Indian J. Agron. **41** (4) : 586—590 (December 1996)

Efficiency of slow-release nitrogen fertilizers in rice (*Oryza sativa*) on partially reclaimed sodic Vertisols

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Received: July 1993

ABSTRACT

A field experiment was conducted during the rainy season (*kharif*) of 1988 and 1989 on a partially reclaimed sodic clay soil (Vertisol) to assess the relative efficiency of urea-G (phosphogypsum urea-36.8% N), [neemcake-coated urea (NCU) 34.5% N], ammonium sulphate (20.6% N) and urea (46.% N) at 4 levels (40, 80, 120 and 160 kg/ha) applied in 3 splits. Urea-G and NCU increased the grain yield significantly over urea and ammonium sulphate. The urea-G recorded highest yields (45.0 and 43.9 q/ha), followed by NCU (43.1 and 41.3 q/ha) in 1988 and 1989 respectively. The grain yield increased significantly with the increasing level of N, being the highest at 160 kg N/ha. The soil NH_4^+-N content at 22, 33 and 56 days after transplanting (DAT) was low in urea-G and NCU-treated plots than that observed under ammonium sulphate and urea. However, at 70 DAT, the NH_4^+-N content was higher in urea-G and NCU-treated plots than in ammonium sulphate and urea. The soil NO_3^--N content was higher under urea-G and NCU at latter stages. The soil NH_4^+-N and NO_3^--N contents increased with the increasing levels of N at all the stages of growth.

Rice (*Oryza sativa* L.) is an important crop on sodic Vertisols and the heavy feeder of nitrogen. At present major portion of N-fertilizer is applied in the form of urea which can be lost by NH_3-volatilization, leaching and denitrification in the soil. When urea is applied to the soil, rapid enzymatic hydrolysis takes place and ammonia so released tends to volatilize into the atmosphere. This is one of the serious problems in sodic soils due to high pH value and the presence of exchangeable sodium.

The present study was undertaken to assess the relative efficiency of slow-release phosphogypsum urea and neem-coated urea against the traditional N-fertilizers in transplanted rice on a partially reclaimed sodic clay soil.

MATERIALS AND METHODS

A field experiment was conducted in randomized block design with 4 replications during the rainy season (*kharif*) of 1988 and 1989 at the Soil Salinity Research Station, Barwaha (Madhya Pradesh) in Vertisols (sodic phase). The soil had pH 8.75 and 8.60, ECe 1.29 and 1.53 dS/m and exchangeable sodium (ESP) 22.00 and 22.05% in the 2 seasons. The soil belongs to fine smectitic, hyperthermic family of Typic Chromusterts (48.2%) and with $CaCO_3$ 7.5%. The treatments consisted of 4 levels of N (40, 80, 120 and 160 kg/ha) and 4 sources, viz. ammonium sulphate, urea, urea-G (phosphogypsum urea 36.8% N) and neemcake-coated urea (NCU, 34.5% N) applied in 3 splits (half at transplanting +

Table 1. Effect of sources and levels of nitrogen on the grain yield (kg/ha) of rice on sodic Vertisols

N (kg/ha)	N source											
	Ammonium sulphate			Urea			Urea-G			NCU		
	1988	1989	Mean	1988	1989	Mean	1988	1989	Mean	1988	1989	Mean
40	2,682	2,537	2,610	2,986	3,098	3,042	3,434	3,072	3,253	3,139	2,577	2,858
80	3,419	3,258	3,339	3,802	3,232	3,517	3,861	3,766	3,814	3,772	3,459	3,616
120	4,170	4,247	4,209	4,200	4,474	4,337	4,863	5,101	4,982	4,709	4,955	4,832
160	4,863	5.088	4,976	4,819	5,115	4,967	5,365	5,609	5,487	5,615	5,529	5,572
	3,784	3,782		3,952	3,980		4,506	4,387		4,307	4,130	

	1988		*1989*	
	SEm ±	*CD (P = 0.05)*	*SEm* ±	*CD (P = 0.05)*
N levels	112.0	321.0	109	303
N sources	112.0	321.0	109	303
In x S interaction	223.0	NS	219	606

one-fouth at tillering + one-fourth at booting stages). Three seedlings (25 days old) of 'CSR 4' rice were transplanted at 15 cm x 15 cm spacing in puddled soil condition. The plots were kept flooded with 5 cm water throughout the growing period. Soil sample (0–15 cm) were drawn with the help of post-hole auger from each plot in one of the replications before transplanting and subsequently 22, 33, 56, 70 days after transplanting (DAT) and at harvest and were analysed for NH_4^+-N by Nessler's method using 10% NaCl solution of pH 2.5 as extractant and NO_3^--N, colorimetrically with phenoldisulphonic acid.

RESULTS AND DISCUSSION

Urea-G and NCU resulted in significantly higher grain yield than ammonium sulphate and urea in both the years. The highest grain yield was recorded under urea-G-treated plots in 1989, followed by NCU, whereas in 1988 the NCU was found superior to urea-G. The lowest yield was obtained under ammonium sulphate at each level of application in both the years. This can be attributed to the retarted rate of nitrification and maintenance of NH_4^+–N availability for longer period which the rice is capable of absorbing in this form, resulted in higher yields. Similar findings were also reported by Sharma and Prasad (1980). The grain yield of rice increased significantly with increasing levels of N from 40 to 160 kg/ha. This is due to beneficial effect on growth and biomass production. The results confirms the findings of Awasthe and Mishra (1987).

The interaction between sources and levels of nitrogen was non-significant in 1988, while it was significant in 1989. The yields increased with increasing levels of N in each of the sources, but the magnitude was much higher in urea-G and NCU. The yield obtained at 120 kg N/ha with urea-G was almost equal to that obtained at 160 kg N/ha through ammonium sulphate and Urea. It could be corroborated with the observations of Awasthe and Mishra (1987).

The soil NH_4^+–N was highest under urea followed by ammonium sulphate, NCU and Urea-G, respectively at 22, 33 and 56 days after transplanting (DAT), however, the soil NH_4^+–N increased considerably under urea-G and NCU at 70 DAT (Table 2). At harvest the NH_4^+–N status of soil was almost equal under all 4 sources. The results confirm the findings of Mishra *et al.* (1990). The NH_4^+–N content of the soil increased with the increasing levels of N at each of the

Table 2 Effect of sources and levels of nitrogen on NH^+_4-N status (kg/ha) in soidc clay sol under rice

N source	Sampling time (DAT)	N (kg/ha) 40	80	120	160	Mean
Ammonium sulphate		4.85	4.90	4.95	4.70	4.85
Urea	0	4.75	4.80	4.74	4.65	4.74
Urea-G		4.65	4.85	4.62	4.90	4.75
NCU		4.75	4.65	4.73	4.90	4.76
Mean		4.75	4.80	4.76	4.79	
Ammonium sulphate		23.75	41.85	52.85	66.22	46.17
Urea	22	28.38	47.30	56.76	70.95	50.85
Urea-G		18.92	28.38	37.84	56.70	35.48
NCU		23.65	37.84	52.03	61.49	46.75
Mean		23.68	38.84	49.87	63.85	
Ammonium sulphate		18.92	37.84	42.57	61.49	40.21
Urea	33	23.70	41.80	52.00	66.20	46.93
Urea-G		14.19	23.75	33.15	47.65	29.69
NCU		18.92	28.30	37.84	52.03	34.27
Mean		18.93	32.92	41.39	56.84	
Ammonium sulphate		23.70	41.84	52.50	66.32	46.09
Urea	56	28.50	47.53	56.84	71.00	50.97
Urea-G		19.00	28.56	38.00	57.00	38.64
NCU		24.00	38.00	52.05	62.00	44.01
Mean		23.80	38.98	49.85	64.08	
Ammonium sulphate		18.90	38.00	47.00	61.40	41.38
Urea	70	23.75	42.00	56.80	71.00	38.94
Urea-G		24.20	38.56	43.10	68.00	43.48
NCU		34.00	38.30	47.84	62.00	43.54
Mean		25.21	39.22	48.70	65.60	
Ammonium sulphate		14.20	28.38	37.84	52.03	33.11
Urea	Harvest	18.90	33.16	42.00	56.80	37.72
Urea-G		19.50	28.90	43.16	52.00	35.89
NCU		24.20	34.00	38.30	52.00	37.13
Mean		19.20	31.11	38.33	53.21	

NCU, Neem-coated urea

sampling periods.

The NO_3^-–N of the soil showed that the status remained almost the same under all the sources at different sampling periods (Table 3). The content increased with the increasing levels of at all the stages of

Table 3. Effect of sources and levels of nitrogen on NO_3^-–N status (kg/ha) in sodic clay soil under rice

N source	Sampling time (DAT)	N (kg/ha)				
		40	80	120	160	Mean
Ammonium sulphate		5.10	2.62	2.64	2.70	3.27
Urea	0	5.10	5.00	5.16	4.86	5.03
Urea-G		4.92	4.90	2.75	2.64	3.80
NCU		2.65	2.70	4.94	4.90	3.80
Mean		6.65	3.81	3.87	3.77	
Ammonium sulphate		5.10	5.10	5.25	4.89	5.06
Urea	22	2.68	2.70	4.92	2.92	3.31
Urea-G		4.90	5.19	2.91	2.56	3.89
NCU		4.88	2.56	2.70	5.00	3.80
Mean		4.39	3.89	3.96	3.84	
Ammonium sulphate				2.56	2.62	2.59
Urea	33			2.85	2.66	2.75
Urea-G				2.80	2.72	
NCU				4.92	4.99	4.95
Mean				3.28	3.25	
Ammonium sulphate					2.58	2.58
Urea	56				2.80	2.80
Urea-G				2.50	2.80	2.65
NCU				2.62	2.92	2.17
Mean				2.56	2.78	
Ammonium sulphate		2.56	2.48	2.60	4.90	3.14
Urea	70	2.68	2.56	4.72	4.92	3.73
Urea-G		2.80	2.75	2.92	5.00	3.87
NCU		2.48	2.52	4.82	5.00	3.71
Mean		2.63	2.59	4.27	4.96	
Ammonium sulphate		2.62	4.70	4.82	5.10	4.31
Urea	Harvest	2.70	5.16	5.18	5.00	4.51
Urea-G		2.58	2.65	7.75	7.80	5.00
NCU		2.62	2.75	7.68	7.80	5.21
Mean		2.63	3.82	6.35	6.43	

growth. The amount of NO_3^-–N was much less than that of NH_4^+–N as would be expected in transplanted rice fields. The NO_3^-–N status at 33 and 56 DAT was lower than earlier or later stages, as there would have been greater uptake during the grand growth phase. The uptake of N during later stages might have depressed due to restricted available N in soil under ammonium sulphate and urea, susceptible to volatilization, resulting in declined productivity whereas the prolonged utilization through slow-release fertilizers, maintained the N supply throughout the growing period and hence the productivity was higher under urea-G and NCU. This is in conformity with number of workers that NCU reduces the hydrolysis of urea, leading to lower down the NH_4^+–N concentration in soil at early stages and its gradual increase at later period. Same is the case with urea-G (phosphogypsum urea).

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