International Journal of Multidisciplinary Informative Research and Review
2020; 1(2): 104-117
Published online October 31, 2020 (https://agribusinessedu.com/ijmirr-journal/)
DOI: 10.5281/zenodo.4309803
ISSN: 2709-6289 (Online)

Effect of NPK Briquette on the Growth and Yield of Boro Rice (BRRI Dhan29)

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To cite this article:
Pijush karmakar, Md. Wahidul Islam. Effect of NPK Briquette on the Growth and Yield of Boro Rice (BRRI Dhan29). *International Journal of Multidisciplinary Informative Research and Review*. Vol. 1, No. 2, 2020, pp. 104 -117.

Abstract: *An experiment was conducted at 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.T1 (No fertilizer; Control), T2 (RFD (Recommended fertilizer dose), T3 (2 NPK briquette of 2.40 sized), T4 (1 NPK briquette of 2.40 sized), T5 (3 NPK briquette of 2.40 sized), T6 (2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF), T7 (1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF) and T8 (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, T3 (2 NPK briquette of 2.40 sized). The lowest results on the respected parameters were found from T1 (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, T3 (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 T8 (3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF) and T1 (No fertilizer; Control) treated soil showed the lowest.*

Keywords: *Rice, Nutrient, Livelihood, Briquette, Experiment.*

1. 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.

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).

2. Literature Review

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 boro rice as affected by method of urea application have been reviewed in this study.

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.

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 P2O5 and 62.5 kg K2O 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.

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 m2, 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.

3. Objectives

In this aspect, the present study was, therefore, undertaken to find out the effect of NPK briquette on the growth and yield of boro rice BRRI 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.

4. Materials and Methods

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.

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.

Experimental details

Treatments

Treatments which were considered areas follow:

T1 = No fertilizer (Control)
T2 = RFD (RFD-N120 P30 K50)
T3 = 2 NPK briquette of 2.40 sized (N130-P30-K55)
T4 = 1 NPK briquette of 2.40 sized
T5 = 3 NPK briquette of 2.40 sized
T6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
T7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
T8 = 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, P2O5, K2O, S and Zn applied in the form of urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum and zinc sulphate respectively (Adhunik Dhaner Chas, 2011). The fertilizers were used according to the treatment designed.

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.

Crop/planting material

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

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.

Seed Collection

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

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.

Fertilizer application

The required fertilizers were applied according to the treatments. All the treatments except T1, T3, T4and T5 received 36 kg Pha-1 and 72 kg K ha-1 from TSP and MoP, respectively. In T3, T4 and T5 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 T1) 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.

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.

Transplanting of seedlings

Seedlings were transplanted on January 11, 2017 in the well-puddled experimental plots. Spacing was 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.

Collection of plant Samples

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

Recording of data

Data were collected on the following parameters-

Growth parameter

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

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 (%)

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.

5. 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.

Growth parameters

Plant height

Plant height of boro rice (BRRI dhan29) at different growth stages was significantly affected by different treatments of NPK briquette (Table 1). Different treatment demonstrated different plant height and results revealed that the treatment, T8 (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, T1 (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 T8 (3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF) which was statistically identical with T6 (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 T5 (3 NPK briquette of 2.40 sized) with T8 (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 T1 (No fertilizer; Control) which was significantly different from all other treatments followed by the treatment T4 (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**
T1	27.54 e	57.30 e	78.80 e	80.24 e
T2	36.94 c	65.81 d	94.40 c	96.14 c
T3	37.12 c	68.70 c	94.67 c	97.58 c
T4	33.66 d	64.42 d	91.38 d	93.57 d
T5	40.84 b	76.62 a	98.48 b	106.66 a
T6	41.32 a	77.48 a	100.75 a	107.42 a
T7	37.50 c	71.64 b	94.36 c	102.52 b
T8	42.56 a	78.90 a	102.60 a	108.68 a
LSD0.05	1.046	1.204	2.012	2.117
CV (%)	6.317	8.529	10.142	10.328

T1 = No fertilizer (Control)

T2 = RFD (RFD-N120 P30 K50)

T3 = 2 NPK briquette of 2.40 sized (N130-P30-K55)

T4 = 1 NPK briquette of 2.40 sized

T5 = 3 NPK briquette of 2.40 sized

T6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF T7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF T8 = 3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF.

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). 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 T3 (2 NPK briquette of 2.40 sized) which was statistically identical with T2 (RFD (Recommended fertilizer dose) followed by T6 (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 T1 (No fertilizer; Control) treatment which was significantly different from all other treatments followed by the treatment T4 (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

Treatment	Number of effective tillers hill-1 at harvest
T1	9.32 f
T2	20.72 a
T3	21.56 a
T4	13.52 e
T5	17.52 c
T6	19.24 b
T7	17.38 c
T8	15.32 d
LSD0.05	1.124
CV (%)	9.317

T1 = No fertilizer (Control)
T2 = RFD (RFD-N120 P30 K50)
T3 = 2 NPK briquette of 2.40 sized (N130-P30-K55)
T4 = 1 NPK briquette of 2.40 sized
T5 = 3 NPK briquette of 2.40 sized
T6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF T7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF T8 = 3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF.

Yield contributing parameters

Number of effective tillers hill-1

Number of effective tillers hill-1 at the time of harvest varied significantly due to different treatments of NPK briquettes (Table 3). Results denoted that the highest number of effective tillers hill-1 (20.66) was found from the treatment, T3 (2 NPK briquettes of 2.40 sized) which was statistically identical with the treatment, T2 (RFD (Recommended fertilizer dose). Treatment, T5 (3 NPK briquette of 2.40 sized) and T7 (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, T1 (No fertilizer; Control) which was nearest to the treatment of T4 (1 NPK briquette of 2.40 sized) but significantly different from each other. Similar results were also observed by Rahman *et al.* (2016), Debnath *et al.* (2013) and Naznin *et al*. (2013).

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

Treatment	Number of effective tillers hill-1
T1	7.72 g
T2	19.80 a
T3	20.66 a
T4	12.40 ef
T5	16.26 bc
T6	15.48 cd
T7	17.70 b
T8	13.20 e
LSD0.05	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

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). Results showed that at the time of harvest, the highest number of non-effective tillers hill-1 (2.12) was found from the treatment, T8 (3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF) which was statistically identical with the treatment, T1 (No fertilizer; Control), T5 (3 NPK briquette of 2.40 sized), T6 (2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF) and T7 (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, T3 (2 NPK briquette of 2.40 sized) which was statistically identical with T2 (RFD (Recommended fertilizer dose).

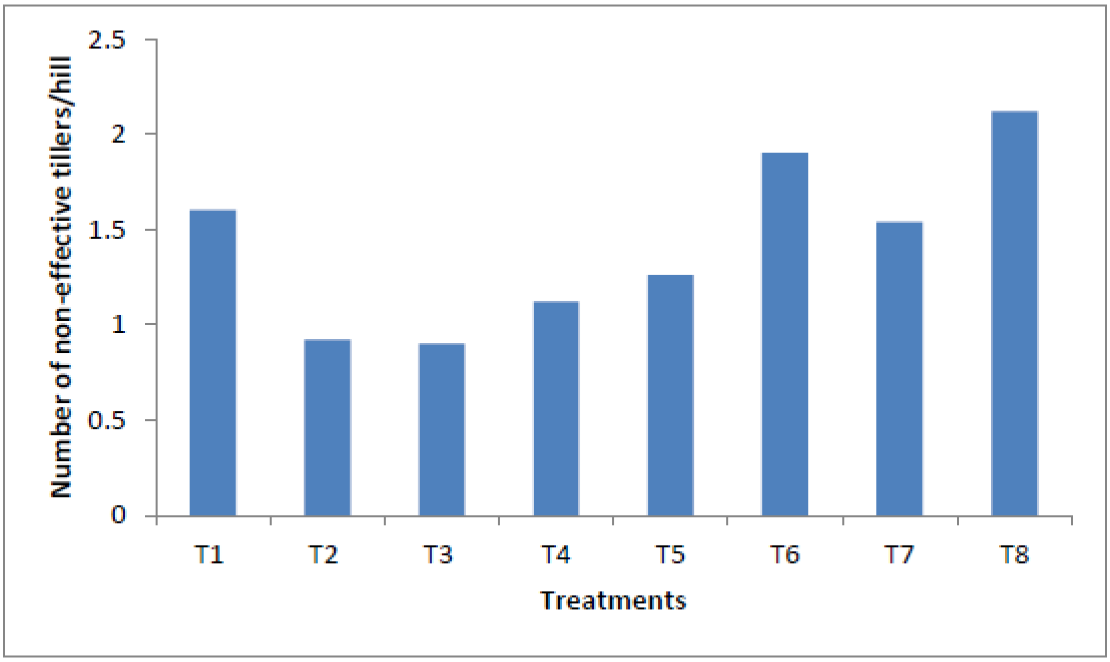

Fig. 1. Number of non-effective tillers hill-1 of boro rice (BRRI dhan29) influenced by NPK briquettes and/or other fertilizers.
T1 = No fertilizer (Control)
T2 = RFD (RFD-N120 P30 K50)
T3= 2 NPK briquette of 2.40 gm sized (N130-P30-K55)
T4 = 1 NPK briquette of 2.40 sized
T5 = 3 NPK briquette of 2.40 sized
T6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF T7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF T8 = 3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF

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). 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).

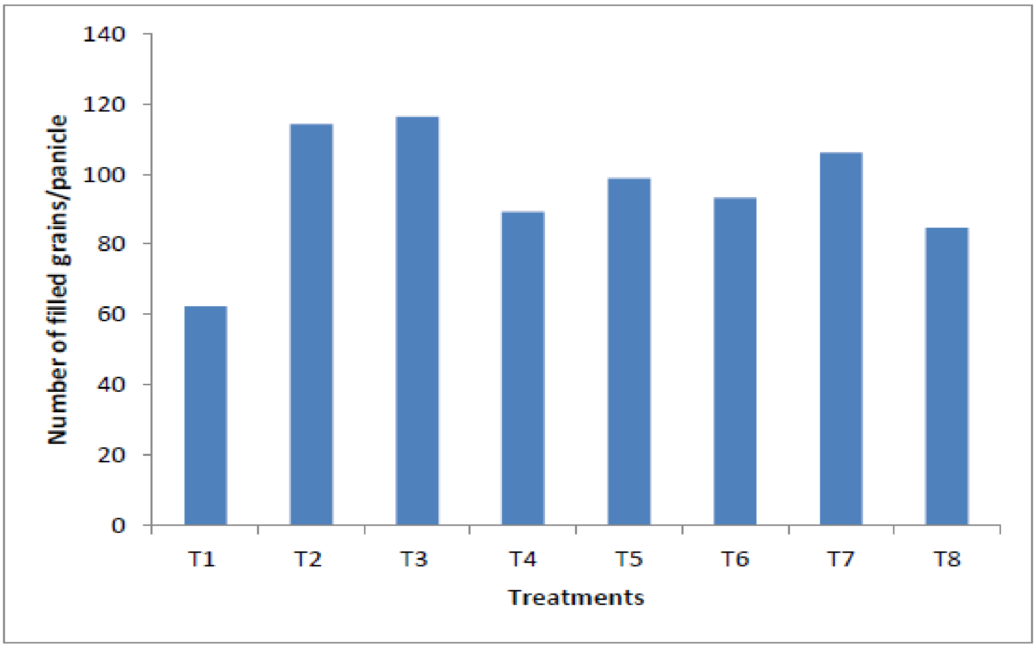

Fig. 2. Number of filled grains panicle-1 of boro rice (BRRI dhan29) influenced by NPK briquettes and/or other fertilizers
T1 = No fertilizer (Control)
T2 = RFD (RFD-N120 P30 K50)
T3= 2 NPK briquette of 2.40 gm sized (N130-P30-K55)
T4 = 1 NPK briquette of 2.40 sized
T5 = 3 NPK briquette of 2.40 sized
T6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF T7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF T8 = 3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF

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, T3 (2 NPK briquettes of 2.40 sized) which was statistically identical with the treatment, T2 (RFD (Recommended fertilizer dose) followed by the treatment, T7 (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, T8 (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 T1 (No fertilizer; Control).

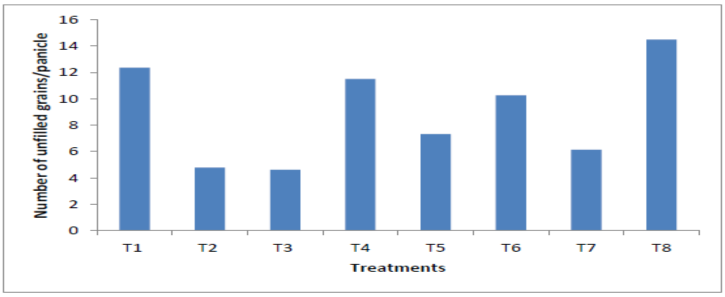

Fig. 3. Number of unfilled grains panicle-1 of bororice(BRRI dhan29) influenced by NPK briquettes and/or other fertilizers

T1 = No fertilizer (Control)
T2 = RFD (RFD-N120 P30 K50)
T3= 2 NPK briquette of 2.40 gm sized (N130-P30-K55)
T4 = 1 NPK briquette of 2.40 sized
T5 = 3 NPK briquette of 2.40 sized
T6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF T7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF T8 = 3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF
Significant variation 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, T3 (2 NPK briquettes of 2.40 sized) which was statistically identical with the treatment, T2 (RFD (Recommended fertilizer dose) followed by the treatment, T7 (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, T1 (No fertilizer; Control) which was significantly different from all other treatments followed by T8 (3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF).

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**
T1	74.56 f
T2	118.96 a
T3	120.98 a
T4	100.80 e
T5	106.12 c
T6	103.43 d
T7	112.29 b
T8	99.11 e
LSD0.05	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

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).

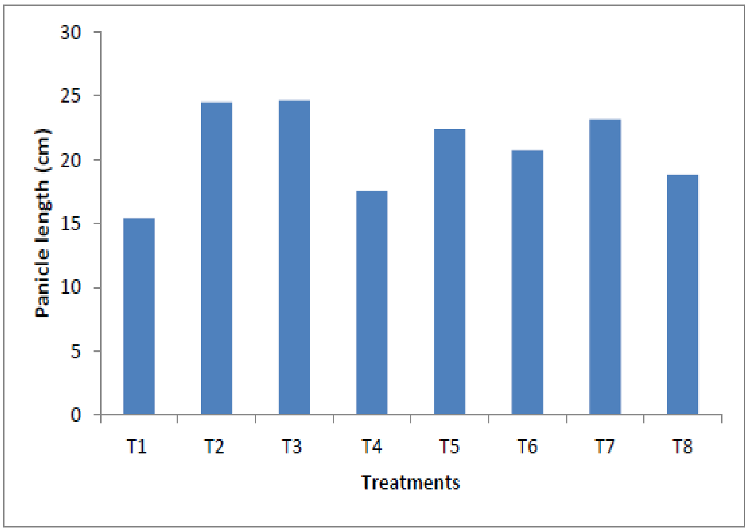

Fig. 4. Panicle length of boro rice(BRRI dhan29) influenced by NPK briquettes and/or other fertilizers
T1 = No fertilizer (Control)
T2 = RFD (RFD-N120 P30 K50)
T3 = 2 NPK briquette of 2.40 sized(N130-P30-K55)
T4 = 1 NPK briquette of 2.40 sized
T5 = 3 NPK briquette of 2.40 sized
T6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF T7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF T8 = 3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF

Weight of 1000 grains

Variation on Weight of 1000 grains was 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, T2 (RFD (Recommended fertilizer dose) which was statistically identical with T3 (2 NPK briquette of 2.40 sized) and T7 (1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF) and statistically similar with T5 (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, T1 (No fertilizer; Control) followed by T6 (2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF). The results under the study were similar with the findings of Rahman *et al.* (2016), Debnath *et al.* (2013) and Naznin *et al*. (2013).

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

Treatment	1000 grain weight (g)
T1	17.30 d
T2	21.20 a
T3	21.12 a
T4	19.44 c
T5	20.42 ab
T6	20.04 b
T7	20.88 a
T8	19.78
LSD0.05	1.016
CV (%)	5.389

T1 = No fertilizer (Control)
T2 = RFD (RFD-N120 P30 K50)
T3 = 2 NPK briquette of 2.40 gm sized (N130-P30-K55)

T4 = 1 NPK briquette of 2.40 sized
T5 = 3 NPK briquette of 2.40 sized
T6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF T7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RD T8 = 3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RD

Yield parameters

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, T3 (2 NPK briquette of 2.40 sized) which was statistically similar with the treatment, T2 (RFD (Recommended fertilizer dose) followed by T5 (3 NPK briquette of 2.40 sized) and T7 (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, T1 (No fertilizer; Control) which was significantly lower than all other treatments followed byT4 (1 NPK briquette of 2.40 sized). The result on grain yield under the present study was in agreement with the findings of Rahman *et al.* (2016), Debnath *et al. (*2013) and Naznin *et al*. (2013).

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 straw yield (9.88 t ha-1) was found from the treatment, T3 (2 NPK briquette of 2.40 sized) which was statistically identical with T2 (RFD (Recommended fertilizer dose)followed by T7 (1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF) and T5 (3 NPK briquette of 2.40 sized). The lowest straw yield (6.14 t ha-1) was found from the treatment, T1 (No fertilizer; Control) which was significantly inferior to all other treatments followed T4 (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)**
T1	3.93 h	6.14 e
T2	8.10 ab	9.72 a
T3	8.44 a	9.88 a
T4	5.60 g	8.10 d
T5	7.36 cd	9.44 b
T6	6.88 e	8.76 c
T7	7.52 c	9.30 b
T8	6.14 f	8.92 c
LSD0.05	0.248	0.304
CV (%)	6.818	7.689

T1 = No fertilizer (Control)
T2 = RFD (RFD-N120 P30 K50)
T3 = 2 NPK briquette of 2.40 gm sized (N130-P30-K55)
T4 = 1 NPK briquette of 2.40 sized
T5 = 3 NPK briquette of 2.40 sized
T6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF T7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RD T8 = 3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RD

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, T3 (2 NPK briquette of 2.40 sized) which was significantly different from all other treatments but the treatment, T2 (RFD (Recommended fertilizer dose) gave closest result with T3 (2 NPK briquette of 2.40 sized). However, the lowest biological yield (10.07 t ha-1) was found from the treatment, T1 (No fertilizer; Control) which was also significantly different from all other treatments followed by T4 (1 NPK briquette of 2.40 sized).

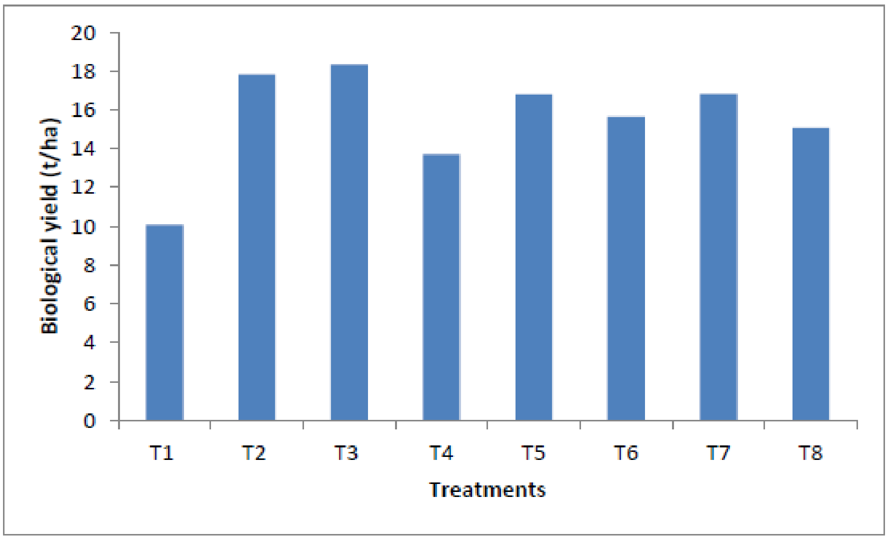

Fig. 5. Biological yield of boro rice (BRRI dhan29) influenced by NPK briquettes and/or other fertilizers .
T1 = No fertilizer (Control)
T2 = RFD (RFD-N120 P30 K50)
T3 = 2 NPK briquette of 2.40 gm sized (N130-P30-K55)
T4 = 1 NPK briquette of 2.40 sized
T5 = 3 NPK briquette of 2.40 sized
T6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF T7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF T8 = 3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF

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, T3 (2 NPK briquette of 2.40 sized) followed by the treatment, T2 (RFD (Recommended fertilizer dose). Again the lowest harvest index (39.03%1) was found from the treatment, T1 (No fertilizer; Control) which was significantly different from all other treatments followed by T4 (1 NPK briquette of 2.40 sized).

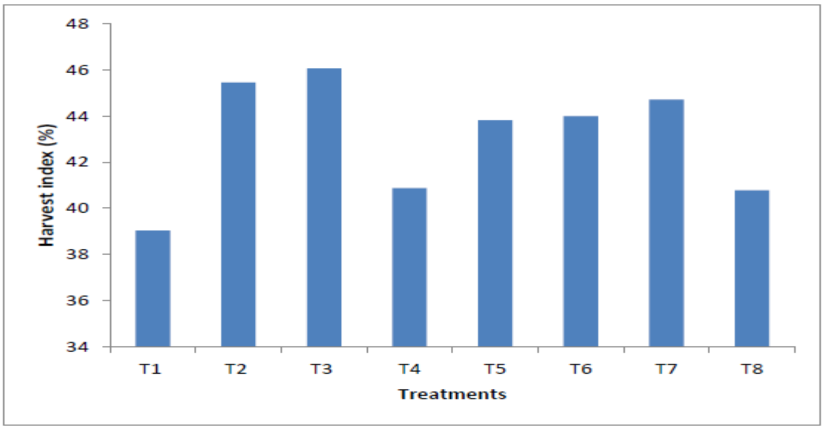

Fig. 6. Harvest index of boro rice (BRRI dhan29) influenced by NPK briquettes and/or other fertilizers .
T1 = No fertilizer (Control)
T2 = RFD (RFD-N120 P30 K50)
T3 = 2 NPK briquette of 2.40 gm sized (N130-P30-K55)
T4 = 1 NPK briquette of 2.40 sized
T5 = 3 NPK briquette of 2.40 sized

T6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF T7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF T8 = 3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF

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

	Nutrient (N, P and K) content in post-harvest soil		
Treatment	N (%)	Available P	Exchangeable K
		(ppm)	(meq/100 g soil)
T1	0.044 d	15.36 e	0.110 d
T2	0.074 bc	19.24 c	0.119 b
T3	0.080 b	19.66 c	0.116 c
T4	0.072 bc	17.54 d	0.112 d
T5	0.087 ab	21.78 ab	0.121 b
T6	0.090 ab	23.18 a	0.126 a
T7	0.084 b	22.94 a	0.120 b
T8	0.096 a	23.72 a	0.129 a
LSD0.05	0.014	1.032	0.013
CV (%)	3.146	3.067	2.841

T1 = No fertilizer (Control)
T2 = RFD (RFD-N120 P30 K50)
T3 = 2 NPK briquette of 2.40 gm sized (N130-P30-K55)
T4 = 1 NPK briquette of 2.40 sized
T5 = 3 NPK briquette of 2.40 sized
T6 = 2 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF T7 = 1 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RD T8 = 3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RD

6. Conclusion

Results also indicated that the highest value of the N, P and K content in postharvest soil were obtained from treatment, T8 (3 NPK briquette of 2.40 sized + 1 top dressing at tiller stage @ ¼ of RDF) and T1 (No fertilizer; Control) treated soil showed the lowest. From the above findings, it can be concluded that the treatment T3 (2 NPK briquette of 2.40 sized) gave the best results regarding growth, yield and yield contributing parameters. The treatment, T2 (RFD (Recommended fertilizer dose) also showed better performance which was very close to the treatment T3 (2 NPK briquette of 2.40 sized) regarding the respected parameters. So, among all the treatments, T3 (2 NPK briquette of 2.40 sized) can be considered as the best treatment followed by T2 (RFD (Recommended fertilizer dose).

7. 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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