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EFFICACY OF BASAL UREA AND DEEP PLACEMENT OF UREA SUPER GRANULES (USG) ON GROWTH AND YIELD OF FLOODED RICE

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A B S T R A C T
The experiment was conducted at the Agronomy Field Laboratory, Rajshahi University during the period from May to November, 2018 in order to study the efficacy of basal urea and deep placement of urea super granules (USG) on growth and yield of flooded rice. The experiment comprised of two factors- Factor A: Basal urea application rates (three rates); B_1: 0 kg ha^{-1}; B_2: 50 kg ha^{-1}, B_3: 100 kg ha^{-1}; Factors B: of Urea super granules deep placement rates (three rates); F_1: 0 kg ha^{-1}, F_2: 50 kg ha^{-1}and F_3: 100 kg ha^{-1}. The experiment was laid out in a randomized completely block design (RCBD) with three replications. Experimental results showed that both basal and deep placement of USG had significant effect on flooded rice growth and yield. Basal urea application @ 100 kg ha^{-1} produced the highest plant height (156.48cm), total tillers hill^{-1} (6.07), effective tillers m^{-2} (88.81), maximum panicle length (25.87cm), maximum filled grains panicle^{-1} (82.02), grain yield (1.75 t ha^{-1}), straw yield (4.83 t ha^{-1}) and biological yield (6.57 t ha^{-1}). Whereas deep placement of USG @ 100 kg ha^{-1} produced the highest plant height (161.83cm), total tillers hill^{-1}(6.11), effective tillers m^{-2} (91.74), maximum panicle length (26.03cm), total grains panicle^{-1}(141.02), grain yield (1.77 t ha^{-1}), straw yield (4.98 t ha^{-1}), biological yield (6.75 t ha^{-1}). Treatment combination of B_3F_3contribute highest grain yield (1.83 t ha^{-1}), straw yield (5.41 t ha^{-1}), and biological yield (7.28 t ha^{-1}). Chalanbeel is one of the largest lowland ecosystem of Bangladesh where most of the farmers use only basal urea @ 100 kg ha^{-1}, where flooded rice (Digha) yield can be achieved 1.7 t ha^{-1}.From our experiment, we would like to suggest them to apply additional urea super granules @ 100 kg ha^{-1} as deep placement (using a self-loaded injector) at 60 DAS, which can achieve additional 7.1 % more yield (1.83 t ha^{-1}) than conventional practice.

1. INTRODUCTION

Rice (*Oryza sativa* L.) belongs to cereal crops under Gramineae family. Nearly half of the population of the world use rice as their main food. Millions of people in Asia subsist entirely on rice and over 90% of the world's rice is grown and eaten in Asia (BBS, 2013). It plays a vital role in the economy of Bangladesh providing significant contribution to the GDP, employment generation and food availability. In Bangladesh, rice is the most extensively cultivated cereal crop. About 75% of the total cropped area and over 80% of the total irrigated area is planted to rice. Thus, rice plays a vital role in the livelihood of the people of Bangladesh. It provides nearly 48% of rural employment, about two-third of total calorie supply and about one-half of the total protein intakes of an average person in the country (BBS, 2013). It provides about 75% of the calories and 55% of the protein in the average daily diet of the people of our country (Bhuiyan et al., 2002). The climatic and edaphic conditions of Bangladesh are favorable for rice cultivation throughout the year. Among the rice growing countries, Bangladesh occupies third position in rice area and fourth position (12.00 million of hectare) in rice production (India 1st, China 2nd, and Indonesia 3rd) (BRRI, 2012). But the average yield is quite low compared to that in other leading rice growing countries. Bangladesh earns about 31.6% gross domestic product (GDP) from agriculture (BBS, 2008) in which rice is the main crop.

Agriculture in Bangladesh is characterized by intensive crop production with rice based cropping systems. The rice crop removes large amounts of N for its growth and grain production. The estimated amount of N removal ranges from 16 to 17 kg for the production of one ton of rough rice, including straw (Chowdhury et al., 1998 and Razib, 2010; Sahrawat, 2000). Total N uptake by rice plant per hectare varies among rice varieties. Most of the rice soils of the world are deficient in N (Chopra, 2000; Castro, 2000). Fertilizer N applications are thus necessary to meet the crop's demands. Generally, urea is the most convenient N source for rice. The efficiency of the urea-N in rice culture is very low, generally around 30–40%, in some cases even lower (Mashkar, 2005).

In Bangladesh, rice is grown under diverse irrigated, rainfed and deep-water conditions in the three distinct seasons, namely Aus(mid-March to mid-August), Aman (mid-June to November) and Boro (Mid December to mid-June). The largest part of the total production of rice comes from Aman rice. Flooded rice is grown during Aman season on about 9 million hectares, mostly in south and south-east Asia comprising India, Bangladesh, Burma, Thailand and Vietnam (Dahatonde, 1992). There are about 10 million hectares where the depth of submergence is from 15 to 50 cm during the crop growth period. In some years, this crop is likely to suffer from drought in the early stages when rainfall is erratic but, submergence with excessive water in later stages is common in most of the years. Traditional tall varieties are being grown in the majority of these areas and virtually no fertilizer nitrogen is generally applied because of high risk, low yields and excessive water depth. In recent years, high yielding varieties to replace these are being successfully introduced and simultaneously, efforts are being directed to developing fertilizer N management schedules for maximum efficiency so as to derive most benefit from the varieties developed.

During Aman season different types of flooded rice varieties are widely spread and very common in different low land areas of Bangladesh. It is grown on the flood plains and deltas of rivers such as the Ganges and Brahmaputra of India and Bangladesh. Flooding usually occurs in the later stages of plant growth and can last for several months. The stipulation that flooding must be sustained for at least one month is to distinguish flooded rice areas from other flood-prone areas. Most flooded rice survives by elongation of stems, whereas other rice types lack this characteristic and are destroyed by flood water. Floating rice can survive and produce grain when floodwaters reach maximum depths of 4 meters or even more. In flooded rice cultivation nitrogen fertilizers are abundantly used.

However, N- use efficiency, the recovery efficiency and the agronomic efficiency in flooded rice is one of the lowest among the plant nutrients, due to large N losses from soil. Nitrogen plays a key role in rice production and it is required in large amount (Hasan et al., 2002). Total N uptake by rice plant ha^{-1}varies among rice varieties. Nitrogen is required in adequate amount at early, at mid-tillering and panicle initiation stage for better grain development (Ahmed et al., 2005). For cultivation of rice, farmers of Bangladesh solely depend on urea fertilizer (BBS, 2012). On the other hand, excessive N fertilization is one of the major concerns in sustainable agriculture for its decreased N-utilization efficiency by crops and increased N release to the environment, resulting atmosphere and water pollution (Zaman et al., 1993).

During our study, a field survey was conducted in Chalanbeel area of Bangladesh and it was found that most of the farmers of the area are not conscious to apply N fertilizer to grow flooded rice (**Table 1**). In this survey, data was collected from total 77 farmers in three different areas of chalanbeel and it was observed that most of the farmers (84.57%) use basal urea but only 0.33% of them use topdressing urea. Inadequate crop stands due to variable patterns of rainfall and consequent occurrence of drought and flooding conditions influenced farmer for less input and less expected yield (around 1 t ha^{-1}). Less knowledge about fertilizer (urea) application under flooding condition is also a reason for topdressing urea application. Deep placement of urea super granules (USG) using urea injector could be a possible way to maximize yield (IFDC, 2007).

Table 1: Field survey for urea application status of flooded rice at Chalanbeel area of Bangladesh

Number of observation / location	Number of Farmer	Basal urea application (%)	Top dressing urea application (%)
Domdoma	27	82.5	0
Kantonagar	31	79.4	0
Sthapondighi	19	91.8	1
Average		84.57	0.33

Nitrogen has a positive influence on the production of effective tiller per plant, yield and yield attributes (Iqbal, 2011; BRRI, 2013). It is necessary to find out the suitable rate of nitrogen fertilizer for efficient management and better yield of rice. Rice plant cannot produce higher grain yield without addition of fertilizer in the crop field (BRRI, 2011). Basal fertilization improves initial plant vigour and tiller production, whereas N application at later stages helps in reducing tiller mortality and increasing panicle size (Nayak et al., 2002; Sharma, 1995).

Considering the above facts, the present research was undertaken with the following objectives:

i. To estimate the efficacy of urea deep placement on the yield of flooded rice.
ii. To optimize proper urea application rate on growth and yield of flooded rice.
iii. To increase nitrogen fertilizer use of flooded soil.

MATERIALS AND GROWTH CONDITION: The research was conducted at the Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, Rajshahi University, Rajshahi, during the period from May to November 2018, to investigate the efficacy of basal urea and deep placement of urea super granules (USG) on growth and yield of flooded rice.

Geographically the experimental field is located at 24°22’36” N latitude and 88°38’27” E longitude at an average altitude. The experimental area belongs to the subtropical climate under Central Southern Part of High Ganges River flood plain i.e., under the Agro-Ecological Zone-11. The land of the experimental field below flood level (Low land). The soil was sandy loam textured having pH value of 8.1 and with moderately slow permeability. The experimental area under the sub-tropical climate that is characterized by high temperature (42^0C), high humidity and heavy rainfall with occasional gusty winds in kharif season (July-October) and rainfall associated with moderately temperature during the kharif-1I season (July-October). During the experiment, highest (353.4 mm) rainfall was observed in the month of July and average rainfall (123.8 mm) was found in rest of the other months. Average minimum and maximum temperature were found 24° C and 37.72° C, respectively. Flooded rice, variety DIGHA was used in the present experiment collected from Natore. It is very popular and locally cultivated in low land areas of Bangladesh.

Experimental treatments: The experiment was carried out with two factors. Factor A, Basal urea application rate (three rates) B_1= 0 kg ha^{-1}, B_2= 50 kg ha^{-1} and B_3= 100 kg ha^{-1} and Factor B, Urea super granules (USG) deep placement rate (three rates) F_1= 0 kg ha^{-1}, F_2= 50 kg ha^{-1} and F_3= 100 kg ha^{-1}. The experiment was laid out in a Randomized Completely Block Design with three replications. The size of each unit plot was $10m^2$ (4m ×2.5m). The total number of plots was 27 in the experiment.

Crop cultivation and agronomic management: At first the land was opened by two times ploughing by power tiller on 18 May, 2018. Later on, it was ploughed and cross ploughed three times with bullock drawn country plough followed by laddering to obtain a desirable condition. The corners of the lands were spaded well. Weeds and stubbles were removed from the field prior to sowing of seeds. The layout of the experimental field was made according to the design adopted. The bunds around the individual plots were prepared before sowing. Finally, the total experimental area was isolated from nearby fields through the formation of a big and raised ail (bunds). The experimental land was fertilized with phosphorous (P_2O_5), potash (K_2O), Sulphur 150, 70, 60, kg ha^{-1} respectively, in the form of triple super phosphate, muriate of potash and gypsum. The whole amount of triple super phosphate, gypsum, muriate of potash were applied as basal dose at final land preparation. Nitrogen was applied as per experimental treatments; basal urea was applied during final land preparation and deep placed urea was applied at 60 DAS. For basal application, prilled urea (46% N) was used, while for deep placement urea super granules (USG) was used. Urea super granules was applied (spacing 10cm apart and depth 8-10cm) with the help of a self-loaded injector. Bold and healthy seeds were broadcasted in the soil.

The experimental field was frequently observed during the growing period of the crop for ensuring and maintaining the normal growth of the crop. The crop was infested by yellow rice stem borer (Scirpophagaincertulus), green leaf hopper and rice leaf roller at vegetative stages, which were successfully controlled by applying Basudin 10G @ 10 kg ha^{-1} at 15 days’ interval for two times at tillering stage. No major disease incidence in the crop was observed.

Three hills (excluding the border hills) from each plot were randomly selected to collect data about growth parameters. Selected hills were uprooted, tagged and properly cleaned from dirt materials before collect data. The operation was done at 21 days’ intervals up to harvest.

The crop was harvested at optimum maturity when grains were filled properly. Harvesting was done on 16

November. After harvesting, the crop of each plot was separately bundled, properly tagged and then brought to the threshing floor. After drying, the crops were threshed by paddle thresher separately plot-wise. Then the grains were dried in the sun and cleaned. Straws were also sun dried properly. Finally, grain and straw yield were adjusted to 14 percent moisture and converted to ton ha^{-1}.
Maturity of crop was determined when about 80 percent grains become golden yellow. Five hills (excluding border hills) were randomly selected from each plot and tagged for recording necessary data. After sampling, the whole plot was harvested at full maturity on 16November, 2018. The harvested crop was threshed, cleaned and sun dried to record the yields of grain and straw plot-wise and converted into tons per hectare.At final harvest, data on some morpho-physiological, yield components and yield were also collected.
Statistical Analysis: The collected data were analyzed statistically using the analysis of variance technique and the mean differences were adjudged by Duncan's Multiple Range Test (Chew, V. 1976) with the help of STATVIEW (Gomez *et al.*, 1984) software.

RESULTS

During our study growth, yield contributing characters of rice were evaluated. Significant difference was observed in plant height of flooded rice for basal urea application rate during most observations except 21 days after sowing (DAS). At 21 DAS, the maximum plant height (28.02 cm) was observed in B_2, where basal urea was applied at 50 kg ha^{-1} and the minimum (25.76 cm) was in B_1, where urea was not applied. At 42 DAS, the maximum plant height (36.90 cm) was observed in B_3 (urea was applied @100 kg ha^{-1}) and the minimum (29.74 cm) was observed in B_1. At 63DAS, the maximum Plant height (59.90cm) was observed in B_3 and the minimum (44.26 cm) was observed in B_1. At 84 DAS, maximum plant height (89.89 cm) was observed in B_3 and minimum plant height (78.37cm) was observed in B_1. At 105 DAS, the maximum plant height (117.13cm) was found in B_3 and the minimum plant height (97.66cm) was found in B_1. At 126 DAS, the maximum (119.58 cm) and the minimum (106.65cm) plant height was observed in B_3 and $B_{1,}$ respectively. At 147 DAS, maximum plant height (156.48 cm) was observed in B_3 and minimum plant height (136.51cm) was in B_1. Here B_3 was 6.43% and 13.03% higher than B_2 and $B_{1,}$ respectively (**Table 2**).
The efficacy of deep placement urea super granules on plant height of flooded rice was statistically significant in case of most observations except 21 and 42 DAS (**Table 2**). At 21and 42 DAS no significant difference was observed in plant height due to deep placement of USG (USG was deep placed at 60 DAS). At 63 DAS, the tallest plant (55.05 cm) was recorded in F_3 (USG was deep placed @100 kg ha^{-1}) and the smallest plant (48.63cm) was recorded in F_1 (USG was not deep placed). At 84 DAS, the maximum plant height (94.03cm) was observed in F_3 and the minimum was (74.29 cm) in F_1. At 105 DAS, maximum plant height (115.35cm) was recorded in F_3 and minimum plant height (95.81cm) was recorded in F_1. At 126 DAS, the maximum plant height (121.66 cm) and the minimum plant height (104.74cm) was observed in F_3 and $F_{1,}$ respectively. At 147 DAS, the tallest plant (161.83cm) was recorded in F_3 which reduced significantly 10.10% and 18.37% in F_2 (USG was deep placed @50 kg ha^{-1}) and $F_{1,}$ respectively.
Plant height of flooded rice was statistically significant due to interaction between basal urea application and urea deep placement rates at all observation (42, 63, 84,105,126 and 147 DAS) except 21 DAS. At 21 DAS, the highest plant height (29.94 cm) was observed in the interaction of B3 with F1 and the lowest (23.61cm) was in B1F1. At 42 DAS, maximum plant height (39.33cm) was found in the combination of B3 with F3 and minimum (28.66 cm) was in B1F1. At 63 DAS, the tallest plant height (65.77 cm) was recorded in combination of B3 with F3 and the shortest (42.16 cm) was in B1F1. At 84 DAS, the tallest plant (99.66cm) was obtained from combination of B3 with F3 and the smallest plant height (69.89cm) was in B1with F1. At 105 DAS, the highest plant (127.11cm) was found in combination of B3 with F3 and the lowest (92.83cm) was found in B1F1. At 126 DAS, maximum plant height (129.22cm) was recorded in combination of B3 with F3 and minimum (99.16cm) was recorded in B1F1. At 147 DAS, the tallest plant (170.46 cm) was obtained from combination of B3 with F3 and the smallest plant height (123.71cm) was observed in B1F1 (Table 2). The results were similar with the findings of Meena *et al.* (2003); Sahrawat *et al.* (2000) and Thakur (1993) who observed higher plant height with the higher doses of nitrogen.
The data recorded on dry matter accumulation by rice at 21, 42, 63, 84,105 and 126 DAS were presented in **Table 3**. At 21 DAS, the highest TDM (0.19 g $plant^{-1}$) was observed in B_3, which reduced significantly 21.05% and 42.11% in B_2 and $B_{1,}$ respectively. At 42 DAS, maximum TDM (0.34 g $plant^{-1}$) was found in $B_{3,}$ which reduced significantly 2.94% and 14.70% in B_2 and $B_{1,}$ respectively. At 63 DAS, maximum TDM

(1.53 g plant^{-1}) was obtained in B_3 that reduced significantly 9.15% and 28.76% respectively in B_2 and B_1. At 84 DAS, the highest TDM (4.22 g plant^{-1}) was observed in B_3 which reduced significantly 9.95% and 17.29% in B_2 and B_1. At 105 DAS, maximum TDM (14.38 g plant^{-1}) was recorded in B_3 that reduced significantly 8.41% and 16.27% in B_2 and B_1, respectively. At 126 DAS, maximum TDM (19.67 g plant^{-1}) was found in B_3 which reduced 14.23% and 20.39% in B_2 and B_1, respectively.

The efficacy of deep placementof urea super granules on total dry matter (TDM) of flooded rice varied significantly at 21,42,63,84,105 and 126 DAS **(Table 3)**. At 21 DAS, the highest TDM (0.17g plant^{-1}) was observed in F_3 and the lowest (0.14 g plant^{-1}) was in F_1. The highest TDM reduced significantly 11.76% and 17.65% in F_2 and F_1, respectively. At 42 DAS, maximum TDM (0.38 g plant^{-1}) was obtained in F_3 that reduced significantly 18.42% and 26.32% in F_2 and F_1, respectively. At 63 DAS, the highest TDM (1.72 g plant^{-1}) was found in F_3 which reduced significantly 25% and 41.28% in F_2 and F_1, respectively. At 84 DAS, maximum TDM (4.32 g plant^{-1}) was found in F_3 that reduced significantly 14.12% and 19.44% respectively in F_2 and F_1. At 105 DAS, the highest TDM (15.09 g plant^{-1}) was recorded in F_3 that reduced significantly 12.79% and 24.85% in F_2 and F_1, respectively. At 126 DAS, maximum TDM (21.04 g plant^{-1}) was recorded in F_3 which reduced significantly 20.53% and 31.46% in F_2 and F_1, respectively.

TDM was significantly influenced by the interaction of basal urea application and deep placement of urea super granules rate at most of the growth stages (**Table 3**). At 21 DAS, the highest TDM (0.22 g plant^{-1}) was observed in combination of B_3 with F_3 and the lowest value (0.10 g plant^{-1}) was in B_1F_1. At 42 DAS, maximum TDM (0.42 g plant^{-1}) was obtained in combination of B_3 with F_3 and minimum (0.24g plant^{-1}) was in B_1F_1. At 63 DAS, the highest TDM (2.08g plant^{-1}) was observed in interaction of B_3 with F_3 and the lowest (0.88g plant^{-1}) in B_1F_1. At 84 DAS, the highest TDM (4.67 g plant^{-1}) was recorded in combination of B3 with F3 and the lowest (3.17 g plant^{-1}) in B_1F_1. At 105 DAS, maximum TDM (16.30 g plant^{-1}) was found in combination of B_3 with F_3 and minimum value (10.43 g plant^{-1}) was found in B_1F_1. At 126 DAS, the highest value of TDM (24.70 g plant^{-1}) was recorded in B_3F_3 and the lowest value (13.03 g plant^{-1}) was obtained in B_1F_1. From above narration, it can be told that the total dry matter production was slow at the initial stage but it accelerated on the latter stages according to basal urea application rate and deep placement of urea super granules rate. Geethadevi *et al.*, (2000) concluded that application of 100 kg USG ha^{-1} gave highest total dry matter per plant. This result is on conformity with that of Jaiswal *et al.*, (2011).

Results showed that at 21-42, 42-63, 63-84, 84-105 and 105-126 DAS, basal urea application rate had significant effect on crop growth rate except 21-42 DAS and 105-126 DAS (**Table 3**). At 21-42 DAS, no significant difference was found in CGR due to basal urea application of flooded rice. At 42-63 DAS, the highest CGR (0.47 g m^{-2}day^{-1}) was recorded in B_3 which reduced significantly 10.64% and 31.91% in B_2 and B_1, respectively. At 63-84 DAS, maximum value of CGR (1.07 g m^{-2}day^{-1}) was observed in B_3 that reduced significantly (10.28%) and (11.21%) in B_2 and B_1, respectively. At 84-105 DAS, the highest CGR value (4.03 g m^{-2}day^{-1}) was found in B_3 which reduced significantly 7.69% and 15.88% in B_2 and B_1, respectively. At 105-126 DAS, no significant difference was found in CGR due to basal urea application of flooded rice. In spite of non-significant variation, numerically the highest CGR (2.09 g m^{-2}day^{-1}) was observed in B_3 and the lowest value (1.43 g m^{-2}day^{-1}) was observed in B_1.

Deep placement of urea super granules rate had significant effect on crop growth at 21-42, 42-63, 84-105 and 105-126 DAS except at 63-84 DAS **(Table 3)**. At 21-42 DAS, the highest CGR value (0.083 gm^{-2}day^{-1}) was obtained in F_3, and the lowest (0.056 g m^{-2}day^{-1}) was found in F_1. CGR value reduced significantly (24.09%) and (32.53%) in F_2 and F_1, respectively. At 42-63 DAS, maximum CGR (0.53 g m^{-2}day^{-1}) was observed in F_3 which reduced significantly (26.42%) and (45.28%) in F_2 and F_1, respectively. At 63-84 DAS, no significant difference was found in CGR due to deep placement of urea super granules. At 84-105 DAS, the highest CGR value (4.27 g m^{-2}day^{-1}) was recorded in F_3 that reduced significantly 11.02% and 26.93% in $F_2$and F_1, respectively. At 105-126 DAS, maximum CGR value (2.36 g m^{-2}day^{-1}) was found in F_3 which reduced significantly 39.83% and 48.31% in F_2 and F_1, respectively.

The interaction effect between basal urea application rate and deep placement of urea super granules rate showed significant effect on CGR. At 21-42DAS, the highest CGR (0.08 gm^{-2}day^{-1}) was observed in combination of B_3 with F_3 and the lowest value (0.06 gm^{-2}day^{-1}) was in B_1F_1. At 42-63 DAS, maximum CGR (0.65g m^{-2}day^{-1}) was obtained in interaction of B_3 with F_3 and minimum CGR (0.25g m^{-2}day^{-1}) was in B_1F_1. At63-84 DAS the highest CGR (1.04g m^{-2}day^{-1}) was recorded in combination of B_3 with F_3 and the lowest (0.86 g m^{-2}day^{-1}) in B_1F_2. At 84-105DAS the highest CGR (4.62 g m^{-2}day^{-1}) was found in combination B_3 with F_3 and the lowest CGR (2.88 g m^{-2}day^{-1}) was found in B_1F_1.At 105-126 DAS maximum CGR (3.33g $m^{-2}day^{-1}$) was obtained in combination of B_3 with F_3 and minimum CGR (1.03 g $m^{-2}day^{-1}$) was obtained in B_1F_1 (**Table 3**).

Number of effective tiller m^{-2} was significantly affected due to different basal urea rates. The highest number of effective tiller m^{-2} (88.81) was observed in B_3 and the lowest (70.95) was in B_1. Effective tiller m^{-2} was significantly higher in B_3 which reduced 13.27% and 20.11% in B_2 and B_1, respectively. Number of effective tiller m^{-2} was significantly affected due to different deep placement rates of urea super granules. The highest number of effective tiller m^{-2} (91.74) was recorded in $F_3$and the lowest (64.69) was in F_1. Effective tiller m^{-2} was significantly higher in F_3 which reduced 12.42% and 29.49% in F_2 and F_1, respectively. Singh (2003) also found that effective tillers m^{-2} significantly affected by the increasing level of USG.The interaction effect between basal urea application and urea deep placement of urea super granules rate on effective tiller m^{-2} was significant. However, numerically the highest number of effective tiller m^{-2} (101.62) was found in the combination of B_3 with $F_3$and the lowest number of effective tiller m^{-2} (55.36) was found in B_1F_1. Hari et al. (2000); Thakur (1991) and Tanaka et al. (1964) also found similar result that increasing levels of nitrogen increased the number of effective tillers.

Number of non-effective tiller m^{-2} was not significantly affected due to different basal urea rates. The highest number of non-effective tiller m^{-2} (30.39) was observed in B_3 and the lowest (22.23) was in B_2. Number of non- effective tiller m^{-2} was affected due to different deep placement rates of urea super granules rates. The highest number of non-effective tiller m^{-2} (33.15) was recorded in F_3 and the lowest (18.64) was in F_1. Non-effective tiller m^{-2} reduced significantly 18% and 43.77% in F_2 and F_1, respectively. The interaction effect between basal urea application and deep placement of urea super granules rates on non-effective tiller m^{-2} was significant. However, numerically the highest number of non-effective tiller m^{-2} (37.03) was found in the combination of B_3 with F_2 and the lowest number of non-effective tiller m^{-2} (13.83) was found in the combination of B_2F_1.

Panicle length was affected due to different basal urea rates. The longest panicle (25.87cm) was observed in B_3 and the shortest (24.53cm) was in B_1. Panicle length reduced significantly (3.25%) in B_2 and (5.18%) B_1 (**Table 4**). Singh (2003) also reported that panicle length increases with the increased level of urea fertilizer. Panicle length was significantly affected due to different deep placement rates of urea super granules. Panicle length increased with increasing level of deep placed urea super granules up to 100 kg ha^{-1}. The longer panicle (26.03cm) was recorded in F_3. However, the shortest panicle (24.11cm) was recorded in F_1. Panicle length was longer in F_3 which reduced significantly 2.84% and 7.38% in F_2 and F_1, respectively (**Table 4**). Interaction effect between basal application of urea and deep placement of urea super granules on panicle length was significant. The longest panicle (26.63cm) was found in the combination of B_3 with F_3 and the shortest panicle (23.33cm) was found in the combination of B_1F_1. Dalai and Dixit (1987) reported that the panicle length increase with increasing level of USG.

Basal urea application rate had non-significant effect on grains $panicle^{-1}$. The highest number of grains $panicle^{-1}$ (139.87) was observed in B_3, and the lowest number (134.02) was observed in B_1. Different deep placement of urea super granules rate had slight effect on grains $panicle^{-1}$. The highest number of grains $panicle^{-1}$ (141.02) was observed in F_3 which reduced slightly (3.05% and 5.78%) in F_2 and F_1, respectively. Interaction effect between basal application of urea and deep placement of urea super granules rate on grains $panicle^{-1}$ was non-significant. However, numerically the highest number of grains $panicle^{-1}$ (144.50) was found in the interaction of B_3 with F_3 and the lowest number of grains $panicle^{-1}$ (130.63) was found in B_1F_1. Lang et al., (2003) also found that increasing in deep placement of urea super granules rate enhanced grains $panicle^{-1}$.

Filled grains were significantly affected due to different basal urea application rates. The highest number of filled grains $panicle^{-1}$ (82.02) was observed in B_3 that reduced significantly (4.07%) and (11.57%) in $B_2$and B_1, respectively. The effect of deep placement of urea super granules rate on number of filled grains $panicle^{-1}$ was found to be significant at 5% level of probability. Number of filled grains $panicle^{-1}$ increased with increasing levels of urea super granules. The highest number of filled grains $panicle^{-1}$ (79.47) was recorded in F_3 and the lowest one (75.82) was recorded in F_1. Filled grains $panicle^{-1}$ reduced slightly 1.93% and 4.59% in F_2 and F_1, respectively compared with F_3. Interaction effect of basal application of urea and deep placement of urea super granules rate on filled grains $panicle^{-1}$ was significant. However, numerically the maximum number of filled grains $panicle^{-1}$ (83.22) was found in the combination of B_3 with F_3 and the minimum number of filled grains $panicle^{-1}$(69.33) was found in B_1F_1. Alam and Ahmed (2002) found the similar result.

Basal urea rate had non-significant effect on unfilled grains panicle^{-1}. The highest number of unfilled grains panicle^{-1} (61.57) was found in B_1 and the lowest number (57.04) was found in B_2. Deep placement of urea super granules rate had non-significant effect on unfilled grains panicle^{-1}. The highest number of unfilled grains panicle^{-1} (61.55) was observed in F_3 and the lowest number (55.91) was observed in F_1. Interaction effect between basal application of urea and deep placement of urea super granules rate on unfilled grains panicle^{-1} was non-significant. However, numerically the maximum number of unfilled grains panicle^{-1} (62.03) was found in the combination of B_1F_3 and the minimum number of unfilled grain panicle^{-1} (51.97) was found in the combination of B_2F_1.

1000 grains weight was slightly affected due to different basal urea rates. The maximum weight of 1000 grains (25.93g) was observed in $B_{3,}$ that reduced slightly (3.24%) and (6.83%) in B_2 and B_1, respectively.1000 grains weight was significantly affected due to different deep placement of urea super granules rate. The maximum weight of 1000grains (26.18g) was observed in F_3, which reduced significantly 3.63% and 9.21% in F_2 and $F_{1,}$ respectively. Interaction effect between basal application of urea and deep placement of urea super granules rate on 1000 grains weight was significant. However, numerically the maximum grain weight (26.93 g) was found in the combination of B_3 with F_3 and the minimum grain weight (22.53 g) was found in B_1F_1. The result fairly agreed with the findings of Mohaddesi et al. (2011) that 1000 grains weight had significant effect with increasing nitrogen levels but Rahman (2003) and Azad et al. (1995) found that the level of nitrogen did not influence the weight of 1000 grains weight significantly which is dissimilar with this finding.

Grain yield was slightly affected due to different basal urea application rates. The maximum grain yield (1.75 t ha^{-1}) was recorded in B_3, which reduced slightly 4% and 7.43% in B_2 and $B_{1,}$ respectively. Grain yield was slightly affected due to different deep placement of urea super granules rates. The maximum grain yield (1.77 t ha^{-1}) was obtained in F_3, which reduced slightly 4.52% and 10.17% in F_2 and $F_{1,}$ respectively. Grain yield was significantly affected by the interaction between basal application of urea and deep placement of urea super granules rate. Apparently, the highest grain yield (1.83 t ha^{-1}) was found in the combination of B_3 with F_3 and the lowest grain yield (1.48 t ha^{-1}) was found in B_1F_1 **(Table 4)**. Idris and Matin (1990) reported that application of urea fertilizer as a source of nitrogen increased the yield of rice which supports the results.

Straw yield was significantly affected due to different basal urea rates (**Table 4**). Straw yield was significantly highest (4.83 t ha^{-1}) at treatment B_3, which reduced significantly 9.52% and 21.53% in B_2 and $B_{1,}$ respectively.Straw yield was significantly affected due to different deep placement of urea super granules rates (**Table 4**). Straw yield was highest (4.98 t ha^{-1}) in F_3, which reduced significantly 11.04% and 28.11% in F_2 and $F_{1,}$ respectively. Straw yield was significantly affected by the interaction between basal application of urea and deep placement of urea super granules rate. Apparently, the highest straw yield (5.4 t ha^{-1}) was found in the combination of B_3 with F_3 and the lowest straw yield (3.13 t ha^{-1}) was found in B_1F_1. Hussain (2008); Meena et al. (2003) observed similar view on straw yield due to deep placement of urea super granules.

Biological yield was significantly affected due to different basal urea rates (**Table 4**). The maximum biological yield (6.57 t ha^{-1}) was observed in B_3, that reduced significantly 7.76% and 17.65% in B_2 and $B_{1,}$ respectively. Biological yield was significantly affected due to different rate of deep placement of urea super granules. The maximum biological yield (6.75 t ha^{-1}) was found in F_3, which reduced significantly 9.33% and 23.41% in F_2 and $F_{1,}$ respectively. Biological yield was significantly affected by the interaction between basal application of urea and deep placement of urea super granules rate. It revealed that the highest biological yield (7.28 t ha^{-1}) was found in the combination of B_3 with F_3 and the lowest biological yield (4.61 t ha^{-1}) was found in B_1F_1. The result agreed with the findings of Ahmed et al. (2005) who observed the significant effect of USG on biological yield (t ha^{-1}) of flooded rice.

Significant variation was observed in harvest index due to different basal urea application rates. However, the highest harvest index (30.29) was recorded in B_1, which reduced slightly 7.29% and 11.35% in B_2 and $B_{3,}$ respectively. Different rates of deep placement of urea super granules rate showed significant variations with harvest index. However, the highest harvest index of (30.99) was observed in F1, which reduced slightly 10.26% and 14.71% in F2 and F3, respectively compared with F1 (Table 4). In case of harvest index, the interaction of the treatments showed significant differences. Numerically, the highest harvest index (32.47%) was found in the combination of B1 with F1 and the lowest harvest index (25.07%) was found in the combination of B3F2 (Table 4).

Table 2: Efficacy of basal and deep placement of urea rates and its interaction effect on plant height (cm) of flooded rice at different days after sowing (DAS)

	Plant height (cm)						
	21DAS	**42 DAS**	**63 DAS**	**84 DAS**	**105 DAS**	**126 DAS**	**147 DAS**
Basal Urea Application Rates							
B_1	25.76	29.74 c	44.26c	78.37b	97.66c	106.65c	136.51c
B_2	28.02	32.54b	50.42b	83.66ab	103.90b	113.27b	146.41b
B_3	27.66	36.90a	59.9a	89.89a	117.13a	119.58a	156.48a
LS	NS	0.05	0.01	0.05	0.05	0.01	0.01
Urea deep placement Rates							
F_1	26.94	31.61	48.63c	74.29c	95.81 c	104.74c	132.09c
F_2	27.67	34.63	50.91b	83.59b	101.53b	113.09b	145.47b
F_3	26.83	32.94	55.05a	94.03a	115.35a	121.66a	161.83a
LS	NS	NS	0.05	0.05	0.05	0.01	0.01
Interaction effect							
B_1F_1	23.61	28.66e	42.16g	69.89d	92.83d	99.16g	123.71h
B_1F_2	26.05	30.05de	44.67fg	76.72cd	97.05cd	107.67ef	134.19fg
B_1F_3	27.61	30.5de	45.94ef	88.49abc	103.11cd	113.11c	151.62cd
B_2F_1	27.28	31.2d	47.99de	73.22d	94.89d	106.22f	131.28gh
B_2F_2	28.17	32.33cd	49.83d	83.83bcd	100.99cd	110.94cd	144.53de
B_2F_3	28.61	34.05bc	53.44c	93.94ab	115.83b	122.67b	163.43ab
B_3F_1	29.94	34.95b	55.72bc	79.77cd	99.72cd	108.85de	141.29ef
B_3F_2	28.78	36.44b	58.22b	90.22abc	106.55bc	120.67b	157.69bc
B_3F_3	24.28	39.33a	65.77a	99.66a	127.11a	129.22a	170.46a
LS	NS	0.05	0.05	0.05	0.05	0.05	0.05
CV%	12.03	4.09	3.06	8.87	5.09	1.29	3.72

Mean values in a column having the same letter (s) or without letter do not differ significantly, whereas; with a dissimilar letter (s) differ significantly as per DMRT. NS= Non-significant, CV= Co-efficient of variation, LS= Level of significance. B1=0 kg ha^{-1}, B2= 50 kg ha^{-1}, B3= 100 kg ha^{-1}, F1=0 kgha$^{-1,}$ F2= 50 kgha^{-1}, F3= 100 kg ha^{-1}.

Table 3: Efficacy of basal and deep placement of urea rates and its interaction effect on TDM and CGR of flooded rice at different days after sowing (DAS)

	Total dry matter (g $plant^{-1}$)						Crop growth rate (g $m^{-2}day^{-1}$)				
Basal Urea Application Rates											
	21 DAS	42 DAS	63 DAS	84 DAS	105 DAS	126 DAS	21-42 DAS	42-63 DAS	63-84 DAS	84-105 DAS	105-126 DAS
B_1	0.11c	0.29c	1.09c	3.49c	12.04c	15.66c	0.07	0.32b	0.95b	3.39c	1.43
B_2	0.15b	0.33b	1.39b	3.80b	13.17b	16.87b	0.071	0.42a	0.96b	3.72b	1.47
B_3	0.19a	0.34a	1.53a	4.22a	14.38a	19.67a	0.067	0.47a	1.07a	4.03a	2.09
LS	0.05	0.05	0.05	0.05	0.01	0.05	NS	0.05	0.05	0.05	NS
Urea Deep Placement Rate											
F_1	0.14c	0.28c	1.01c	3.48b	11.34c	14.42c	0.056b	0.29 c	0.98	3.12c	1.22b
F_2	0.15b	0.31b	1.29b	3.71b	13.16b	16.72b	0.063b	0.39 b	0.95	3.75b	1.42b
F_3	0.17a	0.38 a	1.72a	4.32a	15.09a	21.04a	0.083a	0.53 a	1.03	4.27a	2.36a
LS	0.05	0.05	0.05	0.05	0.01	0.05	0.05	0.05	NS	0.05	0.05
Interaction effect											
B_1F_1	0.1d	0.24f	0.88d	3.17f	10.43e	13.03d	0.06b	0.25e	0.91ab	2.88d	1.03b
B_1F_2	0.11cd	0.29de	1.1bcd	3.27ef	11.57de	15.33cd	0.07ab	0.32cde	0.86b	3.29cd	1.49b
B_1F_3	0.13bcd	0.33c	1.3bc	4.03bc	14.13b	18.6bc	0.08a	0.38cde	1.09a	4.01b	1.77b
B_2F_1	0.14bcd	0.28e	1.02cd	3.4def	11.17de	14.37cd	0.06 ab	0.29de	0.94ab	3.08cd	1.27b
B_2F_2	0.15bc	0.32cd	1.36bc	3.73cde	13.5bc	16.4bcd	0.06ab	0.41cd	0.94ab	3.88b	1.15b
B_2F_3	0.16b	0.38b	1.8a	4.27ab	14.83b	19.83b	0.09a	0.56ab	0.98ab	4.19ab	1.98b
B_3F_1	0.16b	0.3de	1.12bcd	3.87bcd	12.43cd	15.87bcd	0.05b	0.32cde	1.09a	3.39c	1.36b
B_3F_2	0.18ab	0.31de	1.43b	4.13bc	14.4b	18.43bc	0.05b	0.45bc	1.07a	4.07b	1.6b
B_3F_3	0.22a	0.42a	2.08a	4.67a	16.3a	24.7a	0.08a	0.65a	1.04ab	4.62a	3.33a
LS	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
CV (%)	21.08	13.97	14.15	6.94	6.19	13.23	45.83	17.67	11.06	7.08	14.98

Mean values in a column having the same letter (s) or without letter do not differ significantly, whereas; with a dissimilar letter (s) differ significantly as per DMRT. NS= Non significant, CV= Co-efficient of variation, LS= Level of significance. B_1=0 $kgha^{-1}$, B_2= 50 $kgha^{-1}$, B_3= 100 $kgha^{-1}$, F_1=0 $kgha^{-1}$, F_2= 50 $kgha^{-1}$, F_3= 100 kg ha^{-1}.

Table 4: Efficacy of basal and deep placement of urea rates and its interaction effect on growth and yield of flooded rice at different days after sowing (DAS)

	Effective tiller m^{-2}	Non-effective tiller m^{-2}	Panicle length (cm)	Grain $panicle^{-1}$	Filled grain $panicle^{-1}$	Unfilled grain $panicle^{-1}$	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{1})	Harvest Index (%)
Basal urea rates											
B_1	70.95c	26.34	24.53b	134.02	72.53c	61.57	24.16b	1.62b	3.79c	5.41c	30.29a
B_2	77.02b	22.23	25.03b	136.72	78.68b	57.04	25.09ab	1.68ab	4.37b	6.06b	28.08ab
B_3	88.81a	30.39	25.87a	139.87	82.02a	57.63	25.93a	1.75a	4.83a	6.57a	26.85b
LS	0.01	NS	0.05	NS	0.05	NS	0.05	0.05	0.05	0.05	0.05
Urea Deep Placement Rates											
F_1	64.69c	18.64b	24.11b	132.87b	75.82b	55.91	23.77b	1.59b	3.58c	5.17c	30.99a
F_2	80.35b	27.18a	25.29a	136.72ab	77.94a	58.78	25.23a	1.69ab	4.43b	6.12 b	27.81b
F_3	91.74a	33.15a	26.03a	141.02a	79.47a	61.55	26.18a	1.77a	4.98a	6.75a	26.42b
LS	0.01	0.05	0.05	0.05	0.05	NS	0.05	0.05	0.05	0.05	0.05
Interaction effect											
B_1F_1	55.36g	19.64bcd	23.33d	130.63	69.33f	61.56	22.53d	1.48c	3.13d	4.61e	32.47a
B_1F_2	71.87e	28.17abc	24.83bc	133.9	72.77e	61.13	24.6bcd	1.65abc	3.67cd	5.41cde	30.55ab
B_1F_3	85.62bc	31.21ab	25.43abc	137.53	75.5de	62.03	25.33abc	1.73ab	4.49bc	6.22bc	27.87bc
B_2F_1	61.17f	13.83d	24cd	132.4	77.43cd	51.97	23.83cd	1.59bc	3.65cd	5.24de	30.4ab
B_2F_2	81.93cd	16.34cd	25.07bc	136.73	78.91bc	57.82	25.17abc	1.7ab	4.42bc	6.12bcd	27.82bc
B_2F_3	87.97b	36.53a	26.03ab	141.03	79.7bc	61.33	26.27ab	1.76ab	5.05ab	6.81ab	26.03bc
B_3F_1	77.55d	22.45bcd	25bc	135.57	80.7ab	54.2	24.93abc	1.7ab	3.95cd	5.65cd	30.09ab
B_3F_2	87.25b	37.03a	25.97ab	139.53	82.13ab	57.4	25.93abc	1.72ab	5.12ab	6.83ab	25.07c
B_3F_3	101.62a	31.71ab	26.63a	144.5	83.22a	61.28	26.93a	1.83a	5.41a	7.28a	25.38c
LS	0.05	0.05	0.05	NS	0.05	NS	0.05	0.05	0.05	0.05	0.05
CV(%)	3.27	22.25	3.13	5.33	2.27	11.57	4.78	6.24	10.41	7.93	8.36

Mean values in a column having the same letter (s) or without letter do not differ significantly, whereas; with a dissimilar letter (s) differ significantly as per DMRT. NS= Non significant, CV= Co-efficient of variation, LS= Level of significance. B_1=0 $kgha^{-1}$, B_2= 50 $kgha^{-1}$, B_3= 100 $kgha^{-1}$, F_1=0 $kgha^{-1}$, F_2= 50 $kgha^{-1}$, F_3= 100 kg ha^{-1}.

DISCUSSION AND CONCLUSION

The experiment was carried out at the Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, Rajshahi University, Rajshahi, during the period from May 2018 to November2018 to study on "efficacy of basal urea and deep placement of urea super granules (USG) on growth and yield of flooded rice". The experiment included two factors viz. basal urea application rates (three rates) viz.0 kg ha^{-1} (B_1), 50 kg ha^{-1} (B_2) and 100 kg ha^{-1}(B_3) and deep placement of urea super granules (USG) rates (three rates) i.e. 0 kg ha^{-1} (F_1), 50 kg ha^{-1} (F_2), 100 kg ha^{-1} (F_3). The experiment was laid out in a randomized completely block design with three replications. The size of each unit plot was 10m^2 (4m×2.5m). The experimental plots were fertilized with phosphorous (P_2O_5), potash (K_2O), Sulphur 150, 70, 60, kg ha^{-1} respectively, in the form of triple super phosphate, muriate of potash and gypsum. Rice seeds were sown in broadcasting method on 20th May, 2018. Urea was applied as per experimental treatments. Intercultural operations were done when required. The crop was harvested at full maturity.

The data were recorded on phonological characteristics such as plant height, number of tillers, total dry matter and CGR at 21 days' intervals beginning from 21 to 147 DAS. Three hills were randomly selected and uprooted from each unit plot after harvest for recording data on different crop characters such as plant height (cm), number of total tillers hill^{-1}, effective tillers m^{-2}, non-effective tillers m^{-2}, panicle length (cm), total grains panicle^{-1}, filled grains panicle^{-1}, unfilled grains panicle^{-1}, weight of 1000 grains (g), grain yield (t ha^{-1}), straw yield (t ha^{-1}), biological yield (t ha^{-1}), and harvest index (%).The data were analyzed statistically and mean differences were adjudged by Duncan's Multiple Range Test (DMRT) with the help of STATVIEW software.

Effect of basal urea application significantly influenced growth and yield of flooded rice and application of urea @ 100 kg ha^{-1} produced the highest plant height (156.48cm) ,total tillers hill^{-1}(6.07), effective tillers m^{-2} (88.81), maximum panicle length (25.87cm), maximum filled grains panicle^{-1} (82.02), grain yield (1.75 t ha^{-1}), straw yield (4.83 t ha^{-1}) and biological yield (6.57 t ha^{-1}).

Effect of deep placement of urea super granules rate significantly influenced growth and yield of flooded rice and deep placement of urea super granules @ 100 kg ha^{-1}produced the highest plant height (161.83cm), total tillers hill^{-1}(6.11), effective tillers m^{-2} (91.74), maximum panicle length (26.03cm), total grains panicle^{-1}(141.02), grain yield (1.77 t ha^{-1}), straw yield (4.98 t ha^{-1}), biological yield (6.75 t ha^{-1}).

The interaction effect showed marginal effect on all the yield and yield contributing characters. Apparently, the highest grain yield (1.83 t ha^{-1}), straw yield (5.41 t ha^{-1}) and biological yield (7.28 t ha^{-1}) were found in the combination of B_3F_3, while the lowest grain yield (1.48 t ha^{-1}), straw yield (3.13 t ha^{-1}) and biological yield (4.61 t ha^{-1}) were observed in the combination of B_1F_1.

Chalanbeel is one of the largest lowland ecosystem of Bangladesh where most of the farmers are not conscious to apply N fertilizer to grow flooded rice. Most of the farmers in that area use basal urea (84.57%) but only 0.33% of them use topdressing urea. Inadequate crop stands due to variable weather condition and lack of knowledge about fertilizer (urea) application method under flooding condition is the reason for no application of topdressing urea. Deep placement of urea super granules by using urea injector could be a possible way to maximize yield, which has been proven in our experiment. Most of the farmers in the area use only basal urea @ 100 kg ha^{-1}, where flooded rice (Digha) yield can be achieved 1.7 t ha^{-1}, whereas, from our experiment, we would like to suggest them to apply additional urea super granules @ 100kg ha^{-1} as deep placement (using a self-loaded injector) at 60 DAS, which can achieve additional 7.1 % more yield (1.83 t ha^{-1}) than conventional practice.

Therefore, the farmers can be suggested to use the above-mentioned treatment combination for maximizing yield of flooded rice. Further research is needed to arrive at a definite conclusion.

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