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Integrated nitrogen management in rainfed rice (*Oryza sativa*) - linseed (*Linum usitatissimum*) cropping system

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ABSTRACT

Field experiments were conducted for two years (1993-94 to 1994-95) to investigate direct effect of Urea-Nitrogen with or without organic materials (paddy straw, farm yard manure and green manure) on productivity of rice and its residual effect on yield of linseed grown after rice under a rainfed low-land vertisol. Application of fertilized green manure as *Sesbania rostrata* proved to be superior as compared to paddy straw and farm yard manure. Rice yield and nitrogen uptake was significantly higher under combined application of green manure and urea-nitrogen on an equivalent basis. Thus, saving of urea-N upto 50% can be achieved by applying 1.0 t ha^{-1} (dry weight) *Sesbania rostrata* in rice. Residual fertility in terms of organic carbon was more under the plots treated with paddy straw during the wet season which reflected in terms of higher grain yield of linseed grown after harvest of wet season rice. Direct application on N to linseed crop during dry season increased the grain yield considerably. The yield increased with the increasing levels of N upto recommended level (40 kg N ha^{-1}). However, N use efficiency decreased with the increasing levels of N from 0 to 40 kg N ha^{-1}.

INTRODUCTION

Approximately 90% of the global rice production is obtained from irrigated and rainfed lowland paddies cropped under submerged soil conditions. No major expansion of lowland rice is anticipated in the foreseeable future, yet total rice production must increase by 60-70% by 2025 to meet the food requirement of ever increasing population (Hossain and Fischer 1995). By some estimates, rainfed lowland rice must contribute 25-30% of this increased production, and sustained increase in rice yield will require better production technology, including improvement in integrated nutrient management, in particular, the efficacy of nitrogen. Further, with the global shortage of petroleum products used for the manufacture of fertilizer and 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 based cropping system towards organic enrichment for maintaining or enhancing food production in the long term need to be evaluated. In the Chhattisgarh region of India, linseed which is a drought and cold tolerant crop is usually grown as relay and drilled crop after rice without application 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 linseed grown after rice with varying levels of mineral nitrogen under rainfed lowland eco-system.

MATERIALS AND METHODS

The field experiments were conducted during wet and dry season of 1993-94 and 1994-95 at Indira Gandhi Agricultural University, Raipur (Madhya Pradesh), India. The soil was clayee having pH 8.0 and CEC 39.0 m eq/100 g and 191.0, 11.4 and 398.0 kg ha^{-1} of available N,P and K respectively. During wet seson, eight treatments including three organic materials viz., paddy straw (PS), farm yard manure (FYM), and green manure (GM), besides one recommeded practice (60: 30 : 20 NPK ha^{-1}) and a control (0 :30 :20 NPK ha^{-1}) were laid out in a randomized complete block design and replicated thrice. Chopped PS was applied fifteen days before transplanting, and well decomposed FYM was applied three days before transplanting. GM (*Sesbania rostrata*) was incorporated in the soil at the age of 55 days. During 1st year, the GM crop was fertilized with 0:30:20 kg ha^{-1} NPK, but in the second year half of the crop was fertlized with 30:30:20 kg ha^{-1} NPK 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. PS was low in N content (0.534%) and had a wide C:N ratio (70:1), whereas, FYM and GM had 1.6 & 2.95% N and 17.6:1& 14.3:1 C:N ratio respectively i.e. within suitable range of mineralization. A common basal dose of 30 kg ha^{-1} P_2O_5 and 20 kg ha^{-1} 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 during both the years. At harvest, grain and straw smaples of rice were collected to analyse N content and soil sample (0-20 cm depth) to analyse organic carbon and available N in soil.

Linseed cultivar R-552 was grown in subsequent dry season. Split plot design was used for rabi season where each main plot of rice was devided in to three sub-plots during 1993-94 and four sub-plots during 1994-95 to accommodate different levels of N, i.e. 0, 13, 26 and 40 kg ha^{-1}. A common basal dose of 30 kg P_2O_5 and 20 kg K_2O ha^{-1} 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 linseed crop was sown in the second week of November and harvested in the month of March in both the years.

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

Treatment Main plot (Rice)	Composition, % C	N	P	K	C:N ratio	Organic matter added, t ha^{-1} +Urea, kg ha^{-1}
PS+U(3:1)=45+15 kgN ha^{-1}	37.4	0.534	0.110	1.481	70.0:1	8.15+32.5
PS+U(1:1)=30+30 kgN ha^{-1}	37.4	0.534	0.110	1.481	70.0:1	5.44+65.1
FYM+U(3:1)=45+15 kgN ha^{-1}	28.3	1.60	0.190	1.913	17.6:1	2.81+32.5
FYM+U(1:1)=30+30 kgN ha^{-1}	28.3	1.60	0.190	1.913	17.6:1	1.87+65.1
GM*=60+00kgN ha^{-1}	42.3	2.95	0.387	1.690	14.3:1	2.00+00.0
GM+U(1:1)=30+30kgN ha^{-1}	42.3	2.95	0.387	1.690	14.3:1	1.02+65.1
Recommeded=60kgN ha^{-1}	-	46	-	-	-	00.0+130.2
Control =0 kg N ha^{-1}						
Sub-plots(linseed)N, kg ha^{-1}						
00	Applied directly to the linseed crop					
13						
26						
40						

* = Modified as GMF +U (1:1) i.e.30+30 kg N ha^{-1} in 1994-95
PS = Paddy straw, U = Urea, FYM = Farm yard manure
GM = Green manure, Control = No Nitrogen

RESULTS AND DISCUSSION

Rice

The crop performance was significantly improved by the 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^{-1} increased grain yield of rice by 41% 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 nitrogen uptake, which ultimately increased the grain yield considerably during 1993. Combined application of unfertilized green manure and urea-N on an equivalent basis also produced significantly higher grain yield and this was at par to 60 kg N ha^{-1} through urea alone during both the years. In 1994, significant increase in grain yield (23.8%) was obtained over control when green manure crop was fertlized initially with 30 kg N ha^{-1}, which was marginally higher than the yield obtained under urea-N alone (Table 2). This proves significance of initial N fertilization to green manure crop. This might be due to improved N release in comparison to unfertilized green manure crop. Booster dose of 30 kg N ha^{-1} increased the growth, nodulation and total N accumulation by GM. This also confirms the findings of Becker *et al.* (1990 and 1991). As the C:N ratio of GM was in the active mineralization range which was further stimulated by anaerobic condition of soil, it can be assumed that an adequate quantity of nitrogen was released for healthy growth of crop from initial stage. Similar results were reported by Singh (1984).

High concentration of available N in soil tend 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 added advantage due to continues supply of nitrogen, initially from GM and afterwards from applied urea-N. Similar results were obtained by Matiwade and Sheelavantar (1994). Combined application of FYM with urea at an equivalent basis also proved to be at 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 found to be adversely affected. This can be attributed to greater nutritional contribution for FYM in the initial stage and later on, supply of N was maintained by urea. Such beneficial effects of FYM were also reported by Zia *et al.* (1992). Incorporation of paddy straw with urea was also found to be advantageous in increasing the grain yield. However, the gain in yield was not satisfactory as compared to other organic materials. This might be due to excessive immobilisation and fixation of available soil N, causing temporary deficit and severe N starvation of rice plants. This is in conformity with the findings of Sarmah and Bordoloi (1994). Consequently, the N shortage resulted in fewer panicles and low rice yields. Such adverse effects of paddy straw have also been reported by Zia *et al* (1992).

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

Treatments	Grain yield, t ha^{-1}		Straw yield, t ha^{-1}		Total N uptake, kg ha^{-1}		Organic carbon, %		Available soil N, kg ha^{-1}	
	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994
PS+U(3:1)	2.84	3.23	2.97	3.14	51.2	62.5	0.565	0.567	186.6	195.0
PS+U(1:1)	2.99	3.59	3.06	3.53	59.1	70.7	0.561	0.563	190.6	220.0
FYM+U(3:1)	2.94	3.56	3.04	3.60	56.9	68.8	0.560	0.561	190.6	216.7
FYM+U(1:1)	3.51	3.65	3.64	3.64	78.8	74.2	0.556	0.558	232.6	228.0
GM	3.35	-	3.45	-	68.7	-	0.555	-	199.2	-
GM+U(1:1)	3.73	3.54	3.78	3.56	86.2	74.7	0.553	0.554	240.3	224.7
GMF+U(1:1)	-	3.91	-	4.00	-	90.2	-	0.556	-	255.3
Recommended	3.74	3.38	3:80	3.78	91.5	88.9	0.551	0.552	241.0	250.7
Control	2.18	2.98	2.26	2.84	39.3	48.9	0.549	0.550	171.7	177.3
CD at 5%	0.361	0.266	0.363	0.248	2.92	4.34	-	-	3.77	5.48

Table 3. Effect of residual - N and varying levels of nitrogen on grain and straw yield of linseed and total N uptake.

Treatments Residual	Grain yield, kg ha^{-1}		Straw yield, kg ha^{-1}		Total N uptake, kg ha^{-1}	
	1993-94	1994-95	1993-94	1994-95	1993-94	1994-95
PS+U(3:1)	602	825	1026	1367	38.18	37.25
PS+U(1:1)	530	771	987	1346	35.74	34.51
FYM+U(3:1)	574	788	1025	1379	37.85	34.88
FYM+U(1:1)	532	750	1014	1269	35.20	32.24
GM	539	-	1021	-	36.58	-
GM+U(1:1)	498	725	1002	1250	34.76	30.65
GMF+U(1:1)	-	739	-	1250	-	31.72
Recommended	521	713	942	1154	36.13	29.45
Control	460	688	895	1275	31.50	27.71
CD at 5%	051	053	047	081	0.98	1.97
Directly applied N, kg ha^{-1}						
0	-	567	-	918	-	20.86
13	489	698	896	1150	33.11	29.07
26	529	808	998	1392	35.87	34.69
40	627	925	1113	1573	41.25	44.64
CD at 5%	025	038	019	086	0.67	1.23

Linseed

The application of organic materials improved the soil fertility appreciably over the initial content. Linseed grown after harvest of rainfed rice responded favorably to the residual effect of various treatments of organic materials applied to wet season rice. Highest grain yield was obtained in the treatment with paddy straw applied at higher rates during both the years (Table 3). In the season of 1993-94, the linseed yield increased from 61 kg ha^{-1} in plots supplied with only urea to 142 kg ha^{-1} in those receiving PS + Urea (3:1) for previous rice crop. The respective figures for 1994-95 season were 25 kg ha^{-1} and 137 kg ha^{-1}. This was mainly due to increased organic matter and available residual N as well as improved soil physical conditions as a long term effect of paddy straw. Such beneficial effects of paddy straw have also been reported by Nur - E - Elahi (1991). Directly applied N also increased the linseed yield significantly up to the highest level of 40 kg N ha^{-1}. However, N-use efficiency decreased from 10.1 kg grain/kg of N at 13 kg N ha^{-1} as against 8.9 kg grain/kg of N at the recommended level of 40 kg N ha^{-1} during second year. Similar trend was noted for first year also (Table 3). This indicates that the residual N was inadequate to obtain the healthy growth and high yield of linseed crop. Hence, supplemental chemical fertilization up to recommended level was essential. This confirms the findings of Uhlen *et al.* (1994).

Thus, for sustaining a desired level of yield of both first and second crop under rainfed conditions, organic manuring once a year to save mineral N up to 50% along with supplemental chemical fertilization to both the crops is essential for higher productivity in rice- linseed cropping system. In future research, attempts should be made to minimizes the use of chemical fertilizers up to 50% in the subsequent linseed crop through the incorporation of poultry manure or farm yard manure etc, in rice-linseed cropping system.

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