EFFECT OF NPK BRIQUETTE ON THE GROWTH AND YIELD OF BORO RICE (BRRI dhan29)

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Dedicated To

My Beloved Parents

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The Author

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ABSTRACT

An experiment was conductedat the Research Farm, Sher-e-Bangla Agricultural University, Dhaka during the period from **November 2016 to May2017** to study the effect of NPK briquette on the growth and yield of boro rice (BRRI dhan29). The experiment consisted of eight treatments viz.T_1 (No fertilizer; Control), T_2 (RFD (Recommended fertilizer dose), T_3 (2 NPK briquette of 2.40 sized), T_4 (1 NPK briquette of 2.40 sized), T_5 (3 NPK briquette of 2.40 sized), T_6 (2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF), T_7 (1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF) and T_8 (3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF). BRRI dhan29 was used as a test crop for the experiment. The experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. Results showed that the highest number of tillers hill^{-1} (21.56), number of effective tillers hill^{-1} (20.66), number of filled grains panicle^{-1} (116.36), number of total grains panicle^{-1} (120.98), panicle length (24.62 cm), grain yield (8.44 t ha^{-1}), straw yield (9.88 t ha^{-1}), biological yield (18.32 t ha^{-1}) and harvest index (46.07%) were found from the treatment, T_3 (2 NPK briquette of 2.40 sized). The lowest results on the respected parameters were found from T_1 (No fertilizer; Control). The lowest number of non-effective tillers hill^{-1} (0.90) and number of unfilled grains panicle^{-1} (4.62) was found from the treatment, T_3 (2 NPK briquette of 2.40 sized). The highest value of the N, P and K content in post-harvest soil was obtained from treatment T_8 (3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF) and T_1 (No fertilizer; Control) treated soil showed the lowest.

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ABBREVIATIONS AND ACRONYMS

%	=	Percentage
AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
Ca	=	Calcium
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan’s Multiple Range Test
e.g.	=	exempli gratia (L), for example
et al.,	=	And others
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram (s)
GM	=	Geometric mean
i.e.	=	id est (L), that is
K	=	Potassium
Kg	=	Kilogram (s)
L	=	Litre
LSD	=	Least Significant Difference
M.S.	=	Master of Science
m^2	=	Meter squares
mg	=	Miligram
mL	=	MiliLitre
NaOH	=	Sodium hydroxide
No.	=	Number
^oC	=	Degree Celceous
P	=	Phosphorus
SAU	=	Sher-e-Bangla Agricultural University
USA	=	United States of America
var.	=	Variety
WHO	=	World Health Organization
µg	=	Microgram

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.) is a semi-aquatic grass belongs to the family Poaceae. It is the most important food crop of the world and the staple food of more than 3 billion people or more than half of the world’s population (IRRI 2005). About 95% of the world rice is consumed in Asia (Rotshicld, 1996), grown in wide range of climatic zones, to nourish the mankind (Chaturvedi, 2005).

The area and production of total rice in Bangladesh is about 11.52 million hectares and 33.89 million tons, respectively where boro covers the production of 18.76 million tons. In boro season local and HYV rice covers about 41.6 lac hectares area with production of 157.4 lac metric tons and hybrid rice covers about 6.4 lac hectares area with production of 30.2 lac metric tons, respectively (BBS, 2015). Rice is also the main food crop of Bangladesh and it covers about 80% of the total cropped area of the country (AIS, 2013). But the grain yield per hectare is still low compared to other major rice growing countries of the world. Rice provides nearly 48% of rural employment, about two-third of total calorie supply and about one-half of the total protein intakes of an average per person in the country. About 75% of the total cropped area and over 80% of the total irrigated area is covered by rice. Thus, rice plays a vital role in the livelihood of the people of Bangladesh.

Total rice production in Bangladesh was about 10.97 million tons in the year 1971 when the country's population was only about 70.88 millions. At present the country is now producing about 34.45 million tons to feed her 156.6 million people (BBS, 2013). This indicates that the increase of rice production was much faster than the increase of population. This increased rice production has been possible largely due to the adoption of modern rice varieties on around 70.24% of the rice land which contributes to about 83.39% of the country's total rice production (BBS, 2012). However, there is no reason to be complacent. Population growth rate in Bangladesh is two million people per year and the population will reach 233.2 million by 2050, going by the current trend (BBS, 2014). Bangladesh will require more than 55.0

million tons of rice per year to feed its people by the year 2050. Bangladesh will require about 31.3 to 42.0 million tons of rice for the year 2030 (IFPRI, 2012). During this time total rice area will also shrink to 10.68 million hectares. Rice (clean) yield therefore, needs to be increased from the present average yield 4.34 t ha^{-1} (BRRI, 2011). Therefore, it is an urgent need of the time to increase rice production through increasing the yield.

Proper fertilization is an important management practice which can increase the yield of rice. Judicious and proper use of fertilizers can markedly increase the yield and improve the quality of rice (Youshida, 1981).Generally, the farmers of our country use non urea fertilizer as basal during final land preparation. In tidal flooded condition, most of the applied fertilizers are lost through different ways. Deep placement of all essential fertilizers may be more efficient and farmers can be more benefited from this compared to broadcast method. The use of NPK briquette, which is a mixture of urea, triple super phosphate (TSP) and muriate of potash (MOP) may help to reduce the loss of nutrients in tidal flooded ecosystem.

Farmers in Vietnam and Cambodia obtained 25 % higher yields with deep placement of NPK briquettes over the broadcasting of fertilizer (IFDC, 2007). In Bangladesh, 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 (IFPRI, 2004). A national survey conducted in Bangladesh during 2004 showed that more than 1800 briquette-making machines had been manufactured and sold and about 550000 rice farmers were using the technology in their fields (IFDC, 2007).Applied NPK fertilizers are washed-out from rice field during tidal flood or heavy rainfall. So, deep placement of all fertilizers (NPK briquette) would be effective rather than broadcasting (IFDC, 2007).

Nitrogen, phosphorus and potassium are the most important and key nutrient for rice production all over the world for their huge requirements and instability in soil. It is the most limiting element for increasing rice productivity in the tropical countries like

Bangladesh. In the tidal wet land situation, where it is not possible to follow the recommendation schedule of split application of urea and other nutrients and where the risk of loses of surface applied N or other nutrients exists, an effective alternative may be the use of Urea Super Granule (USG)/NPK briquette for higher yield of rice. Deep placement of fertilizers (USG and NPK briquette) into the anaerobic soil zone is an effective method to reduce volatilization loss (Mikkelsen*et al*., 1978). Deep placement of briquette at 8-10 cm depth of soil can save nutrients compared to prilled fertilizer, increases absorption rate, improves soil health and ultimately increases rice yield (Savant *et al*., 1991).

In this aspect, the present study was, therefore, undertaken to find out the effect of NPK briquette on the growth and yield of boro riceBRRI dhan29. So, the present experiment was conducted with the following objectives:

1. To study the efficacy of NPK briquette on the growth and yield of BRRI dhan29.
2. To find out the dose of NPK briquette for maximum yield of BRRI dhan29.

CHAPTER II

REVIEW OF LITERATURE

Growth and development of rice plants are greatly influenced by the environmental factors i.e. air, day length or photoperiod, temperature, variety and agronomic practices like transplanting time, spacing, number of seedlings, depth of planting, fertilizer management etc. Among the factors, which are responsible for the yield of rice, fertilizer management of boro rice is one of them. Yield and yield contributing characters of rice are considerably influenced by different doses of NPK fertilizers and their combined application. Research works related to the growth and yield of bororice as affected by method of urea application have been reviewed in this chapter.

2.1 Effect of NPK fertilizers on rice

2.1.1 Effect of NPK fertilizers on growth parameters

The highest plant height, number of tillers, leaf area index and dry weight were obtained with 100 per cent recommended NPK @80-40-20 kg ha^{-1} over 50 and 75 per cent of recommended NPK (Prasad *et al.*, 2001). However, Murali and Setty (2001) obtained significant increase in total dry matter production with NPK application up to 150-75-75 kg ha^{-1} at all the growth stages. Plant height and leaf area index were higher with 150-100-60 kg NPK than 100-60-40 kg NPK ha^{-1} (Pandey*et al.*, 2001). However, experiment conducted by Mahato*et al.* (2007) in Coochbihar showed that plants height of rice increased with increasing NPK levels up to 120-60-60 kg ha^{-1}.

Kundu and Kundu (2002) recorded maximum plant height, number of tillers and dry- matter accumulation due to application of 180-90-90 kg NPK ha^{-1}. Plant height, tillers $hill^{-1}$ and leaf-area index considerably increased with 150-50-50 kg NPK ha^{-1} (Lenin and Rangaswamy, 2002). However, Singh *et al.* (2008) showed that plant height of rice significantly increased with increasing NPK levels up to 120-60-60.

Mubarak (2008) observed that the application of NPK at 150-60-80 kg ha^{-1} produced significantly higher values of growth parameters in hybrid rice cultivars PHB-71, KRH-2 and CNHR-3, which were at par with 150-60-40 kg NPK ha^{-1}.

Parashivamurthy*et al.* (2012) observed that, application of 150-60-75 kg NPK ha^{-1} recorded significantly higher plant height and number of tillers per hill as compared to lower levels.

Banerjee and Pal (2012) reported that plant height, dry matter production, leaf area index and crop growth rate of hybrid rice cultivar increased with increasing doses of N, P and K fertilizers and all these growth attributes showed their maximum values with 100% recommended dose of fertilizers (RDF) NPK @ 80-40-40 kg ha^{-1}.

Experiment conducted by Mondal*et al.* (2013) at Institute of Agriculture, Viswavarati, Sriniketan, West Bengal showed that application of 125 kg N, 62.5 kg P_2O_5 and 62.5 kg K_2O ha^{-1} significantly improved the growth attributes *viz.* plant height, number of tillers m^{-2}, leaf area index, dry matter accumulation m^{-2} and crop growth rate of rice as compared to its lower levels.

Singh *et al.* (2014) revealed that application of NPK @ 100% RDF *(i.e.* 120-60-60 kg ha^{-1}) produced significantly better growth attributes like plant height, dry matter accumulation $hill^{-1}$, number of tillers $hill^{-1}$ than its lower levels.

2.1.2 Effect of NPK management on yield attributes and yield

A significant increase in panicle length, grains $panicle^{-1}$, grain and straw yield was obtained due to increase in NPK levels up to 80-60-40 kg ha^{-1} (Deshmukh*et al.*, 1988). Balasubramanian and Palaniappan (1991) reported that application of 150 kg N + 75 kg K_2O and 150 kg N + 50 kg K_2O ha^{-1} were the optimum fertilizer doses for *kharif*and*rabi* seasons, respectively for rice-rice cropping system.

Application of NPK (100-80-60 kg NPK ha^{-1}) increased the effective tillers $plant^{-1}$, grains $panicle^{-1}$ and yield of rice (Paraye*et al.*, 1993). Kanungo and Roul (1994) found significant increase in effective tillers $hill^{-1}$, panicle length, grain and straw yields with the increasing fertility levels up to 100-50-50 kg NPK ha^{-1}.

Application of 150-75-75 kg $N\text{-}P_2O_5\text{-}K_2O$ ha^{-1} in rice cv. IR-64 significantly increased the panicles m^{-2}, grain and straw yields (Chaunabasappa*et al.* 1998). Setty*et al.* (1999) noted that sterility percentage was higher in the hybrids than in rice cv. IR-60 and increased with increasing NPK rates. Application of recommended NPK level (100-60-40 kg NPK ha^{-1}) produced significantly higher panicles m^{-2}, panicle weight, grain and straw yields when compared with their lower rates of application (Dwivediand Thakur, 2000).

Singh and Jain (2000) studied the morpho-physiological analysis of growth and yield in traditional and improved rice cultivars, grown at moderate (100 - 50 -40 kg NPK ha^{-1}) and high NPK levels (200-100-80 kg NPK ha^{-1}) and concluded that high level of NPK fertilization in all rice cultivars gave significantly higher economic and biological productivity ha^{-1} day^{-1}, panicles m^{-2}, grain and straw yields. However, grains $panicle^{-1}$ was reduced drastically under high level of NPK.

Prasad *et al.* (2001) obtained the highest panicles m^{-2}, filled grains $panicle^{-1}$, 1000-grain weight, grain and straw yield with recommended NPK application (80-40- 20 kg NPK ha^{-1}) in transplanted rice over 50 and 75 percent of recommended NPK. Kundu and Kundu (2002) recorded higher panicles per unit area as well as a higher percentage of filled grains $panicle^{-1}$ and yield with 150 percent of the recommended fertilizer dose (180-90-90 kg NPK ha^{-1}).

Similarly, significant improvement in number of panicles, weight of panicles, grain and straw yield were obtained with N=120, P=60, K=40 kg ha^{-1} (Singh *et al.*, 2002). Subbaiah*et al.* (2002) reported that rice hybrid KRH-2 recorded maximum grain yield at N=150,P=60,K=80 kg ha^{-1} whereas, the high yielding varieties performed better with N=150, P=60, K=40 kg ha^{-1}. Significant increase in the yield up to recommended level of 100-50-50 kg NPK $ha^{-1}$was also obtained by Kumar *et al.* (2002). Similarly, Upadhyay*et al.* (2002) noticed significant increase in the yield up to 125-75-50 kg NPK ha^{-1}.

Each increment in fertilizer level up to 100-50-50 kg NPK ha^{-1} significantly increased the yield attributes *viz.*no.of panicles m^{-2} and no.of filled grains $panicle^{-1}$ and grain and straw yield of rice (Mahato*et al.*, 2007). However, Singh *et al.* (2008) opined that yield attributes *viz.* number of effective tillers m^{-2} and 1000 grain weight and grain yield of rice significantly increased up to 120-60-60 kg NPK ha^{-1}.

Banerjee and Pal (2012) revealed that yield attributes like number of panicles m^{-2}, filled grains $panicle^{-1}$, 1000- grain weight showed the maximum value with 100% RDF *i.e.* NPK @ 80:40:40 kg ha^{-1}. Maximum grain yield and biological yield were recorded with 100% RDF.

Kumari*et al.* (2013) conducted an experiment at Ranchi and reported that the scented rice (Birsamati) grown with 100:21.8:20.8 kg NPK ha^{-1} through inorganic fertilizer produced maximum grain and straw yield with increased number of effective panicles m^{-2}, number of grains $panicle^{-1}$ and 1000 grain weight.

Singh *et al.* (2014) revealed that application of NPK @ 100% RDF (i.e. 120-60-60 kg ha^{-1}) produced significantly better yield attributes *viz.* number of panicles m^2, number of filled grains $panicle^{-1}$, 1000 grain weight, grain and straw yield of rice than its lower levels.

Srivastava*et al.* (2014) opined that application of 100% RDF (150-75-75) significantly increased number of effective tillers m^{-2}, number of filled grains $panicle^{-1}$, test weight, grain yield and straw yield of rice over 50% RDF.

2.2 Effect of NPK briquettes on growth and yield of rice

Rahman *et al*. (2016) carried out a field experiment to assess the comparative advantages of using Urea Super Granule (USG) and NPK briquette over prilled urea and also predict the better performing transplanted Aus rice in the tidal ecosystem. The effect of different levels of fertilizer was studied on growth, yield and yield attributing character of transplanted Aus rice. Five fertilizer treatments (N_1 = Recommended doses of all fertilizers, N_2 = Urea super granule at 112.5 kg/ha during 10 DAT at available tide free time, N_3 = NPK briquette at 150 kg ha^{-1} during 14 DAT at available tide free time, N_4 = Nitrogen control, N_5 = Absolute control) with four HYV Aus rice varieties (V_1 = BRRIdhan27, V_2 = BRRIdhan48, V_3 = BRRIdhan55 and V_4 = BRRIdhan65). The experiment was laid out in a split plot design with 3 replications. Results revealed that different fertilizer management practices with a few exceptions significantly influenced the growth, yield and yield attributes of the transplanted Aus rice varieties. Plant height, number of effective tillers per hill, panicle length (cm), number of grains panicle^{-1}, nitrogen use efficiency (%), straw yield (t ha^{-1}) and **grain yield**(t ha^{-1}) were found highest when USG was applied with BRRIdhan48 and all the characters showed lowest value for absolute control with BRRIdhan55. Highest number of effective tillers per hill (11.15) and **grain yield** (3.33 t ha^{-1}) was obtained from USG and BRRIdhan48 and where lowest number of effective tillers per hill (9.21) and **grain yield**(2.28 t ha^{-1}) in absolute control with BRRIdhan55. The NPK briquettes showed higher agronomic efficiency than Prilled Urea (PU) and Urea Super Granule (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. There was no residual effect of USG on soil **chemical properties**. The USG with BRRIdhan48 were found beneficial to the farmers in tidal ecosystem.

Islam *et al.* (2011) conductedan experiment to evaluate the effectiveness of NPK briquette on rice in tidal flooded soil condition during boro season. NPK briquettes of size 2.4 g and 3.4 g were compared with urea super granules (USG) and prilled urea (PU), each supplemented with PKS. The results showed that NPK briquettes, USG and PU produced statistically similar grain yield. N-treated plots (briquettes, USG and PU) gave significantly higher grain yield over N control. The highest grain yield (7.47 t ha^{-1}) was observed in NPK briquette (2.4 g × 2) followed by PU. There was no significant difference between N control and absolute control plots in respect of yield indicating that N was the only yield limiting factor under that condition. 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. There was no residual effect of NPK briquettes on soil chemical properties. The NPK briquettes were found beneficial to the farmers in tidal ecosystem.

Debnath *et al.* (2013) carried out an experiment to assess the comparative advantages of using Urea Super Granule (USG) and NPK briquette over normal urea, Triple super phosphate and Muriate of Potash and also predict the better performing T. aman rice. The effect of different levels of fertilizer was studied on growth, yield and yield attributing character of T. aman. Six fertilizer Treatments (F_0= Control(No urea), F_1 = Total urea (150 kg ha^{-1}) during land preparation at available tide free time, F_2 = Urea (75 kg ha^{-1})at 2 split, F_3 = Urea (50 kg ha^{-1})at 3 split, F_4 = Urea Super Granule (54 kg N ha^{-1}) at 10 days after transplanting and F_5 = NPK briquette (42Kg N ha^{-1} 9 Kg P ha^{-1} 12 Kg K ha^{-1})at 10 days after transplanting of T. aman rice). Besides, TSP, MOP, zinc sulphate and Gypsum were applied @100, 70, 50 and 12 kg ha^{-1} respectively as basal dose. 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 $panicle^{-1}$, nitrogen use efficiency (%), straw yield(t ha^{-1}) and grain yield (t ha^{-1}) were found highest when NPK briquette was applied and all the characters showed lowest value with 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}).The NPK briquettes showed higher agronomic efficiency than Prilled urea(PU) and Urea super granule(USG). The small size briquettes (2.4 g) could save 33 kg N ha^{-1} compared to recommend PU. There was no residual effect of NPK briquettes on soil chemical properties.The NPK briquettes were found beneficial to the farmers in tidal ecosystem.

Naznin*et al*. (2013) conductedan experiment during the aman season of 2012 to investigate the effects of prilled urea (PU), urea super granule (USG) and NPK briquette on NH_4-N concentration in field water, yield and nitrogen (N) use efficiency (NUE) of BR22 rice under reduced water conditions. There were altogether eight treatment combinations *viz*. T_1: Control (No N fertilizer), T_2: 52 kg N ha^{-1} from USG, T_3: 104 kg N ha^{-1} from USG, T_4: 78 kg N ha^{-1} from PU, T_5: 120 kg N ha^{-1} from PU, T_6: 51 kg N ha^{-1} from NPK briquette, T_7: 78 kg N ha^{-1} from USG and T_8: 78 kg N $ha^{-1}$from NPK briquette. Water samples were collected from rice field for seven consecutive days after deep placement of USG and the first split application of PU and the samples were analyzed for NH_4-N. The Highest concentration of NH_4-N in water was observed at the second day of PU application followed by gradual decrease with time. The yield contributing characters like plant height, panicle length, number of effective tillers hill^{-1} and grains panicle^{-1} were significantly influenced by different treatments. The highest grain yield of 3.93 t ha^{-1} was recorded from 104 kg N ha^{-1} as USG (T_3) and the lowest value of 2.12 t ha^{-1}wasobtained from control. The N use efficiency 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.

Radhika*et al*. (2013) carried out a study and found that placement of nutrients and fertilizer rates are important factors to be considered to produce maximum yield of crops. Particularly deep placement of nutrients might be beneficial to crop growth. Increased early growth has been observed with deeper P placement as well as by deep band placement of K when compared to broadcast application. The method of N, P and K placement has typically been found effective over broadcasting on the top of the soil, and it is also influenced by the amount of water used for irrigation. Normally fertilizers are broadcasted. Many a time, straight fertilizers are used as the source of nutrients. In order to manage the losses with these highly soluble fertilizers split application is recommended, particularly for urea. However, the entire quantity of P and K is applied basally at the time of sowing. Due to variations in their solubility and kinetics, the added nutrients are found to be available to plants at varying rates in different soils. In order to achieve the expected yields a comprehensive technology is required that can demonstrate an efficient use of added nutrients and irrigation water. Other than crop improvement aspects, this would be possible by switching over to nutrient management that employs methods like deep placement of fertilizer nutrients. Deep placement if can be done with simple tools and incidentally aim in the reduction in labour requirement then farmers can prefer to adopt easily. The literature pertaining to methods of fertilizer application on nutrient availability, response of maize and other crops to applied nutrients and nutrient use efficiency are reviewed.

Durgude*et al*. (2008) conducted a field experiment on a TypicHaplustepts soil to study the effect of NPK briquette on yield of rice. NP (56: 30: 00) briquette added with 30 kg ha^{-1} potassium (56: 30: 30 NPK briquette) applied in modified spacing 15-25 × 15-25 cm is recommended on Inceptisol soils for increasing the yield of lowland rice and maintaining the fertility of soil.

Chouhan (2017) conductedan experiment to evaluating the effect of rice response and nutrient use efficiency to deep placement of nitrogen and sulphur under submerged condition. There were seven treatment combinations of sulphur and vermi compost with urea briquette. The treatments include T_1 (N_0:P_0:K_0), T_2 (N_{100}:P_{60}:K_{40}, N through prilled urea), T_3 (N_0:P_{60}:K_{40}:S_{10}, sulphur broadcast), T_4 (N_{80}:P_{60}:K_{40}, N through urea briquettes), T_5 (N_{80}:P_{60}:K_{40}, N through VC briquettes), T_6 (N_{80}:P_{60}:K_{40}:S_{10} N and S through briquettes), T_7 (N_0:P_{60}:K_{40}) phosphorus + potassium. Prilled urea was applied in three equal splits. USG, Urea+ Sulphurbriquette and Urea + Vermicompostbriquettes were applied in between 7- 10 DAT and the briquettes were placed at 8-10 cm depth between four hills (USG, Urea + Sulphurbriquette) and 10×20 cm (Urea + Vermicompostbriquette). The yield and yield attributing characters of rice responded significantly superior with T_5 (N_{80}:P_{60}:K_{40}, N through VC briquettes) over GRD (N_{100}:P_{60}:K_{40}). The highest grain and straw yield, N content and N uptake was recorded in T_5 (N_{80}:P_{60}:K_{40} N through VC briquettes). The results revealed that the deep placement of urea briquettes accelerated regular flow of N to root may be reason for accumulation of high N in plant tissue and grain, then rice (rajeshwari) yield and yield attribute also increases in rice. Therefore, the application of 80kg N/ha as urea + VC briquettes may be recommend.

Sarker(2013) conducted nine experiments at BRRI research farm at Gazipur, Barisal and farmer's field at Babuganj and Gournodi under Barisal district in Boro, T Aus and T Aman seasons, 2012 to evaluate the NPK briquette efficiency in rice production. Eight treatments were tested under each experiment. The tested varieties were BRRI dhan29in Boro, BRRI dhan27 in T Aus and BRRI dhan49 in T Aman season. USG and NPK briquettes were deep placed between four hills as per treatment after 7 days of transplanting. The results revealed that the deep placement of NPK briquette (2 ×

2.4 g) increased about 10% yield and saved 37% N, 30% P, and 44% K than BRRI recommended rate of fertilizer in Boro season. Similarly, NPK briquette (1 × 3.4 g) produced 28% and 18% more rice yield over BRRI recommended rate of fertilizer for T Aus and T Aman season, respectively and also resulted in savings of 26-39% N. Deep placement of NPK briquette resulted in 4-10% higher rice yield and nutrient savings of 20-35 percent N, 18% percent P and 17-24% K over the recommended practice of NPK incorporation. Undiscounted benefit cost ratio (BCR) was 1.44, 2.40 and 3.20 for Boro, T Aus and T Aman seasons respectively when comparing at the same rates of N application. Thus, use of NPK briquette over NPK broadcast and incorporation was economically viable and efficient for rice cultivation.

CHAPTER III

MATERIALS AND METHODS

This chapter deals with a brief description on experimental period, experimental site, climate, soil, and land preparation, layout of the experimental design, intercultural operations, data recording and their analyses. Details of materials and methods used in this experiment are given below:

3.1 Experimental period

The experiment was conducted at the Research Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the boro season of December 2016 to May 2017.

3.2 Geographical location

The experimental site is geographically situated at 23°7N latitude and 90°33' E longitude at an altitude of 8.4meter above sea level. The experimental field belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28 (Anon., 1988). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain. For better understanding,experimental site has been shown in the Map of AEZ of Bangladesh in Appendix I.

3.3 Climate

The experimental site under the sub-tropical climate that is characterized by high temperature, high relative humidity and heavy rainfall with occasional gusty winds in Kharif season (April-September) and scanty rainfall associated with moderately low temperature during Rabi season (October-March). The weather data during the study period at the experimental site are shown in Appendix II.

3.4 Soil

The soil of the experimental field belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon soil series. Soil pH ranges from 5.4-5.6. The land was above flood level and sufficient sunshine was available during the experimental period. Soil samples from 0-15 cm depths were collected from the experimental field. The soil analyses were done at Soil Resource and Development Institute (SRDI), Dhaka. The physico-chemical properties of the soil are presented in Appendix III.

3.5 Experimental details

3.5.1 Treatments

Treatment which wereconsidered areas follows:

1. T_1 = No fertilizer (Control)
2. T_2 = RFD (RFD-N120 P30 K50)
3. T_3 = 2 NPK briquette of 2.40 sized(N130-P30-K55)
4. T_4 = 1 NPK briquette of 2.40 sized
5. T_5 = 3 NPK briquette of 2.40 sized
6. T_6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
7. T_7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
8. T_8 = 3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF

The experimental plots were fertilized with recommended doses of 120, 80, 140, 100 and 5 kg ha^{-1} N, P_2O_5, K_2O, S and Zn applied in the form of urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum and zinc sulphate respectively (AdhunikDhaner Chas, 2011). The fertilizers were used according to the treatment designed.

3.6 Experimental design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The total numbers of unit plots were 24. The size of unit plot was 7 m (3.5 m × 2 m). Layout of the experiment was done on December 15, 2016 with the distances between plot to plot and replication to replication were 0.5 m and 1.0 m, respectively. For better understanding the layout of the experiment has been presented in Appendix IV.

3.7 Crop/planting material

High yielding boro rice variety BRRI dhan29 was used as test crop.The description of the variety is given below:

3.7.1 BRRI dhan29

BRRI dhan29, a high yielding variety of boro season was developed by the Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur, Bangladesh. It takes about 155 to 160 days to mature. It attains at a plant height of 95-100 cm. The grains are medium slender with light golden husks and kernels are white in color. The cultivar gives an average grain yield of 7.5 t ha^{-1}.

3.8 Crop Management

3.8.1 Seed Collection

Healthy seeds of BRRI dhan29 was collected from the Breeding Division, BRRI, Joydebpur, Gazipur.

3.8.2 Sprouting of seed

The seeds were soaked in water in bucket for 24 hours. Then seeds were taken out of water and kept thickly in gunny bags. The seeds started sprouting after 48 hours and became suitable for sowing after 72 hours.

3.8.3 Raising of seedlings

Seedlings were raised on a high land in the south-east side of the Research farm of SAU. Seeds were sown in the seedbed on December 07, 2016 for raising seedlings. Each variety of seed was sown in separate beds. The nursery beds were prepared by puddling with repeated ploughing followed by laddering. The sprouted seeds were sown as uniformly as possible. Irrigation was gently provided to the bed as and when needed. Proper care was taken to raise seedlings in the nursery bed. The beds were kept weed free throughout the period of seedling raised.

3.8.4 Collection and preparation of initial soil sample

The initial soil samples were collected before land preparation from a 0-15 cm soil depth. The samples were collected by means of an auger from different location covering the whole experimental plot and mixed thoroughly to make a composite sample. After collection of soil samples, the plant roots, leaves etc. were picked up and removed. Then the sample was air-dried and sieved through a sieve and stored in a clean plastic container for physical and chemical analysis.

3.8.5 Preparation of experimental field

The experimental field was first ploughed on December 22, 2016 with the help of a tractor drawn rotary plough, later on December 24, 2016 the land was irrigated and prepared by three successive ploughing and cross ploughing with a tractor drawn plough and subsequently leveled by laddering. All weeds and other plant residues of previous crop were removed from the field. Immediately after final land preparation, the field layout was made on January 10, 2017 according to experimental specification.

3.8.6 Fertilizer application

The required fertilizers were applied according to the treatments. All the treatments except T_1, T_3, $T_4$and T_5 received 36 kg Pha^{-1} and 72 kg K ha^{-1} from TSP and MoP, respectively. In T_3, T_4 and T_5 treatments, P and K were supplied from NPK briquettes. Sulphur 18 kg ha^{-1} and zinc2.5 kg ha^{-1} were applied to all plots (except T_1) as basal dose from gypsum and zinc oxide, respectively.NPKbriquettes were placed at 8-10 cm depth between four hills at alternate rows. Before application of N fertilizers, the water in the rice plots was drained out.

3.8.7 The uprooting of seedlings

From nursery bed 35 days old seedlings were uprooted carefully on January 11, 2017 and were kept in soft mud in shade**.** The seedbeds were made wet by application of water in previous day before uprooting the seedlings to minimize mechanical injury of roots.

3.8.8 Transplanting of seedlings

Seedlings were transplanted on January 11, 2017 in the well-puddled experimental plots. Spacingwas given 25 cm × 15 cm for all the plots. Soil of the plots was kept moist without allowing standing water at the time of transplanting. Two seedlings of BRRI dhan29 were transplanted hill^{-1}.

3.9 Inter-cultural operations

3.9.1 Gap filling

After one week of transplanting gap filling was done to maintain population number. After transplanting the seedlings gap filling was done whenever it was necessary using the seedling from the previous source.

3.9.2 Weeding

Weed infestation was a severe problem during the early stage of crop establishment. The experimental plots were infested with some common weeds. To minimize weedinfestation, manual weeding through hand pulling was done three times during entire growing season.

3.9.3 Irrigation and drainage

Irrigation was done by alternate wetting and drying from transplanting to maximum tillering stage. From panicle initiation (PI) to hard dough stage, a thin layer of water (2-3 cm) was kept on the plots. Water was removed from the plots during ripening stage.

3.10 Harvesting and post harvest processing

Maturity of crop was determined when 90% of the grains become golden yellow in color. The harvesting of BRRI dhan29 was done on May 18, 2017. Hills from the central one m^2 area of each plot were harvested for collecting data on crop yield. The harvested crop of each plot was bundled separately, tagged properly and brought to the clean threshing floor. The crops were threshed by pedal thresher and then grains were cleaned. The grain and straw weights for each plot were recorded after proper sun drying and then converted into ton hectare^{-1}. The grain yield was adjusted at 14% moisture level.

3.10.1 Collection of plant Samples

Five hills were randomly selected from each plot at maturity to record the yield contributing characters.

3.11 Recording of data

Data were collected on the following parameters-

3.11.1 Growth parameter

1. Plant height (cm) at 30 days interval starting from 30 DAT
2. Number of tillers hill^{-1}with 30 daysinterval starting from 30 DAT

3.11.2 Yield components and yield

1. Plant height at harvest (cm)
2. Number of tillers hill^{-1} at harvest
3. Number of effective tillers hill^{-1} at harvest
4. Number of non-effective tillers hill^{-1} at harvest
5. Panicle length (cm)
6. Number of filled grains panicle^{-1}
7. Number of unfilled grains panicle^{-1}
8. Weight of 1000-grains (g)
9. Grain yield (t ha^{-1})
10. Straw yield (t ha^{-1})
11. Biological yield (t ha^{-1})
12. Harvest index (%)

3.12 Procedure of recording data

A brief outline on data recording procedure followed during the study is given below:

3.12.1 Plant height (cm)

The first plant height was measured at 30 DAT and continued up to harvest with 30 days interval. The height of the plant was determined by measuring the distance from the soil surface to the tip of the leaf before heading and to the tip of the flag leaf after heading. From each plot, plants of 5 hills were measured and averaged.

3.12.2 Number of tiller hill^{-1}

Number of tillers hill^{-1} was counted at 30 days interval starting from 25 DAT. Only those tillers having three or more leaves were used for counting.

3.12.3 Number of total tillers hill^{-1}

Tillers with at least one visible leaf were counted. It included both effective and non-effective tillers.

3.12.4 Number of effective tillers hill^{-1}

Tillers having panicles which had at least one grain were considered as effective tillers.

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

The panicle which had no grain was recorded as non-effective tillers.

3.12.6 Panicle length (cm)

The measurement of panicle length was taken from basal node of the rachis to apex of each panicle and expressed in centimeter (cm). Each observation was an average of 5 hills.

3.12.7 Number of filled grains panicle^{-1}

Presence of any kernel in the spikelet was considered as grain and total number of filled grain on each panicle was counted.

3.12.8 Number of unfilled grains panicle^{-1}

Spikelet having no food material inside was considered as unfilled spikelet i.e. sterile spikelet and the number of such spikelet present in each panicle was recorded.

3.12.9 Weight of 1000-grain (g)

One thousand clean dried grains from the seed stock of each plot were counted separately and weighed by using a digital electric balance at the stage the grain retained 14% moisture and the mean weight were expressed in gram.

3.12.10 Grain yield (t ha^{-1})

Grains obtained from the central 2m^2 areas of each plot were sun dried, cleaned, weighed carefully and adjusted at 14% moisture level. Dry weight of grams of each plot was converted into t ha^{-1}.

3.12.11 Straw yield (t ha^{-1})

Straw obtained from the central one m^2 area of each plot were sun dried, cleaned, weighed separately and finally converted into t ha^{-1}.

3.12.12 Biological yield (t ha^{-1})

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

Biological yield (t ha^{-1}) = Grain yield (t ha^{-1}) + Straw yield (t ha^{-1})

3.12.13 Harvest index (%)

It is the ratio of economic yield to biological yield and was calculated with the following formula:

$$\text{Harvest index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

3.13 Analyses of pre-harvest soil samples

Soil samples were analyzed for both physical and chemical properties such as texture, pH, organic carbon, total nitrogen, available P and exchangeable K. These results have been presented in Appendix III.

3.14 Determination of N, P and K from post harvest soil samples

3.14.1 Nitrogen

One gram of oven dried ground soil sample was taken into micro Kjeldahl flask to which 1.1 g catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$: Se=100: 10: 1), 2 mL 30% H_2O_2 and 5 mL H_2SO_4 were added. The flasks were swirled and allowed to stand for about 10 minutes. Then heating was continued until the digest was clear and colorless. After cooling, the content was taken into 100 mL volumetric flask and the volume was made up to the mark with distilled water. A reagent blank was prepared in a similar manner. These digest was used for nitrogen determination. After completion of digestion, 40% NaOH was added with the digest for distillation. The evolved ammonia was trapped into 4% H_3BO_3 solution and 5 drops of mixed indicator of bromocressol green ($C_{21}H_{14}O_5Br_4S$) and methyl red ($C_{10}H_{10}N_3O_3$) solution. Finally the distillate was titrated with standard 0.01 NH_2SO_4 until the color changed from green to pink. The amount of N was calculated using the following formula.

$$\% N = \frac{(T-B)\times N\times 0.014\times 100}{S}$$

Where, T= Sample titration value (mL) of standard H_2SO_4

B= Blank titration value (mL) of standard H_2SO_4

N = Strength of H_2SO_4

S= Sample weight in gram

3.14.2 Phosphorus content (%)

Available phosphorus was extracted from the soil samples by shaking with 0.5 M $NaHCO_3$ solution at pH 8.5 following Olsen method (Olsen *et al.,* 1954). The extracted phosphorus was determined by developing blue color by $SnCl_2$ reduction of phosphomolybdate complex and measuring the intensity of color colorimetrically at 660 nm wavelength and the readings were calibrated to the standard P curveforPotassium content (%)**.**

3.14.3 Exchangeable potassium

Exchangeable potassium was extracted from the soil samples with 1.0 N NH_4OAc (pH=7) and K was determined from the extract by flame photometer and calibrated with a standard curve (Black, 1965).

3.15 Statistical analysis of the data

The analysis of variance for different crop characters as well as for different nutrient concentrations of the treatments were made and the mean differences were judged at 5% level of significance by using a computer operated program named MSTAT-C.

CHAPTER IV

RESULTS AND DISCUSSION

Result obtained from the study on the effect of NPK briquette on the growth and yield of boro rice have been presented and discussed in this chapter. Treatments effect of NPK briquette along with other fertilizer on all the studied parameters have been presented in various tables and figures and discussed below under the following sub-headings.

4.1 Growth parameters

4.1.1 Plant height

Plant height of boro rice (BRRI dhan29) at different growth stages was significantly affected by different treatments of NPK briquette (Table 1 and Appendix V). Different treatment demonstrated different plant height and results revealed that the treatment, T_8 (3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF) showed highest plant height at all growth stages where the treatment, T_1 (No fertilizer; Control) showed lowest plant height at all growth stages. It was recorded that the highest plant height (42.56, 78.90, 102.60 and 108.68 cm at 30, 60, 90 DAT and at harvest, respectively) was achieved from the treatment of T_8 (3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF) which was statistically identical with T_6 (2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF) at all growth stages. Identical results on plant height was also found from T_5 (3 NPK briquette of 2.40 sized) with T_8 (3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF) at 60 DAT and at the time of harvest.The lowest plant height (27.54, 57.30, 78.80 and 80.24 cm at 30, 60, 90 DAT and at harvest, respectively) was observed from T_1 (No fertilizer; Control) which was significantly different from all other treatments followed by the treatment T_4 (1 NPK briquette of 2.40 sized). Similar results was also observed by Rahman *et al*. (2016) and Debnath *et al*. (2013). They also found that nutrient application using deep placement methods had significant influence on plant height of rice.

Table 1. Plant height of boro rice influenced by NPK briquettes and/or other fertilizers

Treatment	Plant height (cm)			
	30 DAT	60 DAT	90 DAT	At harvest
T_1	27.54 e	57.30 e	78.80 e	80.24 e
T_2	36.94 c	65.81 d	94.40 c	96.14 c
T_3	37.12 c	68.70 c	94.67 c	97.58 c
T_4	33.66 d	64.42 d	91.38 d	93.57 d
T_5	40.84 b	76.62 a	98.48 b	106.66 a
T_6	41.32 a	77.48 a	100.75 a	107.42 a
T_7	37.50 c	71.64 b	94.36 c	102.52 b
T_8	42.56 a	78.90 a	102.60 a	108.68 a
$LSD_{0.05}$	1.046	1.204	2.012	2.117
CV (%)	6.317	8.529	10.142	10.328

T_1 = No fertilizer (Control)
T_2 = RFD (RFD-N120 P30 K50)
T_3 = 2 NPK briquette of 2.40 sized(N130-P30-K55)
T_4 = 1 NPK briquette of 2.40 sized
T_5 = 3 NPK briquette of 2.40 sized
T_6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
T_7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
T_8 = 3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF

4.1.2 Number of tillers hill^{-1}

Different treatments of NPK briquette had significant influence on number of tillers hill^{-1} of boro rice (BRRI dhan29) at different growth stages (Table 2 and Appendix VI). Results signified that most of the treatment showed promising effect on number of tillers hill^{-1} compared to control treatment. It was noted that the highest number of tillers hill^{-1} (4.60, 16.44, 22.90 and 9.32 at 30, 60, 90 DAT and at harvest, respectively) was achieved from the treatment of T_3 (2 NPK briquette of 2.40 sized) which was statistically identical with T_2 (RFD (Recommended fertilizer dose) followed by T_6 (2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF). The lowest number of tillers hill^{-1}(1.50, 7.60, 10.12 and 9.32 at 30, 60, 90 DAT and at harvest, respectively) was observed from T_1 (No fertilizer; Control) treatment which was significantly different from all other treatments followed by the treatment T_4 (1 NPK briquette of 2.40 sized). The result on number of tillers hill^{-1} under the present study was in agreement with the findings of Rahman *et al*. (2016), Debnath *et al*. (2013) and Naznin*et al*. (2013).

Table 2. Number of tillers hill^{-1} of boro rice influenced by NPK briquettes and/or other fertilizers

Treatment	Number of effective tillers hill^{-1} at harvest
T_1	9.32 f
T_2	20.72 a
T_3	21.56 a
T_4	13.52 e
T_5	17.52 c
T_6	19.24 b
T_7	17.38 c
T_8	15.32 d
$LSD_{0.05}$	1.124
CV (%)	9.317

T_1 = No fertilizer (Control)
T_2 = RFD (RFD-N120 P30 K50)
T_3 = 2 NPK briquette of 2.40 sized(N130-P30-K55)
T_4 = 1 NPK briquette of 2.40 sized
T_5 = 3 NPK briquette of 2.40 sized
T_6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
T_7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
T_8 = 3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF

4.2 Yield contributing parameters

4.2.1 Number of effectivetillers hill^{-1}

Number of effective tillers hill^{-1} at the time of harvest varied significantly due to different treatments of NPK briquettes (Table 3 and Appendix VII). Results denoted that the highest number of effective tillers hill^{-1} (20.66) was found from the treatment, T_3 (2 NPK briquettes of 2.40 sized) which was statistically identical with the treatment, T_2 (RFD (Recommended fertilizer dose). Treatment, T_5 (3 NPK briquette of 2.40 sized) and T_7 (1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF) also gave comparatively higher results on number of effective tillers hill^{-1} but significantly different from highest results. Results also revealed that the lowest number of effective tillers hill^{-1} (7.72) was found from the treatment, the treatment, T_1 (No fertilizer; Control) which was nearest to the treatment of T_4 (1 NPK briquette of 2.40 sized) but significantly different from each other. Similar results was also observed by Rahman *et al*. (2016), Debnath *et al*. (2013) and Naznin*et al*. (2013).

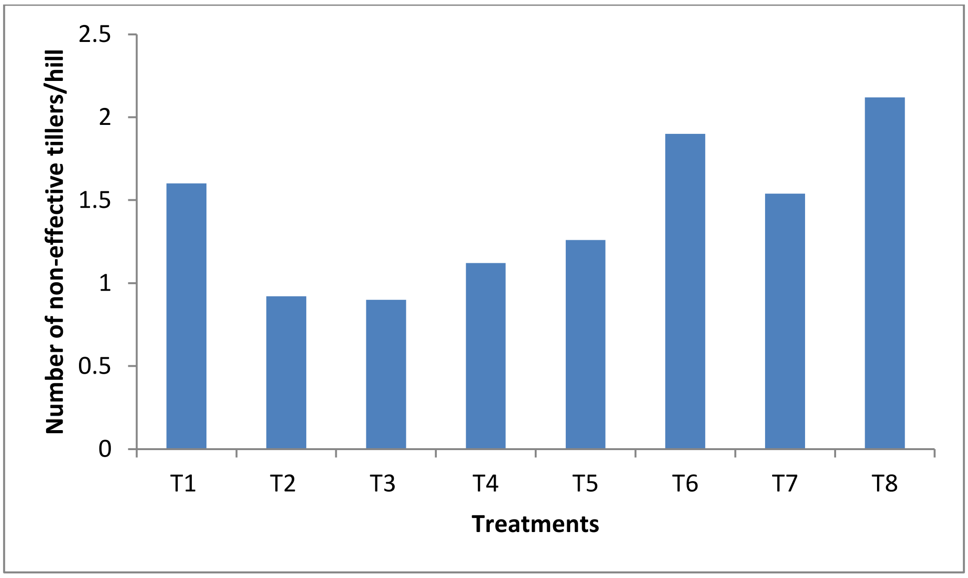
1. Table 3. Number of effective tillers hill^{-1} of boro riceBRRI dhan29 influenced by NPK briquettes and/or other fertilizers.

Treatment	Number of effective tillers hill^{-1}
T_1	7.72 g
T_2	19.80 a
T_3	20.66 a
T_4	12.40 ef
T_5	16.26 bc
T_6	15.48 cd
T_7	17.70 b
T_8	13.20 e
$LSD_{0.05}$	1.042
CV (%)	8.146

T_1 = No fertilizer (Control)
T_2 = RFD (RFD-N120 P30 K50)
T_3 = 2 NPK briquette of 2.40 sized(N130-P30-K55)
T_4 = 1 NPK briquette of 2.40 sized
T_5 = 3 NPK briquette of 2.40 sized
T_6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
T_7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
T_8 = 3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF

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

Different treatments of NPK briquettes showed significant influence on number of non-effective tillers hill^{-1} (Fig. 1 and Appendix VII). Results showed that at the time of harvest, the highest number of non-effective tillers hill^{-1} (2.12) was found from the treatment, T_8 (3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF) which was statistically identical with the treatment, T_1 (No fertilizer; Control), T_5 (3 NPK briquette of 2.40 sized), T_6 (2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF) and T_7 (1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF). The lowest number of non-effective tillers hill^{-1} (0.90) was found from the treatment, T_3 (2 NPK briquette of 2.40 sized) which was statistically identical with T_2 (RFD (Recommended fertilizer dose).

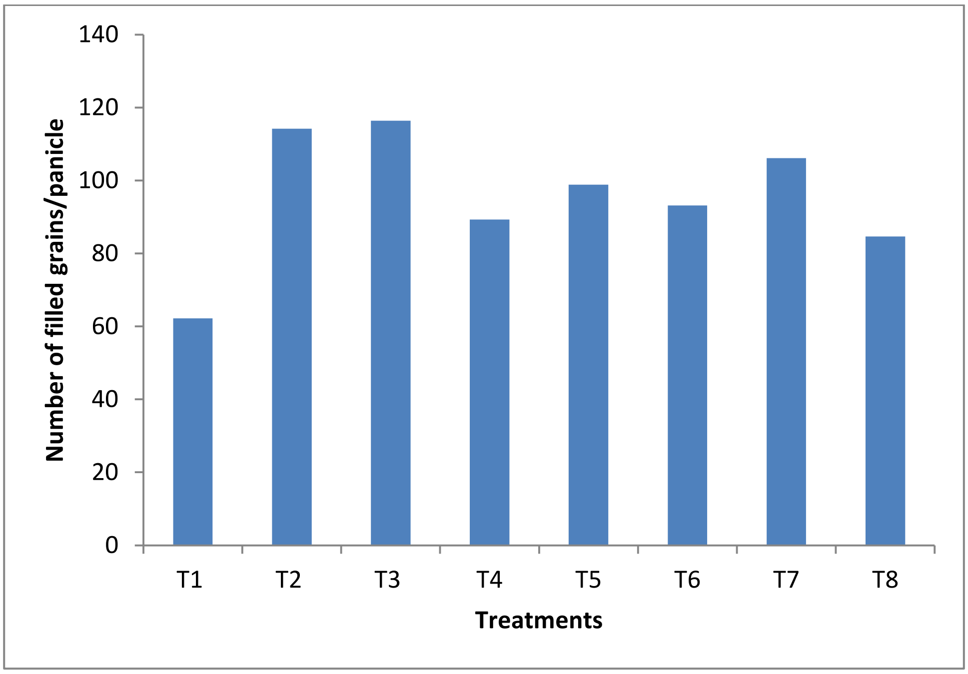


1. Fig. 1. Number of non-effective tillers hill^{-1} of boro rice (BRRI dhan29) influenced by NPK briquettes and/or other fertilizers.

T_1 = No fertilizer (Control)
T_2 = RFD (RFD-N120 P30 K50)
T_3= 2 NPK briquette of 2.40 gm sized (N130-P30-K55)
T_4 = 1 NPK briquette of 2.40 sized
T_5 = 3 NPK briquette of 2.40 sized
T_6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
T_7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
T_8 = 3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF

4.2.3 Number of filled grains panicle^{-1}

Remarkable variation was observed on number of filled grains panicle^{-1} influenced by different treatments of NPK briquettes (Fig. 2 and Appendix VIII). Results signified that that the highest number of filled grains panicle^{-1}(116.36) was found from the treatment, T_3 (2 NPK briquettes of 2.40 sized) which was statistically identical with the treatment, T_2 (RFD (Recommended fertilizer dose) followed by the treatment, T_7 (1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF). The lowest number of filled grains panicle^{-1}(62.20) was found from the treatment, T_1 (No fertilizer; Control) which was significantly different from all other treatments followed by T_8 (3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF). The treatment of T_4 (1 NPK briquette of 2.40 sized) and T_7 (1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF) also showed comparatively lower number of filled grains panicle^{-1} but significantly different from T_1 (No fertilizer; Control).

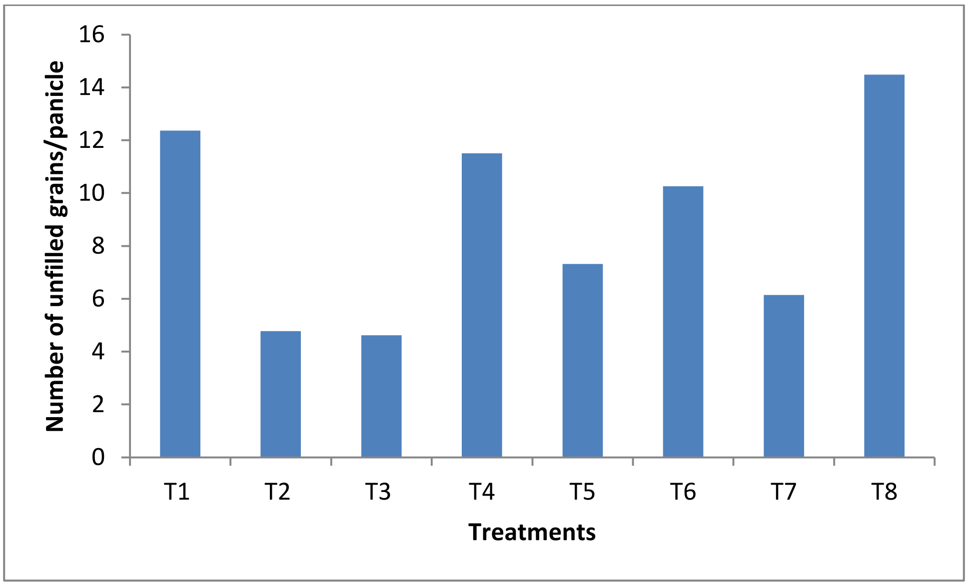


1. Fig. 2. Number of filled grains panicle^{-1} of boro rice (BRRI dhan29) influenced by NPK briquettes and/or other fertilizers

T_1 = No fertilizer (Control)
T_2 = RFD (RFD-N120 P30 K50)
T_3= 2 NPK briquette of 2.40 gm sized (N130-P30-K55)
T_4 = 1 NPK briquette of 2.40 sized
T_5 = 3 NPK briquette of 2.40 sized
T_6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
T_7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
T_8 = 3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF

4.2.4 Number of unfilled grains panicle^{-1}

Remarkable variation was observed on number of unfilled grains panicle^{-1} influenced by different treatments of NPK briquettes (Fig. 3 and Appendix VIII). It was noted that that the lowest number of unfilled grains panicle^{-1} (4.62) was found from the treatment, T_3 (2 NPK briquettes of 2.40 sized) which was statistically identical with the treatment, T_2 (RFD (Recommended fertilizer dose) followed by the treatment, T_7 (1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF). The highest number of unfilled grains panicle^{-1} (14.48) was found from the treatment, T_8 (3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF) which was significantly different from all other treatments followed by T_1 (No fertilizer; Control).



1. Fig. 3. Number of unfilled grains panicle^{-1} of bororice(BRRI dhan29) influenced by NPK briquettes and/or other fertilizers

T_1 = No fertilizer (Control)
T_2 = RFD (RFD-N120 P30 K50)
T_3= 2 NPK briquette of 2.40 gm sized (N130-P30-K55)
T_4 = 1 NPK briquette of 2.40 sized
T_5 = 3 NPK briquette of 2.40 sized
T_6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
T_7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
T_8 = 3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF

Significantvariation was observed on number of total grains panicle^{-1} influenced by different treatments of NPK briquettes (Table 3 and Appendix VIII). Results signified that that the highest number of total grains panicle^{-1} (120.98) was found from the treatment, T_3 (2 NPK briquettes of 2.40 sized) which was statistically identical with the treatment, T_2 (RFD (Recommended fertilizer dose) followed by the treatment, T_7 (1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF). The lowest number of total grains panicle^{-1} (74.56) was found from the treatment, T_1 (No fertilizer; Control) which was significantly different from all other treatments followed by T_8 (3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF).

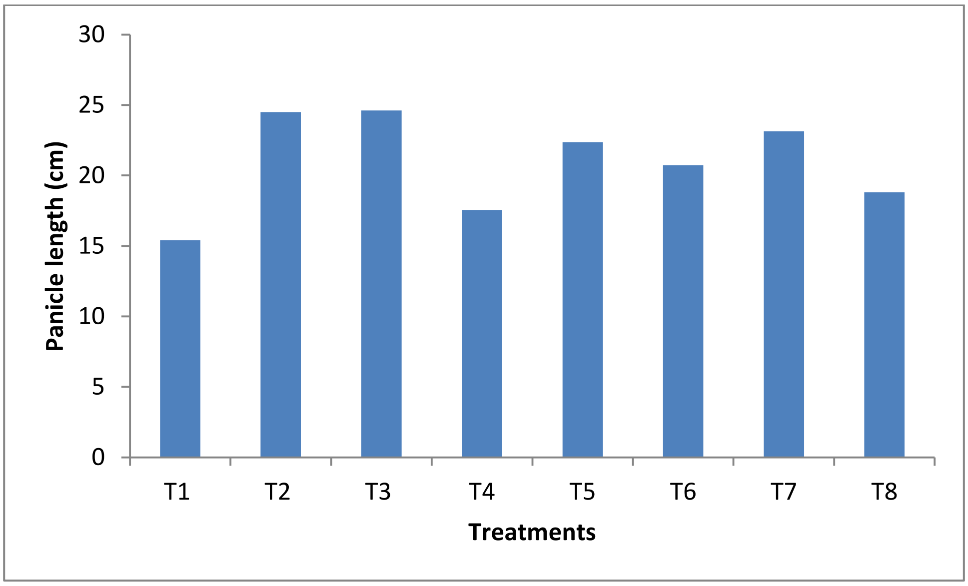
1. Table 4. Number of total grains panicle^{-1} of boro rice (BRRI dhan29) influenced by NPK briquettes and/or other fertilizers

Treatment	Number of total grains panicle^{-1}
T_1	74.56 f
T_2	118.96 a
T_3	120.98 a
T_4	100.80 e
T_5	106.12 c
T_6	103.43 d
T_7	112.29 b
T_8	99.11 e
$LSD_{0.05}$	1.104
CV (%)	10.249

T_1 = No fertilizer (Control)
T_2=RFD (RFD-N120 P30 K50)
T_3 = 2 NPK briquette of 2.40 gm sized (N130-P30-K55)
T_4 = 1 NPK briquette of 2.40 sized
T_5 = 3 NPK briquette of 2.40 sized
T_6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
T_7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RD
T_8 = 3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RD

4.2.6 Panicle length (cm)

Significant variation was remarked on panicle length (cm) as influenced by different treatments of NPK briquettes (Fig. 4 and Appendix IX). Results exposed that the highest panicle length (24.62 cm) was found from the treatment, T_3 (2 NPK briquette of 2.40 sized) which was statistically identical with T_2 (RFD (Recommended fertilizer dose) followed by T_5 (3 NPK briquette of 2.40 sized) and T_7 (1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF). Similarly, the lowest panicle length (15.40 cm) was found from the treatment, T_1 (No fertilizer; Control) which was close to the treatment of T_8 (3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF) but significantly different to each other. The result on number of tillers hill^{-1} under the present study was in agreement with the findings of Rahman *et al*. (2016), Debnath *et al*. (2013) and Naznin*et al*. (2013).



1. Fig. 4. Panicle length of boro rice(BRRI dhan29) influenced by NPK briquettes and/or other fertilizers

T_1 = No fertilizer (Control)
T_2 = RFD (RFD-N120 P30 K50)
T_3 = 2 NPK briquette of 2.40 sized(N130-P30-K55)
T_4 = 1 NPK briquette of 2.40 sized
T_5 = 3 NPK briquette of 2.40 sized
T_6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
T_7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
T_8 = 3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF

4.2.7 Weight of 1000 grains

Variation onWeight of 1000 grainswas noted influenced by different treatments of NPK briquettes (Table 1 and Appendix IX). It was observed that the highest 1000 grain weight (21.20 g) was found from the treatment, T_2 (RFD (Recommended fertilizer dose) which was statistically identical with T_3 (2 NPK briquette of 2.40 sized) and T_7 (1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF) and statistically similar with T_5 (3 NPK briquette of 2.40 sized). It was also noted that that the lowest 1000 grain weight (17.30 g) was found from the treatment, T_1 (No fertilizer; Control) followed by T_6 (2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF). The results under the study was similar with the findings of Rahman *et al*. (2016), Debnath *et al*. (2013) and Naznin*et al*. (2013).

1. Table 5. Weight of 1000 grains ofboro rice(BRRI dhan29) influenced by NPK briquettes and/or other fertilizers

Treatment	1000 grain weight (g)
T_1	17.30 d
T_2	21.20 a
T_3	21.12 a
T_4	19.44 c
T_5	20.42 ab
T_6	20.04 b
T_7	20.88 a
T_8	19.78
$LSD_{0.05}$	1.016
CV (%)	5.389

T_1 = No fertilizer (Control)
T_2 = RFD (RFD-N120 P30 K50)
T_3 = 2 NPK briquette of 2.40 gm sized (N130-P30-K55)
T_4 = 1 NPK briquette of 2.40 sized
T_5 = 3 NPK briquette of 2.40 sized
T_6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
T_7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RD
T_8 = 3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RD

4.3 Yield parameters

4.3.1 Grain yield

Significant variation was observed on the grain yield of rice as influenced by different treatments of NPK briquettes (Table 4 and Appendix X). Results revealed that the highest grain yield (8.44 t ha^{-1}) was found from the treatment, T_3 (2 NPK briquette of 2.40 sized) which was statistically similar with the treatment, T_2 (RFD (Recommended fertilizer dose) followed by T_5 (3 NPK briquette of 2.40 sized) and T_7 (1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF). The lowest grain yield (3.93 t ha^{-1}) was found from the treatment, T_1 (No fertilizer; Control) which was significantly lower than all other treatments followed byT_4 (1 NPK briquette of 2.40 sized). The result on grain yieldunder the present study was in agreement with the findings of Rahman *et al*. (2016), Debnath *et al*. (2013) and Naznin*et al*. (2013).

4.3.2 Straw yield

Variation on straw yield was noted influenced by different treatments of NPK briquettes (Table 4 and Appendix X). It was observed that the highest strawyield (9.88 t ha^{-1}) was found from the treatment, T_3 (2 NPK briquette of 2.40 sized) which was statistically identical with T_2 (RFD (Recommended fertilizer dose)followed by T_7 (1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF) and T_5 (3 NPK briquette of 2.40 sized). The lowest straw yield (6.14 t ha^{-1}) was found from the treatment, T_1 (No fertilizer; Control) which was significantly inferior to all other treatments followed T_4 (1 NPK briquette of 2.40 sized).

Table 6. Grain yield and straw yield of boro rice (BRRI dhan29) influenced by NPK briquettes and/or other fertilizers

Treatment	Yield parameters	
	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	3.93 h	6.14 e
T_2	8.10 ab	9.72 a
T_3	8.44 a	9.88 a
T_4	5.60 g	8.10 d
T_5	7.36 cd	9.44 b
T_6	6.88 e	8.76 c
T_7	7.52 c	9.30 b
T_8	6.14 f	8.92 c
$LSD_{0.05}$	0.248	0.304
CV (%)	6.818	7.689

T_1 = No fertilizer (Control)
T_2 = RFD (RFD-N120 P30 K50)
T_3 = 2 NPK briquette of 2.40 gm sized (N130-P30-K55)
T_4 = 1 NPK briquette of 2.40 sized
T_5 = 3 NPK briquette of 2.40 sized
T_6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
T_7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RD
T_8 = 3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RD

4.3.3 Biological yield

Similarly there was a significant variation was remarked on biological yield as influenced by different treatments of NPK briquettes (Fig. 5 and Appendix X). Results revealed that the highest biological yield (18.32 t ha^{-1}) was found from the treatment, T_3 (2 NPK briquette of 2.40 sized) which was significantly different from all other treatments but the treatment, T_2 (RFD (Recommended fertilizer dose) gave closest result with T_3 (2 NPK briquette of 2.40 sized). However, the lowest biological yield (10.07 t ha^{-1}) was found from the treatment, T_1 (No fertilizer; Control) which was also significantly different from all other treatments followed by T_4 (1 NPK briquette of 2.40 sized).

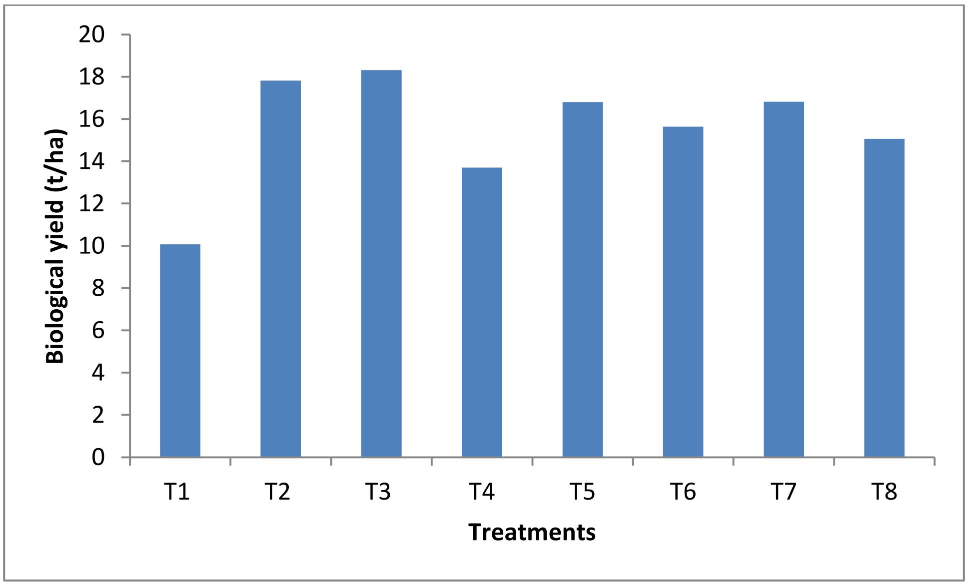


Fig. 5. Biological yield of boro rice (BRRI dhan29) influenced by NPK briquettes and/or other fertilizers .

T_1 = No fertilizer (Control)
T_2 = RFD (RFD-N120 P30 K50)
T_3 = 2 NPK briquette of 2.40 gm sized (N130-P30-K55)
T_4 = 1 NPK briquette of 2.40 sized
T_5 = 3 NPK briquette of 2.40 sized
T_6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
T_7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
T_8 = 3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF

4.3.4 Harvest index

Significant variation was recorded on harvest index of rice as influenced by different treatments of NPK briquettes (Fig.6 and Appendix X). Results signified that the highest harvest index (46.07%) was found from the treatment, T_3 (2 NPK briquette of 2.40 sized) followed by the treatment, T_2 (RFD (Recommended fertilizer dose). Again , the lowest harvest index (39.03%[1]) was found from the treatment, T_1 (No fertilizer; Control) which was significantly different from all other treatments followed by T_4 (1 NPK briquette of 2.40 sized).

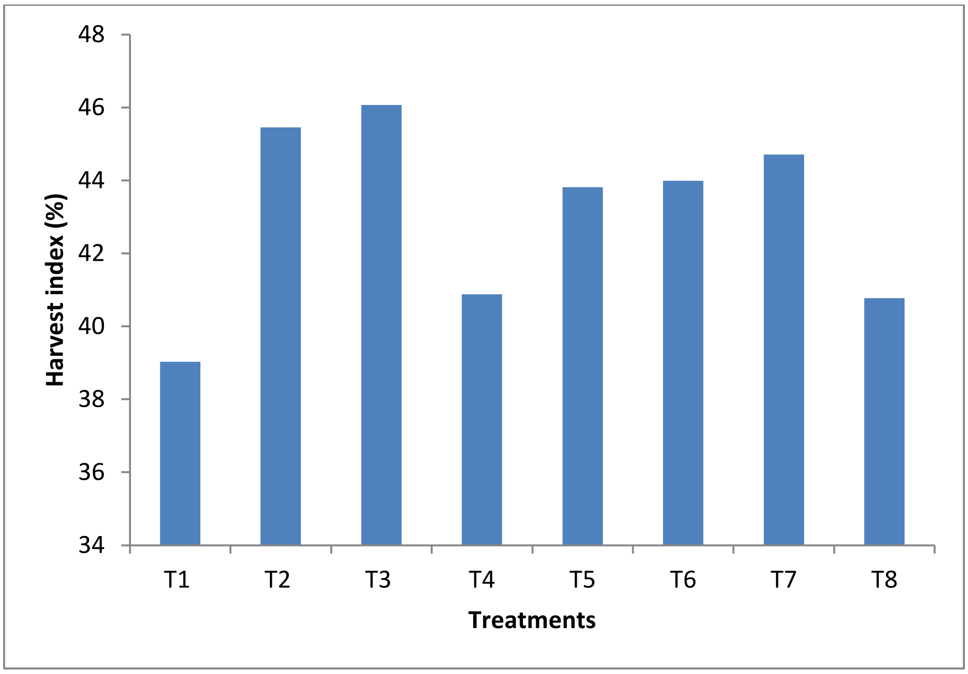


Fig. 6. Harvest index of boro rice (BRRI dhan29)influenced by NPK briquettes and/or other fertilizers .

T_1 = No fertilizer (Control)
T_2 = RFD (RFD-N120 P30 K50)
T_3 = 2 NPK briquette of 2.40 gm sized (N130-P30-K55)
T_4 = 1 NPK briquette of 2.40 sized
T_5 = 3 NPK briquette of 2.40 sized
T_6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
T_7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
T_8 = 3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF

4.4 Nutrient (N, P and K) content in post-harvest soil

Nutrient (N, P and K) content in post-harvest soil showed significant variation due to the effect of NPK briquettes (Table 1 and Appendix V). It was observed that the N content varied from 0.044% to 0.096%, available P content varied from 15.36 ppm to 23.72ppm and exchangeable K content varied from 0.110 to 0.129meq/100 g soil (Table 7). Results indicated that the highest value of the N, P and K content in post-harvest soil were obtained from those soils which was treated by the treatment, T_8 (3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF). Similarly, the treatment, T_1 (No fertilizer; Control) treated soil showed the lowest N, P and K content.

Table 7. Nutrient (N, P and K) content in post-harvest soil of bororice(BRRI dhan29) influenced by NPK briquettes and/or other fertilizers

Treatment	Nutrient (N, P and K) content in post-harvest soil		
	N (%)	Available P (ppm)	Exchangeable K (meq/100 g soil)
T_1	0.044 d	15.36 e	0.110 d
T_2	0.074 bc	19.24 c	0.119 b
T_3	0.080 b	19.66 c	0.116 c
T_4	0.072 bc	17.54 d	0.112 d
T_5	0.087 ab	21.78 ab	0.121 b
T_6	0.090 ab	23.18 a	0.126 a
T_7	0.084 b	22.94 a	0.120 b
T_8	0.096 a	23.72 a	0.129 a
$LSD_{0.05}$	0.014	1.032	0.013
CV (%)	3.146	3.067	2.841

T_1 = No fertilizer (Control)
T_2 = RFD (RFD-N120 P30 K50)
T_3 = 2 NPK briquette of 2.40 gm sized (N130-P30-K55)
T_4 = 1 NPK briquette of 2.40 sized
T_5 = 3 NPK briquette of 2.40 sized
T_6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
T_7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RD
T_8 = 3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RD

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was carried out at the Research Farm, Sher-e-Bangla Agricultural University, Dhaka during the period from November 2016 to May 2017 to study the effect of NPK briquette on the growth and yield of boro rice (BRRI dhan29) . 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 consisted of one factor*viz*.T_1 (No fertilizer; Control), T_2 (RFD (Recommended fertilizer dose), T_3 (2 NPK briquette of 2.40 sized), T_4 (1 NPK briquette of 2.40 sized), T_5 (3 NPK briquette of 2.40 sized), T_6 (2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF), T_7 (1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF) and T_8 (3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF). BRRI dhan29 was used for the experiment. The experiment was laid out following split plot design with three replications. There were 24 unit plots. The size of unit plot was 7 m (3.5 m ×2 m).

Results revealed that the entire treatments had significant effect on different growth yield and yield contributing parameters and also nutrient content in post-harvest soil. It was observed that the highest plant height (42.56, 78.90, 102.60 and 108.68 cm at 30, 60, 90 DAT and at harvest, respectively) was achieved from the treatment of T_8 (3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF) where the highest number of tillers hill^{-1} (4.60, 16.44, 22.90 and 9.32 at 30, 60, 90 DAT and at harvest, respectively) was achieved from the treatment of T_3 (2 NPK briquette of 2.40 sized).Again, the highest number of non-effective tillers hill^{-1} (2.12) and number of unfilled grains panicle^{-1} (14.48) were found from the treatment, T_8 (3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF). Results also revealed that the highest number of effective tillers hill^{-1} (20.66), number of filled grains panicle^{-1} (116.36), number of total grains panicle^{-1} (120.98), panicle length (24.62 cm), grain yield (8.44 t ha^{-1}), stover yield (9.88 t ha^{-1}), biological yield (18.32 t ha^{-1}) and harvest index (46.07%) were found from the treatment, T_3 (2 NPK briquette of 2.40 sized) but the highest 1000 grain weight (21.20 g) was found from the treatment, T_2 (RFD (Recommended fertilizer dose).

On the other hand, the lowest plant height (27.54, 57.30, 78.80 and 80.24 cm at 30, 60, 90 DAT and at harvest, respectively) and number of tillers hill^{-1} (1.50, 7.60, 10.12 and 9.32 at 30, 60, 90 DAT and at harvest, respectively) were observed from T_1 (No fertilizer; Control). Similarly, the lowest number of effective tillers hill^{-1} (7.72), lowest number of filled grains panicle^{-1} (62.20), lowest number of total grains panicle^{-1} (74.56), lowest panicle length (15.40 cm), lowest 1000 grain weight (17.30 g) , lowest grain yield (3.93 t ha^{-1}) , lowest straw yield (6.14 t ha^{-1}) , lowest biological yield (10.07 t ha^{-1}) and lowest harvest index (39.03%^{1}) were found from T_1 (No fertilizer; Control). But the lowest number of non-effective tillers hill^{-1} (0.90) and number of unfilled grains panicle^{-1} (4.62) was found from the treatment, T_3 (2 NPK briquettes of 2.40 sized).

Results also indicated that the highest value of the N, P and K content in postharvest soil were obtained from treatment, T_8 (3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF) and T_1 (No fertilizer; Control) treated soil showed the lowest.

From the above findings, it can be concluded that the treatment T_3 (2 NPK briquette of 2.40 sized) gave the best results regarding growth, yield and yield contributing parameters. The treatment, T_2 (RFD (Recommended fertilizer dose) also showed better performance which was very close to the treatment T_3 (2 NPK briquette of 2.40 sized) regarding the respected parameters. So, among all the treatments, T_3 (2 NPK briquette of 2.40 sized) can be considered as the best treatment followed by T_2 (RFD (Recommended fertilizer dose).

Recommendations

The experiment was conducted using only one rice variety in one growing season. However, to reach a specific conclusion and recommendation further research is suggested with different application methods of NPK (along with other fertilizer and manure) with some other varieties and season in different agro-ecological zones of Bangladesh.

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APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location

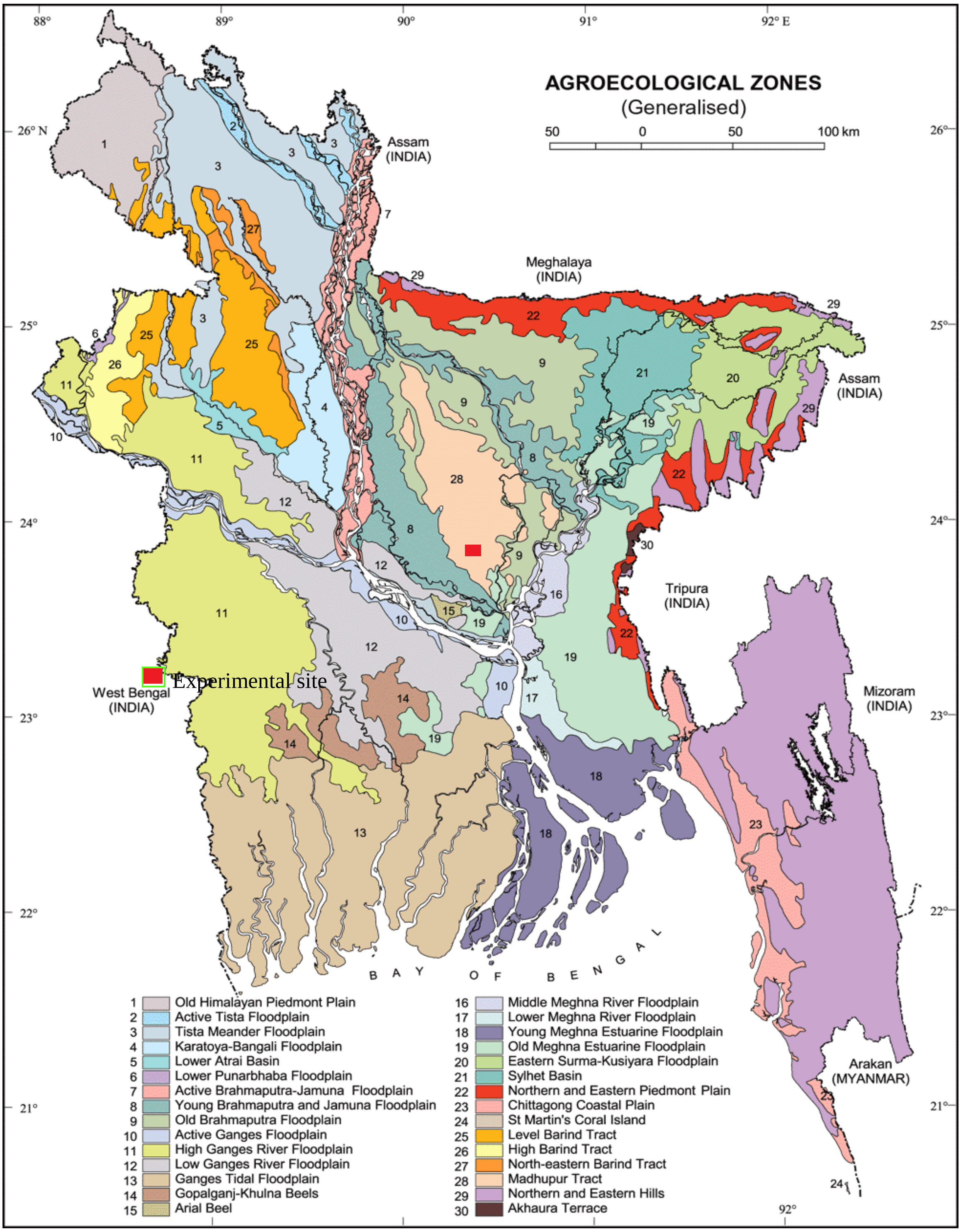

Fig. 7. Experimental site

Appendix II. Monthly records of air temperature, relative humidity, rainfall and sunshine hours during the period from March to June, 2017

Month	RH (%)	Air temperature (C)			Rainfall (mm)
		Max.	*Min.*	*Mean*	
December,	54.80	25.50	6.70	16.10	0.0
January, 2017	46.20	23.80	11.70	17.75	0.0
February, 2017	37.90	22.75	14.26	18.51	0.0
March, 2017	52.44	35.20	21.00	28.10	20.4
April, 2017	65.40	34.70	24.60	29.65	165.0
May, 2017	68.30	32.64	23.85	28.25	182.2

Appendix III.

The mechanical and chemical characteristics of soil of the experimental site as observed prior to experimentation

Particle size constitution:

Sand	:	40 %
Silt	:	40 %
Clay	:	20 %
Texture	:	Loamy

Chemical composition:

Constituents	:	0-15 cm depth
pH	:	5.61
Total N (%)	:	0.07
Available P (µ gm/gm)	:	18.49
Exchangeable K (m. eq./100gm)	:	0.12
Available S (µ gm/gm)	:	12.0

Appendix IV. Layout of the experiment field

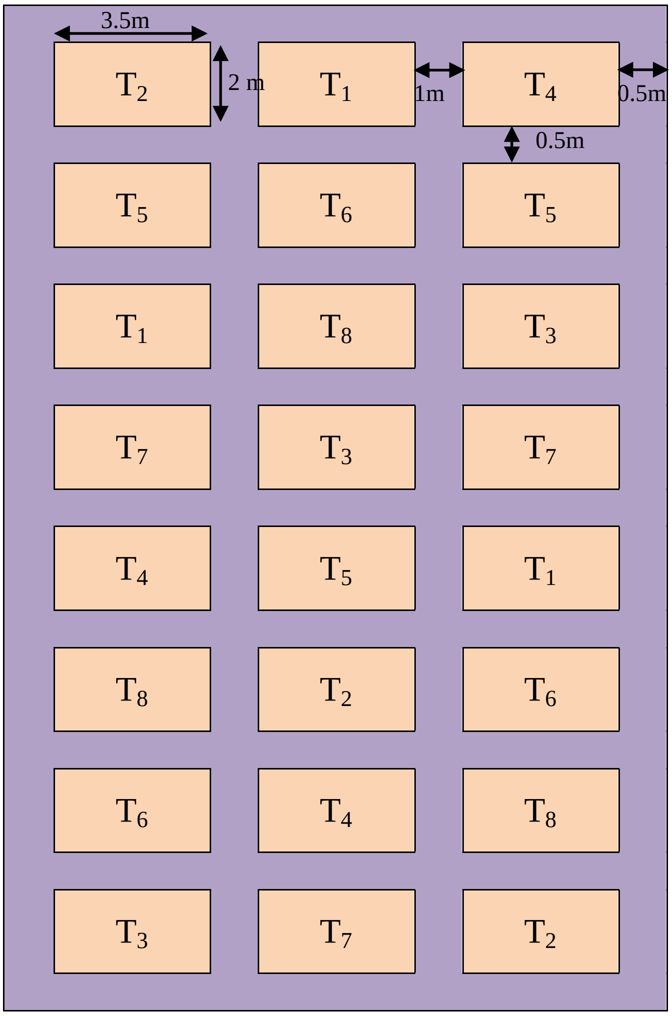

Fig. 8. Layout of the experimental plot

Appendix V. Plant height of boro rice influenced by NPK granules and/or other fertilizers

Source of variation	Degrees of freedom	Mean square of plant height			
		30 DAT	60 DAT	90 DAT	At harvest
Replication	2	0.544	1.316	1.056	1.247
Factor A	7	12.322*	18.391*	23.48*	28.319*
Error	14	1.507	1.347	2.445	2.048

Appendix VI.Number of tillers hill^{-1} of boro rice influenced by NPK granules and/or other fertilizers

Source of variation	Degrees of freedom	Mean square of number of tillers hill^{-1}			
		30 DAT	60 DAT	90 DAT	At harvest
Replication	2	0.116	0.148	0.228	1.074
Factor A	7	4.218**	7.379**	8.204*	13.546*
Error	14	0.162	0.312	0.417	1.252

Appendix VII.Number of effective and non-effective tillers hill^{-1} of boro rice influenced by NPK granules and/or other fertilizers

Source of variation	Degrees of freedom	Mean square of	
		Number of effective tillers hill^{-1}	Number of non-effective tillers hill^{-1}
Replication	2	0.311	0.075
Factor A	7	7.017**	3.228*
Error	14	0.526	0.214

Appendix VIII.Number of grains panicle^{-1} (filled and unfilled grains) of boro rice influenced by NPK granules and/or other fertilizers

Source of variation	Degrees of freedom	Mean square of Number of grains panicle^{-1}		
		Filled grains	Unfilled grains	Total
Replication	2	0.622	0.418	1.258
Factor A	7	32.482*	4.906*	38.216*
Error	14	2.302	0.216	2.421

Appendix IX.Panicle length and 1000 grain weight of boro rice influenced by NPK granules and/or other fertilizers

Source of variation	Degrees of freedom	Mean square of	
		Panicle length (cm)	1000 grain weight (g)
Replication	2	0.326	0.412
Factor A	7	12.421**	16.2371**
Error	14	1.042	1.128

Appendix X. Yield parameters of boro rice influenced by NPK granules and/or other fertilizers

Source of variation	Degrees of freedom	Mean square of yield parameters			
		Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index
Replication	2	0.522	0.483	0.129	0.107
Factor A	7	9.86*	12.49*	15.16*	10.29*
Error	14	0.541	1.316	1.227	0.731

Appendix XI.Nutrient (N, P and K) content in postharvest soil of boro rice influenced by NPK granules and/or other fertilizers

Source of variation	Degrees of freedom	Mean square of Nutrient (N, P and K) content in postharvest soil		
		N (%)	P (%)	K (%)
Replication	2	0.002	0.001	0.001
Factor A	7	0.882**	0.406*	0.516*
Error	14	0.007	0.006	0.003