

Green-manuring in Combination with Fertilizer Nitrogen on Rice under Double Cropping System in an Alluvial Soil

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Abstract : *The direct and carryover effect of green-manuring on upland rice under rice-wheat rotation in a light textured alluvial soil was studied for two years. Beneficial effect of green-manuring alone and in combination with fertilizer N on grain yield and uptake of N, P and K by rice and also availability of these nutrients in soil was noticed. Green-manuring plus 40 kg N/ha compared well with 120 kg N/ha alone. Transplanting rice just after ploughing down the green-manure crop or after 15 days' time allowed for decomposition did not make significant difference. Residual fertility due to green-manuring increased yield of the succeeding wheat crop significantly. (Key words: Green-manuring; nitrogen fertilization; rice-wheat cropping sequence; nutrient availability in soil)*

In a country like India, the combined use of organic manures and chemical fertilizers is essential for sustaining soil productivity. Tiwari *et al.* (1978) reported that in a rice-wheat cropping sequence, green-manuring can be practised as a catch crop after the harvest of wheat for manuring the subsequent rice in a partially reclaimed saline sodic soil. The present investigation was conducted to study the direct and residual effect of green-manuring on crop yield, accumulation of nutrients in soil and availability of such nutrients in a light textured alluvial soil of Kanpur district.

EXPERIMENTAL

Field experiments were conducted at Government Fertilizer Research Station, Pura, of Chandra Shekhar Azad University of Agriculture and Technology, in an alluvial soil (pH 7.2, organic C 0.285-0.325 %, CEC 14.5-16.0 m.e.% and 82-105, 6-8 and 115-128 ppm available N, P₂O₅ and K₂O, respectively) for two consecutive years commencing from 1975-76. During 1975-76, for rice there were 8 treatments consisting of 4 levels of nitrogen (0, 40, 80 and 120 kg N/ha) in presence and absence of green-manuring. During 1976-77, there were 12 treatments involving all combinations of the above 4 levels of N along with no green-manuring (fallow) and two types of green-manuring preceding transplantation of rice, namely, allowing 15 days time (GM₁) for decomposition of green-manure ploughed *in situ* and (ii) no time lapse (GM₂).

Dhaincha (Sesbania aculeata) was sown during both the years as green-manure crop with pre-sowing irrigation and basal application of N and P @ 20 and 40 kg/ha, respectively. In each case 50-day old crop was turned in and rice (cv. IET-1991) was

transplanted. Basal application of potassium and zinc sulphate to rice was done @ of 30 and 15 kg/ha, respectively. Fallow treatments further received P @ 40 kg/ha as this quantity of phosphate had already been applied for raising green-manure in case of other treatments. Wheat (var. Sonalika) was grown after harvesting rice crop in order to study the residual effect of green-manuring at varying levels of nitrogen applied to rice.

Plant samples of rice were collected at tillering stage and analysed for N and P contents by colorimetric methods as described by Linder and Harley (1942) and Jackson (1967), respectively and for K by flame photometer (Piper 1950). Available N, P and K in soil samples collected after the harvest of rice were determined by standard methods (Jackson 1967).

RESULTS AND DISCUSSION

Grain yield of rice : Green-manuring raised the grain yield of rice significantly, and there was 29.0 and 40.0% increase over control during 1975-76 and 1976-77, respectively. However, these increases were definitely lower than those observed by Tiwari *et al.* (1978) under partially reclaimed saline sodic soil conditions. Transplanting of rice just after turning in the green-manure crop or allowing 15 days' time for decomposition of organic matter did not make any significant difference in grain yield.

Grain yield improved significantly up to the highest level of N application. The mean increase due to highest N level as compared to control (no N) was of the order of 66.4 and 87.7% during 1975-76 and 1976-77, respectively.

Interaction effect of green-manuring and nitrogen was found to be positive and significant. Nitrogen fertilization at 120 kg/ha brought about significant increase in grain yield under fallow and the response during both the years was linear (Fig. 1). Responses to N after green-manuring were also significant up to the highest level, but the nature of response curve as exhibited in fig. 1 was

quadratic in both the years. Optimum dose of fertilizer N per ha after green-manuring was also worked out and it was found to be 101 kg during 1975-76 and 110 and 117 kg during 1976-77 in relation to two types of green-manuring practices. A point of interest noticed in both the years was the yield level of rice grain recorded with an application of 40 kg N/ha plus green-manuring which was comparable to the yield obtained with a dose of 120 kg N/ha after fallow.

During 1975-76, responses to N at 80 and 120 kg N per hectare were higher after fallow as compared to that after green-manuring. In 1976-77 responses only to highest level of N after green-manuring were lower as compared to that after fallow. Relatively poor fertility of the experimental field during 1976-77 may be one of the reasons for the higher response even after green-manuring. Observations made earlier by Tiwari *et al.* (1978) corroborate the findings of the present investigation.

Uptake and utilization of nutrients by rice crop : It is observed from the data presented in table 1 that the mean concentration of N, P and K at tillering stage was significantly higher with green-manuring than that under fallow treatment in both the years of experimentation. The uptake of nutrients in grain and straw also increased considerably with green-manuring (Fig. 2) and they followed the trend similar to grain yield.

Increasing supply of nitrogen further increased the concentration of N, P and K in the plants at tillering stage (Table 1) and their uptake in grain and straw (Fig. 2). The mean concentrations of these nutrients in plant and their uptake in grain and straw were highest at highest level of N applied and lowest at control. It is of interest to mention that at a 40 kg N/ha after green-manuring the concentration of N, P and K in plant at tillering stage was at par with that under 120 kg/ha N without green-manuring. Favourable effect of green-manuring and nitrogen fertilization on the uptake of nitrogen has been reported by Mitra and Singh (1959), Boawn *et al.* (1963), Debnath and Hajra (1972) and Tiwari *et al.*

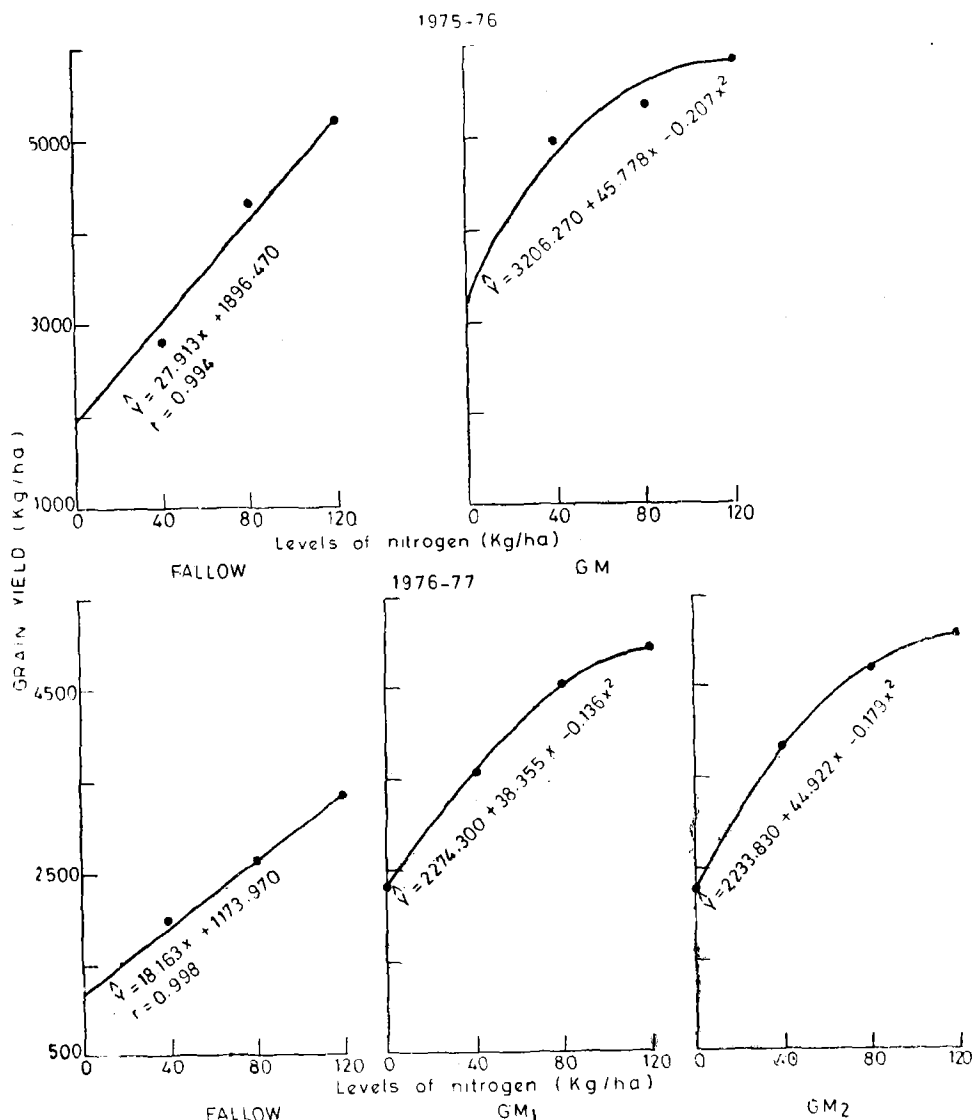


Fig. 1. Response equations as influenced by green-manuring and nitrogen fertilization

(1978). Increased concentration of P as a result of green-manuring and N application has been reported by Kute and Mann (1969). The total removal of P at 40 kg N/ha after green-manuring was always higher than that under 120 kg N/ha without green-manuring. The favourable effect of green-manuring on uptake and utilization of P by the crop was perhaps due to the liberation of organic anions

and hydroxy acids such as tartaric, citric, malonic and malic acids during the decomposition of organic matter which could have complexed or chelated Fe, Al, Mg and Ca and prevented these cations from reacting with phosphate ions to form insoluble phosphate, thereby improving the availability of P in soil, and subsequently increasing its uptake by the crop plants.

TABLE 1
Effect of green-manuring at varying levels of N on nutrient contents of rice at tillering stage

Treatment	1975-76				Mean	1976-77				Mean
	Levels of N (kg/ha)					Levels of N (kg/ha)				
	0	40	80	120		0	40	80	120	
	Nitrogen (%)									
Fallow	1.22	1.24	1.72	1.92	1.52	1.37	1.72	1.97	1.58	
GM ₁	1.27	1.93	1.97	2.12	1.82	1.93	2.08	2.14	1.88	
GM ₂	1.25	1.59	1.85	2.02	—	1.92	2.12	2.13	1.88	
Mean						1.74	1.76	2.07	—	
	Phosphorus (%)									
SEm±										
CD 5%										
	Potassium (%)									
SEm±										
CD 5%										

GM₁ = Transplanting rice after 15 days of turning in green-manure crop
 GM₂ = Transplanting rice soon after turning in green-manure crop

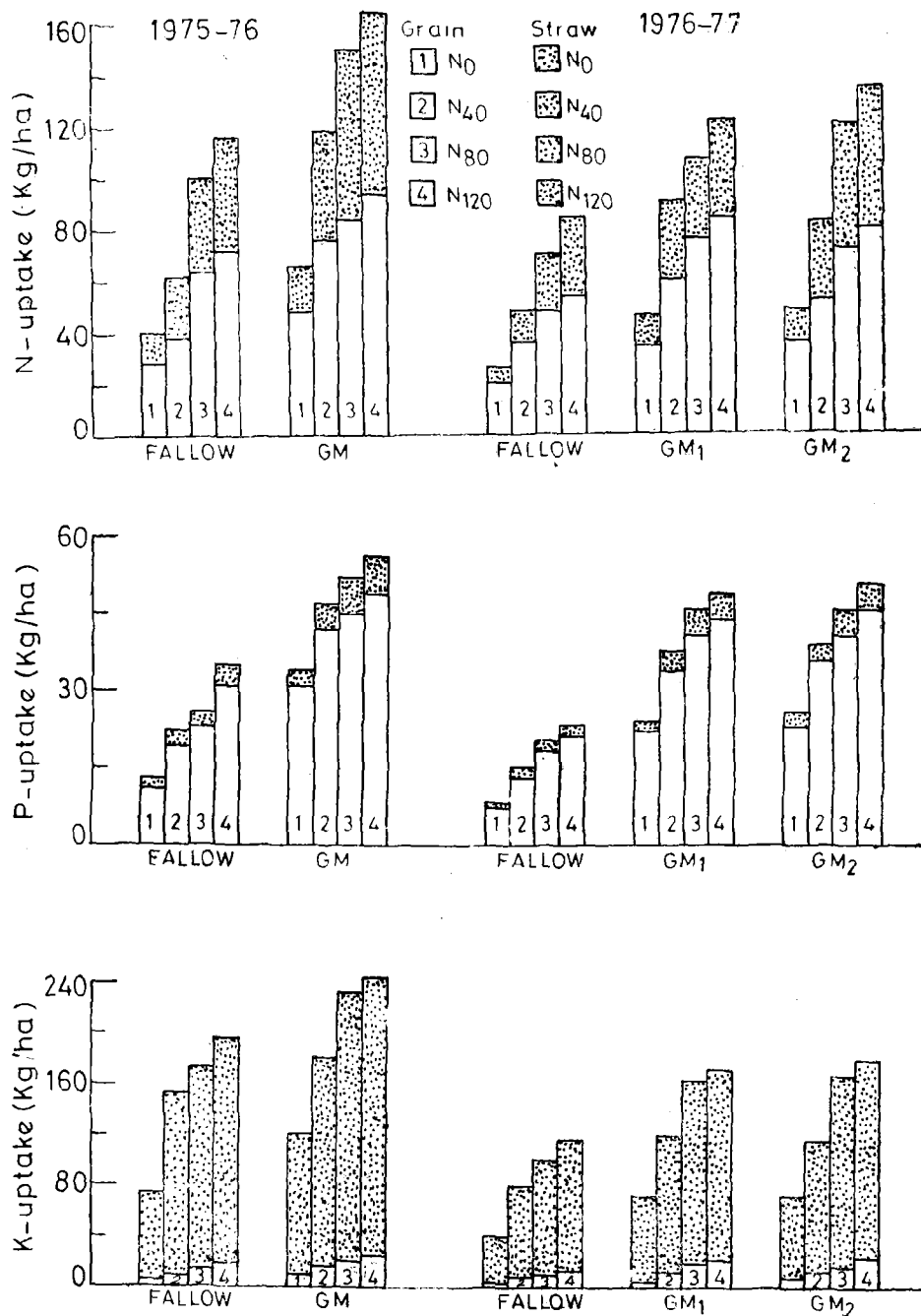


Fig. 2. Uptake of nutrients by rice at various levels of nitrogen after fallow and green-manuring

Beneficial role of green-manuring on the uptake and utilization of K by the crop appears to be quite possible as most of the K in plants remains in inorganic form. The decomposing organic matter might also have solubilised native potassium of the soil. Kute and Mann (1969) and Debnath and Hajra (1972) also reported increased availability of K in soil and its higher uptake by crop after green-manuring.

Availability of nutrients in soil : A perusal of the data presented in table 2 clearly indicates that after green-manuring there was 51.8 and 61.3% increase in available N

content of soil during 1975-76 and 1976-77, respectively. Green-manuring also increased the available P and K contents of the soil, the extent of increase being 107 and 65% in case of available P and 75 and 51% in respect of available K during the two years. It may be mentioned that the differences between the two practices of green-manuring which were tested during 1976-77 only, were not significant.

Application of fertilizer N improved significantly the available N, P and K contents of the soil (Table 2). As compared to control

TABLE 2

Effect of green-manuring at varying levels of fertilizer nitrogen on available nutrient (ppm) in soil after harvest of rice

Treatment	1975-76					1976-77				
	Levels of N (kg/ha)				Mean	Levels of N (kg/ha)				Mean
	0	40	80	120		0	40	80	120	
<i>Available N</i>										
Fallow	93	104	127	132	114	75	101	131	152	115
GM ₁	142	163	181	205	173	142	164	208	230	186
GM ₂						140	166	205	227	185
Mean	118	134	154	169	—	119	144	181	203	—
<i>Available P</i>										
Fallow	6	9	10	10	9	6	8	11	13	9
GM ₁	11	18	20	22	18	10	13	18	21	15
GM ₂						10	12	19	21	15
Mean	8	13	15	16	—	9	11	16	18	—
<i>Available K</i>										
Fallow	161	170	180	182	173	148	153	160	166	157
Gm ₁	290	301	300	315	302	220	232	245	245	236
Gm ₂						225	230	245	250	238
Mean	226	236	240	249	—	198	205	217	220	—

there was 14, 31 and 43% increase in available N content of soil at harvest during 1975-76 and 21, 52 and 71% in 1976-77 at 40, 80 and 120 kg levels of nitrogen application, respectively. Increasing doses of nitrogen significantly promoted the available P and K contents of the soil at all the stages of plant growth. Highest P and K contents as a result, were registered at highest N application and the lowest under no nitrogen treatment.

Data presented in table 2 further show a very pronounced effect of green-manuring and nitrogen interaction on the availability of N, P and K in soil. In general, the maximum availability of these nutrients was registered at the highest level of nitrogen application after green-manuring and the minimum at no-nitrogen under fallow. This trend was observed during both the years.

A number of workers have reported increased availability of N in soil after green-manuring (Mitra & Singh 1959; Boawn *et al.* 1963; Debnath & Hajra 1972). Significant improvement in available P content of red sandy loam and black clay loam has been reported by Prabhakar *et al.* (1972) after the treatments of green manure in an incubation study. Kute and Mann (1969) and Debnath and Hajra (1972) have also reported increased availability of P and K in soil after green-manuring.

Carry-over effect on wheat: It is observed from the data in table 3 that the yield of wheat increased significantly due to residual fertility remaining after harvest of the rice crop. Effect of green-manuring, nitrogen fertilization and their interaction was found to be significant on grainyield. As compared to fallow there was 54.1 and 101.3% increase after green-manuring during the years 1975-76 and 1976-77, respectively.

Response in terms of kg wheat grain per kg N applied to rice after fallowing and after green-manuring, respectively ranged from 0.9 to 5.0 and 8.7 to 11.8 during 1975-76 and 2.7 to 4.6 and 4.7 to 10.5 in

1976-77. These results indicated that in a rice-wheat rotation, green-manuring to rice would be beneficial not only in enhancing its grain yield but also in promoting the yield of succeeding wheat crop.

TABLE 3

Residual effect of green-manuring on wheat

Treatment	Yield without N (Q/ha)	Response to N at			Mean
		N ₄₀	N ₈₀	N ₁₂₀	
(a) 1975-76					
Fallow	16.75	0.35	2.05	6.00	18.85
Response (kg grain per kg N)	—	0.9	2.6	5.0	—
Green-manuring	23.10	4.70	8.70	10.40	29.05
Response (kg grain per kg N)	—	11.8	10.9	8.7	—
	<i>GM</i>	<i>N</i>	<i>GM</i> × <i>N</i>		
SEm ±	0.28	0.39	0.57		
CD 5%	0.83	1.14	1.66		
(b) 1976-77					
Fallow	7.17	1.08	2.48	5.55	9.45
Response (kg grain per kg N)	—	2.7	3.1	4.6	—
GM ₁	13.65	2.25	7.37	11.57	18.95
Response (kg grain per kg N)	—	5.6	9.2	9.6	—
GM ₂	13.87	1.87	6.48	12.55	19.09
Response (kg grain per kg N)	—	4.7	8.1	10.5	—
	<i>GM</i>	<i>N</i>	<i>GM</i> × <i>N</i>		
SEm ±	0.25	0.29	0.50		
CD 5%	0.71	0.83	1.44		

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