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Effect of soil enrichment in conjunction with organics and chemical fertilizer on rice (*Oryza sativa*)–chickpea (*Cicer arietinum*) cropping system

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ABSTRACT

A field experiment was undertaken at Raipur (M.P.) during wet and dry seasons of 1993-94 and 1994-95 to study the direct effect of urea-N with or without organic materials (paddy straw, farmyard manure and green manure) on productivity of rice (*Oryza sativa* L.) and its residual effect on yield of chickpea (*Cicer arietinum* L.) grown after rice under rainfed low land vertisol. Application of fertilized green manure as *Sesbania rostrata* proved superior as compared to paddy straw and farmyard manure. Rice yield and N-uptake were significantly higher under combined application of green manure and urea on an equivalent N basis. Thus, urea-N can be substituted up to 50% by applying *Sesbania rostrata* in rice. Residual fertility in terms of organic carbon was pronounced under farmyard manure and paddy straw which reflected in terms of higher grain yield of chickpea grown after harvest of wet season rice. Direct application of N up to the recommended level (20 kg N/ha) increased the grain yield of chickpea considerably. However, N-use efficiency decreased with the increasing levels of N from 0 to 20 kg N/ha.

Key words: Rice-chickpea cropping system, Soil enrichment, Fertilizer

Globally, no major expansion of area under lowland rainfed rice is anticipated in the foreseeable future, yet total rice production must increase by 60 - 70% by 2025 (Hossain and Fischer, 1995). By some estimates, rainfed lowland rice has to contribute 25-30% of this increased production, which will necessitate development of better production technology, including improvement in integrated nutrient management, in particular, the efficacy of nitrogen. In the present energy crisis and increased cost of fertilizers, the current emphasis on the use of renewable environmental resources for sustainable development, it is timely to assess the different organic materials to complement or replace fertilizer input and to consider its contribution to the N fertility of agricultural land. Among other issues, the capacity of rice-

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pulse cropping system towards organic enrichment for maintaining or enhancing food production in long term need to be evaluated in the south-eastern part of Madhya Pradesh, where chickpea is generally grown in fallow-chickpea or soybean-chickpea cropping sequence with a very meagre amount of fertilizer. Hence, this study was undertaken to find out the effect of various locally available organic materials on rice and their residual effect on chickpea grown after rice with varying levels of nitrogen under rainfed lowland eco-system.

MATERIALS AND METHODS

The field experiment was conducted during wet and dry seasons of 1993-94 and 1994-95 at Raipur (M.P.). The soil was clayey having pH 8.1 and CEC 40.0 M eq/100 g and 93.6, 5.30 and 178.0 ppm of available N, P and K, respectively. During wet season, 8 treatments comprising 3 organic materials viz. paddy straw (PS), farmyard manure (FYM) and green manure (GM), besides 1 recommended practice and a control were laid out in randomized block design and replicated thrice. Chopped PS was applied 15 days before transplanting, whereas, well decomposed FYM was applied 3 days before transplanting. However, GM (*Sesbania rostrata*) was incorporated at the age of 55 days.

During 1st year, the GM was fertilized with 0 : 30 : 20 kg/ha N : P_2O_5 : K_2O but in

Table 1. Treatment details, chemical composition of organic materials, and quantity added on dry weight basis

Treatment	Composition (%)				C : N ratio	Amount of organic material added (t/ha) + urea (kg/ha)
Mainplot (rice)						
PS + U (3 : 1) = 45 + 15 kg N/ha	37.4	0.534	0.110	1.481	70.0 : 1	8.15 + 32.5
PS + U (1 : 1) = 30 + 30 kg N/ha	37.4	0.534	0.110	1.481	70.0 : 1	5.44 + 65.1
FYM + U (3 : 1) = 45 + 15 kg N/ha	28.3	1.60	0.190	1.913	17.6 : 1	2.81 + 32.5
FYM + U (1 : 1) = 30 + 30 kg N/ha	28.3	1.60	0.190	1.913	17.6 : 1	1.87 + 65.1
GM* = 60 + 00 kg N/ha	42.3	2.95	0.387	1.690	14.3 : 1	2.00 + 0.0
GM + U (1 : 1) = 30 + 30 kg N/ha	42.3	2.95	0.387	1.690	14.3 : 1	1.02 + 65.1
Recommended = 60 kg N/ha	–	46	–	–	–	0.0 + 130.2
Control = Nil						
Sub-plots (chickpea)						
N, kg/ha						
0	Applied directly to the crop of chickpea					
6						
13						
20						

* = Modified as GMF + U (1 : 1) i.e. 30 + 30 kg N/ha in 1994-95
PS = Paddy straw, U = Urea, FYM = Farmyard manure
GM = Green manure, Control = No nitrogen

the second year half of the crop was fertilized with 30 : 30 : 20 kg/ha N : P_2O_5 : K_2O to study the effect of initial fertilization of GM crop. Treatment details, chemical composition, quantity and nutrients added by organic materials are given in Table 1. A common basal dose of 30 kg/ha P_2O_5 and 20 kg/ha K_2O was applied to the rice crop at final puddling, whereas N was applied as per treatments in 4 splits. Seedlings of IR 36 rice at the age of 28 days were planted @ 2-3 seedlings/hill.

Chickpea cv 'JG-315' was grown in subsequent dry season by dividing each main plot of rice into 3 sub-plots during 1993-94 and 4 sub-plots during 1994-95 to accommodate different levels of N, *i.e.* 0. 6, 13, and 20 kg/ha. A common basal dose of 60 kg P_2O_5 and 20 kg K_2O/ha along with N as per treatment was given. The rice crop was transplanted in the first week of August and harvested in the first week of November. The chickpea crop was sown in second week of November and harvested in March. No irrigation was given to both the crops.

RESULTS AND DISCUSSION

Performance of rice crop

The crop performance was significantly improved by application of different organic materials and urea - N alone or in combination as compared to control. Application of urea - N alone at 60 kg N/ha increased grain yield of rice by 42.8% over control (Table 2). This was mainly due to availability of N at critical or high demanding stage of rice plant. Timely availability through urea - N also enhanced total N uptake, which ultimately increased the grain yield considerably in 1993. Combined use of unfertilized green manure and urea - N on an equivalent basis also produced significantly higher grain yield and this was on par with 60 kg N/ha through urea alone during both the years. In 1994, a significant increase in grain yield (35.8%) of rice over control was recorded when the green manure crop was fertilized initially with 30 kg N/ha, which was 1.5% higher than the yield obtained under urea - N alone

Table 2. Effect of organic and chemical soil enrichment on grain and straw yields of rice, total N uptake, OC and available soil N

Treatment	Grain yield, (t/ha)		Straw yield, (t/ha)		Total N uptake (kg/ha)		Organic carbon (%)		Available soil N (kg/ha)	
	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994
PS + U (3 : 1)	3.01	3.40	3.09	3.46	56.4	65.3	0.567	0.563	187	197
PS + U (1 : 1)	3.33	3.54	3.37	3.40	65.4	70.1	0.563	0.561	192	219
FYM + U (3 : 1)	3.19	3.41	3.10	3.30	63.1	68.1	0.561	0.558	188	218
FYM + U (1 : 1)	3.65	3.68	3.50	3.58	78.4	78.1	0.558	0.556	235	229
GM	3.44	–	3.40	–	69.0	–	0.556	–	203	–
GM + U (1 : 1)	3.71	3.71	3.87	3.70	89.3	77.4	0.554	0.552	246	224
GMF + U (1 : 1)	–	3.86	–	3.81	–	89.3	–	0.555	–	256
Recommended -N	3.88	3.80	3.85	3.78	96.9	88.4	0.552	0.551	248	248
Control	2.21	2.48	2.15	2.55	40.9	46.9	0.550	0.548	172	178
CD (P = 0.05)	0.27	0.26	0.35	0.30	2.84	6.04	–	–	4.72	6.07

(Table 2). This proves significance of initial N fertilization to green manure crop. This might be due to the promoted N release in comparison to unfertilized green manure crop. Booster dose of 30 kg N/ha increased the growth, nodulation and total N accumulation by GM (Becker *et al.*, 1991). As the C : N ratio of GM was in the active mineralization range and was further stimulated by anaerobic condition of soil, an adequate quantity of N was released for healthy growth of crop from initial stage. High concentration of available N in soil tends to increase the grain yield. The combined application of fertilized GM with urea indicates that GM can substitute 50% urea - N. Combination of GM with urea was of the added advantage due to continuous supply of nitrogen, initially from GM and afterwards from applied urea - N (Matiwade and Sheelavantar, 1994). Combined application of FYM with urea on an equivalent basis also proved on par with the combined application of GM + urea or urea alone. Favourable effect of FYM was visible as at no stage growth of rice plant was adversely affected due to greater nutritional contribution from FYM (Zia *et al.*, 1992) in the initial stage and later on supply of N was maintained by urea. Incorporation of paddy straw with urea was also found to be advantageous in increasing the grain yield.

Table 3. Effect of residual - N and varying levels of nitrogen on grain and stover yields of chickpea and total N uptake

Treatments	Grain yield (t/ha)		Stover yield (t/ha)		Total N uptake (kg/ha)	
	1993-94	1994-95	1993-94	1994-95	1993-94	1994-95
Residual						
PS + U (3 : 1)	1.44	1.33	1.13	1.13	61.1	57.3
PS + U (1 : 1)	1.44	1.24	1.00	1.08	56.5	55.9
FYM + U (3 : 1)	1.47	1.30	1.26	1.10	63.7	54.6
FYM + U (1 : 1)	1.35	1.17	1.11	1.04	55.6	49.8
GM	1.41	–	1.20	–	61.7	–
GM + U (1 : 1)	1.36	1.20	0.99	0.97	54.8	44.3
GMF + U (1 : 1)	–	1.22	–	1.01	–	45.3
Recommended-N	1.31	1.15	0.97	0.94	52.4	42.2
Control	1.29	1.09	0.88	0.92	51.2	40.9
CD (P = 0.05)	0.07	0.13	0.05	0.12	3.06	3.02
Directly applied N, kg/ha						
0	–	0.92	–	0.75	–	31.9
6	1.30	1.17	0.88	0.95	52.9	43.6
13	1.38	1.24	1.06	1.10	56.6	52.7
20	1.53	1.50	1.25	1.29	67.9	66.9
CD (P = 0.05)	0.03	0.06	0.02	0.08	1.69	1.91

However, the gain in yield was not satisfactory as compared to the other organic materials. This might be due to excessive immobilisation and fixation of available soil N, which caused temporary deficit and severe N starvation of rice plants (Sarmah and Bordoloi, 1994). Consequently, the N shortage resulted in fewer panicles and low rice yield (Zia *et al.*, 1992).

Performance of chickpea

The application of organic materials improved the soil fertility appreciably over the initial content. Chickpea grown after harvest of rainfed rice responded favourably to the residual effect of various treatments applied to rice. Chickpea yield was the maximum under the residual effect of FYM + urea (3 : 1) followed by PS + urea (3 : 1) during 1993-94. However, during 1994-95, the yield was the maximum under PS + urea (3 : 1) followed by FYM + urea (3 : 1). An additional grain yield of 231 and 241 kg/ha over control was obtained under the residual effect of FYM + urea (3 : 1) and PS + urea (3 : 1), respectively during first and second year. This could be attributed to increased organic matter and available residual N as well as improved soil physical condition. Directly applied N increased the grain yield of chickpea significantly up to the recommended level of 20 kg N/ha. N-use efficiency of directly applied N was to the extent of 42 kg grain/kg of N at 6 kg N/ha as against 29 kg grain/kg of N at 20 kg N/ha during 1994-95 (Table 3). This indicates that the residual N was inadequate to obtain the healthy growth and high yield of crop, hence, supplemental application of chemical fertilizer up to recommended level was essential (Uhlen *et al.*, 1994). Thus in rice-chickpea system, for realizing the desired level of yield of both *kharif* and *rabi* crops under rainfed condition, organic manuring once a year along with chemical fertilizer to both the crops is essential.

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