*Indian J. Agron.* **41** (2) : 215–220 (June 1996)

# Efficient nitrogen management for sustained productivity in lowland rice (*Oryza sativa*)

K. S. RAO, B. T. S. MOORTHY AND C. R. PADALIA

*Division of Agronomy, Central Rice Research Institute, Cuttack, Orissa 753 006*

Received: March 1992

ABSTRACT

A study on rice (*Oryza sativa* L.) made during 1987–90 at Cuttack under shallow-submerged situation in an alluvial sandy-loam soil revealed that integrated N-management system involving a combination of organics, viz. green-manures or *Azolla* compost or farmyard manure (FYM) or water-hyacinth compost and inorganics each source meeting 37.5 kg N/ha gave comparable yields to the application of 75 kg N/ha as inorganic N alone.

During dry season, at a suboptimal level of 40 kg N/ha, 2-equal split applications (at active tillering and panicle initiation or planting and panicle initiation) proved superior. During wet season at 20 kg N/ha, 2-equal split applications (at planting and tillering or active tillering and panicle initiation) were more ideal. During wet season, single basal application of urea coated with Mussorrie rock phosphate or gypsum or neem (*Azadirachta indica* L.) at 30 and 60 kg N/ha gave similar yield as that of conventional 3-split application.

Low recovery (30–40%) of applied nitrogen in lowland rice (*Oryza sativa* L.) and higher price necessitate use of alternative to inorganic N fertilizers to maintain productivity. Integrated nutrient management involving both organics and inorganics is relevant.

To increase efficiency of applied nitrogen and reduce losses under low land condition, slow-release nitrogen fertilizers and nitrification inhibitors have been suggested (Budhar *et al.*, 1991 and Joseph *et al.*, 1991). Besides these, split application of prilled urea at times commensurate with crop needs based on its growth habit and duration is the most common approach for increasing the efficiency of applied N in rice. There is a need to identify appropriate time of application particularly with suboptimal levels, i.e. resource constraint condition. Hence an experiment was conducted on these lines.

## MATERIALS AND METHODS

Three field trials on related aspects were carried out on rice at the Central Rice Research Institute, Cuttack, under shallow submerged land situation in an alluvial (Inceptisol-aeric tropaquept) soil of sandy-loam texture with pH 6.0, total N 0.058%, organic carbon 0.5%, available P 36 ppm, exchangeable K 1.0 meq/100 g, exchangeable Ca 8.0 meq/100 g, exchangeable Mg 4.7 meq/100 g and a percolation rate of 6 mm/day.

### *Integrated nutrient-management trial*

This investigation was conducted for 3 wet seasons of 1988 to 1990 to evaluate the inorganic fertilizer applied alone or in combination with 5 organic manures, viz. *Azolla*

**Table 1.** Yield and yield components of rice as influenced by integrated use of organic and inorganic fertilizers, wet seasons of 1988–90

| Treatment | Grain yield (tonnes/ha) | | | | Panicles/m$^2$ | | | Panicle weight (g) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1988 | 1989 | 1990 | Mean | 1988 | 1989 | 1990 | 1988 | 1989 | 1990 |
| Control (no N) | 4.12 | 4.02 | 3.77 | 3.97 | 228 | 289 | 253 | 2.07 | 2.07 | 1.70 |
| USG (7 DAT), point placed | 6.23 | 5.48 | 5.28 | 5.66 | 306 | 322 | 295 | 2.28 | 2.35 | 1.67 |
| PU, conventional 3 split applications | 6.32 | 5.41 | 5.40 | 5.71 | 309 | 317 | 311 | 2.10 | 2.33 | 2.03 |
| *Azolla* compost + PU (50 : 50) | 6.21 | 5.55 | 5.35 | 5.70 | 301 | 316 | 303 | 2.41 | 2.42 | 2.07 |
| *Sesbania rostrata* + PU (50 : 50) | 6.32 | 5.66 | 5.35 | 5.78 | 305 | 318 | 316 | 2.48 | 2.41 | 2.10 |
| *Sesbania aculeata* + PU (50 : 50) | 6.37 | 5.61 | 5.38 | 5.79 | 304 | 324 | 304 | 2.51 | 2.42 | 2.05 |
| FYM + PU (50 : 50) | 6.16 | 5.65 | 5.37 | 5.73 | 301 | 319 | 304 | 2.42 | 2.45 | 2.10 |
| Water-hyacinth compost + PU (50 : 50) | 6.25 | 5.57 | 5.41 | 5.74 | 302 | 315 | 291 | 2.44 | 2.45 | 2.05 |
| CD (P = 0.05) | 0.25 | 0.47 | 0.34 | | 14 | NS | 34 | 0.23 | 0.16 | 0.32 |

DAT, Days after transplanting
N level in all treatments excepting control : 75 kg/ha

**Table 2.** Efficiency of single and split applications of N at optimal and suboptimal levels in dry season of 1987

| Treatment | Fractional application at crop-growth stage | | | Grain yield (tonnes/ha) at 2 levels of N (kg/ha) | | |
|---|---|---|---|---|---|---|
| P | T | PI | | 40 | 80 | Mean |
| 100% | 0 | 0 | | 4.55 | 5.36 | 4.96 |
| 0 | 100% | 0 | | 4.77 | 5.38 | 5.07 |
| 0 | 0 | 100% | | 4.61 | 5.20 | 4.91 |
| 50% | 50% | 0 | | 4.83 | 5.24 | 5.03 |
| 0 | 50% | 50% | | 5.12 | 5.64 | 5.38 |
| 50% | 0 | 50% | | 5.18 | 5.70 | 5.44 |
| 50% | 25% | 25% | | 4.89 | 5.96 | 5.43 |
| | | | Mean | 4.85 | 5.50 | |
| CD (P = 0.05) | | | | | | |
| N levels | 0.06 | | | | | |
| N splits | 0.11 | | | | | |
| Levels x splits | 0.16 | | | | | |

P, Planting; T, tillering; PI, panicle initiation

compost (1.55% N), water-hyacinth compost (1.25 N) farmyard manure (FYM, 1.25%) green-manures, viz. *Sesbania aculeata* (1.85%) and *Sesbania rostrata* (1.50%). There were 8 treatments (Table 2) with a control (no nitrogen), 75 kg N/ha as prilled urea in splits [half N at planting and the remaining in 2 equal splits each at 21 days after transplanting (DAT) and panicle-initiation stages], 75 kg N/ha as rea supergranules (USG) at 7 DAT and 5 combinations of organics and inorganic fertilizer (urea) to supply 37.5 kg N/ha each. Both green-manure crops were grown for 40 days and then incorporated *in situ* (keeping required quantity). A basal dose of 30 kg/ha each of $P_2O_5$ and $K_2O$ was common to all the treatments. A long-duration (155 days) variety 'Gayatri' was planted in the second fortnight of July at a spacing of 15 cm x 15 cm.

*Fractional application of N at suboptimal levels*

This trial was carried out during dry and wet seasons of 1987. During dry season, there were 14 treatments (Table 3) comprising 40 (suboptimal) and 80 (optimal) kg N/ha and 7 different schedules of single and split applications at planting, active tillering and panicle-initiation stages. The design used was split-plot with N levels in the main plot and split application in subplots. The treatments were replicated 4 times. The variety 'Udaya' of 130 days duration was planted in the second week of February.

This experiment was repeated in wet season with only 1 level (lower than optimum) of 20 kg N/ha. An additional treatment of a 'no nitrogen control' was included making the total number of treatments 8 (Table 4). The treatments were replicated 4 times in randomized block design. The variety 'Salivahana' ('IET 7590') of 145 days was planted during the first fortnight of July at a spacing of 15 cm x 15 cm.

*Relative efficiency of amended urea materials*

This study was carried out during wet season of 1988 and 1989 to find out the agronomic effectiveness of the newly amended urea materials. There were 12 treatments (Table 5) comprising a no nitrogen control, application of 2 levels of N (30 and 60 kg/ha) in the form of Mussorrie rock phosphate-coated urea (MRPU; N 36%), gypsum-coated urea (GCU; N 36%), neem-coated urea (NCU; N 34%) either all at planting or in 2 splits—half at planting and the rest at active tillering, i.e. 4 weeks after planting. These treatments were compared with conventional 3 split applications of prilled urea (PU) (half at planting, one-fourth at active tillering and the rest at panicle-initiation stage) at 30 and 60 kg N/ha levels. The treatments were replicated 4 times in randomized block design. The variety 'Salivahana' was planted during second fortnight of July with a spacing of 15 cm x 15 cm.

An uniform dose of 30 kg/ha each of $P_2O_5$ and $K_2O$ was given to the crop at planting in all the trials.

## RESULTS AND DISCUSSION

*Integrated nutrient-management trial*

Combined use of different organics (*Azolla* compost, green-manures, FYM and water-hyacinth compost) and prilled urea each source 37.5 kg N/ha showed comparable yield performance as that of prilled urea @ 75 kg N/ha applied in 3 splits or USG applied by point placement 7 DAT. A mean yield increase of 45.8% was observed with these treatments over no nitrogen control (Table 1). The increase in yield was attributed due to improvement in overall growth characters as reflected in number of panicles and panicle weight and their significant

**Table 3.** Efficiency of single and split application of N at suboptimal rate (20 kg/ha) in wet season of 1987

| Treatment: Fractional application at different growth stages | | | Grain yield (tonnes/ha) | Panicles/$m^2$ | Panicle weight (g) |
|---|---|---|---|---|---|
| P | T | PI | | | |
| 0 | 0 | 0 | 4.07 | 227 | 2.21 |
| 100% | 0 | 0 | 4.62 | 251 | 2.22 |
| 0 | 100% | 0 | 4.62 | 262 | 2.33 |
| 0 | 0 | 100% | 4.40 | 241 | 2.62 |
| 50% | 50% | 0 | 5.05 | 259 | 2.28 |
| 0 | 50% | 50% | 5.06 | 256 | 2.55 |
| 50% | 0 | 50% | 4.66 | 250 | 2.34 |
| 50% | 25% | 25% | 4.66 | 251 | 2.49 |
| CD (P = 0.05) | | | 0.22 | 9 | 0.11 |

P, Planting; T, tillering; PI, panicle initiation

**Table 4.** Effect of different modified urea materials and their time of application on yield attributes and yield of rice

| Treatment | Panicles/ $m^2$ | | Panicle weight (g) | | Grain yield (tonnes/ha) | | | Mean N-use efficiency (kg grain/ kg N) |
|---|---|---|---|---|---|---|---|---|
| | 1988 | 1989 | 1988 | 1989 | 1988 | 1989 | Mean | |
| Control (No. N) | 198 | 204 | 2.48 | 2.42 | 3.98 | 3.65 | 3.82 | |
| MRPU, 30 kg N/ha (all basal) | 206 | 224 | 2.71 | 2.68 | 4.63 | 4.04 | 4.34 | 17.3 |
| NCU, 30 kg N/ha (all basal) | 208 | 223 | 2.74 | 2.58 | 4.71 | 4.09 | 4.40 | 19.3 |
| GCU, 30 kg N/ha (all basal) | 208 | 222 | 2.79 | 2.65 | 4.69 | 4.13 | 4.41 | 19.7 |
| Split application of PU at 30 kg N/ha (3 times) | 206 | 218 | 2.79 | 2.65 | 4.42 | 4.09 | 4.26 | 14.7 |
| MRPU, 60 kg N/ha (all basal) | 219 | 232 | 2.78 | 2.62 | 4.82 | 4.38 | 4.60 | 26.0 |
| NCU, 60 kg N/ha (all basal) | 217 | 230 | 2.71 | 2.68 | 4.86 | 4.33 | 4.60 | 26.0 |
| GCU, 60 kg N/ha (all basal) | 219 | 233 | 2.68 | 2.72 | 4.91 | 4.28 | 4.60 | 36.0 |
| Split application of PU at 60 kg N/ha (thrice) | 277 | 232 | 2.94 | 2.85 | 5.21 | 4.49 | 4.85 | 34.3 |
| Split application of MRPU (twice), 60 kg N/ha | 214 | 232 | 2.85 | 2.65 | 4.75 | 4.45 | 4.60 | 26.0 |
| Split application of NCU (twice), 60 kg N/ha | 215 | 235 | 2.88 | 2.68 | 4.71 | 4.33 | 4.52 | 23.5 |
| Split application of GCU (twice), 60 kg N/ha | 211 | 232 | 2.90 | 2.65 | 4.77 | 4.37 | 4.57 | 25.0 |
| CD (P = 0.05) | 13 | NS | NS | NS | 0.41 | 0.31 | | |

positive correlation with yield (r values : panicle vs yield : 0.98, panicle weight vs yield : 0.83). Thus there is a scope to minimize fertilizer consumption by 50% by adopting this system. The results confirm the findings of Sharma and Mittra (1990) and Panda *et al.* (1991).

*Fractional application of N at suboptimal levels*

During dry season, at optimum level of 80 kg N/ha, the grain yield with conventional 3-split applications (at planting, active tillering and panicle initiation) was significantly higher than the other treatments (Table 2). At suboptimal level of 40 kg N/ha, application in 2 splits either at tillering and panicle initiation or at planting and panicle initiation proved superior to other treatments. Thus it is possible to skip 1 fraction either at planting or tillering stage for higher production. In treatments with single dressing, application at active tillering stage was found superior to application at planting or at panicle-initiation stage.

During wet season, application of 20 kg N/ha in 2 equal splits, either at planting and active tillering or active tillering and panicle initiation, significantly increased the grain yield over single application or 3 split applications (Table 3). Among single application treatments, nitrogen given at planting or at active tillering was comparable and superior to that applied at panicle initiation. Application of nitrogen at panicle initiation increased the grains panicle, whereas application at planting or active tillering increased the panicles/m$^2$. Nitrogen absorbed up to maximum tillering stage results in panicle number (Takahashi, 1975) and that absorbed at panicle-initiation stage increases spikelets panicle (Matsushima, 1964).

*Relative efficiency of modified forms of urea*

At 2 N levels (30 and 60 kg/ha) tested, basal applications of modified urea forms—MRPU, GCU and NCU—gave comparable yield as that of conventional 3 split applications of PU (Table 4). Split application of these materials at 60 kg N/ha level 2 times during the crop growth was of no additional advantage in over single basal application. The number of panicles/m$^2$ and panicle weight also did not differ markedly among these treatments. As might be expected, the grain yield increased significantly from 0–30 kg N/ha. Increasing of N from 30 to 60 kg/ha caused significant improvement in yield in case of conventional 3-split applications of PU during both the years and split application of MRPU during 1989. The N-use efficiency (kg grain/kg N applied) with single application of 3 amended urea was higher than that of conventional 3 split applications at lower level of 30 kg N/ha. At higher level (60 kg N/ha) however, the reverse was true. Thus it is evident that a basal application of modified urea forms was as good as conventional 3 split applications of PU under shallow submerged condition. Their effectiveness is likely be better under higher water depths where split application of PU is not feasible.

REFERENCES

Budhar, M. N., Ramaswamy, C. and Kareem, A. A. 1991. Relative efficiency of coated N fertilizers in lowland rice. *Indian Journal of Agronomy* **36** (1) : 124–125.

Joseph, K., Tony, P. J. and Nair, N. R. 1991. Effect of sources and levels of nitrogen on the growth, yield and nitrogen use efficiency of wetland rice. *Indian Journal of Agronomy* **36** (1) : 40–43.

Matsushima, S. 1964. Nitrogen requirement, at different growth stages. (*In*) *Mineral Nutrition of the Rice Plant*, pp. 219–242. John Hopkins Press, Baltimore, USA.

Panda, D., Samantaray, R. N., Mohanty, S. K. and Patnaik, S. 1991. Green manuring with *Sesbania aculeata*–its role in N nutrition and yield of rice, (*In*) *Biological N fixation associated with Rice Production*. pp. 305–313. Oxford & IBH Pvt. Ltd, New Delhi.

Sharma, A. R. and Mittra, B. N. 1990. Complementary effects of organic and mineral fertilizers in rice based cropping system. *Fertiliser News* **35** (2) : 43–51.

Takahashi, J. 1975. Studies on the improvement of rice culture in the eastern part of Tonoku district. *Bulletin Miyagi Pref. Agric. Res. Ctr.* **45** : 1–58.