Pak.J.Bot., 29(2): 319-322, 1997.

NITROGEN LOSSES FROM TOPS OF THREE RICE VARIETIES GROWN IN NUTRIENT CULTURE SOLUTION

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Abstract

During the growth of rice crop upto 7-54% of fertilizer N is generally lost from soil plant system. Using ^{15}N labelling technique, the balance of vegetative N between anthesis and maturity in 3 rice cultivars showed a loss of 7-21% from foliar parts. Grain yield of the plants was dependent on the efficiency of plants to utilize vegetative N assimilated before anthesis, a factor that plays a significant role in N fertilizer economy of crop plants.

Introduction

Rice production is heavily dependent on nitrogen fertilizers in Asia where approximately 60% of N fertilizer is used. However, lowland rice is known for its poor fertilizer N use efficiency of ca. 40% or even less (De Datta, 1988; Azam *et al.*, 1991). The low N use efficiency is because of high (20-70%) N losses. Therefore, increased crop utilization and decreased losses of fertilizer N will remain an important goal for effective N management. Experiments were therefore carried out to examine: i) the remobilization of vegetative N to reproductive parts and ii) loss of vegetative N between anthesis and maturity in 3 varieties of rice (*Oryza sativa* L.).

Materials and Methods

One month old rice seedlings of three cultivars viz., Bas-385, Bas-370 and IR-6 were transplanted in plastic pots of 5 litre capacity filled with acid-washed white gravel. A glass tube (30x0.6 cm) was installed in each pot for pumping out nutrient solution when required. Eighteen pots were used for each variety with three seedlings in each pot. Two litres of nutrient solution (Yoshida *et al.*, 1976) were applied to each pot at transplantation using ^{15}N - labelled $(NH_4)_2SO_4$ (1.0 atom % ^{15}N excess) as N source (160 mg pot^{-1}). pH of the culture medium was maintained at 5.5 ± 0.5. A total of 600 mg of ^{15}N- labelled nitrogen was supplied to each pot till anthesis when one set of plants (9 pots $variety^{-1}$) was harvested. The rooting medium in the remaining pots was thoroughly washed with tap water to remove ^{15}N-labelled nutrient solution using the glass tube and a vacuum pump. The liquid was removed by evacuation and the process

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repeated several times using fresh volumes of water to ensure almost complete removal of ^{15}N. Two litres of the nutrient solution containing 160 mg of unlabelled N as $(NH_4)_2SO_4$ was then applied pot^{-1}.

The first harvest was taken at anthesis i.e., at 69, 72, and 80 days and second at maturity after 120 days of transplanting Bas-385, Bas-370 and IR-6, respectively. Nine replicates of each variety were harvested at either growth stage. Representative samples of root, shoot and grain from each variety were analyzed for total N (including No_3-N) and ^{15}N. The isotope-ratio analysis of the samples was performed on a mass-spectrometer (Varian Mat GD 150) with a precision of 0.002 atom % ^{15}N.

Results and Discussion

Statistical analyses showed a significant variation among the varieties for total dry matter yield at the two growth stages (Table 1). Total N yield of the varieties at anthesis was similar while at maturity it was significantly different with maximum in IR-6. Among the three varieties, maximum dry matter was accumulated by Bas-370. Harvest index (HI) and nitrogen harvest index (NHI) were highest in IR-6, which showed the efficiency of this variety to utilize dry matter and N resources after anthesis.

Approximately 42-61% of nitrogen was translocated to grain with 11.0-12.6% retained in root and 21-27% in straw (Table 2). The extent of translocation to grain portion in IR-6 was higher than the other two varieties which translocated almost similar amounts. A maximum loss of 21% was observed in Bas-385 and minimum of 7% in IR-6.

Rice plants are known to lose significant amounts of nitrogen from their tops and in the present study, 7 to 21% of N fertilizer assimilated at anthesis was not recovered at maturity. The three rice varieties showed significant differences. The decrease in N after anthesis has been attributed to different loss pathways. It was suggested that N losses occurred as plant parts sloughed off, but this might result in a significant decrease in dry matter yield of plant while in our study and the studies reported by Daigger *et al.*, (1976) and Schjorring *et al.*, (1989) this has not been the case. It has also

Table 1. Total dry matter and nitrogen yield at anthesis and maturity of rice.

Variety	Dry matter (g pot^{-1})		HI	N yield (mg pot^{-1})		NHI
	Anthesis	Maturity		Anthesis	Maturity	
Bas-385	28.7aA*	63.7aB	0.40	465.2aB	557.0aB	0.63
Bas-370	30.0bA	71.8bB	0.39	476.4aA	602.3bB	0.64
IR-6	33.0aA	67.9cB	0.51	462.3aA	630.3cB	0.75

HI (Harvest Index) = Grain yield (g)/Straw + Grain yield (g) NHI (Nitrogen Harvest Index) = Grain N (mg)/ Straw + Grain N (mg)

*Figures sharing a similar letter (lowercase) in a column, and of each character (uppercase) in a row are not significantly different at 5% level of significance according to DMR test.

Table 2. Balance at maturity of ^{15}N-labelled nitrogen assimilated at anthesis by three rice varieties.

Variety	N recovered (mg pot^{-1})				
	Straw	Root	Grain	Total	Unaccounted
Bas-385	111.4aA*	53.7aB	200.7aC	365.9a	99.3a
	(24.0)**	(11.5)	(43.2)	(78.7)	(21.3)
Bas-370	130.8bB	60.2bB	201.4aC	392.4b	84.0b
	(27.5)	(12.6)	(42.3)	(82.4)	(17.6)
IR-6	96.4cA	51.8aB	282.1bC	430.2c	32.1c
	(20.9)	(11.2)	(61.0)	(93.1)	(6.9)

*Figures sharing a similar letter (lowercase) in a column, and of each character (uppercase) in a row are not significantly different at 5% level of significance according to DMR test.

**Figures in parentheses are percent of vegetative N (at anthesis) recovered at maturity.

been postulated that N losses from tops of plants occur due to leaching of nitrogenous compounds by dew and rain from plant leaves but Schjorring *et al.*, (1989) reported the occurrence of such types of losses in relatively dry season. Moreover, this nitrogen is ultimately returned to the soil. Burd (1919), Terman & Allen (1974) attributed losses to movement of plant N back through the roots into the root media. In the present study however, negligible amounts of N were detected in the nutrient medium at maturity (data not shown) which could not make significant contribution to observed N losses. Similar results have been reported by Hooker *et al.*, (1980) and Schjorring *et al.*, (1989). Thus the root system or rhizosphere of annual species does not seem to be a sink for N surplus in the shoots.

Several authors have suggested the possibility of gaseous N losses from tops of plants (Farquhar *et al.*, 1979; Parton *et al.*, 1988) and the major part (more than 85%) of N volatilized seemed to be in reduced forms e.g., ammonia or volatile amines (Weiland & Stutte, 1979). Limited sink capacity during grain filling when N is remobilized from old senescing leaves to younger tissues may probably favour NH_3 generating processes and thus lead to a higher rate of NH_3 volatilization. The losses reported here indicated the difference in behavior of the rice varieties in utilizing the remobilized N. Bas-385 and Bas-370 showed similar loss. Although the three varieties derived similar amount of fertilizer N at anthesis, the extent of N loss was different. Bas-385 and IR-6 seemed to be more efficient than Bas-370 in translocating root N to foliar parts, IR-6 was more efficient in translocating shoot N towards grain. This variety also showed a greater potential to utilize remobilized N in grain formation.

Acknowledgment

The authors are grateful to Mr. G.R. Tahir, PSO of NIAB, Faisalabad, for statistical analysis of the data.

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(Received for publication 24 September, 1995)