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Effect of integrated nitrogen application and spacing on yield of rice (*Oryza sativa*) in foot-hill soils of West Bengal

S.K. GUNRI[1], S.K. PAL[2] AND A. CHOUDHURY

North Bengal Campus, Bidhan Chandra Krishi Viswavidyalaya, Cooch Behar, West Bengal 736 165

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ABSTRACT

The effect of integrated use of fertilizer nitrogen along with *Gliricidia* leaves @ 10 tonnes/ha as green-manure and spacing was examined in a field trial with rice (*Oryza sativa* L.) during the wet season of 1999 and 2000. Application of green-leaf manure improved yield attributes, grain and straw yields of rice. Each unit increase in N level led to significant increase in yield-attributing characters and yield of rice. The maximum grain yield was recorded with the highest level of N. The nitrogen-use efficiency and apparent nitrogen recovery (%) were significantly higher at lower level of N and decreased significantly with increasing N levels. Closer row spacing (15 cm × 15 cm) proved better in grain and straw yields of rice, nitrogen-use efficiency and nitrogen uptake than the wider row spacing (20 cm × 15 cm).

Key words : Fertilizer N, Green leaf manure, Rice Yield, Spacing

There is a wide gap between production and consumption of nitrogen fertilizers and considerable interest has been aroused on supplementing the use of chemical fertilizers with renewable and low-priced organic sources of nutrients. Fertilizer N applied in conjunction with organic manure produced equivalent or even higher dry matter and N uptake than inorganic source alone (Saravanan *et al.*, 1987). Among the organic sources, green leaf manure is preferred particularly for low temperature zone, where rate of decomposition is low, as organic nitrogen source. Optimum plant density per unit area is an important factor needed for realizing higher yield (Balasubramaniyan and Palaniappan, 1991). Hence present investigation was conducted to evaluate the effect of fertilizer N in conjunction with green leaf manure and spacing on rice yield in an Entisol of foot-hills agro-climatic region of West Bengal representing resource-poor farming condition and light-textured acid soil with high rainfall.

MATERIALS AND METHODS

The field experiment was conducted at North Bengal Campus, Bidhan Chandra Krishi Viswavidyalaya, Pundibari, during the wet seasons (May–September) of 1999 and 2000 under lowland irrigated condition. The soil was sandy loam, classified taxonomically as Typic Udipsamment, low in available N (136 and 120 kg/ha), high in available P (50 and 54 kg/ha), medium in available K (168 and 161 kg/ha), total N (2,760 and 2,600 kg/ha), with pH 5.6 and 5.7 in 1999 and 2000 respectively. The organic carbon content, electrical conductivity and cation-exchange capacity were 14.0 g/kg, 0.042 dS/m and 10.46 c mol (p^+)/kg respectively. The experiment was laid out in split split-plot design with 3 replications. The main plot treatments included without and with green leaf manure as *Gliricidia maculata* leaves (2.05% N on dry weight basis) @ 10 tonnes/ha. Six levels of fertilizer N as sub-plot treatments were 0,40,80,100,120, and 140 kg N/ha. Two spacings, viz. 15 cm × 15 cm and 20 cm × 15 cm, were adopted as sub-plot treatment.

Nitrogen was applied in 3 equal splits, one-third as basal, one-third at active tillering stage and rest one-third at flowering stage. A uniform basal dose of 50 kg P_2O_5 and 50 kg K_2O/ha was applied through single superphosphate and muriate of potash respectively. Twenty-four days old seedlings of rice var. 'Ajoya' ('IET 8585') were transplanted 4 days after green-manure addition.

Mature plants were harvested and dry weight of grain and straw were recorded. Grain and straw samples were analysed for N content (Jackson, 1973). Nitrogen-use efficiency and apparent recovery (%) were computed by

Present address: [1] Regional Research Station (Red and Laterite Zone), BCKV, Jhargram, West Midnapur, West Bengal 721 507; [2]AICRP on Water Management, BCKV, Gayeshpur, Nadia, West Bengal 741 234

Table 1. Influence of integrated nitrogen management and spacing on yield attributes and yield of rice

Treatment	Length of panicle (cm)			Panicle number/m²			Number of filled grains/pancile			1,000-grain weight (g)			Grain yield (tonnes/ha)			Straw yield (tonnes/ha)			Harvest index (%)		
	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean
Organic N																					
Control	27.0	27.4	27.2	222	223	222	81.4	82.3	81.9	20.7	26.1	26.8	3.49	3.53	3.51	5.39	5.95	5.67	39.3	38.9	39.1
Green leaf manure	27.1	27.6	27.4	226	227	227	85.0	87.1	86.1	26.1	26.6	26.3	4.01	4.03	4.02	5.86	5.71	5.79	40.4	40.4	40.4
CD (P = 0.05)	NS	NS		0.5	1.5		2.41	0.79		NS	0.2		0.02	0.04		0.02	0.04				
Inorganic N																					
N_0	24.6	25.0	24.8	187	187	187	62.1	61.0	61.6	25.5	25.4	25.4	2.36	2.35	2.36	3.24	3.29	3.27	42.9	42.9	42.9
N_{40}	25.4	25.7	25.6	213	215	214	81.6	83.8	82.7	26.1	26.2	26.1	3.22	3.29	3.26	4.79	4.99	4.89	40.0	39.8	39.9
N_{80}	26.3	27.5	26.9	227	228	227	86.9	88.4	87.7	26.2	26.7	26.5	4.01	4.02	4.02	5.99	6.05	6.02	40.0	39.6	39.8
N_{100}	28.4	28.8	26.6	234	236	235	88.7	90.4	8.6	26.2	26.7	26.5	4.19	4.23	4.21	6.41	6.54	6.48	39.6	39.3	39.5
N_{120}	28.7	28.9	28.8	238	240	239	89.7	92.1	90.9	26.3	26.5	26.4	4.32	4.36	4.34	6.60	6.63	6.62	39.4	40.0	39.7
N_{140}	29.0	29.2	29.1	243	244	244	90.2	92.2	91.2	26.3	26.5	26.4	4.39	4.41	4.40	6.70	6.78	6.74	39.6	39.3	39.8
CD (P=0.05)	0.44	0.67		1.7	1.4		1.56	1.08		0.03	0.4		0.05	0.08		0.09	0.13				
Spacing (S)																					
S_1 (15 cm × 15 cm)	27.1	27.6	27.4	224	225	225	83.4	84.7	84.1	26.1	26.3	26.2	3.82	3.85	3.84	5.73	5.79	5.76	40.0	39.6	39.8
S_2 (20 cm × 15 cm)	27.0	27.3	27.2	223	224	224	83.1	84.6	83.9	26.1	26.3	26.2	3.67	3.71	3.69	5.51	5.64	5.58	40.2	39.8	40.0
CD (P=0.05)	NS	NS		1.0	0.6		NS	NS		0.2	NS		0.02	0.04		0.02	0.06				

NS, Not significant

difference method.

RESULTS AND DISCUSSION

Yield-attributing characters

Application of green-leaf manure significantly affected the number of panicles/m² and number of filled grains/panicle (Table 1). This was probably due to continuous supply of phased release of mineral N from green manure into the soil solution matching the required absorption rate of rice plant (Srinivasalu Reddy, 1988). However, length of panicle was not significantly influenced on its application. Increasing the levels fertilizer N significantly improved all the yield-attributing characters studied. The effects of N on yield parameters is primarily a function of assimilate accumulation and in turn facilitating higher plant N assimilation with adequate supply of photosynthates to grain (Krishna Kumar, 1986). Barring few exceptions, all the parameters increased significantly up to 120 kg N/ha. Further increase in N levels could not bring about any significant changes. In both the years, neither panicle length nor number of filled grains/panicle were affected by plant density. The results supported the findings of Balasubramaniyan and Palaniappan (1991).

Yield and harvest index

The beneficial effect of green-leaf manure could be seen in grain and straw yields of rice in both the years (Table 1). Green manuring improved grain yield by 14.9 and 14.2% over its control in the respective years. Application of *Gliricidia* leaves increased straw yield by 0.47 tonne/ha in first year and 0.24 tonne/ha in the second year. Rao and Sitaramayya (1997) also reported similar results. Grain and straw yields of rice increased significantly with the addition of fertilizer N. The result also revealed that the effect of 140 kg N/ha was at par with 120 kg N/ha in 2000. Application of 140 kg N/ha coupled with green-leaf manure @ 10 tonnes/ha recorded the highest grain and straw yields of 4.58 and 6.91 tonnes/ha in 1999 and 4.60 and 6.78 tonnes/ha in 2000 respectively (data not presented). Closer row spacing (15 cm × 15 cm) was found to be superior by registering higher rice grain and straw yields to wider spacing (20 cm × 15 cm). Chandrakar and Khan (1981) also reported similar findings.

In both the years, green manuring improved the harvest index (Table 1). However, with the increase in the level of N application, in general, a decreasing trend in harvest index up to 100 kg N/ha and thereafter a increasing trend was noticed. This was due to utilization of assimilates with increase in N supply more towards the development of dry matter than the grain. The results also revealed that higher plant density reduced harvest index

Table 2. Total N uptake, apparent N recovery and N-use efficiency in rice

Treatment	Total N uptake (kg/ha)			Apparent N recovery (%)			Nitrogen-use efficiency (kg grain/kg N)		
	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean
Organic N									
Control	61.8	63.9	62.9	39.9	31.9	35.9	16.4	16.9	16.7
Green-leaf manure	79.7	77.9	78.8	43.7	35.4	39.6	20.3	20.6	20.5
CD (P = 0.05)	1.2	0.6		NS	NS		1.2	NS	
Inorganic N									
N_0	38.6	44.6	41.6						
N_{40}	57.9	59.8	58.9	48.3	38.1	43.2	21.6	23.3	22.5
N_{80}	74.0	71.4	72.7	44.3	33.6	3.0	20.8	20.9	20.9
N_{100}	80.3	76.8	78.6	41.7	32.3	37.0	18.4	18.8	18.6
N_{120}	84.8	83.3	84.1	38.5	32.3	35.4	16.4	15.9	16.2
N_{140}	89.1	89.4	89.3	36.1	32.0	34.1	14.5	14.7	14.6
CD (P=0.05)	1.5	1.5		2.4	3.1		0.6	1.5	
Spacing (S)									
S_1 (15 cm × 15 cm)	72.4	73.7	73.1	42.2	34.3	38.3	18.6	19.4	19.0
S_2 (20 cm × 15 cm)	69.2	68.1	68.7	41.47	33.0	37.2	18.1	18.1	18.1
CD (P=0.05)	1.0	0.7		NS	NS		0.4	0.7	

N_0, N_{40}, N_{80}, N_{100}, N_{120}, N_{140}, 0, 40, 80, 100, 120 and 140 kg N/ha respectively
NS, Not significant

compared with lower plant density which might be due to more straw yield at closer row spacing particularly during rainy season (Wagh and Thorat, 1987).

Nitrogen uptake, apparent recovery and N-use efficiency

The N uptake increased significantly with the application of green-leaf manure, which might be attributed to improvement of soil environment and better N availability over control (Table 2). However, the grain, straw and total N uptake by rice increased significantly with levels of N owing to production of higher amount of biomass. The highest N level recorded the maximum N uptake. Again, higher biomass production associated with closer row spacing recorded higher N uptake than wider row spacing.

Application of *Gliricidia* leaves improved apparent N recovery (ANR), but was comparable with control in the both the years. With the levels of fertilizer N, apparent N recovery (ANR) (%) varied from 36.1 to 48.3 and 32.0 to 38.1 in 1999 and 2000 respectively (Table 2). The highest ANR was recorded with 40 kg N/ha and declined with the increase in the levels of fertilizer N. Higher amount of N loss through leaching and denitrification associated with higher N level might have led to lower utilization of applied N and thereby decreased ANR in wetland rice. However, there was no significant effect of row spacing on ANR (%).

Nitrogen-use efficiency (NUE) was always higher in green manure-treated plot than the control (Table 2). It decreased significantly with the increase in the level of fertilizer N. Closer row spacing proved to be superior to wider row spacing with respect to the efficiency of N utilization by rice grain (kg rice produced/kg nitrogen absorbed).

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