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EFFICIENT USE OF NITROGEN IN WETLAND RICE CULTIVATION

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ABSTRACT

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A field experiment was conducted at the Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh during *boro season* of 2012 to evaluate the effects of prilled urea (PU), urea super granule (USG) alone or in combination with poultry manure (PM) on N use efficiency (NUE) and yield performance of rice (BRRI dhan29). The experiment was laid out in a randomized complete block design with three replications. There were eight treatments namely, T_1: Control (no N fertilizer); T_2: 104 kg N ha^{-1} from USG; T_3: 104 kg N ha^{-1} from PU; T_4: 52 kg N ha^{-1} from USG; T_5: 52 kg N ha^{-1} from USG + 52 kg N ha^{-1} from PU; T_6: PM 4 t ha^{-1}; T_7: 52 kg N ha^{-1} from USG + 2 t ha^{-1} PM and T_8: 52 kg N ha^{-1} from PU + 2 t ha^{-1} PM. The recommended doses of P, K, S and Zn fertilizers were applied to all the experimental plots during final land preparation. USG was deep placed at 8-10 cm below the soil surface at 7 days after transplanting and PU was applied in different splits. Application of N as PU, USG alone or in combination with PM resulted in a significant increase in yield components, grain and straw yields of BRRI dhan29. The treatment T_5 (52 kg N ha^{-1} from USG + 52 kg N ha^{-1} from PU) produced the highest grain (5.82 t ha^{-1}) and straw (7.28 t ha^{-1}) yields. The lowest grain (2.78 t ha^{-1}) and straw (3.26 t ha^{-1}) yields were recorded in control plots. The treatment T_7 (52 kg N ha^{-1} USG + 2 t ha^{-1} PM) attained the superior position in NUE and apparent N recovery (ANR) by BRRI dhan29. The overall results indicate that application of USG in combination with PM could be considered more effective in rice production in aspect of increased rice yields and efficiency of applied N.

***Key words**: prilled urea, urea super granule, poultry manure, yield and N use efficiency*

INTRODUCTION

Agriculture is the most important sector of Bangladesh's economy and it contributes to gross domestic product to about 20% (BBS 2009). The cropping systems of Bangladesh are mainly rice based. Rice (*Oryza sativa* L.) is the most important food crop in the world. Geographical as well as climatic conditions of Bangladesh are favorable for year round rice cultivation. Unfortunately, yield is low compared to other rice growing countries like Japan and China where the average yield is 7.12 and 6.73 t ha^{-1}, respectively (FAO 2012).

Nitrogen (N) is one of the major essential plant nutrients which can contribute to the increment of rice production to a greater extent and urea fertilizer is widely used as a source of N. Farmers of Bangladesh apply urea in rice field mainly on the soil surface. As urea is a highly water-soluble and quick release fertilizer, its application to the soil surface may result in a significant loss in various ways such as leaching, surface run off, NH_4^+ volatilization, thus reducing its efficiency. It has been reported that the efficiency of urea nitrogen in wetland rice is only about 35% of the applied urea and even less in many cases (IFDC 2007). However, low efficient use of nitrogen fertilizer is one of the main causes of low production of rice.

Deep placement of USG in rice field can increase the efficiency of applied nitrogen by improving absorption to a certain extent. There are evidences that USG performs better than PU in aspect of yield and NUE in rice (Ahmed *et al*. 2002; Jena *et al*. 2003; IFDC 2007) It has been shown that placement of USG in the root zone is the most effective method for increasing nitrogen use efficiency and rice yield (Pandey and Tiwary, 1996).

Again soil organic matter plays an important role in maintaining soil fertility and productivity. The problem of nutrient deficiencies as well as nutrient mining caused by intensive cropping with HYV of rice and nutrient imbalance can be minimized by judicious application of nutrients through organic manures. Poultry manure (PM) is one of the most promising manures in Bangladesh. Chemical fertilizers are always expensive inputs for crop production, especially in developing countries like Bangladesh. Application of PM along with chemical fertilizers like PU or USG could contribute to the sustainable crop production. Moreover, PM could minimize the requirement of nitrogenous fertilizers, allowing small farmers to save a part of the cost of production. In this study, we investigated the effects of PU, USG and PM on rice yield, nutrient uptake and NUE.

MATERIALS AND METHODS

Location and soils

The field experiment was conducted at Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh. The soil belongs to the Sonatala series under the Agro Ecological Zone 9 (Old Brahmaputra Floodplain). The soil was silt loam in texture having soil pH 6.7, organic carbon 0.93%, total N 0.121%, available phosphorus 10.91 ppm, exchangeable K 0.141 me/100 g soil, available sulphur 13.20 ppm.

Experimental design and treatments

The experiment was laid out in a randomized complete block design with three replications. There were eight treatment combinations *viz*; T_1: Control (no N fertilizer); T_2: 104 kg N ha^{-1} from USG; T_3: 104 kg N ha^{-1} from PU; T_4: 52 kg N ha^{-1} from USG; T_5: 52 kg N ha^{-1} from USG + 52 kg N ha^{-1} from PU; T_6: PM 4 t ha^{-1}; T_7: 52 kg N ha^{-1} from USG + 2 t ha^{-1} PM and T_8: 52 kg N ha^{-1} from PU + 2 t ha^{-1} PM.

Application of fertilizers and manure

The recommended doses of P, K, S and Zn fertilizers were 104 kg ha^{-1}, 25 kg ha^{-1}, 80 kg ha^{-1}, 15 kg ha^{-1}, and 1 kg ha^{-1}, respectively. All the fertilizers except N were applied in all the plots as a basal dose during final land preparation. PU was applied in three splits. The first split of PU was applied at 7 days after transplanting (DAT); the second and the third splits were applied as top dressing at 35 DAT (active tillering stage) and 55 DAT (panicle initiation stage). Urea super granule (USG) was deep placed at 7 DAT at 8-10 cm depth. One USG of 1.8g size was employed for every four hills. The granules were deep placed in puddled soil by hand and leveled immediately after placement. Well decomposed PM was added in the plots as per treatment at 7 days before transplanting of rice seedlings. PM was mixed thoroughly with the soil at the time of final land preparation. The N, P, K and S contents in PM were 1.18, 1.13, 0.81 and 0.35% respectively.

Crop variety and transplanting of seedlings

BRRI dhan29, a high yielding variety of rice, was used as the test crop in this experiment. Seedlings of 45 days were transplanted in the experimental plots on 31 January 2012, maintaining 20cm x 20cm spacing. Three healthy seedlings were transplanted in each hill of the experimental plots. The unit plot size was 4m x 2m.

Intercultural operations

Irrigation water was applied to the crop field during transplantation and as when necessary. The crop was infested with some common weeds, which were controlled by uprooting thrice from experimental plots by hand. The crop was infested with rice hispa which was controlled by spraying Diazinoin 60 EC.

Harvesting

The crop was harvested at maturity (May 10, 2012). Five hills from each plot (except the border hills) were selected randomly at mature stage for recording plant height, number of effective tillers $hill^{-1}$, panicle length, number of filled grains $panicle^{-1}$ and 1000 grain weight. The grain and straw yields were recorded plot wise and expressed as kg ha^{-1}. The grain yield was obtained on 14% moisture basis while the straw yield was recorded on sun dry basis.

Chemical analysis of plant samples

The grain and straw samples were analyzed for nitrogen concentration by semi-micro Kjeldahl method (Bremner and Mulvaney, 1982). The nitrogen uptake was calculated from the N concentration and yield data. The N use efficiency (kg grain yield increase kg^{-1} N applied) and apparent N recovery were determined by the following formulae: 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}) and ANR (kg ha^{-1}) = $(UN_{+N}-UN_{0N})$/FN Where, UN_{+N} is total N uptake (kg ha^{-1}) with grain and straw; UN_{0N} is the N uptake (kg ha^{-1}) in control; FN is amount of fertilizer N applied (kg ha^{-1}).

Statistical analysis

Data were statistically analyzed by F-test and the mean differences were adjusted by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Growth and yield components

Growth and yield contributing characters such as plant height, panicle length, effective tillers $hill^{-1}$ and number of grains $panicle^{-1}$ were significantly influenced by application of PU and USG alone or in combination with PM (Table 1). The 1000-grain weight remained unaffected by the treatments under study.

Table 1. Effect of PU, USG and PM on various plant characteristics of BRRI dhan29

Treatments	Plant height (cm)	Effective tillers $hill^{-1}$ (no.)	Panicle length (cm)	Filled grains $panicle^{-1}$ (no.)	1000-grain wt. (g)
T_1	69.10d	8.33c	20.03c	85.00d	21.13
T_2	91.10a	13.33ab	22.22ab	121.10ab	22.43
T_3	80.30bc	11.33abc	21.13ab	100.00cd	21.86
T_4	83.90b	10.33bc	22.10ab	96.50cd	21.29
T_5	88.83a	14.67a	22.50a	125.22a	22.75
T_6	71.30d	9.00c	20.63bc	85.80d	21.19
T_7	84.24b	12.67ab	22.72a	105.70bc	22.16
T_8	79.70c	10.67bc	21.60ab	96.50cd	22.01
SE ±	1.49	0.50	0.23	3.09	0.18
CV (%)	2.83	4.40	3.08	4.03	0.84

In a column, the figure(s) having same letter(s) do not differ significantly at 5% level of probability by DMRT

The tallest plant of 91.1 cm was found in T_2 (104 kg N ha^{-1} from USG) which was identical to T_5 (52 kg N ha^{-1} from USG + 52 kg N ha^{-1} from PU) with the value of 88.83 cm. The shortest plant of 69.1cm was observed in T_1 (control). Combined application of USG and PU (T_5 treatment) produced the maximum tillers (14.67). On the other hand, the minimum tillers (8.33) were recorded in the control. The highest panicle length (22.72 cm) was found in T_7 (52 kg N ha^{-1} from USG + PM 2 t ha^{-1}) and the lowest panicle length (20.03cm) was observed in T_1. The number of filled grains $panicle^{-1}$ varied from 85.00 to 125.22. The highest value was found in T_5 (52 kg N ha^{-1} from USG + 52 kg N ha^{-1} from PU) which was identical with the treatment T_2 (104 kg N ha^{-1} from USG) and lowest value was found in the control. The highest 1000-grain weight of 22.75g was found in T_5 (52 kg N ha^{-1} from USG + 52 kg N ha^{-1} from PU) and lowest value was found in the control. Mizan (2010) reported that the highest plant height of rice was obtained from 160 kg N ha^{-1} followed by 120 kg N ha^{-1}. These results are in agreement with Kabir *et al.* (2009) and Islam *et al.* (2012) who also reported that combined application of PU, USG and poultry manure significantly increased the yield contributing characters.

Grain and straw yields

Application of PU, USG and PM showed a significant increase in grain and straw yields of BRRI dhan29. The grain yield ranged from 2.78 to 5.82 t ha^{-1} (Table 2). The highest grain yield of 5.82 t ha^{-1} was recorded in T_5 (52 kg N ha^{-1} from USG + 52 kg N ha^{-1} from PU) which was identical with the treatment T_2 (104 kg N ha^{-1} from USG), T_3 (104 kg N ha^{-1} from PU) and T_7 (52 kg N ha^{-1} from USG + 2 t ha^{-1} PM). On the other hand, the lowest (2.78 t ha^{-1}) yield was recorded in the treatment T_1. The increase in grain yield over control ranged from 4.46 to 52.23% where the highest increase was observed in the treatment T_5 and the lowest value (4.46) in T_6 (PM 4 t ha^{-1}). Khan *et al.* (2007) reported that grain yield was significantly increased due to application of organic manure and chemical fertilizers. This might be due to the spontaneous release of nutrients from PM and USG which increases the grain yield to some extent. These results are also in agreement with the findings of Rahman *et al.* (2007) and Parvez *et al.* (2008). Azam *et al.* (2012) also conducted a field experiment with rice and obtained highest grain yield (5.41 t ha^{-1}) from USG treated plots and lowest grain yield from control. Combined application of PU and USG (T_2 treatment) showed the highest (7.28 t ha^{-1}) straw yield whereas the lowest (3.26 t ha^{-1}) straw yield was observed in control. Rahman *et al.* (2009) reported that the application of urea-N in combination with cowdung and poultry manure increased the straw yields of rice.

Table 2. Effect of PU, USG and PM on grain and straw yields of BRRI dhan29

Treatments	Grain yield (t ha^{-1})	% increase over control	Straw yield (t ha^{-1})	% increase over control
T_1	2.78c	-	3.26f	-
T_2	5.64a	50.71	7.28a	55.22
T_3	5.43a	48.80	6.51b	49.92
T_4	4.44b	37.38	5.90c	44.74
T_5	5.82a	52.23	7.07ab	53.88
T_6	2.91c	4.46	3.90e	16.41
T_7	5.48a	49.27	6.47bc	49.61
T_8	4.69b	40.72	5.17d	36.94
S.E (±)	0.23	-	0.28	-
CV (%)	4.86	-	4.85	-

In a column, the figure(s) having same letter(s) do not differ significantly at 5% level of probability by DMRT

N content and uptake by rice

The N content in rice grain and straw was significantly influenced due to the application of PU and USG alone or in combination with PM (Table 3). The grain N content varied from 0.89% to 1.19%. The highest N content of 1.19% was observed in treatment T_5 and the lowest N content of 0.89% was noted in the treatment T_1. The straw N content varied from 0.50% to 0.70% and the highest value was observed in T_5. The lowest value was observed in control.

Table 3. Effect of PU, USG and PM on nitrogen content and uptake by BRRI dhan29

Treatments	N Content (%)		N Uptake (kg ha^{-1})			ANR (%)	NUE
	Grain	Straw	Grain	Straw	Total		
T_1	0.89g	0.50e	24.58e	16.28e	40.86d	-	-
T_2	1.17b	0.68b	65.98a	49.64a	115.62a	71.88	27.5
T_3	1.11c	0.67b	60.39b	43.35b	103.74b	60.46	25.5
T_4	0.91f	0.51e	40.58d	29.85d	70.42c	56.85	31.9
T_5	1.19a	0.70a	69.26a	49.80a	119.06a	75.20	29.2
T_6	0.90fg	0.51e	26.66e	19.87e	46.53d	23.63	5.41
T_7	1.09d	0.61c	59.95b	39.20c	99.15b	91.07	42.2
T_8	0.97e	0.54d	45.75c	27.65d	73.40c	50.84	29.8
SE ±	0.02	0.02	3.22	2.42	5.59	-	-
CV (%)	2.25	4.97	6.56	6.59	4.49	-	-

In a column, the figure(s) having same letter(s) do not differ significantly at 5% level of probability by DMRT

The N uptake by rice increased significantly due to application of PU, USG and PM alone or in combination. The total N uptake ranged from 40.86 to 119.06 kg ha^{-1}. The highest N uptake by grain (69.26 kg ha^{-1}) and straw (49.8 kg ha^{-1}) was obtained in USG in combination with PM while the lowest N uptake by grain (24.58 kg ha^{-1}) and straw (6.28 kg ha^{-1}) was found in control (Table 3). Naher *et al.* (2011) conducted an experiment on rice and reported that application of USG increased N use efficiency compared to PU.

Apparent N recovery and nitrogen use efficiency

The apparent N recovery indicates the absorption efficiency of applied N. Mean apparent recovery of N by rice ranged from 23.63% to 91.06%. The highest value of apparent N recovery was obtained in T_7 (52 kg N ha^{-1} from USG + 2 t ha^{-1} PM) and the lowest value was found in T_6 (4 t ha^{-1} PM). Again, NUE represents the response of rice plant in terms of grain yield to N fertilizer. The NUE as influenced by different treatments is shown in Table 3. The range of NUE varied from 5.41 to 42.2. The highest value of NUE was obtained in T_7 (52 kg N ha^{-1} from USG + 2 t ha^{-1} PM) and the lowest value was found in T_6 (4 t ha^{-1} PM).

From these results, it is clear that combined application of USG with PM showed better performances in respect of ANR and NUE. This might be due to the continuous supply of nitrogen from USG and PM throughout the growth period of crop. These results are also in agreement with Jahan *et al.* (2014) who found that combined application of USG with PM showed better performances in respect of ANR and NUE.

CONCLUSIOIN

It can be concluded that application of USG at 7 DAT and PU in splits showed superior performances in respect of grain and straw yields of rice whereas application of USG along with PM showed a higher ANR and NUE. Therefore, the application of PU or USG along with manure at different growth stages might be recommended for profitable rice cultivation in wetland condition. Further studies are needed to confirm these findings.

REFERENCES

Ahmed MH, Islam MA, Kader MA, Anwar MP (2002) Evaluation of urea super granules as source of nitrogen in transplant aman rice. *Pakistan Journal of Biological Sciences* 3, 735-737.

Azam TM, Ali HM, Karim FM, Rahman A, Jalal JM, Mamun MFA (2012) Growth and yield of boro rice as affected by different urea fertilizer application methods. *International Journal of Sustainable Agriculture* 4(3), 45-51.

BBS (Bangladesh Bureau of Statistics) (2009) Statistical Year Book of Bangladesh. Dhaka. pp. 131-132.

Bremner JM, Mulvaney CS (1982) Nitrogen- total, In Methods of Soil Analysis Part 2, Page AL, Miller RH, Keeney DR (Editors): American Society of Agronomy, Inc, Publisher, Madison, Wisconsin USA. pp. 595-624.

FAO (Food and Agriculture Organization) (2012) Rice Conference proceedings, RGA, USDA FAS.

Gomez KA, Gomez AA (1984) Statistical Procedures for Agricultural Research. John Wilely and Sons. New York.

IFDC (International Fertilizer Development Centre) (2007) Mitigating poverty and environmental degradation through nutrient management in south Asia. IFDC Report (March 2007).

Islam MS, Sarkar MAR, Uddin S, Parvin S (2012) Yield of Fine Rice Varieties as Influenced by Integrated Management of Poultry Manure Urea Super Granules and Prilled Urea. *Journal of Environmental Science and Natural Resources* 5(1), 129 -132.

Jahan N, Islam MR, Siddique AB, Islam MR, Hasan MM, Shamsuzzaman SM, Samsuri AW (2014) Effects of integrated use of prilled urea, urea super granule and poultry manure on yield of transplant aus rice and field water quality. *Life Science Journal* 11(8), 101-108.

Jena D, Mishra C, Bandyopadhyay KK (2003) Effect of prilled urea and urea supergranule on dynamics of ammonia volatilization and nitrogen use efficiency of rice. *Journal of Indian Society of Soil Science* 51, 257-261.

Kabir MH, Sarkar MAR, Chowdhury AKMSH (2009) Effect of urea super granules, prilled urea and poultry manure on the yield of transplant Aman rice varieties. *Journal of Bangladesh Agricultural University* 7(2), 259-263.

Khan MU, Qasim M, Khan IU (2007) Effect of integrated nutrient management on crop yields in rice-wheat cropping system. *Sarhad Journal of Agriculture*. 23(4), 1019-1025.

Mizan R (2010) Effect of nitrogen and plant spacing on the yield of boro rice cv. BRRI dhan45. MS Thesis, Department of Agronomy, Bangladesh Agricultural University, Mymensingh.

Naher AU, Saleque AM, Panhwar AQ, Radziah O, Jusop S (2011) Techniques of efficient fertilizer management for wetland rice- a review. *Australian Journal of Crop Science* 5(12), 1661-1669.

Pandey A, Tiwari KL (1996) Effect of prilled urea, modified urea and coated urea on transplanted rice. Advances in Agricultural Research in India 5, 83-85.

Parvez MS, Islam MR, Begum MS, Rahman MS, Miah MJA (2008) Integrated use of manure and fertilizers for maximizing the yield of BRRI dhan30. *Journal of Bangladesh Society of Agricultural Science and Technology* 5(1&2), 257-260.

Rahman MS, Islam MR, Naser HM, Hoque MM, Hossain A (2007) Effects of combined use of manures and fertilizers on the yield and nutrient uptake by BRRI dhan30, ISSN 1811-6221, *Journal of Bangladesh Society of Agricultural Science and Technology* 4(3&4), 37-40.

Rahman MS, Islam MR, Rahman MM, Hossain MI (2009) Effect of cowdung, Poultry manure and Urea-N on the yield and nutrient uptake of BBRI dhan29. *Bangladesh Research Publication Journal* 2(2), 552-558.