 treatment. The highest exchangeable K (0.176 meq/100 g soil) was recorded from T_6 treatment, on the other hand, the lowest exchangeable K (0.102 meq/100 g soil) from T_0 treated plot. From the above findings, it was revealed that applications of T_6 treatment (80% RFD + 1 NPK briquette within 4 hills) was found the superior among the other treatments in consideration of yield attributes of T. Aman rice variety BRRI dhan75.

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INTRODUCTION

Rice (*Oryza sativa* L.) belongs to the family Gramineae, is second most widely grown cereal and primary source of food for more than half of the world population, and about 90% of the world rice grown in Asia which is carrying about 60% of world population (Haque *et al*., 2015). It is grown in more than a hundred countries of the world and in the year 2014-15, worldwide total 474.86 million metric tons of rice has been produced from 159.64 million hectares of land (USDA, 2015). Rice contributes on an average 20% of apparent calorie intake of the world and also 30% of Asian populations (Hien *et al.*, 2006). In Bangladesh, annual production of rice is 34.71 million tons from the cultivation of 11.39 million hectares of land which is about 72.24% of total cropped area (BBS, 2017). Bangladesh ranks 4th in both area and production of rice and also 6th in per hectare production of rice yield (Sarkar *et al*., 2016).

In Bangladesh, the average production of rice is about 2.92 t ha^{-1} (FAO, 2014) which is very low compared to other rice growing countries of the world, like Japan (6.60 t ha^{-1}), China (6.30 t ha^{-1}) and Korea (6.30 t ha^{-1}). The population will swell progressively to 223 million by the year 2030 which will demand additional 48 million tons of food grains (Julfiquar *et al*., 2008). Increasing food demand to meet the global rice demand in the world is becoming challenged in terms of food security. It is generally estimated that about 114 million tonnes of additional milled rice will be produce by 2035 which is equivalent to overall increase of 26 percent in the next 25 years (Kumar and Ladha, 2011). Population growth of Bangladesh required continuous increase of rice production and the highest priority has been given to produce more rice in same land by increasing per hectare yield (Bhuiyan, 2004). Yearly increment of rice production in Bangladesh needs to be sustained to feed her ever increasing population although there are very little scope to increase rice area (Sarkar *et al*., 2016) rather agricultural land is declining @ 0.7% per annum (BBS, 2017).

In post green revolution era total rice production are either stagnating/declining day by day mainly due to different factors that are related to crop production (Prakash, 2010). In Bangladesh, due to the storage of land the possibility of horizontal expansion of rice production area has come to a standstill, so that the rice growers and scientists are diverting their attention towards vertical expansion of rice production. Therefore, efforts should be given to increase the rice production from per unit area of land. For vertical expansion of rice yield, it is necessary to use of modern production technologies. In Bangladesh, BRRI, BINA, IRRI and different seed companies has been introduced high yielding rice variety and it gains positive monumentaion in rice production for the specific three distinct growing seasons (Haque and Biswas, 2011). Improving and increasing the world's supply will also depend upon the development and improvement of rice varieties with better yield potential, and to adopt various conventional and biotechnological approaches for the development of high yielding varieties that having resistance against different biotic and abiotic stresses (Khush, 2005).

Very recently various new rice varieties were developed by BRRI with exceptionally high yield potential. Now-a-day's different high yielding rice variety are available in Bangladesh which have more yield potential than different conventional varieties (Akbar, 2004). The growth process of rice plants under different agro-climatic condition differs due to the specific rice variety (Alam *et al*., 2012). Compared with conventional cultivars, the high yielding varieties have larger panicles resulting in an average increase of rice grain is 7.27% (Bhuiyan *et al*., 2014). These high yielding and hybrid rice variety however, needs further evaluation under different adaptive condition to interact with different agro-climatic conditions. In Bangladesh, intensive crop cultivation using high yielding varieties with imbalanced fertilization has lead to mining out the inherent plant nutrients and thereby fertility status of soils severely declined day by day.

It is reported that chemical fertilizers today hold the key role to success of production systems of Bangladesh agriculture being responsible for about 50% of the total crop production. Imbalance fertilizer use and practice of inappropriate production technologies are common among farmers. There is need to develop appropriate management technique to evaluate the performance and to assess the nutrient requirement for rice cultivation in the country. For rice cultivation although fertilizer is a mandatory input materials but excessive fertilizer application would lead to increased production cost and negative effects of blocking agricultural sustainable development such as environmental pollution and rice quality decline. The submerged conditions of wetland soils produces fertilizer losses through NH_3-volatilization, denitrification, leaching, surface runoff, and chemical fixation. Deep placement of fertilizer into the anaerobic soil zone is a recognized effective method to reduce loses. The NPK briquette is a mixture of urea, TSP and MoP which helps to reduce the loss of nutrients in flooded condition. In an amount, 100 kg briquette provide 50 kg urea, 20 kg TSP and 30 kg MoP (Islam *et al.*, 2011). Farmer in Vitenam and Combodia obtained 25% higher yields with deep placement of NPK briquettes over the broadcasting of fertilizers (FAO, 2014). In Bangladesh yield of rice would be increased by 15-25%, while expenditure on commercial fertilizer was decreased by 24-32% when fertilizers briquettes were used as a source of N, P and K (IFDC, 2007).

With this background information, and situation the present study was conducted for fulfilling the following objectives:

1. To evaluate the efficiency of NPK briquette for increasing the yield of T. Aman BRRI dhan75.
2. To find out the optimum doses of NPK briquette on the growth and yield of T. Aman BRRI dhan75.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Rice has remarkable adaptability to different environmental conditions as is evident from its worldwide distribution. Many researchers at home and abroad investigated various aspects of successful rice production. Fertilizer is one of the major elements which greatly influence the vegetative growth and yield of rice. Judicious use of chemical fertilizer is a key factor in rice based production system which can increase crop yield and reduce production cost. Agronomic performances of rice varieties as affected by recommended doses of fertilizer Different researcher reported the effect of recommended dose of fertilizer with different form on yield attributes and grain yield but it is not adequate and conclusive in agro-climatic condition of Bangladesh. An attempt was taken to review the available important and informative works and research findings that are related to the recommended dose of fertilizer in granule form on the yield and yield attributes of rice have been reviewed in this chapter under the following headings:

2.1 Effect of chemical fertilizer on growth and yield of rice

Lukman *et al*. (2016) reported that the combined application of cow dung and NPK fertilizer significantly increased most of the results obtained with regards to locations compared to the control plots. The growth and yield parameters of rice considered were significantly affected by the treatments except one thousand grain weight. Application of 8 t ha^{-1} of cowdung in combination with 400 kg ha^{-1} NPK 20:10:10 gave the highest grain yield (5.77 t ha^{-1}) at Sokoto and it is recommended that application of 12 t ha^{-1} of cowdung in combination with 300 kg ha^{-1} NPK 20:10:10 resulted in the best soil nutrient enrichment and yield of rice in Sokoto and Talata Mafara.

Imrul *et al.* (2016) carried out a field experiment to investigate the influence of N and phosphorus (P) on the growth and yield of BRRI dhan57. They reported that 120 kg N and 35 kg P ha^{-1} treatment gave the highest effective tillers hill^{-1}, length of panicle, filled grains panicle^{-1}, 1000 grain weight (20.85 g), grain yield (4.95 t ha^{-1}), straw yield (5.39 t ha^{-1}) and biological yield (10.34 t ha^{-1}).

An experiment was carried out by Pandey *et al*. (2014) at research farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh India. Experiment was comprised of different levels of inorganic fertilizer (NPK) and its conjunction with different organic fertilizers. Yield and yield attributing characters was significantly increased with increasing fertilizer levels from 50:30:20 kg, NPK ha^{-1} to 150:80:60 kg, NPK ha^{-1} during both the year of experiment. Grain yield and yield attributes were significant among different treatments. Application of 100:60:40 kg NPK ha^{-1} + blending of N with cowdung urine (T_9) or poultry manure (T_{10}) resulted higher effective tillers, panicle length, and test weight which is statistically at par to that of inorganic level 150:80:60 kg NPK ha^{-1} (T_1).

Islam *et al*. (2014) found that the yield contributing characters like plant height, effective tillers hill^{-1}, panicle length and grains panicle^{-1} of BRRI dhan49 were significantly influenced by the application of manures and fertilizers. The highest grain yield of 4.87 t ha^{-1} was observed in the treatment T_3 [PM + STB–CF (HYG)] and the lowest value of 3.61 t ha^{-1} was found in T_0 i.e. control condition. The straw yield also ranged from 4.10 to 5.51 t ha^{-1} due to the different treatments. The NPKS uptake by BRRI dhan49 was markedly influenced by manures and fertilizers under this field conditions. Based on overall experimental results, the treatment T_3 [PM + STB–CF (HYG)] was found to be the best combination of manures and fertilizers for obtaining the maximum yield and quality of BRRI dhan49 rice variety.

Sarkar (2014) found that the application of 75% RD of inorganic fertilizers + 50% cowdung showed superiority in terms of plant height (123.3 cm) and total tillers hill^{-1} (13.87) where those were also highest in combination of BRRI dhan34 × 75% RD of inorganic fertilizers + 50% cowdung. Nutrient management of 75% RD of inorganic fertilizers + 50% cowdung (5 t ha^{-1}) gave the highest grain yield (3.97 t ha^{-1}) and the lowest grain yield (2.87 t ha^{-1}) was found in control. The highest grain yield (4.18 t ha^{-1}) was found in BRRI dhan34 coupled with 75% RD of inorganic fertilizers + 50% cowdung and the lowest grain yield (2.7 t ha^{-1}) was found in BRRI dhan37 in control.

Islam *et al*. (2013) studied to evaluate the effect of nitrogen supplied from organic sources and inorganic source (urea) on the yield and nitrogen use efficiency of BRRI dhan28. The treatments were T_0 (Control), T_1 (100% N from RFD), T_2 (70% N from RFD, RFD + 30% N from CD), T_3 (70% N from RFD + 30% N from PM), T_4 (70% N from RFD + 30% N from CoM), T_5 [70% N from RFD + 30% N from (CD + PM + CoM)], T_6 [100% N from (CD + PM + CoM), T_7 [100% N from RFD + 30% N from (CD + PM + CoM)]. The highest grain yield of 5847 kg ha^{-1} was observed in the treatment T_7 and the lowest grain yield of 2426 kg ha^{-1} was found in T_0. The highest N uptake (138.9 kg ha^{-1}) was found in T_7 followed by T_1 (119.8 kg ha^{-1}).

An experiment was conducted by Rattanapichai *et al*. (2013) to study the effects of various soil conditioners, MK doses (0, 1.56, 3.12 and 6.25 tons ha^{-1}) and NPK fertilizers (16-8-8 and 16-16-8) on growth and yield of rice grown in acid sulfate soil in Thailand, a Rangsit (Rs) soil series. The result showed that application of MK caused an increase in tillers per plants, biomass and grain yield as well as silicon uptake. However, there was no effect on native phosphorus in soil and phosphorus uptake. The 16-16-8 fertilizer application increased the number of tillers per plants; shoots dry matter and grain yield were higher than in 16-8-8 fertilizer model.

Sukristiyonubowo *et al*. (2013) reported that the application of 2 ton ha^{-1} $year^{-1}$ dolomite, 2 ton ha^{-1} $season^{-1}$ rice straw compost and mineral fertilizers (200 kg urea, 100 kg SP-36 and 100 kg KCl ha^{-1} $season^{-1}$) improve the rice yield by combined addition of organic matter (straw compost), lime and mineral fertilizer. With these applications the rice yield was observed about 3.5-4.2 tons ha^{-1} $season^{-1}$ can be reached under weathered soils.

Hossain (2013) conducted an experiment to investigate the effects of inorganic fertilizers alone and in combination with different organic fertilizers in order to achieve high yield and sustainable soil chemical and organic matter balance. The experiment was conducted at the field laboratory of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. The treatment combinations were T_1 (NPK), T_2 (NPK+ FYM), T_3 (NPK+ Vermicompost), T_4 (NPK+ Rotten Rice Straw) and T_5 (NPK+ Poultry Manure). The results showed that grain and straw yields were significantly influenced by the treatments. The highest grain yield was obtained in T_2 followed by T_3 and T_5. The grain yield of wheat due to different treatment followed the order of: $T_2>T_3>T_5>T_4>T_1$ with the record of 2.48, 2.28, 1.83, 1.82 and 1.59 t ha^{-1}, respectively.

Tasnin (2012) observed that the height of rice plant, number of leaves, number of tillers and dry matter accumulation per hill was significantly higher with application of 50% recommended NPK through fertilizers + 50% N through gliricidia, which was closely followed by 50% recommended NPK through fertilizers + 50% N through FYM. Rice supplied with 50% recommended NPK through fertilizers + 50% N through gliricidia produced higher number of panicles per hill, length of panicles, number of grains and weight of grains per panicle. They also observed that Application of 50% recommended NPK through fertilizers + 50% N through gliricidia, 50% recommended NPK through fertilizers + 50% N through FYM to rice recorded 105.41 and 103.33% higher grain yield compared to that of 100% recommended NPK, respectively, while 50% recommended NPK through fertilizers + 50% N through gliricidia produced higher straw yield of rice followed by 50% FYM substitution.

Vetayasuporn (2012) conducted an experiment to determine the effects of organic–chemical fertilizer and chemical fertilizer (NPK 16:16:8) on the growth and yield of rice in acidic soil of Roi-Et province, Northeast Thailand. Five treatments were compared consisting of: T_1 (control without fertilizer); T_2 (312.5 kg ha^{-1} organic-chemical fertilizer); T3 (625 kg ha^{-1} organic–chemical fertilizer);

T_4 (937.5 kg ha^{-1} organic–chemical fertilizer) and T_5 (chemical fertilizer; 312.5 kg ha^{-1} NPK 16:16:8). Yield of rice grains under all treatments increased between 2-4 times when compared to the control (1.37 t ha^{-1}). Application of organic-chemical fertilizer alone showed 2-2.5 times (2.66-3.43 t ha^{-1}) increased yield of grains over the control. However, maximum grain yield (5.57 t ha^{-1}) was obtained from T_5 (chemical fertilizer) which also gave the highest all yield parameters such as number of grain per panicle (108.20), total number panicle per hill (14.82), plant height (62.48 cm) and percentage of filled grain (82.17%).

Basu *et al*. (2012) conducted a field experiment to study the quality aspect of rice (cv. BRRI dhan28) as response to chemical fertilizers and organic manure (cowdung) treatments comprised of four doses of chemical fertilizers (0, 0.5, 0.75 and full recommended dose) and four cowdung doses (0, 1.0, 1.5, two times of full recommended dose). The grain yield ranged from 1.92 to 4.58 t ha^{-1}. The highest grain yield was observed in treatment containing the full recommended dose of chemical fertilizers along with the double dose of cowdung (F_1M_3) and it was the lowest in without chemical fertilizers and recommended dose of cowdung (F_0M_1). Application of cowdung and chemical fertilizers had significant effect on the content of N, P, K, S, Ca, Mg, B, Zn, protein, starch and amylose in rice grain. Grain yield of rice was increased by application of half the recommended dose of chemical fertilizers along with recommended dose of cowdung.

Dey (2012) found that the highest grain (6.20 t ha^{-1}) and straw yields (7.75 t ha^{-1}) were produced by the T_7 (USG at transplanting + 50% PKS at transplanting + 50% PKS at maximum tillering) treatment. The P, K and S uptake by BRRI dhan29 significantly increased due to split fertilization. So, split application of P, K and S fertilizers along with USG exerted a beneficial effect on yield contributing characters, resulting in higher grain and straw yields for BRRI dhan29 as compared to their single application.

Hossaen *et al*. (2011) studied on the yield and yield attributes of Boro Rice due different organic manure and inorganic fertilizer. At 30, 50, 70, 90 DAT and at harvest stage the tallest plant (24.18, 31.34, 44.67, 67.05 and 89.00 cm) and the greatest number of total tillers hill^{-1} (5.43, 11.64, 21.01 and 17.90) at same DAT was recorded from T_5 (70% NPKS +2.4 t PM ha^{-1}) and the lowest was observed from T0 (control) in every aspect. The maximum number of effective tillers hill^{-1} (13.52), the longest panicle (24.59 cm), maximum number of total grains plant^{-1} (97.45), the highest weight of 1000 seed (21.80 g), the maximum grain yield (7.30 t ha^{-1}) and straw yield (7.64 t ha^{-1}) was recorded from T_5 treatment whereas the lowest number of effective tillers hill^{-1} (6.07), the shortest panicle (16.45 cm), the minimum total grains plant^{-1} (69.13) , the lowest weight of 1000 seed (16.73 g), the lowest grain yield (2.06 t ha^{-1}) and straw yield (4.63 t ha^{-1}) was observed from T_0.

Naing *et al*. (2010) investigated the effect of organic and inorganic fertilizers on growth and yield of five upland black glutinous rice varieties and soil property. Four fertilizer treatments (control, FYM or cattle manure @ 10 t ha^{-1}, NPK at the rate of 50-22-42 kg N-P-K ha^{-1}, the combination of the FYM and NPK were randomized in the main plots and five black glutinous rice varieties were randomized in the sub plots. Number of tillers and panicles per hill and grains per panicle, thousand grain weight, number of filled and unfilled grains and grain yield were recorded at harvest time. The results from both years indicated that using the combination of FYM cattle manure and inorganic fertilizers increased tiller and panicle number hill^{-1}, grain number panicle^{-1} and grain yield.

An experiment was conducted by Islam *et al.* (2008) to determine the response and the optimum rate of nutrients (NPK) for Chilli- Fallow-T. *aman* cropping pattern. They found that grain yield influenced significantly due to application of different rates of nutrients and 60-19-36 kg ha^{-1} NPK maximized the yield of T. Aman rice varieties in respect of yield and economics.

Muangsri *et al*. (2008) found that the effect of rice straw and rice hull in combination NPK fertilizer on yield of rice grown on Phimai soil series. The treatments consisted of the control, rice straw at the rate of 0.75, 1.5 and 3.0 g kg^{-1} soil in combination with NPK fertilizers, and rice hull at the rate of 0.75, 1.5, 3.0 and 4.5 g kg^{-1} soil in combination with NPK fertilizer. The results showed that the growth, yield and nutrient uptake of rice plant without fertilizer were the lowest. Yield of rice plant grown on the soil amended with rice straw in combination with NPK fertilizer showed to be higher than that of rice plant grown on the soil amended with only NPK fertilizer.

Ndaeyo *et al.* (2008) carried out an experiment with five rice varieties (WAB340-8-8-2HI, WAB881-10-37-18-8-2-HI, WAB99-1-1, WAB224-8-HB, WAB189-B-B-B-8-HB) and four rates of NPK (15:15:15) fertilizer (0, 200, 400 and 600 kg ha^{-1}). The results showed that 600 kg ha^{-1} NPK (15:15:15) fertilizer rate significantly increased plant height, number of leaves and tillers per plant in both years. The 400 kg ha^{-1} rate increased the number of panicles per plant, length of central panicle per plant and the overall grain yield, straw yield over other rates by 4-32% and 2-21% in 2005 and 2006, respectively.

A field experiment was conducted by Rahman *et al.* (2007) a using rice (cv. BRRI dhan29) as a test crop and found that application of S had a significant positive effect on tillers ha^{-1}, plant height, panicle length and grains $panicle^{-1}$. They also indicated that application of S fertilizer at a recommended rate (20 kg S/ha) might be necessary for obtaining higher grain yield as well as straw yield of Boro rice (BRRI dhan29).

Jumei *et al*. (2005) conducted a field experiment in Qiyang, Hunan province, a typical red soil region of southern China, to study the effects of organic and inorganic N fertilizers on ammonia volatilization and rice yield in paddy soil. Four treatments were PK treatment as control, NPK treatment (urea as N), NPKM treatment (half chemical fertilizers + half manure), M treatment (pig manure as N), same amount of N, P, K either organic or inorganic forms (N 150 kg m^{-2}, P_2O_5 100.5 kg m^{-2} and K_2O 109.5 kg m^{-2}) were applied in each plot. All fertilizers were applied once as base fertilizers before one day of rice transplanted. The rice yields of NPKM, NPK, M treatments were increased by 68.6%, 68.1% and 60.0% respectively for early rice, and increased by 72.0%, 69.6% and 34.2% for late rice compared with control treatment. Not only the yield of rice with NPKM treatment increased by 70 % averagely compared with PK treatment, but also the nitrogen loss was less compared with NPK treatment. N use efficiency of NPKM treatment was 34.9%, higher than that of NPK treatment (33.2%) and M treatment (28.0%).

Hossain *et al.* (2005) carried out a study to assess the effects of nitrogen (30, 60, 90 and 120 kg ha^{-1} N) and phosphorus (20, 40 and 60 kg ha^{-1} P_2O_5) on the growth and yield of rice/sorghum inter-crop. Application of nitrogen up to 90 kg ha^{-1} enhanced the growth and yield of rice crop and application of phosphorus @ 40 kg ha^{-1} P_2O_5 resulted in higher growth and yield of rice crop.

Saha *et al.* (2004) conducted an experiment with the objectives to create and compare a suitable fertilizer recommendation model for lowland rice. Five different fertilizer recommendation models were tested and compared with one check plot. Results showed that the application of different packages estimated by different fertilizer models significantly influenced panicle length, panicle numbers, spikelet number per panicle, total grains per panicle, number of filled grain and unfilled grain per panicle. The combination of NPK gave the highest result (120-13-70-20 kg ha^{-1} NPKS).

Saleque *et al*. (2004) studied with six treatments viz. absolute control (T_1), 1/3 of RFD (T_2), 2/3 of RD (T_3), full doses of RF (T_4), T_2 + 5 t cowdung and 2.5 t ash ha^{-1} (T_5) and T_3 + 5 t cowdung ha^{-1} + 2.5 t ash ha^{-1} (T_6) were compared. The results showed that application of cowdung and ash (T_5 and T_6) increased rice yield by about 1 t ha^{-1} $year^{-1}$ over that obtained with chemical fertilizer alone.

Amin *et al.* (2004) conducted an experiment to evaluate the effect of increased plant density and fertilizer dose on yield of rice variety IR-6. They found that increased fertilizer dose of NPK increased plant height.

Singh *et al.* (2003) conducted an experiment and reported that crop growth rate and relative growth rate such as total dry matter production was significantly influenced by NPK fertilizers. The tiller number and total dry matter production are closely correlated with yield depending on the rice cultivar which can be greatly enhanced by applying proper nutrient.

Rasheed *et al.* (2003) observed from an experiment that the effect of different NP levels i.e., 0-0, 25-0, 50-25, 75-50, 100-75 and 125-100 kg ha^{-1} on yield and yield attributes of rice Bas-385. Yield attributes (No. of effective tillers per hill, spikelet per panicle, normal kernels per panicle, 1000-grain weight) were improved linearly with increasing NP levels up to 100-75 kg ha^{-1}. The NP level of 100-75 kg ha^{-1} resulted in the highest grain yield of 4.53 t/ha with minimum kernel abnormalities (Sterility, abortive kernels and opaque kernels) as against the minimum of 2.356 t ha^{-1} in the control (0-0) followed by 25-0 kg NP ha^{-1} with maximum kernel abnormalities.

Haq *et al.* (2002) carried out a field experiment with twelve treatments combination of N, P, K, S and Zn with objectives to find out the optimum doses of N, P, K, S, Zn for rice cultivation. They found that all the treatments significantly increased the grain and straw yields of BRRI dhan30 rice over control. 90 kg N + 50 kg P_2O_5 + 40 kg K_2O + 10 kg S + 4 kg Zn ha^{-1} gave the highest grain and straw yields.

Asif *et al.* (2000) carried out an experiment and found that NPK levels significantly increased the panicle length, number of primary and secondary branches $panicle^{-1}$ when NPK fertilizer applied in 180-90-90 kg ha^{-1} this might be attributed to the adequate supply of NPK for the plant and produced the highest yield compared to other.

2.2 Effect of granule fertilizer on growth and yield of rice

Rahman *et al.* (2016) carried out a field experiment to assess the comparative advantages of using USG and NPK briquette over normal urea and also predict the better performing transplanted Aus rice in the tidal ecosystem. They reported that plant height, number of effective tillers hill^{-1}, panicle length, number of grains panicle^{-1}, NUE (%), straw yield (t ha^{-1}) and grain yield (t ha^{-1}) were found highest when USG was applied with BRRI dhan48 and all the characters showed lowest value when absolute control with BRRI dhan55. Highest number of effective tillers hill^{-1} (11.15) and grain yield (3.33 t ha^{-1}) was obtained from USG and BRRI dhan48 and where lowest number of effective tillers hill^{-1} (9.21) and grain yield (2.28 t ha^{-1}) in absolute control with BRRI dhan55. The NPK briquettes showed higher agronomic efficiency than PU and USG. The USG (1.8 g) and NPK briquettes (2.4 g) could save 11.3 and 19.55 kg N ha^{-1} compared to recommended PU.

Haque and Pervin (2015) conducted an experiment to study the effect of varieties and number of guti urea hill^{-1} on the yield of T. *aman* rice. They found that, the tallest plant (136.4 cm), higher straw yield (10.99 t ha^{-1}) and higher biological yield (16.49 t ha^{-1}) were recorded in 2 guti hill^{-1} of Shakorkura while 2 guti hill^{-1} interaction with BRRI dhan51 showed the maximum effective (8.767) and total tillers hill^{-1} (9.833), maximum total grains panicle^{-1} (147.4), 1000-grain weight (32.07 g) and grain yield (6.420 t ha^{-1}). These results suggested that the variety BRRI dhan51 and 2 guti hill^{-1} individually or combined would be more effective for greater yield of T. *aman* rice.

Ferdous *et al.* (2014) conducted a field experiment to evaluate the effects of PU, USG on NUE and yield performance of rice (BRRI dhan29). Application of N as PU and USG resulted in a significant increase in yield components, grain and straw yields of BRRI dhan29. 52 kg N ha^{-1} from USG + 52 kg N ha^{-1} from PU produced the highest grain (5.82 t ha^{-1}) and straw (7.28 t ha^{-1}) yields. The lowest grain (2.78 t ha^{-1}) and straw (3.26 t ha^{-1}) yields were recorded in control plots.

Afroz (2013) conducted a field experiment to investigate the effects of PU, USG, and NPK briquettes on growth and yield of BRRI dhan28. She found that USG performed better in increasing grain yield of rice compared to PU. Hasanuzzaman *et al.* (2013) carried out a field experiment was to study the influence of PU and USG on the growth and yield of hybrid rice Heera1. 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.

Debnath *et al.* (2013) carried out a field experiment to assess the comparative advantages of USG and NPK briquette over normal urea, Triple super phosphate and Muriate of Potash and also predict the better performing T. *aman* rice. The analysis revealed that different fertilizer management practices with a few exceptions significantly influenced the growth, yield and yield attributes of the T. *aman* rice. Plant height, number of effective tillers hill^{-1}, number of non-effective tillers hill^{-1}, panicle length (cm), number of grains panicle^{-1}, number of sterile spikelet's panicle^{-1}, NUE (%), straw yield and grain yield were found highest when NPK briquette was applied and all the characters showed lowest value when control. Highest number of effective tillers hill^{-1} (13.00) and grain yield (6.60 t ha^{-1}) was obtained from NPK briquette and where lowest number of effective tillers hill^{-1} (5.66) and grain yield (4.48 t ha^{-1}) from USG. The NPK briquettes showed higher agronomic efficiency than PU and USG. The small size briquettes (2.4 g) could save 33 kg N ha^{-1} compared to recommend PU.

Islam *et al.* (2013) conducted a field experiment to find out the varietal performance of *aman* rice as affected by different methods of urea application. The results showed that urea fertilizer application method significantly influenced plant height, tillering production, leaf area index, effective tillers hill^{-1}, filled grains panicle^{-1}, unfilled grains panicle^{-1}, total grains panicle^{-1}, 1000-

grain weight, grain yield, straw yield, and biological yield. Application of USG N as at 7 DAT gave highest yield (7.82 t ha^{-1}) while application of 15 kg N ha^{-1} as PU 30 DAT+ 15 kg N ha^{-1} as PU at 50 DAT gave lowest yield (4.88 t ha^{-1}).

Naznin *et al.* (2013) conducted an experiment to investigate the effects of PU, USG and NPK briquette on NH_4- N concentration in field water, yield and NUE of BR22 rice under reduced water conditions. The highest grain yield (3.93 t ha^{-1}) was recorded from 104 kg N ha^{-1} as USG and the lowest value of 2.12 t ha^{-1} was obtained from control. The NUE was increased when the N was applied as USG. The overall results revealed that application of USG and NPK briquette may be practiced for obtaining better yields in addition to increasing the efficiency of N fertilizer.

Shah *et al*. (2013) conducted experiments at the Bangladesh Rice Research Institute (BRRI) farm, Gazipur, BRRI regional station Sagordi, Barisal to evaluate the NPK briquette efficiency in rice production. Experimental results revealed that deep placement of NPK briquette (2×2.4 g) 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 (1×3.4 g) 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.

Paul *et al.* (2013) conducted an experiment with three USG levels and showed that leaf area index was significantly influenced by application of USG. He reported that the highest leaf area was found at 60 DAT when 1.8 g USG was applied and lowest was found at 15 DAT when 2.7 g USG was applied. Sabnam (2013) conducted a field experiment at Bangladesh Agricultural University, Mymensingh to investigate the effects of PU, USG, and NPK briquettes on yield of BR22 rice under continuous flooded condition. She reported that rice grain yield was higher from USG in comparison with Prilled Urea.

Naznin (2012) conducted an experiment at Bangladesh Agricultural University, Mymensingh during the *aman* season of 2012 to investigate the effect of PU, USG and NPK briquette on ammonium concentration in rice field water, yield and NUE of BR 22 rice under reduced water conditions. Application of PU, USG and NPK briquette showed a positive effect on yield of BR 22 rice. The highest grain yield of 3.93 t ha^{-1} was recorded from 104 kg N ha^{-1} from USG which was significantly superior to PU. This might be due to optimum release of N from deep placed fertilizers (USG) for a prolonged period.

Islam *et al*. (2011) conducted an experiment on the effectiveness of NPK briquette on rice in tidal flooded soil condition and they observed that NPK briquettes, USG and prilled urea (PU) produced statistically similar grain yield but gave significantly higher grain yield than N control.

Singh *et al.* (2008) reported 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.

Bulbule *et al*. (2008) carried out an experiment to study the effects of NPK briquettes on yield and nutrient content of rice. The results showed that grain yield of rice significantly increased when the crop was fertilizer through briquettes (56-30-30 kg NPK ha^{-1}) as compared to the application of conventional fertilizers (100-50-50 kg NPK ha^{-1}).

From the review of literature cited above it is clear that recommended doses of fertilizer in different form than the conventional form have tremendous influence on the growth and yield components of rice. Therefore, research on aforesaid issues effect of NPK granule fertilization emerges as an integrate part for better crop production.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh during the period from July to November, 2017 to study the effect of NPK briquette fertilization on the growth and yield of T. Aman rice variety BRRI dhan75. This chapter includes materials and methods that were used in conducting the experiment. The details are presented below under the following headings -

3.1 Experimental site and soil

The experiment was conducted in typical rice growing Silty Clay Loam soil at the Soil Science Farm, SAU, Dhaka. The morphological, physical and chemical characteristics of the soil are shown in the Table 1 and 2.

3.2 Climate

The climate of the experimental area is characterized by high temperature, high humidity and medium rainfall with occasional gusty winds during the *kharif* season (March-September) and a scanty rainfall associated with moderately low temperature in the *rabi* season (October-February). The weather information regarding temperature, rainfall, relative humidity and sunshine hours prevailed at the experimental site during the cropping season July to November 2017 have been presented in Appendix I.

3.3 Planting material

BRRI dhan75 were used as the test crop in this experiment. This variety was developed in Philippine by International Rice Research Institute (IRRI) through hybridization between genotypes Yuefenghan and E-Zhong5 and Bangladesh Rice Research Institute introduced this variety from IRRI. It is recommended for *Aman* season. Plant height of the variety is 101-110 cm at the ripening stage. The grains are medium and fine. It requires about 110-115 days for completing its life cycle with an average grain yield of around 4.5 t ha^{-1} (BRRI, 2016).

Table 1. Morphological characteristics of the experimental field

Morphology	Characteristics
Locality	SAU farm, Dhaka
Agro-ecological zone	Madhupur Tract (AEZ 28)
General Soil Type	Shallow Red Brown Terrace Soil
Parent material	Madhupur Terrace
Topography	Fairly level
Drainage	Well drained
Flood level	Above flood level

(FAO and UNDP, 1988)

Table 2. Initial physical and chemical characteristics of the soil (0-15 cm depth)

Characteristics	Value
Mechanical fractions:	
% Sand (2.0-0.02 mm)	18.60
% Silt (0.02-0.002 mm)	45.40
% Clay (<0.002 mm)	36.00
Textural class	Silty Clay Loam
Consistency	Granular and friable when dry
pH (1: 2.5 soil- water)	6.1
Organic Matter (%)	1.38
Total N (%)	0.06
Available P (mg kg^{-1})	19.85
Exchangeable K (mol kg^{-1})	0.12
Available S (mg kg^{-1})	14.40

3.4 Treatment of the experiment

The experiment comprised of 7 treatments as-

T_0: Control

T_1: 100% RFD

T_2: 120% RFD

T_3: 80% RFD

T_4: 1 NPK briquette within 4 hills

T_5: 2 NPK briquette within 4 hills

T_6: 80% RFD + 1 NPK briquette within 4 hills

RFD-Recommended Fertilizer Doses (120, 20, 80, 16 and 2 kg ha^{-1} of N, P, K, S and Zn, respectively)

The NPK briquette is a mixture of urea, TSP and MoP which helps to reduce the loss of nutrients in flooded condition. So, it is helpful for tidal flooded ecosystem. In an amount, 100 kg briquette provide 50 kg urea, 20 kg TSP and 30 kg MoP (Islam *et al.*, 2011).

3.5 Seed collection and sprouting

Seeds were collected from BRRI (Bangladesh Rice Research Institute), Gazipur just 25 days ahead of the sowing of seeds in seed bed. For seedling raising clean seeds were immersed in water in a bucket for 24 hours. The imbibed seeds were then taken out of water and kept in gunny bags. The seeds started sprouting after 48 hours which were suitable for sowing within 72 hours.

3.6 Raising of seedlings

The nursery bed was prepared by puddling with repeated ploughing followed by laddering for creating a good condition for seedling raising. The sprouted seeds were sown on beds on 13th July, 2017 as uniformly as possible. Irrigation was gently provided to the bed as and when needed. No fertilizer was used in the nursery bed for seedling raising.

3.7 Land preparation

The plot selected for conducting the experiment was opened in the 28th July 2017 with a power tiller, and left exposed to the sun for 4 days. After o4 days the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good puddle condition. Weeds and stubbles were removed. The experimental plot was partitioned into unit plots in accordance with the experimental design. Fertilizer were mixed in each unit plot with as per the treatment of this experiment.

3.8 Experimental design and layout

The experiment was laid out in a randomized complete block design (RCBD), where the experimental area was divided into three replications to reduce soil heterogenetic effects. Each replication was divided into 7 unit plots as per treatments of the experiment. Thus the total numbers of plots were 21. The unit plot size was 3.75 m × 3.5 m and was separated from each other by 0.5 m ails. The distance maintained between two blocks and two plots were 0.75 m and 0.5 m respectively. The layout of the experiment is shown in Figure 1.

3.9 Fertilizers application

The fertilizers were applied as per treatment and the entire amounts of TSP, MoP, gypsum and zinc sulphate were applied during the final preparation of experimental plot. NPK briquette in between 4 hills were applied 21st August, 2017 and 2nd and 3rd split of urea were applied 03th September, 2017 and 24th September, 2017, respectively.

3.10 Transplanting of seedling

Twenty five days old seedlings were carefully uprooted from the nursery bed and transplanted on 7th August, 2017 in well puddled plot. 2/3 number of seedlings hill^{-1} was transplanted in each hill with maintaining distance plant to plant 15 cm and row to row 20 cm. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings of the same source whenever required.

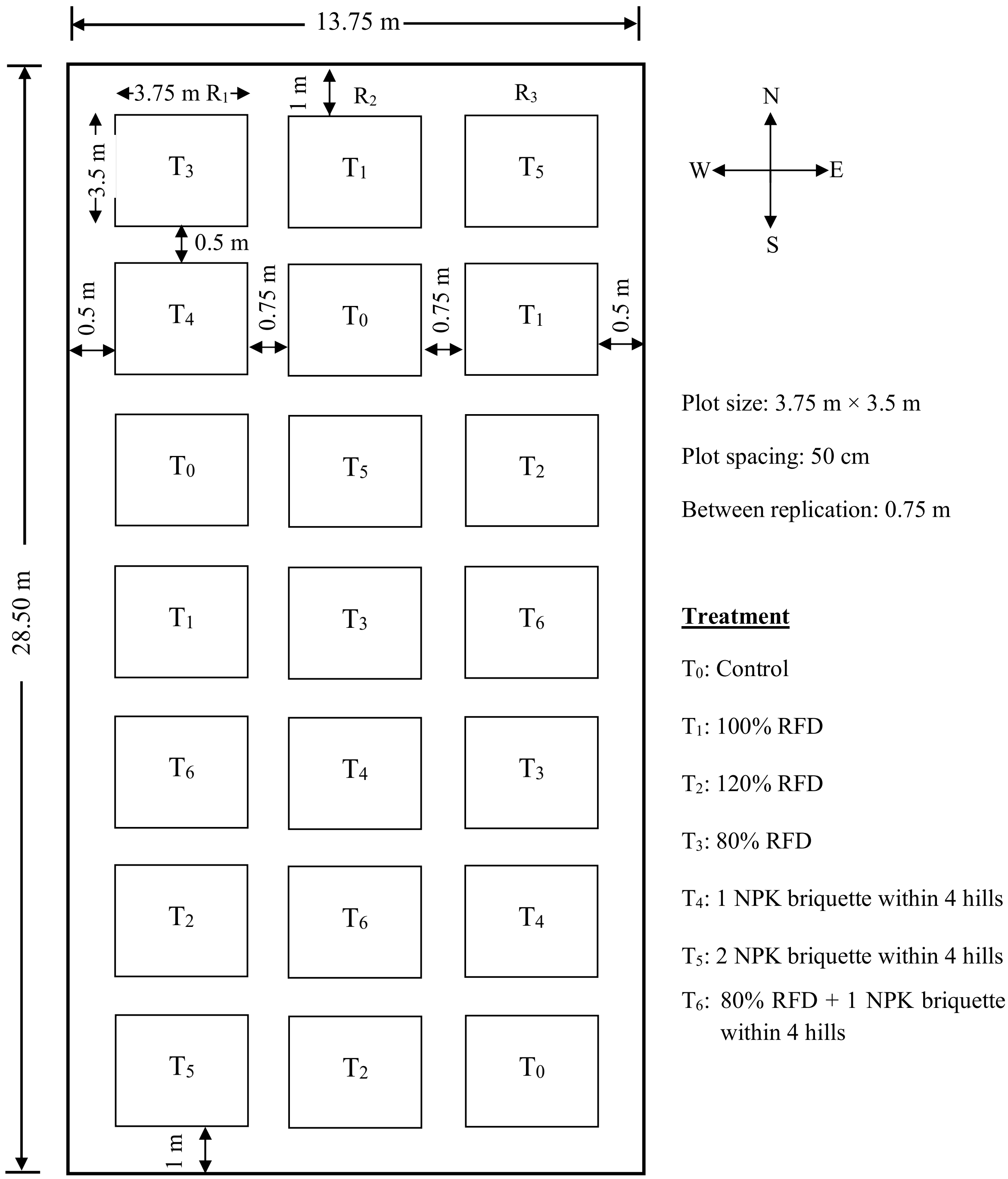

Figure 1. Layout of the experimental plot

3.11 Intercultural operations

Intercultural operations were done to ensure normal growth of the crop. Plant protection measures were followed as and when necessary. The following intercultural operations were done.

3.11.1 Irrigation

In the early stages to establishment of the seedlings irrigation was provided to maintain a constant level of standing water upto 6 cm and then maintained the amount drying and wetting system throughout the entire vegetative phase. No water stress was encountered in reproductive and ripening phase. The plot was finally dried out at 15 days before harvesting.

3.11.2 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 25 DAT and 45 DAT by hand weeding.

3.11.3 Insect and pest control

There was no infection of diseases in the field but leaf roller (*Chaphalocrosis medinalis*, Pyralidae, Lepidoptera) was observed in the field and used Malathion @ 1.12 L ha^{-1}.

3.12 Harvesting, threshing and cleaning

The crop was harvested at full maturity at 24^{th} November, 2017 when 80-90% of the grains were turned into straw colored. The harvested crop was bundled separately, properly tagged and brought to threshing floor. Enough care was taken during threshing and cleaning period of rice grain. Fresh weight of rice grain and straw were recorded plot wise from 3 m^2 area. The grains were dried up to moisture content 12%, then cleaned and weighed for individual plot. Yields of rice grain and straw 3 m^2 were recorded from each plot and converted to hectare yield and expressed in t ha^{-1}.

3.13 Collected data on yield components

3.13.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 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 panicle.

3.13.2 Effective tiller hill^{-1}

The total number of effective tiller hill^{-1} was counted as the number of panicle bearing hill plant^{-1}. Data on effective tiller hill^{-1} were counted from 10 selected hills and average value was recorded.

3.13.3 Non-effective tiller hill^{-1}

The total number of in-effective tiller hill^{-1} was counted as the number of non-panicle bearing hill plant^{-1}. Data on non effective tiller hill^{-1} were counted from 10 selected hills and average value was recorded.

3.13.4 Total tiller hill^{-1}

The total number of tiller hill^{-1} was counted as the number of effective tiller hill^{-1} and non-effective tiller hill^{-1}. Data on total tiller hill^{-1} were counted from 10 selected hills and average value was recorded.

3.13.5 Filled grain panicle^{-1}

The total numbers of filled grain was collected randomly from selected 10 plants of a plot on the basis of grain in the spikelet and then average numbers of filled grain panicle^{-1} was recorded.

3.13.6 Unfilled grain panicle^{-1}

The total numbers of unfilled grain was collected randomly from selected 10 plants of a plot on the basis of not grain in the spikelet and then average numbers of unfilled grain panicle^{-1} was recorded.

3.13.7 Total grain panicle^{-1}

The total numbers of grain was collected randomly from selected 10 plants of a plot by adding filled and unfilled grain and then average numbers of grain panicle^{-1} was recorded.

3.13.8 Length of panicle

The length of panicle was measured with a meter scale from 10 selected plants and the average value was recorded as per plant.

3.13.9 Weight of 1000 seeds

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

3.13.10 Grain yield

Grains obtained from each unit plot were sun-dried and weighed carefully. The dry weight of grains of central 3 m^2 area to record the final grain yield plot^{-1} and finally converted to t/ha.

3.13.11 Straw yield

Straw obtained from each unit plot were sun-dried and weighed carefully. The dry weight of straw of central 3 m^2 area to record the final straw yield plot^{-1} and finally converted to t/ha.

3.13.12 Biological yield

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

Biological yield = Grain yield + Straw yield.

3.14 Post harvest soil sampling

After harvest of crop soil samples were collected from each plot at a depth of 0 to 15 cm. Soil samples of each plot was air-dried, crushed and passed through a two mm (10 meshes) sieve. The soil samples were kept in plastic container to determine the physical and chemical properties of soil.

3.15 Post harvest soil analysis

Soil samples were analyzed for both physical and chemical characteristics. The soil samples were analyzed by the following standard methods as follows:

3.15.1 Soil pH

Soil pH was measured with the help of a glass electrode pH meter, the soil water ratio being maintained at 1: 2.5.

3.15.2 Organic matter

Organic carbon in soil sample was determined by wet oxidation method. The underlying principle was used to oxidize the organic matter with an excess of 1N $K_2Cr_20_7$ in presence of conc. H_2SO_4 and conc. H_3PO_4 and to titrate the excess $K_2Cr_20_7$ solution with 1N $FeSO_4$. To obtain the content of organic matter was calculated by multiplying the percent organic carbon by 1.73 (Van Bemmelen factor) and the results were expressed in percentage (Page *et al.*, 1982).

3.15.3 Total nitrogen

Total N of soil were determined followed by the Micro Kjeldahl method. One gram of oven dry soil sample was taken into micro Kjeldahl flask to which 1.1 gm catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$: Se in the ratio of 100:10:1), and 6 ml H_2SO_4 were taken. The flasks were swirled and heated 200^0C and added 3 ml H_2O_2 and then heating at 360^0C was continued until the digest was colorless. After cooling, the content was transferred into 100 ml volumetric flask and volume was made up to the mark with distilled water. A blank was prepared in similar way. These digests were used for N determination (Page *et al*., 1982).

Then 20 ml digest solution was taken into the distillation flask, Then 10 ml of H_3BO_3 indicator solution was taken into a 250 ml conical flask which is marked to indicate a volume of 50 ml and placed the conical flask under the condenser outlet so that the delivery end dipped in the acid. Add sufficient amount of 10N-NaOH solutions in the container with distillation apparatus. Water runs through the condenser of distillation apparatus was checked. The conical flask was removed by washing several times the delivery outlet with distilled water. Finally the distillate was titrated with standard 0.01 N H_2SO_4 until the color changes from green to pink. The amount of N was calculated using the following formula:

$$\% N = (T-B) \times N \times 0.014 \times 100/S$$

Where,

T = Sample titration (ml) value of standard H_2SO_4

B = Blank titration (ml) value of standard H_2SO_4

N = Strength of H_2SO_4

S = Sample weight in gram

3.15.4 Available phosphorus

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

3.15.5 Exchangeable potassium

Exchangeable K was determined by 1N NH_4OAc (pH 7) extraction methods and by using flame photometer and calibrated with a standard curve (Page *et al.*, 1982).

3.16 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference of different treatments on yield contributing characters, yield and nutrient status of post-harvest soil. The mean values of all the characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test using MSTAT-C software. The significance of the difference among the treatment means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the effect of NPK briquette fertilization on the growth and yield of T. Aman rice variety BRRI dhan75. Data on different yield attributes, yield and characteristics of post-harvest soil was recorded. The results of this experiment have been presented and discussed under the following headings and sub-headings:

4.1 Yield attributes and yield of rice

4.1.1 Plant height

Plant height of BRRI Dhan75 at harvest was found statistically significant differences due to the effect of different chemical fertilization (Figure 2 and Table 3). Data revealed that at harvest, plant height varied (95.96-115.87 cm) for different treatments. At the time of plant harvest, the longest plant (115.87 cm) was found from T_6 treatment (80% RFD + 1 NPK briquette within 4 hills) which was statistically similar (109.32 and 108.46 cm, respectively) with T_1 (100% RFD) and T_2 (120% RFD) treatment and followed (103.18, 102.95 and 101.12 cm, respectively) by T_3 (80% RFD), T_5 (2 NPK briquette within 4 hills) and T_4 (1 NPK briquette within 4 hills) treatment, whereas the shortest plant (95.96 cm) was observed from T_0 (Control condition i.e. no chemical fertilizer) treatment. It was revealed from the recorded data that all the treatments produced significantly taller plants compared to the control condition. It was also observed that less than the recommended doses of fertilizer and briquette produced the longest plant of transplanted aman rice compared to control condition and plant growth was seriously hampered when types of fertilizer were not applied. Generally different varieties produced different size of plant because plant height is a genetical character and it is controlled by the genetic make up of the specific varieties. Shah *et al*. (2013) use of NPK briquette over NPK broadcast and incorporation and reported that NPK briquette was very much efficient for rice cultivation and NPK briquette produced the tallest plant.

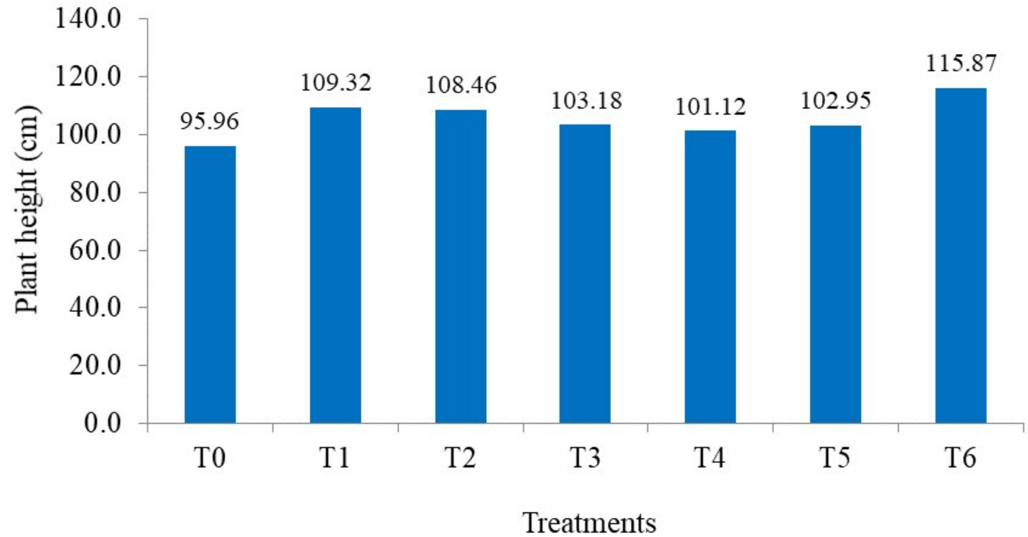

Figure 2. Effect of NPK briquette fertilization on plant height of T. Aman rice variety BRRI dhan75

4.1.2 Number of effective tillers hill^{-1}

Statistically significant variation was observed for number of effective tillers hill^{-1} due to the effect of different treatments (Table 3). The maximum number of effective tillers hill^{-1} (15.00) was found in T_6 treatment which was statistically similar (14.33) with T_1 treatment, while the minimum number (10.00) was recorded from T_0 treatment. Rahman *et al.* (2016) recorded highest number of effective tillers hill^{-1} (11.15) was obtained from USG and lowest number of effective tillers hill^{-1} (9.21) in absolute control.

4.1.3 Number of non-effective tillers hill^{-1}

Different treatments showed statistically significant differences in terms of number of non-effective tillers hill^{-1} (Table 3). The maximum number of non-effective tillers hill^{-1} (3.33) was found from T_0 treatment which was statistically similar (3.00 and 2.67, respectively) with T_5 and T_4 treatment, whereas the minimum number (1.67) was recorded from T_6 treatment which was statistically similar (2.00) with T_1 and T_2 tretament. Islam *et al*. (2011) that NPK briquettes, USG and prilled urea (PU) produced statistically similar for non-effective tillers hill^{-1} but gave significantly highest non-effective tillers hill^{-1} than control.

Table 3. Effect of NPK briquette fertilization on plant height, effective, non-effective and total tillers hill^{-1} of T. Aman rice variety BRRI dhan75

Treatments	Plant height (cm)	Number of effective tillers hill^{-1}	Number of non-effective tillers hill^{-1}	Total tillers hill^{-1}
T_0	95.96 d	10.00 e	3.33 a	13.33 e
T_1	109.32 ab	14.33 a	2.00 c	16.33 a
T_2	108.46 abc	14.00 b	2.00 c	16.00 a
T_3	103.18 cd	13.33 b	2.33 bc	15.67 bc
T_4	101.12 bcd	11.33 cd	2.67 ab	14.00 cd
T_5	102.95 bcd	12.00 c	3.00 a	15.00 cd
T_6	115.87 a	15.00 a	1.67 c	16.67 a
$LSD_{(0.05)}$	9.67	0.73	0.56	1.14
Significance level	0.05	0.05	0.01	0.01
CV(%)	5.21	3.43	13.47	4.47

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_0: Control

T_1: 100% RFD

T_2: 120% RFD

T_3: 80% RFD

T_4: 1 NPK briquette within 4 hills

T_5: 2 NPK briquette within 4 hills

T_6: 80% RFD + 1 NPK briquette within 4 hills

RFD-Recommended Fertilizer Doses (120, 20, 80, 16 and 2 kg ha^{-1} of N, P, K, S and Zn, respectively)

4.1.4 Number of total tillers hill^{-1}

Statistically significant variation was observed for number of total tillers hill^{-1} due to the effect of different treatments (Table 3). The maximum number of total tillers hill^{-1} (16.67) was found from T_6 treatment which was statistically similar (16.33 and 16.00, respectively) with T_1 and T_2 treatment, whereas the minimum number (13.33) was recorded from T_0 treatment. Afroz (2013) reported that the highest number of tillers hill^{-1} (13.00) was obtained from NPK briquette and where lowest number of tillers hill^{-1} (5.66) from USG.

4.1.5 Length of panicle

Length of panicle showed statistically significant differences due to the effect of different treatments (Figure 3). The longest panicle (24.85 cm) was found from T_6 treatment which was statistically similar (24.48, 24.24 and 23.78 cm, respectively) with T_1, T_2 and T_3 treatment and followed (23.06 cm) by T_5 treatment, whereas the shortest panicle (20.55 cm) was recorded from T_0 treatment. Islam *et al*. (2011) that NPK briquettes, USG and prilled urea (PU) produced statistically similar for panicle length but gave significantly longest panicle than control.

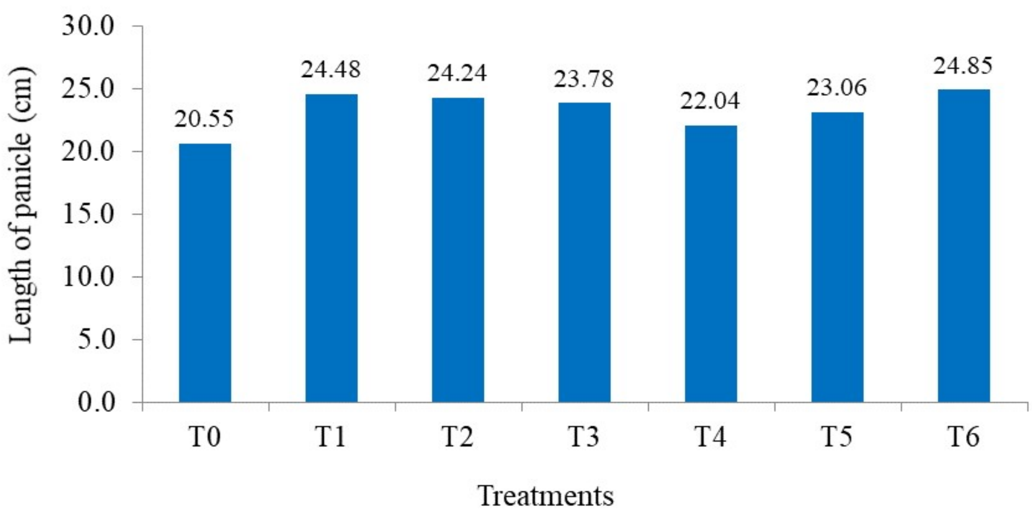

Figure 3. Effect of NPK briquette fertilization on length of panicle of T. Aman rice variety BRRI dhan75

4.1.6 Number of filled grains panicle^{-1}

Statistically significant variation was recorded in terms of number of filled grains panicle^{-1} due to the effect of different treatments (Table 4). The maximum number of filled grains panicle^{-1} (90.33) was found from T_6 treatment which was statistically similar (85.00) with T_1 treatment, while the minimum number (61.33) was recorded from T_0 treatment. Hasanuzzaman *et al.* (2013) recorded the highest number of filled grains panicle^{-1} (154.67) from the application of USG in earlier experiment.

4.1.7 Number of unfilled grains panicle^{-1}

Number of unfilled grains panicle^{-1} varied significantly due to the effect of different treatments (Table 4). The maximum number of unfilled grains panicle^{-1} (7.00) was found from T_0 treatment which was followed (6.33 and 6.00, respectively) by T_1, T_2, T_3, T_5 and T_4 treatment and they were statistically similar, while the minimum number (4.67) was recorded from T_6 treatment which was statistically similar (5.00) with T_5 treatment. Hasanuzzaman *et al.* (2013) recorded the highest application of USG showing 10% less more unfilled grains panicle^{-1} than PU.

4.1.8 Number of total grains panicle^{-1}

Statistically significant variation was recorded in terms of number of total grains panicle^{-1} due to the effect of different treatments (Table 4). The maximum number of total grains panicle^{-1} (95.00) was observed from T_6 treatment which was statistically similar (91.33) with T_1 treatment and followed (88.00 and 87.67, respectively) by T_2 and T_3 treatment and they were statistically similar, while the minimum number (68.33) was recorded from T_0 treatment. Data revealed that different treatment different number of total grains panicle^{-1}. Naznin *et al.* (2013) stated from earlier experiment that application of USG and NPK briquette may be practiced for obtaining better yields by increasing total number of grains panicle^{-1}.

Table 4. Effect of NPK briquette fertilization on length of panicle, number of filled, unfilled and total grains of T. Aman rice variety BRRI dhan75

Treatments	Length of panicle (cm)	Number of filled grains panicle^{-1}	Number of unfilled grains panicle^{-1}	Total grains panicle^{-1}
T_0	20.55 d	61.33 d	7.00 a	68.33 d
T_1	24.48 ab	85.00 ab	6.33 b	91.33 ab
T_2	24.24 ab	82.00 bc	6.00 b	88.00 bc
T_3	23.78 ab	81.67 bc	6.00 b	87.67 bc
T_4	22.04 cd	78.33 bc	6.00 b	84.33 c
T_5	23.06 bc	79.33 bc	5.00 c	84.33 c
T_6	24.85 a	90.33 a	4.67 c	95.00 a
$LSD_{(0.05)}$	1.50	6.17	0.56	6.37
Significance level	0.05	0.01	0.05	0.05
CV(%)	3.78	4.64	5.62	4.46

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_0: Control

T_1: 100% RFD

T_2: 120% RFD

T_3: 80% RFD

T_4: 1 NPK briquette within 4 hills

T_5: 2 NPK briquette within 4 hills

T_6: 80% RFD + 1 NPK briquette within 4 hills

RFD-Recommended Fertilizer Doses (120, 20, 80, 16 and 2 kg ha^{-1} of N, P, K, S and Zn, respectively)

4.1.9 Weight of 1000 grains

Weight of 1000 grains varied non-significantly due to the effect of different treatments (Figure 4). The highest weight of 1000 grains (21.78 g) was found from T_6 treatment, while the lowest weight (20.94 g) was recorded from T_0 treatment. Hasanuzzaman *et al.* (2013) recorded the highest 1000-grain weight (29.35 g) from the application of USG showing 10% more grain yield than PU.

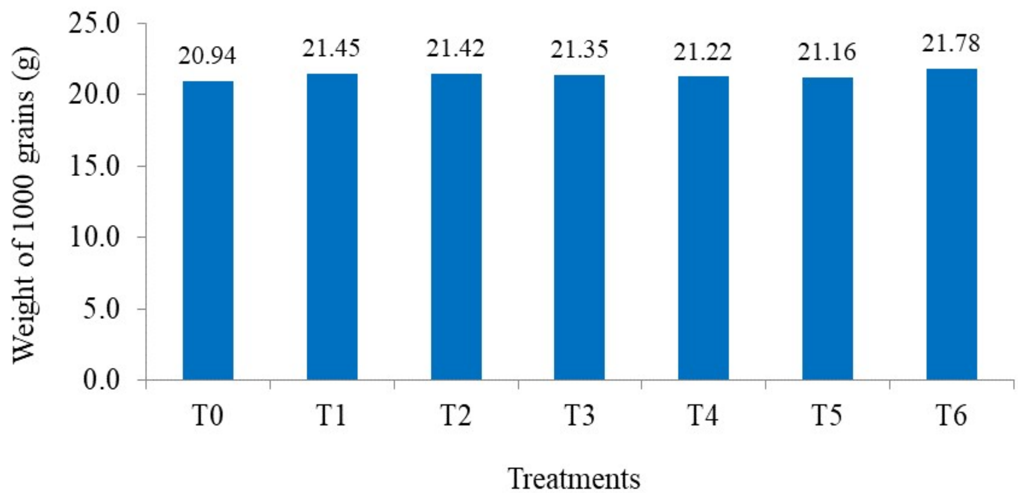

Figure 4. Effect of NPK briquette fertilization on weight of 1000 grains of T. Aman rice variety BRRI dhan75

4.1.10 Grain yield

Statistically significant variation was recorded in terms of grain yield due to the effect of different treatments (Table 5). The highest grain yield (4.47 t ha^{-1}) was found from T_6 treatment which was statistically similar (4.38 t ha^{-1}) with T_2 and closely followed by other treatments except T_0, whereas the lowest grain yield (2.81 t ha^{-1}) was recorded from T_0 treatment. Naznin *et al.* (2013) stated that that application of USG and NPK briquette may be practiced for obtaining better yields in addition to increasing the efficiency of N fertilizer. Afroz (2013) reported that the highest grain yield (6.60 t ha^{-1}) was obtained from NPK briquette and the lowest grain yield (4.48 t ha^{-1}) from USG.

Table 5. Effect of NPK briquette fertilization on grain, straw and biological yield of T. Aman rice variety BRRI dhan75

Treatments	Weight of 1000 grains (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})
T_0	20.94	2.81 c	4.05 c	6.86 c
T_1	21.45	4.05 b	5.02 b	9.07 b
T_2	21.42	4.38 a	5.71 a	10.09 a
T_3	21.35	4.04 b	4.81 b	8.85 b
T_4	21.22	3.73 b	4.88 b	8.61 b
T_5	21.16	3.95 b	5.06 b	9.01 b
T_6	21.78	4.47 a	5.82 a	10.29 a
$LSD_{(0.05)}$	--	0.35	0.43	0.46
Significance level	NS	0.01	0.01	0.01
CV(%)	5.73	5.55	4.97	3.72

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_0: Control

T_1: 100% RFD

T_2: 120% RFD

T_3: 80% RFD

T_4: 1 NPK briquette within 4 hills

T_5: 2 NPK briquette within 4 hills

T_6: 80% RFD + 1 NPK briquette within 4 hills

RFD-Recommended Fertilizer Doses (120, 20, 80, 16 and 2 kg ha^{-1} of N, P, K, S and Zn, respectively)

4.1.11 Straw yield

Straw yield showed statistically significant differences due to the effect of different treatments (Table 5). The highest straw yield (5.82 t ha^{-1}) was recorded from T_6 treatment which was statistically similar (5.71 t ha^{-1}) with T_2 treatment and followed by other treatments except T_0 and the lowest straw yield (4.05 t ha^{-1}) was recorded from T_0 treatment. Hasanuzzaman *et al.* (2013) recorded the highest straw yield (13.33 t ha^{-1}) from the application of USG showing 10% more grain yield than PU.

4.1.12 Biological yield

Statistically significant variation was recorded in terms of biological yield due to the effect of different treatments (Table 5). The highest biological yield (10.29 t ha^{-1}) was found from T_6 treatment which was statistically similar (10.09 t ha^{-1}) with T_2 treatment and followed by other treatments of this study except T_0 treatment, while the lowest biological yield (6.86 t ha^{-1}) was recorded from T_0 treatment. Naznin *et al.* (2013) stated that that application of USG and NPK briquette may be practiced for obtaining better biological yields in addition to increasing the efficiency of N fertilizer.

4.2 Soil pH, organic matter total N, available P and exchangeable K in post-harvest soil

4.2.1 Soil pH

Statistically non-significant variation was recorded in terms of soil pH in post-harvest soil due to the effect of different treatments (Table 6). The highest soil pH (6.13) was recorded from T_6 treatment and the lowest soil pH (5.99) was found from T_0 treatment.

Table 6. Effect of NPK briquette fertilization on nutrient content of post-harvest soil

Treatments	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (meq/100 g soil)
T_0	5.99	1.21	0.031 d	18.76 d	0.102 c
T_1	6.08	1.32	0.068 a	28.77 ab	0.174 a
T_2	6.11	1.39	0.054 ab	25.62 bc	0.161 ab
T_3	6.08	1.38	0.051 bc	24.45 c	0.153 b
T_4	6.05	1.31	0.049 bc	24.09 c	0.154 b
T_5	6.02	1.35	0.052 bc	24.15 c	0.151 b
T_6	6.13	1.34	0.073 a	29.58 a	0.176 a
$LSD_{(0.05)}$	--	--	0.017	1.136	0.017
Significance level	NS	NS	0.01	0.01	0.01
CV(%)	4.76	7.05	14.55	8.74	8.49

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_0: Control

T_1: 100% RFD

T_2: 120% RFD

T_3: 80% RFD

T_4: 1 NPK briquette within 4 hills

T_5: 2 NPK briquette within 4 hills

T_6: 80% RFD + 1 NPK briquette within 4 hills

RFD-Recommended Fertilizer Doses (120, 20, 80, 16 and 2 kg ha^{-1} of N, P, K, S and Zn, respectively)

4.3.2 Organic matter

Organic matter content in post-harvest soil showed **s**tatistically non-significant variation due to the effect of different treatments (Table 6). The highest organic matter (1.44%) was found from T_6 treatment and the lowest organic matte (1.21%) was observed from T_0 treatment.

4.2.3 Total N

Statistically significant differences was recorded in terms of total N in post-harvest soil due to the effect of different treatments (Table 6). The highest total N (0.073%) was recorded from T_6 treatment which was statistically similar (0.068% and 0.054%, respectively) with T_1 and T_2 treatment and followed (0.052%, 0.051% and 0.049%, respectively) by T_5, T_3 and T_4 treatment and the lowest soil total N (0.031%) was found from T_0 treatment.

4.2.4 Available P

Available P in post-harvest soil showed statistically significant differences in terms of due to the effect of different treatments (Table 6). The highest available P (29.58 ppm) was recorded from T_6 treatment which was statistically similar (28.77 ppm) with T_1 treatment and followed (25.62 ppm) by T_2 treatment and the lowest available P (18.76 ppm) was found from T_0 treatment.

4.2.5 Exchangeable K

Statistically significant differences was recorded in terms of exchangeable K in post-harvest soil due to the effect of different treatments (Table 6). The highest exchangeable K (0.176 meq/100 g soil) was recorded from T_6 treatment which was statistically similar (0.174 and 0.161 meq/100 g soil, respectively) with T_1 and T_2 treatment and followed (0.154, 0.053 and 0.051 meq/100 g soil, respectively) by T_4, T_3 and T_5 treatment and the lowest exchangeable K (0.102 meq/100 g soil) was found from T_0 treatment.

CHAPTER V

SUMMARY AND CONCLUSION

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The experiment was conducted in the Farm of Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh during the period from July to November, 2017 to study the effect of NPK briquette fertilization on the growth and yield of T. Aman rice variety BRRI dhan75. The experiment comprised of 7 treatments as- T_0: Control, T_1: 100% RFD, T_2: 120% RFD, T_3: 80% RFD, T_4: 1 NPK briquette within 4 hills, T_5: 2 briquette within 4 hills and T_6: 80% RFD + 1 briquette within 4 hills. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Data on different yield attributes, yield and characteristics of post-harvest soil was recorded and statistically significant variation was observed for different treatment under the study.

The longest plant (115.87 cm) was found from T_6 treatment, whereas the shortest plant (95.96 cm) was observed from T_0 treatment at harvest. The maximum number of effective tillers hill^{-1} (15.00) was found from T_6 treatment, while the minimum number (10.00) was recorded from T_0 treatment. The maximum number of non-effective tillers hill^{-1} (3.33) was found from T_0 treatment, whereas the minimum number (1.67) was recorded from T_6 treatment. The maximum number of total tillers hill^{-1} (16.67) was found from T_6 treatment, whereas the minimum number (13.33) was recorded from T_0 treatment. The longest panicle (24.85 cm) was found from T_6 treatment, whereas the shortest panicle (20.55 cm) was recorded from T_0 treatment. The maximum number of filled grains panicle^{-1} (90.33) was found from T_6 treatment, while the minimum number (61.33) was recorded from T_0 treatment. The maximum number of unfilled grains panicle^{-1} (7.00) was found from T_6 treatment, while the minimum number (4.67) was recorded from T_0 treatment. The maximum number of total grains panicle^{-1} (97.33) was observed from T_6 treatment, while the minimum number (66.00) was recorded from T_0 treatment. The highest weight of 1000 grains (21.78 g) was found from T_6 treatment, while the lowest weight (20.94 g) was recorded from T_0 treatment. The highest grain yield (4.47 t ha^{-1}) was found from T_6 treatment, while the lowest grain yield (2.81 t ha^{-1}) was recorded from T_0 treatment. The highest straw yield (5.71 t ha^{-1}) was recorded from T_6 treatment, while the lowest straw yield (4.05 t ha^{-1}) was recorded from T_0 treatment. The highest biological yield (10.29 t ha^{-1}) was found from T_6 treatment, while the lowest biological yield (6.86 t ha^{-1}) was recorded from T_0 treatment.

The highest soil pH (6.13) was recorded from T_6 treatment and the lowest soil pH (5.99) was found from T_0 treatment. The highest organic matter (1.34%) was found from T_6 treatment and the lowest organic matte (1.21%) was observed from T_0 treatment. The highest total N (0.073%) was recorded from T_6 treatment and the lowest soil total N (0.031%) was found from T_0 treatment. The highest available P (29.58 ppm) was recorded from T_6 treatment and the lowest available P (18.76 ppm) was found from T_0 treatment. The highest exchangeable K (0.176 meq/100 g soil) was recorded from T_6 treatment, whereas the lowest exchangeable K (0.102 meq/100 g soil) was found from T_0 treatment.

Recorded information revealed that applications of T_6 treatment (80% RFD + 1 NPK briquette within 4 hills) was the superior among the other treatments in consideration of yield attributes and yield of T. Aman rice variety BRRI dhan75.

Considering the results of the present experiment, further studies in the following areas may be suggested:

1. Such study is needed to be repeated in different agro-ecological zones (AEZ) of Bangladesh for the evaluation of regional adaptability,
2. Other management practices may be used for further study, and
3. Other combination of organic manures and chemicals fertilizer may be used for further study to specify the specific combination.

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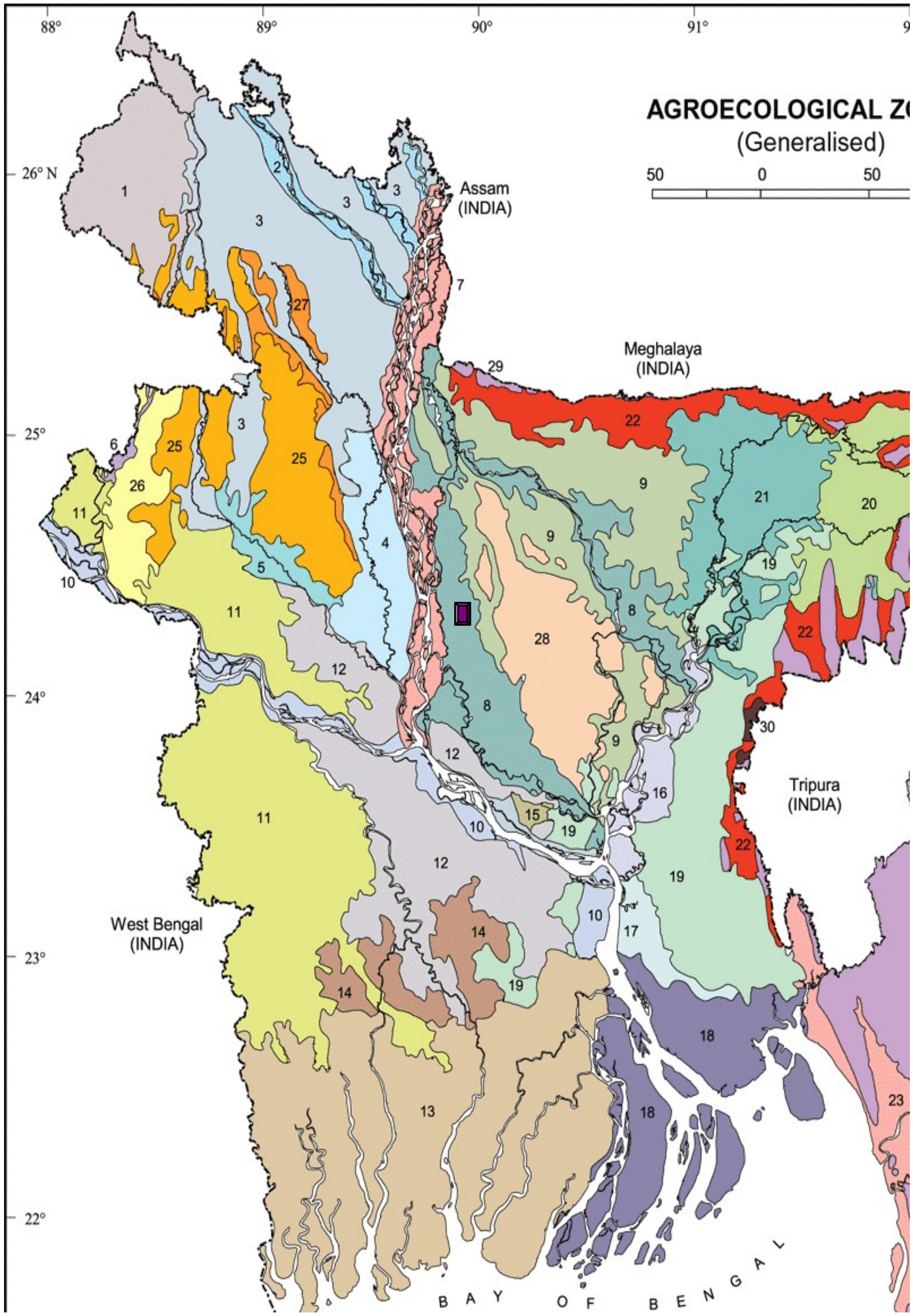
APPENDICES

APPENDICES

Appendix I. The Map of the experimental site



Appendix II. Monthly record of air temperature, relative humidity, rainfall, and sunshine (average) of the experimental site during the period from July to November 2017

Month (2017)	Air temperature (^{0}c)		Relative humidity (%)	Rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
July	36.8	24.9	85	573	5.5
August	35.2	23.3	87	303	6.2
September	33.7	22.6	82	234	6.8
October	26.6	19.5	79	34	6.5
November	25.1	16.2	77	00	6.7

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka–1207