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Integrated effect of organic and inorganic fertilizer on the productivity and profitability of rice grown under rice-rice crop sequences in the Gangetic West Bengal

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ABSTRACT

A field experiment was carried out for two consecutive years (June 2002 to May 2004) during *kharif* and *boro* seasons in each year to study the effect of integrated nutrient supply system under rice (*Oryza sativa* L.) – rice (high yielding) cropping system in the subhumid subtropical climatic condition of West Bengal at Regional Research Sub-Station (RRS), Chakdaha, Nadia, West Bengal. The farm is situated at 23°5.3' N latitude and 83°5.3' E longitude and 9.75 m above the mean sea level. The rice variety used was IET 4786 (Satabdi). The experiment was laid out in a randomised block design (RBD) with twelve treatments and three replications. The land was medium land and the soil was sandy clay loam in texture. The plot size was 15 m². Experimental results revealed that maximum production (9.26 t/ha/year) was recorded when the crop received 50% recommended doses of nutrients through fertilizer along with 50% doses of nutrient through green leaf manuring during *kharif* season and 100% recommended doses of nutrients through fertilizer during *boro* season. The above treatment also gave highest value of *net* return and return/rupee investment (Rs. 24939.25/ha/year and Rs 1.66, respectively). The next highest production, *net* return and return/rupee investment was recorded where the crop was fertilized with 100% recommended doses of nutrient through chemical fertilizer in both *kharif* and *boro* seasons. 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 composed to sole chemical fertilization.

Key words : Organic, Inorganic, Growth, Yield, Uptake, High-yielding rice.

Rice-rice, a main cropping system in the eastern coast of India, requires heavy amount of plant nutrients which results in decline in net returns per unit area (Anonymous, 2001). Long-term fertilizer experiments conducted all over India showed, on an average, thar rice removed 20.7 kg N, 5.17 kg P and 35.5 kg K during wet season for every tonnes 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 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 meeting the growing nutrient demands of intensive agriculture and maintaining the crop productivity at a fairly high level. The combined use of organic manures and inorganic fertilizer help 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 oiut a suitable integrated nutrient supply system in a high yielding rice – rice cropping system.

MATERIALS AND METHODS

A field experiment, for high yielding rice (IET 4786 or Satabdi), was conducted for two consecutive years (June 2002 to May 2004) during *kharif* and *boro* seasons in each years at Region Research Sub-Station, Chakdaha, Nadia, West Bengal. The farm is situated at 23°5.3' N latitude and 83°5.3'E longitude and 9.75 m above the mean sea level. The land was 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 and available K 126.00 kg/ha. The treatments are written as in *kharif* season then *boro* season respectively in Table 1. The experiment was laid out in a randomised block design (RBD) with twelve treatment combinations and three replications. The plot size was 15m². The same layout plan was followed in the same site for both *kharif* and *boro* seasons in both the years of experimentation. Rice was transplanted in the forth week of August and forth week of January during *kharif* and *boro* season 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 substitute a specified amount of N as per the treatments were calculated. All organic were applied 7 days before transplanting during *kharif* season of 2002 and 2003.

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

Treatment	*Kharif* season	*Boro* season
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_2O_5 and K_2O/ha)	Farmer's practice (120, 50 and 50 kg N, P_2O_5 and K_2O/ha)

NB : FYM – Farm yard manure; CR – Crop residues (Paddy straw); GM – Green manuring (Dhanicha green leaf). Recommended doses of fertilizer 60 : 30 : 30 and 120 : 60 : 60 kg N, P_2O_5 and K/ha in *kharif* and *boro* season, respectively.

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
Dhanicha green leaf	0.60	0.37	1.25	12.0

RESULTS AND DISCUSSION

System productivity

Under this crop sequence highest system productivity (9.26 t/ha/year) was obtained when the crop received 50% recommeded doses of NPK through fertilizer in combination with 50% recommended doses of nutrients through green leaf manure during *kharif* season and 100% reocmmended doses through chemical fertilizer during *boro* season resulting 48.16% increase over control (Table 3). Similar results were obtained by Yadav *et al* (1998). *Sesbania* might have helped to release N speedily which matched the stage of crop needs. The results are in line with those of Hiremath and Patel (1998). The next highest production was records where the crop was fertilized with 100% recommended doses of nutrients through chemical fertilizer in both *kharif* and *boro* seasons (47.20% increase over control). The commercial famer's practice of avoiding K in fertilizer schedule showed the lowest system productivity due to unbalanced nutrition.

Uptake of nutrient

In high yielding rice – rice crop sequence, the nutrient uptake by the rice crop after each harvest have been estimated and it is evident that uptake of N, P, K and total uptake by IET 4786 (Satabdi) increased with increasing levels of nutrients (Table 3). Singh and Sharma (1995) reported the similar observation. Maximum uptake of N, P and K were recorded when the crop received 100% RDF during both *kharif* and *boro* season. This statement is also true in case of total uptake (NPK). It was closely followed by the treatment having application of 50% RDF and remaining 50% recommended dose of nutrients through green leaf manure in *kharif* followed by 100% RDF in *boro* season.

Economic analysis of high yielding rice-high yeilding rice cropping sequence

The economics of different treatments in both *kharif* and *boro* sequence under high yielding rice – rice cropping sequence were worked out and relevant data have been depicted in the Table 4. Under this cropping sequence the maximum net return (Rs. 24939.25) and return /rupee investment (Rs. 1.66) were obtained when the crop received 50% RD as fertilizers + 50% RD as green leaf manure in *kharif* season followed by 100% RD as fertilizers in *boro* seasons. Application of 100% RD as fertilizers in both *kharif* and *boro* seasons also gave satisfactory net return (Rs. 24224.51) and return/rupee investment (Rs. 1.64). When the crop received control treatment in both the seasons (*kharif* and *boro*) if gave very poor results.

Table 3 Productivity and uptake of nutrients of high yielding rice – rice crop sequence (Average of two years)

Treatment (Mainly in *kharif* and *boro* season)	Grain yield (t/ha)		System productivity (t/ha)	Increase over control (%)	Average N uptake (kg/ha)	Average P uptake (kg/ha)	Average K uptake (kg/ha)	Average N, P, K uptake (kg/ha)
	Kharif	*Boro*						
T_1	2.60	3.65	6.25	-	93.60	24.90	43.95	83.35
T_2	2.85	4.55	7.40	18.40	139.55	27.30	55.65	112.50
T_3	2.81	5.38	8.19	31.04	147.00	32.50	68.75	124.35
T_4	2.96	5.20	8.16	30.56	152.35	40.75	93.95	142.60
T_5	3.45	5.75	9.20	47.20	171.35	51.60	108.15	166.65
T_6	2.98	5.85	8.83	41.28	168.00	50.40	107.70	163.60
T_7	3.04	5.35	8.39	34.24	158.55	40.05	104.85	154.45
T_8	3.02	5.90	8.92	42.72	161.85	41.05	96.35	150.20
T_9	3.07	5.45	8.52	36.32	166.55	39.45	95.00	149.60
T_{10}	3.11	6.15	9.26	48.16	165.20	46.25	106.10	162.55
T_{11}	3.14	5.45	8.59	37.44	160.15	44.90	89.95	149.35
T_{12}	2.73	5.10	7.83	25.28	156.15	31.65	67.15	127.8
CD at 5%	0.54	0.46	0.35	-	-	-	-	-

Table 4 Economic analysis of the cropping sequence

Treatments (Mainly in *kharif* and *boro* season	Cost of cultivation except the cost of test and manures (Rs.)	Cost of test and manures (Rs.)	Total cost (Rs.)	Gross turn (Rs.)	Net return (Rs.)	Return per repee investment (Rs.)
T_1	33023.78	0	33023.78	42185.0	9161.22	1.27
T_2	33023.78	2347.53	35371.31	49815.0	1443.69	1.40
T_3	33023.78	3746.97	36770.75	54920.0	18149.25	1.49
T_4	33023.78	3397.12	36420.90	54630.0	18209.10	1.49
T_5	33023.78	4446.71	3747.49	61695.0	24224.51	1.64
T_6	33023.78	4946.97	37970.75	59360.0	21389.25	1.56
T_7	33023.78	3997.12	37020.90	56470.0	19449.10	1.52
T_8	33023.78	5411.97	38435.75	60125.0	21689.25	1.56
T_9	33023.78	4229.62	37253.40	57190.0	19936.60	1.53
T_{10}	33023.78	4496.97	37520.75	62460.0	24939.25	1.66
T_{11}	33023.78	3772.12	36795.90	57875.0	21079.10	1.57
T_{12}	3772.12	3738.36	36762.14	52530.0	15767.86	1.42

Soil nutrient status after harvesting of each crop in the sequence

The nutrient status of soil after harvesting of each crop in different season and the extent of increment or depletion of major plant nutrients (N, P and K) from soil as compared to their initial values have been estimated (Table 5). Under this crop sequence improvement of P and K was noticed but N content was declined over initial values in all the treatment combinations. Raju and Reddy (2000) reported that P and K were increased remarkably in all organic sources. Supply of NPK through chemical farms caused heavy depletion of N and K in the long term. This declining trend of nutrients warrants the importance of conjunctive use of organic and inorganic in rice – rice system.

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Table 5 Change in nutrient status of soil during 2002-2004 [Figure in parenthesis give gain (%) or loss (%)]

Treatment	Available N (kg/ha)				Available P (kg/ha)				Available K (kg/ha)			
	2002		2003		2002		2003		2002		2003	
	Kharif	*Boro*	*Kharif*	*Boro*	*Kharif*	*Boro*	*Kharif*	*Boro*	*Kharif*	*Boro*	*Kharif*	*Boro*
T_1	770.00	792.00	748.00	770.00	12.64	12.69	12.13	12.51	112.93	116.25	111.75	113.92
	(30%)	(28)	(32)	(30)	(21)	(20.68)	(24.18)	(21.81)	(10.37)	(7.73)	(11.30)	(9.58)
T_2	814.00	836.00	792.00	814.00	12.51	13.10	12.78	13.46	112.50	113.45	112.36	113.20
	(26%)	(24)	(28)	(26)	(21.81)	(13.12)	(20.12)	(15.87)	(10.71)	(9.96)	(10.82)	(10.15)
T_3	236.00	858.00	836.00	880.00	13.68	14.12	13.45	14.32	120.45	124.25	121.39	122.31
	(24%)	(22)	(24)	(20)	(14.5)	(11.75)	(15.93)	(10.5)	(4.40)	(1.38)	(3.65)	(2.92)
T_4	880.00	924.00	8580.00	880.00	13.95	14.35	14.00	14.73	124.72	125.39	125.50	127.28
	(20%)	(16)	(22)	(20)	(12.81)	(10.31)	(12.5)	(7.93)	(1.01)	(0.61)	(0.39)	+(1.01)
T_5	902.00	902.00	946.00	924.00	16.25	16.99	15.66	16.21	126.13	130.42	126.91	129.39
	(18%)	(18)	(14)	(16)	+(1.56)	+(6.18)	(2.12)	+(1.31)	+(0.10)	+(4.42)	+(0.72)	+(2.69)
T_6	1034.00	1056.00	1078.00	1078.00	16.12	16.31	16.50	16.56	131.85	134.35	132.37	133.05
	(6%)	(4)	(2)	(2)	+(0.75)	+(1.93)	+(3.12)	+(3.5)	+(4.64)	+(6.62)	+(5.05)	+(5.59)
T_7	1056.00	1078.00	1056.00	1100.00	14.72	15.32	14.37	15.70	129.38	131.42	130.45	132.67
	(4%)	(2)	(4)	(0)	(8)	(4.25)	(10.13)	(1.87)	+(2.68)	+(4.30)	+(3.53)	+(5.29)
T_8	924.00	946.00	924.00	968.00	14.35	15.90	15.75	15.50	128.25	129.38	129.37	130.21
	(16%)	(14)	(16)	(12)	(10.31)	(0.62)	(1.56)	(3.12)	+(1.787)	+(2.68)	+(2.67)	(3.34)
T_9	946.00	968.00	946.00	1012.00	15.25	16.59	15.21	16.32	127.66	128.31	126.35	128.42
	(14%)	(12)	(14)	(8)	(4.63)	(3.68)	(4.93)	+(2)	+(1.31)	+(1.83)	+(0.27)	+(1.92)
T_{10}	924.00	946.00	1034.00	1078.00	16.10	16.25	16.35	16.55	128.73	129.67	127.33	128.20
	(16%)	(14)	(6)	(2)	+(0.62)	+(1.56)	+(2.18)	+(3.43)	+(2.16)	+(2.16)	+(1.05)	(1.74)
T_{11}	902.00	946.00	1034.00	1056.00	15.45	15.92	14.75	15.20	127.42	127.82	126.92	127.05
	(18%)	(14)	(4)	(4)	(3.43)	(0.5)	(7.81)	(5)	+(1.12)	+(1.28)	+(0.73)	+(0.83)
T_{12}	880.00	858.00	924.00	880.00	14.00	14.25	14.10	15.01	113.85	114.25	112.42	115.31
	(20%)	(22)	(16)	(20)	(12.5)	(10.25)	(11.87)	(6.18)	(9.64)	(9.32)	(10.77)	(98.48)