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Integrated nutrient management in rice (*Oryza sativa*)–rice crop sequence

M. K. JANA AND B. C. GHOSH

Agricultural Engineering Department, Indian Institute of Technology, Kharagpur, West Bengal 721 302

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ABSTRACT

A field experiment was conducted during the rainy and winter seasons of 1988, 1989 and 1990 to study the integrated nutrient management through organic and inorganic sources of fertilizer in a rice (*Oryza sativa* L.)–rice crop sequence. Grain yield of rainy-season rice was higher under 100% recommended dose of NPK fertilizer supplied through either inorganic source alone or 75% through inorganic and 25% through organic source. Application of NPK at suboptimal dose, i.e. 75% and 50% of recommended NPK dose, or following farmer's practice reduced the grain yield significantly. The total land productivity in rice–rice crop sequence was higher when both rainy-season and winter-season rice received 100% recommended dose of NPK fertilizer. For the rainy-season rice, the uptake of the nutrients NPK was more when 75% of the fertilizer were applied as inorganic and 25% as organic sources, whereas in winter season maximum uptake of the nutrients by rice was recorded when 100% of NPK was supplied as inorganic source.

Rice (*Oryza sativa* L.)–rice cropping sequence is most dominant system in eastern and southern parts of India, particularly under irrigated condition, where fertilizer is considered to be the major input. In these rice fields fertility replenishment involves supply of both organic and inorganic sources of fertilizers. Organic sources from farmyard manure (FYM), green-manure and crop residues etc. play an important role in sustained productivity of tropical region soil, particularly in lateritic soil which remain conspicuously low in organic matter content (Mahapatra *et al.*, 1985). It is well recognized that inorganic fertilizer is not a complete substitute for organic matters and vice versa and their role is complementary. In the past, fertilizer recommendation was made based on nutrient requirement of individual crop, ignoring the residual effect of the previous crop on the succeeding crop. With the development of improved varieties of rice it has become imperative to develop a suitable fertilizer-management schedule including the type of sources that need to be used. The present investigation was aimed to study the direct and residual effect of inorganic and organic sources of fertilizer used in different proportions in a rice–rice crop sequence.

MATERIALS AND METHODS

The experiment was conducted at Agricultural Engineering Department Farm, Indian Institute of Technology, Kharagpur, during rainy (*kharif*) as well as winter (*rabi*) seasons of 1988–89 and 1989–90 and 1990–91. The soil of the experimental site

was lateritic, sandy clay-loam with pH 5.4, cation-exchange capacity 8.7 meg/100 g soil, organic carbon 0.38%, total P 0.004% and total K 0.03%. The treatments consisted of applying different levels of inorganic fertilizers either alone or in combination with organic manures at different proportions to rainy-season rice and only inorganic fertilizers at different levels to the following winter-season rice (Tables 1, 2). The fertilizer levels were 100, 75 and 50% of the recommended dose. The recommended fertilizers at 100% level were applied @ 60 kg N, 30 kg P_2O_5 and 30 kg K_2O/ha for rainy-season rice and 100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha for winter-season rice. The inorganic fertilizers were supplied through urea, single superphosphate and muriate of potash. The organic fertilizer materials used in the experiment were farmyard manure (FYM) green-manure crop prickly sesban or *dhaincha* [*Sesbania cannabina* (Retz.) Pers. and paddy straw. The experiment was laid out in randomized block design with 4 replications. Rice 'IR 36' was used as the test crop during both rainy and winter seasons. All phosphatic and potassic fertilizers as well as organic sources of fertilizers were applied basal at the time of puddling, while inorganic N fertilizer was applied in splits. N content of grain and straw was determined by kjeldahl's method (Jackson, 1973) and N uptake was calculated with the data of dry-matter production.

RESULTS AND DISCUSSION

Grain yield of rice

The grain yield of both rainy and winter-season rice increased significantly due to application of different organic and inorganic sources of fertilizers compared with the control (Table 1). During rainy season the grain yield was recorded maximum at 100% level and the yield was significantly less at 75 and 50% levels of the recommended dose. There was a considerable reduction in grain yield when 50% of the nutrient was supplied through paddy straw or FYM and 50% through inorganic source. Application of 25% of the nutrient through any of the organic source and 75% through inorganic source were at par with the 100% recommended dose of inorganic fertilizers. The poor effect of organic source at 50% level could be due to addition of high amount of carbonaceous residues which might lead to spurt of biochemical activities in the flooded soil causing toxicity (Yoshida, 1978). Farmer's practice of fertilizer management provided lowest grain yield compared with other fertilizer treatments.

During the winter season, the rice yield in general, was higher than that obtained in rainy season. In maximum grain yield of rice was recorded when 100% recommended dose was used. The grain yield showed significant reduction, when the fertilizer application was reduced to 50 or 75% of the recommended dose. The fertilizer application in rainy-season rice affected the yield of winter-season rice grown in sequence. A sharp increase in yield of *rabi* rice was observed when in *kharif* the recommended 100% dose was split into half inorganic and half organic form of FYM. This was evidently due to the residual effect of FYM. However, with a change in the source of organic matter the residual benefit was less conspicuous. The results though favour partial application of organic manure in rainy season, in a rice–rice sequence, the trend of benefit was not consistent.

Total land productivity

The total land productivity was found to be higher in those treatmets where both

Table 1. Grain yield, land productivity of rainy-season and winter-season rice as influenced by integrated nutrient supply system in rice–rice cropping sequence

Treatment (rainy-season)	Grain yield (rainy-season) (tonnes/ha)			Treatment (winter season)	Grain yield (winter season) (tonnes/ha)			Total land productivity (tonnes/ha/year)		
	1988–89	1989–90	1990–91		1988–89	1989–90	1990–91	1988–89	1989–90	1990–91
No fertilizer	2.17	3.00	2.46	No fertilizer	2.27	2.24	2.12	5.40	5.24	4.58
50% NPK	2.82	3.90	3.34	50% NPK	3.41	3.24	3.20	6.23	7.14	6.54
50% NPK	2.96	3.80	3.21	100% NPK	3.23	4.50	4.11	6.19	7.03	7.32
75% NPK	2.82	4.18	4.14	75% NPK	3.43	3.65	3.48	6.25	7.83	7.62
100% NPK	3.03	5.13	4.76	100% NPK	3.40	5.10	4.45	6.43	10.23	9.21
50% NPK + 50% FYM	2.66	3.72	4.28	100% NPK	5.10	5.40	4.94	7.76	9.12	9.22
75% NPK + 25% FYM	3.01	4.63	4.45	75% NPK	3.49	3.75	3.40	6.50	8.38	7.85
50% NPK + 50% PS	2.72	4.30	4.21	100% NPK	3.38	4.63	4.34	6.10	8.93	8.55
75% NPK + 25% PS	3.11	4.40	4.64	75% NPK	4.36	4.34	4.06	7.47	8.74	8.70
50% NPK + 50% GM	2.88	4.00	4.29	100% NPK	4.25	5.42	4.45	7.13	9.42	8.74
75% NPK + 25% GM	2.77	4.52	4.33	75% NPK	3.38	3.89	3.40	6.15	8.41	7.73
Farmer's practice	2.69	3.67	3.87	Farmer's practice	3.23	3.24	3.01	5.92	6.91	6.88
CD (P = 0.05)	0.15	0.79	0.45		0.27	0.36	0.46			

PS, Paddy straw; GM, green manure

Table 2. Total uptake of N, P and K nutrients by rainy and winter rice as influenced by integrated nutrient suppl system in rice—rice cropping sequence

Treatment	Nutrient uptake (kg/ha)*						Treatment	Nutrient uptake (kg/ha)**					
	1989–90			1990–91				1989–90			1990–91		
	N	P	K	N	P	K		N	P	K	N	P	K
No fertilizer	58.1	11.1	47.6	51.2	9.74	44.3	No fertilizer	39.0	10.6	51.3	40.0	10.4	51.7
50% NPK	88.3	14.7	67.2	75..9	12.93	61.1	50% NPK	75.8	13.3	84.8	60.6	12.9	76.5
50% NPK	84.1	12.6	61.0	74.3	11.42	59.9	100% NPK	110.4	20.6	87.2	79.8	24.1	107.0
75% NPK	106.0	16.3	72.8	105.0	17.18	76.3	75% NPK	71.1	12.3	79.0	68.8	14.1	82.4
100% NPK	113.3	25.7	92.2	124.0	25.29	96.0	100% NPK	119.5	19.2	141.1	112.1	21.8	97.7
50% NPK + 50% FYM	93.2	14.2	101.6	107.8	16.89	108.6	100% NPK	126.7	20.6	136.6	118.3	22.8	101.2
75% NPK + 25% FYM	111.2	19.2	123.9	113.8	19.35	107.7	75% NPK	91.6	14.0	79.3	78.8	12.0	77.5
50% NPK + 50% PS	101.0	17.4	94.3	102.0	16.91	96.9	100% NPK	118.0	14.1	130.7	119.2	21.0	108.2
75% NPK + 25 PS	113.1	20.3	90.0	113.7	22.16	102.8	75% NPK	109.2	17.1	112.4	83.9	15.3	87.4
50% NPK + 50% GM	106.2	17.1	77.0	109.7	11.13	93.4	100% NPK	147.3	17.3	132.1	114.5	20.6	108.6
75% NPK + 25% GM	115.6	18.7	87.2	114.5	19.12	92.0	75% NPK	82.9	16.2	110.4	76.7	14.2	89.1
Farmer's practice	87.6	12.2	57.3	96.6	14.12	68.0	Farmer's practice	66.9	11.4	86.3	61.0	11.0	80.9

*Rainy season; **winter season

PS, Paddy straw; GM, green-manure; FYM, farmyard manure

rainy-season and winter-season crops received 100% recommended dose of NPK (Table 1). There was considerable reduction in the land productivity with reduction of the fertilizer levels to 75 or 50% of the recommended dose. Maximum grain yield production of 8.7 tonnes/ha/year (average of 3 years) was obtained when 100% NPK was supplied through inorganic source to *rabi* rice, preceeded by application of 50% NPK through FYM, and 50% through inorganic source, to the rainy-season rice. The land productivity value was also considerably high when rainy-season rice received 50% NPK as green-manuring or as paddy straw, along with 50% NPK as inorganic source, followed by application during winter season. When 100% NPK farmer's practice was followed the land productivity was found 6.5 tonnes/ha/year, which was only 1.4 tonnes/ha/year more than the control (no fertilizer treatment).

N, P and K uptake

During rainy season, the uptake of NPK by the plants was considerably higher when fertilizer was applied at 100% recommended level only as inorganic source. In such case, the higher uptake of N, P and K nutrients could be due to greater release of nutrients and their ready availability in the soil. The uptake of NPK by the plants was less, when 50% NPK was supplied as inorganic source and remaining 50% as organic source (Table 2). The reduction is likely to be due to slow release of NPK from the organic sources. Uptake of NPK showed further reduction when NPK was supplied at suboptimal level, i.e. 75% of the recommended dose.

During the winter season, maximum uptake of NPK nutrients was recorded where the rice crop received 100% of the recommended dose of fertilizer preceded by the treatment receiving 50% fertilizer through inorganic source and 50% through organic source applied to rainy-season rice. This could be due to residual effect of the nutrients available through organic sources to the succeeding winter-season crop. Beneficial effect of combined application of FYM and inorganic source of fertilizer in rice crop supports the observation of Gill and Meelu (1980). It is evident that higher uptake of the nutrients by the crop has contributed towards the increased grain yield which was not possible in the control (no fertilizer treatment).

It could be inferred that in acid lateritic soil, the rice productivity could be improved with application of fertilizers at 100% recommended level of the nutrients. It is clear that for maintenance of stable soil fertility in a rice–rice cropping sequence a part of the total nutrient should be supplied through organic source like farmyard manure, green-manure or paddy straw.

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