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Effect of integrated management of organic manure and inorganic N fertilizer on rice (*Oryza sativa*) and its residual effect on *utera* linseed (*Linum usitatissimum*) and soil fertility

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ABSTRACT

A field experiment was carried out during rainy (*kharif*) and winter (*rabi*) seasons of 2004-2005 and 2005-2006 at the Regional Research Substation, Sekhampur, West Bengal, to study the effect of integrated management of organic manure and inorganic N fertilizer on rice (*Oryza sativa* L.) and its residual effect on *utera* crop linseed (*Linum usitatissimum* L.) and fertility build up of soil. The yield, yield attributes, N content and N uptake of rice (cv. IR-36) were significantly higher under 75% recommended dose of nitrogen (RDN) along with 2 tonnes poultry manure than all other treatments on pooled data basis, but remained on a par with 75% RDN + 4 tonnes *Sesbania* green-leaf manure and 75 % RDN + 5 tonnes FYM. The per cent increase in grain yield with 75% RDN + 2 tonnes poultry manure, 75% RDN + 4 tonnes green manure and 75% RDN + 5 tonnes FYM/ha over 100% RDN (60 kg/ha) alone were 27.7, 25 and 22.8% respectively. The nitrogen use-efficiency parameters revealed that agronomic efficiency and recovery efficiency were highest with 75% RDN + 2 tonnes poultry manure, followed by 75% RDN + 4 tonnes green manure and 75% RDN + 5 tonnes FYM. After harvest of rice, the organic carbon status of soil was enhanced in all organic added treatments than initial level. Substantial build up P was noticed in FYM and *Sesbania* green-leaf applied plots. The available K was in declining trend under all the treatments except rice straw incorporated plots. The residual effect of different treatments (applied to *kharif* rice) on the succeeding *utera* linseed (cv. Neela) during *rabi* season was not significant.

Key Words : Integrated nutrient management, rice, *utera* crop, linseed, soil fertility

Integrated nutrient supply involving conjunctive use of chemical fertilizers and organic sources has a great significance for improving crop productivity due to inadequate availability of fertilizers. Integrated nutrient supply leads to soil and crop sustainability by balanced application of nutrients, as these supply micronutrients to meet the crop needs which is also pre-requisite to increase fertilizer-use efficiency (Singh *et al.*, 1999). Nitrogen, a key element, is considered to be the most limiting factor for realizing higher yield of rice. Nitrogen management is distinctly fundamental considering the amount of loss to the extent of 40-60% that persistently occur in rice growing conditions. Fertilizer N-use efficiency varies from 18 to 40% in rice soils, because applied inorganic N is rapidly lost from the soil by ammonia volatilization and denitrification (Natarajan and Pushpavalli, 1994). Acid lateritic soils are deficient in plant nutrient elements and organic matter. Therefore, nutrient scheduling through inorganic and organic sources is necessary. The existing system of fertilizer application is based on the nutrient requirement of individual crop ignoring the carry-over effect of the manure or fertilizer applied to the preceding crop. Organic sources of nutrients applied to the preceding crop benefit the succeeding crop to a great extent (Hegde, 1998). Keeping this in view, the present study was undertaken to evaluate a suitable integrated nitrogen supply system to rainy (*kharif*) season rice and its residual effect on succeeding *utera* crop linseed and soil fertility.

MATERIALS AND METHODS

A field experiment was conducted during 2004-2005 and 2005-2006 at the Regional Research Substation (RRSS) of Bidhan Chandra Krishi Viswavidyalaya, Sekhampur, Birbhum, West Bengal, on a medium land situation. The soil was lateritic (Entisol) having sandy-clay loam in texture, pH 5.6, organic carbon 0.43%, available N 230 kg/ha, available P 11.63 kg/ha and available K 210 kg/ha. Ten treatments, viz. T_1, no nitrogen; T_2, 100% recommended dose of N (RDN) *i.e.*, 60 kg/ha; T_3, 75% RDN + 5 tonnes FYM; T_4, 50% RDN + 5 tonnes FYM; T_5, 75% RDN + 4 tonnes green leaf manure (GLM) with *Sesbania aculeata*; T_6, 50% RDN + 4 tonnes GLM; T_7, 75% RDN + 2 tonnes poultry manure (PM); T_8, 50% RDN + 2 tonnes PM; T_9, 75% RDN + 7 tonnes rice straw (RS) and T_{10}, 50% RDN + 7 tonnes RS, were replicated thrice in randomized block design. The recommended dose of inorganic N was applied as urea in 3 equal splits at transplanting, tillering and panicle-initiation stages.

Application of P_2O_5 and K_2O were uniform @ 30 kg/ha each as single super phosphate and muriate of potash respectively. Full dose of P_2O_5 and K_2O were applied as basal. The N content in various organic manures was analyzed (Table 1). All organics were applied 10 days before transplanting. Seedlings of 'IR-36' (120 days) rice were transplanted at 20 cm x 10 cm at an age of 28 days during last week of July. The plot size was 20 m^2. N uptake in grain and straw was determined separately and the total uptake was calculated. Nitrogen use efficiency such as recovery efficiency and agronomic efficiency were computed as described by Stalin *et al.* (1999). Soil was analyzed initially and after harvest of rice (0-15 cm depth) for organic C and available P and K by standard methods. Seeds of linseed cv. 'Neela' were broadcasted @ 15 kg/ha over the standing rice crop (15 days before harvesting of rice) during 2nd week of November and harvested on 1st week of March. Observation on yield and yield components were recorded after harvest of the crop. The total rainfall during the cropping period was 1090 and 1160 mm in 1st and 2nd year of experimentation.

RESULTS AND DISCUSSION

Rice

Yield components, yield and harvest index

Yield components of rice, viz. effective tillers/m^2 and grains/panicle were varied significantly under different treatments, however, the test weight remained at par with each other on the basis of pooled analysis (Table 2). Application of 75% RDN through inorganic fertilizer along with 2 tonnes poultry manure (PM) recorded the maximum effective tillers/m^2 and grains/panicle, followed by application of 75% RDN + 4 tonnes green-leaf manure (GLM) and 75% RDN + 5 tonnes FYM. The effect may be attributed to slow and steady supply of N through PM, GLM and FYM, resulting in efficient utilization. However, reduction of RDN by 50% markedly reduced the yield components of rice irrespective of the various organic manuring to rice.

Grain yield of rice under 75% RDN + 2 tonnes PM was significantly superior to all others treatments, but remained on a par with 75% RDN + 4 tonnes GLM and 75% RDN + 5 tonnes FYM. The increase in grain yield owing to 75% RDN + 2 tonnes PM, 75% RDN + 4 tonnes GLM and 75% RDN + 5 tonnes FYM over 100% RDN alone were 27.7, 25 and 22.8% respectively. This may be attributed to higher yield components under these treatments. The straw yield was also maximum with 75% RDN + 2 tonnes PM, being on a par with 75% RDN + 4 tonnes GLM and 75% RDN + 5 tonnes FYM. The superior performance under these three treatments may also be owing to improvement in physical, chemical and microbiological environment of soil favouring increased availability of macro and micro-nutrients (Sengar *et al.*, 2000). The influence of treatments on harvest index was significant in pooled data. However, treatments involving integrated N application were statistically similar but remained superior to no-nitrogen and 100% RDN alone.

N content and uptake

The mean data on N content in grain and straw of rice for 2 years are presented in Table 2. The treatments 75% RDN applied with 2 tonnes PM or 4 tonnes GLM or 5 tonnes FYM were comparable and recorded significantly higher N content in grain than other treatments. A similar trend was noticed in case of N content in straw.

Table 1. Chemical composition of organic manures applied (on dry-weight basis)

Manure	Mineral composition (%)			C:N ratio
	N	P	K	
Farm yard manure	0.61	0.27	0.52	20.0
Sesbania green-leaf	0.82	0.31	0.95	12.0
Poultry manure	1.60	0.89	1.05	16.0
Rice straw	0.45	0.13	1.65	80.0

Table 2. Yield attributes, yield, harvest index, N content and N uptake of rice as influenced by integrated nutrient management (mean data of 2 years)

Treatment	Panicles/ m^2	Grains/ panicle	Test weight (g)	Grain yield (t ha^{-1})	Straw yield	Harvest index	N content(%)		Total N Uptake
							Grain	Straw	
T_1	211	41	20.2	2.18	4.28	33.75	1.12	0.29	36.83
T_2	271	62	21.3	3.28	5.63	36.81	1.18	0.34	57.84
T_3	346	98	22.5	4.05	6.27	39.24	1.38	0.46	84.73
T_4	288	70	20.6	3.38	5.73	37.10	1.20	0.39	62.91
T_5	354	100	22.7	4.10	6.31	39.39	1.36	0.47	85.42
T_6	305	76	20.8	3.45	5.83	37.18	1.22	0.41	65.99
T_7	366	103	22.1	4.19	6.42	39.49	1.36	0.48	87.80
T_8	297	79	21.2	3.42	5.88	36.77	1.23	0.40	65.59
T_9	320	87	21.8	3.85	6.10	38.69	1.27	0.43	75.13
T_{10}	279	64	20.5	3.30	5.70	36.67	1.19	0.38	60.93
CD (P=0.05)	24	6.48	NS	0.16	0.27	2.1	0.07	0.03	6.04

Treatments details are given in materials and methods; NS, Not significant

Table 3. Nitrogen-use efficiency and soil fertility as influenced by integrated nutrient management (mean data of 2 years)

Treatment	Nitrogen-use efficiency		Organic	Available P	Available K
	Agronomic	Recovery			
T_1	-	-	0.38	10.33	168
T_2	18.33	35.02	0.40	11.54	172
T_3	24.76	63.44	0.54	17.85	195
T_4	19.83	43.11	0.50	16.18	189
T_5	24.69	62.45	0.53	17.81	207
T_6	20.22	46.43	0.52	15.79	191
T_7	26.10	66.19	0.51	13.70	198
T_8	20.00	46.39	0.49	12.61	188
T_9	21.83	50.06	0.59	12.65	240
T_{10}	18.21	39.19	0.56	11.89	231

Treatment details are given in materials and methods

Table 4. Yield and yield attributes of *utera* linseed as influenced by different treatments of *kharif* rice (mean data of 2 years)

Treatment	Plant height (cm)	Branches/ plant	Capsules/ plant	Seeds/ capsule	100-seed weight (g)	Seed yield (q/ha)
T_1	36.1	2.98	29.6	5.23	6.35	5.47
T_2	37.1	3.07	30.2	5.55	6.41	5.64
T_3	38.6	3.18	33.6	5.63	6.46	5.95
T_4	36.5	3.14	31.4	5.28	6.34	5.78
T_5	38.1	3.20	33.1	5.72	6.42	5.87
T_6	37.3	3.11	31.9	5.55	6.38	5.59
T_7	37.9	3.16	33.3	5.43	6.45	5.85
T_8	36.7	3.12	30.6	5.34	6.39	5.65
T_9	37.4	3.17	32.3	5.57	6.48	5.78
T_{10}	36.9	3.10	29.8	5.39	6.37	5.53
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Treatments details are given in materials and methods; NS, Not significant

Significantly higher uptake of nitrogen in total of grain and straw was observed under 75% RDN + 2 tonnes PM than the other treatments. But comparable N uptake was also recorded from 75% RDN + 4 tonnes GLM or 75% RDN + 5 tonnes FYM. This organic manure mineralized slowly and released the nutrients for the crop later that led to higher uptake of N. The treatment of no-nitrogen showed the lowest N uptake.

Nitrogen-use efficiency

The nitrogen-use efficiency was computed through agronomic efficiency and recovery efficiency and the mean values revealed that the agronomic efficiency was highest with 75% RDN + 2 tonnes PM (26.10), followed by 75% RDN + 4 tonnes GLM (24.69) and 75% RDN + 5 tonnes FYM (24.76) (Table 3). This is indicative of the fact that these treatments increase the production capacity per kg N applied, which might be due to prolonged N availability (Lakpale *et al.*, 1999). The recovery efficiency of 75% RDN + 2 tonnes PM was highest (66.19), followed by 75% RDN + 5 tonnes FYM (63.44) and 75% RDN + 4 tonnes GLM (62.45). This could be attributed to higher N uptake under these treatments. Similar observation was also reported by Upadhyaya *et al.* (2000). Higher agronomic efficiency under these treatments could be a reflection of higher recovery efficiency.

Soil fertility

The residual soil fertility was determined in terms of organic carbon (%) and available P and K after harvest of rice (Table 3). The organic carbon status of soil enhanced substantially in all organics added treatments compared with its initial level. Its status was declined markedly in the no-nitrogen and 100% RDN plots. Among the treatments, more organic carbon was present in rice straw incorporated plots where the mineralization was slow due to wider C: N ratio. This result confirms the findings of Prasad and Power (1991).

Available P was enhanced in all organics added plots. The build up was maximum with FYM, followed by *Sesbania* green-leaf manure. Soil supply of N only through chemical fertilizer resulted in slight decline in available P. Similar observation was also made by Raju and Reddy (2000).

There was a decline in available K in all the treatments, except rice-straw incorporated plots. Being rich in K (1.6%), rice-straw enriched the K status of soil despite heavy removal by the crop. The magnitude of decline was high in no-nitrogen and inorganic N fertilizer plot but low in organic-added plots. The uptake of K by rice was much higher than its application, but still the changes in available K status after rice cropping was of smaller magnitude. This may probably be due to utilization of large amounts of non-exchangeable K from soil colloids.

Linseed

Performance of *utera* crop linseed grown under residual soil fertility after harvest of *kharif* rice was studied in both the years of experimentation, to assess the effect of different treatments applied to rice on linseed (Table 4). The study revealed that application of organic manures (FYM, GLM, PM and rice-straw) with 75% and 50% recommended dose of nitrogen fertilizer to the preceding crop did not exhibit any significant residual effect to the succeeding *utera* linseed in both the years. However, the maximum seed yield (5.95 q/ha) was obtained from *utera* linseed which received 75% RDN + 5 tonnes FYM in *kharif* rice. Similar observation was also made by Sharma and Mitra (1990) in chickpea grown on residual soil fertility after harvest of rice.

Hence, considering the sustainability of crop productivity and soil fertility, instead of sole application (chemical fertilizer) integrated use of chemical N fertilizer @ 45 kg ha^{-1} along with organic manures like 2 tonnes poultry manure or 4 tonnes *Sesbania* green-leaf manure or 5 tonnes FYM can be recommended for rainy season rice in the laterite zone of West Bengal. On the residual soil fertility to the succeeding *utera* crop linseed, the result was not encouraging and this indicated that for higher linseed yield in this system, additional nutrients have to be applied to linseed.

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