Asian Journal of Crop Science

ISSN 1994-7879

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Asian Journal of Crop Science

ISSN 1994-7879
DOI: 10.3923/ajcs.2016.1.12

Research Article
Urea Super Granule and NPK Briquette on Growth and Yield of Different Varieties of Aus Rice in Tidal Ecosystem

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Abstract
A field experiment was carried out at the field laboratory of Department of Agronomy, Patuakhali Science and Technology University, Dumki, during the period from March 2015 to August 2015 to assess the comparative advantages of using Urea Super Granule (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. Five fertilizer treatments (N_1 = Recommended doses of all fertilizers, N_2 = Urea super granule at 112.5 kg/during 10 DAT at available tide free time, N_3 = NPK briquette at 150 kg ha^{-1} during 14 DAT at available tide free time, N_4 = Nitrogen control, N_5 = Absolute control) with four HYV Aus rice varieties (V_1 = BRRIdhan27, V_2 = BRRIdhan48, V_3 = BRRIdhan55 and V_4 = BRRIdhan65). The experiment was laid out in a split plot design with 3 replications. 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 (t ha^{-1}) and grain yield (t ha^{-1}) were found highest when USG was applied with BRRIdhan48 and all the characters showed lowest value 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 Prilled Urea (PU) and Urea Super Granule (USG). The USG (1.8 g) and NPK briquettes (2.4 g) could save 11.3 and 19.55 kg N ha^{-1} compared to recommended PU. There was no residual effect of USG on soil chemical properties. The USG with BRRIdhan48 were found beneficial to the farmers in tidal ecosystem.

Key words: USG, NPK briquette, Aus rice, tidal ecosystem

Received: October 12, 2015 Accepted: November 04, 2015 Published: December 15, 2015

Citation: M.M. Rahman, S.C. Samanta, M.H. Rashid, M. Abuyusuf, M.Z. Hassan and K.F.N. Sukhi, 2016. Urea super granule and NPK briquette on growth and yield of different varieties of Aus rice in tidal ecosystem. Asian J. Crop Sci., 8: 1-12.

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The total area of Bangladesh is 147,570 km^2. The coastal region covers about 20% of the country and over 30% in the total cultivable area of Bangladesh. It extends inside up to 150 km from the coast. Out of 2.85 million ha of the coastal and offshore areas about 0.83 million ha are arable lands, which cover over 30% of the total cultivable lands of Bangladesh. A part of the coastal area, the Sundarbans, is a reserve natural mangrove forest covering about 4,500 km^2. The remaining part of the coastal area is used in agriculture. The cultivable areas in coastal districts are affected with varying degrees of soil salinity and tidal inundation. The coastal and offshore area of Bangladesh includes tidal, estuaries and river flood plains in the south along the Bay of Bengal. Agricultural land use in these areas is very poor, which is roughly 50% of the country's average (Petersen and Shireen, 2001). Tidal wetland (non-saline) is one of the important areas of less favorable environments in Bangladesh covering a large area (2 Mha) of tidal flood plain in the southern part of the country (Khatun *et al*., 2007). The major environmental problem for crop production in tidal non saline wetland situation is twice daily tidal inundation of land at over a period of 4-7 months (April-October) of the year. About 80% of the cultivable land of greater Barisal and Patuakhali is inundated up to the range of 6-90 cm during this period (BRRI., 2010). Kayenat and Jalil (2008) reported that the cultivation of rice in Bangladesh varies according to seasonal changes in the water supply. The largest harvest is Aman, occurring in November and December and accounting for more than half of annual production. The second harvest is Aus, involving traditional strains but more often including high-yielding, dwarf varieties. Rice for the Aus harvest is sown in March or April, benefits from April and May rains, matures during in the summer rain and is harvested during the summer. With the increasing use of irrigation, there has been a growing focus on another rice-growing season extending during the dry season from October to March. It is normal for fields throughout Bangladesh to produce rice for two harvests annually. Between rice-growing seasons, farmers will do everything possible to prevent the land from lying fallow and will grow vegetables, peanuts, pulses, or oilseeds if water and fertilizer are available and efficient utilization. BBS (2015) reported that Aus is one of the major crops in Bangladesh. It has been contributing to food production in addition to other two rice (aman and boro) crops. The weather condition for Aus cultivation was favourable in the growing stage this year. In a subjective manner, farmers were interviewed on some management system of seed and fertilizer. They opined that the incentives provided by the government to grow more Aus rice and the timely distribution of seed and fertilizer led to substantial higher production this year. Total area under Aus crop has been estimated at 1.05 million ha this year as compared to almost same area in the last year and the total Aus production (husked paddy) of 2013-2014 has been estimated at 2.326 million metrictons with 2.213 t ha^{-1}. Pre-monsoon rice (Aus rice) is grown on 150,000 ha in Southern Bangladesh. Much of this rice is grown on low lying land where the height of water in creeks changes daily with the tides. This causes a daily movement of water in and out of rice paddies. This results in broadcast applied nitrogen fertilizer being washed out of the paddies resulting in reduced nitrogen uptake and river pollution. One solution to this problem is to deep place urea fertilizers as urea granules (Alam *et al.,* 2014). Fertilizer recommendation guide is available for 30 agro-ecological zones with little differentiation for different crop-seasons (BARC., 2012). On the other hand, because of limited access to soil-testing services and small land parcels (0.1-0.3 ha), fertilizer recommendations based on soil-test results are not yet practical in the farmers' fields. For modern rice cultivation, Bangladesh Rice Research Institute (BRRI) has given a fertilizer recommendation guide but it is a too general guideline for Bangladesh (BRRI., 2011). Soil fertility, fertilizer use and crop response to fertilizer may vary among rice fields within smaller irrigated and rain-fed environments (Cassman *et al*., 1996). We have national soil map but it is difficult to recognize soil fertility difference within a village of 150 ha by the national soil map. Farmers do not apply uniform fertilizers in all plots of a national map unit due to different productivity level, but they desire uniform yields from all plots.

Nitrogen is the most important and key nutrient for rice production all over the world for its 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 wetland 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. Urea was much quickly hydrolysis by urease to ammonia and carbon dioxide ($NH_2CONH_2+H_2O\rightarrow 2NH_3+CO_2$) in the soil solution, ammonium ions in the soil solution exist in equilibrium with ammonia ($NH_4^++OH^-\rightarrow NH_2+H_2O$). More than 40% of N lost through ammonia gas when urea was applied on soil surface (Catchpoole *et al*., 1983). Deep placement of all essential fertilizers may be more efficient and farmers can be more benefited from this compared to broadcast method. In rice cultivation farmers in this area usually use non urea fertilizer as basal during final land preparation. In this reason, most of the applied fertilizers are lost through different ways. An effective alternative may be the use of Urea Super Granule (USG) or NPK briquette for higher yield and efficient use of nitrogen in rice cultivation. Therefore, in order to augment and sustain the productivity of tidal flood region, super granule form of fertilizer application deserves special attention. But deep placement of granular fertilizers is a labor intensive operation and for this region this technology is not popular. An easy but effective method of application can help in solving the problem (Miah and Masum, 2006). Nitrogen use efficiency for rice crop largely ranges between 25 and 35% and seldom exceeds 50% (Sharma, 1985). Nitrogen is one of the major nutrient elements for crop production that influences the growth and yield of rice. Unfortunately the nitrogen fertilizer in wetland rice culture is very low. Numerous N use experiments have shown that the efficiency at which N is utilized by wetland rice is only about 30% of the applied fertilizer N and in many cases even less (Prashad and de Datta, 1979).

According to Crasswell and de Datta (1980) broadcast application of urea on the surface soil causes losses up to 50% but point placement of USG in 10 cm depth may negligible loss. Urea Super Granule (USG) is a fertilizer that can be applied in the root zone at 8-10 cm depth of soil (reduced zone of rice soil) which can save 30% nitrogen than prilled urea, increase absorption rate, improve soil health and ultimately increase the rice yield. 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. In Bangladesh, yield of rice was increased by 15-25% while expenditure on commercial fertilizer was decreased by 24-32% when fertilizer briquettes were used as the source of plant nutrients. Deep placement of fertilizer briquettes also environmental and economic benefits (IFPRI., 2004). A national survey conducted in Bangladesh during 2004 showed that more than 1800 briquette-making machines had been manufactured and sold and about 550000 rice farmers were using the technology in their fields (IFDC., 2007). Therefore, a study was undertaken to evaluate the effect of urea super granules and NPK briquette fertilizer for better means of Aus rice culture under tidal ecosystem.

MATERIALS AND METHODS

An experiment was carried out at the field laboratory of the Department of Agronomy, Patuakhali Science and Technology University, Patuakhali during the period of March to August, 2015 to see the effects of Urea Super Granule (USG) and NPK briquette on growth and yield of different varieties of Aus rice in tidal ecosystem, The experimental details are described below under different subheads. The research was conducted at the field laboratory of the Department of Agronomy, Patuakhali Science and Technology University, Patuakhali. The experimental field was located at 22°27'9'' N latitude and 90°23'2'' E longitude at an altitude of 03 masl.

The experimental area belongs to the non-calcareous clay loam soil in texture with pH 5.50-6.50 under agro-ecological zone of the Ganges Tidal Floodplain (AEZ-13). The region covers several river born sediments of silt (UNDP/FAO., 1988). The present experiment was conducted during kharif-1 season from March-August 2015. The experimental area was located under the sub-tropical climate, which is specialized by moderately high temperature and heavy rainfall during the kharif season (April-September) (Biswas, 1987). The average temperature and rainfall of the month of April, May, June, July and August were 29.5, 28.5, 30, 29, 29° C and 6, 42, 20, 85, 28 cm, respectively. The data was collected from Weather station, Patuakhali. The field of the experimental site belongs to the Ganges Tidal Floodplain (AEZ 13) which was characterized by non calcareous Grey Floodplain clay loam soil. The soil was mildly acidic and non-saline. The soil having soil pH ranges from 5.50- 6.50. Organic matter content was moderate (2.69%). The nutrient status of initial soil is given (Table 1) on the basis of soil test by SRDI, District office, Barisal as follows.

Experimental treatments

Factor A: Treatments 5

N_1 = Recommended doses of all fertilizers (137.09 kg urea, 86.66 kg TSP and 39 kg MOP)

N_2 = Urea super granule at 112.5 kg ha^{-1} (1.8 g each granule) for nitrogen and recommended dose of P and K

Table 1: Initial status of soil on soil test value

Soil analysis	Soil test value	Soil test value interpretation	Range of interpretation class	Recommended fertilizer class
Total N (%)	0.134	Low	0.091-0.18	51-75
Available P (μg g^{-1})	3.2	Very low	≤6.000	16-20
Exchangeable K (meq/100 g)	0.20	Medium	0.151-0.225	16-30
Available S (μg g^{-1})	31	Optimum	27.100-36.0	0-3
Soil type	Clayey loam soil for wetland			
Yield goal	rice crops 4-4.5 t ha^{-1}			

N_3 = NPK briquette at 150 kg ha^{-1} (2.4 g each granule×1 granule)
N_4 = Nitrogen control (no nitrogen) and recommended dose of P and K
N_5 = Absolute control (no fertilizers apply)

Fertilizer recommendation are calculated by the following formula:

$$\text{Fr} = \text{Uf} - \frac{\text{Ci}}{\text{Cs}} \times (\text{St} - \text{Ls})$$

Where:
Fr : Fertilizer nutrient required for given soil test value
Uf : Upper limit of the recommended fertilizer nutrient for the respective STVI class
Ci : Units of class intervals used for fertilizer nutrient recommendation
Cs : Units of class intervals used for STVI class
St : Soil test value
Ls : Lower limit of the soil test value within STVI class
Source : BARC (2012)

Description of the fertilizers: Ordinary or PU, TSP, MOP, USG and NPK briquette were used as the source of nutrients.

Prilled urea: Ordinary or PU is the most common form of urea available in the market. It contains 46% of N. The mean diameter of PU is 1.5 mm.

Urea super granule: The USG fertilizer is manufactured from a physical modification of ordinary urea fertilizer. The international Fertilizer Development Center (IFDC), Muscle Shoals, Alabama 35660, USA, has developed it. Its nature and properties are similar to that of urea but its granule size is bigger and condensed with some conditions for slow hydrolysis. USG is spherical in shape containing 46% N which is similar to that of PU. Average diameter of the granule is 11.5 mm and weight is 1.8 g used in Aus season.

NPK briquette: The NPK briquette is a mixture of urea, TSP and MOP which helps to reduce the loss of nutrients in flooded condition. So, it is helpful for tidal flooded ecosystem. Weight of each NPK briquette is 2.4 g containing 29% N, 6% P and 8% K (Islam *et al*., 2011).

Factor B; Variety 4: Four high yielding variety of Aus rice was selected which have short duration of life cycle and suitable for tidal flooded ecosystem. These are V_1 = BRRIdhan27, V_2 = BRRIdhan48, V_3 = BRRIdhan55 and V_4 = BRRIdhan65.

Conduction of the experiment: Seeds of the selected four HYV rice varieties collected from Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur on 29th March 2015. The seeds were dipped in water in a bucket for 24 h on 4th April 2015. The seeds were then taken out of water and kept thickly in gunny bags. The seeds started sprouting after 24 h and completed within 48 h and become suitable for sowing in the seed bed by 72 h. The land was puddle by power tiller, cleaned and leveled thoroughly with ladder to get a well puddle and leveled seed bed. The length and breadth of the seedbed was 8×1.25 m. Four different seedbeds were prepared for 4 varieties. The sprouted seeds were sown in the prepared seed beds on 8th April, 2015. Proper care was taken to protect the seeds and seedlings in the nursery bed. The initial soil samples were collected before land preparation from a 0-15 cm soil depth. The samples were mixed thoroughly to make a composite sample. The plant roots, leaves etc. were removed from the sample. Then the samples were air-dried in room condition and sieved through a 10-mesh sieve and stored in a clean plastic container for physical and chemical analysis. Then it is send to regional centre of Soil Resource Development Institute, Barisal for test and analysis. The experimental field was first ploughed on April 15, 2015 with the help of a power tiller, later on May 04, 2015. The land was saturated by rain water and prepared by three successive cross ploughings with a power tiller 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 May 08, 2015 according to experimental specification. Individual plots were cleaned and finally leveled with the help of wooden plank so that no water pocket could remain in the puddled field. Plots were laid out in the field following split-plot design. Ails, drains and channels were made according to the layout. Fertilizers were applied to the plots according to recommended rate for the variety and treatments (Table 2). The whole amount of fertilizers except nitrogen was applied before final land preparation. Nitrogen fertilizer and NPK briquette was applied according to the treatment set of fertilizer application. First split of urea, whole amount of USG and NPK briquette were applied at 10 DAT. Second and third split of urea were applied to the field at 30 and 50 DAT, respectively.

The seedling were uprooted from the seed bed early in the morning on the early morning of 10th April 2015 with due care so as to avoid injury and kept on soft mud in shade to avoid mechanical injury to the roots. The uprooted seedlings

Table 2: Applied amount of fertilizers for different treatments

Fertilizers	N_1 (recommended fertilizers) (kg ha^{-1})	N_2 (USG at 112.5 (kg ha^{-1}))	N_3 (NPK briquette at 150 kg ha^{-1}) (29% N, 6% P, 8% K)	N_4 (Nitrogen control)	N_5 (Absolute control)	Nutrient present in soil
Urea (N)	137 (63.05)	112.5 (51.75)	94.56 (43.5)	0	0	12 kg N
TSP (P)	86.66 (17.33)	86.66 (17.33)	45 (9)	86.66 (17.33)	0	2.66 kg P
MOP (K)	39 (19.5)	39 (19.5)	24 (12)	39 (19.5)	0	10.5 kg K

TSP: Triple super phosphate, MOP: Muriate of Potash, USG: Urea super granule

were transplanted in the main field at 2 seedlings per hill with 20×20 cm spacing. Seedlings in some hills died off and those were replaced by the healthy seedlings from the source on 17th May 2015. The water requirement in the experimental field was maintained through the tidal flooded water and natural source such as rain water. Excess water was drained out during the heavy rainfall in order to maintain a constant water level in the field by a sluice gate. Before top dressing of urea, water was drained out from the plots. The plots were again irrigated after the application of urea. Before 15 days of harvest the field was finally drained out to enhance maturity. The crop was infested with some weeds during the early stage of crop establishment. Two hand weeding were done for entire field, first weeding was done at 15 days after transplanting followed by second weeding at 20 days after first weeding. Proper crop protection measures were taken during the entire course of crop production. The crop was infested by the rice hispa at the seedling stage and which were successfully controlled by the application of carbofuran at 2 g m^{-2} on April 20, 2015. Also total experimental area was covered by net for controlling birds during panicle initiation to harvesting. Maturity of the crop was determined when 80-90% of the grains become golden yellow in color or filled properly. The harvested crop was bundled and properly tagged. Threshing was done using pedal thresher. The grains were cleaned and samples were collected for measuring the moisture content to adjust the moisture content at 14% level. Straw sample were also collected for oven dry for measuring the straw weight. Finally grain and straw yield per plot were determined and converted to ton per hectare. The varieties of transplanted Aus rice were harvested when they got 80-85% maturity. Nitrogen use efficiency is defined as kg grain yield increase kg^{-1} N applied. As N fertilizers were applied in different plots at different doses, the use efficiency N was calculated by the following formula (Afroz, 2013):

$$NUE = (G_{y+N-}G_{y0N})/FN$$

Where:

G_{y+N} = Grain yield in treatment with N application
G_{y0N} = Grain yield in treatment without N application
FN = Amount of fertilizer N applied (kg ha^{-1})

The data on different parameters were recorded to observe the effect of different fertilizer management on yield and yield contributing characters if Aus rice. Data is collected from selected hills in each unit plot. To avoid border effect with the highest precision, 5 hills were selected randomly from each plot. The recorded data for different parameters were compiled and tabulated in proper form for statistical analysis. Analysis of variance was done with the help of computer software package MSTAT-C program. The mean differences among the treatments were compared by Duncan's Multiple Range Test (DMRT) at 5% level of significant (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effect of fertilizer management on plant height: Fertilizer management significantly affected plant height at all stages of rice plant (Fig. 1). Significantly highest plant height (75.08, 112.2 and 128.6 cm) was found in USG (N_2) followed by the NPK briquette treated plots (74.8, 109.5 and 128.6 cm) and lowest (65.92, 102.5 and 116.3 cm) in absolute control (N_5) at 30, 50 and harvesting time respectively. These findings supported the results reported by Azam *et al*. (2012), BRRI (2010) and Mizan (2010). They found that the application of N increased the plant height significantly.

Effect of variety on plant height: Significant variations of plant height among the four varieties of Aus rice were found at all the growth stages (Fig. 2). The plant heights were measured at 30 and 50 DAT and harvesting time. Results revealed that the tallest plant height (75.80, 122.1 and 157.3 cm) were obtained from BRRIdhan27 which is statistically significant to BRRIdhan48 (72.20, 105.1 and 117.5 cm), BRRIdhan55 (67.40, 103.5 and 113.8 cm) and BRRIdhan65 (66.67, 97.60 and 103.1), respectively. The variation in plant height was due to genetic variability and variation in growth behavior. Similar findings were obtained by Uddin *et al*. (2010), Ashrafuzzaman *et al*. (2009) and Islam *et al*. (2007).

Effect of fertilizer management on number of tillers hill: Level of different fertilizer management had significant effect on the number of tillers per hill (Fig. 3). The highest number of

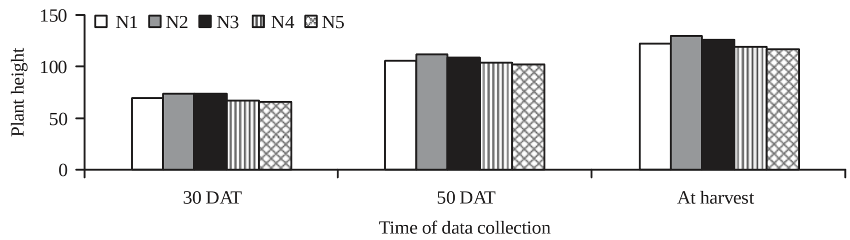

Fig. 1: Effects of fertilizer management on plant height of Aus rice under tidal ecosystem [$S_{\bar{x}}$ = 0.3291, 0.2563 and 0.3112, CV% = 1.62, 0.83 and 0.87, respectively at 30 and 50 DAT and harvesting time]

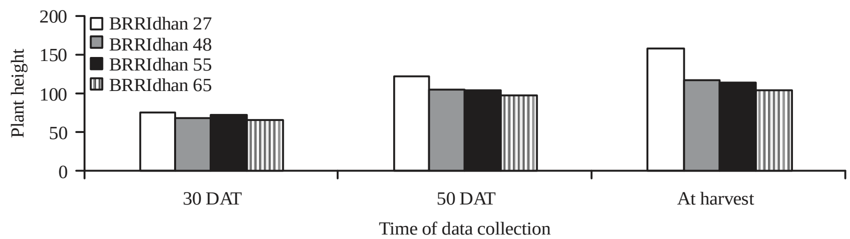

Fig. 2: Varietal Effect on plant height of Aus rice under tidal ecosystem [$S_{\bar{x}}$ = 0.2756, 0.1876 and 0.3972, CV% = 1.51, 0.68 and 1.25, respectively at 30 DAT, 50 DAT and harvesting time]

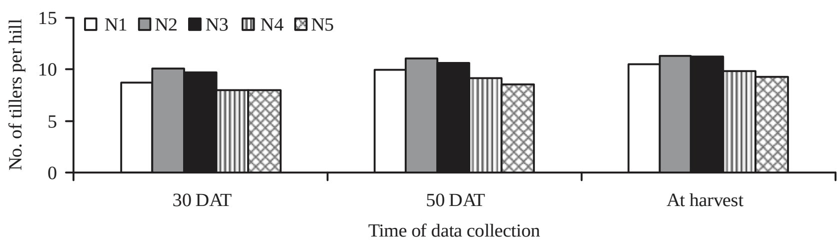

Fig. 3: Effects of fertilizer management on number of tiller per hill of Aus rice under tidal ecosystem [$S_{\bar{x}}$ = 0.1017, 0.0769 and 0.1369, CV% = 3.99, 2.70 and 4.6, respectively at 30 DAT, 50 DAT and harvesting time]

effective tillers per hill (10.0, 10.94 and 11.15) were counted with USG, the lowest number of tillers per hill (7.92, 8.54 and 9.21) were recorded in absolute control the second highest result were obtained from NPK briquette (9.69, 10.58 and 11.13) at 30 DAT, 50 DAT and harvesting time. At 30 DAT and Harvesting time the tiller number with USG (10.0 and 11.15) and NPK briquette (9.69 and 11.13) were statistically non-significant. Adequacy of nitrogen probably favored the cellular activity during tiller formation and development, which led to increased number of tillers per hill. Azam *et al.* (2012), Das (2011) and Yaqub *et al.* (2010) also reported the similar results from their experiments.

Effect of variety on number of tillers per hill: Varietal effects were significantly influenced on number of tillers per hill (Fig. 4). Results showed that BRRIdhan48 (9.48a, 10.83a and 11.47a) performed the beast than other varieties. BRRIdhan27 (8.52c, 9.12d and 9.73c), BRRIdhan55 (8.40c, 9.32c and 9.7c) and BRRIdhan65 (8.89b, 10.05b and 10.42b) showed these pattern of tillering habit at 30 DAT, 50 DAT and harvesting time. The difference might be due to the variation in the genotype of the varieties. Razzaque *et al.* (2009) and Jeng *et al.* (2006) also found similar findings.

Interaction effects of fertilizer management and variety on plant height and number of tillers per hill: The effect of interaction between fertilizer management and varieties on plant height was significant (Table 3). The tallest plant (81.0, 131.7 and 161.7 cm) was found in BRRIdhan27 treated with USG after transplanting (N_2V_1) and the lowest (62.67, 94.0 and 98.67 cm) at BRRIdhan65 with absolute control (N_5V_4) at 30 DAT, 50 DAT and harvesting time, respectively. Islam *et al.*(2011) reported that taller plants were observed in NPK briquette, USG and prilled urea treated

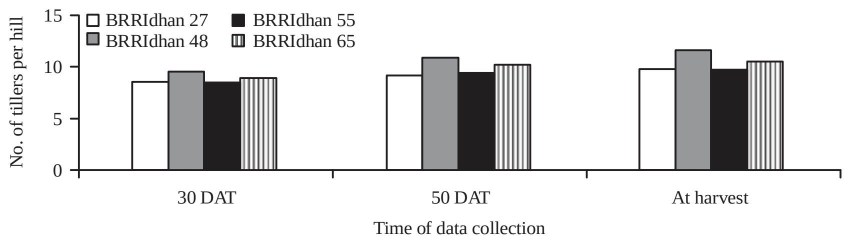

Fig. 4: Varietal effect on number of tiller per hill of Aus rice under tidal ecosystem [S_{x^-} = 0.0724, 0.06218 and 0.08981, CV% = 3.08, 2.44 and 3.36, respectively at 30 DAT, 50 DAT and harvesting time]

Table 3: Interaction effect of fertilizer management and varieties on plant height and tillers per hill at different days after transplanting

	Plant height at different DAT			Total number of tillers per hill at different DAT		
Treatment combination	30 DAT	50 DAT	At harvest	30 DAT	50 DAT	At harvest
N_1V_1	75.67^{c}	120.7^{c}	158.3^{b}	8.25	9.0^{hi}	9.5^{ghi}
N_1V_2	67.00^{g}	105.0^{h}	116.7^{fg}	9.25	10.92^{c}	11.67^{ab}
N_1V_3	72.67^{d}	103.0i	114.7^{g}	8.17	9.42f^{gh}	9.83f^{gh}
N_1V_4	63.33^{h}	97.33^{l}	103.7^{j}	8.59	10.33^{d}	1067^{cd}
N_2V_1	81.00^{a}	131.7^{a}	161.7^{a}	9.75	10.17^{de}	10.58^{d}
N_2V_2	73.00^{d}	109.3^{f}	123.7^{e}	10.75	11.92^{a}	12.25^{a}
N_2V_3	75.67^{c}	107.7^{g}	122.0^{e}	9.58	10.33^{d}	10.50^{de}
N_2V_4	70.67^{ef}	100.0^{k}	107.0^{hi}	9.92	11.33^{b}	11.25^{bc}
N_3V_1	78.33^{b}	125.3^{b}	159.3^{ab}	9.5	9.83^{ef}	10.33d^{ef}
N_3V_2	71.67^{de}	107.0^{g}	123.3^{e}	1033	1158^{ab}	12.25^{a}
N_3V_3	76.00^{c}	105.7^{h}	119.0^{f}	9.25	10.1^{de}	10.67^{cd}
N_3V_4	70.33^{ef}	100.0^{k}	105.3^{ij}	9.67	10.83^{c}	11.25^{bc}
N_4V_1	72.00^{de}	117.7^{d}	155.3^{c}	7.58	8.5^{jk}	9.25^{hi}
N_4V_2	63.33^{h}	102.7^{ij}	114.0^{g}	8.75	10.25^{de}	10.75^{cd}
N_4V_3	69.67^{f}	101.7^{j}	108.3^{h}	7.42	8.67^{ij}	9.1^{i}
N_4V_4	66.33g	96.67^{l}	100.7^{k}	8.0	9.25^{gh}	9.92^{efg}
N_5V_1	72.00^{de}	115.0^{e}	151.7^{d}	7.5	8.1^{k}	9.0^{ij}
N_5V_2	62.00^{h}	101.7^{j}	109.7^{h}	8.33	9.5^{fg}	10.42^{j}
N_5V_3	67.00^{g}	99.33^{k}	105.0^{ij}	7.58	8.1^{k}	8.42^{j}
N_5V_4	62.67^{h}	94.00^{m}	98.67^{k}	8.25	8.5^{jk}	9.0^{ij}
Sx	0.6162	0.4195	0.8883	0.1571	0.1390	0.2008
Level of significance	**	**	**	NS	*	*
CV (%)	1.51	0.68	1.25	3.08	2.44	3.37

**Significant at p<0.01; *Significant at p<0.05; NS: Non-Significant, Means having similar latter(s) do not differ significantly whereas means having dissimilar latter(s) differ significantly as per DMRT at 5% level, CV: Coefficient of variation, N_1: Recommended doses of all fertilizers, N_2: Urea super granule at 112.5 kg ha^{-1}, N_3: NPK briquette at 150 kg ha^{-1} (2.4 g each granule × 1 granule), N_4: Nitrogen control and N_5: Absolute control, V_1: BRRIdhan27, V_2: BRRIdhan48, V_3: BRRIdhan55, V_4: BRRIdhan65, CV: Coefficient of variation

plots compared to control plots both at 30 and 60 DAT. Number of tillers per hill differed significantly due to the interaction of fertilizer management and varieties (Table 3). Results showed that the highest number of tillers per hill (10.75, 11.92 and 12.25) was obtained from BRRIdhan48 coupled with USG. Other results are showed in the table.

Effect of fertilizer management, variety and their interaction at 50% flowering (leaf area index and dry matter) and at maturity (panicle length): Application of PU, USG and NPK briquette fertilizers showed a positive effect on flowering and maturity. The lowest days required for 50% flowering and maturity were observed in USG treated plots (53.83 and 71.58 DAT). The second lowest days required in NPK briquette applied plots (55.0 and 72.67 DAT) and the highest result obtained from absolute control (58.58 and 78.50 DAT). These results are statistically similar with Halder (2013) and Rahman *et al.* (2011). The flowering and maturity dates were significantly influenced by the different varieties of *Aus* rice. Where BRRIdhan27 needed longer time for 50% flowering and maturity (62.60 and 80.67 DAT) and BRRIdhan65 needed shortest time (52.27 and 69.07 DAT). The similar result was reported by Das (2014). Combined effect of absolute control (N_5) and BRRIdhan27 required the highest duration for 50%flowering and maturity (64.67 and 83.33 DAT) and application of N as USG with BRRIdhan65 needed shortest duration (50.33 and 64.0 DAT) (Table 4).

Table 4: Effect of fertilizer management, varieties and combined effect of fertilizer management and varieties on 50% flowering, maturity, LAI, dry matter and panicle length

Treatments	50% flowering (DAT)	Maturity (DAT)	LAI	Dry matter	Panicle length
	Fertilizer effect				
N_1	55.83^{c}	75.42^{b}	2.58^{c}	22.55^{b}	22.86^{b}
N_2	53.83^{e}	71.58^{c}	2.92^{a}	24.18^{a}	23.58^{a}
N_3	55.00^{d}	72.67^{c}	2.85^{b}	23.93^{a}	23.44^{a}
N_4	57.83^{b}	77.67^{a}	2.50^{d}	21.39^{c}	22.39^{c}
N_5	58.58^{a}	78.50^{a}	2.34^{e}	21.75^{c}	21.93^{d}
Sx	0.2174	0.5147	0.02236	0.1725	0.08851
Level of significance	**	**	**	**	**
CV (%)	1.33	2.37	2.93	2.63	1.34
Variety	Varietal effect				
V_1	62.60^{a}	80.67^{a}	3.30^{a}	24.73^{a}	24.45^{a}
V_2	56.13^{b}	72.00^{c}	2.67^{b}	23.49^{b}	22.82^{b}
V_3	53.87^{c}	78.93^{b}	2.24^{d}	20.90^{d}	22.26^{c}
V_4	52.27^{d}	69.07^{d}	2.40^{c}	21.93^{c}	21.84^{d}
Sx	0.1806	0.2245	0.01155	0.1855	0.04619
Level of significance	**	**	**	**	**
CV (%)	1.24	3.65	1.7	3.16	0.78
Treatment combination	Interaction effect of fertilizer management and variety of Aus rice				
N_1V_1	62.33^{b}	81.33^{b}	3.31^{b}	24.76	24.30^{b}
N_1V_2	56.67^{ef}	71.67^{hi}	2.55^{g}	23.50	23.13^{ef}
N_1V_3	52.67^{ij}	79.33^{c}	2.20^{i}	20.38	22.17^{hi}
N_1V_4	51.67^{jk}	69.33^{jk}	2.25^{i}	21.58	21.83^{jk}
N_2V_1	60.33^{c}	78.00^{c}	3.60^{a}	26.45	25.47^{a}
N_2V_2	53.0^{hi}	68.33^{k}	3.07^{c}	25.09	23.60^{cd}
N_2V_3	51.67^{jk}	76.00^{d}	2.50^{gh}	22.42	22.93^{fg}
N_2V_4	50.33l	64.00^{m}	2.72^{e}	22.79	22.33^{h}
N_3V_1	62.00^{b}	78.00^{c}	3.52^{a}	25.86	25.33^{a}
N_3V_2	54.33^{g}	70.33^{ij}	2.72^{e}	24.44	23.30^{de}
N_3V_3	52.67^{ij}	76.00^{d}	2.5^{1g}	22.40	22.80^{g}
N_3V_4	51.00^{kl}	66.33^{l}	2.64^{f}	23.02	22.33^{h}
N_4V_1	63.67^{a}	82.67^{ab}	3.11^{c}	23.10	23.83^{c}
N_4V_2	57.67^{e}	74.33^{ef}	2.56^{g}	22.09	22.17^{hi}
N_4V_3	56.00^{f}	81.33^{b}	2.10^{j}	19.62	21.97^{ij}
N_4V_4	54.00^{gh}	72.33^{gh}	2.23^{i}	20.74	21.60^{kl}
N_5V_1	64.67^{a}	83.33^{a}	2.95^{d}	23.48	23.30^{e}
N_5V_2	59.00^{d}	75.33^{de}	2.42^{h}	22.31	21.90^{ijk}
N_5V_3	56.33^{f}	82.00^{ab}	1.91^{k}	19.71	21.43^{l}
N_5V_4	54.33^{g}	73.33^{fg}	2.10^{j}	21.52	21.10^{m}
Sx	0.4037	0.5020	0.02582	0.4147	0.1033
Level of significance	*	*	**	NS	**
CV (%)	1.24	1.69	1.7	3.16	0.78

**Significant at $p<0.01$; *Significant at $p<0.05$ and NS: Non-Significant, Means having similar latter(s) do not differ significantly whereas means having dissimilar latter(s) differ significantly as per DMRT at 5% level, CV: Coefficient of variation

Urea Super Granule (USG) and NPK briquette fertilizers provide a better effect on LAI and Dry matter production (Table 4). The highest result for LAI and Dry matter were observed in USG treated plots (2.97 and 24.18 g per hill) followed by NPK briquette applied plots (2.85 and 23.93 g per hill). The absolute control plots showed the lowest results (2.34 and 21.39 g per hill). In dry matter USG and NPK briquette showed statistically similar results. Similar results were reported by Yaqub *et al*. (2010) and Ahammed (2008). Variety significantly influenced leaf area index and dry matter production of Aus rice at 50% flowering stage (Table 4). The highest LAI and dry matter were found in BRRIdhan27 (3.295 and 24.73 g per hill) followed by BRRIdhan48(2.67 and 23.49 g per hill) and BRRIdhan65 (2.4 and 21.93 g per hill). BRRIdhan55 (2.24 and 20.9 g per hill) showed the lowest results. These results are similar as Das (2014). Interaction effect between Fertilizer management and varieties of Leaf area index and Dry matter at 50% flowering stage were non-significantly influenced (Table 4). The highest LAI and dry matter were found in USG (N_2) and BRRIdhan27 (3.6 and 26.45 g per hill) and the lowest results were found in absolute control (N_5) with BRRIdhan55 (1.91 and 19.71 g per hill). In dry matter production absolute control (N_5) with BRRIdhan65 (19.62 g per hill) was statistically non-significant with

BRRIdhan55. Significant differences in panicle length were observed due to fertilizer management (Table 4). USG (23.58 cm) and NPK briquette (23.44 cm) showed statistically similar result and lowest result was found in absolute control (21.93 cm). The similar result was found by Debnath (2012). Panicle length was significantly affected by different Aus rice varieties (Table 4). Numerically the highest (24.45 cm) panicle length was found in BRRIdhan27 and lowest (21.84 cm) in BRRIdhan65. From the result it was observed that panicle length was significantly influenced by the interaction of fertilizer management and varieties (Table 4). However numerically the highest panicle length was found in USG treated BRRIdhan27 (25.47 cm) and the lowest result was found in absolute control with BRRIdhan65 (21.10 cm). Statistically similar result was found by Debnath (2012).

Effect of fertilizer management, variety and their interaction on filled grain, thousand seed weight, grain yield, straw yield and harvest index: The effect of fertilizer management on number of filled grain per panicle and 1000 seed weight were significant (Table 5). The highest number of filled grain (58.91) was observed with USG while lowest (47.59) was found in no fertilizer. In 1000 seed weight USG (25.07 g) and NPK briquette (24.84 g) showed statistically similar result but lowest result found in no fertilizer (24.23 g). These results are supported by Halder (2013), Debnath (2012) and Nori *et al.* (2008). Filled grain per panicle and 1000 seed weight were significantly influenced by different *Aus* rice varieties (Table 5).

Table 5: Effect of fertilizer management, varieties and combined effect of fertilizer management and varieties on grain yield, straw yield and harvest index

Treatments	Filled grain	1000 seed wight	Grain yield	Straw yield	Harvest index
	Fertilizer effecte				
N_1	51.738^{c}	24.571^{b}	2.790^{c}	3.299^{c}	44.487^{bc}
N_2	58.912^{a}	25.072^{a}	3.332^{a}	4.030^{a}	44.982^{abc}
N_3	55.430^{b}	24.845^{a}	3.226^{b}	3.851^{b}	45.544^{a}
N_4	50.076^{d}	24.459^{b}	2.452^{d}	3.083^{d}	45.167^{ab}
N_5	47.693^{e}	24.229^{c}	2.280^{e}	2.869^{e}	44.078^{c}
Sx	0.1981	0.07012	0.03028	0.02415	0.2672
Level of significance	**	**	**	**	*
CV (%)	1.30	0.98	3.72	2.43	2.06
Variety	Varietal effect				
V_1	55.118^{b}	29.559^{a}	3.137^{b}	3.852^{a}	44.834^{b}
V_2	60.615^{a}	24.171^{b}	3.355^{a}	3.684^{b}	47.627^{a}
V_3	44.785^{d}	22.158^{d}	2.263^{d}	2.988^{d}	42.927^{d}
V_4	50.560^{c}	22.653^{c}	2.509^{c}	3.182^{c}	44.018^{c}
Sx	0.2987	0.1434	0.2000	0.01414	0.1995
Level of significance	**	**	**	**	**
CV (%)	2.07	2.46	2.75	1.6	1.72
Treatment combination	Interaction effect of fertilizer management and variety of Aus rice				
N_1V_1	54.520^{ef}	29.263^{c}	3.210^{d}	3.770^{d}	45.990^{bc}
N_1V_2	60.350^{c}	24.233^{ef}	3.310^{d}	3.600^{e}	47.3903^{a}
N_1V_3	43.363^{jk}	22.197^{kl}	2.244^{l}	2.777^{l}	40.080^{g}
N_1V_4	48.720^{h}	22.590^{ij}	2.394^{jk}	3.050^{k}	43.973^{de}
N_2V_1	62.410^{b}	30.103^{a}	3.757^{b}	4.570^{a}	45.117^{cd}
N_2V_2	67.830^{a}	24.623^{d}	4.051^{a}	4.337^{b}	48.297^{a}
N_2V_3	49.153^{h}	22.413^{jk}	2.510^{ij}	3.513^{ef}	41.667^{f}
N_2V_4	56.253^{e}	23.147^{h}	3.009^{ef}	3.700^{d}	44.850^{cde}
N_3V_1	58.200^{d}	29.763^{b}	3.555^{c}	4.400^{b}	44.690^{cde}
N_3V_2	63.723^{b}	24.400^{de}	3.717^{b}	4.177^{c}	47.090^{ab}
N_3V_3	45.850^{i}	22.373^{jkl}	2.888^{f}	3.400^{gh}	45.933^{bc}
N_3V_4	53.947^{fg}	22.843^{hi}	2.745^{g}	3.427^{fg}	44.463^{de}
N_4V_1	52.397^{g}	29.437^{c}	2.610^{ghi}	3.327^{hi}	43.957^{de}
N_4V_2	56.043^{e}	23.917^{fg}	3.030^{e}	3.293^{i}	47.920^{a}
N_4V_3	43.803^{j}	22.037^{lm}	1.860^{n}	2.697l	45.413^{cd}
N_4V_4	48.060^{h}	22.447^{jk}	2.311^{kl}	3.017^{kl}	43.377^{e}
N_5V_1	48.063^{h}	29.227^{c}	2.552^{hi}	3.193^{j}	44.417^{de}
N_5V_2	55.130^{ef}	23.680^{g}	2.664^{gh}	3.013^{k}	46.927^{ab}
N_5V_3	41.757^{k}	21.770^{m}	1.816^{n}	2.554^{m}	41.543^{f}
N_5V_4	45.820^{i}	22.240^{jkl}	2.087^{m}	2.717^{l}	43.427^{e}
Sx	0.6678	0.1111	0.0447	0.0316	0.4461
Level of significance	**	*	**	**	**
CV (%)	2.2	0.78	2.69	1.70	1.72

**Significant at $p<0.01$, *Significant at $p<0.05$. Means having similar latter(s) do not differ significantly whereas means having dissimilar latter(s) differ significantly as per DMRT at 5% level

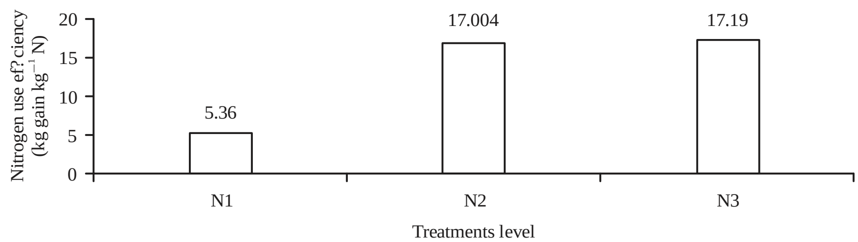

Fig. 5: Nitrogen use efficiency of different nitrogenous fertilizers; N1: Recommended doses of fertilizers, N2 = USG+Recommended doses of other fertilizers and N3 = NPK briquette

The highest filled grain per panicle (60.62) was observed in BRRIdhan48 and lowest (44.79) in BRRIdhan55. On the other hand the 1000 seed weight was highest (29.56 g) in BRRIdhan27 and lowest (22.65 g) in BRRIdhan55. Ashrafuzzaman *et al.* (2009) found that significant difference of 1000 grain weight among varieties. Jeng *et al.* (2006) found the similar result in respect of 1000 grain weight. Filled grain per panicle was highest in USG and BRRIdhan48 (67.83) andlowest in no fertilizer with BRRIdhan55. And in case of 1000 seed weight USG and BRRIdhan27 (30.10 g) provide the highest result and lowest in absolute control with BRRIdhan55 (21.77 g) (Table 5). The fertilizer management had a significant influence on grain yield and straw yield (Table 5). Results showed that the highest (3.33 and 4.03 t ha^{-1}) grain and straw were found in USG treated plots. Absolute control gave the lowest (2.28 and 2.87 t ha^{-1}) grain and straw. Adequacy of nitrogen probably favored to produce the highest plant height, number of effective tillers per hill, total number grains per panicle, 1000 seed weight which ultimately gave higher grain yield. Though at recommended dose of all fertilizers (N1) applied highest amount of urea but it was applied in three splits where last two split was applied more than 30 cm flooded water. It may influence the wash out of the nutrient from the field. On the other hand harvest index showed highest (45.54 %) in NPK briquette and lowest (44.08) in absolute control. In USG higher amount of N may favored the straw yield. Fertilizer management differences regarding grain yield and Straw yield were also reported by Shah *et al.* (2013), Das (2011), Qiao *et al.* (2011) and Tahura (2011). There was a significant difference among the varieties in respect of grain yield, straw yield and harvest index (Table 5). Among the four varieties BRRIdhan48 produced the highest (3.35 t ha^{-1}) grain yield which was identically (3.13 t ha^{-1}) followed by BRRIdhan27, BRRIdhan65 (2.51 t ha^{-1}) and BRRIdhan55 (2.26 t ha^{-1}). In case of straw yield BRRIdhan27 (3.85 t ha^{-1}) showed the best performance and BRRIdhan55 (2.98 t ha^{-1}) produce the lowest straw. BRRIdhan48 (47.63%) got the highest HI and BRRIdhan55 (42.93%) had the lowest. Hosain *et al.* (2014) reported that BRRIdhan48 (3.51 t ha^{-1}) produce the height grain yield among different varieties. Uddin *et al.* (2010) and Sohel *et al.* (2009) reported that these variations in yield might be due to genetic makeup of the varieties. Grain yield, straw yield and harvest index also varied significantly due to interaction effect between Fertilizer management and varieties (Table 5). It is evident that the highest grain yield (4.05 t ha^{-1}) was found in USGand BRRIdhan48, highest straw yield (4.57 t ha^{-1}) was found in USG and BRRIdhan48 and highest HI (48.30%) at USG and BRRIdhan48. The lowest result found in grain yield and straw yield (1.82 t ha^{-1} and 2.55 t ha^{-1}) at no fertilizer with BRRIdhan55. Lowest harvest index (40.08%) at recommended dose with BRRIdhan55.

Nitrogen use efficiency: The observed result provided that the highest NUE (17.19 kg grain kg^{-1} N) was observed in NPK briquette followed by USG (17.004 kg grain kg^{-1} N) and recommended doses (5.36 kg grain kg^{-1} N) (Fig. 5).

CONCLUSION

The USG briquette (1.8 g) showed better performance in terms of growth and yield of rice with 17.004 kg grain kg^{-1} N use efficiency. NPK briquettes gave statistically significant yield with PU and nitrogen control. But the USG and NPK briquettes saved 11.3 and 19.55 kg ha^{-1} N compared to prilled urea respectively. On the other hand among the four varieties BRRIdhan48 (3.33 t ha^{-1}) showed the best performance. So, it may be concluded that USG 1.8 g as the source of N with BRRIdhan48 might be beneficial to the farmers in the tidal ecosystem.

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