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Evaluation of placement methods for urea supergranules in wetland rice (*Oryza sativa*) soil

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ABSTRACT

A field experiment was carried out in a lowland soil, having fine loamy mixed hyperthermic Epiaquept, during winter season of 1994–95 and 1995–96 to evaluate the method of urea supergranule (USG) placement in wetland rice (*Oryza sativa* L.). The experimental plan was randomized block design with 3 replications. The USG was applied @ 76 kg N/ha either as surface broadcast or as deep placement at soil depths of 2.5, 5 or 7.5 cm by manual or mechanical means along with prilled urea (PU) split. Placement of USG significantly increased both the grain and straw yields of rice in comparison to PU or USG broadcast. The response of rice to nitrogen was more under USG placement than split application of PU. Nitrogen-use efficiency of rice was increased from 18 kg grain/kg N applied as PU to as high as 26 kg grain/kg N applied as USG. Similarly, the relative efficiency of USG was increased by 40% over PU. The apparent recovery of N in rice was also increased from 21% in case of PU to 40% for USG.

Key words : USG applicator, Urea split application, Nitrogen-use efficiency; Relative efficiency, Apparent nitrogen recovery

Application of prilled urea (PU) for rice at times becomes difficult under wetland condition, for which its nitrogen-use efficiency (NUE) is greatly reduced. The efficiency of applied N could be increased through modifying the size, time and method of application of PU. Kumar *et al.* (1996) examined various methods of urea application and reported that placement of urea supergranule (USG) through applicator resulted in 6% more grain yield than broadcasting of prilled urea (2:1:1) in sandy-loam soil of Tamil Nadu. However, the efficiency of USG applicator on various soils has not yet been tested widely and the present investigation was carried out to test the efficiency of USG applicator (Swain *et al.*, 1992) in a fine-textured soil.

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MATERIALS AND METHODS

A field experiment was carried out at the central farm of OUAT, Bhubaneshwar (20°N, 85°E, and 100 m) during winter season of 1994–95 and 1995–96 with transplanted rice ('Lalat') as test crop. The mean monthly temperature and mean open pan evaporation varied from 21°C and 3 mm in December to 31°C and 7.5 mm in April respectively during these 2 years. The total rainfall was 117.5 mm in the year 1994–95 and 12.2 mm in 1995–96 during the crop growth. The soil of the experimental plot was fine loamy mixed hyperthermic Epiaquept. The surface soil had pH 5.0, organic carbon 6.6 g/kg and electrical conductivity 0.05 dS/m. The experiment was laid out in randomized block design with 7 methods of N application. During 1994–95 application of PU/USG was done as per the following treatment: T_1, surface broadcast of PU (1:2:1) @ 76 kg N/ha; T_2; surface broadcast of USG at transplanting @ 76 kg/ha, T3-Manual placement of USG at 2.5 cm soil depth @ 76 kg N/ha at 7 days after transplanting (DAT); T_3, USG point placed @ 76 kg N/ha at a soil depth of 2.5 cm; T_4, manual placement of USG at 5 cm soil depth @76 kg N/ha at 7 DAT; T_5, mechanical placement of USG at 5 cm soil depth @ 38 kg N/ha at 7 DAT; T_6, mechanical placement of USG at 7.5 cm soil depth @ 38 kg N/ha at 7 DAT; T_7, manual placement of USG at 5 cm soil depth @ 38 kg N/ha at 7 DAT. During 1995–96, in addition to the above 4 treatments (T_1 to T_4), the 3 treatments that were replaced in the pre–existing plan were: T_5, mechanical placement of USG at 5 cm soil depth @ 76 kg N/ha at 7 DAT;

Table 1. Grain and straw yields of rice as affected by different methods of USG placement

Treatment	Grain yield (q/ha)		Straw yield (q/ha)	
	1994–95	1995–96	1994–95	1995–96
T_1, PU surface broadcast	57.72	50.99	48.14	55.08
T_2, USG surface broadcast	53.92	54.03	43.92	61.12
T_3, USG manual placement at 2.5 cm soil depth	64.26	57.05	57.26	67.53
T_4, USG manual placement at 5 cm soil depth	61.98	59.78	57.31	69.59
T_5, USG mechanical placement at 5 cm soil depth	48.53	56.43	40.27	63.79
T_6, USG mechanical placement at 2.5/7.5 cm soil depth	51.55	56.57	40.69	66.19
T_7, Control**	53.93	37.23	43.06	41.33
CD (P = 0.05)	6.61	5.01	6.22	7.15
CV (P = 0.05)	6.12	5.30	6.75	6.58

** In 1994-95, manual placement of USG @ 38 kg N/ha and in 1995-96 no N was applied.

T_6, mechanical placement of USG at 2.5 cm soil depth @ 76 kg N/ha at 7 DAT; T_7, control (no N). The PU was broadcast in proportion of 1:2:1 at the time of transplanting, maximum tillering and panicle-initiation stage. A common dose of single superphosphate and muriate of potash was applied @ 50 kg P_2O_5 and 50 kg K_2O/ha to each of the treatment plot at the time of puddling. The treatments were replicated thrice. The grain and straw yields of rice were recorded at harvest.

These samples were also used to determine the N content (AOAC, 1970), so as to calculate the N-use efficiency (NUE), relative efficiency (RE) and apparent nitrogen recovery (ANR) for various methods of N fertilizer application.

RESULTS AND DISCUSSION

Grain and straw yield

In 1994–95, grain yield (Table 1) was minimum when USG was applied @ 38 kg N/ha with the mechanical applicator at 5 cm soil depth and increased to a maximum (T_3) when USG was manually point placed @ 76 kg N/ha at a soil depth of 2.5 cm. Application of N either as PU or USG at high dose (76 kg N/ha) resulted in more yield than its application at lower dose (38 kg N/ha). Further, the increase in grain yield of rice was significant when USG was manually placed at soil depth of 2.5 cm (T_3) and the grain yield was at par (T_4) when the placement depth was lowered to 5 cm soil. Thus, placement of USG at lower dose (38 kg N/ha) by applicator had no beneficial effect on grain yield of rice. This finding is contradictory to the previous findings of Mitra *et al.* (1989), who stated that the N dose in case of USG placement could be reduced to half as compared to application in form of PU. During 1995–96, the grain yield varied from 37.23 q/ha without N to a maximum value of 59.78 q/ha when USG was point placed manually @ 76 kg N/ha at a soil depth of 5 cm. The grain yield was 50.99 q/ha when PU was broadcast in splits @76 kg N/ha. Obviously, application of PU or USG significantly increased the grain yield of rice in comparison to no N application. Compared to PU, the surface application of USG resulted non-significant increase in yield (54 q/ha). Further, compared with various methods of USG placement, application of USG either by manual or by mechanical placement at soil depth of 2.5 cm or 5 cm significantly increased the rice yield in comparison to PU application. This shows that the placement of USG at reduced zone was a better method for N application than surface broadcast. The rice yields were found at par when USG was applied mechanically or manually at soil depth of either 2.5 cm or 5 cm. The yield differences between the manual and mechanical placement (Table 1) were not found to be significant, although the grain yield of rice by mechanical placement was slightly lower than that obtained by manual placement.

During 1994–95, straw yields varied from a minimum value of 40.27 q/ha (T_5) with application of USG @ 38 kg N/ha by mechanical applicator to a maximum value of 57.3 q/ha (T_4) in case of manual placement of USG @ 76 kg N/ha (Table 1) . In the subsequent year, i.e. 1995–96, the straw yields varied from 41.33 q/ha (T_7)

with no N application to as high as 69.59 q/ha, (T_4) due to manual placement of USG (Table 1). As compared with grain yields, the straw yields were recorded low in 1994–95 and high in 1995–96. The apparent deviation might have been due to climatic effect. The cloudy weather during 1995–96 resulted low grain formation for which straw yields were more than grain yield and even more than the straw yields of the previous year. During 1994–95, like that of grain yields, the straw yields in case of PU split (T_1) or USG surface broadcast (T_2) @ 76 kg N/ha was at par with manual or mechanical placement of USG @ 38 kg N/ha (T_5, T_6 and T_7). However, the straw yield was significantly increased when USG was manually placed @ 76 kg N/ha (T_4 and T_5). Thus, the placement of USG at high dose (76 kg N/ha) was found to be a suitable method in increasing both the grain and the straw yields of rice in the first year of the experiment. During the second year, application of N fertilizer (PU or USG) increased significantly not only the grain yield but also the straw yield as compared to no-N application. However, the increase in straw yield was significantly more for USG than for PU application. This shows that application of USG at high dose either by manual placement or mechanical placement significantly increased both the grain and straw yields of rice as compared to PU application.

Yield-attributing characters

During 1995–96, plant height was the shortest when no N fertilizer (T_7) was applied (Table 2). But, there was a significant increase in plant height due to application of USG. The plant was the tallest when USG fertilizer was placed manually at soil depth of 2.5 cm (T_3), the treatment resulting the maximum grain and straw yields (Table 1). Thus, the crop was benefited due to its tallness resulting from USG application in waterlogged condition. The panicle was the shortest when no N was applied and the longest when USG was applied mechanically at 5 cm depth (Table 2). Although there was a slight increase in panicle length due to N application, the

Table 2. Methods of nitrogen fertilizer application on yield-attributing characters of rice

Treatment	Plant height (cm)		Panicle length (cm)		No. of tillers	
	1994–95	1995–96	1994–95	1995–96	1994–95	1995–96
T_1	86.2	81.3	22.3	22.4	13.9	12.6
T_2	83.9	83.1	22.2	22.3	14.1	14.0
T_3	89.9	89.6	22.4	23.5	14.5	12.3
T_4	90.5	85.7	22.8	22.6	15.5	14.2
T_5	78.9	82.4	21.8	24.4	13.5	12.8
T_6	82.1	84.6	21.9	22.2	14.5	14.2
T_7	84.1	79.1	22.3	22.0	14.6	9.5
CD (P = 0.05)	4.9	4.14	NS	NS	NS	NS

Details of treatments are given in Table 1

Table 3. Methods of nitrogen fertilizer application on nitrogen uptake by rice during 1995–96

Treatment	Total N uptake (kg/ha)	kg N uptake/q grain
T_1	70.64	1.52
T_2	77.97	1.59
T_3	83.68	1.61
T_4	85.77	1.58
T_5	102.45	1.99
T_6	80.06	1.56
T_7	54.50	1.61

Detail of treatments are given in Table 1

Table 4. Efficiency of rice to applied nitrogen during 1995–96 as affected by different methods of USG placement

Treatment	(NUE)**	(% RE)	(ANR%)
T_1	18.10	100	21.24
T_2	22.19	122.11	30.88
T_3	26.07	144.15	38.39
T_4	26.47	146.33	41.14
T_5	25.44	140.65	63.09
T_6	25.25	139.56	33.63

Details of treatments are given in Table 1.
**NUE in kg grain/kg nitrogen fertilizer

difference in the increase of panicle length was not significant. Thus, the method of USG application had little influence in increasing the panicle length. Further, effective tillers/plant increased from 10 with no N (T_7) to 17 with N fertilizers (Table 2). But, the increase in tillers was not found significant among the treatments. Thus, application of USG appeared to have little influence on increasing the grain and straw yields resulting from beneficial effects of panicle length and tillering.

Nitrogen uptake

The N uptake varied from 54.50 kg/ha and 1.61 kg N/q grain in no N (T_7) to 102.45 kg/ha and 1.99 kg N/q grain with N application @ 76 kg N/ha by mechanical means (T_5) (Table 3). Obviously, the application of N either as urea or USG increased the N uptake. Further, the N uptake was increased more due to mechanical application of USG than that observed in the case of PU broadcast or manual placement of USG. This shows that mechanical placement of USG appeared to increase the quality of rice in terms of nitrogen uptake.

Nitrogen-use efficiency

The agronomic efficiency of N was increased from 18.10 kg grain/kg N applied in the case of PU to 22.19 kg grain/kg N applied in the case of USG surface broadcast (Table 4). These values were found slightly more than that reported by Martinez (1983), corroborate with his findings that USG happened to produce more yield than PU when applied at equivalent N dose. The efficiency of USG was further increased from 25.3 kg grain/kg N applied in the case of mechanical placement to 26.3 kg grain/kg N in the case of manual placement of USG. Thus, placement of USG at reduced zone either by mechanical or manual means resulted in more yield than surface broadcast of PU or USG. In comparison to PU, the efficiency of USG in increasing the rice yield was increased, being about 22% over PU when

Table 5. Economic evaluation for different methods of nitrogen fertilizer application

Parameter	PU broadcasting 1 : 2 : 1	USG broadcasting (basal)	Manual placement of USG	Mechanical placement by 2-row USG applicator
Man–hr requirement/ha(for fertilizer application)	24	24	120	15
Cost (Rs) of labour	90	90	450	60
Cost (Rs) of fertilizer	561	619	619	619
Total cost (Rs) for fertilizer application	651	709	1,069	679
Grain yield (q/ha)	51	54	58	56.5
Cost (Rs) of produce (@ Rs 360/q)	18,360	19,440	20,880	20,340
Net return (Rs/ha) over fertilizer application	17,709	18,731	19,811	19,661
Extra return (Rs/ha) compared with PU application		1,022	2,102	1,952

the USG was surface applied and was about 40 to 46% over PU when USG was applied manually or by the mechanical placement at various soil depths. Thus, the relative efficiency of USG when placed on surface soil was more than PU. It was also observed that the apparent N recovery from applied N was 21.24% in case of PU and increased to as high as 63% in the case of USG placement due to N uptake in the latter case. This result also corroborates the finding of Craswell *et al.* (1981), that deep placement of urea supergranules recovers more of applied N than the prilled urea. The apparent nitrogen recovery varied from 31 to 63% under various methods of urea supergranules placement. The maximum recovery of applied N was obtained when urea supergranules was manually placed at soil depth of 2.5 cm. The apparent reason for high recovery of applied N is yet to be found out, since the N analysis of grain and straw samples are based on unreplicated samplings.

While the net return for rice cultivation due to urea supergranules application was more than that due to the prilled urea, deep placement of urea supergranules doubled the net return as compared to its application by broadcast method (Table 5). Although manual placement of urea supergranules resulted a marginally higher return (only Rs 150 than its placement by mechanical means, considering the availability of labour, mechanical placement of urea supergranules could be an alternate method for increasing the rice yield.

Thus placement of urea supergranules at reduced zone gave more rice yield, resulting from longer plant height and more N uptake than prilled urea broadcast. Considering the availability of labour, deep

placement of urea supergranules @ 76 kg N/ha by urea supergranules applicator could be an alternate method for increasing the rice yield in waterlogged condition.

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