

UPTAKE OF FERTILIZER NITROGEN AND SOIL NITROGEN BY RICE USING ^{15}N -LABELLED NITROGEN FERTILIZER*

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KEY WORDS

Ammonium Fertilizer-Nefficiency Flooded soils Native soil N N-15 isotope N loss Uptake Urea.

ABSTRACT

Data from five field experiments using labelled nitrogen fertilizer were used to determine the relative effects of soil nitrogen and fertilizer nitrogen on rice yield. Yield of grain was closely correlated with total aboveground nitrogen uptake (soil + fertilizer), less closely correlated with soil nitrogen uptake and not significantly correlated with fertilizer nitrogen uptake. When yield increase rather than yield was correlated with fertilizer nitrogen uptake, the correlation coefficient was statistically significant.

INTRODUCTION

Recent increases in the cost of inorganic fertilizers make it important to examine the relationships between grain yield and N utilization by rice to improve the efficiency of fertilizer N utilization. Recently, in a review article Parr¹ defined fertilizer N use efficiency as the percentage recovery of fertilizer N by crop which may be estimated as the difference in N uptake by the above ground portions of fertilized and unfertilized plants and expressed as a percent of the N applied. This method is often used by the researchers in interpreting the results obtained from fertilizer N experiments. This conventional method of expressing the fertilizer N utilization, includes the uptake of both applied fertilized N and native soil N. Recent studies^{2,3,4,6}, utilizing labelled N demonstrated that

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Table 1. Treatments used in several field experiments involving application of labelled nitrogen fertilizer

Year experiment conducted	N-source	Type of N-15 isotope	Rate of applied kg/ha	Method of application	Time of application	Reference
1. 1973	Ammonium sulfate	depleted N-15	56 112	Incorporated Incorporated	All N at planting All N at planting	2
2. 1974	Ammonium sulfate	depleted N-15	112 112 112	Incorporated Surface applied Surface applied	All N at planting All N at early season Half N at early season half N at midseason	4
			112 112	Surface applied Surface applied	All N at midseason Half N at early season + half N at late season	
3. 1975	Ammonium sulfate	enriched N-15	100 100 100	Incorporated Surface applied Surface applied	All N applied at planting All N applied at early season Half N applied at early season half N at midseason	4
4. 1975 and 1976	Ammonium sulfate Urea	enriched N-15 enriched N-15	60 60	Surface applied Surface applied	2 weeks after planting 2 weeks after planting	5

Early season = 22 days after planting; midseason = 40 days after planting and late season = 63 days after planting.

* In experiments 1, 2, and 3 there were four replications for each treatment; in experiment 4 there were five replications for each treatment.

increased uptake of native soil N in the plots receiving fertilizer N, compared to check plots receiving no fertilizer N.

Although rice yield usually depends on both soil nitrogen and added fertilizer nitrogen, little information is available on the relative contribution of each source of nitrogen to yield. This paper reports the relative uptake of each source of nitrogen and the relationship between yield and uptake in several field experiments utilizing labelled nitrogen fertilizer.

MATERIALS AND METHODS

Five field experiments on Crowley silt loam at the Rice Experiment Station were carried out during the period 1973–1976 in which labelled nitrogen fertilizer was used to determine the efficiency of nitrogen utilization by flooded rice^{2,4,5}. In these experiments, ammonium sulfate or urea labelled with either enriched or depleted ¹⁵N was used. Details of the experiments are given in Table 1. The use of labelled nitrogen made it possible to determine the amount of nitrogen in the grain and straw derived from the added fertilizer and that derived from the native soil nitrogen. This paper reports the relationship between yield (grain or straw) and total nitrogen uptake, soil nitrogen uptake, and labelled fertilizer nitrogen uptake.

RESULTS AND DISCUSSION

The correlation between yield and total nitrogen uptake in grain and straw is shown in Fig. 1. As is usually the case, when rice is grown on nitrogen deficient soils, there was a close correlation between yield of grain and total above-ground nitrogen content. Straw yield was also significantly correlated with total nitrogen uptake, but the degree of association was not as high. When grain yield was correlated with soil nitrogen uptake (Fig. 2), the association was significant but not as close as was the case for total nitrogen uptake. The association between straw yield and soil nitrogen uptake was not significant.

Grain yield as a function of labelled fertilizer nitrogen uptake showed a barely significant association (Fig. 3). Straw yield was not significantly correlated with labelled fertilizer nitrogen uptake. The poor relationship between yield and fertilizer nitrogen uptake is surprising in view of the dependence of yield on added fertilizer nitrogen and the close association between yield and total nitrogen uptake. As shown in Table 2, almost half of the grain yield in these experiments was dependent on fertilizer nitrogen. When the labelled fertilizer nitrogen uptake was correlated with the yield increase obtained from nitrogen fertilizer (in the experiments nitrogen was added at the rates of 56–112 kg/ha), a much closer association was apparent (Fig. 4).

Nitrogen is supplied to the plant uptake from 1) applied fertilizer N; 2) N mineralized from soil organic N; and 3) N₂ fixation. Studies reported by

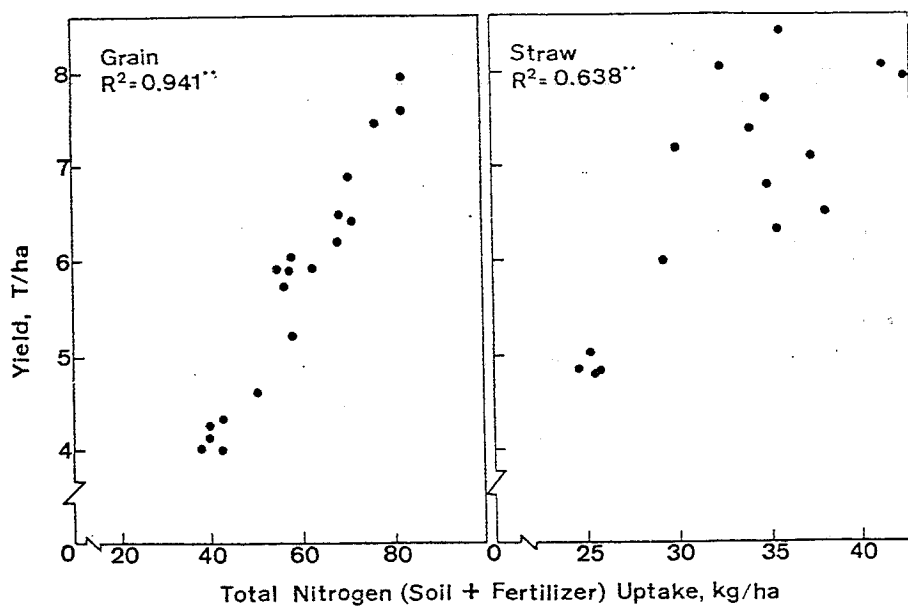


Fig. 1. Relationship between yield and soil + fertilizer nitrogen uptake.

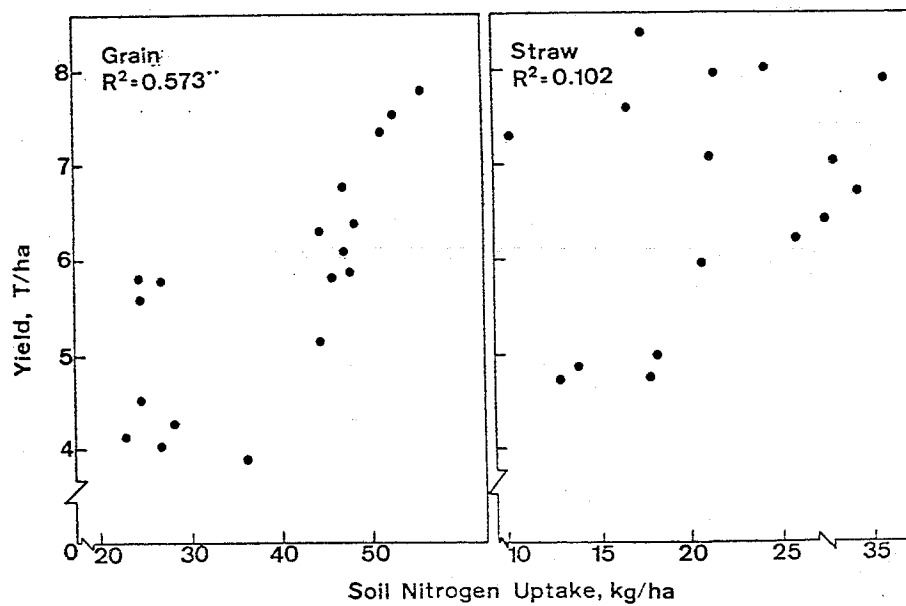


Fig. 2. Relationship between yield and soil nitrogen uptake.

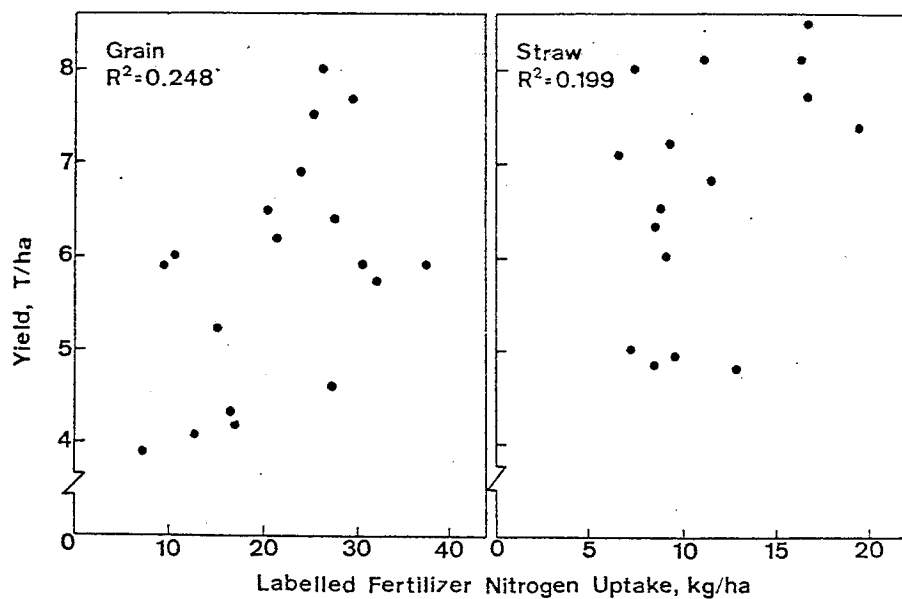


Fig. 3. Relationship between yield and fertilizer nitrogen uptake.

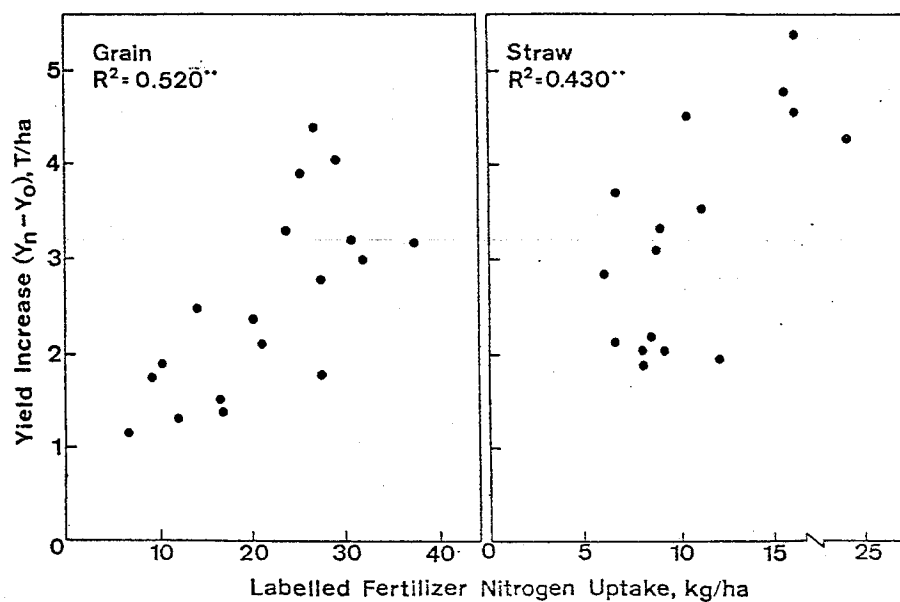


Fig. 4. Relationship between yield increase due to nitrogen fertilizer and fertilizer nitrogen uptake.

Table 2. Grain yields with and without nitrogen fertilizer and source of aboveground plant nitrogen

Experiment	Grain yield (T/ha)		Plant N uptake (kg/ha)	
	Without N	With N*	From fertilizer	From soil
1973	2.7	4.6	17.8	39.8
1974	3.6	7.3	38.3	74.2
1975a	2.8	4.3	27.9	41.1
1975b	2.7	5.8	53.7	39.8
1976	4.1	6.2	23.1	78.0
Average	3.2	5.6	32.2	54.6

* N added at 56–112 kg/ha.

Patrick and Reddy³ show the depletion of fertilizer N supply for the plant uptake within 4 weeks after application, which resulted in the dependence of rice plant on the native soil N, through the remaining growing period. Rapid depletion of fertilizer N in the soil probably resulted in poor relationship between yield and fertilizer N uptake. However, when these relationships were measured using conventional methods (total N uptake in the plots receiving fertilizer N minus total N uptake in the plots receiving no fertilizer N), significant relationship between fertilizer N uptake and grain yield was observed ($R^2 = 0.83$). Application of fertilizer N established good vegetative growth and root system, which aided in the removal of larger proportions of native soil N, compared to the plots receiving no fertilizer N. Further studies are necessary to examine these relationships more closely, which may aid in conserving the fertilizers.

An examination of Figs. 1, 2, and 3 and Table 1 shows that approximately two-thirds of the nitrogen in the plant was derived from soil nitrogen and approximately one-third derived from fertilizer nitrogen.

CONCLUSION

The results of the correlation analysis of these five-field experiments show that grain yield was very closely associated with total nitrogen uptake, less closely associated with soil nitrogen uptake, and poorly associated with fertilizer nitrogen uptake. Fertilizer nitrogen was more closely associated with yield increase than with total yield of grain.

Received 14 March 1980

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