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Rice response to manures and fertility levels in Kosi region of Bihar, India

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ABSTRACT

A field experiment was conducted during the rainy (*kharif*) season of 2002 and 2003 at RRS, Agwanpur, Saharsa (Bihar), to study the effect of manures and fertility levels on the production potential of rice (*Oryza sativa* L.) crop. Green manuring with *dhaincha* [*Sesbania cannabina* (Retz.) Pers.] gave significantly higher yield attributes, grain and straw yield, nutrient uptake, apparent nutrient recovery (%) & agronomic nutrient-use efficiency with low production efficiency of nutrients, followed by other manurial treatments. Higher economic return was received with *Vigna radiata* green manure treatment due to its bonus yield of pulse grain. Optimum fertility level (120 : 60 : 30 kg/ha of N, P_2O_5 and K_2O) recorded higher response than lower levels with higher nutrient uptake, lower apparent nutrient recovery (%), lower agronomic nutrient use efficiency and lower production efficiency of nutrients. Higher benefit : cost ratio was recorded maximum by application of optimum fertility level. The interaction between organic and inorganic sources of nutrients was found significant and saved 66 per cent N : P_2O_5: K_2O in *Sesbania cannabina* and 33 per cent in *Vigna radia* as well as *Crotalana juncea* green manures, respectively. Application of FYM @ 10 t/ha also saved 33 per cent of nutrients. Nata Mahsuri (MTU-7029), a high yielding semi dwarf variety of rice was taken up for the experimentation. Significant nutrient balance due to application of FYM and optimum fertility level has been recorded compared to others and all other green manurial and lower fertility levels showed lower balance of nutrients, while the plots received no nutrients showed a negative balance of nutrients (N, P_2O_5 and K_2O).

Key words : Manures, Fertility levels, Yield, B:C, Nutrient uptake. Apparent fertilizer recovery, Agronomic nutrient use efficiency, Production efficiency of nutrients, Soil nutrient status.

INTRODUCTION

Neither the organic manures alone nor the mineral N, P and K fertilizers can sustain high productivity under modern intensive cropping system, where the nutrient turnover in the soil-plant system is quite high. Several researchers have reported decline in rice production due to deficiency of macro and micro nutrients in soil due to use of only inorganic fertilizers and suggested that integrated use of organic and inorganic becomes imperative in increasing the productivity of cereal crops and sustaining soil health (Modgal *et al.* 1995 and Prasad *et al.* 1995). Kosi zone is a major rice growing area of Bihar during rainy, winter as well as summer season and has adopted rice-rice system in wetlands and rice-wheat/ maize in mid uplands. Therefore, keeping all above facts, an investigation was carried out to know the effect of organic and inorganic fertilizers on the productivity, nutrient uptake, nutrient efficiency and nutrient status of soil in rice crop.

MATERIALS AND METHODS

A field experiment was conducted in *kharif* 2002 and 2003 at Regional Research Station, Agwanpur, Saharsa (Bihar) on sandy loam typic ustifluvent soil with pH 7.4 low inorganic carbon (0.30 %), available N 180 kg/ha, available P_2O_5 25.20 kg/ha and available K_2O 172 kg/ha. Treatments were laid out in a split plot design, keeping 5 organic manures viz. no organic manure, green manure of *Sesbania cannabina, Vigna radiata, Crotalaria juncea* and FYM @ 10 t/ha in main plots and 4 levels of fertility viz., 0 : 0 : 0, 40 : 20 : 10, 80 : 40 : 20 and 120 : 60 : 30 N : P_2O_5 : K_2O kg/ha in subplots with 3 replication. Seeds of *dhaincha* and sunnhemp were sown in plots before 50 days of rice transplantation, while mung was sown in first week of April after wheat harvest and FYM was incorporated one month prior to rice transplanting. All organics were buried properly during final field preparation. Half of N, whole P and K were applied at the time of puddling. Rest half N was applied in two equal splits, one fourth at maximum tillering stage and one fourth at panicle initiation stage. The "Nata Mahsuri" (MTU 7029) rice variety was used for the experimental purpose (50 kg seed/ha) and transplanted at 15 cm x 15 cm distance using 2-3 seedlings/hill in mid July during both the years. A thin layer of water (2-3 cm) was maintained during initial stage of seedlings establishment. Thereafter the water was raised to 5 cm and attempts were made to maintain this level upto milk dough stage and all other

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recommended agronomic practices were adopted for growing the crop.

RESULTS AND DISCUSSION

Nutrient added through organic sources

The various organic sources had added considerable amount of N, P and K in the soil. Maximum nutrient, were attributed through *Sesbania cannabina* and influenced the yield of rice crop accordingly (Table 1).

Yield attributes and yield :

As per perusal of data presented in table 2, the prickly sesban or *dhaincha* (*Sesbania cannabina*) green manure recorded significantly higher final plant height, effective tillers/m^2, grains/ear and grain weight/panicle than other manurial treatment. Green manure of *Vigna radiata*, *Crotalaria juncea* and application of FYM showed significant inferior response than *dhaincha* but superior over control and were at par among themselves. The rice grain and straw yield was also recorded significantly higher 51.54 q/ha and 64.43 q/ha, respectively by *dhaincha* green manure than other manurial treatments. However, application of *Crotalaria juncea* and FYM noticed similar yield to each other and significantly higher than *Vigna radiata. Vigna radiata* gave 5.08 q/ha of seed yield which influenced the economic return in positive. All manurial treatment showed significant superiority over control. The higher response due to various manurial treatments might be due to addition of extra nutrients (Table-1). Application of green manures and FYM also exploits the fixed nutrients of soil in available form and regulates its supply to the crop through

Table 1 : Total biomass, dry matter, nutrient content and addition by different organic manures (average of 2 years).

Organic manures	Biomass (t/ha)	Dry matter (t/ha)	Nutrient content (%)			Nutrient added (kg/ha)		
			N	P	K	N	P	K
Sesbania cannabina	25	4.95	1.40	0.32	1.50	69.30	15.84	74.25
Vigna radiata	15	2.94	1.20	0.25	0.98	35.30	7.40	28.80
Crotalaria juncea	18	3.60	1.15	0.24	1.20	41.40	8.64	43.20
FYM	10	6.50	0.65	0.18	0.80	42.25	11.70	52.00

Table 2 : Effect of manures and fertility levels on yield attributes, yield and B:C of rice (Pooled data of 2002 and 2003).

Treatment	Plant height (cm)	Effective tiller/m^2	Grain/ ear	Grain weight/ panicle (g)	Grain yield (q/ha)	Straw yield (q/ha)	B:C Rs/Re
Manure							
No Manure	71.16	173.79	159.00	2.01	35.43	44.28	1.71
Sesbania cannabina	83.17	238.66	213.30	2.31	51.54	64.43	2.33
Vigna radiata	79.39	223.69	195.69	2.14	44.94	59.60	2.58*
Crotalaria juncea	78.68	227.88	199.32	2.14	47.90	59.89	2.08
FYM	77.97	225.60	196.83	2.13	47.67	57.43	1.86**
CD (P=0.05)	2.00	2.54	3.82	0.11	1.78	2.22	0.09
NPK (kg/ha)							
0 : 0 : 0	65.76	165.16	149.17	1.88	30.69	38.37	1.35
40 : 20 : 10	75.79	207.37	177.15	2.14	43.75	54.68	2.27
80 : 40 : 20	83.44	240.89	222.15	2.27	52.40	65.50	2.51
120 : 60 : 30	87.31	251.95	230.57	2.33	55.95	69.94	2.52
CD (P=0.05)	4.32	3.21	5.51	0.05	0.91	1.14	0.04

*Included bonus yield of mung seed; **Higher input cost.

mineralization and prevents them from leaching and other losses (Yadav and Kumar, 1993; Verma *et al.* 1995; Singh *et al*. 1996). Application of FYM showed significantly lower response than green manures. It was due to immobilization of N. Effect of FYM shows significant response when it is applied for long term (Kumar 1994).

Like wise, the fertility level 120 : 60 : 30 (N : P_2O_5 : K_2O kg/ha) recorded significantly higher yield attributes than other fertility levels. However the final plant height with 80 : 40 : 20 and 120 : 60 : 30 recorded at par (Table-2). Significantly higher yield (55.95 q/ha grain & 69.94 q/ha straw) was recorded with optimum fertility (120 : 60 : 30 N : P_2O_5 : K_2O kg/ha) than other fertility level. These finding are conformity with those of Chaudhary and Thakuria (1996) and Dwivedi and Thakur (2000).

Higher benefit : cost were recorded with *Vigna radiata* manurial treatment (1.00 : 2.58) than others. This was due to bonus yield of pulse seed (5.08 q/ha) by *Vigna radiata*. Other manurial treatments viz. *Sesbania cannabina* and *Crotalaria Juncea* also recorded higher B : C than control and FYM. Application of FYM resulted poor B : C due to its higher input cost. Variation in B : C due to fertility levels were also noticed. Higher B : C was found with optimum fertility level followed by lower doses.

Interaction effect :

The interaction effect of organic manures and fertility levels on grain yield indicated significant response during the experimentation. *Sesbania cannabina* green manure in conjunction with 40 : 20 : 10 (N : P_2O_5 : K_2O kg/ha) recorded equivalent yield (50.33 q/ha) to optimum dose of fertility (51.03 q/ha). Application of FYM at 80 : 40 : 20 fertility level recorded at par yield to only application of 120 : 60 : 20 fertility level as inorganics. However, all green manures showed significantly higher response at 80 : 40 : 20 as compare to 120 : 60 : 30 (N : P_2O_5 : K_2O kg/ha) (Table-3). The result revealed that 33 to 66 per cent saving of inorganic fertilizers can be achieved through organic manures. However, a saving of 66 per cent nutrients has been noticed due to *Sesbania cannabina* treatment. Saving of nutrients from 25 to 50 per cent due to application of FYM and green manures in rice crop was reported by Prasad and Sinha (1995) and Dwivedi and Thakur (2000).

Nutrient uptake :

Green manuring through *Sesbania cannabina* recorded significantly higher amount of total nutrient uptake followed by other organic manures (Table 4) and all manures significantly surpassed over no manurial treatment. Higher fertility level resulted significantly maximum uptake of nutrient compared with lower fertility levels. There findings are conformity with those of Dwivedi and Thakur (2000).

Apparent nutrient recovery (%) :

The highest N, P and K apparent recovery per cent was noticed with all manurial treatment compared to no manure application. However, *Sesbania cannabina* recorded top most among all. At higher fertility level, the apparent nutrient recovery per cent was significantly poor than the reduced levels of fertilizer application (Table-4). Application of organic sources of nutrient influenced the nutrient use efficiency positively and use efficiency decreased due to incremental use of inorganic nutrient in rice has already been reported by Sharma and Mitra (1990) and Kumar (1994).

Table 3 : Interaction effect of manures x fertility levels on yield of rice (pooled data of 2002 and 2003).

Treatment	NPK (kg/ha)				
	0 : 0 : 0	40 : 20 : 10	80 : 40 : 20	120 : 60 : 30	Mean
Manure					
No manure	16.80	31.00	42.87	51.03	35.43
Sesbania cannabina	36.57	50.33	58.77	60.50	51.54
Vigna radiata	33.53	46.42	54.13	56.60	47.67
Crotalaria juncea	33.53	46.47	54.77	56.86	47.91
FYM	33.03	44.50	51.47	54.77	45.94
Mean	30.69	43.74	52.40	55.95	-
CD (P=0.05)	For comparing 2 fertility levels at a given manure treatment = 2.04				
	For comparing 2 manure treatment either at same or different fertility=1.47				

Table 4 : Effect of manures and fertility levels on nutrient uptake and apparent nutrient recovery in rice crop (pooled data of 2002 and 2003).

Treatment	N-uptake (kg/ha)	P-uptake (kg/ha)	K-uptake (kg/ha)	Apparent N-recovery (%)	Apparent P-recovery (%)	Apparent K-recovery (%)
Manure						
No manure	66.19	19.19	77.48	32.68	19.30	169.18
Sesbania cannabina	100.78	30.51	110.44	59.70	43.67	261.05
Vigna radiata	89.69	26.66	100.66	54.60	35.71	224.81
Crotalaria juncea	89.90	26.23	101.25	54.27	35.60	226.06
FYM @ 10 t/ha	87.47	24.71	95.14	53.62	31.52	211.66
CD (P=0.05)	2.02	0.55	1.83	2.93	2.02	14.44
NPK (kg/ha)						
0 : 0 : 0	51.30	13.82	60.55	00.00	00.00	00.00
40 : 20 : 10	80.00	22.50	90.87	71.80	43.40	303.20
80 : 40 : 20	101.44	30.60	113.78	62.60	41.90	266.20
120 : 60 : 30	114.50	35.00	122.65	52.60	35.30	207.00
CD (P=0.05)	1.19	0.66	2.38	2.74	1.70	16.68

***Agronomic fertilizer use efficiency* :**

Use of organic sources of nutrients significantly influenced the agronomic use efficiency of rice. *Sesbania cannabina* gave significantly higher AFUF than others. At higher fertility level, the AFUE was lower compared to all lower doses of fertilizer with significantly differences to each other (Table 5). Similar observations were recorded by Sharma and Mitra (1990) and Kumar (1994).

Nutrient production efficiency :

Efficiency of fertilizer utilization under no organic manure treatment was recorded 55.21 kg rice grain per

Table 5 : Effect of manures and fertility levels on agronomic nutrient use efficiency, nutrient production efficiency and soil nutrient status in rice crop (Pooled data of 2002 and 2003).

Treatment	Agronomic N-use efficiency	Agronomic P-use efficiency	Agronomic K-use efficiency	N-production efficiency	P-production efficiency	K-production efficiency	Soil nutrient status		
							Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
Manure									
No manure	16.15	28.35	51.70	55.21	196.87	46.31	178.60	23.30	168.40
Sesbania cannabina	31.39	54.23	108.46	52.18	175.50	47.24	188.50	29.20	179.00
Vigna radiata	25.48	46.23	90.91	54.07	186.19	47.80	183.60	26.40	176.90
Crotalaria juncea	25.75	46.*51*	91.21	54.14	187.94	47.91	183.90	26.50	177.10
FYM @ 10 t/ha	23.06	44.07	87.16	53.81	193.27	48.79	194.00	33.60	184.35
CD (P=0.05)	2.00	2.94	9.96	0.93	3.42	1.01	2.35	1.68	2.85
NPK (kg/ha)									
0 : 0 : 0	00.00	00.00	00.00	60.02	224.67	50.33	174.50	20.40	165.35
40 : 20 : 10	32.60	65.25	130.50	54.84	196.04	48.26	182.39	26.30	176.25
80 : 40 : 20	27.10	54.28	108.60	51.76	170.81	46.05	188.30	29.71	178.35
120 : 60 : 30	21.10	42.10	84.20	48.92	160.30	45.65	191.05	31.55	182.45
CD (P=0.05)	1.16	2.52	7.04	0.74	2.70	0.87	1.96	1.31	2.40

kg utilization of nitrogen absorbed, 196.87 kg grain per kg absorption of phosphorus and 46.31 kg grain per kg absorption of potassium which was closed to FYM treatment, while *Sesbania cannabina* treatment resulted poor production efficiency compared to other manurial treatments. Lower nutrient productions efficiency was noticed with higher fertility level and showed high ascending trend toward lower dose of fertilizer application as well as at control treatment (Table 5). This finding is conformity with those of Kumar (1994).

Soil nutrient status :

Soil of experiment plot was almost neutral in reaction. Amongst the manurial treatments, application of FYM @ 10 t/ha showed significant positive influence on the nutrient status of soil than others. However, various green manures showed least increment in the nutrient status of soil which were at par among themselves. No manure and no inorganic fertilizer application resulted a negative balance of nutrients specially the potassium balance was for negative (Table 5). Various fertility levels recorded difference in nutrient balance in soil after rice crop. Application of optimum fertilizer noticed a positive nitrogen, phosphorus and potassium balance. Prasad and Sinha (1995) also reported similar finding in cereal based cropping system.

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