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Effects of PU, USG and NPK briquette on nitrogen use efficiency and yield of BR22 rice under reduced water condition

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Abstract

An experiment was conducted at the Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh during the aman season of 2012 to investigate the effects of prilled urea (PU), urea super granule (USG) and NPK briquette on NH_4- N concentration in field water, yield and nitrogen (N) use efficiency (NUE) of BR22 rice under reduced water conditions. The experiment was laid out in a randomized complete block design with three replications. There were altogether eight treatment combinations viz. T_1: Control (No N fertilizer), T_2: 52 kg N ha^{-1} from USG, T_3: 104 kg N ha^{-1} from USG, T_4: 78 kg N ha^{-1} from PU, T_5: 120 kg N ha^{-1} from PU, T_6: 51 kg N ha^{-1} from NPK briquette, T_7: 78 kg N ha^{-1} from USG and T_8: 78 kg N ha^{-1} from NPK briquette. Water samples were collected from rice field for seven consecutive days after deep placement of USG and the first split application of PU and the samples were analyzed for NH_4-N. The Highest concentration of NH_4-N in water was observed at the second day of PU application followed by gradual decrease with time. The yield contributing characters like plant height, panicle length, number of effective tillers $hill^{-1}$ and grains $panicle^{-1}$ were significantly influenced by different treatments. The highest grain yield of 3.93 t ha^{-1} was recorded from 104 kg N ha^{-1} as USG (T3) and the lowest value of 2.12 t ha^{-1} was obtained from control. The N use efficiency was increased when the N was applied as USG. The overall results revealed that application of USG and NPK briquette may be practised for obtaining better yields in addition to increasing the efficiency of N fertilizer.

Keywords: Prilled urea, Urea super granule, NPK briquette, BR22 rice, Nitrogen use efficiency

Introduction

Rice is one of the most important cereals in the world. It is the staple food for more than half of the world's population and grows in more than 100 countries. Rice is the staple food for the people of Bangladesh which is intrinsically associated with their culture, rites and rituals. Among the leading rice growing countries of the world, Bangladesh ranks the fourth both in area and production (BRRI, 2007). Rice is grown in three distinct seasons namely aus, aman and boro. BR22 is a modern variety suitable for cultivation in aman season which produces higher yield than many other varieties. Nitrogen (N) is one of the essential plant nutrients which can augment the production of rice to a great extent. Application of urea-N plays a vital role in vegetative growth, development of yield components and yield of rice (BRRI, 1990). Farmers of Bangladesh use mainly urea as the most available source of nitrogen. Generally, urea is applied as conventional broadcast method. But, the efficiency of applied N from urea fertilizer is very low (30-35 %) in rice cultivation. The low utilization efficiency is attributed to losses like volatilization, denitrification, leaching and surface run-off. These losses can be reduced by management practices like proper timing, rate and modified forms of urea and deep placement of N fertilizers. Deep placement of fertilizers (USG and NPK briquette) into the anaerobic soil zone is an effective method to reduce volatilization loss (Mikkelsen *et al*., 1978). Deep placement of USG at 8-10 cm depth of soil can save 30% N compared to PU, increases absorption rate, improves soil health and ultimately increases rice yield (Savant *et al.*, 1991). Moreover, deep placement method of fertilizer application is environment-friendly and will not decrease the normal fertility of land (BRRI, 2010). However, information regarding a comparative performance of PU, USG and NPK briquette as the sources of N for rice cultivation and the availability of NH_4-N in rice field water in Bangladesh are limited. Therefore, the present study was undertaken to evaluate the effect of PU, USG and NPK briquette on N use efficiency and yield of BR22 rice under reduced water condition.

Materials and Methods

The study was carried out at the Soil Science Field laboratory of Bangladesh Agricultural University, Mymensingh during the aman season of 2012. The soil of the experimental site belongs to the Sonatala series under the AEZ of Old Brahmaputra Floodplain. The soil was silt loam in texture having pH 6.07, organic matter content 1.10%, total N 0.055%, available P 3.8 ppm, exchangeable K 0.24 me% and available S 12.56 ppm. There were eight treatments as follows:

T_1 : Control (No N fertilizer)
T_2 : 52 kg N ha^{-1} from USG
T_3 : 104 kg N ha^{-1} from USG
T_4 : 78 kg N ha^{-1} from PU
T_5 : 120 kg N ha^{-1} from PU
T_6 : 51 kg N ha^{-1} from NPK briquette
T_7 : 78 kg N ha^{-1} from USG
T_8 : 78 kg N ha^{-1} from NPK briquette

The experiment was laid out in a Randomized Complete Block Deign (RCBD) with three replications. The total number of unit plots was 24 and the size of unit plot was 6 m × 4 m. All the treatments except T_6 and T_8 received 16 kg P and 42 kg K ha^{-1} from TSP and MoP, respectively. About 35 day-old rice seedlings of BR22 were transplanted in the experimental plots on September 8, 2012 by maintaining a spacing of 20 cm × 20 cm. The USG and NPK briquette were collected from IFDC, Bangladesh and PU urea was obtained from the local market of Mymensingh. The USG, NPK briquette and first split of PU were applied after 10 days of transplanting. The second and third splits of PU were applied after 32 and 52 days of transplanting, respectively. After draining out water properly from the plots, PU was applied to the plots followed by mixing with the soils. The USG and NPK briquettes were placed at 8-10 cm depth between four hills at alternate rows. Different intercultural operations such as irrigation, weeding, pest control, etc. were done as and when required.

During sampling, water depth was always maintained at 6 cm and for this reason time to time irrigation was done. The field was supposed to irrigate after 3-5 days of depletion of water from the field in order to maintain reduced water condition (alternate wetting and drying condition), although, it was not always feasible practically due to frequent rains. Water samples were collected immediately after application of PU for determining NH_4-N concentration. The concentration of NH_4-N was determined by Phenol-hypochlorite method (Solorzano, 1969).The crop was harvested at full maturity and the data on plant height, panicle length, effective tillers $hill^{-1}$, grains $panicle^{-1}$, 1000-grain weight, grain and straw yields were recorded. The grain and straw yields were expressed at 14% moisture basis. The grain and straw samples were analyzed for N content following semi-micro Kjeldahl method (Bremner and Mulvaney, 1982). The N uptake by grain and straw was determined from N content and yield data. The N use efficiency (kg grain yield increase kg^{-1} N applied) was determined by the following formula: NUE = (Gy_{+N} - Gy_{ON})/ FN, where Gy_{+N} = grain yield in treatment with N application; Gy_{ON} = grain yield in treatment without N application and FN = amount of fertilizer N applied (kg ha^{-1}). All the data were statistically analyzed by F-test and the mean differences were ranked by DMRT at 5% level (Gomez and Gomez, 1984).

Results and Discussion

Ammonium concentration in rice field water

The results on NH_4-N concentration of BR22 rice field water demonstrate that the PU treated plots (T_4 and T_5) had much higher concentration of NH_4-N compared to the plots treated with USG (T_2, T_3 and T_7) and NPK briquette (T_6 and T_8) as shown in Fig. 1. The treatment T_5 (120 kg N ha^{-1} from PU) showed the highest NH_4-N concentration followed by the treatment T_4 (78 kg N ha^{-1} from PU). For both treatments T_4 and T_5, the highest concentration of NH_4-N was observed at the second day and this concentration decreased with time. Within six days, the NH_4^+ concentration in all the treatments became almost similar.

The USG (T_2, T_3 and T_7) and NPK briquette treated plots (T_6 and T_8) had much lower concentration of NH_4-N in water indicating that deep placement of urea fertilizer can reduce N loss by NH_3 volatilization. Deep placement of N reduces NH_4-N in water. This not only improves fertilizer N use efficiency of rice but also minimizes N loss resulting from ammonia volatilization and denitrification (Savent and Stangel, 1990; Mohanty *et al.* 1999). This finding is also accorded with Xiang *et al.* (2013).

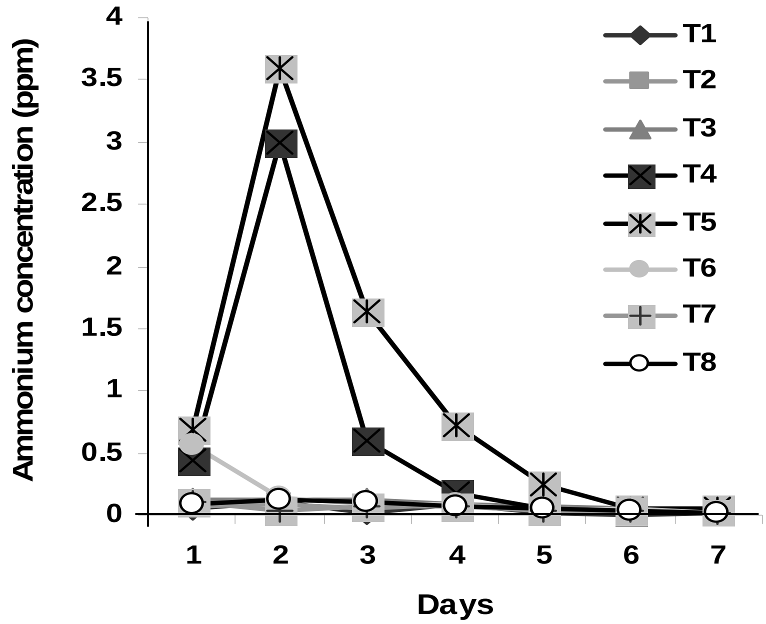

Fig.1 Effects of PU, USG and NPK briquette on NH_4-N concentration of water samples

Yield components of BR22

Yield attributes such as plant height, panicle length, effective tillers hill^{-1} and number of grains panicle^{-1} were significantly influenced by the application of PU, USG and NPK briquette (Table 1). The 1000-grain weight remained unaffected by the treatments under study. The tallest plant of 102.7 cm was found in T_6 (51 kg N ha^{-1} from NPK briquette), which was identical with treatment T_2 (52 kg N ha^{-1} from USG), T_3 (104 kg N ha^{-1} from USG), T_7 (78 kg N ha^{-1} from USG) and T_8 (78 kg N ha^{-1} from NPK briquette). The shortest plant of 85.0 cm was observed in T_1 (control).The panicle length varied from 20.67 cm to 25.1 cm due to different treatments. The highest panicle length (25.1 cm) was found in T_6 which was identical with T_2, T_3, T_7 and T_8 and the lowest panicle length (20.67 cm) was observed in T_1. The highest number of effective tillers hill^{-1} of 13.33 was found in T_3 and the lowest value of 8.33 was observed in T_1. The number of grains panicle^{-1} varied from 72.67 to 124.7 with the highest value in T_6 [USG, two-1.8g briquettes ($N_{104}P_{25}K_{64}$)] which was identical with all other treatments except T_1 and T_8. The lowest number of grains panicle^{-1} (72.67) was found in control. The USG and NPK briquette treated plots performed better than that of PU treated plots. Islam *et al.* (2011), Kabir *et al.* (2009) and Miah and Masum (2004) also observed increased plant height and panicle length, as well as higher number of effective tillers hill^{-1} and grains panicle^{-1} in rice due to application of USG.

Grain and straw yields of BR22

Application of PU, USG and NPK briquette showed a positive effect on yield of BR22 rice (Fig. 2). The highest grain yield of 3.93 t ha^{-1} was recorded from T_3 (104 kg N ha^{-1} from USG) which was statistically similar to T_5 (120 kg N ha^{-1} from PU), T_7 (78 kg N ha^{-1} from USG) and T_8 (78 kg N from NPK briquette) but significantly superior to all other treatments. The lowest value of 2.12 t ha^{-1} was recorded from T_1 (control).This might be due to optimum release of N from deep placed fertilizers (USG and NPK briquette) for a prolonged period. Hasanuzzaman *et al.* (2012) reported that grain yield was significantly increased due to deep placement of USG. These results were also in agreement with the findings of Kabir *et al.* (2009) and Islam *et al.* (2011). In this study, both NPK briquette (T_8 and T_6) and USG (T_2, T_3 and T_7) showed statistically similar grain yield which support the findings of BRRI (2010). On the other hand, the straw yield of BR22 rice was also influenced significantly due to the application of USG, NPK briquette and PU. The straw yield obtained from different treatments ranged from 2.41 to 5.56 t ha^{-1}. The highest straw yield of 5.56 t ha^{-1} was recorded from T_3 (104 kg N ha^{-1} from USG) and the lowest value of 2.12 t ha^{-1} was recorded from T_1 (control Jena *et al*. (2003) reported that the deep placement of USG significantly increased the straw yields of rice.

Table 1. Effects of PU, USG and NPK briquette on the yield components of BR22 rice

Treatments	Plant height (cm)	Panicle length (cm)	Effective tillers hill^{-1} (No.)	Grains panicle^{-1} (No.)	1000-grain weight (g)
T_1 (Control)	85.00c	20.67c	8.33d	72.67c	26
T_2 (52 kg N ha^{-1} from USG)	101.0a	24.0ab	11.33abc	120.0a	26.33
T_3 (104 kg N ha^{-1} from USG)	102.0a	25.0a	13.33a	123.7a	28.33
T_4 (78 kg N ha^{-1} from PU)	94.67b	23.0b	11.30abc	114.3ab	27.33
T_5 (120 kg N ha^{-1} from PU)	95.33b	22.67b	11.67abc	110.7ab	27
T_6 (51 kg N ha^{-1} from NPK briquette)	102.7a	25.1a	11.00bc	124.7a	27.67
T_7 (78 kg N ha^{-1} from USG)	101.01a	23.33ab	12.33ab	110.0ab	26.67
T_8 (78 kg N ha^{-1} from NPK briquette)	98.67ab	23.67ab	10.00cd	103.0b	28
CV (%)	2.92	4.05	10.27	7.36	3.65
SE (±)	1.64	0.547	0.66	4.66	0.29

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CV = Coefficient of variation; SE = Standard error of means

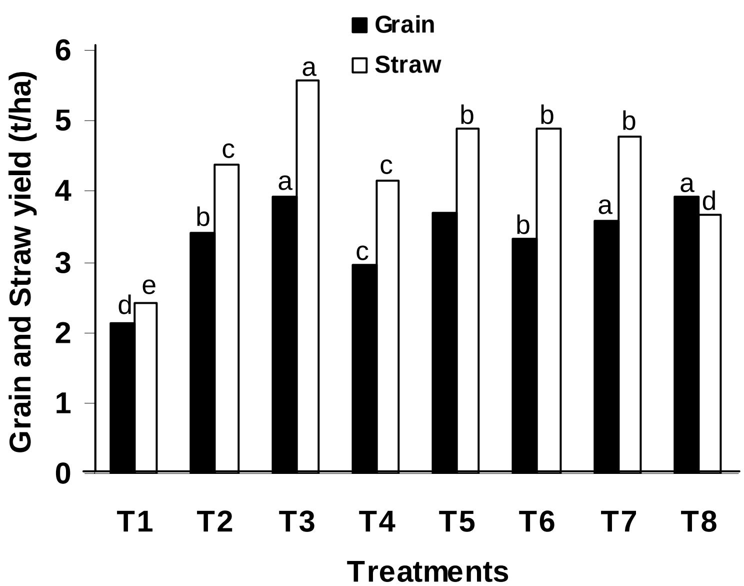

Fig. 2. Effects of PU, USG and NPK briquette on grain and straw yields of BR22 rice

Nitrogen content and uptake

The nitrogen content and uptake by grain and straw of BR22 rice increased significantly due to application of PU, USG and NPK briquette (Table 2). The highest N content and uptake by grain and straw were obtained from T_3 (120 kg N ha^{-1} from PU) and the lowest N content and uptake from T_1 (control). The N content in grain and straw varied from 1.07-1.21% and 0.54-0.69%, respectively. Again, the N uptake by grain and straw varied from 22.68-47.55 kg ha^{-1} and 13.01-38.36 kg ha^{-1}, respectively. For rice grain and straw, higher N content and uptake due to application of nitrogenous fertilizers like USG and PU were reported by Wang (2004).

Table 2. Effects of PU, USG and NPK briquette on N content and uptake of BR22 rice

Treatments	N content (%)		N uptake (kg ha^{-1})	
	Grain	Straw	Grain	Straw
T_1 (Control)	1.07c	0.54c	22.68f	13.0e
T_2 (52 kg N ha^{-1} from USG)	1.18ab	0.64ab	44.99abc	31.87 c
T_3 (104 kg N ha^{-1} from USG	1.2a	0.69a	47.55a	38.36a
T_4 (78 kg N ha^{-1} from PU)	1.16ab	0.65ab	34.34e	27.04d
T_5 (120 kg N ha^{-1} from PU)	1.14b	0.64ab	41.15d	31.23c
T_6 (51 kg N ha^{-1} from NPK briquette)	1.20ab	0.67ab	46.92ab	34.57b
T_7 (78 kg N ha^{-1} from USG)	1.17ab	0.62b	43.88c	31.31c
T_8 (78 kg N ha^{-1} from NPK briquette)	1.16ab	0.66ab	44.3bc	33.59b
CV (%)	2.84	4.94	3.51	3.13
SE (%)	0.019	0.018	0.825	0.54

The figure(s) having common letter(s) in a column do not differ significantly at 5% level of significance.
CV = Coefficient of variation; SE = Standard error of means

Nitrogen use efficiency (NUE) of rice

The nitrogen use efficiency of BR22 rice as influenced by different treatments is shown in Fig. 3. The highest value of NUE was recorded in T_6 (51 kg N ha^{-1} from NPK briquette) and the lowest value in T_4 (78 kg N ha^{-1} from PU). The values for NUE in BR22 rice due to various treatments ranged from 10.77 to 35.09 kg grain increase per kg N applied. The second highest value of NUE was recorded in T_2 (52 kg N ha^{-1} from USG). From these results, it is clear that NUE was always higher in case of NPK briquette and USG as compared to PU. Higher NUE of rice due to deep placement of N fertilizer was also reported by Wang (2004), Jena *et al.* (2003) and Dash *et al.* (2003).

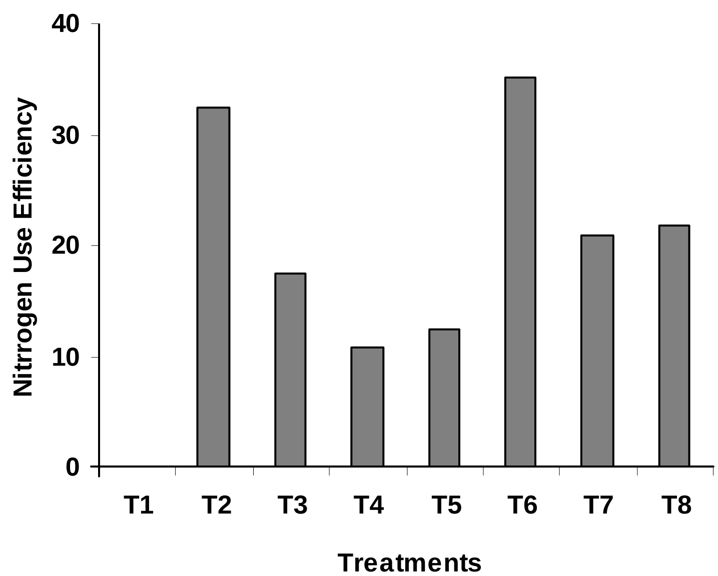

Fig. 3. Effect of PU, USG and NPK briquette on nitrogen use efficiency (kg grain yield increase per kg N applied) of BR22 rice

Conclusion

In our study, the deep placement of N fertilizers (USG and NPK briquette) showed better performance with respect to yield and NUE of BR22 rice compared to broadcast application of PU. From overall results, it can be concluded that the treatment T2 (52 kg N from USG) can be considered as the better treatment for efficient use of N fertilizer and better yield of rice.

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