Nitrogen Rates in Single and Split Applications and Yield of Flooded Rice[1, 2]

José M. Lozano and Fernando Abruña[3]

ABSTRACT

Yields of rough rice increased from 3,830 to 7,950 kg/ha when N rates were increased from 0 to 224 kg/ha in one application. Rice yields increased from 3,830 to 8,210 kg/ha when N rates were increased from 0 to 112 kg/ha, used in two applications. Yields were not increased further by heavier applications of N. The N rates from the single applications did not affect yields of a subsequently planted rice crop that received no N fertilizer. The split applications, however, did increase yields of the following crop. In another experiment, applications of more than 112 kg of N/ha sharply increased damage by blast, when the fungus was not controlled by spraying, and limited yield response to N applications.

INTRODUCTION

Although about 200,000 tons are consumed yearly on the island, rice is not planted commercially in Puerto Rico. Recent studies by Vicente-Chandler et al. (15) have shown that high economic yields of rice can be obtained in Puerto Rico with all of the three types: short, medium and long grain.

The response of rice to N fertilization has been studied under various conditions throughout the world (1,3,4,5,6,7,9,10,11,12,13,14,16,17,18) with widely varying results. Rosers et al. (10) in Colombia found no response to N fertilization by the Bluebonnet 50 variety, while the IR 8 variety responded to 100 kg of N/ha. Sánchez et al. (12) in Peru found that the IR-8 variety responded significantly to applications of up to 480 kg of N/ha. In Puerto Rico, Ramírez et al. (8) found that three rice varieties grown with intermittent flooding on a Vertisol at Lajas responded strongly to the application of 224 kg of N/ha.

The present study determined the effect on rice yields of five N levels applied either at planting time or in two applications, and on the incidence of blast disease (*Piricularia oryzae,* Cav.).

MATERIALS AND METHODS

Two experiments were carried out at the Gurabo Substation in east central Puerto Rico. The soil is a Coloso clay, an Aeric Tropic Fluva-

[1] Manuscript submitted to Editorial Board November 21, 1979.

[2] Research conducted cooperatively between Agricultural Research, Science and Education Administration, USDA and the College of Agricultural Sciences, Mayagüez Campus, University of Puerto Rico.

[3] Research Assistant, Agricultural Experiment Sxation, College of Agricultural Sciences, Mayagüez Campus, University of Puerto Rico and Soil Scientist, Agricultural Research, Science and Education Administration, USDA, respectively.

quents, with a pH of 6.8 and a cation exchange capacity[4] of 33 meq/100 g of soil, and about 240 kg of exchangeable K/ha and a N content of 0.12%. Annual rainfall is about 1,600 mm with the wettest period from August to December.

During the pervious 6 years the experimental area had been planted continuously to rice (14 crops). Each crop received N at a rate of 120 kg of N/ha. All grain and straw had been removed from the plots. To crop out any residual N, just before the start of the experiments reported in this paper, the area was planted to two consecutive crops of rice that received no N.

The plots were 4 × 4 m. They were surrounded by dikes 1 m wide and 45 cm high to prevent movement of fertilizer from one plot to another. Before planting, 140 kg of K/ha and 40 kg of P/ha were incorporated into the upper 5 cm of soil. Rice of the medium grain Brazos variety was planted in all plots at the rate of 100 kg/ha in rows 20 cm apart.

Weeds were controlled by applying 20 L/ha of Propanil[5] just before permanent flooding. Insects were controlled by spraying periodically with Diazinon or Malathion. Rice blast (*Piricularia oryzae* Cav.) was controlled by spraying periodically with Benomyl. All plots were kept flooded after the rice plants were about 15 cm tall until 3 weeks before harvesting, when irrigation was discontinued and the soil allowed to dry out. The rice straw was removed from all plots at harvest time.

Nitrogen levels tested were 0, 56, 112, 168, 224 and 336 kg/ha applied as $(NH_4)_2SO_4$ either all at planting or half at planting and the remainder 45 days later at panicle initiation. All treatments were replicated four times in a randomized block design.

The first experiment was planted in March 1976 and harvested in July. All plots were then planted again to determine the residual effect of the N treatments. All plots received 75 kg of K and 40 of P/ha, but no N was applied.

A second experiment was planted in the same plots in October 1977 and harvested in February 1978. In this case in order for the researchers to study the effect of N levels on damage by rice blast, this disease was not controlled by spraying.

Leaf samples consisting of the third blade from the tip were taken in all plots 75 days after planting, when the rice started to bloom. Samples were analyzed for N, P, K, Ca, Mg and Mn with standard analytical procedures.

[4] By sum of cations.

[5] Trade names in this publication are used only to provide specific information. Mention of a trade name does not constitute a warranty of equipment or materials by the Agricultural Experiment Station of the University of Puerto Rico, nor is this mention a statement of preference over other equipment or materials.

The rice was harvested when the grain contained 20-22% moisture and was dried to 12% moisture.

RESULTS AND DISCUSSIONS

Figure 1 shows that there was a close correlation between N rates and rice yields when N was applied in one application at planting. Yields

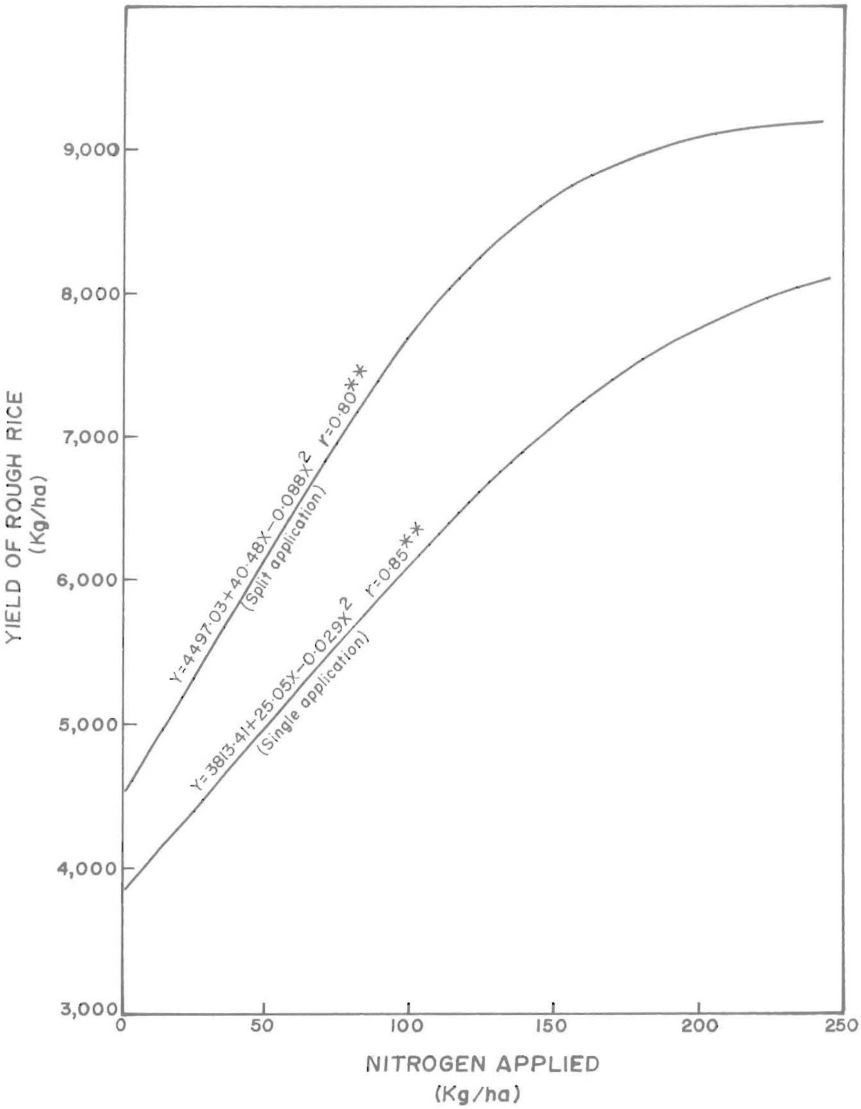

FIG. 1.—Response of flooded rice to nitrogen rates applied in single and split applications.

TABLE 1.—*Effect of nitrogen rates applied in single or split applications on yield and foliar composition of rice*

Nitrogen rate	All nitrogen applied at planting							Half of the nitrogen applied at planting and half 45 days after						
	Yield of rough rice	Foliar composition						Yield of rough rice	Foliar composition					
		N	P	K	Ca	Mg	Mn		N	P	K	Ca	Mg	Mn
Kg/ha	*Kg/ha*	*Per Cent*					*P/m*	*Kg/ha*	*Per Cent*					*P/m*
0	3,830	1.56	.22	1.34	.36	.27	314	3,830	1.56	.22	1.34	.36	.27	314
56	5,080	1.54	.21	1.45	.34	.26	406	7,485	1.66	.21	1.61	.33	.26	526
112	6,280	1.33	.17	1.37	.33	.27	357	8,210	1.66	.22	1.79	.30	.25	458
168	7,200	1.38	.19	1.52	.31	.25	471	8,380	1.85	.20	1.60	.33	.23	522
224	7,950	1.50	.19	1.58	.31	.24	375	8,700	1.91	.21	1.81	.31	.24	564
336	—	—	—	—	—	—	—	8,360	2.09	.20	1.74	.28	.27	822

[1] On a 12.5% moisture basis.

increased sharply with N rates up to the maximum rate tested: 224 kg/ha. Yields of rough rice increased from 3,830 kg/ha, when no N was applied, to 7,950 kg/ha with the application of 224 kg of N/ha.

When N applications were split, rice yields increased with N rates only up to 112 kg/ha. The split application was much more profitable, since only 112 kg of N/ha was required to attain the yield level obtained with 224 kg N/ha in one application at planting. These data are in agreement with the findings of other researchers (3,5,10,11).

Table 1 shows that N content of the rice leaves at panicle emergence was not modified by N rates applied in one application at planting. On the other hand, N content of the rice leaves was higher at all N rates applied in split applications and increased consistently with N levels. Walliham et al. (16) in Los Baños, Philippines, report that the optimum N content of rice leaves varies from 1.8% to 2.5% for different cultivars of long grain rice.

TABLE 2.—*Effect of N rates applied to the previous crop in single or split applications on the following rice crop*

Nitrogen level applied to previous crop	Yield of rough rice (kg/ha)	
	Nitrogen applied at planting	Half of N applied at planting and remainder 45 days later
(Kg/ha)		
0	3,920	3,920
56	3,780	4,900
112	3,600	4,100
168	3,970	4,470
224	3,950	4,470
336	—	4,700
	N.S.	N.S.

The Mn content of the leaves was higher when N was applied in split applications, but did not correlate with N levels. The other leaf constituents were not affected by N levels.

Table 2 shows that N rates applied in one or two applications to the previous rice crop did not significantly affect yields of the following crop which received no N. When N was applied in split applications higher yields were obtained in the following crop, which received no N.

The lack of residual N suggests considerable loss of applied N. Amer (2) has shown that N recovered from applied $(NH_4)_2SO_4$ decreased with increased levels and that losses were lower with deep placement than with a surface application. Heavy losses of N applied at the oxidized surface (1 cm on flooded rice) is caused by biological oxidation to NO_3 which is readily lost by leaching or biological reduction of NO_3 to gaseous N.

TABLE 3.—*Effect of nitrogen rates on rice yields and damage by the blast disease* (Piricularia oryzae *Cav.*)

Nitrogen rates	All nitrogen applied at planting		Half of nitrogen applied at planting and half 45 days later	
	Yields of rough rice[1]	Foliage affected by blast	Yields of rough rice[1]	Foliage affected by blast
Kg/ha	*Kg/ha*	%	*Kg/ha*	%
0	1,970 b[2]	2	1,970 b	2
56	3,260 a	5	3,685 a	10
112	3,580 a	5	4,143 a	20
168	3,685 a	12	3,558 a	40
224	3,610 a	15	3,328 ab	70
336	—	—	2,862 ab	85

[1] On a 12.5% moisture basis.

[2] Values followed by the same letters do not differ significantly. (Duncan's multiple range test).

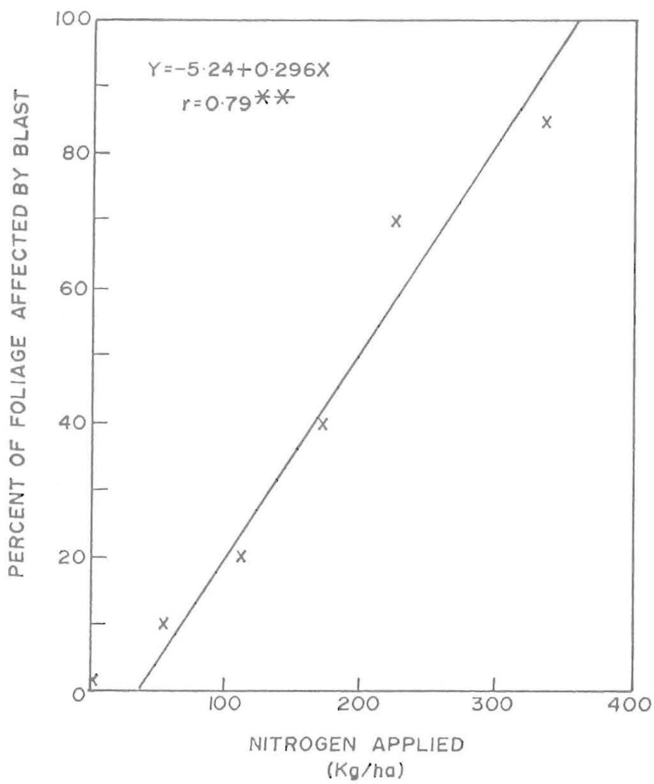

FIG. 2.—Relationship between nitrogen rates and percentage of rice foliage affected by blast (*Piricularia oryzae* Cav.)

The experiment planted in October 1977 was seriously affected by rice blast, to which the Brazos variety is susceptible, since no control measures were used. Table 3 shows that rice responded only to the application of 56 kg of N/ha whether applied in one or two applications. There was a steady increase in blast damage with increased N rates. Damage was greatest when N was applied in split applications. The steady supply of N when applied in split application apparently favored development of the fungus.

Figure 2 shows that there was a significant correlation between N levels and damage by blast. Sánchez et al. (11) in Peru obtained similar results with the IR 8 and Minabir varieties. It is evident that high N rates increase susceptibility to blast and can thus reduce yields or prevent response to higher N rates.

RESUMEN

El efecto de cinco niveles de nitrógeno sobre la producción de arroz se determinó cuando éstos se aplicaron en dos formas: 1) todo incorporado al suelo al sembrarse el arroz; 2) una mitad al sembrar y la otra a los 45 días cuando se inicia la formación de la espiga.

Cuando el nitrógeno se aplicó de una sola vez, el arroz aumentó en producción según se aumentó el nivel de nitrógeno hasta la máxima cantidad estudiada: 224 kg/ha. La producción aumentó de 3,830 kg/ha de arroz en cáscara cuando no se aplicó nitrógeno hasta 7,950 kg/ha cuando se aplicaron 224 kg/ha de nitrógeno. Sin embargo, cuando el nitrógeno se aplicó en dos dosis, se logró una producción similar con sólo 112 kg de nitrógeno/ha. Es evidente que resulta más rentable aplicar N en dos porciones.

Los niveles de nitrógeno aplicados a la siembra inicial no tuvieron efecto residual sobre una segunda cosecha que no recibió nitrógeno. Sin embargo, el dividir el nitrógeno en dos porciones produjo mayores rendimientos en la cosecha siguiente que cuando se aplicó de una sola vez a la cosecha anterior.

En otro experimento en el cual no se controló el hongo *Piricularia oryzae* hubo una relación directa entre el daño causado por el hongo y los niveles de nitrógeno. A medida que aumentaron las dosis de nitrógeno, aumentó el daño causado por la *Piricularia* evitando que el arroz respondiera a niveles que sobrepasaron los 56 kg/ha.

LITERATURE CITED

1. Ahichandani, C. T. and Patnaik, S., 1955. Mineralization action of lime on soil N in water logged rice soils, Int. Rice Comm. Newslt. 13: 11-3.
2. Amer, F., 1960. Evaluation of dry sub-surface and wet-surface ammonium sulfate application for rice, Plant Soil 13: 47-54.

3. Chatterjee, B. N. and Maiti, S., 1977. Timings and applications techniques for efficient use of fertilizers. Fert. Technol. 14: 55–9.
4. De Datta, S. K., Magnaye, C. P. and Moomaw, J. C., 1968. Efficiency of fertilizer nitrogen for flooded rice, Trans. Int. Cong. Soil Sci. 9th Cong., Australia, 4: 67–76.
5. Hall, V. L., Sims, J. L. and Johnston, T. H., 1968. Timing of nitrogen fertilization of rice. II. Culm elongation as a guide to optimum timing of application near midseason, Agron. J. 60: 450–3.
6. Mikkelsen, D. S. and Finfrock, D. C., 1957. Availability of ammoniacal nitrogen to lowland rice as influenced by fertilizer placement, Agron. J. 49: 296–300.
7. Rajale, G. B. and Prasad, R., 1975. Nitrogen and water management for irrigated rice, Riso 24(2): 117–25, New Delhi, India.
8. Ramírez, C. T., Abruña, F., Lozano, J., and Vicente-Chandler, J., 1975. Effect of fertilizer on yields of three varieties of rice at two locations in Puerto Rico, J. Agri. Univ. P.R. 56 (1): 1–4.
9. Ramírez, G. E. and Sánchez, P., 1971. Factores que afectan la eficiencia de utilización de nitrógeno en el arroz bajo riego intermitente, Prog. Rac. Arroz Inf. Tec. 59.
10. Rosero, M. J. and Moreno, P., 1970. Resultados preliminares sobre fertilizactión del cultivo del arroz en Aracata, Magdalena, Prog. Nac. Arroz, ICA. Palmira, Colombia.
11. Sánchez, P. A. and Calderón, M. V., 1971. Timing of nitrogen applications of rice grown under intermittent flooding in the coast of Peru, Int. Symp. Soil Fert. Eval. Proc. 1: 595–602.
12. ——, 1972. Nitrogen fertilization and management in tropical rice, N. C. Agri. Exp. Stn. Bull. 213.
13. Sims, J. L. and Blackman, B. G., 1967. Predicting nitrogen availability to rice: Assessing available nitrogen in silt loams with different previous year crop history, Soil Sci. Soc. Am. Proc. 31: 676–80.
14. Tusnum, M. E. and Patrich, Jr. W. A., 1971. Nitrogen transformations in water logged soils, La. Agri. Exp. Stn. Bull. 657 Baton Rouge, La.
15. Vicente-Chandler, J., Abruña, F., Lozano, J., Silva, S., Rodríguez, A., and Ramírez, C. T., 1977. Cultivo intensivo y perspectivas del arroz en Puerto Rico, Bol. 250, P.R. Exp. Agri. Esta.
16. Wallihan, E. F., Moomaw, J. C., and De Datta, S. K., 1974. Variable optimum concentrations of nitrogen in rice plants, Soil Sci. 118 (4): 263–6.
17. Wells, B. R. and Schockley, P. A., 1975. Conventional and controlled-released nitrogen sources for rice, Soil Sc.
18. Westfall, D. G., 1969. The efficiency of applied N in rice producing soils, Rice J. 72 (7): 66–7.