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Urea-nitrogen, yield and nutrient-use efficiency in lowland rice (*Oryza sativa*) as affected by band placement of urea solution

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ABSTRACT

A field experiment was conducted during 2 seasons (1992–93) with 'IR 50' and 'ADT 36' rice (*Oryza sativa* L.) to evaluate the band placement of urea solution in comparison with the conventional fertilizer application, neem-coated urea (NCU) application and point placement of urea supergranules. Higher NH^+_4-N and lower NO^-_3-N content in the soil was observed with band placement of urea solution in both 'IR 50' and 'ADT 36'. Higher NH^+_4–N content was observed, 1 day after fertilizer application and it subsequently decreased. Band placement of one-third urea solution N at 15 days after transplanting, two-thirds N at 35 days after transplanting at 50 and 100 kg N/ha excerted a significant positive influence on the yield parameters, yield of rice, agronomic efficiency and recovery of N.

The efficiency of fertilizer N in lowland rice cultivation in the tropics is low (Yoshida, 1981) due to low N recovery by plants, as considerable N is lost by ammonia volatilization, denitrification, leaching or run-off (Schnier *et al.*, 1988; De Datta and Buresh, 1989). Placement of N fertilizer in the reduced soil layer at 5–10 cm depth reduces the ammoniacal N concentration in flood water (Cao *et al.*, 1984; Schnier *et al.*, 1988) and crop N recovery rates up to 70%. To overcome the laborious process of placing the small urea prills or urea supergranules (USG) in the deeper layers, a mechanical applicator that delivers the urea solution in a continuous band at 7.5 cm depth in the soil has been fabricated at the IRRI. Band application of urea solution in rice through the IRRI model urea-solution applicator gives higher yields and nitrogen-use efficiency (NUE) (Schnier *et al.*, 1988). Hence an experiment was conducted to evaluate newly designed IRRI model urea-solution applicator on the pattern of release of NH^+_4–N and NO^-_3–N, NUE and yield of rice (*Oryza sativa* L.).

MATERIALS AND METHODS

A field experiment was conducted during 1992–93 at Agricultural Research Station, TNAU, Aliyarnagar, with short-duration rice varieties, viz. 'IR 50' and 'ADT 36', in 2 seasons. The experimental soil had pH 7.5, organic C 23 g/kg. The experiment was conducted in randomized complete-block design with 11 treatments and 3 replications. Land preparation and other cultural operations excluding the treatments were done as per the standard recommendations. Nitrogen @ 100 kg N/ha was applied in all the treatments except band placement. In the band placement of urea solution treat-

Table 1. Effect of treatments on yield component, yield and nitrogen-use efficiency

Treatment		Panicles/m^2		Yield (q/ha)				NUE			
Particulars	N (kg/ha)	'IR 50'	'ADT 36'	Grain		Straw		Agronomic efficiency (kg/kg)		Apparent recovery (%)	
				'IR 50'	'ADT 36'	'IR 50'	'ADT 36'	'IR 50'	'ADT 36'	'IR 50'	'ADT 36'
T_1, Control (no N)	0	460	420	35.5	38.3	37.5	46.6				
T_2, BC 50% N basal + 25% N each at 15, 35 DAT as PU	100	510	435	45.8	54.1	45.8	56.1	10.25	15.78	18.25	22.80
T_3, BC 50% N at 15 DAT + 25% N each at 35, 45 DAT as PU	100	555	490	47.0	55.3	47.7	68.0	11.50	16.95	21.83	26.34
T_4, BC 25% N at 7 DAT as PU + BP of urea solution @ 25% N each at 15, 25, 35 DAT	50	540	515	46.7	55.9	48.1	66.8	22.32	35.12	40.28	49.80
T_5, BC 25% N at 7 DAT as PU + BP of urea solution @ 25% N each at 15, 25, 35 DAT	100	560	555	47.0	56.6	50.7	69.1	11.50	18.23	22.95	29.35
T_6, BP of urea solution @ 1/3 N each at 15, 25, 35 DAT	50	590	580	50.0	59.5	52.1	72.4	29.00	42.30	54.10	66.82
T_7, BP of urea solution @ 1/3 N each at 15, 25, 35 DAT	100	600	575	51.5	61.1	52.7	78.8	16.00	22.73	30.09	36.37
T_8, BP of urea solution @ 1/3 N each at 15,25, 35 DAT	50	600	603	50.5	67.9	60.8	83.0	30.00	59.10	62.08	95.20
T_9, BP of urea solution @ 1/3 N at 15 DAT + 2/3 N at 35 DAT	100	615	625	51.8	70.7	62.2	84.2	16.25	32.40	35.30	55.85
T_{10}, Point placement of USG	100	565	550	49.0	65.8	51.8	75.0	13.50	27.45	29.75	42.87
T_{11}, BC 50% N basal as NCU 25% N at 15 DAT as NBU 25% N at 35 DAT as PU	100	555	495	47.8	65.7	49.6	79.8	12.25	27.30	22.47	40.94
CD (P = 0.05)		12	29	3.3	7.3	2.9	8.6	Statistically not analysed			

BC, Broadcasting; BP, band placement; NCU, neem-coated urea; NBU, neem-blended urea; PU, prilled urea, USG, urea supergranules

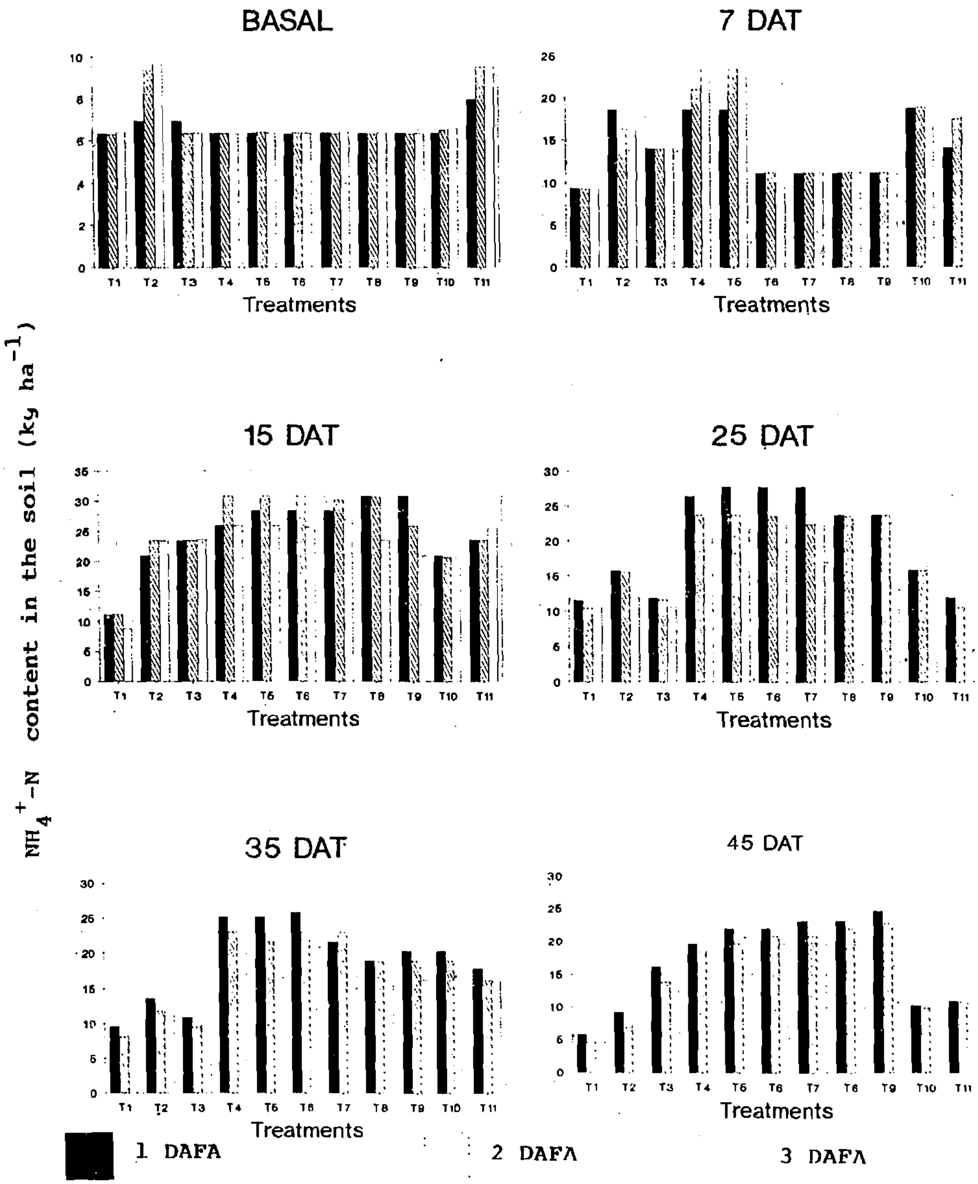

Fig. 1. NH_4^+–N content (kg/ha) under 'IR 50' rice (Details of treatments are given in Table 1)

ments 2 doses, viz. 50 and 100 kg N/ha, were applied. In treatments of band placement of urea solution, the required quantity of prilled urea was dissolved in pre-calculated volume of water to get the urea solution and applied through the urea solution appli-

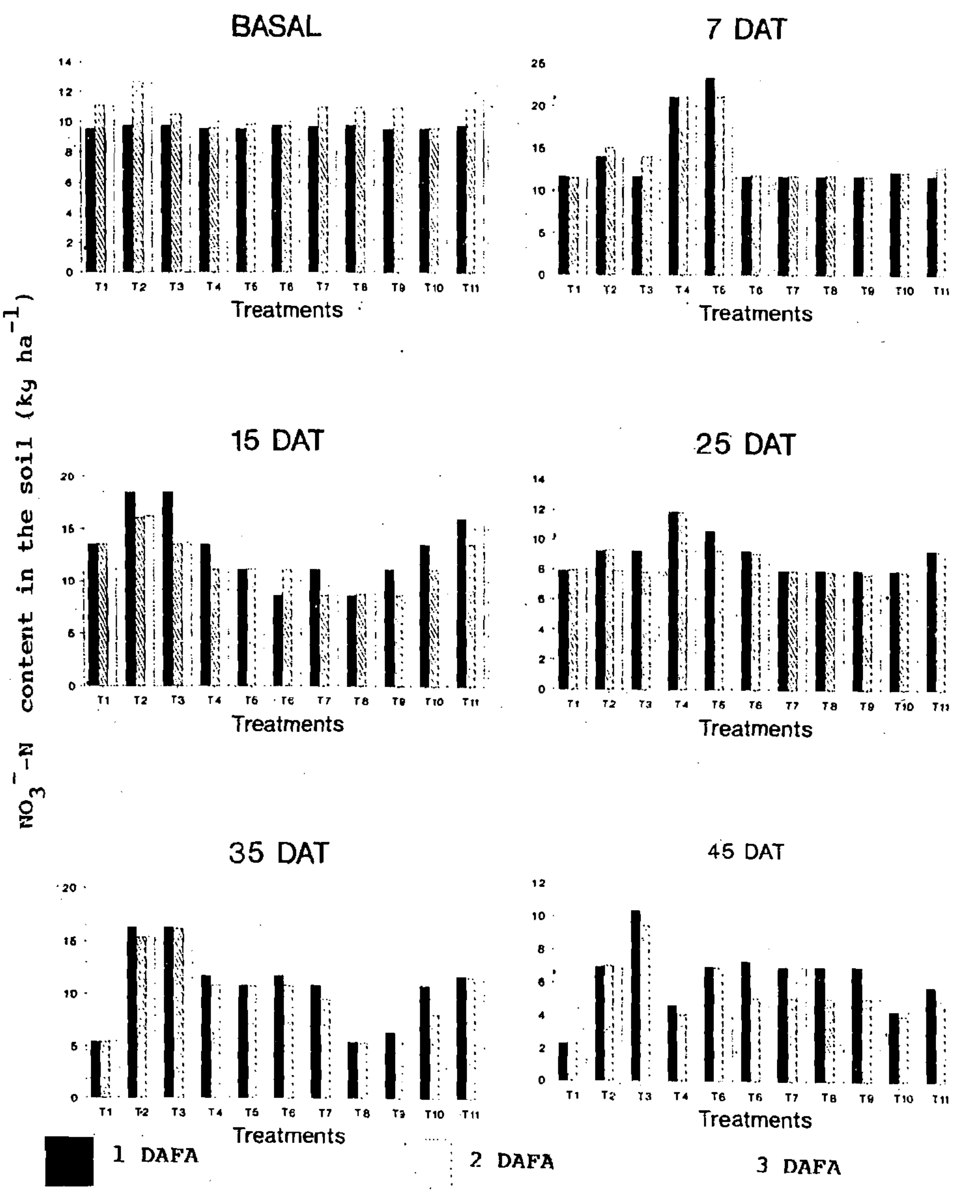

Fig. 2. NO_3^-–N content (kg/ha) under 'IR 50' rice (details of treatments are given in Table 1)

cator. For the neemcake coating 20% by weight of neem powder was used. The urea supergranules required/plot was weighed and counted and then placed in alternate rows at a depth of 7.5 cm at equal intervals at 7 days after transplanting. The NH^+_4-N

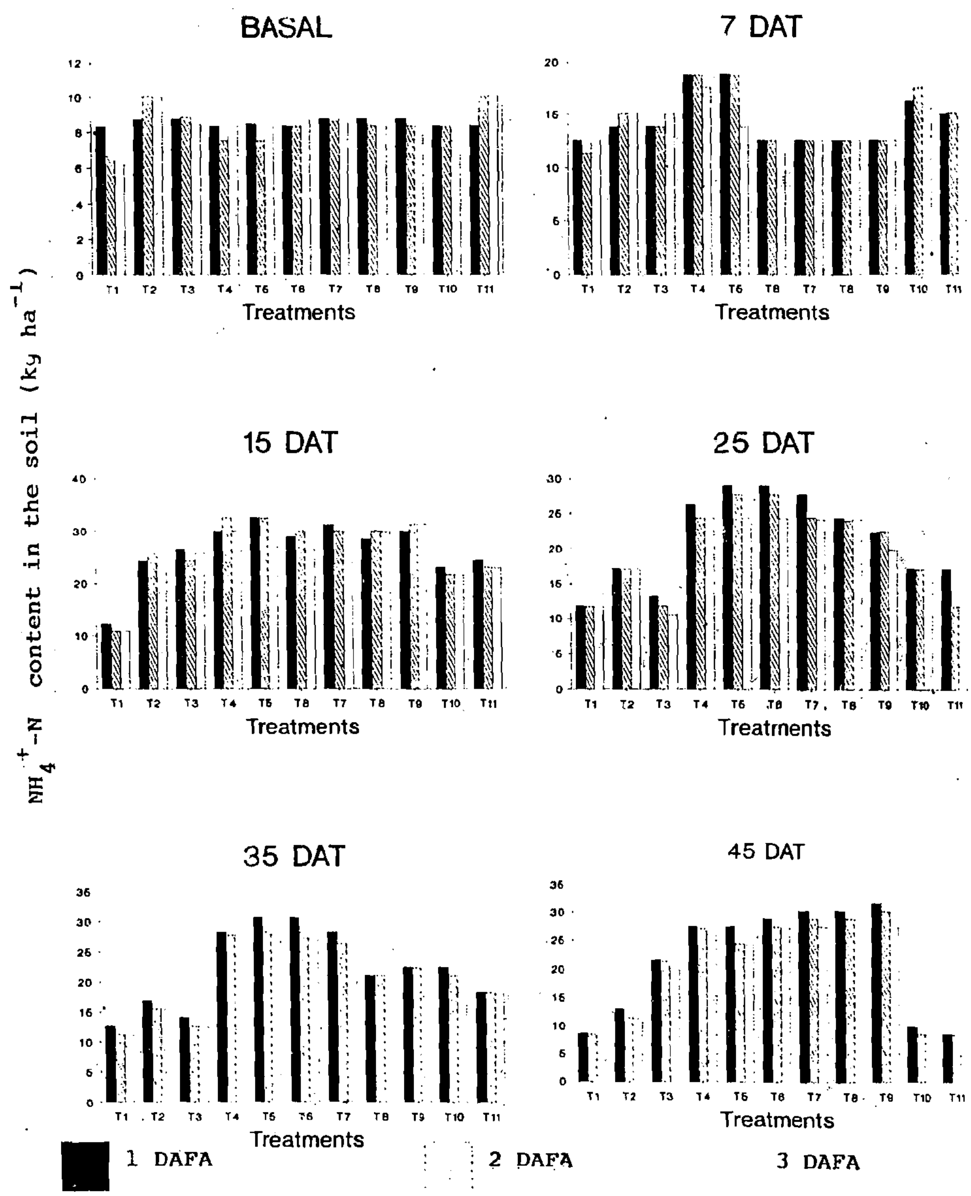

Fig. 3. NH_4^+–N content soil (kg/ha) under 'ADT 36' rice (details of treatments are given in Table 1)

and NO^-_3-N contents were estimated and worked out as per the methods suggested by Bremner and Keeney (1966) and Buresh (1991). The grain and straw yields from net plots were weighed and the yields were expressed at 14% moisture.

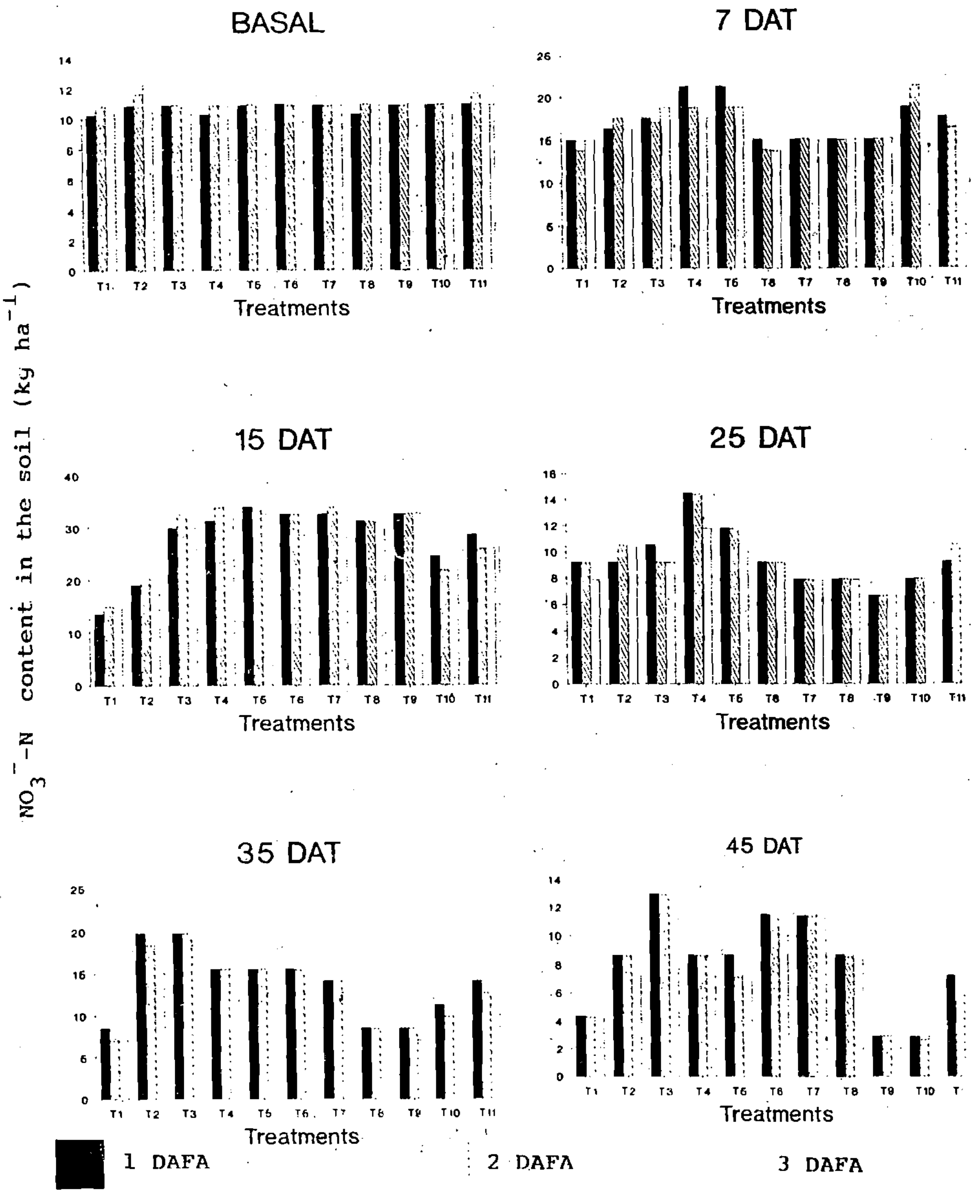

Fig. 4. NO_3^--N content in soil (kg/ha) under 'ADT 50' rice (Details of treatments are given in Table 1)

RESULTS AND DISCUSSION

Teatment effect on NH_4^+-N and NO_3^--N in soil

Higher NH_4^+-N and lower NO_3^--N contents in the soil were observed with band placement of urea solution under both 'IR 50' and 'ADT 36', varieties of rice. The beneficial effect of band placement of urea solution could be attributed to the reduced losses of fertilizer N (Schnier *et al.*, 1988). Higher NH^{+}_{4}-N content was observed 1 day after fertilizer application which decreased subsequently, indicating the crop uptake of the readily available form of N (Figs 1, 3). In the case of prilled urea (PU) broadcast, it was dissolved in flood water and transported to the soil surface by diffusion or convection before it got hydroysed. This coupled with little or no urease activity in the flood water, might be the reason for delayed NH^{+}_{4}-N production in the conventionally applied PU (Katyal and Gadalla, 1990). The high concentration of of NH^{+}_{4}-N in the root zone due to band or deep placement of N could be toxic to the nitrifying bacteria and hence also reduced the nitrification and denitrification losses (Subbiah *et al.*, 1989).

Treatment effect on yield components, yield and nitrogen-use efficiency

Band placement of urea solution one-third at 15 days and two-thirds at 35 days after transplanting at both 50 and 100 kg N/ha levels, had a significant positive influence on the yield component, yield and nitrogen-use efficiency (NUE). Higher availability and reduced losses of N in these treatments led to improvement in number of panicles/m^2 which ultimately result in higher yield. The increase in grain yield with band placement of urea solution in 2 splits @ 50 and 100 kg N/ha was 10.26 and 25.45% more than that obtained with conventional 3 splits of prilled urea in 'IR 50' and 'ADT 36' respectively.

Band placement of urea solution @ 50 kg N/ha resulted in higher agronomic efficiency of 30 and 59 kg grain/kg of N in 'IR 50' and 'ADT 36' respectively. Higher apparent recovery of N was also obtained with this treatment. The rate of N release in these treatments matched well with the N requirement of rice, enabling the realization of higher efficiency and recovery as reported by Schnier *et al.* (1988).

Band placement of urea solution (one-third N at 15 days and two-thirds N at 35 days after transplanting @ 50 kg N/ha) resulted in increased yield component, yield and recovery of N in rice.

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