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Integrated management of green leaf, compost, crop-residues and inorganic fertilizers in rice (*Oryza sativa*)–rice system

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ABSTRACT

A field experiment was carried out in both rainy and winter seasons during 1992–98 at Maruteru, Andhra Pradesh, to find out the effect of integrated nutrient supply system in rice (*Oryza sativa* L.)–rice system of coastal ecosystem. The highest (121.1 q/ha) system productivity was obtained with the use of sesbania green leaf to substitute 50% NPK need. All organics in conjunction with inorganic fertilizers were superior to sole chemical fertilization in terms of agronomic efficiency. Green-leaf manuring with sesbania resulted in the maximum energy output (170, 079 MJ/ha) and with lesser energy (8,292 MJ/ha) involvement and resulted in the highest energy ratio (19 : 5). When half of the NPK was substituted through green leaf manure, there was maximum uptake of NPK and a low negative N balance. Phosphorus balance was positive in all treatments and its accumulation was particularly high when large amounts of compost, green-manure, and rice straw were incorporated. The pH values of all treatments declined after 6 years of continuous rice cropping. Organic carbon status declined in the control and among the normal fertilized plots, more organic carbon was present in straw-incorporated plots. Potassium values were remarkably augmented in all organic fertilized plots but more conspicuous in straw-applied treatments.

Key words : Integrated management, Green leaf, Crop residue, Rice–rice system

Rice–rice, a main cropping system in the eastern coast of the India, requires heavy amount of plant nutrients which results in decline in net returns per unit area. Rice crop removes about 15 kg N, 4 kg P_2O_5 and 24 K_2O to produce 1 tonne grain with an equal amount of straw from the soil (Hegde, 1992). Nutrient mining by high-yielding rices was usually more than that applied through fertilizers. This negative balance over of the years led to impoverishment of soil fertility and decline in crop productivity (Nambiar, 1992). Besides, the associated pollution hazard of groundwater further complicates the problem. Hence an integrated nutrient management was initiated for sustained crop production, which involves meeting a part of nutrient need of crop through crop residues, green-manures and other organics along with inorganic fertilizers.

MATERIALS AND METHODS

The study was initiated during rainy and winter seasons of 1992–93 and continued up to 6 years in Godavari delta (16.38°N, 81.44° E and 5 m mean sea-level). The soil was clay loam in texture with 61% clay content. The soil had pH 7.1, organic carbon 0.91%, available P_2O_5 38 kg/ha and K_2O 344 kg/ha. There were 12 treatments (Table 1); 4 treatments of different levels of recommended fertilizers in rainy and winter seasons, 6 treatments of integration of chemical fertilizers with organic sources like compost, crop residues (rice straw) and green leaf (*Sesbania rostrata*) along with one each of unfertilized control and farmer's practice of manuring. The treatments were laid out in randomized block design with 4 replications.

Varieties used were 'MTU 2067' in

Table 1. Fertilizer treatments in rainy and winter seasons

Treatment	Rainy	Winter
T_1	No fertilizer manure	No fertilizer manure
T_2	50% RDF of NPK through of fertilizers	50% RDF of NPK through fertilizers
T_3	50% RDF of NPK through fertilizers	100% RDF of NPK through fertilizers
T_4	75% RDF of NPK through fertilizers	75% RDF of NPK through fertilizers
T_5	100% RDF of NPK through fertilizers	100% RDF of NPK through fertilizers
T_6	50% RDF of NPK through fertilizers + 50% through compost	100% RDF of NPK through fertilizers
T_7	75% RDF of NPK through fertilizers + 25% through compost	75% RDF of NPK of through fertilizers
T_8	50% RDF of NPK through fertilizers + 50% through paddy straw	100% RDF of NPK through fertilizers
T_9	75% RDF of NPK through fertilizers + 25% through paddy straw	75% RDF of NPK through fertilizers
T_{10}	50% RDF of NPK through fertilizers + 50% through sesbania green leaf	100% RDF of NPK through fertilizers
T_{11}	75% RDF of NPK through fertilizers + 25% through sesbania green leaf	75% RDF of NPK through fertilizers
T_{12}	Farmer's practice (60, 40, 0 N,P, K kg/ha)	Farmer's practice (120,40,0 N, P, K kg/ha)

RDF, Recommended dose of fertilizers : 60, 40 and 110 kg N, P and K/ha in rainy season and 120, 40 and 40 kg N, P and K/ha in winter season.

Table 2. Composition of organic manures applied (dry-weight basis)

Manure	Mineral composition (%)			C : N ratio
	N	P	K	
Sesbania green-leaf	2.25	0.37	1.25	13
Compost	0.50	0.20	0.50	18
Rice straw	0.45	0.13	1.66	85

rainy and 'IR 64' in the winter seasons. The plot size was 40 m^2. One-third of N and full dose of P and K were given before transplanting and remaining N was top-dressed equally at active tillering and before panicle-initiation stages. Rice was transplanted in the second week of July during rainy season and the second week of December during winter season.

The N content in various organic manures were analysed (Table 2) and their quantities required to substitute a specified amount of N as per the treatments was calculated. All organics were applied 10 days before transplanting. The NPK uptake in grain and straw was determined separately and the total uptake was calculated. Soil was analysed initially and after 6 years for important chemical parameters. The energy budgeting of cropping system was worked out as per Freedman (1980) and Baishya and Sharma

Table 3. Grain yield, system productivity and agronomic N-use efficiency of rice–rice crop sequence (average data of 6 years)

Treatment	Grain yield (q/ha)		Systems productivity (q/ha)	Increase over control	Agronomic efficiency of system
	Rainy	Winter			
T_1	27.6	24.3	51.9		
T_2	34.4	30.5	64.9	20.0	14.4
T_3	33.8	31.7	65.5	20.8	8.7
T_4	41.1	42.3	83.4	37.7	16.7
T_5	49.4	50.5	99.9	48.0	11.1
T_6	53.6	57.3	110.9	53.2	14.7
T_7	52.2	54.1	106.3	52.2	15.7
T_8	45.3	52.6	97.9	46.9	13.0
T_9	46.8	51.8	98.6	47.4	14.6
T_{10}	59.7	61.4	121.1	57.1	16.1
T_{11}	56.5	59.2	115.7	55.1	17.1
T_{12}	42.4	45.7	88.1	41.0	9.9
CD (P = 0.05)	2.6	3.5	3.1		

Details of treatments are given in Table 1

RDF, Recommended dose of fertilizers : 60, 40 and 40 kg N, P and K/ha in rainy season and 120, 40 and 40 kg N, P and K/ha

(1990). Agronomic efficiency was calculated as per the formula suggested by Novoa and Loomis (1981).

RESULTS AND DISCUSSION

System productivity

The productivity of rice–rice system was influenced significantly due to different fertilizer treatments (Table 3). The rice–rice system required application of the 100% recommended fertilizer in both seasons. However, it was possible to reduce the total fertilizer needs by 25% without any adverse effect on system productivity when a part of the NPK was supplied through organics. The crop productivity decreased by 33.0% and 16.5% when 50% and 75% recommended NPK was given to the system respectively.

The highest system productivity was obtained with the use of *Sesbania* green leaf to substitute 50% NPK need. Use of *Sesbania* green leaf and compost to substitute half of the recommended NPK enhanced the system's productivity by 21.2% and 11.0% respectively over sole chemical fertilization at the recommended level. Similar was the response to compost. Rice straw though slightly decreased the crop productivity, it was on par with sole chemical fertilization. All organics in combination with inorganic fertilizers were superior to sole chemical fertilization for agronomic efficiency. Similar results were obtained by Yadav *et al.* (1998). Highest agronomic efficiency was obtained with the treatments where a part of NPK was supplied through *Sesbania* green leaf. *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 conventional farmer's practice of avoiding K in fertilizer schedule showed the lowest agronomic efficiency of the system due to unbalanced nutrition.

Energy input–output relationship of system

Highest energy input was involved under T_5 where the entire recommended fertilizer dose was supplied through chemical form (Table 4). Energy input, in general, enhanced with the increase in fertilizer dose. However, the magnitude of

Table 4. Energy input, output, net return and ratio of rice–rice system under different treatments (mean data of 6 years)

Treatment	Energy input (Mj/ha)	Energy output (Mj/ha)	Net return (Mj/h)	Energy ratio
T_1		76.293	76,293	
T_2	6,025	95,403	89,378	14.8
T_3	9,639	96,285	86,646	9.0
T_4	5,413	122,598	117,185	21.6
T_5	11,633	146,853	135,220	11.6
T_6	9,573	163,023	153,450	16.0
T_7	8,354	156,261	147,907	17.7
T_8	9,542	143,913	134,371	14.1
T_9	8,299	144,492	136,193	16.4
T_{10}	9,479	178,017	168,538	17.8
T_{11}	8,292	170,079	161,787	19.5
T_{12}	11,183	129,507	118,319	10.5

Details of treatments are given in Table 1

Energy equivalent (MJ) of various fertilizers and labour: N (kg) 60.00; P (kg) 4.85; K (kg) 5.56; Rice grain (kg) 14.70, Adult man (8 hr) 15.68

quantitative enhancement varied with manure. The traditional practices like green-manuring and compost application involved minimum input of energy. Freedman (1980) opined that increasing modernization and chemical application involves larger input of energy in crop production.

Green-leaf manuring with *Sesbania* showed the maximum energy output and also correspondingly lesser energy involvement which resulted in highest energy ratio. Efficient energy utilization was in the treatment where 75% NPK dose was given to the system. Substituting 50% and 25% NPK through green-manuring increased 19.8% and 16.4% energy output respectively compared with sole chemical fertilization. The farmer's practice of avoiding K in fertilizer schedule did not show correspondingly higher unit of energy output and energy ratio due to lesser economic yield.

Nutrient balance

Maximum nutrient balance was noticed when 50% NPK was substituted through *Sesbania* green-leaf manure, followed by 25% NPK supplied through same manure (Table 5). This could be attributed to fast decomposition and steady supply of N throughout crop growth with *Sesbania*. Similarly, phosphorus and potassium uptakes were highest when half of the N was supplied through green-manure. Further there was a heavy draining of about 268 kg/ha major nutrients (116 N, 19 P_2O_5 and 133 kg/ha) for each cycle even from unfertilized plots where the crop growth was suboptimum.

There was negative N balance in almost all treatments but the magnitude was very low when the half of N was supplied with compost and paddy straw. Phosphorus balance was positive in all treatments and conspicuous amounts were accumulated when a specified amount of NPK was substituted through compost. These findings confirm those of Hegde (1996). Potassium balance was negative in most of the treatments, even with recommended level of K application. However, it was positive when large amounts of rice straw was incorporated, possibly due to high content of K in straw. Thus compost and rice straw increased the additions of P and K to the system when a part of N was substituted with these sources. The results are in conformity with those of Nambiar *et al* (1992).

Soil-fertility change

The pH showed decline after 6 years of continuous cropping in all treatments. Lower EC values were noticed in unfertilized and under-fertilized plots. The organic carbon status of soil increased substantially in most of the treatments compared with its initial level. Its status was declined markedly in the control and 50% recommended NPK fertilizer plots. Among the fertilized plots, more organic carbon was present in 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 compost and green-manured plots, whereas it was stabilized in straw-incorporated plots.

Table 5. Balance sheet of major nutrients (kg/ha) in rice–rice system

Treatment		Fertilizer nutrient added (A)	Nutrients added through organics (B)	Nutrients removed (C)	Balance in soil at the end (A+B)–C
T_1	N			116	–116
	P			19	–19
	K			133	–133
T_2	N	90		149	–59
	P	70		24	+46
	K	60		153	+93
T_3	N	150		181	–31
	P	100		27	+73
	K	80		180	–100
T_4	N	100		167	–67
	P	80		28	+52
	K	70		171	–101
T_5	N	180		185	–5
	P	100		36	+64
	K	80		209	–119
T_6	N	150	30	184	–4
	P	100	12	35	+77
	K	80	30	196	–86
T_7	N	135	15	187	–37
	P	85	6	38	+53
	K	70	15	180	–95
T_8	N	150	30	178	+2
	P	100	8.7	34	+74.7
	K	80	110.6	175	+15.6
T_9	N	135	15.0	177	–27
	P	85	4.4	34	+55.4
	K	70	55.3	186	–60.7
T_{10}	N	150	30.0	200	–20
	P	100	4.9	43	+62
	K	80	16.7	212	–115
T_{11}	N	195	15.0	194	–54
	P	85	2.5	42	+45.5
	K	70	8.4	202	–123.6
T_{12}	N	180		163	+17
	P	100		32	+68
	K	0		177	–177

Tables 6. Soil-fertility status under various treatments of rice–rice system (after 6 rotations)

Treatment	pH	EC (dS/m)	Organic carbon (%)	Available (kg/ha)	
				P_2O_5	K_2O
Intial	7.1	0.38	0.90	38.0	344
T_1	5.8	0.29	0.71	32.4	274
T_2	5.9	0.33	0.82	33.1	288
T_3	5.9	0.32	0.81	33.0	291
T_4	5.8	0.34	0.86	34.3	300
T_5	5.6	0.38	0.98	36.5	302
T_6	6.7	0.33	1.20	55.3	322
T_7	6.6	0.33	1.18	51.0	315
T_8	5.6	0.33	1.29	40.2	371
T_9	5.6	0.31	1.26	38.5	357
T_{10}	5.7	0.32	1.03	43.4	331
T_{11}	5.6	0.33	0.99	40.1	315
T_{12}	5.8	0.34	0.82	35.0	294

Details of treatments are given in Table 1

Potassium increased remarkably in all organic sources, particularly with straw. Supply of NPK through chemical form caused heavy depletion of K in a long run. This declining trend of nutrients warrants the importance of conjunctive use of organics and inorganics in rice–rice system.

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