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Integrated nutrient management for rice–rice cropping system

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ABSTRACT

Integrated nutrient management for rice (Oryza sativa L.) – rice cropping system in the subhumid subtropical climatic condition was studied at Regional Research Sub-Station (RRS), Chakdaha, Nadia, West Bengal. Considering the system productivity, economics of production and soil fertility condition it may be concluded that maximum production (9.26 and 10.37 t ha^{-1} yr^{-1} under HYV-HYV and hybrid-hybrid crop sequences, respectively) was obtained when rice crop received 50% recommended doses of nutrients through chemical fertilizer along with 50% recommended doses of nutrients through green leaf manuring during wet season and 100% recommended doses of nutrients through chemical fertilizer during boro season. Under the same treatment combination the net returns/annum were Rs. 24939.25 and Rs. 25875.59 ha^{-1} yr^{-1} and the returns $rupee^{-1}$ investment were Rs. 1.66 and Rs. 1.62 in HYV-HYV and hybrid-hybrid rice crop sequences, respectively. Under similar conditions soil N, P and K content improved over initial value by 1–17%, 1– 5% and 0 –6%, respectively under hybrid rice-hybrid rice crop sequence.

Key words: *High yielding rice, hybrid rice, growth and yield attributes, yield, system productivity*

Rice-rice, the main cropping system in the eastern coast of India, requires heavy amount of plant nutrients that results in decline in net returns per unit area (Anonymous, 2001). Long-term fertilizer experiments conducted all over India showed, on an average, that rice removed 20.7 kg N, 5.17 kg P and 35.5 kg K during wet season for every tone of grain yield (Yoshida, 1981). It is therefore, necessary to apply fertilizer elements particularly N, P and K either through organic or through inorganic sources in optimal quantity to improve and sustain the productivity. However, application of inorganic fertilizers alone in large quantities over a long period of time results in imbalance in supply of other nutrients. In this context, integrated nutrient management holds a great promise in maintaining yield stability through correction of marginal deficiencies of secondary and micronutrients, enhancing efficiency of applied nutrients and providing favourable soil physical condition. Keeping the above ideas in view, the present investigation was planned to find out a suitable integrated nutrient supply system in a rice – rice cropping system.

MATERIALS AND METHODS

Two separate field experiments, one for high yielding variety (HYV)IET 4786 and another for the hybrid Pro Agro 6444 were conducted for two consecutive years (June 2002 to May 2004) during wet season and boro seasons in each year to study the effect of integrated nutrient management under rice– rice cropping system in the subhumid subtropical climatic condition of West Bengal at the Regional Research Sub-Station (RRS), Chakdaha, Nadia, West Bengal. The farm where the experiment was conducted is situated at New Alluvial Zone (NAZ) of West Bengal at $23^0$5.3´ N latitude and $83^0$5.3´ E longitude and 9.75 m above the mean sea level. The land topographically known as medium land and the soil was sandy clay loam in texture having pH 7.7, EC 0.06 ds/m, organic carbon 0.67%, available P 16.00 kg ha^{-1} and available K 126.00 kg ha^{-1}. Both the experiments were laid out in a randomized block design (RBD) with twelve treatments (Table 1) and three replications. The plot size was 15 m^2. The same layout plan was followed at the same site for both wet and *boro* seasons in both the years of experimentation. Rice was transplanted in the fourth week of August and fourth week of January during wet and *boro* seasons, respectively in both the years of experimentation. One third of N and full dose of P and K were given before

transplanting (as basal) and remaining N was top-dressed equally at active tillering and before panicle initiation stages. The N content of various organic manures were analysed (Table 2) and their quantities required to substitude a specified amount of N as per the treatments were calculated. All organics were applied 7 days before transplanting during wet season of 2002 and 2003.

RESULTS AND DISCUSSION

Under both the rice-rice crop sequences (HYV-HYV and hybrid-hybrid) maximum production per annum was recorded where the crop was fertilized with 100% recommended dose of nutrient through chemical fertilizer in both the seasons (9.20 and 10.25 t ha^{-1} yr^{-1} in HYV-HYV and hybrid-hybrid rice sequence respectively). Use of green leaf to substitute half of the recommended NPK enhanced productivity by 0.6 to 1.1% over sole chemical fertilization at the recommended level. Crop residue and FYM slightly decreased crop productivity as compared to sole chemical fertilization (Table 3 and 4). Pal and Banerjee (2006) reported similar type of results.

Uptake of nitrogen, phosphorus, potash as well as total uptake by both PA 6444 and IET 4786 under both the rice-rice crop sequences increased with increasing levels of nutrients. Maximum uptake of N, recorded where the crop received 50% recommended doses of nutrients through fertilizer along with 50% doses of nutrients through green leaf manuring during wet season and 100% recommended doses of nutrients through fertilizer during boro season (9.26 and 10.37 t ha^{-1} yr^{-1} under HYV-HYV and hybrid-hybrid crop sequences, respectively). Under the same treatment combination the rate of increment over control was more in HYV-HYV crop sequence (48.2%) than in that of hybrid-hybrid sequence (37.53%). Similarly under both the crop sequences the next highest production was

Table 1. Treatment details of the experiment during wet and *boro* seasons

Treatment	Wet season	*Boro*
T_1	No fertilizer, no organic manure (Control)	No fertilizer, no organic manure (Control)
T_2	50% recommended NPK dose through fertilizer	50% recommended NPK dose through fertilizer
T_3	50% recommended NPK dose through fertilizer	100% recommended NPK dose through fertilizer
T_4	75% recommended NPK dose through fertilizer	75% recommended NPK dose through fertilizer
T_5	100% recommended NPK dose through fertilizer	100% recommended NPK dose through fertilizer
T_6	50% recommended NPK dose through fertilizer + 50% through FYM	100% recommended NPK dose through fertilizer
T_7	75% recommended NPK dose through fertilizer + 25% through FYM	75% recommended NPK dose through fertilizer
T_8	50% recommended NPK dose through fertilizer + 50% through CR	100% recommended NPK dose through fertilizer
T_9	75% recommended NPK dose through fertilizer + 25% through CR	75% recommended NPK dose through fertilizer
T_{10}	50% recommended NPK dose through fertilizer + 50% through GM	100% recommended NPK dose through fertilizer
T_{11}	75% recommended NPK dose through fertilizer + 25% through Gm	75% recommended NPK dose through fertilizer
T_{12}	Farmer's practice (60, 20 and 0 kg N, P and K ha^{-1})	Farmer's practice (120, 50 and 50 kg N, P and K ha^{-1})

NB : FYM – Farm yard manure; CR – Crop residues (Paddy straw); GM – Green manuring (Dhanicha green leaf). Recommended dose of fertilizers : 60, 30 and 30 kg N, P and K ha^{-1} in wet season and 120, 60 and 60 kg N, P and K ha^{-1} in *boro* season.

Table 2. Chemical composition of organic manures applied (on dry-weight basis)

Manure	Mineral Composition (%)			C : N ratio
	N	P_2O_5	K_2O	
Farm yard manure	0.50	0.20	0.50	18.0
Paddy straw	0.45	0.13	1.66	80.0
Sesbania green leaf	0.60	0.37	1.25	12.0

Table 3. Grain yield and system productivity of hybrid rice - hybrid rice crop sequence (average of 2 years)

Treatment		Grain yield (t ha^{-1})		System productivity (t ha^{-1})	Increase over control (%)
Wet	Boro	Wet	Boro		
T_1 = Control	- Control	3.23	4.31	7.54	-
T_2 = 50% RD as fert.	- 50% RD as fert.	3.55	5.12	8.67	14.98
T_3 = 50% RD as fert.	- 100% RD as fert.	3.65	5.82	9.47	25.59
T_4 = 75% RD as fert.	- 75% RD as fert.	3.95	5.58	9.53	26.39
T_5 = 100% RD as fert.	- 100% RD as fert.	4.40	5.85	10.25	35.94
T_6 = 50% RD as fert.+ 50% RD as FYM	- 100% RD as fert.	3.86	6.05	9.91	31.43
T_7 = 75% RD as fert.+ 25% RD as FYM	- 75% RD as fert.	3.95	5.86	9.81	30.10
T_8 = 50% RD as fert.+ 50% RD as CR	- 100% RD as fert.	4.05	6.15	10.20	35.27
T_9 = 75% RD as fert.+ 25% RD as CR	- 75% RD as fert.	3.97	5.67	9.64	27.85
T_{10} = 50% RD as fert.+ 50% RD as GM	- 100% RD as fert.	4.05	6.32	10.37	37.53
T_{11} = 75% RD as fert.+ 25% RD as GM	- 75% RD as fert.	4.15	5.82	9.97	32.22
T_{12} = Farmer's practice	- Farmer's practice	3.40	5.31	8.71	15.51
S.Em (±)	0.23	0.43	0.05	-	
CD (P=0.05)	0.66	1.28	0.15	-	

Table 4. Grain yield and system productivity of high yielding rice - high yielding rice crop sequence (average of 2 years)

Treatment		Grain yield (t ha^{-1})		System productivity (t ha^{-1})	Increase over control (%)
Wet	Boro	Wet	Boro		
T_1 = Control	- Control	2.60	3.65	6.25	-
T_2 = 50% RD as fert.	- 50% RD as fert.	2.85	4.55	7.40	18.40
T_3 = 50% RD as fert.	- 100% RD as fert.	2.81	5.38	8.19	31.04
T_4 = 75% RD as fert.	- 75% RD as fert.	2.96	5.20	8.16	30.56
T_5 = 100% RD as fert.	- 100% RD as fert.	3.45	5.75	9.20	47.20
T_6 = 50% RD as fert.+ 50% RD as FYM	- 100% RD as fert.	2.98	5.85	8.83	41.28
T_7 = 75% RD as fert.+ 25% RD as FYM	- 75% RD as fert.	3.04	5.35	8.39	34.24
T_8 = 50% RD as fert.+ 50% RD as CR	- 100% RD as fert.	3.02	5.90	8.92	42.72
T_9 = 75% RD as fert.+ 25% RD as CR	- 75% RD as fert.	3.07	5.45	8.52	36.32
T_{10} = 50% RD as fert.+ 50% RD as GM	- 100% RD as fert.	3.11	6.15	9.26	48.16
T_{11} = 75% RD as fert.+ 25% RD as GM	- 75% RD as fert.	3.14	5.45	8.59	37.44
T_{12} = Farmer's practice	- Farmer's practice	2.73	5.10	7.83	25.28
S.Em (±)	0.20	0.41	0.10	-	
CD (P=0.05)	0.59	1.26	0.29	-	

P and K nutrients were recorded when the crop received 100% recommended doses of nutrients through fertilizers during both wet and boro seasons. This statement is also true in case of total uptake (NPK). It was closely followed by the treatment having application of 50% recommended nutrients through fertilizers and remaining 50% recommended dose of nutrients through organics in wet followed by 100% recommended doses of nutrients through fertilizers for both the crop sequences (Raju and Reddy, 2000).

As regards economic analysis under both the rice-rice cropping sequences maximum net return and return per rupee investment was recorded where the crop received 50% recommended NPK through fertilizer along with 50% NPK through green leaf

manure during wet season and 100% NPK through chemical fertilizer during boro season (Rs. 24939.25 and Rs. 25875.59 per ha per year net return and Rs. 1.66 and 1.62 per rupee investment in HYV-HYV and hybrid-hybrid rice crop sequences, respectively (Table 5 and 6). The next best net return and return per rupee investment was obtained for the crop sequences when the crop was fertilized with 100% NPK through chemical fertilizer (Rs. 24224.51 and Rs. 25075.85 ha^{-1} yr^{-1} net return and Rs. 1.64 and Rs. 1.60 per rupee investment in HYV-HYV and hybrid-hybrid rice sequences, respectively). The results corroborated with that of Banerjee et al. (2006).

The nutrient status of soil after harvesting of each crop in different seasons was analyzed and the extent of increment or depletion of major nutrients (N, P and K) from soil as compared to the their initial values were calculated for both rice-rice sequences with different forms of fertilizer management along with organic manure. It was clearly observed that nitrogen and potassium content improved over initial level by 1 to 17% and 1 to 5%, respectively where crop received 100% recommended doses of nutrients either through 100% chemical fertilizer or 50 or 25% organics were added with inorganics in hybrid rice-hybrid rice crop sequence. In the same crop sequence phosphorus content also increased by 0 to 6% where crop was fertilized by 100% recommended NPK through chemical fertilizer and 50% organics with 50% inorganic fertilizer. Under high yielding-high yielding rice crop sequence improvement of phosphorus and potassium was noticed as in the case of hybrid-hybrid rice sequence but nitrogen content was declined over initial values in all the treatment combinations.

Considering the system productivity, economics of production and soil fertility condition under rice – rice (both for HYV-HYV and hybrid-hybrid) cropping system it may be concluded that an integrated nutrient management system can be developed for sustained

Table 5. Economic analysis of hybrid rice – hybrid rice cropping sequence ha^{-1} yr^{-1}

Treatments (Manuring in wet season - *Boro* season)	Cost of cultivation except the cost of Fert. and Manures (Rs.)	Cost of Fert.and Manure (Rs.)	Total Cost (Rs.)	Gross return (Rs.)	Net return (Rs.)	Return $rupee^{-1}$ investment (Rs.)
T_1 = Control - control	18491.22 x 2 =36982.44	0	36982.44	48760.0	11777.56	1.31
T_2 = 50% RD as Fert. – 50% RD as Fert.	36982.44	2347.53	39329.97	56055.0	16725.03	1.42
T_3 = 50% RD as Fert. – 100% RD as Fert.	36982.44	3746.97	40729.41	61070.0	20340.59	1.49
T_4 = 75% RD as Fert. –75% RD as Fert	36982.44	3397.12	40379.56	61425.0	21045.44	1.52
T_5 = 100% RD as Fert. – 100% RD as Fert	36982.44	4446.71	41429.15	66505.0	25075.85	1.60
T_6 = 50% RD as Fert. + 50%RD as FYM –100% RD as Fert	36982.44	4946.97	41929.41	64230.0	22300.59	1.53
T_7 = 75% RD as Fert. + 25% RD as FYM –75% RD as Fert.	36982.44	3997.12	40979.56	64195.0	23215.44	1.56
T_8 = 50% RD as Fert. + 50% RD as CR –100% RD as Fert.	36982.44	5411.97	42394.41	65435.0	23040.59	1.54
T_9 = 75% RD as Fert. + 25% RD as CR –100% RD as Fert.	36982.44	4229.62	41212.06	62750.0	21537.94	1.52
T_{10} = 50% RD as Fert. + 50% RD as GM – 100% RD as Fert.	36982.44	4496.97	41479.41	67355.00	25875.59	1.62
T_{11} = 75% RD as Fert. + 25% RD as GM –75% RD as Fert.	36982.44	3772.12	40754.56	64540.0	23785.44	1.58
T_{12} = Farmer's practice – farmer's practice	36982.44	3738.36	40720.8	56250.0	15529.2	1.38
S.Em(±)	-	-	-	707	395	0.01
CD (P=0.05)	-	-	-	2050	1145	0.03

Table 6. Economic analysis of high yielding rice – high yielding rice cropping sequence ha^{-1}yr^{-1}

Treatments (Manuring in wet season - *Boro* season)	Cost of cultivation except the cost of Fert. and Manures (Rs.)	Cost of Fert.and Manure (Rs.)	Total Cost (Rs.)	Gross return (Rs.)	Net return (Rs.)	Return rupee^{-1} investment (Rs.)
T_1 = Control - control	16511.89 x 2 = 33023.78	0	33023.78	42185.00	9161.22	1.27
T_2 = 50% RD as Fert. – 50% RD as Fert.	33023.78	2347.53	35371.31	49815.00	14443.69	1.40
T_3 = 50% RD as Fert. – 100% RD as Fert.	33023.78	3746.97	36770.75	54920.00	18149.25	1.49
T_4 = 75% RD as Fert. – 75% RD as Fert	33023.78	3397.12	36420.90	54630.00	18209.10	1.49
T_5 = 100% RD as Fert.– 100% RD as Fert	33023.78	4446.71	37470.49	61695.00	24224.51	1.64
T_6 = 50% RD as Fert. + 50%RD as FYM –100% RD as Fert	33023.78	4946.97	37970.75	59360.00	21389.25	1.56
T_7 = 75% RD as Fert. + 25% RD as FYM –75% RD as Fert.	33023.78	3997.12	37020.9	56470.00	19449.10	1.52
T_8 = 50% RD as Fert. + 50% RD as CR –100% RD as Fert.	33023.78	5411.97	38435.75	60125.00	21689.25	1.56
T_9 = 75% RD as Fert. + 25% RD as CR –100% RD as Fert.	33023.78	4229.62	37253.40	57190.00	19936.60	1.53
T_{10} = 50% RD as Fert. + 50% RD as GM – 100% RD as Fert.	33023.78	4496.97	37520.75	62460.00	24939.25	1.66
T_{11} = 75% RD as Fert. + 25% RD as GM –75% RD as Fert.	33023.78	3772.12	36795.90	57875.00	21079.10	1.57
T_{12} = Farmer's practice – farmer's practice	33023.78	3738.36	36762.14	52530.00	15767.86	1.42
S.Em (±)	-	-	-	705	442	0.01
CD (P=0.05)	-	-	-	2045	1282	0.03

crop production which involves NPK application through integration of organic and inorganic sources of fertilizer.

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