COMPARATIVE STUDY OF USG AND NPK BRIQUETTE ON THE PERFORMANCE OF AROMATIC RICE VARIETY BRRI dhan70

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CERTIFICATE

*This is to certify that the thesis entitled '**Comparative Study of USG and NPK briquette on the Performance of Aromatic Rice Variety BRRI dhan70**' submitted to the Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in SOIL SCIENCE**, embodies the results of a piece of bona fide research work carried out by **MST. SHAMIMA AKTAR**, Registration No. **16-07556** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated: December, 2017
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TO

MY BELOVED PARENTS

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ABSTRACT

The experiment was conducted in the farm area of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period of July to November, 2017 for comparative study of USG (urea super granule) and NPK briquette on the performance of aromatic rice variety BRRI dhan70. In this experiment BRRI dhan70 aromatic rice were used as the test crop. The experiment comprised of the treatments of T_0: Control, T_1: 100% RFD, T_2: 1 USG (1.8 g) within 4 hills + PKSZn, T_3: 80% RFD + 2 USG within 4 hills, T_4: 1 NPK briquette within 4 hills, T_5: 2 NPK briquette within 4 hills and T_6: 80% RFD + 1 NPK briquette within 4 hills. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data were recorded on different yield contributing characters, yield and characteristics of post-harvest soil and statistically significant variation was recorded for most of the studied characters. The tallest plant (134.47 cm), maximum number of total tillers hill^{-1} (19.07), maximum number of total grains panicle^{-1} (145.20), the longest panicle (28.75 cm), highest grain yield (4.83 t ha^{-1}) and highest straw yield (6.26 t ha^{-1}) was recorded from T_6 treatment, while the shortest plant (106.17 cm), minimum number of total tillers hill^{-1} (15.00), the shortest panicle (22.88 cm), minimum number of total grains panicle^{-1} (120.47), lowest grain yield (2.88 t ha^{-1}) and lowest straw yield (4.40 t ha^{-1})was found in T_0 treatment. The highest total N (0.064%), highest available P (32.23 ppm) and highest exchangeable K (0.178 meq/100 g soil) was recorded in T_6 treatment, while the lowest total N (0.032%), lowest available P (17.29 ppm) and lowest exchangeable K (0.081 meq/100 g soil) was found in T_0. Application of 80% RFD + 1 NPK briquette within 4 hills was the package of nutrient for achieving higher yield of aromatic rice (variety BRRI dhan70) at Tejgaon series soil of SAU farm.

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Introduction

CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.), belongs to the family Poeaceae, is the most important food in tropical and subtropical regions (Singh *et al*., 2012) and the principal staple food for more than 50% of the world's population (Jahan *et al.,* 2017). Rice grain has shaped the culture, diet, and economies of billions of people in the world (Farooq *et al.,* 2009). It is grown in more than a hundred of the countries of world and total 474.86 million metric tons of rice was produced from 159.64 million hectares of land in the year of 2014-15 (USDA, 2015). Rice contributes on an average 20% of apparent calorie intake of the world and 30% of asian populations (Hien *et al.*, 2006). Bangladesh ranks 4th in both area and production and 6th in the production of per hectare yield (Sarkar *et al*., 2016). The country is said to have among the highest per capita consumption of rice is about 170 kg annually and its food security and economy largely depend on good harvests year after year (BBS, 2017).

In Bangladesh 11.39 million hectares of land is used for rice cultivation which is about 72.24% of total cropped area, with annual production of 34.71 million tons (BBS, 2017). According to FAO (2014) the average yield of rice of Bangladesh is about 2.92 t ha^{-1} which is very low compared to other rice growing countries like Korea (6.30 t ha^{-1}), China (6.30 t ha^{-1}) and Japan (6.60 t ha^{-1}). Population growth in Bangladesh demand a continuous increase of rice production and the highest priority has been given to produce more rice (Bhuiyan, 2004). World food security become challenged for increasing food demand and estimated that about 114 million tonnes of additional milled rice will be needed by 2035 which is equivalent to overall increase of 26% for next 25 years (Kumar and Ladha, 2011). Rice production has to be increased at least 60% by 2020 to meet up food requirement of increasing population (Masum, 2009). Thus, the population by the year 2030 will swell progressively to 223 million which will demand additional 48 million tons of food grains (Julfiquar *et al*., 2008).

Rice yields are either stagnating or declining in post green revolution era mainly due to different factors that are related to crop production (Prakash, 2010). The reasons for this includes various factors but the major reason attributed to prevalence of local varieties instead of high yielding varieties and without practicing proper management practices (Singh *et al*., 2012). On the other hand due to the storage of land, the possibility of horizontal expansion of rice production area has come to a standstill for Bangladesh, so that the farmers and scientists are diverting their attention towards vertical expansion of rice production. Therefore, attempts should be taken to increase the rice yield from per unit area. For vertical expansion of rice yield it is necessary to use of modern production technologies such as use of quality high yielding varieties, seedlings raising techniques, optimum seedling age and time of transplanting, appropriate number of seedling hill^{-1}, proper plant protection measures, water management, weed management use of appropriate doses of fertilizers especially N and so on.

In Bangladesh, intensive crop cultivation using high yielding varieties with imbalanced fertilization has lead to mining out the inherent plant nutrients and thereby fertility status of soils severely declined. The farmers of our country have a tendency to use indiscriminate amount of macro nutrients and very limited amount of other micro nutrients (Rahman *et al*., 2008). In Bangladesh, on an average to produce one ton of rice grain of high-yielding varieties is removed about 22 kg N, 7 kg P_2O_5, 32 kg K_2O, 5 kg MgO, 4 kg CaO, 1 kg S and 40 g Zn from the soil (Chaudhary *et al*., 2007). Emergence of widespread multi-nutrient deficiencies causing serious stagnation in yields and declining productivity of various rice ecosystems (Mangala Rai, 2006). Excess use of fertilizer nutrients implies increase of cost and decreases of returns and risk of environmental and soil pollution (Sharma *et al.* 2003). On the other hand, under use of nutrients depress the scope for increasing the present level of nutrients to the economically optimum level to exploit production potential to a larger extent (Singh *et al.*, 2001). So, application of inadequate and imbalanced fertilization to crops is the results of low crop yields.

Judicious use of fertilizer is a key factor in rice based production system which can increase crop yield and reduce production cost. The utilization efficiency of applied fertilizer by the rice plant is very low especially for nitrogen. Urea in the form of USG (Urea Super Granule) has been proved to be superior to granular urea in all aspects. Instead of 247 kg granular urea, only 160 kg ha^{-1} of USG was required (35% less) even to increase 20% rice yield (Hoque *et al.,* 2013). Depending on agro-climate and nitrogen use, deep-placed USG can save urea fertilizer up to 65% with a 33% increase in grain yields, and up to 50% with 15 to 20% yield increase over the same amount of split-applied N as prilled urea (Fatema-Tuz-Zohra *et al.,* 2013). NPK briquette is a mixture of urea, TSP and MoP which helps to reduce the loss of nutrients in flooded condition. So, it is helpful for tidal flooded ecosystem. Total 50 kg Urea, 20 kg TSP and 30 kg MoP could be found from 100 kg briquette (Islam *et al*., 2011). Farmer in Vitenam and Combodia obtained 25% higher yields with deep placement of NPK briquettes over the broadcasting of fertilizers and in Bangladesh yield of rice would be increased by 15-25%, while expenditure on commercial fertilizer was decreased by 24-32% when fertilizers briquettes were used as a source of N, P and K (IFDC, 2007). Therefore, it is necessary a comparative study of USG and NPK briquette on the performance of rice variety.

Considering the above mentioned perspectives this research work was undertaken with the following objectives:

- To evaluate comparative effect of the USG and NPK briquette for increasing the productivity of aromatic rice BRRI dhan70;
- To find out the optimum dose of USG and NPK briquette for maximizing the yield of BRRI dhan70.

Chapter II

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Recommended dose of chemical fertilizer is the essential factor for sustainable soil fertility and crop productivity. Sole and combined use of inorganic recommended fertilizers in different forms increase plant growth, yield attributes and yield of rice. Experimental evidences that the use of recommended dose of fertilizers (nitrogen, phosphorus, potassium, sulphur and zinc) have an intimate effect on the yield and yield attributes of rice. But research works related to recommended fertilizer doses of fertilizers from different sources are limited in Bangladesh context. However, some of the important and informative research findings on these aspects so far been done at home and abroad have been reviewed in this chapter under the following headings-

2.1 Effect of recommended doses of chemical fertilizers on rice

2.1.1 Effect of nitrogen on yield attributes and yield of rice

Kumar *et al.* (1995) conducted a field experiment with four levels of nitrogen (0, 60, 120 and 180 kg N ha^{-1}) and reported that productive tillers increased significantly with the increase of N doses from 0-120 kg N ha^{-1}, but differences in productive tillers between 120 and 180 kg N ha^{-1} were not significant.

Adhikary and Rhaman (1996) reported that rice grain yield ha^{-1} in various treatments of N showed significant effect. The highest yield was obtained from 100 kg N ha^{-1} (4.52 t ha^{-1}) followed by 120 kg N ha^{-1} (4.46 t ha^{-1}) and 80 kg N ha^{-1} (4.40 t ha^{-1}).

Verma and Achraya (1996) observed that LAI (Leaf Area Index) increased significantly at maximum tillering and flowering stages with increasing levels of N. BINA (1996) stated that the effect of different levels of N was significant only for number of tillers $hill^{-1}$, effective tillers $hill^{-1}$, straw yield and crop duration. The highest number of total and productive tillers $hill^{-1}$ was obtained from the highest level (120 kg ha^{-1}) of N application.

Dwibvedi (1997) noticed that application of N significantly increased in growth, yield and yield components, grain yield, straw yield as well as harvest index with 60 kg N ha^{-1}. BRRI (1997) reported during *boro* and transplant *aman* to determine rice seed yield. The experiment was laid out with four N levels i.e., 0, 50, 100 and 150 kg ha^{-1} and noted that seed yield increased gradually with the gradual increase of N.

Islam (1997) studied the effect of N and P on the growth, yield and nutrient uptake of deep-water rice. They observed that N and P fertilization significantly increased the number of fertile tiller m^{-2} and also that of grains $panicle^{-1}$, which in turn resulted in significant increase in grain yield. The application of 60 kg N ha^{-1} alone gave 22% yield benefit over control.

Singh *et al.* (1998) studied the performance of three hybrids KHR 1, Pro Agro 103 and MGR 1 using Jaya and Rasi as standard checks at four levels of N (0, 60, 120, and 180 kg ha^{-1}). They observed that the varieties responded linearly to the applied N level up to 120 kg ha^{-1}.

Kumar and Sharma (1999) conducted a field experiment with 4 levels of N (0, 40, 80 and 120 kg N ha^{-1}) and observed that dry matter accumulation in rice increased from 0-40 kg N ha^{-1} at 40 DAS, 0-120 kg N ha^{-1} at 60 DAS, 0-80 kg ha^{-1} at 80 DAS. Nitrogen application also hastened the growth and resulted in higher percentage of total dry matter accumulation in early stage of crop growth.

Bellido *et al*. (2000) evaluate a field experiment with 4 levels of N (0, 50, 100 and 150 kg N ha^{-1}) and reported that the amount of total dry matter was significantly greater at the N fertilizer rates of 100 and 150 kg N ha^{-1}.

BRRI (2000) reported that the grain yield was linearly increased with increasing N rates. Castro and Sarker (2000) conducted a field experiment to see the effects of N applications as basal (80, 60, and 45kg N ha^{-1}) and top dressing (10, 30 and 45 kg ha^{-1}) on the yield and yield components of Japonica rice and obtained high effective tiller, percentage of ripened grains and high grain yields from 45 kg N

ha^{-1} (basal) and 45 kg N ha^{-1} (top dressing). Singh *et al.* (2000) stated that each increment dose of N significantly increased grain and straw yields of rice over its preceding dose. Consequently the crop fertilized with 100 kg N ha^{-1} gave maximum grain yield (2647 kg ha^{-1}).

Pully *et al*. (2000) observed that increased yield associated with application of nitrogen stage, although booting stage nitrogen application had no effect or shoot growth or N uptake. These preliminary results suggested a single application of N is sufficient to maintain healthy rice growth, alleviating the need for additional N application after flooding. Rice may be responded to N applied as late as booting, but only when the rice is N limited and not severely N stressed.

Munnujan *et al*. (2001) treated 4 levels of N fertilizer (0, 40, 80, and 160 kg ha^{-1}) application at three levels each planting density (20, 40 and 80 hill m^{-1}) and conducted that the highest grain yield (3.8 t ha^{-1}) was obtained with 180 kg N ha^{-1}, which was similar to the yield obtained at 80 kg N ha^{-1} (3.81 t ha^{-1}).

Angayarkanni and Ravichandran (2001) conducted a field experiment in Tamil Nadu, India from July to October 1997 to determine the best split application of 150 kg N ha^{-1} for rice cv. IR20. They found that applying 16.66% of the recommended N as basal, followed by 33.33% N at 10 DAT, 25% N at 20 DAT and 25% N at 40 DAT recorded the highest grain (6189.4 kg ha^{-1}) and straw (8649.6 kg ha^{-1}) yields, response ratio (23.40) and agronomic efficiency (41.26).

Duhan and Singh (2002) reported that the rice yield and uptake of nutrients increased significantly with increasing N levels. Moreover, the application along with various green manures (GM) showed additive effect on the yield and uptake of micronutrients. Under all GM treatments, the yield and uptake were always higher with 120 kg ha^{-1} than with lower level of N.

Mondal and Swamy (2003) found that application of N (120 kg ha^{-1}) as urea in equal splits during transplanting, tillering, panicle initiation and flowering resulted in the highest number of panicle, number of grains panicle^{-1}, 1000-grain weight, straw yield and harvest index.

Naznin *et al*. (2013) investigate the effects of prilled urea (PU), urea super granule (USG) and NPK briquette on NH_4-N concentration in field water, yield and N use efficiency (NUE) of BR22 rice under reduced water conditions and reported that the highest grain yield of 3.93 t ha^{-1} from 104 kg N ha^{-1} as USG and the lowest value of 2.12 t ha^{-1} was obtained 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.

Murthy *et al*. (2015) conducted an experiment with an objective to revise the existing fertilizer doses of major nutrients in Krishna Godavari delta regions of Andhra Pradesh. Grain yield was increased by 11.5% and 6.3% due to increase in recommended dose of N from 100% (120 kg ha^{-1}) to 125% and 150%.

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

2.1.2 Effect of phosphorus on yield attributes and yield of rice

Ghosal *et al*. (1998) conducted a field experiment in Bihar on rice cv. Pankaj with 10–40 kg P/ha as triple super phosphate (TSP), highly reactive Morocco Rock Phosphate (HRMRP), Florida Rock Phosphate (FRP) and stated that yield increased with increasing P rates of four sources. They further proposed that grain yield was the highest with TSP followed by PAPR, HRMRP and FRP.

Sarkunan *et al*. (1998) conducted a pot experiment to find out the effect of P and S on yield of rice under flooded condition, on a P and S deficient sandy loam soil. They found increased yield with increasing level of P from 16.9 to 42.5 g/pot. Sulphur addition at 25 mg/kg resulted in 9% increase in grain yield. The treatment combination of 100 mg P and 10 mg S/kg soil gave significantly higher grain yield than other treatments.

Sahrawat *et al*. (2001) conducted a field experiment for six years (1993-1998) to determine the response of four promising upland rice cultivars with 0, 45, 90, 135, and 180 kg/ha as triple super phosphate (TSP). Only once used in 1993 and its residual value in 1994, 1995, 1996 and 1998 stated that grain yields of the rice cultivars were significantly increased by fertilizer P in 1993 and by the fertilizer P residues in the subsequent years although the magnitude of response decreased rapidly with time since the fertilizer was not applied.

Nair and Rajasree (2004) conducted a field experiment to assess comparative efficiency of super phosphate and PR (34/74) at different levels in the yield characters and composition of rice. The treatments were 30 and 45 kg P_2O_5 ha^{-1} in the form of superphosphate and PR (34/74) with and without organic matter. The results showed that high grade phosphate rock (M, 34/74) with organic manure performed well and were followed by PR (34/74) with iron pyrites and green manure. Thus, PR (34/74) performed well with organic matter, FeS_2 and green manure in deciding growth and yield of rice. Higher contents of N, P, K, Ca and Mg of grain and straw were obtained at higher levels of 45 kg P_2O_5 ha^{-1} treatment.

Li *et al.* (2007) conducted an experiment to evaluate the contributions of rice root morphology and P uptake kinetics to P uptake by rice from iron phosphates. The Fe-P treatment significantly decreased plant dry weight, P uptake per plant, and P concentration in plant dry matter of all cultivars in comparison with the control plants.

Dunn and Stevens (2008) conducted a field experiment to evaluate the effect of polymer coating of phosphate fertilizer on rice yield. Three rates of phosphate fertilizer, including polymer coated and non coated, were compared to an untreated check. Net return was calculated based on crop price and input costs. At the rate of 25 lb/acre P_2O_5 rate the polymer coated treatments produced greater yields than equivalent non coated treatments.

Islam *et al*. (2010) conducted a field experiment with five P rates (0, 5, 10, 20 and 30 kg P ha^{-1}) with four rice genotypes in Boro and T. Aman season. Phosphorus rates did not influence grain yield irrespective of varieties in T. aman season while in Boro season P response was observed among the P rates. Application of P @ 10 kg ha^{-1} significantly increased the grain yield. But when P was applied @ 20 and 30 kg P ha^{-1}, the grain yield difference was not significant. The optimum and economic rate of P for T. Aman was 20 kg P ha^{-1} but in Boro rice the optimum and economic doses of P were 22 and 30 kg ha^{-1}, respectively. Hybrid entries (EH_1 and EH_2) used P more efficiently than inbred varieties. A negative P balance was observed up to 10 kg P ha^{-1}.

Tang *et al*. (2011) conducted a field experiment on winter wheat (*Triticum aestivum* L.) and rice (*Oryza sativa* L.) crop rotations in Southwest China to investigate P fertilizer utilization efficiency, including the partial factor productivity (PFP), agronomic efficiency (AE), internal efficiency (IE), partial P balance (PPB), recovery efficiency (RE) and the mass (input–output) balance. This study suggests that, in order to achieve higher crop yields, the P fertilizer utilization efficiency should be considered when making P fertilizer recommendations in wheat–rice cropping systems.

2.1.3 Effect of potassium on yield attributes and yield of rice

Singh *et al.* (2000) evaluated the effect of levels of K application on rice at different places. Results indicated that K application significant enhanced the growth and yield of rice over no application. The highest grain and straw yields of rice was obtained at 90 kg K_2O ha^{-1} all the cropping seasons.

Sarkar and Singh (2002) conducted a field experiment to determine the effect of P and S. They applied 110 kg N: 90 kg P: 70 kg K: 20 kg S ha^{-1}. They observed that the number of tillers m^{-2}, 1000-grain weight, paddy and straw yield significantly increased with the application K with other fertilizer.

Shen *et al*. (2003) studied the effects of N and K fertilizer on the yield and quality of rice. Potassium fertilizer significantly improved all quality parameters and yield at 150 kg N ha^{-1} and equal amounts of K fertilizer applied to rice fields are optimum to obtain high yield.

Hong *et al*. (2004) conducted the field experiments to investigate the potassium uptake, distribution and use efficiency of hybrid and conventional rice under different low K stress conditions. The grain yield and total k uptake by rice increased.

Natarajan *et al*. (2005) conducted an experiment during 2002-2003 with two rice hybrids, KRH2 and DRRHI in main plots and three levels of K (0, 40, and 80 kg ha^{-1}) in subplots to study the performance of rice hybrids with different K levels. The results clearly indicated that hybrid KRH2 performed superior with different levels of K.

Krishnappa *et al.* (2006) reported that increasing K rates increased paddy yields. Potassium applied in split dressings were more effective than when applied at transplanting time. Application of K fertilizer with organic manure increased soil K availability, K content and the number of grains $panicle^{-1}$.

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

Mostofa *et al*. (2009) carried a pot experiment in the net house at the Department of Soil Science, Bangladesh agricultural University, Mymensingh. Four doses of potassium (0, 100, 200, and 300 kg ha^{-1}) were applied. They observed that the yield contributing characters like plant height, tiller number, and dry matter yield were the highest in 100 kg ha^{-1} of K.

Wan *et al*. (2010) evaluated the effects of application of fertilizer, pig manure (PM), and rice straw (RS) on rice yield, uptake, and usage efficiency of potassium, soil K pools, and the non-exchangeable K release under the rice-rice cropping system. The field treatments included control (no fertilizer applied), NP, NK, NPK, and NK + PM, NP + RS, NPK + RS. The application of K fertilizer (NPK) increased grain yield by 56.7 kg ha^{-1} over that obtained with no K (NP).

Wang (2011) conducted a field experiment to study the effects of N, P and K fertilizer application on grain yield, grain quality as well as nutrient uptake with four levels of N, P and K fertilizers. The results revealed that the application of N, P and K fertilizer significantly increased grain yield, and the highest yield was found under the combined application of N, P and K fertilizer.

2.1.4 Effect of sulphur on yield attributes and yield of rice

Peng *et al*. (2002) carried out a field experiment where the average content of available S in these soil samples was 21.7 mg kg^{-1}. The soil with available S content was lower than the critical value of 16 mg kg^{-1} accounted for 57.8%. Field experiments showed that there was a different yield-increasing efficiency by applying S at the doses of 20-60 kg ha^{-1} to rice plant.

Singh and Singh (2002) carried out a field experiment to see the effect of different N levels and S levels (0, 20 and 40 kg ha^{-1}) on rice cv. Swarna and PR-108 in Varanasi, Uttar Pradesh. India. They reported that plant height, tillers m^{-2} row length, dry matter production, panicle length and grains panicle $^{-1}$ were significant with increasing levels of S up to 40 kg S ha^{-1}. They also found that total N uptake, grain, straw and grain protein yields significantly improved with the increasing level S application being the maximum at 40 kg S ha^{-1} respectively.

Chandel *et al*. (2003) conducted a field experiment to investigate the effect of S nutrition on the growth and S content of rice and mustard grown in sequence with 4 S levels (0, 15, 30 and 45 kg ha^{-1}). They stated that increasing S levels in rice significantly improved yield attributes i.e. tiller number, leaf number, dry matter production and harvest index of rice up to 45 kg ha^{-1}.

Biswas *et al*. (2004) reported the effect of S in different region of India. The optimum S varied between 30-45 kg ha^{-1}. Rice yields increased from 5 to 51%. Across the crops and regions the agronomic efficiency varied from 2 to 27%.

Islam *et al*. (2006) to evaluated the effect of gypsum (100 kg ha^{-1}) applied before planting, and at 30 and 60 days after planting, on the nutrient content of transplanted Aus rice (BR-2) in the presence of basal doses of N,P,K, fertilizers. Application of gypsum at different dates increased N, P, K, S, Ca and Mg contents progressively, whereas the Na content was found to decrease. The highest increase of N, P, K, S, Ca and Mg was obtained when the gypsum was applied at 30 days after planting. Synthesis of protein was accelerated with all the treatments of gypsum, and the content was much higher due to application of gypsum at 30 days after planting.

Basumatary and Talukdar (2007) carried out a field experiment at the Jorhat University, Assam, India to observe the direct effect of S alone and in combination with graded doses of farmyard manure on rapeseed and also its residual effects on rice for yield, uptake and protein content. The N:S ratio in both crops progressively decreased with increasing sulphur levels up to 45 kg ha^{-1}. The lowest N:S ratio was observed upon treatment with 45 kg S ha^{-1} alone with 3.0 t/ha farmyard manure.

Bhuvaneswari *et al*. (2007) conducted a field experiment during kharif season, to observe the effect of S at different levels, i.e. 0, 20, 40 and 60 kg ha^{-1}, with different organics, each applied at 12.5 t ha^{-1}, on yield, S use efficiency. The results showed that rice responded significantly to the application of S and organics compared to the control. The highest grain (5065 kg ha^{-1}) and straw yield (7524 kg ha^{-1}) was found with 40 kg S ha^{-1}.

Alamdari *et al*. (2007) carried out a field experiment to observe the effect of S and sulfate fertilizers on Zn and Cu by rice and reported that both Zn and Cu contents in the grain increased when N, P, K, S and Zn, Cu and Mn sulfate were applied together.

Mrinal and Sharma (2008) conducted a field trials during the kharif season to study the relative efficiency of different sources (gypsum, elemental S and cosavet) and different levels of S (0, 10, 20, 30 and 40 kg S ha^{-1}) in rice. The growth and yield of rice increased with the S application. The grain and straw yield of rice increased significantly with increasing levels of S up to 30 kg S ha^{-1}. The difference between S sources was generally insignificant.

Rahman *et al*. (2009) carried out an experiment to know the effect of different levels of S on growth and yield of BRRI dhan41 at Soil Science laboratory field of Bangladesh Agricultural University, Mymensingh during T. Aman season. There were eight treatments and they were T_0 (without S), T_1 (50% RFD of S), T_2 (75% RFD of S), T_3 (100% RFD of S), T_4 (125% RFD of S), T_5 (150% RFD of S), T_6 (175% RFD of S) and T_7 (200% RFD of S). All yield contributing characters like effective tillers hill^{-1}, filled grain panicle^{-1}, grain yield, straw yield, biological yield and 1000-grain weight except plant height and panicle length of BRRI dhan41 significantly increased due to different levels of S application.

Jawahar and Vaiyapuri (2011) conducted an experiment at Experimental Farm, Annamalai University, Annamalai Nagar, Tamil Nadu, India to study the effect of S and silicon fertilization on yield and nutrient uptake. The treatments comprised four levels of sulphur as 0, 15, 30 and 45 kg ha^{-1} and they observed highest yield and nutrient uptake of rice due to application 45 kg S ha^{-1}.

Dixit *et al*. (2012) carried out a field experiment to study the effect of S and Zn on yield, quality and nutrient uptake by hybrid rice grown in sodic soil and found that application of 40 kg S ha^{-1} recorded significantly high grain and straw yield, protein content and sulphur uptake.

The productivity of wheat–rice cropping system is declining over time despite adequate supply of major nutrients is reported by Singh and Singh (2014). It may be due to deficiency of nutrients like S. A field experiment was conducted with treatments consisting of three levels of sulphate-sulphur (0, 15, 30 and 45 kg ha^{-1}) to study the S balance and productivity in wheat-rice cropping sequence in a sandy clay loam soil. The agronomic efficiency and apparent S recovery decreased with increase in levels of sulphate but the percent response increased with increasing sulphate application. Application of S showed the positive S balance, while it was negative for control.

2.1.5 Effect of zinc on rice yield attributes and yield

Ullah *et al*. (2001) conducted an experiment in Mymensingh, Bangladesh, to study the effect of zinc sulfate (0, 10, and 20 kg ha^{-1}) on rice cv. BR30. Zinc sulfate, along with 60 kg P_2O_5 and 40 kg K_2O ha^{-1}, was incorporated during land preparation. 80 kg N ha^{-1} was applied by 3 equal installments during land preparation, and at 25 and 60 days after transplanting. Plant height; tiller number; 1000-grain weight; grain and straw yields; and grain, straw, and soil Zn contents increased with zinc sulfate application. The tallest plants (75.667 cm) and the highest number of tillers (10.60 $hill^{-1}$), 1000-grain weight (28.700 g), and the concentration of Zn in straw (101.93 ppm) and grain (73.33 ppm) were obtained with 20 kg zinc sulfate ha^{-1}.

Cheema *et al*. (2006) carried out an experiment to evaluate the effect of four Zn levels on the growth and yield of coarse rice cv. IR-6 at Faisalabad, Pakistan. Four zinc levels viz., 2.5, 5.0, 7.5 and 10.kg $ZnSO_4$ ha^{-1} increased yield and yield component as compared with control. Plant height, number of tillers $hill^{-1}$, panicle bearing tillers, number of primary and secondary spikelets, panicle size, 1000 grain weight, paddy and straw yield and harvest index showed positive correlation with the increase in $ZnSO_4$ levels from 2.5 to 10 kg ha^{-1}.

Naik and Das (2007) reported that rice is mostly transplanted under puddled low land soil conditions in India, where Zn deficiency is a common problem. The objective of this study was to find out the efficacy of split application of Zn on growth and yield of rice in an inceptisol. The split application of Zn as d$ZnSO_4.7H_2O$ performed better than its single basal application, while the split application of Zn-EDTA did not show any significant difference on yield and yield components of rice over its single basal application. Zn-EDTA was found to be better for growth and yield of rice among the two sources of Zn. The soil application of Zn at 1.0 kg ha^{-1} as Zn-EDTA (T_7) recorded highest grain yield of 5.42 t ha^{-1}, filled grain percentage of 90.2%, 1000-grain weight of 25.41 g and number of panicles m^{-2} of 452. The Zn content of grain and straw were also found to be maximum in the treatment T_7 i.e. 38.19 and 18.27 mg Zn kg^{-1}, respectively. Linear regression studies indicated that grain yield of rice is significantly influenced by Zn content of grain, Zn content of straw and DTPA extractable Zn content of soil at the level of 95.96, 96.74 and 95.57%, respectively.

Mustafa *et al*. (2011) conducted an experiment at agronomic research area, University of Agriculture, Faisalabad, to evaluate the effect of different methods and timing of Zn application on growth and yield of rice. Experiment was comprised of eight treatments viz., control, rice nursery root dipping in 0.5% Zn solution, $ZnSO_4$ application at the rate of 25 kg ha^{-1} as basal dose, foliar application of 0.5% Zn solution at 15, 30, 45, 60 and 75 days after transplanting. Maximum productive tillers per m^2 (249.80) were noted with basal application at the rate 25 kg ha^{-1} of $ZnSO_4$ (21% Zn) and minimum (220.28) were recorded with foliar application at 60 DAT @ 0.5% Zn solution. Zinc application methods and timing had significantly pronounced effect on paddy yield. Maximum paddy yield (5.21 t ha^{-1}) was achieved in treatment Zn_2 (Basal application at the rate of 25 kg ha^{-1} of $ZnSO_4.7H_2O$) and minimum paddy yield (4.17 t ha^{-1}) was noted in Zn_7 (foliar application at 75 DAT @ 0.5% Zn solution).

Muthukumararaja and Sriramachandrasekhara (2012) reported that Zn deficiency in flooded soil is impediment to obtain higher rice yield. Zn deficiency is corrected by application of suitable Zn fertilizer. The results revealed that rice responded significantly to graded dose of Zn. The highest grain (37.53 g pot^{-1}) and straw yield (48.54 g pot^{-1}) was noticed at 5 mg Zn kg^{-1}, which was about 100% and 86% greater than control (no zinc) respectively. The highest Zn concentration and uptake in grain and straw and DTPA-Zn at all stages was noticed at 7.5 mg Zn kg^{-1}. The linear regression analysis showed grain Zn concentration and grain Zn uptake caused 89.64 and 89.01% variation in rice yield. Similarly, the linear regression analysis of DTPA-Zn caused 98.31, 96.34 and 93.12% variation in yield of rice at tillering, panicle initiation and harvesting stages, respectively. The agronomic, physiological and agro-physiological apparent recovery and utilization efficiencies was highest at lower level of Zn application and decreased with Zn doses.

Singh *et al.* (2012) carried out an experiment at Sari, Mazandaran, Iran. This experiment was done as split plot in randomized complete blocks design based three replications. Zinc fertilizer application was chosen as main plots (0, 2 and 4 kg ha^{-1}) and genotypes as sub plots. The maximum panicle number m^{-2} and harvest index were observed with 4 kg Zn ha^{-1} and the least of those was obtained in control treatment. The highest zinc content in grain, zinc uptake in grain and straw, and nitrogen uptake in grain were observed with 4 kg Zn ha^{-1}, as the most zinc content in straw, nitrogen, potassium, phosphorus and sulphur content in grain and straw, and nitrogen uptake in straw were observed highest with application of 4 and 2 kg Zn ha^{-1}.

Dixit *et al*. (2012) conducted a field experiment to study the effect of sulphur and zinc on yield, quality and nutrient uptake by hybrid rice grown in sodic soil and that positive response of hybrid rice to zinc application was noticed significantly up to the zinc dose @ 10 kg ha^{-1}.

Kabeya and Shankar (2013) reported that rice (*Oryza sativa*) is the worlds' most important cereal and potentially an important source of zinc (Zn) for people who eat mainly rice. Zn deficiency being a major constraint to reduce the potential yield of rice. To improve Zn delivery by rice, plant Zn uptake and internal allocation need to be better investigated. Field experiments were carried out to find out the effect of three different levels of Zn on rice Zn contrasting lines, high Zn groups and low Zn groups. The experiments revealed that increased Zn supply induced increased plant Zn uptake rate throughout the crop development in both high Zn groups and low Zn groups. The highest effect was observed when treated with 30 kg $ZnSO_4$ ha^{-1} irrespective of zinc groups. However, high Zn groups showed better uptake ability in Zn content and overall performance in growth characteristics.

2.2 Effect of NPK briquettes on rice

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

Singh *et al.* (2008) reported that the deep-point placement of N, P and K briquettes significantly increased grain and straw yields, total N, P and K uptake, also N and P use efficiencies compared to broadcast incorporation of N, P and K in rice.

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

Shah *et al*. (2013) conducted experiments at the Bangladesh Rice Research Institute (BRRI) farm, Gazipur, BRRI regional station Sagordi, Barisal to evaluate the NPK briquette efficiency in rice production. Experimental results revealed that deep placement of NPK briquette (2×2.4 g) increased rice yield about 10 percent and it saved 37 percent N, 30 percent P and 44 percent K than BRRI fertilizer recommended rate in boro season. Similarly, NPK briquette (1×3.4 g) produced 28 percent and 18 percent more rice yield than BRRI fertilizer recommended rate for T. aus and T. aman, respectively. Thus, use of NPK briquette over NPK broadcast and incorporation was very much efficient for rice cultivation.

Rahman *et al*. (2016) carried out a field experiment to assess the comparative advantages of using USG and NPK briquette over normal urea and also predict the better performing transplanted Aus rice in the tidal ecosystem. The effect of different levels of fertilizer was studied on growth, yield and yield attributing character of transplanted Aus rice. The analysis 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 and grain yield were found highest when USG was applied with BRRIdhan48 and all the characters showed lowest value when 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 PU and USG. The USG (1.8 g) and NPK briquettes (2.4 g) could save 11.3 and 19.55 kg N ha^{-1} compared to recommended PU.

Above cited literature revealed that the effect of recommended dose of fertilizers-RDF (N, P, K, S and Zn) of application significantly effect in terms of yield attributes and yield of rice and different form or source significantly affect the grain yield of rice in different growing seasons.

Chapter III

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted for comparative study of USG and NPK briquette on the performance of aromatic rice variety BRRI dhan70. The details of the materials and methods i.e. experimental period, location, soil and climatic condition of the experimental area, materials used, treatment and design of the experiment, growing of crops, data collection and data analysis procedure that followed in this experiment has been presented under the following headings:

3.1 Description of the experimental site

3.1.1 Experimental period

The experiment was conducted during the period of July to November, 2017.

3.1.2 Experimental location

The present research work was conducted in the farm area of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is $23^0 74^/$N latitude and $90^0 35^/$E longitude with an elevation of 8.4 meter above from sea level. Experimental location presented in Appendix I.

3.1.3 Climatic condition

The geographical location of the experimental site is under the subtropical climate and its climatic conditions is characterized by three distinct seasons, namely winter season from the month of November to February, the pre-monsoon period or hot season from the month of March to April and monsoon period from the month of May to October (Edris *et al.*, 1979). Details of the meteorological data of the experimental period were presented in Appendix II.

3.1.4 Soil characteristics

The soil belonges to Tejgaon series under “The Modhupur Tract”, AEZ-28 (FAO, 1988). Top soil was Silty Clay Loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 6.08 and had organic matter 1.33%. The experimental area was flat having available irrigation and drainage system and above flood level. The details have been presented in Table 1 and 2.

Table 1. Morphological characteristics of the experimental field

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

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

Characteristics	Value
Mechanical fractions:	
% Sand (2.0-0.02 mm)	18.30
% Silt (0.02-0.002 mm)	45.50
% Clay (<0.002 mm)	36.20
Textural class	Silty Clay Loam
Consistency	Granular and friable when dry
pH (1: 2.5 soil- water)	6.08
Organic Matter (%)	1.33
Total N (%)	0.062
Available P (mg kg^{-1})	19.92
Exchangeable K (mol kg^{-1})	0.119
Available S (mg kg^{-1})	14.37

3.2 Experimental details

3.2.1 Planting material

In this experiment BRRI dhan70 aromatic rice were used as the test crop which was developed at the Bangladesh Rice Research Institute hybridization and released in the year 2014. It is recommended for *Aman* season. Average plant height of the variety is around 125 cm at the ripening stage. The grains are long, slender, aromatic and white. It requires about 130 days completing its life cycle with an average grain yield of around 4.8 t ha^{-1} (BRRI, 2016).

3.2.2 Treatment of the experiment

The experiment comprised of the following 7 treatment:

T_0: Control

T_1: 100% RFD

T_2: 1 USG (1.8 g) within 4 hills + PKSZn

T_3: 80% RFD + 2 USG within 4 hills

T_4: 1 NPK briquette within 4 hills

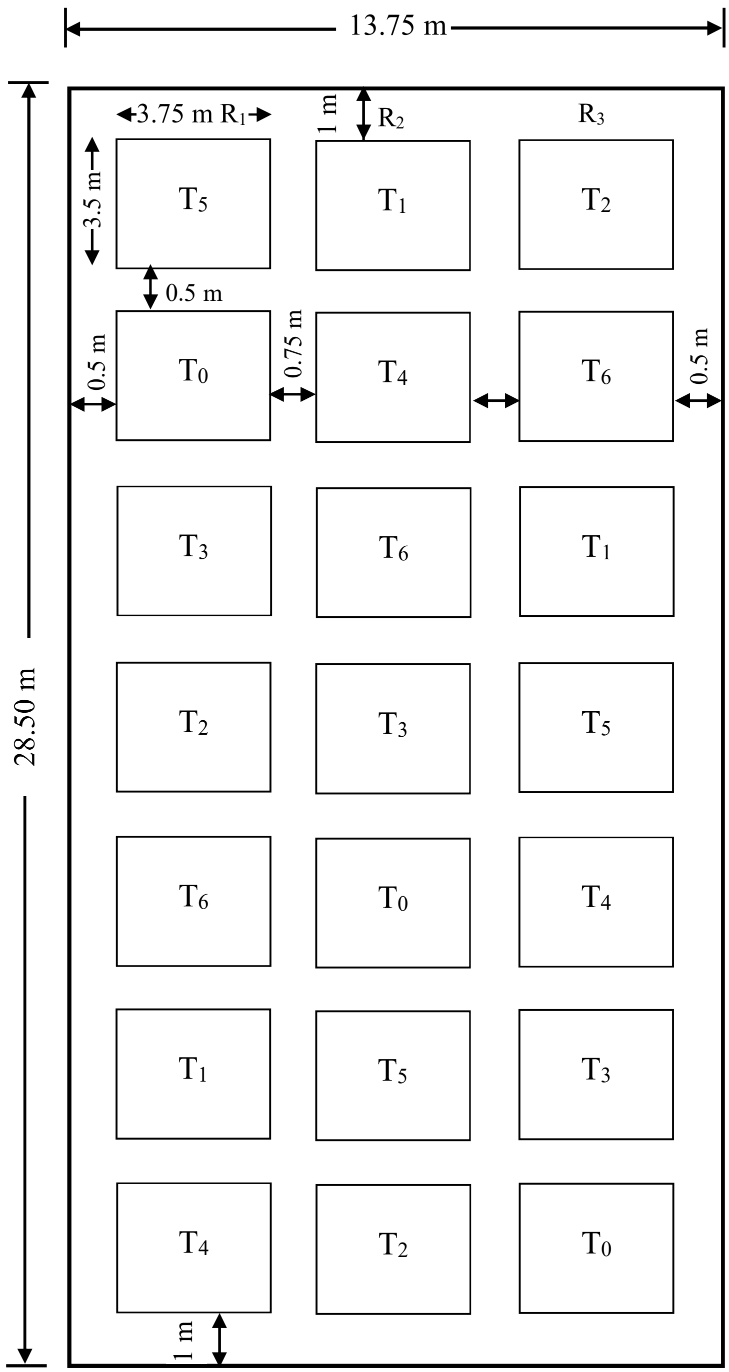
T_5: 2 NPK briquette within 4 hills

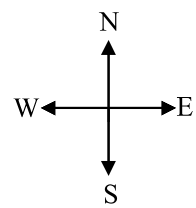
T_6: 80% RFD + 1 NPK briquette within 4 hills

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

3.2.3 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. An area of 28.50 m × 13.75 m was divided into 3 blocks. The size of the each unit plot was 3.75 m × 3.50 m. The space between two blocks and two plots were 0.75 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.





Plot size: 3.75 m × 3.50 m

Plot spacing: 0.5 m

Between replication: 0.75 m

Treatment

T_0: Control

T_1: 100% RFD

T_2: 1 USG (1.8 g) within 4 plants + PKSZn

T_3: 80% RFD + 2 USG within 4 plants

T_4: 1 NPK briquette within 4 hills

T_5: 2 NPK briquette within 4 hills

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

Figure 1. Layout of the experimental plot

3.3 Growing of crops

3.3.1 Seed collection and sprouting

Seeds were collected from BRRI (Bangladesh Rice Research Institute), Gazipur just 20 days ahead of the sowing of seeds in seed bed. For seedling raising clean seeds were immersed in water in a bucket for 24 hours. The imbibed seeds were then taken out of water and kept in gunny bags. The seeds started sprouting after 48 hours which were suitable for sowing after 72 hours.

3.3.2 Raising of seedlings

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

3.3.3 Land preparation

The plot selected for conducting the experiment was opened in the 26th July 2017 with a power tiller, and left exposed to the sun for 4 days. After o4 days the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain good puddle condition. Weeds and stubbles were removed. The experimental plot was partitioned into unit plots in accordance with the experimental design.

3.3.4 Fertilizers application

The fertilizers were applied as per treatment and the entire amounts of TSP, MoP, gypsum and zinc sulphate were applied during the final preparation of experimental plot. USG and NPK briquette in between 4 hills were applied 21st August, 2017 and 2nd and 3rd split of urea were applied 05th September, 2017 and 25th September, 2017, respectively as per treatment.

3.3.5 Transplanting of seedling

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

3.3.6 Intercultural operations

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

3.3.6.1 Irrigation and drainage

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

3.3.6.2 Weeding

Weedings were done to keep the plots free from weeds, which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully at 25 DAT and 45 DAT by sickles.

3.3.6.3 Insect and pest control

There was no infection of diseases in the field but leaf roller (*Chaphalocrosis medinalis*) was found in the field and used Malathion @ 1.12 L ha^{-1} at 30 DAT with using a hand sprayer.

3.4 Harvesting, threshing and cleaning

The crop was harvested at full maturity at 22th November, 2017 when 80-90% of the grains were turned into straw colored. The harvested crop was bundled separately, properly tagged and brought to threshing floor. Enough care was taken during threshing and cleaning period of rice grain. Fresh weight of rice grain and straw were recorded plot wise from 1 m^2 area. The grains were dried up to moisture content 12%, then cleaned and weighed for individual plot. Yields of rice grain and straw 1 m^2 were recorded from each plot and converted to hectare yield and expressed in t ha^{-1}.

3.5 Data recording

3.5.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 30, 40, 50, 60, 70 days after transplanting (DAT) and at harvesting stage. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot. The plant height was measured from the ground level to the tip of the panicle with the help of a meter scale.

3.5.2 Effective tiller $hill^{-1}$

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

3.5.3 In-effective tiller $hill^{-1}$

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

3.5.4 Total tiller $hill^{-1}$

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

3.5.5 Length of panicle

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

3.5.6 Filled grain panicle^{-1}

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

3.5.7 Unfilled grain panicle^{-1}

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

3.5.8 Total grain panicle^{-1}

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

3.5.9 Weight of 1000 seeds

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

3.5.10 Grain yield

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

3.5.11 Straw yield

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

3.5.12 Biological yield

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

Biological yield = Grain yield + Straw yield.

3.6 Post harvest soil sampling

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

3.7 Soil analysis

Soil samples were analyzed for both physical and chemical characteristics viz. pH, organic matter, Total N, available P and exchangeable K contents. The soil samples were analyzed by the following standard methods as follows:

3.7.1 Soil pH

Soil pH was measured with the help of a glass electrode pH meter, the soil water ratio being maintained at 1: 2.5 as described by Page *et al.*, 1982.

3.7.2 Organic matter

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

3.7.3 Total nitrogen

Total N content of soil were determined followed by the Micro Kjeldahl method. One gram of oven dry ground soil sample was taken into micro kjeldahl flask to which 1.1 g catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se in the ratio of 100:10:1), and 6 ml H_2SO_4 were added. The flasks were swirled and heated 200^0C and added 3 ml H_2O_2 and then heating at 360^0C was continued until the digest was 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 digests were used for nitrogen determination (Page *et al*., 1982).

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

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

Where,

T = Sample titration (ml) value of standard H_2SO_4

B = Blank titration (ml) value of standard H_2SO_4

N = Strength of H_2SO_4

S = Sample weight in gram

3.7.4 Available phosphorus

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

3.7.5 Exchangeable potassium

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

3.8 Statistical Analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference of different treatments. The mean values of all the characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the differences among the treatment means were estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted for comparative study of USG and NPK briquette on the performance of aromatic rice variety BRRI dhan70. Data on different yield contributing characters, yield and characteristics of post-harvest soil was recorded. The finding of the study has been presented and discussed with the help of different Table and Graphs under the following headings and sun-headings:

4.1 Yield attributes and yield of rice

4.1.1 Plant height

Plant height of BRRI dhan70 at 30, 40, 50, 60, 70 DAT and harvest showed statistically significant differences due to different treatments (Table 3). At 30 DAT, the highest plant (25.08 cm) was observed in T_6 (80% RFD + 1 NPK briquette within 4 hills) which was statistically similar (24.88 cm, 23.72 cm, 23.27 cm and 23.02 cm, respectively) to T_3 (80% RFD + 2 USG within 4 hills), T_1 (100% RFD), T_2 (1 USG (1.8 g) within 4 hills + PKSZn) and T_5 (2 NPK briquette within 4 hills) and closely followed (22.20 cm) by T_4 (1 NPK briquette within 4 hills) treatment, whereas the shortest plant (21.02 cm) was observed in T_0 (Control condition i.e. no fertilizer) treatment. Similar tends of results also recorded at 40, 50, 60 and 70 DAT. Similarly at harvest, the tallest plant (134.47 cm) was recorded from T_6 treatment, which was statistically similar with other treatment except T_0, where the shortest plant (106.17 cm) was found in T_0. Basically plant height is a genetical character and it is controlled by the genetic make up of the specific variety and in normal condition different varieties produced different size of plant but management practices may influences plant height and in suitable environmental condition specific variety produces tallest plant that the adverse situation. Rahman *et al*. (2016) observed that plant height was highest when USG or briquette were applied and the lowest value of plant height was found in control condition.

Table 3. Effect of USG and NPK briquette on plant height at different days after transplanting (DAT) and harvest of aromatic rice variety BRRI dhan70

Treatments	Plant height (cm) at					
	30 DAT	40 DAT	50 DAT	60 DAT	70 DAT	Harvest
T_0	21.02 c	39.21 b	63.76 b	74.81 b	95.87 b	106.17 b
T_1	23.72 a-c	45.28 a	76.67 a	93.81 a	113.28 a	131.45 a
T_2	23.27 a-c	44.58 a	75.37 a	90.43 a	111.17 a	130.02 a
T_3	24.88 ab	45.90 a	77.32 a	95.07 a	114.20 a	132.20 a
T_4	22.20 bc	41.87 ab	73.20 a	86.42 ab	108.01 a	127.86 a
T_5	23.02 a-c	43.70 ab	75.14 a	89.23 a	109.96 a	128.53 a
T_6	25.08 a	46.61 a	78.59 a	97.63 a	117.40 a	134.47 a
$LSD_{(0.05)}$	2.510	4.448	6.179	11.93	9.286	12.15
Significance level	0.05	0.05	0.01	0.05	0.01	0.01
CV(%)	6.05	5.72	4.68	7.48	4.75	5.37

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

T_0: Control

T_1: 100% RFD

T_2: 1 USG (1.8 g) within 4 hills + PKSZn

T_3: 80% RFD + 2 USG within 4 hills

T_4: 1 NPK briquette within 4 hills

T_5: 2 NPK briquette within 4 hills

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

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

4.1.2 Number of effective tillers hill^{-1}

Statistically significant differences was recorded due to different treatments in terms of number of effective tillers hill^{-1} of BRRI dhan70 (Table 4). The maximum number of effective tillers hill^{-1} (16.53) was observed in T_6 treatment which was statistically similar with other treatments except T_0 and T_4 treatment, while the minimum number (10.73) was observed in T_0 treatment. Rahman *et al*. (2016) observed that number of effective tillers hill^{-1} was highest when USG and briquette was applied and the lowest in control condition.

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

Number of in-effective tillers hill^{-1} of BRRI dhan70 varied significantly due to different treatments (Table 4). The minimum number of in-effective tillers hill^{-1} (2.53) was observed in T_6 treatment which was statistically similar (2.60, 2.87 and 3.27, respectively) with T_3, T_1 and T_2 treatment respectively, while the maximum number (4.27) was observed in T_0 treatment which was closely followed (3.53 and 3.33, respectively) by T_4 and T_5 treatment, respectively. Naznin *et al*. (2013) reported that application of USG and NPK briquette may be practiced for obtaining lowest number of non-effective tillers hill^{-1}.

4.1.4 Number of total tillers hill^{-1}

Statistically significant differences was recorded due to different treatments in terms of number of total tillers hill^{-1} of BRRI dhan70 (Table 4). The maximum number of total tillers hill^{-1} (19.07) was observed in T_6 treatment which was statistically similar (18.40, 18.20, 18.13 and 17.67, respectively) with T_3, T_2, T_1 and T_5 treatment, while the minimum number (15.00) was observed in T_0 treatment which was statistically similar (17.67) with T_5 treatment. Shah *et al*. (2013) reported that use of NPK briquette over NPK broadcast and incorporation was very much efficient for the production of number of total tillers hill^{-1}. Rahman *et al*. (2016) observed that number of total tillers hill^{-1} was highest when USG and briquette was applied and the lowest was found in control condition i.e. no fertilizer.

Table 4. Effect of USG and NPK briquette on number of effective, non-effective and total tillers^{-1} of aromatic rice variety BRRI dhan70

Treatments	Number of effective tillers hill^{-1}	Number of in-effective tillers hill^{-1}	Total tillers hill^{-1}
T_0	10.73 c	4.27 a	15.00 b
T_1	15.27 ab	2.87 b-d	18.13 a
T_2	14.93 ab	3.27 b-d	18.20 a
T_3	15.80 a	2.60 cd	18.40 a
T_4	13.33 b	3.53 b	16.87 b
T_5	14.33 ab	3.33 bc	17.67 ab
T_6	16.53 a	2.53 d	19.07 a
$LSD_{(0.05)}$	2.126	0.700	2.158
Significance level	0.01	0.01	0.05
CV(%)	8.29	12.31	6.88

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

T_0: Control

T_1: 100% RFD

T_2: 1 USG (1.8 g) within 4 hills + PKSZn

T_3: 80% RFD + 2 USG within 4 hills

T_4: 1 NPK briquette within 4 hills

T_5: 2 NPK briquette within 4 hills

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

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

4.1.5 Length of panicle

Statistically significant differences was recorded due to different treatments in terms of length of panicle of BRRI dhan70 (Figure 2). The longest panicle (28.75 cm) was observed in T_6 treatment which was statistically similar (28.57, 27.84, 26.23 and 26.12 cm, respectively) with T_3, T_1, T_2 and T_5 treatment respectively and closely followed (25.52 cm) by T_4 treatment, while the shortest panicle (22.88 cm) from T_0 treatment. Rahman *et al*. (2016) observed that panicle length was highest when USG was and all the characters showed lowest value when absolute control. Shah *et al*. (2013) reported that use of NPK briquette over NPK broadcast and incorporation was very much efficient for the production of longest panicle but the shortest was observed in control condition.

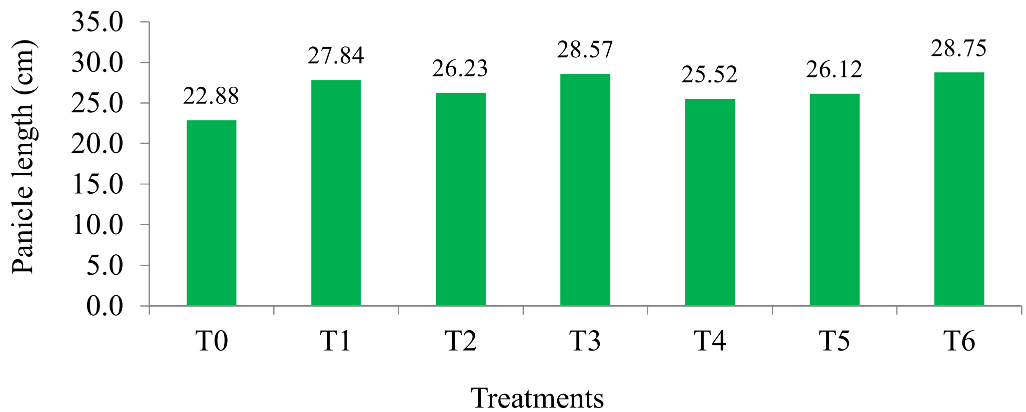


Figure 2. Effect of USG and NPK briquette on panicle length of aromatic rice variety BRRI dhan70

4.1.6 Number of filled grains panicle^{-1}

Statistically significant differences was recorded due to different treatments in terms of number of filled grains panicle^{-1} of BRRI dhan70 (Table 5). The maximum number of filled grains panicle^{-1} (133.73) was observed in T_6 treatment which was statistically similar with other treatments except T_0, while the minimum number (103.20) was observed in T_0 treatment. Rahman *et al.* (2016) observed that number of total tillers hill^{-1} was highest when USG and briquette was applied and the lowest was found in control condition i.e. no fertilizer were applied.

Table 5. Effect of USG and NPK briquette on length of panicle, number of filled, unfilled and total grains panicle^{-1} of aromatic rice variety BRRI dhan70

Treatments	Length of panicle (cm)	Number of filled grain panicle^{-1}	Number of unfilled grain panicle^{-1}	Total grain panicle^{-1}
T_0	22.88 c	103.20 b	17.27 a	120.47 b
T_1	27.84 ab	128.73 a	12.27 b	141.00 a
T_2	26.23 ab	125.13 a	12.47 b	137.60 a
T_3	28.57 a	130.13 a	12.00 b	142.13 a
T_4	25.52 bc	122.80 a	13.20 b	136.00 a
T_5	26.12 ab	124.33 a	12.80 b	137.13 a
T_6	28.75 a	133.73 a	11.47 b	145.20 a
$LSD_{(0.05)}$	2.769	12.89	1.888	13.51
Significance level	0.01	0.01	0.01	0.05
CV(%)	5.86	5.84	8.12	5.54

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

T_0: Control

T_1: 100% RFD

T_2: 1 USG (1.8 g) within 4 hills + PKSZn

T_3: 80% RFD + 2 USG within 4 hills

T_4: 1 NPK briquette within 4 hills

T_5: 2 NPK briquette within 4 hills

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

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

4.1.7 Number of unfilled grains panicle^{-1}

Statistically significant differences was recorded due to different treatments in terms of number of unfilled grains panicle^{-1} of BRRI dhan70 (Table 5). The minimum number of unfilled grains panicle^{-1} (11.47) was observed in T_6 which was statistically similar with other treatments except T_0, whereas the maximum number (17.27) in T_0 treatment. Bulbule *et al*. (2008) observed that NPK briquettes reduced the number of unfilled grains panicle^{-1} of rice.

4.1.8 Number of total grains panicle^{-1}

Number of total grains panicle^{-1} of BRRI dhan70 varied significantly due to different treatments (Table 5). The maximum number of total grains panicle^{-1} (145.20) was observed in T_6 treatment which was statistically similar with other treatment except T_0, while the minimum number (120.47) was observed in T_0 treatment. Rahman *et al*. (2016) observed that number of grains panicle^{-1} was highest when USG was and all the characters showed lowest value in control.

4.1.9 Weight of 1000 grains

Weight of 1000 grains of BRRI dhan70 varied non-significantly due to different treatments (Figure 3). The highest weight of 1000 grains (22.98 g) was observed in T_6 treatment, while the lowest weight (22.02 g) from T_0 treatment. Naznin *et al*. (2013) reported that application of USG and NPK briquette may be practiced for obtaining better yields with highest weight of 1000 grains.

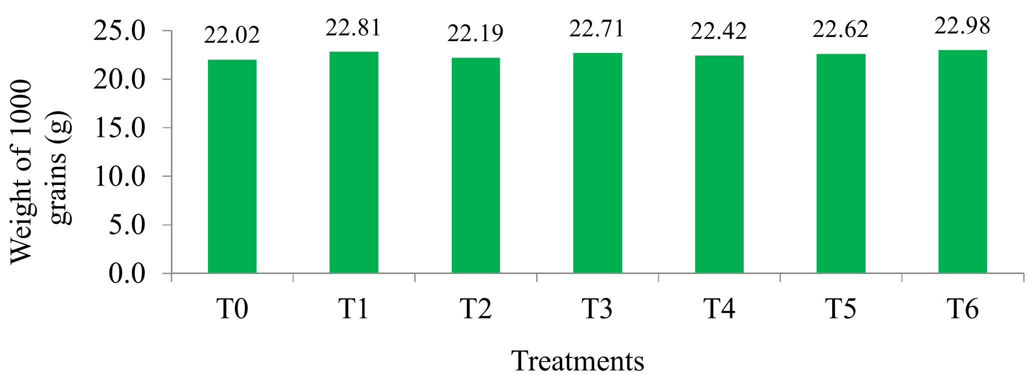


Figure 3. Effect of USG and NPK briquette on weight of 1000 grains of aromatic rice variety BRRI dhan70

Table 6. Effect of USG and NPK briquette on weight of 1000 grains, grain, straw, biological yield and harvest index of aromatic rice variety BRRI dhan70

Treatments	Weight of 1000 grains (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})
T_0	22.02	2.88 c	4.40 c	7.28 d
T_1	22.81	4.23 b	5.69 b	9.92 b
T_2	22.19	4.11 b	5.57 b	9.68 b
T_3	22.71	4.52 a	6.14 a	10.66 a
T_4	22.42	4.08 b	5.58 b	9.66 b
T_5	22.62	3.94 b	5.37 b	9.31 b
T_6	22.98	4.83 a	6.26 a	11.09 a
$LSD_{(0.05)}$	--	0.563	0.539	1.119
Significance level	0.05	0.01	0.05	0.01
CV(%)	694	9.53	5.23	6.41

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

T_0: Control

T_1: 100% RFD

T_2: 1 USG (1.8 g) within 4 hills + PKSZn

T_3: 80% RFD + 2 USG within 4 hills

T_4: 1 NPK briquette within 4 hills

T_5: 2 NPK briquette within 4 hills

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

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

4.1.10 Grain yield

Statistically significant differences was recorded due to different treatments in terms of grain yield of BRRI dhan70 (Table 6). The highest grain yield (4.83 t ha^{-1}) was recorded in T_6 treatment which was statistically similar (4.52 t ha^{-1}) with T_3 and closely followed by other treatments except T_0, while the lowest grain yield (2.88 t ha^{-1}) was observed in T_0 treatment. Data revealed that application of 80% RFD and 1 NPK briquette within 4 hills ensured proper growth and development of rice plant and ultimately this treatment produced the highest grain yield also. Shah *et al*. (2013) reported that use of NPK briquette over NPK broadcast and incorporation was very much efficient for rice cultivation in terms of rice yield. Bulbule *et al*. (2008) observed that NPK briquettes influenced on yield attributes, yield and nutrient content of rice. The results showed that grain yield of rice was significantly increased when the crop was fertilized through briquettes (56-30-30 kg NPK ha^{-1}) as compared to the application of conventional fertilizers (100-50-50 kg NPK ha^{-1}). Naznin *et al*. (2013) reported that application of USG and NPK briquette may be practiced for obtaining better yields in addition to increasing the efficiency of N fertilizer.

4.1.11 Straw yield

Straw yield of BRRI dhan70 varied significantly due to different treatments under the present trail (Table 6). The highest straw yield (6.26 t ha^{-1}) was found in T_6 treatment which was statistically similar (6.14 t ha^{-1}) to T_3 and closely followed by other treatments except T_0. The lowest straw yield (4.40 t ha^{-1}) was recorded in T_0 treatment. Rahman *et al*. (2016) observed that straw yield was highest when USG was applied and the lowest value was found in control.

4.1.12 Biological yield

Statistically significant differences was recorded due to different treatments in terms of biological yield of BRRI dhan70 (Table 6). The highest biological yield (11.09 t ha^{-1}) was observed in T_6 treatment which was statistically similar (10.66 t ha^{-1}) to T_3 treatment and closely followed by other treatments except T_0. The lowest biological yield (7.28 t ha^{-1}) was observed in T_0 treatment. It was observed that 80% RFD and 1 briquette NPK fertilizer ensured proper growth and development of rice plant and ultimately this treatment produced highest biological yield also. Shah *et al*. (2013) reported that use of NPK briquette over NPK broadcast and incorporation was very much efficient for rice cultivation in terms of rice yield.

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

4.2.1 Soil pH

Soil pH of post-harvest soil showed statistically non-significant differences due to different treatments (Figure 4). The highest soil pH (6.10) was found from T_6 treatment, whereas the lowest soil pH (5.99) was observed from T_0 treatment. Data reveled that different management practices effects soil pH but not significantly.

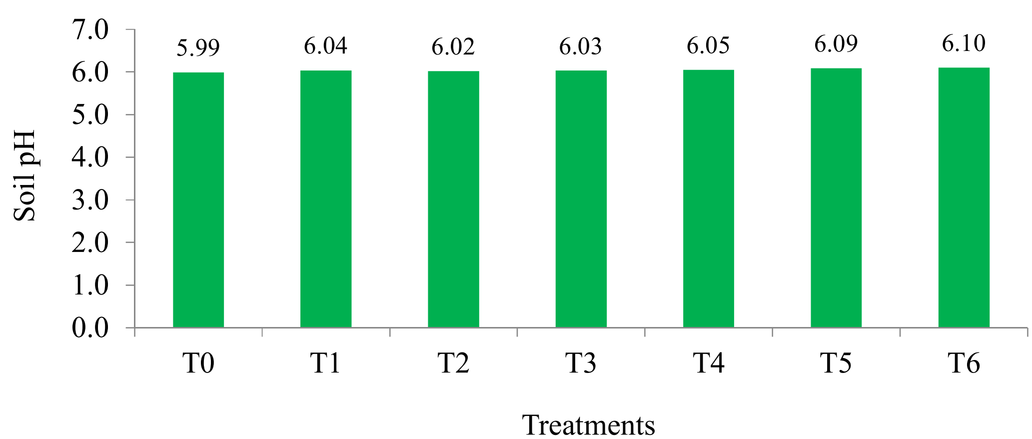


Figure 4. Effect of USG and NPK briquette on pH of post harvest soil

Table 7. Effect of USG and NPK briquette on nutrient content of post-harvest soil

Treatments	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Available K (meq/100 g soil)
T_0	5.99	1.27	0.032 c	17.29 c	0.081 d
T_1	6.04	1.35	0.062 a	30.66 a	0.165 ab
T_2	6.02	1.34	0.059 ab	28.20 ab	0.151 bc
T_3	6.03	1.34	0.063 a	31.20 a	0.172 a
T_4	6.05	1.33	0.056 b	24.62 b	0.145 c
T_5	6.09	1.31	0.059 ab	25.88 b	0.150 bc
T_6	6.10	1.35	0.064 a	32.23 a	0.178 a
$LSD_{(0.05)}$	--	--	0.006	4.567	0.018
Significance level	NS	NS	0.01	0.01	0.01
CV(%)	5.11	6.38	6.19	9.45	9.10

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

T_0: Control

T_1: 100% RFD

T_2: 1 USG (1.8 g) within 4 hills + PKSZn

T_3: 80% RFD + 2 USG within 4 hills

T_4: 1 NPK briquette within 4 hills

T_5: 2 NPK briquette within 4 hills

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

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

4.2.2 Organic matter

Organic matter content in post-harvest soil showed statistically non-significant differences due different treatments (Figure 5). The highest organic matter content (1.35%) in soil was recorded in T_6 treatment, but the value (1.27%) being noted in T_0 treatment. It was observed that chemical fertilizer have no significant effects on organic matter.

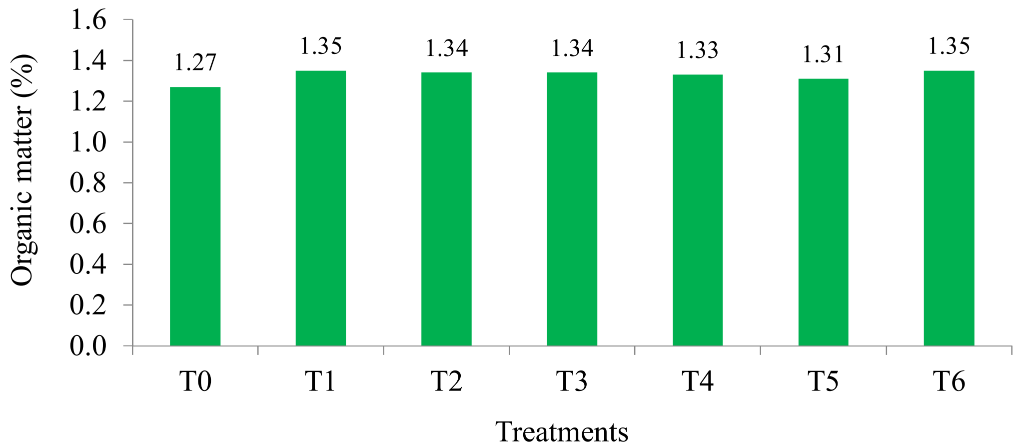


Figure 5. Effect of USG and NPK briquette on organic matter of post harvest soil

4.2.3 Total N

Total N in post harvest soil varied significantly due to different treatments under the present trail (Table 7). The highest total N (0.064%) was recorded in T_6 treatment which was statistically similar with other treatment except T_0 and T_4 treatment, while the lowest total N (0.032%) was found in T_0 treatment .

4.2.4 Available P

Available P in post-harvest soil varied significantly due to different treatments under the present trail (Table 7). The highest available P (32.23 ppm) was recorded in T_6 treatment which was statistically similar (31.20, 30.66 and 28.20 ppm) with T_3, T_1 and T_2 treatment, while the lowest available P (17.29 ppm) was found in T_0 treatment which was followed (24.62 and 25.88 ppm) by T_4 and T_5 treatment.

4.2.5 Exchangeable K

Exchangeable K in post-harvest soil varied significantly due to different treatments under the present trail (Table 7). The highest exchangeable K (0.178 meq/100 g soil) was recorded in T_6 treatment which was statistically similar (0.172 and 0.165 meq/100 g soil) with T_3 and T_1 treatment and followed (0.151 and 0.150 meq/100 g soil) by T_2 and T_5 treatment and they were statistically similar, while the lowest exchangeable K (0.081 meq/100 g soil) was found in T_0 treatment.

Chapter V

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the farm area of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period of July to November, 2017 for comparative study of USG and NPK briquette on the performance of aromatic rice variety BRRI dhan70. In this experiment BRRI dhan70 aromatic rice were used as the test crop. The experiment comprised of the treatments of T_0: Control, T_1: 100% RFD, T_2: 1 USG (1.8 g) within 4 hills + PKSZn, T_3: 80% RFD + 2 USG within 4 hills, T_4: 1 NPK briquette within 4 hills, T_5: 2 NPK briquette within 4 hills and T_6: 80% RFD + 1 NPK briquette within 4 hills. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data were recorded on different yield contributing characters, yield and characteristics of post-harvest soil and statistically significant variation was recorded for most of the studied characters.

Plant height of BRRI dhan70 at 30 DAT, the longest plant (25.08 cm) was observed in T_6 treatment, whereas the shortest plant (21.02 cm) was observed in T_0. Similar tends of results also recorded at 40, 50, 60 and 70 DAT. Similarly at harvest, the tallest plant (134.47 cm) was recorded from T_6 treatment, while the shortest plant (106.17 cm) in T_0 treatment. The maximum number of effective tillers hill^{-1} (16.53) was observed in T_6 treatment, while the minimum number (10.73) in T_0 treatment. The minimum number of non-effective tillers hill^{-1} (2.53) was observed in T_6 treatment, while the maximum number (4.27) was observed in T_0 treatment. The maximum number of total tillers hill^{-1} (19.07) was observed in T_6 treatment, while the minimum number (15.00) in T_0. The longest panicle (28.75 cm) was observed in T_6 treatment and the shortest panicle (22.88 cm) was observed in T_0 treatment. The maximum number of filled grains panicle^{-1} (133.73) was observed in T_6, while the minimum number (103.20) was observed in T_0 treatment. The minimum number of unfilled grains panicle^{-1} (11.47) was observed in T_6 treatment, whereas the maximum number (17.27) was observed in T_0. The maximum number of total grains panicle^{-1} (145.20) was observed in T_6, while the minimum number (120.47) was observed in T_0 treatment. The highest weight of 1000 grains (22.98 g) was observed in T_6, while the lowest weight (22.02 g) was observed in T_0 treatment. The highest grain yield (4.83 t ha^{-1}) was recorded in T_6, while the lowest grain yield (2.88 t ha^{-1}) was observed in T_0 treatment. The highest straw yield (6.26 t ha^{-1}) was recorded in T_6 treatment, while the lowest straw yield (4.40 t ha^{-1}) was observed in T_0. The highest biological yield (11.09 t ha^{-1}) was recorded in T_6 treatment, while the lowest biological yield (7.28 t ha^{-1}) was observed in T_0.

The highest soil pH (6.10) was found from T_6, while the lowest soil pH (5.99) was observed from T_0 treatment. The highest organic matter (1.35%) was recorded from T_6 treatment and the lowest organic matter (1.27%) from T_0 treatment. The highest total N (0.064%) was recorded in T_6 treatment, while the lowest total N (0.032%) in T_0. The highest available P (32.23 ppm) was recorded in T_6, while the lowest available P (17.29 ppm) was found in T_0 treatment. The highest exchangeable K (0.178 meq/100 g soil) was recorded in T_6, while the lowest exchangeable K (0.081 meq/100 g soil) was found in T_0 treatment.

Conclusion:

Applications 80% RFD + 1 NPK briquette within 4 hills was the superior among the other treatments in consideration of yield contributing characters and yield of aromatic rice variety BRRI dhan70.

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

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

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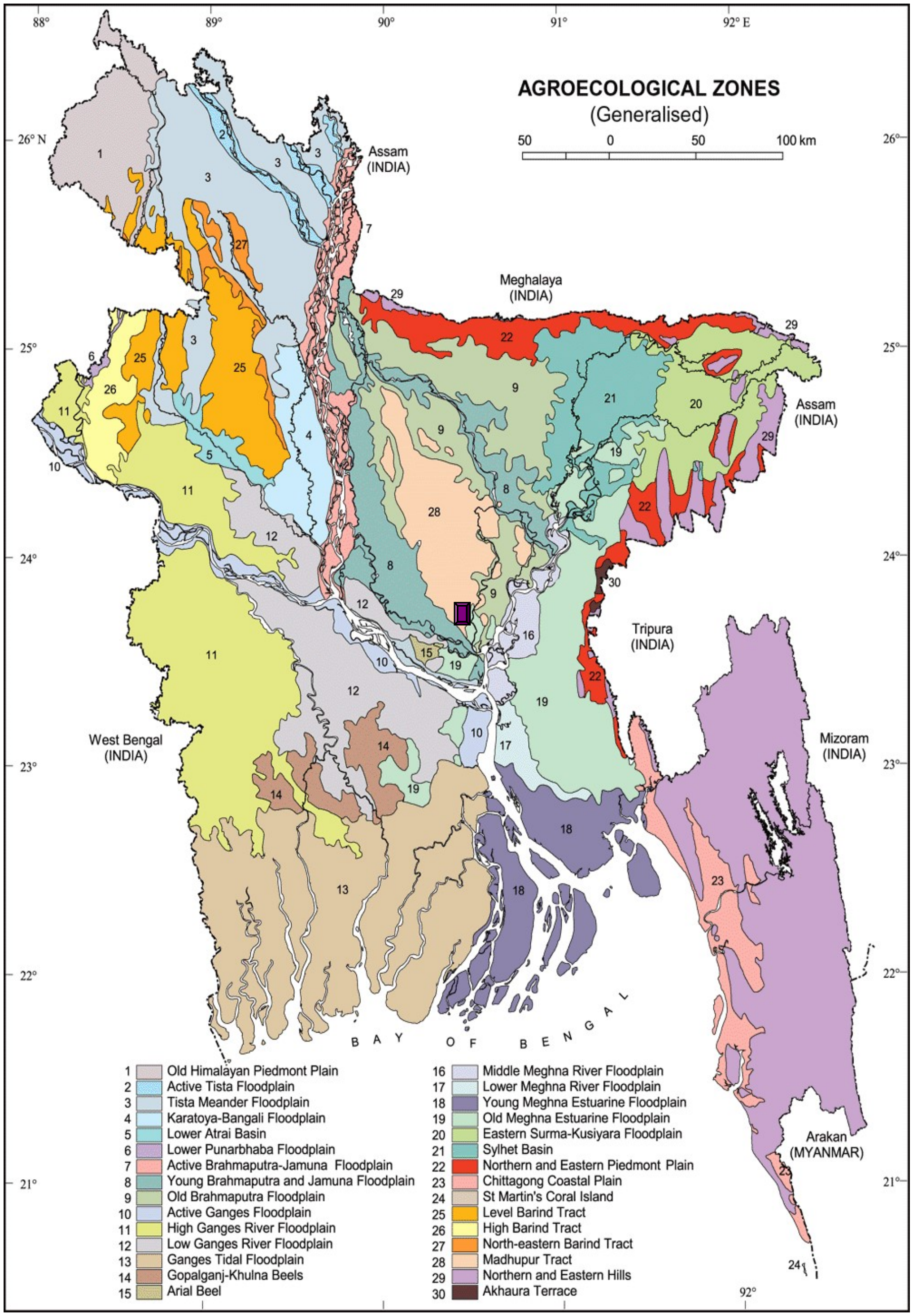
Appendices

APPENDICES

Appendix I. The Map of the experimental site



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

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

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