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Imtiaz Miah
Department of Agricultural Chemistry, Sylhet Agricultural University, Sylhet, Bangladesh

Palash Mandal
Department of Agronomy and Haor Agricultural, Sylhet Agricultural University, Sylhet, Bangladesh

Zinat Jahan Chowdhury
Department of Entomology, Sylhet Agricultural University, Sylhet, Bangladesh

Kamrun Nahar Mousomi
Department of Agricultural Chemistry, Sylhet Agricultural University, Sylhet, Bangladesh

Corresponding Author:
Imtiaz Miah
Department of Agricultural Chemistry, Sylhet Agricultural University, Sylhet, Bangladesh

Impacts of different nitrogen forms and doses on agronomic performance of BRRI dhan29

Imtiaz Miah, Palash Mandal, Zinat Jahan Chowdhury and Kamrun Nahar Mousomi

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Abstract
Nitrogen (N) is one of the most important nutrients for rice cultivation and probably the hardest to maintain in soil. This experiment was conducted to investigate the impacts of different N forms and doses as urea on BRRI dhan29 during *boro* season in Meherpur district, Bangladesh. The two most abundant forms of urea namely granular urea (GU) and urea super granule (USG) were selected with five doses (0, 100, 150, 200, and 250 kg ha^{-1}) for each form. The treatments were replicated thrice in Randomized Complete Block Design (RCBD). GU was broadcasted and USG was applied using deep placement method. Other fertilizers *viz.* triple super phosphate, muriate of potash, gypsum, and zinc sulfate were applied at 100, 70, 60, and 5 kg ha^{-1}, respectively. Agronomic parameters were measured by randomly selecting five hills from each plot. Application of N through USG significantly improved almost all agronomic characteristics such as plant height, total and effective tiller hill^{-1}, panicle length, total and filled grains panicle^{-1}, straw and biological yields, grain yield, and harvest index. BRRI dhan29 produced the highest grain and straw yields with the highest dose of USG application (250 kg ha^{-1}). The 1000-seed weight was not significantly affected by N doses or by forms that might be due to its genetically controlled trait and environmental influence during the grain filling stage. Deep placement of USG ensured adequate N supply for a longer period that resulted in enhancement of growth and yield components of BRRI dhan29.

Keywords: BRRI dhan29, granular urea, urea super granule, nitrogen fertilizer

1. Introduction

Rice (*Oryza Sativa* L.) is a staple food for more than two billion people in Asia [1]. Around 82% of the total agricultural land in Bangladesh is occupied with rice production [2]. It creates the employment of 48% of the total labor force of the rural region and contributes to the livelihood of the people of Bangladesh [3]. The estimated per capita rice consumption of this country stretched about 166 kg year^{-1} [4]. The population increasing rate of the country is 1.34% [5]. The population is increasing every year in this country, approximately two million every year and another 30 million will increase in the next 20 years. Besides, due to development and commercial purposes, agricultural lands are decreasing by 1% per annum [6]. It is necessary to increase rice production per unit of the existing land.

Bangladesh Rice Research Institute (BRRI) released quite a few potential high-yielding rice breeds, among them BRRI dhan29 is one of the popular and high-yielding varieties. Nutrient management is one of the most important factors that plays a crucial role to increase yield if all the other production factors are at optimum level. Crop production is successfully done by the proper utilization of chemical fertilizers as it contributes to 50% of the entire crop production of Bangladesh agriculture [7].

Nitrogen (N) is an essential nutrient for plants and plays a major role in increasing rice production. N is less likely to stay in the soil in the long run and thus, farmers have to use high doses of N fertilizers to get the optimum yield of rice. Over 40% of N applied on soil surface gets lost to the atmosphere as ammonia gas [8]. Rice plants need a huge amount of N at the early and mid-tillering stages. A noteworthy surge in tillering with the increase in N volume was reported [9, 10]. Study shows that within the range of 90-250 kg ha^{-1} N application, rice grain is seen the most yielding growth [11-13, 10].

However, an excessive amount of N causes unnecessary vegetative growth which puts the plants vulnerable to insects, pests and decreases the yield, on the other hand, a lower amount of nitrogen also severely reduces rice production [14]. So, applying the optimum dose of nitrogen fertilizer we can save money and meet the desired food demand, thus an ideal mixture of variety and degree of nitrogen is essential for quality and yield.

Urea is the most common and commercially available form of N fertilizer used in Bangladesh. Among the different physical forms of urea, granular (2.82 to 3.06 mm) and prilled urea (~ 1.65 mm) are mostly used. Granular urea (GU) has been reported more efficient than prilled urea (PU) due to its higher mechanical strength [15]. Another form of urea that has been becoming popular for the past few decades is urea super granule (USG). The size of each granule (~11.5mm) is higher than the granular form [16]. Deep placement of USG reduces the rate of N release in soil, thereby makes it more efficient than GU or PU [17-19]. However, deep placement requires training and labor. Thus, many times farmers shy away from using it for low costing and sometimes due to low availability or popularity of technology [16].

Urea broadcasting on surface soil can lead up to 50% of N loss [20], whereas deep placement (8-10cm from surface soil) can save 30% of applied N [21]. To our knowledge, there was no experiment conducted on the agronomic performance of BRRI dhan29 comparing different sources of N fertilizer. Therefore, our present study was aimed to compare the efficiency of GU and USG on the performance and yield of BRRI dhan29.

2. Materials and Methods

2.1 Location and Setup

The study was conducted on the Baradi Seed Production Farm of Bangladesh Agricultural Development Corporation (BADC) in Meherpur district during *boro* season (from January to May) in 2012. The study area belongs to High Ganges River Floodplain (AEZ-11) and soil type is calcareous Dark Grey Floodplain soil. It was a medium high land with 15 m elevation from sea level. The soil was silty loam with an average pH of 6.4. The average temperature was 23.4 °C ranging between 12.4 to 35.2 °C. The average rainfall during the study period was 26.75 mm. A randomized complete block design was used to lay out the plots with three replications. Two forms of N *viz.* GU and USG were used with five doses for each form (0, 100, 150, 200, and 250 kg ha^{-1}). Hence, in total there were nine treatment combinations including one control (0 kg N ha^{-1}) for both forms of urea (T1: control or 0 N, T2: GU_{100}, T3: GU_{150}, T4: GU_{200}, T5: GU_{250}, T6: USG_{100}, T7: USG_{150}, T8: USG_{200}, T9: USG_{250}). BRRI dhan29 was the test crop. Germinated seeds were sown in the seedbed to raise seedlings. The experimental plots were well-prepared by puddling, leveling, removing plant debris and weeds. Each plot size was 10m^2 (4 m × 2.5 m). After 35 days, the seedlings were carefully transplanted to the main field. Triple super phosphate (TSP), muriate of potash (MOP), gypsum, and zinc sulfate were applied at 100, 70, 60, and 5 kg ha^{-1} during final land preparation. GU was applied at 10, 30 and 45 DAT. USG was applied 10 DAT using a deep placement method (8-10 cm from soil surface) in the center of four hills of all rows.

2.2 Management Practices

The experimental plots were irrigated up to a maximum 3 cm of water layer. On average 1-3cm of water was kept until grain filling. Gap filling and weeding was done by removing weeds manually as per requirement. No insecticides and pesticides were applied during the production period.

2.3 Data Collection and Analysis

Five hills from each plot (excluding the hills from the border area) were selected randomly from each plot to measure plant height, number of tillers, and other growth parameters during final harvesting. The plants were harvested after 90% of them attained maturity (*i.e.*, the color of the seeds became golden yellow). Straw and grain yield were measured by harvesting plants from the central 1m×1m plot area.

2.4 Data Analysis

The collected data were tabulated and analyzed by using SPSS software (version 27). Mean separations were done at 5% level of significance by the Least Significant Difference (LSD) test and F values were considered significant at either 1% or 5% level of probability.

3. Results and Discussions

3.1 Plant Height

Plant height significantly influenced by the different doses of N. The highest plant height was found at USG_{200} and lowest was recorded in the control plot. GU_{250} and USG_{200} gave statistically similar results (Table 1). The higher plant height in response to higher doses of N might be resulting from higher assimilate production that caused more dry matter production. Similar findings were also reported by Mandal *et al*. (1992) [22]. Slow release of nitrogen in soil by USG might have resulted in USG_{200} having the highest plant height. Miah *et al*. (2012) [23] also found similar results and attributed it to the slow releasing property of USG.

3.2 Total Tiller Hill^{-1}

Number of tillers hill^{-1} is the most important yield contributing component [21]. The number of total tiller hill^{-1} was also significantly affected by N doses where the highest being USG_{250} and the lowest was in the control (Table 1). Deep placement of USG resulted in not only a slower release of nitrogen, but also a lower loss of nitrogen from the soil. Hence, continuous availability of N gave the plants an advantage to produce more dry matter. Hamidullah *et al*. (2006) [24] also reported similar findings.

Table 1: Yield contributing characters of BRRI dhan29.

Treatment	Plant height (cm)	Total tiller hill^{-1}	Effective tiller hill^{-1}	Panicle length (cm)	Total grains panicle^{-1}	Filled grains panicle^{-1}	1000-seed weight (g)	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index (t ha^{-1})
Control (T1)	80.03±2.8a	11.96±0.4a	9.15±0.1a	21.63±1a	161.76±4a	149.44±3.7a	22.77±0.3	6.09±0.06a	10.24±0.21a	40.53±1.1a
GU_{100} (T2)	83.19±2.2ab	13.30±0.9ab	10.98±0.5b	23.72±0.8b	177.29±3b	163.47±1.8b	23.32±0.4	6.44±0.08b	11.12±0.06b	42.07±0.52ab
GU_{150} (T3)	87.04±1.4bc	15.27±1.2cd	13.20±0.4cd	24.50±0.5bc	182.03±1.4bc	168.40±1.7bc	23.44±0.2	6.65±0.1bc	11.90±0.18c	44.12±0.42cd
GU_{200} (T4)	90.88±0.3cd	17.19±0.4de	14.16±0.4def	24.85±0.2bcd	189.26±2.3cd	174.31±2.6cd	23.71±0.6	6.93±0.09de	12.35±0.11cd	43.89±0.21bcd
GU_{250} (T5)	94.10±0.9d	19.33±0.4ef	15.56±0.5ef	25.73±0.1cd	194.28±1.4de	178.76±2.0de	23.92±0.8	7.23±0.1f	12.77±0.1de	43.39±0.56bcd
USG_{100} (T6)	83.61±0.4ab	14.44±0.5bc	12.07±0.3bc	23.99±0.5bc	190.33±2.6d	175.28±2.9cde	23.48±0.6	6.44±0.09b	11.18±0.16b	42.40±0.42bc
USG_{150}	90.41±0.6cd	17.46±0.5ef	14.04±1.6de	24.44±0.8bc	198.43±2.6ef	183.05±3.1ef	23.76±0.7	6.75±0.08cd	11.98±0.16c	43.67±0.46bcd

(T7)										
USG_{200} (T8)	94.09±0.5d	19.78±0.8g	15.79±0.5ef	25.54±0.2cd	203.63±2f	187.65±1.1f	23.78±0.6	7.08±0.04ef	12.82±0.11e	44.74±0.21d
USG_{250} (T9)	93.98±0.2d	20.84±0.7g	15.84±0.3f	26.48±0.3d	207.82±2.4f	192.47±3.1f	23.94±0.5	7.62±0.1g	13.47±0.22f	43.46±0.51bcd
$LSD_{0.05}$	3.16	1.34	1.82	2.09	15.53	14.03	0.56	0.36	0.89	1.54
F value	**	**	**	**	**	**	NS	**	**	**

3.3 Effective Tiller Hill^{-1}
Effective tillers hill^{-1}also followed the same trend as total tiller hill^{-1} (Table 1). Since effective tillers were counted based on the number of tillers with intact ears, therefore, having the similar results as total tiller hill^{-1} is not surprising. Probably availability and uniformity of N supply in soil by USG supported high cellular growth at panicle development stage and that increased the number of effective tiller hill^{-1}. Results of Masum *et al*. (2010) [25] also support this finding.

3.4 Panicle Length
With high doses of N, panicle length was also increased significantly (Table 1). The highest one (26.48cm) was found in USG_{250} that was statistically similar with USG_{200}, the lowest was in control (21.63cm). During the panicle initiation period, the gradual release of N by USG probably favored higher growth. The findings are similar to that of Hasanuzzaman *et al*. (2009) [26].

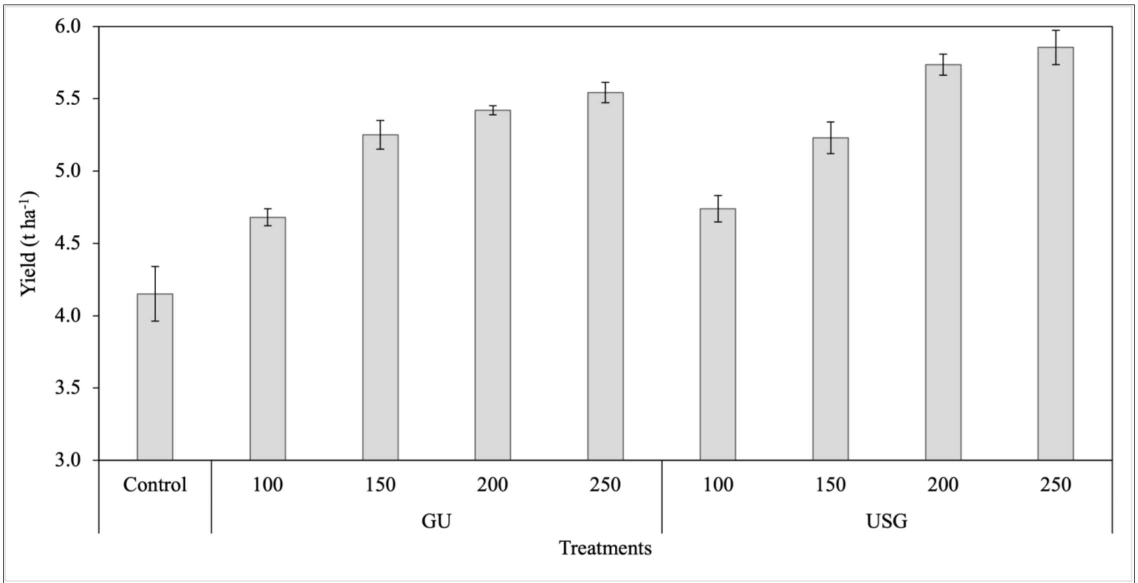

Fig 1: Grain yield of BRRI dhan29.

3.5 Total Grains Panicle^{-1}
The number of total grains panicle^{-1} significantly increased with N application (Table 1). The highest number of grains (207.82) was recorded in USG_{250} which is statistically similar with USG_{200}, and the lowest was found in control (161.76). Adequate and consistent supply of N during the fruiting stage thereby increased partitioning of dry matter probably caused more grain production. The findings are at par with the results of Chamely *et al*. (2015) [14].

3.6 Filled Grains Panicle^{-1}
Higher doses of N application significantly increased filled grains panicle^{-1}. Highest number of grains (192.47) was found in USG_{250} which was statistically similar with USG_{200} (187.65), whereas the lowest was in control (149.44). N availability at flowering stage, followed by seed formation stage might have increased the number of filled grains. These findings are in alignment with that of Kumar *et al*. (1995) [27].

3.7 1000-Seed Weight
Application of N fertilizer did not significantly increase the weight of 1000 seeds (Table 1). The highest 1000-seed weight was observed in USG_{250} (23.94g) and the lowest in control (22.77g), however, those were statistically on par with each other. Since 1000-grain weight is a genetic trait that is highly affected by the environmental condition during the grain filling stage, that might have resulted in not being influenced by N supply [28, 29].

3.8 Straw Yield
Higher straw yields were recorded with increased N supply (Table 1). Highest straw yield was produced by the highest dose used in this experiment (USG_{250}) and the lowest one in control (0 kg N ha^{-1}). N increases the plant vegetative growth. Hence, increased physiological activities probably caused increased straw yield. The results agreed with that of a researcher Miah *et al*. (2012) [23] who found the highest straw yield with USG application.

3.9 Grain Yield
Different N doses varied the grain yield significantly. The highest grain yield was found at USG_{250} that was statistically similar with the second highest N application (USG_{200}), and the lowest in control. Deep placement of USG in soil produced the highest number of total and effective tillers hill^{-1}, panicle length, total and filled grains panicle^{-1} that ultimately resulted in higher grain yield. It also aligned with the close relationship between the most important growth parameters and yield. Similar findings were reported by Hasanuzzaman *et al*. (2009) [26].

4. Conclusion

Almost all the yield components such as panicle length, total number of tillers and effective tillers hill^{-1}, number of total grains and filled grains panicle^{-1} were significantly increased by higher doses of USG. Consequently, grain yield and straw yield were also found higher for increased N supply by USG. The only exception was 1000-grain weight which might be due to its linkage to genetic traits and environmental conditions during the grain filling stage. This experiment reemphasized using an efficient form of N to increase rice yield. Till now, GU is the most popular and available form of N in Bangladesh. Just by switching to a similar alternative can significantly affect the cost-benefit ratio of rice cultivation.

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