Nutrient uptake by BRRI dhan28 as influenced by different forms and doses of urea

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Abstract: A field experiment was conducted at the Bangladesh Agricultural Development Corporation (BADC) Farm, Baradi, Meherpur during the period from January 2012 to May 2012 to find out the effects of prilled urea (PU) and urea super granule (USG) on nutrient contents of *boro* rice cv. BRRI dhan28. The experiment was arranged in a randomized complete block design (RCBD) with three replications. There were ten treatment combinations consisting of two forms of urea *viz.,* PU and USG and five levels of each form (0, 110, 180, 240 and 300 kg ha^{-1}). Besides, TSP, MOP, gypsum and zinc sulphate were applied @ 100, 70, 60 and 5 kg ha^{-1}, respectively as basal dose. The contents of N, K, S and Ca in grain and N, P, S, Ca and Mg in straw were influenced significantly due to different treatments. The uptakes of N, P, K, S, Ca and Mg in grain and N, P, S, Ca and Mg in straw were expressively affected due to different treatments. USG_{240} and PU_{300} treatments showed the best performance for nutrient content and their uptake where the highest values were found in USG_{300}. A positive and significant correlation was found between N and other nutrients in grain. The results suggest that urea super granule @ 240 kg ha^{-1} may be suitable for better quality of *boro* rice cv. BRRI dhan28 in the agroclimatic condition of the study area.

Key words: Prilled urea, Urea super granule and nutrient uptake.

Introduction

Rice is one of the most important food grains in the world, accounting for more than 20 percent of global calories consumed and 29 percent in low income countries. On a global basis, rice ranks second after wheat in terms of area harvested, but in terms of its importance as a food crop, rice provides more calories per hectare than any other cereal food grain. Bangladesh is the fourth largest rice producing and consuming nation (BRRI, 2011). Asia accounts for about 90 percent of the production and consumption of rice with per capita consumption estimated at 104 kg per year, well above the global average of 65.61 kg (USDA, 2001) and provides about 70% of direct human calorie intake, making it the most important food crop in Bangladesh.

Rice is the staple food for the people of Bangladesh intrinsically associated with their culture, rites and rituals. A suitable source of nutrients is necessary for sustainable agriculture that can ensure food production with high quality (Reganold *et al*. 1990).

For rice cultivation, normally urea, MOP and TSP fertilizers have been used in our country of which the highest amount of fertilizer that has been used is urea. Prilled urea (PU) is the most commonly used nitrogenous fertilizer for rice cultivation in Bangladesh. The efficiency of nitrogenous fertilizer especially, PU in rice culture is about 25-30 per cent and rest 70-75 percent is lost for many reasons after application (BRRI, 2008). PU is a very fast releasing nitrogenous fertilizer that usually broadcasted in splits, can cause a considerable loss as ammonia volatilization, denitrification, surface run off and leaching etc (De Datta, 1978).

Slow release nitrogenous fertilizer increases the yield and N uptake by rice due to less loss of nitrogen from the soil (Ramaswamy *et al.* l987, Rao and Ghai, 1987). Moreover, placement of USG in the root zone is the most effective method for increasing the nitrogen use efficiency and rice yield (Prasad *et al*. 1982).The loss of nitrogen can considerably be reduced by deep placement of USG. Deep placement of USG stops denitrification process and minimizes urea concentration in irrigation water. As a result, it reduces nitrogen loss and improves nitrogen use efficiency by 20-25 percent for better grain production (Craswell and De Datta, 1980 and Pillai, 1981). So, considering above, the experiment was conducted with the following objective:

To investigate the effects of different forms of urea on the nutrient contents and uptake by *boro* rice cv. BRRI dhan28.

Materials and Methods

The experiment was carried out at Bangladesh Agricultural Development Corporation (BADC) Farm, Baradi, Meherpur during *boro* season of 2012 (January to May). BRRI dhan28 was used as test crop. The experimental field belongs to calcareous Dark Grey Floodplain soil and it was a medium high land of silty loam soils having pH 6.4, 1.10% organic matter, 0.102% total N, 27.0 µg g^{-1} soil available P, 18.0 µg g^{-1} soil available S and 0.026 me 100 g^{-1} soil exchangeable K. The experiment was laid out in a randomized complete block design (RCBD) with three replications. There were ten treatment combinations consisting of two forms of urea *viz.,* PU and USG and five levels of each form (0, 110, 180, 240 and 300 kg ha^{-1}). Besides, TSP, MOP, gypsum and zinc sulphate were applied @ 100, 70, 60 and 5 kg ha^{-1}, respectively as basal dose. Seeds of BRRI dhan28 were collected from BADC Seed Production Farm, Baradi, Meherpur. The collected seeds were sprouted by soaking in distilled water for 48 hours and seedlings were raised in wet nursery bed. Thirty five days old seedlings were uprooted from the seedbed very carefully and were transplanted in the experimental plots on 26 January, 2012. Two seedlings $hill^{-1}$ was planted maintaining hill spacing of 20 cm and row spacing of 20 cm. Intercultural operations were done as and when necessary. The crop was harvested on 10 May, 2012. Rice grain was chemically analyzed for the determination of total N, P, K, S, Ca and Mg. Total nitrogen was determined by semi-micro kjeldahl method (Page *et al*., 1989) and Phosphorus by $SnCl_2$ method (Jackson, 1973). Potassium was determined by flame photometer method (Page *et al*., 1982) and sulphur by turbidimetric method (Page *et al*., 1989). Calcium and Magnesium were determined by complexometric method of titration (Page *et al*., 1982). The nutrient uptake was calculated by using the formula-

Nutrient uptake (kg ha^{-1}) = [{Minerals constituent (%) × dry matter weight ($kgha^{-1}$)} ÷ 100].

Data were analyzed with the help of MSTAT-C developed by Russel (1986). Mean differences adjusted by least significance difference (LSD) test as outlined by Gomez and Gomez (1984).

Results and Discussion

Effects of different forms and doses of urea on the nutrient contents and uptake by *boro* rice cv. BRRI dhan28

a) Nutrient contents of grain and straw: The grain and straw samples of rice were analyzed for estimating N, P, K, S, Ca and Mg content. The results of N, P, K, S, Ca and Mg content of grain and straw have been presented and discussed under the following sub sections.

i) Nitrogen content: The nitrogen content in grain was slightly influenced by the forms of urea (Table 1). It may be due to cause that, nitrogen has important role on the vegetative growth of plant which was ensured by all forms of urea. At highest treatment, USG obtained highest nitrogen content (1.66%) when prilled urea obtained 1.57% nitrogen in grain. As USG is a slow release N fertilizer, loss of nitrogen was minimum. For this reason, plant utilized more nitrogen at different stages of growth and development. This finding was commensurated with the observation made by Rahman (2007).

Table 1. Effect of different forms and doses of urea on the N, P, K, S, Ca and Mg contents of *boro* rice grain and straw cv. BRRI dhan28

Treatments	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Sulphur (%)		Calcium (%)		Magnesium (%)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Control	0.55d	0.27c	0.25	0.15c	0.55d	1.09	0.11d	0.09d	0.46e	0.30d	0.47d	0.31e
PU110	0.96c	0.58b	0.31	0.17bc	0.63c	1.13	0.13cd	0.10c	0.58d	0.39c	0.57c	0.38d
PU180	1.15bc	0.65ab	0.33	0.19ab	0.65bc	1.15	0.15c	0.12abc	0.62c	0.41b	0.61b	0.41bc
PU240	1.37abc	0.80ab	0.35	0.20ab	0.68ab	1.20	0.18b	0.13ab	0.68b	0.46ab	0.66a	0.44a
PU300	1.57ab	0.93a	0.35	0.21a	0.68ab	1.18	0.19b	0.13ab	0.68b	0.45ab	0.66a	0.43ab
USG110	1.09c	0.64ab	0.31	0.18abc	0.65bc	1.18	0.14c	0.11bc	0.62c	0.41b	0.58c	0.39cd
USG180	1.34abc	0.81ab	0.34	0.20ab	0.66ab	1.19	0.18b	0.13ab	0.68b	0.45ab	0.62b	0.41bc
USG240	1.52ab	0.88ab	0.36	0.21a	0.69a	1.24	0.21a	0.14a	0.73a	0.48a	0.68a	0.46a
USG300	1.66a	0.93a	0.36	0.22a	0.69a	1.20	0.21a	0.14a	0.72a	0.48a	0.68a	0.45a
LSD	0.40	0.31	0.055	0.017	0.055	0.45	0.017	0.017	0.017	0.017	0.017	0.017

In a column, figures with same letter(s) or without letters do not differ significantly whereas figures with different letters differ at 1% level of significance, USG-Urea super granule; PU-Prilled urea

The doses of urea had slightly significant effect on nitrogen content of grain (Table 1). It was apparent from the result that the application of urea increased N content in grain. The highest N content (1.66%) was obtained by using USG_{300} treatment and the lowest N content (0.55%) was found in control. Thakur and Patel (1998) reported that N content increased in rice grain due to application of nitrogen fertilizer.

The N content in straw was also slightly affected by the doses of urea (Table 1). Application of urea increased N content in straw. The highest N content (0.93%) was obtained with the use of 300 kg urea ha^{-1} and the lowest N content (0.27%) was recorded in control. Thakur and Patel (1998) reported that N content increased in rice straw due to application of nitrogen fertilizer.

ii) Phosphorus content: The phosphorus content in grain and straw was not significantly influenced by the forms of urea (Table 1). USG obtained a bit higher P content than prilled urea in grain. In straw, P content was found more or less similar in the two forms of N fertilizer but both were higher than control.

With the use of different doses of urea the phosphorus content in grain was not significantly affected (Table 1). Application of nitrogen very slightly increased P content in grain. The highest P content (0.36%) was obtained in 300 kg urea ha^{-1} and the lowest P content (0.25%) was obtained in control which were statistically identical.

The doses of urea have slight effect on the P content in straw (Table 1). Application of nitrogen increased P content in straw. The highest (0.22%) was obtained in 300 kg urea ha^{-1} in both PU and USG and the lowest (0.15%) was obtained in control. Chopra and Chopra (2000) reported that application of either 80 or 120 kg N ha^{-1} improve P content in straw. This was due to the synergistic relationship between N and P. So, phosphorus content increased with the increase of nitrogen fertilizer.

iii) Potassium content: The K content in grain was very slightly influenced by the forms of urea (Table 1). At the highest dose USG obtained the highest K content (0.69%) when PU obtained 0.68% K in grain. In straw, K content was not influenced by the forms of urea (Table 1). The highest K content (1.24%) was obtained in USG when PU obtained 1.20% potassium.

The doses of urea slightly affected the K content in grain (Table 1). Application of urea increased K content in grain. By using 300 kg urea ha^{-1} the highest K content (0.69%) was recorded which was identical with 240 kg urea ha^{-1} and the lowest K content (0.55%) was found in control. Singh *et al.* (1991) showed that N (0, 40, 80 and 120 kg ha^{-1}) increased K content in rice grain.

The effect of the doses of urea on K content in straw was not significant (Table 1). With the application increased amount of urea, K content in straw increased very slightly but it was statistically insignificant. Singh *et al.* (1991) showed that N (0, 40, 80 and 120 kg ha^{-1}) increased K content in rice straw.

iv) Sulphur content: Forms of urea did not affect the S content in grain (Table 1). Both USG and PU gave higher S content in grain than in control. In straw the highest S content (0.14%) was obtained from both USG_{300} and

USG$_{240}$ when PU obtained 0.13% S at its highest dose. This finding was commensurate with the observation made by Rahman (2007).

The different doses of urea had slight effect on S content in grain (Table 1). Application of urea increased S content in grain. By applying 300 kg urea ha^{-1} the highest S content (0.21%) was obtained in USG which was identical to 240 kg urea ha^{-1} and the lowest S content (0.11%) was recorded in control.

The S content in straw was also slightly affected by the doses of nitrogen (Table 1). With the application of 300 kg urea ha^{-1} the highest S content was obtained (0.14%) in USG which was identical to 240 kg urea ha^{-1} and the lowest (0.09%) was found at control. Singh *et al.* (2005) stated that each increment dose of N fertilizer increased S content in rice straw. However, in the present study after 240 kg ha^{-1}, the S content was not increased.

v) Calcium content: The calcium content in grain was influenced insignificantly by the forms of urea (Table 1). With the use of USG the highest Ca content (0.73%) was obtained at highest dose when PU obtained 0.68% calcium at the same dose in grain. In case of straw, Ca content was slightly influenced by the forms of urea (Table 1). At both 300 and 240 kg ha^{-1} doses, USG obtained the highest Ca content (0.48%) which was statistically similar to Ca content influenced by PU (0.45%) at the highest dose.

A significant effect observed in Ca content in grain by using the different doses of urea (Table 1). Application of urea increased Ca content in grain. The highest Ca content (0.73%) was recorded in 240 kg urea ha^{-1} and the lowest Ca content (0.46%) was found in control.

The doses of urea were also slightly affected the Ca content in straw (Table 1). The application of urea increased Ca content in straw. The highest Ca content (0.48%) was found in 300 kg urea ha^{-1} in case of USG which was identical to 240 kg urea ha^{-1} of the same and the lowest Ca content (0.30%) was obtained in control.

vi) Magnesium content: The Mg content in grain and straw was slightly influenced by the forms of nitrogen (Table 1). At both 300 and 240 kg ha^{-1} doses, USG obtained the highest Mg content (0.68%) in grain which was statistically similar to Mg content (0.66%) influenced by PU at the same doses. In case of straw, USG obtained the highest Mg content (0.46%) at highest dose which was statistically similar to Mg content (0.43%) of PU at the same dose.

The doses of urea slightly affected the Mg content of grain (Table 1). Application of nitrogen increased Mg content in grain. In both PU and USG the Mg content gradually increased with the increase of N application. The highest Mg content (0.68%) was found in 300 kg urea ha^{-1} as USG which was identical to 240 kg urea ha^{-1} and the lowest Mg content (0.47%) was recorded in control.

In straw, application of nitrogen increased Mg content. The highest Mg content (0.46%) was obtained in USG at 240 kg urea ha^{-1} which was statistically similar to 300 kg urea ha^{-1} of the same and the lowest Mg content (0.31%) was found in control. The N content of grain and straw was positively and significantly correlated with the content of P (r = 0.967**), K (r = 0.874**), S (r = 0.962**), Ca (r = 0.970**) and Mg (r = 0.976**, Fig. 1).

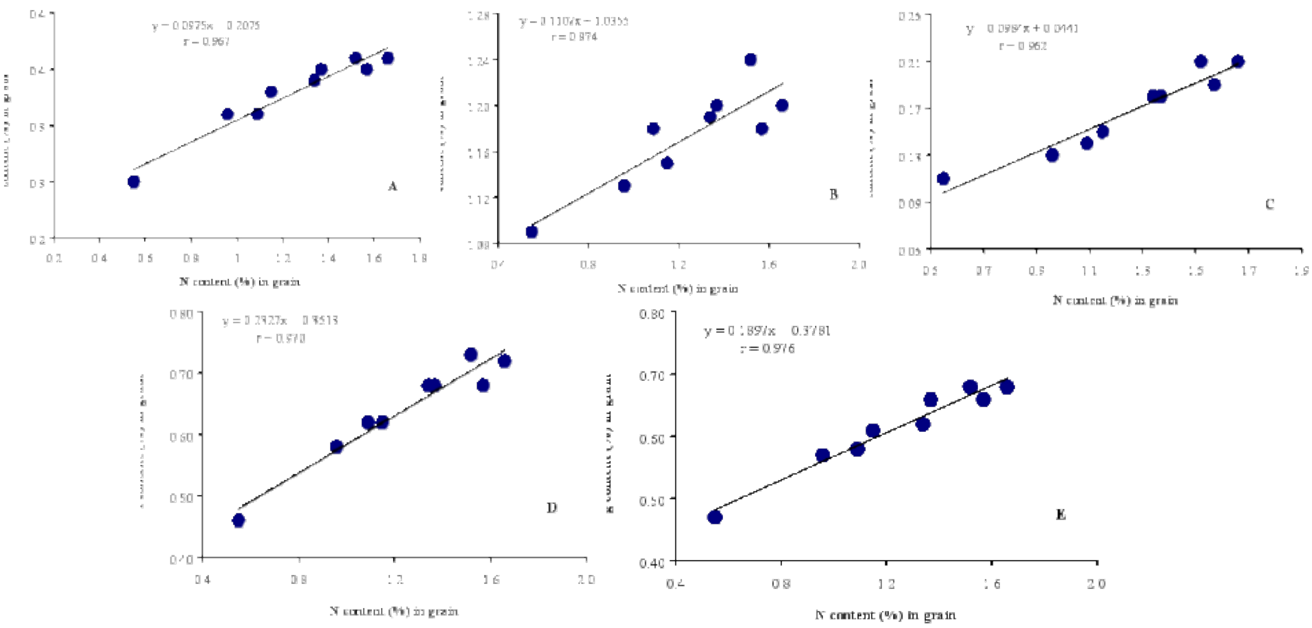

Fig. 1. Relationships between (A) N and P content, (B) N and K content, (C) N and S content, (D) N and Ca content and (E) N and Mg content of rice grain.

b) Nutrient uptake by grain and straw: The uptake of N, P, K, S, Ca and Mg were calculated from the minerals constituent and dry matter weight of rice grain and straw. The results of N, P, K,S, Ca and Mg uptake by grain and straw of BRRI dhan28 are discussed below.

i) Nitrogen uptake: The results presented in the Table 2 indicated that the N uptake by rice grain and straw was significantly increased due to the application of different forms and doses of urea. The highest N uptake (90.97 kg ha^{-1}) was obtained in grain with the application of USG @ 300 kg ha^{-1} when in case of PU, N uptake was 83.33 kg ha^{-}

[1] at the same dose. In straw, the highest N uptake (113.03 kg ha^{-1}) was obtained with the use of highest dose of USG when in case of PU, N uptake was 109.68 kg ha^{-1} at the same dose. The minimum N uptake in grain and straw was noted in control. Singh and Lallu (2005) reported that N uptake increased in rice grain and straw due to the application of nitrogen fertilizer.

ii) Phosphorus uptake: The phosphorus uptake was not significantly affected by the forms of urea (Table 2) in grain and straw. In grain with the application of USG_{240} the uptake was highest (20.84 kg ha^{-1}) while in case of prilled urea it was 19.54 kg ha^{-1} at the same dose. In straw, the highest P uptake, 26.09 kg ha^{-1}, was obtained with the use of USG_{240} while in case of prilled urea it was 24.21 kg ha^{-1} at the same dose. The doses of urea slightly affected the phosphorus uptake in grain and straw (Table 2). The application of increased nitrogen increased P uptake in grain and straw. The highest P uptake (20.84 kg ha^{-1}) in grain was obtained in 240 kg urea ha^{-1} when in straw it was 26.09 kg ha^{-1} in 300 kg urea ha^{-1} as USG and the lowest P uptake was recorded at control.

Table 2. Effect of different forms and doses of urea on the N, P, K, S, Ca and Mg uptake in grain and straw of *boro* rice cv. BRRI dhan28

Treatments	N (kg ha^{-1})		P (kg ha^{-1})		K (kg ha^{-1})		S (kg ha^{-1})		Ca (kg ha^{-1})		Mg (kg ha^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Control	22.60e	22.79d	10.40d	12.64e	22.74f	91.03	4.50e	7.86d	18.92f	25.04f	19.18f	25.94f
PU110	45.81d	55.42cd	14.54c	16.62d	30.04e	108.46	6.13d	10.06c	27.57e	37.16e	27.10ef	36.17e
PU180	58.99bcd	67.75bc	17.01bc	19.21cd	33.60cd	118.77	7.73c	12.07c	31.75d	42.52d	31.51d	42.05c
PU240	76.09ab	87.70abc	19.54ab	22.41abc	38.03ab	131.45	10.21b	14.44b	37.98bc	49.89c	36.92b	48.01b
PU300	83.83a	109.68a	19.00ab	24.21ab	36.66bc	138.55	9.95b	15.70ab	36.55c	53.26b	35.42b	50.93b
USG110	52.70cd	65.60bc	15.20c	18.64cd	31.28de	119.97	6.81cd	11.21c	29.91d	41.82d	28.11e	39.25d
USG180	72.76abc	88.26abc	18.48ab	21.30bc	36.02bc	129.56	9.93b	14.40b	36.81c	48.99c	33.55c	44.82c
USG240	87.65a	95.93ab	20.84a	23.46ab	40.00a	135.59	12.08a	15.58ab	41.96a	52.95b	39.43a	49.93b
USG300	90.97a	113.03a	19.90ab	26.09a	37.59ab	145.66	11.60a	17.48a	39.52b	58.01a	37.10b	54.84a
LSD	20.56	34.39	3.00	3.70	3.11	48.05	0.99	2.17	1.90	3.08	2.09	2.86

In a column, figures with same letter(s) or without letters do not differ significantly whereas figures with different letters differ at 1% level of significance. USG- Urea super granule; PU- Prilled urea

iii) Potassium uptake: There was no significant variation in K uptake by BRRI dhan28 due to the various forms and doses of urea in straw but in grain, the K uptake was slightly influenced by the forms and doses of urea (Table 2). Potassium uptake was significantly increased after 180 kg ha^{-1} dose in both forms. With the use of USG_{240} the highest K uptake (40 kg ha^{-1}) was obtained in grain when in case of PU, K uptake was (38.03 kg ha^{-1}) at the same dose which was statistically similar to the effect of USG_{240} (Table 2). Dixit and Gupta (2000) reported that uptake of K in grain showed increasing trends as a result of NPK fertilizers, farmyard manure and BGA inoculation either alone or in combination.

iv) Sulphur uptake: The forms of urea expressively affected the S uptake after 180 kg ha^{-1} dose (Table 2) both in grain and straw. The highest S uptake (12.08 kg ha^{-1}) was obtained in grain with the use of USG_{240} when in case of PU S uptake was (10.21 kg ha^{-1}) at the same dose. In straw, the highest S uptake (17.48 kg ha^{-1}) was obtained with the use of USG_{300} when in case of PU S uptake was 15.70 kg ha^{-1} at the same dose. There was a significant effect of different doses of urea on the S uptake till 240 kg urea ha^{-1} dose in grain (Table 2). The highest S uptake (12.08 kg ha^{-1}) was obtained in USG_{240} and the lowest S uptake (4.50 kg ha^{-1}) was recorded at control. The doses of urea affected the S uptake in straw slightly (Table 2). The highest S uptake in straw (17.48 kg ha^{-1}) was obtained in USG_{300} and the lowest S uptake (7.86 kg ha^{-1}) was recorded at control.

v) Calcium uptake: The Ca uptake was significantly influenced by the forms of urea both in grain and straw (Table 2). The highest Ca uptake (41.96 kg ha^{-1}) was obtained in grain with the use of USG_{240} when in case of PU Ca uptake was 37.98 kg ha^{-1} at the same dose. In straw, the highest Ca uptake (58.01 kg ha^{-1}) was obtained with the use of USG_{300} when in case of PU Ca uptake was 53.26 kg ha^{-1} at the same dose.

The doses of nitrogen fertilizer have expressive effect on the calcium uptake in grain and straw (Table 2). The highest Ca uptake in grain (41.96 kg ha^{-1}) was obtained in USG_{300} and the lowest Ca uptake (18.92 kg ha^{-1}) was recorded at control. In straw, the highest Ca uptake (58.01 kg ha^{-1}) was observed in 300 kg urea ha^{-1} as USG and the lowest Ca uptake (25.04 kg ha^{-1}) was noted at control.

vi) Magnesium uptake: The forms of urea have significant effect on the Mg uptake both in grain and straw (Table 2). The highest Mg uptake (39.43 kg ha^{-1}) was obtained in grain with the use of USG_{240} when in case of PU Mg uptake was 36.92 kg ha^{-1} at the same dose. In straw, the highest Mg uptake (54.84 kg ha^{-1}) was obtained with the use of USG_{300} when in case of PU Mg uptake was 50.93 kg ha^{-1} at the same dose.

Mg uptake in grain was significantly affected by the doses of urea fertilizer (Table 2). With the use of more urea the Mg uptake in grain increased. The highest Mg uptake (39.43 kg ha^{-1}) was obtained in 240 kg urea ha^{-1} as USG and the lowest Mg uptake (19.18 kg ha^{-1}) was recorded at control. The different doses of urea expressively influenced the Mg uptake in straw (Table 2). The highest Mg uptake (54.84 kg ha^{-1}) was observed in USG_{300} and the lowest Mg uptake (25.94 kg ha^{-1}) was noted at control.

Slow release N fertilizers have increasing demand due to their better nutrient use efficiency than traditional N fertilizers. Present experiment showed that USG and PU affect both nutrient content and nutrient uptake in BRRI dhan28, though the effects were not similar in both forms of fertilizer and in all doses. The doses of fertilizer found to affect more than the forms of fertilizer in the case of nutrient content and nutrient uptake in BRRI dhan28, especially in case of N, P, K and S content and their uptake. Among the doses used in the experiment USG @ 300kg ha^{-1} showed better performance in the case of N, P, K, S and Ca content, which in the most cases were statistically identical with USG_{240} and PU_{300} . In the case of nutrient uptake, in most cases, USG_{240} found better. From the a above discussion, it may be concluded that USG_{240} and PU_{300} treatments showed the best performance for nutrient content and their uptake on *boro* rice cv. BRRI dhan28. The results also suggest that urea super granule @ 240 kg ha^{-1} may be suitable for better growth, yield and quality of *boro* rice in the agroclimatic condition of the study area.

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