# Effect of Urea Super Granule with Cowdung on Nitrogen Use Efficiency and Nitrogen Dynamics in Rice *cv*. BRRI Dhan32

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(Received Date: 16th April 2025, Accepted Date: 7th September 2025)

**Abstract:** A field experiment was conducted at the Soil Science Field Laboratory of Bangladesh Agricultural University to evaluate the effects of prilled urea (PU), urea super granule (USG), and their combinations with cow dung on nitrogen dynamics, nitrogen-use efficiency (NUE), and yield of transplanted Aman rice (cv. BRRI dhan32). The experiment consisted of seven treatments arranged in RCBD. Application of USG alone or integrated with cow dung significantly improved yield components, grain yield, straw yield, and nutrient uptake compared with control and sole PU application. The highest grain yield (5.56 t $ha^{-1}$) and straw yield (5.79 t $ha^{-1}$) were obtained from T6 (5 t cow dung + USG @ 78 kg N $ha^{-1}$), followed closely by T2 (USG @ 104 kg N $ha^{-1}$). Treatments receiving USG also produced higher numbers of effective tillers (up to 13 $hill^{-1}$), longer panicles (up to 24.84 cm), more filled grains $panicle^{-1}$ (up to 124), and heavier 1000-grain weight (24.37 g). Nitrogen uptake was markedly enhanced by USG–cow dung combinations, with the maximum total N uptake (123.72 kg $ha^{-1}$) recorded in T5 (5 t cow dung + USG @ 104 kg N $ha^{-1}$). Pore water analysis revealed that USG treatments released $NH_4^+$-N and $NO_3^-$-N more slowly and steadily throughout the growing period compared to PU, indicating reduced nitrogen losses. The highest agronomic nitrogen-use efficiency was also recorded in T6. Overall, the study demonstrates that integrating cow dung with deep-placed USG improves nitrogen conservation, nutrient uptake, and yield performance, and represents an effective, environmentally sound nitrogen management strategy for BRRI dhan32 rice production.

**Keywords:** USG, BRRI, cow dung, treatments, fertilizers, rice production.

## Introduction

Rice is the staple food for more than 163 million people in Bangladesh and plays a central role in food security and rural livelihoods (BBS, 2019). Nearly half of the country's rural workforce depends on rice cultivation, with about 16.5 million farm families involved in its production (Akter et al., 2019). In coastal regions, particularly the south-central belt, Transplanted Aman (T. Aman) occupies the major share of cultivated land during the Kharif-II season. Despite this large acreage, the productivity of T. Aman rice remains relatively low due to soil nutrient depletion, salinity intrusion, and suboptimal fertilizer management practices (FRG, 2018; Haque, 2020).

Among essential nutrients, nitrogen (N) is the most limiting and heavily required for rice production in Bangladesh. However, nitrogen use efficiency (NUE) is extremely low in conventional fertilizer practices because prilled urea (PU)—the most widely used N source—undergoes substantial losses through ammonia volatilization, leaching, denitrification, and runoff (Dhane et al., 1989; De Datta and Buresh, 1989). As a result, a large proportion of applied nitrogen does not reach the rice plant, causing both economic loss and environmental pollution.

Urea Super Granule (USG), when deep-placed at 8–10 cm soil depth, has been identified as an effective technology for improving nitrogen efficiency. Deep placement slows the conversion of urea, reduces $NH_3$ volatilization, and ensures prolonged availability of ammonium-N in the root zone (Savant et al., 1983; Jena et al., 2003). Studies have shown that USG can save up to 30% of N fertilizer while maintaining or increasing rice yield, because the nitrogen remains available during critical growth stages and minimizes loss pathways (Negrin et al., 2011; Zhao et al., 2008).

In recent years, integrated nutrient management has gained attention, particularly the combination of organic manure with efficient inorganic fertilizers. Cow dung is a rich source of nitrogen, phosphorus, potassium, sulphur, and micronutrients and contributes significantly to improving soil structure, microbial activity, and nutrient-holding capacity. When cow dung is applied together with USG, several advantages emerge:

- **Enhanced nitrogen synchronization** – Cow dung releases nutrients slowly, complementing the gradual N supply from deep-placed USG.
- **Reduced N losses** – Organic matter helps retain ammonium in the soil, reducing volatilization and leaching.
- **Improved soil physical and biological properties** – Cow dung increases soil organic carbon, enhances cation-exchange capacity, and promotes beneficial microbial processes.
- **Lower fertilizer requirement and production cost** – Combining USG with cow dung reduces dependency on costly chemical fertilizers in rice-based systems.
- **Environmental benefits** – Organic amendments improve nutrient cycling and contribute to sustainable soil fertility.

Therefore, integrating USG with cow dung is expected to maximize nitrogen-use efficiency, improve pore water nitrogen dynamics, and support higher and more sustainable rice yields. Considering the importance of efficient N management in coastal N-deficient soils, the present study was undertaken to evaluate the effects of USG alone and in combination with cow dung on nitrogen use efficiency and nitrogen dynamics in BRRI dhan32 rice cultivation.

## Materials and Methods

The experiment was conducted at the Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh. A brief description of materials and methods stated below.

**Soil:** The experimental soil was silt loam, a number of Aeric Haplaquepts. The land is moderately well drained with a silty loam texture.

**Climate:** Climatic condition of the experimental area was sub-tropical with high temperature, humidity and heavy precipitation with occasional winds in Kharif season (April-September) and moderately low temperature during Rabi season (October-March).

**Land Preparation:** The land was prepared by repeated ploughing and cross ploughing followed by laddering. After uniform leveling and puddling, the experimental plots were laid out as per treatments and design of the experiment.

**Crop:** High yielding BRRI dhan 32 rice variety was used in this experiment. It is a transplant Aman rice cultivar and matures after 110 days of transplanting with average yield 5.0-5.5 t $ha^1$.

**Raising Seedlings:** A well puddle land was selected for raising seedling. The sprouted seeds of BRRI dhan32 were sown. Proper care of the seedlings was taken in the seedbed.

**Transplanting of Seedling:** 46 day's old seedlings were transplanted in the experimental plots. A distance of 20 cm from row to row and 20 cm from plant to plant was maintained placing 3 seedlings in each hill.

**Treatments:** There were seven treatments consisting of urea and USG including control. The $T_{o=}$ Control, $T_{1=}$140 kg N/ha from PU, $T_{2=}$104 kg N/ha from USG (2*1.8g/4 hills), $T_{3=}$78 kg N/ha from USG (1*2.7g/4 hills, $T_{4=}$5 t CD+PU on IPNS basis (@140kg N/ha), $T_{5=}$5 t CD+USG (2*1.8g/4 hills) AND $T_{6=}$5 t CD+USG (1*2.7g/4 hills). Total number of unit plots was 21 and the size of the unit plot was 4m × 4m (16$m^2$ each).

**Fertilizer and Cow dung Application:** All the fertilizers except urea i.e. TSP, MoP and gypsum were applied as basal doses in all the plots at final land preparation. PU was applied in three equal splits. The first dose of PU was applied on 27August, 7 days after transplanting (DAT); the second dose was applied on 4 October, 37 DAT and third dose was applied 24 October, 57 DAT. Two USG of 1.8g @ of 104 kg N/ha and one USG of 2.7g @ 78 kg N/ha were deep placed in the centre of every four hills. PU was applied in three equal splits. The first split was applied at 7 days before transplanting of the rice seedlings along with the basal doze of PKS. Cowdung was applied on day before transplanting.

**Porewater sample collection:** Porewater samples were collected by pore water samplers (Rhizon sampler) which were placed into the centre of the plots after rice transplanting from each plot. The water samples were collected after fertilization to record the field porewater available $NH_4$-N and $NO_3$-N. Water sampling was done second, fourth and sixth day after each urea application maintaining same sampling time.

**Determination of $NH_4$-N:** Phenol-Alcohol solution-10 g phenol was added into 100 mL ethyl-alcohol. Na-nitroprusside- 0.5 g nitroprusside solution was added into 100 mL distilled water. Alkaline solution- 100 g trisodium citrate and 5.0 g NaOH was added into 500 mL distilled water. Hypochlorite solution- 1.5 N solutions. Oxidizing solution- 100 mL alkaline solution was added with 25 mL hypochlorite solution. Standard solution- 0.471 g ammonium sulphate was added in 1 L distilled water and stored in refrigerator. The $NH_4$-N concentration in porewater samples were determined by plotting the absorbances in a standard curve.

**Determination of $NO_3^-$N:** Standard solution- 0.722 g potassium Nitrate was added in 1 L distilled water and stored in refrigerator. Pore water samples were run in a UV-Vis spectrophotometer (Spectronic GENESYS 5 UV-Vis spectrophotometer, USA) at wavelengths 210 and 275 nm based on Goldman & Jacobs (1961) without any dilution. The value of $NO_3$-N was determined from absorbance by making a standard curve from standard solution.

**Intercultural operation:** Intercultural cultural operations and harvesting and post-harvest processing operations were done properly.

**Irrigation and Drainage:** Irrigation was applied to the crop field properly.

**Weeding:** The crop was infested with some common weeds, which were controlled by uprooting thrice from experimental plot. Weeding was done after 15, 32 and 52 days of transplanting.

**Harvesting and Post-Harvest Processing:** The crop was harvested at full maturity using 1 $m^2$ area. The harvested crops were threshed, cleaned and processed. Grain and straw yields were recorded and moisture percentage in grain and straw at the time of harvest was calculated after drying in the oven. Both grain and straw yields were recorded on the basis of 14% moisture content. The grain and straw yields were converted into t/ha.

**Plant Sample Collection:** Five hills from each plot were collected randomly for recording data of yield contributing characters like plant height, number of effective tiller $hill^{-1}$, panicle length, filled grain panicle-$^1$ and weight of 1000 grains. 100 g grain and straw sample were kept for chemical analysis.

**Data were collected on following parameters:**

**Plant height:** Plant height was measured from the base of the plant to the top of the panicle.

**Number of effective tiller $hill^{-1}$**: The number of effective tiller $hill^{-1}$ was recorded.

**Panicle length:** Panicle length was measured from the basal node of the rachis to the tip of the panicle. Each observation was an average of 5 hills.

**Number of filled grain $panicle^{-1:}$** Number of filled grain of all fertile tillers were counted and averaged.

**1000 grains weight:** 1000 grains were taken from each plot and their weight was recorded in an electrical balance after sun drying.

**Grain and straw yields:** Grain and straw samples collected from each plot were dried and weighed carefully. The yields were corrected at 14% moisture and expressed in t/ha.

**Collection, preparation and analysis of Soil Sample:** Soil samples were collected from 5 different spots at 0-15 cm depth and all samples were composited to make a single sample for initial soil analysis from each plot. The collected soil samples were air dried ground and sieved through 2 mm sieve and kept in polythene bags for laboratory.

**Determination of total Nitrogen from soil Sample:** The nitrogen contents in the digests were determined by distillation with 40% NaOH followed by titration of the distillate trapped $NH_3$ in 4% $H_3BO_3$ containing 5 drops of mixed indicator of bromocresol green ($C_{21}H_{14}O_5Br_4S$) and methyl red ($C_{10}H_{10}N_3O_3$) solution with 0.01 N $H_2SO_4$ until the color changed from green to pink (Bremner and Mulvaney, 1982) The amount of N was calculated using the following formula.

$$\% N = \frac{(T-B) \times N \times 0.014 \times 100}{S}$$

Were,

T= Sample titration value (ml) of standard $H_2SO_4$
B= Blank titration value (ml) of standard $H_2SO_4$
N= Strength of $H_2SO_4$
S= Sample weight in gram

**Determination of available phosphorus**

0.5M $NaHCO_3$ solution: 42 g $NaHCO_3$ was dissolved in 900 mL distilled water. Then pH of this solution was adjusted to 8.5 with 1 M NaOH and the volume was made 1 L with water.

Carbon black: Carbon black G was used for P determination

Ammonium molybdate solution: 15 g ammonium molybdate was dissolved in 300 mL warm distilled water. After cooling 342 mL conc. HCL was mixed gradually. Then the content was diluted to 1000 mL with distilled water.

Stannous chloride ($SnCl_2$. $2H_2O$) concentrated solution: 10 g $SnCl_2.2H_2O$ was added in 25 ml conc. HCL.

Stannous chloride dilute solution: 0.5 mL conc. $SnCl_2.2H_2O$ solution was added in 66 mL distilled water.

**Determination of exchangeable potassium**

Reagent preparation: Exchangeable potassium in soil was extracted using 1 N $NH_4OAc$ (pH 7.0) (Knudsen *et al*, 1982).

**Determination of available Sulphur**

Reagent preparation: Extracting solution- 1.5 g $CaCl_2$ was dissolved in 1 L distilled water. Acid seed solution- 6 N HCl containing 20 ppm S as $K_2SO_4$. $BaCl_2$- 13 g.

Standard/stock solution: 0.5434 g $K_2SO_4$ was dissolved in 1 L distilled water to make a standard solution of 100 ppm of S.

**Chemical Analysis of Plant Sample**

**Preparation and digestion of plant Sample:** The grain and straw samples were dried in an oven at 65˚C for about 24 hours before they were ground in a grinding machine. Then the powdered samples were passed through a 20-mesh sieve and stored in paper bags and finally they were kept in a desiccator. The grain and straw samples were analyzed for determination of N, P, K and S. For the determination of nitrogen 0.1 g oven dried powdered plant sample (both grain and straw) was taken in a digestion flask. Then 1.1 g catalyst mixture ($k_2SO_4$: $CuSO_4.5H_2O$: Se = 100:10:1) and 5 mL $H_2SO_4$ were added into the flask. The flasks were swirled and allowed to stand for about 10 minutes. The flasks were then placed in a block digester and the heat increased gradually to 380˚C. The heating at 380˚C continued until the digest was clear and colorless. When the digestion was complete, the flasks were cooled and the digest was transferred into 100 mL volumetric flask and the volume was made up to the mark with distilled water. Reagent blanks were prepared in a similar manner.

**Determination of total N in the digest**

The nitrogen contents in the digests were determined by distillation with 40% NaOH followed by titration of the distillate traped in $H_3BO_3$ with 0.01 N $H_2SO_4$ (Bremner and Mulvaney, 1982).

**Digestion of plant Samples for P, K and S determination**

0.5 g oven dried powdered plant sample (both grain and straw) was taken in a digestion flask. Then 10 mL diacid mixture ($HNO_3$: $HClO_4$ in the ratio of 2:1) was added. After leaving for a while, the flask was heated at a temperature slowly raised to 200˚C. The content in the flask was boiled until they became clean and colorless. After cooling, the digest was taken into 50 mL volumetric flask and the volume was made up to the mark with distilled water. P, K and S determined from this single digest (Yoshida *et al.*, 1976). P, K and S concentration in plant samples were determined using the same procedure as described above.

**Nitrogen use efficiency (NUE) in applied N fertilizer**: The NUE of applied N fertilizer was evaluated based on their agronomic efficiency using following equation:

**Agronomic efficiency (AE)**

$AE = (GY_{AN} - GY_{0N})/N_A$,

Where, AE = Agronomic efficiency (kg/kg);

$GY_{AN}$ = Grain yield with added N (kg);

$GY_{0N}$ = Grain yield (kg) without N, and

$N_A$ = total amount of added N (kg) (reproduced from BARC, 2005).

**Statistical Analysis:** The mean comparison of the treatments was made by the Duncan's Multiple Range Test (DMRT).

## Results and Discussion

### Yield contributing Characters of BRRI dhan32 rice

**Effective tillers/hill:** Maximum effective tillers/hill (13.00) was found in $T_5$ at 5t CD+USG@104kg N/ha (Table 1). Statistically similar number of effective tillers were found in $T_2$ (104kg N/ha from USG), $T_6$ (5t CD+USG@78kg/ha), $T_1$ (140kg N/ha from PU), $T_4$ (5t CD+PU @140 kg N/ha) and $T_3$ (78kg N/ha from USG). The lowest number of effective tillers (9.33) was obtained in $T_0$ (control). The treatments may be ranked in the order of decreasing trend $T_5>T_2>T_6> T_1>T_4>T_3>T_0$ in terms of effective tillers/hill.

**Plant height**: Plant height of BRRI dhan32 rice was significantly affected by the treatment combinations designed with PU and USG alone or in combination with cow dung (Table 1). All the treatments produced significantly taller plants compared to control. The tallest plants (109.76cm) was found in $T_2$ (104kg N/ha from USG) and the shortest (102.51cm) in control treatment $T_0$. Statistically similar plant heights were found in $T_5$ (5t CD+USG@104kg N/ha), $T_6$ (5t CD+USG@78kg N/ha), $T_3$ (78kg N/ha from USG), $T_1$ (140kg N/ha from PU) and $T_4$ (5t CD+PU @140 kg N/ha) treatments with the value of 109.75cm, 108.41cm, 106.20cm ,104.16cm and 102.56cm respectively. The treatments may be ranked in the order of decreasing trend $T_2>$ $T_5> T_6> T_3> T_1>T_4>T_0$ with respect to plant height. Cowdung in combination with USG performed better in producing plant height as compared to PU alone or PU in combination with Cowdung.

**Panicle length:** Table 1 reveals that the application of PU and USG alone or in combination with CD showed a significant positive effect on panicle length of BRRI dhan32 rice over control. The longest panicle (24.84cm) was found in the treatment $T_5$ (5t CD+USG@104kg N/ha) and the shortest panicle (21.83 cm) was found in the treatment T0 (control). Statistically similar panicle length was found in $T_3$ (78kg N/ha from USG), $T_2$ (104kg N/ha from USG), $T_6$ (5t CD+USG@78kg/ha), $T_4$ (5t CD+PU @140 kg N/ha) and $T_1$ (140kg N/ha from PU) with the value of 24.48cm, 24.18cm, 24.02cm, 23.13cm and 23.10cm. The treatments may be ranked in the order of decreasing trend $T_5>T_3>T_2>T_6>T_4>T_1>T_0$ in terms of panicle length.

**Number of filled grains/panicle:** Filled grains/panicle of BRRI dhan32 rice was influenced profoundly due to the application of PU and USG alone or in combination with cowdung (Table

1). The number of filled grains/panicle varied from 124 to 97. The highest value was found in $T_5$ (5t CD+USG@104kg N/ha) and the lowest value was found in $T_0$ (control). Statistically similar filled grains/panicle were found in $T_6$ (5t CD+USG@78kg/ha), $T_3$ (78kg N/ha from USG), $T_2$ (104kg N/ha from USG), $T_1$ (140kg N/ha from PU) and $T_4$ (5t CD+PU @140 kg N/ha) with the value of 122, 117, 116, 115 and 109. The treatments may be ranked in the order of decreasing trend $T_5>T_6>T_3>T_2>T_1>T_4>T_0$ in terms of filled grains/panicle.

**Number of unfilled grains/panicles:** Unfilled grains/panicle of BRRI dhan32 rice was affected due to the application of USG combined with cowdung or USG alone. The number of unfilled grains/panicles varied from 17 to 9. The highest value was found in $T_0$ (control) and the lowest value was found in $T_6$ (5t CD+USG@78kg/ha). The treatments may be ranked in the order of $T_0>T_1>T_4>T_3> T_2>T_5>T_6$ in terms of unfilled grains/panicle.

**1000-grain weight:** The 1000-grain weight of BRRI dhan32 rice was influenced significantly due to application of PU and USG alone or in combination with cowdung (Table 1). The 1000-grain weight of rice was ranged from 24.37 to 20.35g. The highest 1000-grain weight of 24.37 g was found in $T_6$ (5t CD+USG@78kg/ha) and the lowest value was noted in $T_0$. Thousand-grain weight may be ranked in the order of $T_6>T_5>T_3>T_2>T_1>T_4>T_0$.

**Table 1.** Effects of PU, USG in combination with cowdung on the growth of Aman rice *cv* BRRI dhan32

| **Treatments** | **Plant height (cm)** | **Effective tillers/hill (No.)** | **Panicle Length (cm)** | **Filled grains/ panicle (No.)** | **Unfilled grains/ panicle (No.)** | **1000 grain weight** |
|---|---|---|---|---|---|---|
| $T_0$: (Control) | 102.51 | 9.33 | 21.83b | 97.00 | 17.67 | 20.35c |
| $T_1$: 140 kg N/ha from PU | 104.16 | 11.67 | 23.10ab | 115.67 | 14.00 | 21.81bc |
| $T_2$: 104 kg N/ha from USG(2 x 1.8g/4 hills) | 109.76 | 12.33 | 24.18ab | 116.67 | 12.00 | 21.98bc |
| $T_3$: 78kg N/ha from USG(1 x 2.7g/4 hills) | 106.20 | 11.00 | 24.48ab | 117.00 | 12.33 | 22.04bc |
| $T_4$: 5 t CD+PU (@140kg N/ha) on IPNS basis | 102.56 | 11.33 | 23.13ab | 109.67 | 12.67 | 21.70bc |
| $T_5$: 5 t CD+USG (2x 1.8g/ 4 hills) on IPNS basis | 109.75 | 13.00 | 24.84a | 124.33 | 11.00 | 23.01ab |
| $T_6$:5 t CD+USG (1x 2.7g/ 4 hills) on IPNS basis | 108.41 | 12.00 | 24.02ab | 122.67 | 9.00 | 24.37a |
| *p value* | *0.251* | *0.229* | *0.034* | *0.222* | *0.151* | *.001* |
| *CV* | *4.60* | *15.18* | *5.45* | *11.92* | *30.15* | 6.11 |

Figures in a column having common letters do not differ significantly at 5% level of significance.

### Grain and Straw Yields of BRRI dhan32 Rice

**Grain yield:** Application of PU, USG and cowdung alone or in combination showed a positive effect on grain yield of BRRI dhan32 rice (Table 2). It was found that the grain yield ranged from 3.63 to 5.56 t/ha. The highest grain yield of 5.56 t/ha was recorded both in $T_6$ (5t CD+USG@78kg/ha). The lowest value of 3.63 t/ha was recorded in $T_0$ (control). The treatment $T_6$ (5t CD+USG@78kg/ha) and $T_2$ (104 kg N ha$^{-1}$ from USG) were statistically similar. USG in association with Cowdung treated plot gave better grain yield than other treatments. This might be due to optimum release of N from deep placed USG for prolonged period and adequate release of N and other nutrient from cowdung. The increase in grain yield over control ranged from 20.39 to 34.71% where the highest %increase was obtained due to $T_6$ (5t CD+USG@78kg/ha) as shown in Table 4.2 and Figure 4.1. The grain yields obtained from different treatments may be ranked in the order of $T_6$>$T_2$>$T_4$>$T_1$>$T_5$>$T_3$>$T_0$.

**Straw yield:** The straw yield of BRRI dhan32 rice was also influenced significantly due to the application of PU, USG and cowdung alone or in combination (Table 2). The straw yield obtained from different treatments ranged from 3.66 t to 5.95 t/ha. The highest straw yield of 5.79 t/ha was obtained in $T_1$ (140kg N/ha from PU) and the lowest of 3.66t/ha was noted in $T_0$ (control). The treatments may be ranked in the order of $T_1$>$T_6$>$T_3$>$T_5$>$T_2$>$T_4$>$T_0$ in terms of straw yield as depicted in Table 2. The percent increase of straw yield was highest (38.48%) at $T_1$ (140kg N/ha from PU) and the lowest increase (24.69%) was found in $T_4$ (5t CD+PU @140 kg N/ha) as demonstrated in Figure 1.

**Table 2.** Effects of PU, USG in combination with cowdung on the yield of Aman rice cv BRRI dhan32

| Treatments | Grain yield (t/ha) | Increase over control (%) | Straw yield (t/ha) | Increase over control (%) |
|---|---|---|---|---|
| $T_0$: (Control) | 3.63b | - | 3.66b | - |
| $T_1$: 140 kg N/ha from PU | 5.17ab | 29.78 | 5.95a | 38.48 |
| $T_2$: 104 kg N/ha from USG(2 x 1.8g/4 hills) | 5.50a | 34.00 | 5.10ab | 28.23 |
| $T_3$: 78kg N/ha from USG(1 x 2.7g/4 hills) | 4.56ab | 20.39 | 5.73ab | 36.12 |

| | | | | |
|---|---|---|---|---|
| $T_4$ : 5 t CD+PU (@140kg N/ha) on IPNS basis | 5.42ab | 33.02 | 4.86ab | 24.69 |
| $T_5$: 5 t CD+USG (2 x 1.8g/4 hills) on IPNS basis | 4.66ab | 22.10 | 5.56ab | 34.17 |
| $T_6$:5 t CD+USG (1 x 2.7g/4 hills) on IPNS basis | 5.56a | 34.71 | 5.79ab | 36.78 |
| *p value* | *0.024* | | *0.033* | |

Figures in a column having common letters do not differ significantly at 5% level of significance.

### Nutrient Content and Uptake by BRRI dhan32 Rice

**Nitrogen content:** Application of PU and USG alone or in combination with cowdung showed significant variation in nitrogen content of grain of BRRI dhan32 rice (Table 3). The grain N content varied from 1.01% to 1.46%. The highest N content of 1.46% was observed in $T_5$ (5t CD+USG@104kg N/ha) and the lowest N content of % was noted in $T_0$ (control). Application of USG in combination with cowdung increased the N content in rice grain markedly in $T_5$ (5t CD+USG@104kg N/ha) which was statistically different from other treatments but identical to $T_2$ and $T_3$. The N content in straw of BRRI dhan32 rice was not varied significantly due to different treatments (Table 4.3). The N content in straw ranged from 0.56% in $T_0$ (Control) to 0.95% in $T_5$ (5t CD+USG@104kg N/ha). The effect of cowdung in combination with USG was also pronounced in increasing the N content both in grain and straw of BRRI dhan32 rice in $T_2$ (104 kg N $ha^{-1}$ from USG) compared to other treatments. The results reveal that the N content in rice grain was higher than that of straw.

**Nitrogen uptake**: The N uptake both in grain and straw of BRRI dhan32 rice increased significantly due to application of PU, USG and cowdung alone or in combination. The N uptake by grain ranged from 37.38 kg/ha to 75.96 kg/ha and that by straw from 19.92 kg/ha to 55.36 kg/ha. The highest N uptake by grain (75.96 kg/ha) was obtained in $T_2$ (104 kg N/ha from USG) and straw (55.36 kg/ha) in $T_5$ (5t CD+USG@104kg N/ha) and the lowest N uptake by grain (17.02 kg/ha) and straw (13.38 kg/ha) was found in $T_0$ (control). The total N uptake both by grain and straw was influenced significantly by different treatments (Table 4.3). The highest total N uptake (123.72 kg/ha) was observed in $T_5$ and the lowest value (57.31 kg/ha) was found in $T_0$ (control). The treatments may be ranked in the order of $T_5>T_2>T_1>T_6>T_3>T_4>T_0$ in terms of N uptake.

**Table 3.** Effects of PU, USG in combination with cowdung nitrogen content and uptake by Aman rice *cv* BRRI dhan32

| Treatment | N content (%) | | N uptake (kg/ha) | | Total N uptake |
|---|---|---|---|---|---|
| | Grain | Straw | Grain | Straw | |
| $T_0$: (Control) | 1.01c | 0.56 | 37.38b | 19.92b | 57.31b |
| $T_1$: 140 kg N/ha from PU | 1.12bc | 0.70 | 60.22ab | 45.96ab | 106.19a |
| $T_2$: 104 kg N/ha from USG (2x1.8g/4 hills) | 1.37ab | 0.84 | 75.96a | 43.43ab | 119.39a |
| $T_3$: 78 kg N/ha from USG (1x2.7g/4 hills) | 1.23abc | 0.75 | 52.47ab | 43.94ab | 96.42ab |
| $T_4$: 5 t CD+PU on IPNS basis (@140kg N/ha) | 1.12bc | 0.72 | 61.79ab | 32.99ab | 94.79ab |
| $T_5$: 5 t CD+USG (2x1.8g/4 hills) | 1.46a | 0.95 | 68.35ab | 55.36a | 123.72a |
| $T_6$:5 t CD+USG(1x2.7g/4 hills) | 1.04c | 0.78 | 54.81 | 44.63ab | 99.45ab |
| *p value* | *0.004* | *0.116* | *0.029* | *0.033* | *0.013* |

Figures in a column having common letters do not differ significantly at 5% level of significance.

**Phosphorus content:** Results in Table 4 show that phosphorus content in grain of BRRI dhan32 rice varied due to different treatments and the variations were also statistically significant. Phosphorus content in grain ranged from 0.13% to 0.19%. The N content in straw of BRRI dhan32 rice was not varied significantly due to different treatments (Table 4). Phosphorus content in rice straw was also influenced due to the use of PU, USG and cowdung alone or in combination. Phosphorus content in straw ranged from 0.03% to 0.06%.

**Phosphorus uptake:** The results presented in Table 4 show that P uptake both by grain and straw of BRRI dhan32 rice was increased significantly by different treatments. The P uptake by grain ranged from 7.17 to 10.38 kg/ha and that by straw ranged from 1.29 to 3.96 kg/ha. The maximum P uptake by grain (10.38 kg/ha) was found in $T_4$ (5t CD+PU @140 kg N/ha) and straw (3.96 kg/ha) was found in $T_5$ (5t CD+USG@104kg N/ha) and the minimum P uptake by grain (7.17 kg/ha) and straw (1.29 kg/ha) was found in $T_0$ (control). The application of PU and USG in combination with cowdung was not varied significantly due to different treatments on the total P uptake by BRRI dhan32 rice. The highest total P uptake (13.08 kg/ha) was obtained from $T_4$ (5t CD+PU @140 kg N/ha) and the lowest total P uptake (8.47 kg/ha) was observed in $T_0$ (control).

**Table 4.** Effects of PU, USG in combination with cowdung on phosphorus content and uptake by Aman rice *cv* BRRI dhan32

| Treatment | P content (%) | | P uptake (kg/ha) | | Total P uptake |
|---|---|---|---|---|---|
| | Grain | Straw | Grain | Straw | |
| $T_0$: (Control) | 0.19a | 0.03 | 7.17 | 1.29b | 8.47 |
| $T_1$: 140 kg N/ha from PU | 0.17ab | 0.05 | 9.24 | 3.75ab | 12.99 |
| $T_2$: 104 kg N/ha from USG (2x1.8g/4 hills) | 0.13b | 0.06 | 7.55 | 3.49ab | 11.04 |
| $T_3$: 78 kg N/ha from USG (1x2.7g/4 hills) | 0.18ab | 0.05 | 8.13 | 2.97ab | 11.11 |
| $T_4$: 5 t CD+PU on IPNS basis (@140kg N/ha) | 0.18ab | 0.05 | 10.38 | 2.69ab | 13.08 |
| $T_5$: 5 t CD+USG (2x1.8g/4 hills) | 0.16ab | 0.06 | 7.64 | 3.96a | 11.60 |
| $T_6$:5 t CD+USG(1x2.7g/4 hills) | *0.16ab* | 0.05 | 8.51 | 3.11ab | 11.62 |
| *p value* | *0.046* | *0.284* | *0.459* | *0.056* | *0.312* |

Figures in a column having common letters do not differ significantly at 5% level of significance.

**Potassium content:** The potassium content in grain of BRRI dhan32 rice due to various treatments ranged from 0.27% to 0.31% in rice grain and 1.81 to 2.27% in rice straw. The highest K content in rice grain (0.31%) and in straw (2.27%) was recorded in $T_1$ (140kg N/ha from PU) and the lowest K content in rice grain (0.27%) and in straw (1.81%) was found in $T_2$ (104kg N/ha from USG) respectively (Table 5).

**Potassium uptake:** The K content in grain and straw of BRRI dhan32 rice was not varied significantly due to different treatments (Table 5). The K uptake by grain ranged from 11.28 to 15.72 kg/ha in $T_6$ (5t CD+USG@78kg/ha) and that by straw ranged from 78.22 to 149.13 kg/ha in $T_1$ (140kg N/ha from PU). The total K uptake by grain and straw was also influenced significantly by different treatments. The highest total K uptake 165.83 kg/ha was obtained in $T_1$ (140kg N/ha from PU) and the lowest value (89.51 kg/ha) was observed in $T_0$ (control). It was found that the K uptake by rice grain was less than that by straw. Nitrogen as USG in combination with cowdung exerted better performance in increasing the K uptake both by grain and straw of BRRI dhan32 rice.

**Table 5.** Effects of PU, USG in combination with cowdung on potassium content and uptake by Aman rice *cv* BRRI dhan32

| Treatment | K content (%) | | K uptake | | Total K uptake |
|---|---|---|---|---|---|
| | Grain | Straw | Grain | Straw | |
| $T_0$: (Control) | 0.30 | 2.19 | 11.28 | 78.22 | 89.51 |
| $T_1$: 140 kg N/ha from PU | 0.31 | 2.27 | 16.70 | 149.13 | 165.83 |
| $T_2$: 104 kg N/ha from USG (2x1.8g/4 | 0.27 | 1.81 | 14.95 | 94.60 | 109.55 |
| $T_3$: 78 kg N/ha from USG (1x2.7g/4 hills) | 0.30 | 2.14 | 13.36 | 125.18 | 138.55 |
| $T_4$: 5 t CD+PU on IPNS basis (@140kg | 0.28 | 2.09 | 15.58 | 95.26 | 110.85 |
| $T_5$: 5 t CD+USG (2x1.8g/4 hills) | 0.29 | 2.01 | 13.67 | 120.26 | 133.94 |
| $T_6$:5 t CD+USG(1x2.7g/4 hills) | *0.29* | 2.22 | 15.72 | 125.41 | 143.14 |
| *p value* | *0.845* | *0.385* | *0.390* | *0.135* | *0.142* |

Figures in a column having common letters do not differ significantly at 5% level of significance

**Sulphur content:** The sulphur content in grain of BRRI dhan32 rice due to various treatments ranged from 0.05% to 0.08% in rice grain and 0.04 to 0.08% in rice straw. The highest S content in rice grain (0.08%) $T_1$ (140kg N/ha from PU), $T_5$ (5t CD+USG@104kg N/ha), $T_3$ (78kg N/ha from USG) and in straw (0.08%) was recorded in $T_3$ (78kg N/ha from USG) and the lowest K content in rice grain (0.05%) was found in $T_6$ (5t CD+USG@78kg/ha) and in straw (0.04%) was found in $T_2$ (104kg N/ha from USG) respectively (Table 6).

**Sulphur uptake:** The S content in grain and straw of BRRI dhan32 rice was not varied significantly due to different treatments (Table 6). The S uptake by grain ranged from 2.55 to 4.56 kg/ha and that by straw ranged from 2.29 to 4.76 kg/ha. The highest S uptake by grain (4.56 kg/ha) and straw (4.76 kg/ha) was obtained in $T_1$ (140kg N/ha from PU) and the lowest S uptake by grain (2.55 kg/ha) and straw (2.29 kg/ha) was found in $T_0$ (control). The total S uptake by grain and straw was also influenced significantly by different treatments. The highest total S uptake 9.33 kg/ha was obtained in $T_1$ (140kg N/ha from PU) and the lowest value (4.84 kg/ha) was observed in $T_0$ (control). Nitrogen as USG in combination with cowdung exerted better performance in increasing the S uptake both by grain and straw of BRRI dhan32 rice.

**Table 6.** Effects of PU, USG in combination with Cowdung on sulphur content and uptake by Aman rice *cv* BRRI dhan32

| Treatment | S content | | S uptake | | Total S |
|---|---|---|---|---|---|
| | Grain | Stra | Grain | Stra | |
| $T_0$: (Control) | 0.06 | 0.06 | 2.55 | 2.29 | 4.84b |
| $T_1$: 140 kg N/ha from PU | 0.08 | 0.07 | 4.56 | 4.76 | 9.33a |
| $T_2$: 104 kg N/ha from USG (2x1.8g/4 hills) | 0.06 | 0.04 | 3.57 | 2.27 | 5.85ab |
| $T_3$: 78 kg N/ha from USG (1x2.7g/4 hills) | 0.08 | 0.08 | 3.41 | 4.65 | 8.07ab |
| $T_4$: 5 t CD+PU on IPNS basis (@140kg N/ha) | 0.06 | 0.07 | 3.30 | 3.18 | 6.49ab |
| $T_5$: 5 t CD+USG (2x1.8g/4 hills) | 0.08 | 0.06 | 4.03 | 3.58 | 7.62ab |
| $T_6$:5 t CD+USG(1x2.7g/4 hills) | *0.05* | 0.07 | 2.90 | 4.15 | 7.06ab |
| *p value* | *0.562* | *0.64* | *0.722* | *0.081* | *0.026* |

Figures in a column having common letters do not differ significantly at 5% level of significance.

**Nitrogen Use Efficiency (NUE)**

Nitrogen use efficiency represents the response of rice plant in terms of grain yield to N fertilizer. Results in figure 1 indicate that application of USG with Cowdung showed the highest value of NUE was obtained in $T_6$ (5t CD+USG@78kg/ha) and the lowest value was found in $T_5$ (5t CD+USG@104kg N/ha). Deep placement of USG significantly improved grain yield, straw yield and nitrogen use efficiency of rice and volatilization loss of ammonia relative to the application of prilled urea. Nitrogen fertilizer use efficiency is relatively low in irrigated rice because of rapid n losses from volatilization and denitrification in soil (De Datta and Burash, 1989). This result indicates that application of USG in combination with Cowdung in rice field decreases the losses of N or the rate of N, leading to efficient uptake and utilization of applied N.

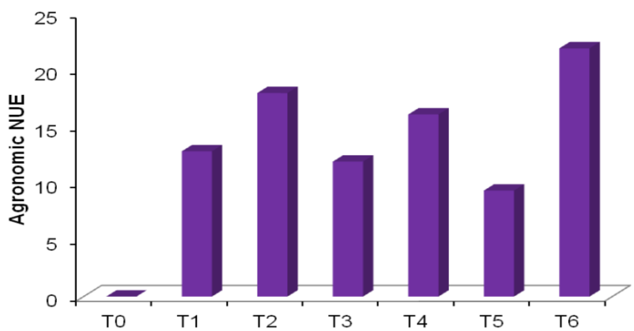


**Figure 1.** Effect of nitrogen supplied from PU, USG, and cow dung on Nitrogen use efficiency (NUE) of BRRI dhan32

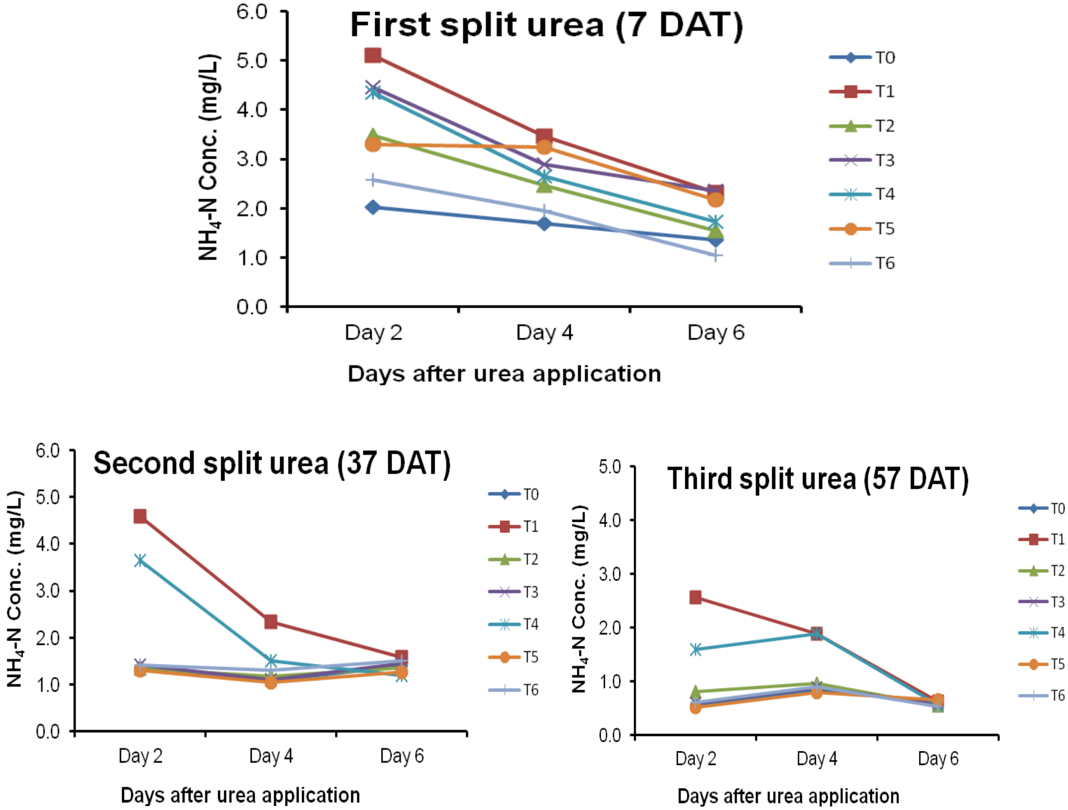


**Figure** 2 Trends of ammonium concentration in BRRI dhan32 rice field porewater after application of pilled urea (7, 37 and 57 DAT)

**Pour water properties of BRRI dhan32 rice field**: Soil porewater was collected using Rhizon samplers (MOM Rhizon, Rhizosphere Research Centre, and the Netherlands) to determine the $NH_4$-N and $NO_3$-N. The porewater collection was done during a specific time of the day (2 pm) at 2, 4, 6 days after split application of PU. Urea was applied in three splits at 7, 37 and 57 DAT and the porewater was collected after the 3 split applications of urea. $NH_4$-N was analyzed in the same day after sampling to get better results for fertilizer trial and water management in combination with fertilizer trial.

**$NH_4$- N dynamics:** In fertilizer trial, $NH_4$-N in rice field porewater was highest at 2 days after urea application (DAUA) and then tended to decease for the prilled urea treated plots. Porewater $NH_4$-N in other plots did not show marked variation between the sampling days. The same trend was observed in the three sampling campaigns at 7, 37 and 57 DAT (Figure 1). In comparison with PU, the USG application specially $T_1$ (140kg N/ha from PU) and $T_4$ (5t CD+PU @140 kg N/ha) generated higher concentration of $NH_4$-N in $4^{th}$ days and then a gradual trend of concentration up to $6^{th}$ days. But in case of $T_2$ (104kg N/ha from USG), $T_5$ (5t CD+USG@104kg

N/ha), $T_6$ (5t CD+USG@78kg/ha) generated available $NH_4$-N slowly rather spontaneously over the time indicating a beneficial role of USG.

**$NO_3$- N dynamics:** In fertilizer trial, $NO_3$-N in rice field porewater showed quite similar trend as we saw for $NH_4$-N. The highest $NO_3$-N was observed at 2 DAUA and then tended to decease for the prilled urea treated plots. The decreasing trend was sharp in $T_4$ (5t CD+PU @140 kg N/ha) compared to $T_6$ (5t CD+USG@78kg/ha) on IPNS basis). Application of Cowdung in combination with prilled urea has potential to maintain a steady supply of $NO_3$ for the rice plant. Porewater $NO_3$-N in other plots did not show marked variation between the sampling days. The trends of $NO_3$-N were quite similar in the 3 sampling campaigns at 7, 37 and 57 DAT (Figure 3). In comparison with PU, the USG alone and in combination with Cowdung generated available $NO_3$-N slowly rather spontaneously over the time indicating a beneficial role of USG.

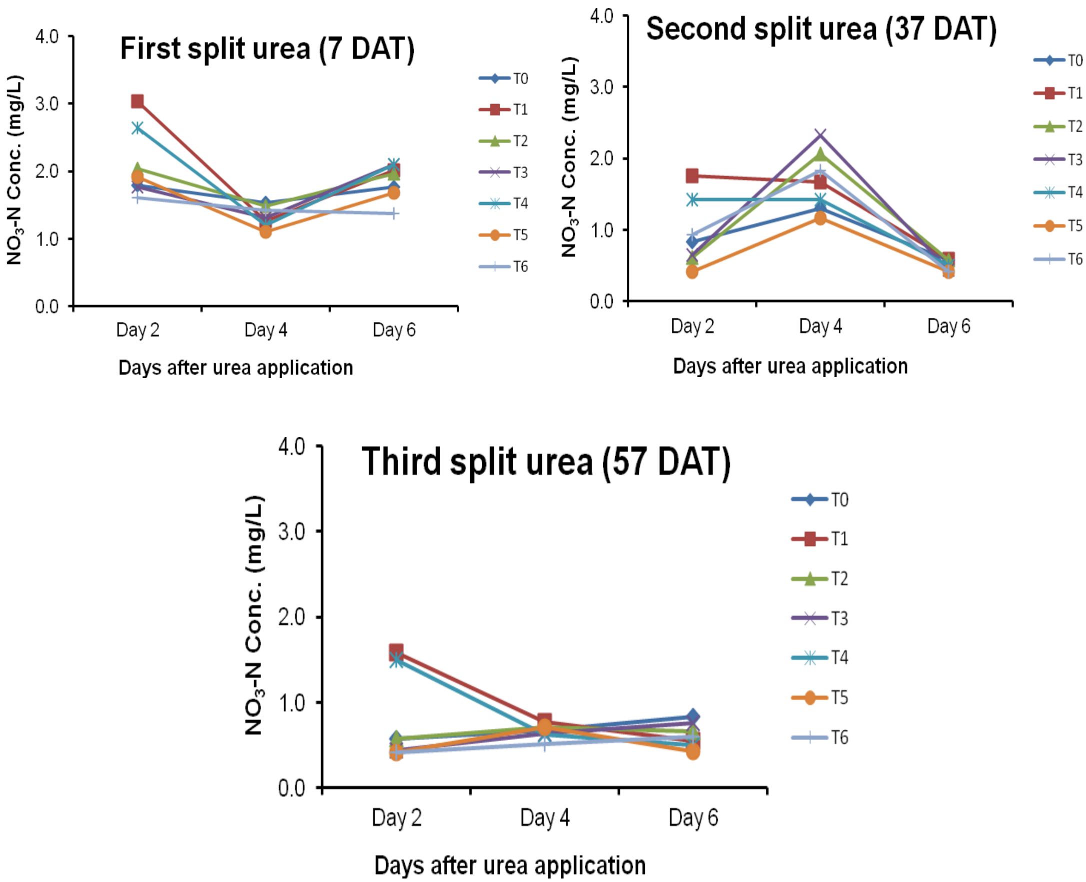


**Figure 3.** Trends of nitrate concentration in BRRI dhan32 rice field porewater after application of pilled urea (7, 37 and 57 DAT)

Considering plant height (109.75 cm), effective tillers/hill (13), panicle length (24.84a), filled grain (124.33) and 1000 grain wt.(23.01ab) dose of 5 t CD+USG (2 x 1.8g/hills on IPNS basis) was best. Again, considering plant height (108.41 cm), effective tillers/hill (12), panicle length (24 ab), filled grain (122.67), unfilled grain (9.00) and 1000 grain wt. (24.37a), grain yield (5.56a), straw yield(5.79ab) and nitrogen uptake(99.45ab) dose of 5 t CD+USG (1x 2.7g/hills on IPNS basis) was best. 5 t CD+PU on IPNS basis @140 kg N/ha increased P and S uptake. 140 kg N/ha from PU increased K uptake (165.83) and at 5t CD+USG (1 x 2.7 g/4 hill) increased K uptake (143.14). Site-specific K management using the fertilizer DSSs can be the better and more efficient K management strategy for maize (Islam et al. 2018). Considering N use efficiency, $NH_4$-N and $NO_3$-N dynamics 5t CD+USG @78 kg/ha was best. Negrin et al. (2011) and XU Zhao et al. (2008) found same result.

## Conclusion

The present study demonstrates that the combined application of urea super granule (USG) with cow dung offers a highly efficient nitrogen management strategy for transplanted Aman rice (cv.BRRI dhan32). Deep placement of USG, particularly when integrated with organic nutrient sources, ensured a steady and prolonged release of plant-available nitrogen, which in turn improved tillering, panicle formation, grain filling, and final productivity. The integrated treatments also enhanced nitrogen uptake and agronomic nitrogen-use efficiency while moderating rapid fluctuations of $NH_4^+$-N and $NO_3^-$-N in soil pore water—an indication of reduced nitrogen losses through volatilization and leaching. Overall, USG applied with cow dung consistently performed better than prilled urea, both in yield advantage and nutrient-use efficiency. Among the evaluated treatments, the combination of cow dung with deep-placed USG at the lower nitrogen rate emerged as the most effective option, showing superior yield performance, greater nitrogen recovery, and more favorable pore water nitrogen dynamics. These findings confirm that integrating organic amendments with deep-placed USG can optimize nitrogen conservation, improve soil nutrient availability, and support sustainable rice production in Bangladesh. The study recommends the USG-cow dung combination as a practical and environmentally sound nitrogen management strategy for BRRI dhan32 under coastal and similar agro-ecological conditions. Further multi-location and multi-season trials are suggested to validate these results across variable soil and climate environments and to refine integrated nitrogen management recommendations for wider adoption.

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