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An Effect of fertilizer management practices on the yield of T. aman rice under tidal ecosystem

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Abstract: The experiment was carried out at the field laboratory of Department of Agronomy, Patuakhali Science & Technology University, Dumki, during the period from July 2011 to December 2011 to assess the comparative advantages of using Urea Super Granule (USG) and NPK briquette over normal urea, Triple super phosphate and Muriate of Potash and also predict the better performing T. aman rice. The effect of different levels of fertilizer was studied on growth, yield and yield attributing character of T. aman. Six fertilizer Treatments (F_0= Control(No urea), F_1 = Total urea (150 kg ha^{-1})during land preparation at available tide free time, F_2 = Urea (75 kg ha^{-1})at 2 split, F_3 = Urea (50 kg ha^{-1})at 3 split, F_4 = Urea Super Granule (54 kg N ha^{-1}) at 10 days after transplanting and F_5 = NPK briquette (42Kg N ha^{-1} 9 Kg P ha^{-1} 12 Kg K ha^{-1})at 10 days after transplanting of T. aman rice). Besides, TSP, MOP , zinc sulphate and Gypsum were applied @100, 70, 50 and 12 kg ha^{-1} respectively as basal dose. The 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 T. aman rice. Plant height, number of effective tillers $hill^{-1}$, number of non-effective tillers $hill^{-1}$, panicle length (cm), number of grains $panicle^{-1}$, number of sterile spikelet's $panicle^{-1}$, nitrogen use efficiency (%), straw yield(t ha^{-1}) and grain yield (t ha^{-1}) were found highest when NPK briquette was applied and all the characters showed lowest value when control. Highest number of effective tillers $hill^{-1}$ (13.00) and grain yield (6.60 t ha^{-1}) was obtained from NPK briquette and where lowest number of effective tillers $hill^{-1}$ (5.66) and grain yield (4.48 t ha^{-1}).The NPK briquettes showed higher agronomic efficiency than Prilled urea(PU) and Urea super granule(USG). The small size briquettes (2.4 g) could save 33 kg N ha^{-1} compared to recommended PU. There was no residual effect of NPK briquettes on soil chemical properties.The NPK briquettes were found beneficial to the farmers in tidal ecosystem.

Keyword: T. Aman, Fertilizer Management, Tidal Ecosystem

1. Introduction

Tidal wetland is one of the important areas of less favorable environments in Bangladesh covering a large area (2 mha) of tidal floodplain in the southern part of the country. The major environmental problem for crop production in tidal non saline wetland situation is 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 districts is inundated up to the range of 6-90 cm for about 4-5 months from June to October (BRRI, 2004). 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 N or other nutrients exists, an effective alternative may be the use of Urea Super Granules (USG)/NPK briquette for higher yield of rice. Therefore in order to augment and sustain the productivity of tidal flood region, granular form of fertilizer application deserves special attention. But deep placement of granular fertilizer is a labor intensive operation and for this region this technology is not popular. An easy but efficient method of application can help in solving the problem (Mia *et al*., 2006). According to Crasswell and De Datta (1980) broadcast application of urea on the surface soil causes losses up to 50% but point placement of urea super granules (USG) in 10 cm depth may negligible loss. Urea super granules (USG) is a fertilizer that can be applied in the rice 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 (Savant *et al.,* 1991). The prilled urea gave N use efficiency up to 36% where USG gave N use efficiency up to 63%. 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; Nommik, 1973). Deep placement of all essential fertilizers may be more efficient and farmers can be more benefited from this compared to broadcast method. The use of NPK briquette, which is a mixture of urea, triple super phosphate (TSP) and muriate of potash (MOP) may help to reduce the loss of nutrients in tidal flooded ecosystem. 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).

The recent literatures on nitrogen use efficiency of rice in general, indicated the superiority of root zone placement of urea super granules as it could reduce the magnitude of nitrogen losses to a considerable extent and improve its use efficiency for better grain production (Crasswell and De Datta, 1980, Pillai, 1981). Therefore, a study was undertaken to evaluate the effect of urea super granule and NPK Briquette fertilizer for better means of rice culture under tidal ecosystem.

2. Materials and Methods

This chapter deals with the materials used and methodology that were used in conducting the experiment. The location of the experiment, climate, materials used and methods followed in different operations during the experiment as well as in data collection are described here under the following sub-heads:

2.1. Experimental Site

The research was conducted at the Agronomy Field Laboratory, Patuakhali Science & Technology University. The experimental field was located at 22o 27.903/ N latitude and 90o 23.291/ E longitude at an altitude of 03 meters above the sea level. The experimental area belongs to the non-calcareous clay soil under Agro-ecological Zone of the Ganges Tidal Floodplain (AEZ-13). The region covers several river borne sediments of silt (UNDP and FAO, 1988). The present experiment was conducted during kharif season from September 2011 to December 2011.

2.2. Climate

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) and low rainfall with moderately low temperature during robi season (October to March).

2.3. Soil

The soil of the experimental land belongs to the Barisal series of non-calcareous clay soil but they become more silty in the east and usually have a buried peat layer in the west under the Ganges Tidal Floodplain (AEZ-13). The experimental field was medium high land with poor drained condition. The land was Clay loam in texture having a soil pH value of 6, moderate in organic matter content.

2.4. Treatments

The factor were included in the experiment, which are as follows:

Fertilizer (F): 5 Treatments of fertilizer

i) Control (No urea) (F_0)
ii) Total urea(150 kg ha^{-1}) at available tide free time (F_1)
iii) Urea (75 kg ha^{-1}) at 2 splits (F_2)
iv) Urea (50 kg ha^{-1})at 3 splits (F_3)
v) Urea Super Granule (USG) (54 kg N ha^{-1}) at 10 days after transplanting (F_4)
vi) NPK briquette(42Kg N ha^{-1} 9 Kg P ha^{-1} 12 Kg K ha^{-1}) at 10 days after transplanting (F_5)

2.4.1. Description of the Fertilizers

Ordinary or PU, TSP, MOP, USG and NPK briqueete were used as the sources of fertilizers.

2.4.2. Prilled Urea

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

2.4.3. Urea Super Granule

Urea Super Granule 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 per granule is 1.8 gram used in aman season. It is not a slow release fertilizer but can be considered as a slowly available N fertilizer.

2.4.4. NPK Briquette

NPK Briquette 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. Weight of NPK briquettes is 2.4 g used in aman season which contains 29% N, 6% P and 8% K.

2.5. Experimental Design and Layout

The experiment was laid out in a split plot design with three replications. Each replication was divided into 18 unit plots where treatment combinations were allocated at random. Separate randomization was carried out for other blocks. Total numbers of unit plots were 54 and each plot size was 4.0 x 2.5 m^2. The distance maintained between the unit plots and replication was 0.5 m and 1m, respectively.

2.6. Conduction of the Experiment

2.6.1. Seed Collection

Seeds were collected from the Agronomy Field Laboratory, Patuakhali Science & Technology University.

2.6.2. Seed Sprouting

Healthy seeds were selected by specific gravity method. The selected seeds were soaked in water for 24 hours in three respective dates on 02 July 2011 and then they were placed in gunny bags for sprouting. The seeds started sprouting after 48 hours and were suitable for sowing after 72 hours.

2.6.3. Preparation of Nursery Bed and Seed Sowing

A piece of high land was selected in the Agronomy Field Laboratory of Patuakhali Science and Technology University for raising seedlings. The land was puddled with country plough, cleaned and leveled with ladder. Then the sprouted seeds of T. aman rice were sown in the prepared nurseries on 05 July 2011. Proper care was taken to protect the seeds and seedlings in the nursery bed. Seed bed size was 1 x 8 m^2 for each spell.

2.6.4. Preparation of Experimental Land

The experimental land was prepared by a power tiller 10 days before transplanting. It was then ploughed well with the help of country plough to make the soil nearly ready for transplanting. The field layout was made on 27 August 2011 according to experimental specification immediately after final land preparation. Individual plots were cleaned off weeds and stubbles and finally leveled by wooden plank.

2.6.5. Fertilizer Application

Fertilizers were applied to the experimental plots at the rate of 150, 100, 70, 50 and 12 kg ha^{-1} of prilled urea, triple super phosphate (TSP), muirate of potash (MoP), gypsum, zinc sulphate and USG (54 kg N ha^{-1}) and NPK briquette (42 kg N ha^{-1}, 9 kg P ha^{-1}, 12 kg K ha^{-1}). The whole amount of triple super phosphate (TSP), gypsum, zinc sulphate and half muriate of potash (MoP) were applied as basal dose at the time of final land preparation. The TSP, MOP and gypsum were applied as basal and the briquettes and USG were inserted 7 to 10 cm deep in the middle of every alternate 4 hills. NPK briquette (F_5) and USG (F_4) were applied 10 days after transplanting (DAT).

Prilled urea (50 kg ha^{-1}) was applied thrice at 15, 30 & 45 DAT (F_2), twice (75 kg ha^{-1}) at 15 & 30 DAT (F_2) and 150 kg ha^{-1}totally at land preparation (F_1). Half MOP at 15 and 30 DAT by dividing equally. The USG, PU and N control treated plots received @ 48-35-10 kg ha^{-1} P, K & S through TSP, MOP, and gypsum.

2.6.6. Uprooting of Seedling

Nursery beds were made wet by application of water both in the morning and evening on the previous day before uprooting the seedlings. Forty-five days old seedlings were uprooted from the nursery bed carefully without causing any mechanical injury to the roots and kept on soft mud in shade before they were transplanted in the main field.

2.6.7. Transplanting of Seedling

Four seedlings $hill^{-1}$ were planted on 16 august 2011 maintaining hill spacing of 20 cm and row spacing of 20 cm.

2.6.8. Intercultural Operations

The following intercultural operations were done for ensuring the normal growth of the crop.

2.6.9. Gap Filling

After one week of transplanting dead seedlings were replaced carefully by planting new seedlings in the field.

2.6.10. Weed Control

Weeding was not needed due to continuous tidal flooding.

2.6.11. Irrigation

Due to frequent raining during crop growth period, no irrigation was needed.

2.6.12. Plant Protection Measure

No remarkable infestation of insect pests was noticed in the field.

2.6.13. Harvesting and Processing

The crop was harvested at full maturity when 80% of the grains turned golden yellow in color. Pedal thresher was used to thresh the crop of individual plot. Grains were sun dried to a moisture content of some 14% and then weighed. Straw was sun dried and weighed. Yields of both grain and straw were converted to ha^{-1}.

2.7. Nitrogen Use Efficiency (NUE)

It is the ratio of N removal with harvest & mineral N input multiplied by 100.NUE calculated with the following formula:

$$NUE = \frac{\text{N removal with harvest}}{\text{Mineral N input}} \times 100$$

2.8. Data Collection

The data on different parameters were recorded to observe the effect of different fertilizer management on yield and yield contributing character. Data are collected from selected plants in each unit plot. To avoid border effect with the highest precision, 5 plants were selected randomly from each plot.

2.9 Statistical Analysis

Data recorded for different parameters were compiled and tabulated in proper form for statistical analysis. The collected data were statistically analyzed using "Analysis of variance technique" with the help of computer package program MSTAT-C and Duncan's Multiple Range Test (DMRT) following (Gomez and Gomez, 1984) adjudged the significance of mean difference.

3. Results and Discussion

3.1 Effect of Fertilizer Management Practices on Plant Height

Fertilizer management practices significantly affected plant height at all stages of rice plant (Fig. 1, Table. 4).

Highest plant height (110.3 cm) was found in NPK briquette (F_5) and lowest (101.6 cm) in no urea (F_0). These findings corroborated with the results reported by Surekha *et al.* (1999) and Singh *et al.* (1996). They found that the higher plant height due to higher application of N.

3.2. Effect of Fertilizer Management Practices on Number of Effective Tiller Hill^{-1}

Levels of different fertilizer had significant effect on the number of effective tillers hill^{-1}. The highest number of effective tillers hill^{-1} (13.00) was counted with NPK briquette (Table 1). The lowest number of effective tillers hill^{-1} (5.66) was recorded in control. Adequacy of nitrogen probably favored the cellular activity during panicle formation and development, which led to, increased number of effective tillers hill^{-1}. Pandey *et al.* (1991) and Thakur (1993) also, reported the similar results from their studies.

3.3. Effect of Fertilizer Management Practices on Number of Non- Effective Tillers Hill^{-1}

Number of non-effective tillers hill^{-1} differed significantly due to fertilizer management practices. The maximum number of non-effective tillers hill^{-1} (4.33) was observed when the crop was fertilized with no urea. However, the lowest number of non-effective tillers hill^{-1} (2.11) was obtained from the plots treated with NPK briquette and USG at 10 days after transplanting (Table 1). Somewhat decreasing trend was observed with decreasing levels of nitrogen.

Table 1. *Main effect of fertilizer management practices on Number of effective tiller hill^{-1} and Number of non- effective tillers hill^{-1}*

Fertilizer levels	Effective tiller hill^{-1}	Non effective tiller hill^{-1}
Control (F_0)	5.667 f	4.333 a
Total Urea (F_1)	7.667 e	3.333 b
Urea at 2 split (F_2)	9.000 d	3.333 b
Urea at 2 split (F_3)	10.33 c	2.667 c
Urea Super granule (F_4)	12.22 b	2.111 d
NPK briquette (F_5)	13.00 a	2.111 d
$S\bar{x}$	0.127	0.062
Level of sig.	**	**
$LSD_{0.05}$	0.366	0.1792
CV%	3.96	6.26

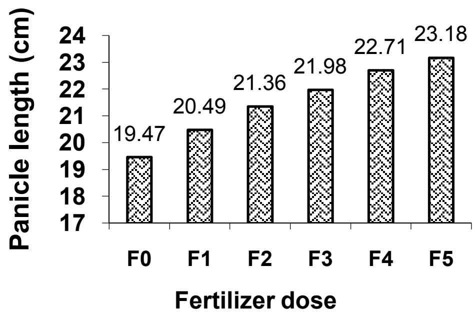

Fig 1. *Main Effect of fertilizer management practices on panicle length of T. aman rice (F_o =Control, F_1= Total urea at available tide free time, F_2= Urea at 2 splits, F3= Urea at 3 splits, F4= Urea Super Granule (USG) at 10 days after transplanting, F5= NPK briquette at 10 days after transplanting.)*

3.4. Effect of Fertilizer Management Practices on Panicle Length

Significant differences in panicle length were observed due to fertilizer management practices. The longest panicle (23.18 cm) was found with NPK briquette that was statistically identical with that of USG at 10 days after transplanting (22.71 cm). The shortest panicle (19.47 cm) was observed in no urea (Fig. 2). Nitrogen took part both in panicle formation and elongation and for this reason panicle length increased with adequate N levels.

3.5. Effect of Fertilizer Management Practices on Number of Grains Panicle^{-1}

The effect of fertilizer management practices on the number of grains panicle^{-1} was significant .The highest number of grains panicle^{-1} was observed with NPK briquette (104.4) while no urea (72.59) produced the lowest number of grains panicle^{-1} (Table 2). Nitrogen took part both in grain formation and development and for this reason number of grains panicle^{-1} increased with higher N levels. Rama *et al.* (1989) reported that the number of grains panicle^{-1} was higher due to deep placement of USG than PU application.

Table 2. *Main effect of fertilizer management practices on Number of grains panicle^{-1}and Number of sterile spikelet's panicle^{-1}*

Fertilizer levels	Grains panicle^{-1}	Sterile spikelets panicle^{-1}
Control (F_0)	72.59 f	22.00 a
Total Urea (F_1)	78.68 e	16.97 b
Urea at 2 split (F_2)	83.96 d	14.29 c
Urea at 2 split (F_3)	96.64 c	12.37 d
Urea Super granule (F_4)	100.6 b	11.69 e
NPK briquette (F_5)	104.4 a	9.967 f
$S\bar{x}$	0.318	0.212
Level of sig.	**	**
$LSD_{0.05}$	0.915	0.611
CV%	1.07	4.38

3.6. Effect of Fertilizer Management Practices on Number of Sterile Spikelet's Panicle^{-1}

Fertilizer management practices had significant effect on the production of sterile spikelets panicle^{-1} (Table 2). The highest number of sterile spikelets panicle^{-1} (22.0) was observed in control. The lowest number of sterile spikelets panicle^{-1} (9.96) was observed with NPK briquette.

3.7. Effect of Fertilizer Management Practices on Grain Yield

The fertilizer management practices had a significant influence on grain yield. Table 3 shows that the grain yield of transplant aman rice was the highest (6.60 t ha^{-1}) with NPK briquette, control gave the lowest yield of (4.48 t ha-*1*). This finding was similar with the observations made by Bowen *et al.* (2005), Miah *et al.* (2004) and Rahman (2003). Increased doses of urea helped to increase panicle length, total tillers hill-1, effective tillers hill^{-1} and filled grains panicle^{-1}. So, ultimately the grain yield was increased. Singh et al. (2005) stated that each increment dose of nitrogen significantly increased grain yield.

3.8. Effect of Fertilizer Management Practices on Straw Yield

Straw yield was significantly influenced by fertilizer management practices .NPK briquette produced the highest straw yield (7.17 t ha^{-1}). The lowest straw yield (5.61 t ha^{-1}) was recorded from control (Table 3). This result are in an agreement with the findings of Dhane *et al.* (1989) who reported that straw yield increases with increasing nitrogen level.

Table 3. *Main effects of fertilizer management practices on different yield and yield component.*

Fertilizer management practices	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index
Control (F_0)	4.489 f	5.611 e	44.25 e
Total Urea (F_1)	5.011 e	5.933 d	45.59 d
Urea at 2 split (F_2)	5.267 d	6.167 c	45.93 cd
Urea at 3 split (F_3)	5.856 c	6.644 b	46.81 bc
Urea Super granule (F_4)	6.344 b	7.011 a	47.41 ab
NPK briquette (F_5)	6.600 a	7.178 a	47.90 a
$S\bar{x}$	0.0605	0.0802	0.333
Level of sig.	**	**	**
$LSD_{0.05}$	0.174	0.230	0.959
CV%	3.27	3.76	2.16

Table 4. *Main Effect of fertilizer management practices on plant height of T. aman rice.*

Fertilizer levels	Plant height (cm)
Control (F_0)	101.6 f
Total Urea (F_1)	103.3 e
Urea at 2 split (F_2)	104.5 d
Urea at 2 split (F_3)	106.4 c
Urea Super granule (F_4)	108.2 b
NPK briquette (F_5)	110.3 a
$S\bar{x}$	0.139
Level of sig.	**
$LSD_{0.05}$	0.399
CV%	0.39

3.9. Effect of Fertilizer Management Practices on Harvest Index

Harvest index was significantly influenced by fertilizer management practices.

Numerically the maximum harvest index (47.90%) was recorded in NPK briquette while the lowest (44.25%) was obtained from control (Table 3).

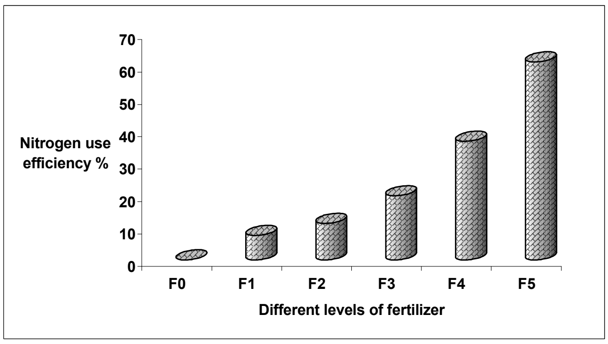

Fig 2. *Main effect of fertilizer management practices on N uses efficiency (%) of T. aman rice Fo =Control, F1= Total urea at available tide free time, F2= Urea at 2 splits, F3= Urea at 3 splits, F4= Urea Super Granule (USG) at 10 days after transplanting, F5= NPK briquette at 10 days after transplanting.*

3.10. Effect of Fertilizer Management Practices on Nitrogen use Efficiency (%)

The observed result proved that the highest N use efficiency (61.19%) was observed in NPK briquette. And lowest N use efficiency (0.00%) was recorded from control (Fig. 2).

4. Conclusions

The NPK briquette (2.4 g) showed better performance in terms of growth and yield of rice and higher N use efficiency. NPK briquettes gave statistically similar yield as USG and PU, but the former saved 33 kg ha-1 N compared to prilled urea. So, it may be concluded that NPK briquette 2.4 g might be beneficial to the farmers in the tidal ecosystem.

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