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COMPARISON OF TWO METHODS OF NITROGEN APPLICATION IN LOWLAND RICE USING NITROGEN-15 TRACER TECHNIQUE

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ABSTRACT: The efficiency of two methods of nitrogen (N) application to rice was evaluated using N^{15} labelled fertilizer. The method involving no puddling but mere application of N fertilizer to the ploughed surface of dry soil, followed by planking and flooding, resulted in better utilization of N fertilizer and higher rice yields.

Key Words: Rice, Nitrogen Fertilizers; Application Methods; Tracer Techniques

INTRODUCTION

The efficiency with which rice utilizes N is notoriously low. Mitsui (1954) estimated that rice recovers only 30–40 percent of applied N whereas dryland crops recover 50–60 percent. To improve N utilization efficiency, it is important to develop more efficient management practices.

Nitrogen fertilizer is usually applied to rice either frequently to provide a continuous supply (Evatt, 1965; Ishizuka, 1965; Seetanum and De Datta, 1973) for optimum grain yields or as single application in a specific soil zone to minimize nitrification-denitrification reactions. The proper method of N application to rice depends on several factors such as soil texture, permeability, climatic conditions and water management practices (Sims, 1965; De Datta et al., 1969; IRRI, 1967; IRRI, 1970; Patrick and Tusneem, 1972).

In the past, low cost of fertilizer N usually made it more convenient for the farmers to apply extra N rather than making much effort to improve fertilizer N efficiency. Recent increase in the cost of fertilizer made it worthwhile to examine methods of its application for improving N utilization by rice.

In Pakistan, the most common method (conventional method) is the top dressing with ammonium sulphate or urea, soon after the establishment of rice seedlings (15 days after transplanting), occasionally followed by a second top dressing near mid-season (Chaudhry, 1980). Several other methods tried in the field revealed that N fertilizer application to ploughed surface of dry soil followed by planking, flooding and transplanting, was the most promising method for increasing rice yield (PARC, 1980). In the present investigation, the efficiency of this method in comparison to the conventional method has been studied in the field using labelled N fertilizer. Because of high cost of labelled N material, relatively small field plots were used.

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MATERIALS AND METHODS

The field experiment was conducted on a clay loam soil. The soil had 0.86 pereent organic matter and 0.069 percent total N contents. The pH of the soil was 7.9. The experiment was laid out with plots of 2.2 m x 2.2 m size. Sub-plots of 0.6 m x 0.6 m were established in the centre of the large plots by fixing polythene lined GI sheet barriers (15 cm deep and 22.5 cm above the soil surface) to prevent labelled N from moving out of the plot through the flood water as well as through diffusion within the plough layer. The detail of treatments used are as under:

T_1 – Rice seedlings were transplanted after puddling operation but no N fertilizer was applied.

T_2 – Transplanting was done after puddling operation and all N fertilizer (@ 80 kg N/ha as ammonium sulphate) was applied by surface broadcast after seedling establishment (15 days after transplanting).

T_3 — All N fertilizer (@ 80 kg N/ha as ammonium sulphate) was broadcast on the ploughed surface in dry soil, incorporated by planking and immediately flooded. Transplanting was done the next day (no puddling operation).

Each treatment was replicated thrice in a randomized block design. All the plots received a basal application of 50 kg P_2O_5/ha as single superphosphate. The sub-plots received ammonium sulphate enriched with five atom % N^{15} excess. The plots were transplanted with rice variety 'Kashmir Basmati' (row-to-row and plant-to-plant distance was 20 cm) and were kept flooded during the entire growth period of rice.

Grain and straw yield data were recorded from larger plots. Sub-samples of grain and straw after oven drying at 70°C for 48 hour were ground and analysed for total Kjeldahl N(Bremner, 1965a). Sub-plots were used to obtain plant samples at primordial initiation (PI) stage and straw and grain samples at harvest. After determining total Kjeldahl N in these samples, the NH_4—N in the titrated solutions was concentrated to approximately 1 mg/2ml and analysed for N^{15} abundance on a Mass Spectrometer Mat GD 150 using sodium hypobromite method (Bremner, 1965b). Percentages of N derived from fertilizer and N utilization efficiency were calculated as follows:

Percent N derived from fertilizer (percent Ndff)

$$= \frac{N^{15} \text{ excess abundance (sample)}}{N^{15} \text{ excess abundance (fertilizer)}} \times 100$$

Percent utilization of the applied N fertilizer

$$= \frac{\text{Percent Ndff x yield of N in plant (kg/ha)}}{\text{Rate of N fertilizer application (kg/ha)}}$$

RESULTS AND DISCUSSION

Application of N fertilizer increased the straw and grain yield markedly ($P<0.01$, Table 1). Dry soil application, before flooding (T_3) produced significantly higher straw and grain yield ($P<0.01$ and $P<0.05$, respectively) as compared to surface broadcast of N fertilizer 15-days after transplanting (T_2). These results are in conformity with the results reported earlier by PARC researchers (1980). Plant analysis for total N showed that N application markedly increased the N contents of rice straw and grain. Addition of N by the method T_3 considerably increased N contents of rice straw and grain as compared to the other method (T_2).

The Plant analysis for labelled N (Table 2) indicated, in general, a substantial increase in percent N, derived from fertilizer by rice shoot at PI stage and at harvest. A decrease in percent N, derived from fertilizer in straw at harvest as compared to that of shoot at PI stage indicated that the plants were more dependent on mineralized soil N during the later part of the growth period, because most of the N fertilizer had been absorbed by plants, immobilized into soil organic matter, or lost from the system. An increase in the percent N utilization efficiency by rice shoot at PI stage and at harvest clearly indicated the superiority of the method T_3 over T_2. While comparing the two methods, the respective values for percentages of N, derived from fertilizer and N utilization efficiency in case of rice grain, were not, however, much different (Table 2).

The over all results of the present study indicated that the method of N application to the ploughed dry surface of the soil before flooding is better than the conventional method as far as the rice yields and N utilization efficiency is concerned. The possible mechanism of the superiority of this method seems that the N fertilizer broadcast in the furrows of ploughed dry soil, is incorporated into the soil with planking and it goes further

Table 1. Dry matter, N concentration and N contents of rice as influenced by N application method

Treatment	Straw			Grain		
	T.D.M. (kg/ha)	N concentration (%)	N contents (kg/ha)	T.D.M. (kg/ha)	N concentration (%)	N contents (kg/ha)
T_1	2,638.7	0.502	13.3	2,089.0	1.059	22.3
T_2	4,415.6	0.462	20.4	3,574.5	1.041	37.3
T_3	5,659.8	0.411	23.3	3,940.7	1.041	40.9

Table 2. Percent N derived from fertilizer and percent N utilization efficiency of rice as influenced by N application method

Treatment	% N derived from fertilizer by			% N utilization efficiency of rice		
	Shoot at PI stage	Straw at harvest	Grain at harvest	Shoot at PI stage	Straw at harvest	Grain at harvest
T_2	48.5	35.6	35.1	30.7	9.1	16.3
T_3	56.8	37.8	33.7	35.7	11.0	17.2

deep with the downward movement of irrigation water applied immediately after planking. In this way, the N fertilizer is less subjected to NH_3 volatilization losses and, therefore, the efficiency of fertilizer N is increased. Field studies conducted in the microplots by various researchers to measure the crop recovery of N^{15} labelled fertilizer have shown that surface application, in general, produce the lowest values for N^{15} recovery. They reported that recovery is much improved with deep placement of N fertilizer (Koyama et al., 1973; Khind and Datta, 1975; Reddy and Patrick, 1976; Murayama, 1977). But concerning the top dressing 15 days after transplanting (conventional method), lower efficiency of N fertilizer might be due to the obviously higher losses of N as volatile NH_3. N^{15} balance studies in the rice fields conducted by Wetselaar et al. (1973) and Patrick and Reddy (1976) have shown that surface application of ammonium sulphate caused greater N losses than deep application.

Another main advantage of the method T_3 is that no puddling, the most laborious operation in cultivation of rice is involved. The main objectives of the puddling operation in the rice cultivation are: i) to break the soil aggregates and to produce an impervious soil layer to reduce the infiltration of standing water to minimum, and ii) to control weeds. According to the observations of PARC researchers (1980), in areas which are continuously under rice for over 20 years, an impervious layer has developed under the soil and water could stand on the soil surface even if no puddling operation is practiced. In these areas, the method (T_3) could be helpful in getting better utilization of N fertilizer and higher rice yields. However, in areas where puddling operation in rice field is done mainly to control the peculiar hardy weeds, which is not possible otherwise, the present study suggests that mere incorporation of N fertilizer during puddling operation could help in reducing NH_3 losses, better fertilizer N recovery and higher rice yields. Khind and

Datta (1975) and Murayama (1977) reported that incorporation of N fertilizer resulted in improved recovery.

Patnaik and Broadbent (1967) reported that split application of ammonium sulphate, two-third at planting and one-third at PI stage resulted in almost double N recovery than its complete application at planting or top dressing it at tillering stage. The results of the present study indicate that N utilization efficiency by rice would have been further improved, if split application instead of one complete application of N fertilizer, would have been followed. Such management practices have not been evaluated properly in Pakistan. Nitrogen fertilizer is an extremely expensive commodity in this country which force the poor farmers to under-fertilize their crops. The improved practices of N application could be much helpful under these conditions. The data of the present study warrant further investigations to develop more efficient methods of N application to improve its utilization efficiency by rice.

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