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Research Paper

Influence of organic nutrient sources on productivity of rice (*Oryza sativa*)-based cropping systems in Jharkhand

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ABSTRACT

A field experiment was conducted at Ranchi for 4 years (2004-05 to 2007-08) on a fixed site in split plot design consisting two crop sequences: basmati rice (O*ryza sativa L*.)–wheat {*Triticum aestivum* (L.) *emend. Fiori & Paol*} and basmati rice–lentil (*Lens esculenta Mocnch*) in the main plots, where rice was grown after incorporation of green manure *dhaincha* (*Sesbania aculeata*) and four combinations of organic sources *viz.* Farmyard manure (FYM) + vermicompost (VC), FYM + karanj cake (KC), VC + KC in 50: 50 ratio and VC + KC + FYM (1/3rd each) with one absolute control in the sub plots. The productivity of rice–wheat was 21.4% higher than rice–lentil system (3.09 REY t/ha). All combinations of organic manuring were equally effective in increasing productivity of system, decreased the bulk density and increased water holding capacity, microbial population, soil fertility than the initial values as compared to control treatment over a period of four years study.

Key words: Green manure, Lentil, Organic manure, Rice based cropping systems, Rice equivalent yield, Wheat

Green revolution in the mid-sixties gave tremendous boost to food grain production and transformed the nation from importer to exporter with introduction of high yielding varieties, extension of irrigated areas, use of chemical fertilizers, pesticides and increase in cropping intensity. Actually, success always has its costs and the green revolution had no exceptions. We are now facing post–green revolution problems such as: depletion of soil nutrient, water resources, creation of salinity and water logging, resurgence of pest and diseases, increased environment pollution and decline in factor productivity and quality of life due to continuous over use of chemical pesticides and fertilizers (Ramesh *et al.*, 2005). Jharkhand, a newly created state shares 2.5% (7.97 million ha) of area and 2.63% (30 million) population of the country, suits well for organic farming, where negligible amount of fertilizers and pesticides are used. The forest cover of state is 28.5% of its geographical area, which is naturally managed organically and is a storehouse of organic inputs and outputs. The tribal farming community in the vicinity of forest even today practice aborigine technique (organic) for growing crops without chemicals. Under such situation organic farming has significant role for improving productivity of crops and soil fertility as well. As it solely depends on the use of natural wastes, (crop residues, animal manures, off-farm organic wastes), green manure, legumes in sequence, biofertilizers and bio-pesticides/biocontrol agents. Inclusion of legumes in crop rotation under organic farming is must as it improves soil organic matter and soil nitrogen. Incorporation of *Sesbania* green manuring over the years before transplanting of rice helps in improving DTPA–extractable micro–nutrient cations of soil (Nayyar and Chhibba, 2000). It may be due to recycling of the micronutrients from subsurface layer to the surface layer of the soil and the build–up of organic carbon in the surface soil layer.

Actually, the philosophy of organic farming is to feed the soil and it is a means of giving back to the nature, what has been taken from it. With a perception that tomorrow's ecology is more important than today's economy. Keeping this information, the present experiment was undertaken to study the impact of various on farm produced organic resources on nutrient supplying capacity, soil health and crop yield.

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MATERIALS AND METHODS

A field experiment was conducted at Birsa Agricultural

University, Ranchi during 2004-05 to 2007-08 in two crop sequence *viz*. basmati rice–wheat and basmati rice–lentil. The soil was sandy loam (27.50% silt and 4.70% clay) with pH 5.40, low organic carbon (0.39%), high available P (45 kg/ha) and medium in available K (260 kg/ha). The rice crop was grown after incorporation of *Dhaincha* (*Sesbania aculeata)* which received 250 kg/ha rock phosphate equivalent to phosphorus requirement of *kharif* and *rabi* in all the plots except control. *Dhaincha* as green manure crop was sown on 15–20 May using 60 kg seed/ha and harvested after 45 days of sowing, weighed, chopped and incorporated @ 12 t biomass/ha one day before transplanting in the puddled field. Twenty five days old seedlings of 'Birsamati' scented rice were transplanted on 14–18 July at a spacing of 20 cm × 10 cm and were harvested during 5–10 November in all the four years. *Rabi* crop *viz.* wheat 'K 9107' and lentil 'BR 25' received 100 kg N and 20 kg N/ha through different combination of organic inputs *i.e.* Farmyard manure (FYM) + vermicompost (VC), FYM + karanj cake (KC), VC + KC in 50: 50 ratio and VC + KC + FYM (1/3 each) with one absolute control (no fertilizer). *Dhaincha* (*Sesbania aculeata*), FYM, VC and KC contained 2.62–0.68–1.62, 0.5–0.3–0.5, 1.2–0.45–1.4 and 4.0–1.0–1.0% N-P-K respectively. The dose of compost was given on the basis of full dose of nitrogen and applied 15 days before date of sowing. The yield of all the crops was converted into rice equivalent yield (REY) based on prevailing market price for comparison of treatments. The returns were calculated on yearly basis and then averaged. Benefit: cost ratio (B: C ratio) of systems was expressed as ratio of net returns and cost of cultivation. The change in soil fertility status was monitored after four crop cycles *i.e.* after completion of experimentation. The soil samples were analyzed for organic carbon, available N, P and K by standard methods.

RESULTS AND DISCUSSION

Rice

The productivity of rice was similar after wheat (2.28 t/ha) or lentil (2.25 t/ha) as heavy application of organic manure in wheat compared to lentil compensated the residual N gain of soil after lentil (Table 1). All combinations of organic manuring were almost equally effective in increasing productivity of rice. Yield attributing characters followed similar trends. Green manuring refers to addition of green plant tissue to soil. It increased organic matter content of soils, maintained and improved soil structure, reduced loss of nutrients particularly N, provided a source of N for the succeeding crop and reduced soil erosion and thereby increased the production of crops. (Selvi *et al.*, 2005).

Wheat and lentil

Wheat grain as well as lentil grain yield were significantly affected by various organic sources of nutrients (Table 2). The grain yield of wheat crop was higher during 2007-2008 seasons compared with those of 2004-05, 2005-06 and 2006-07 seasons. Further all the combinations of organic sources being similar to each other established their edge over control during all the years. The higher value of grain yield of wheat may be due to greater availability of nutrient in soil, improvement of soil environment resulting in higher root proliferation leading to better absorption of moisture and nutrient and ultimately resulting in higher grain yield. (Singh and Agrawal 2004).

In case of lentil, among different combination of or-

Table 1. Effect of different combinations of organic sources on yield attributes (Pooled data over four years) and yield of rice under rice–wheat and rice–lentil cropping system

Treatment	Yield attributes				Grain yield (t/ha)				
	Effective tillers/m^2	Grains/ panicle	1,000–grains wt. (g)	Biological yield (t/ha)	2004-05	2005-06	2006-07	2007-08	Pooled
Cropping systems									
Rice–wheat	186.7	7.76	18.68	5.41	2.41	1.98	2.02	2.71	2.28
Rice–lentil	186.7	7.78	18.64	5.38	2.37	2.14	2.00	2.50	2.25
SEm±	4.8	1.60	0.10	0.19	0.07	0.04	0.06	0.08	0.07
CD(P=0.05)	NS	NS	NS	NS	NS	0.13	NS	NS	NS
Nutrient sources									
FYM+VC	199.7	81.24	19.43	5.74	2.46	2.10	2.37	2.77	2.43
FYM+KC	197.3	81.25	18.82	5.89	2.60	2.28	2.18	2.96	2.51
VC+KC	193.5	79.64	18.81	5.82	2.59	2.21	2.15	2.91	2.47
FYM+KC+VC	190.7	83.16	18.88	5.71	2.49	2.04	2.27	2.64	2.36
Control	152.4	67.11	17.36	3.82	1.78	1.65	1.11	1.92	1.62
SEm±	4.6	1.58	0.15	0.15	0.06	0.07	0.05	0.11	0.06
CD(P=0.05)	13.7	4.72	0.46	0.46	0.17	0.21	0.16	0.32	0.19

FYM: Farmyard manure; VC: Vermicompost; KC: Karanj cake ganic sources VC+KC being similar to VC+KC+FYM showed edge over rest of nutrient sources in all the years. Results of yield components revealed that residual effect of previously applied green manure had benefited the wheat and lentil crop. Banwasi and Bajpai (2006) reported earlier that green manuring with *Sesbania* significantly increased grain yield.

Rice equivalent yield (REY) of system

On the basis of four year pooled data, rice–wheat system produced significantly higher REY (21.04%) over rice–lentil system (Table 3) preceded by green manure (*Sesbania*) crop. Increase in REY over control (2.33 t/ha) was 60.1, 59.7, 58.4 & 54.5% due to application of FYM+KC, VC+KC, FYM+VC+KC and FYM+VC respectively. This trend was observed in all the four years. Green manuring, which is organic in origin offers the twin benefit of soil quality and fertility enhancement, while meeting a part of nutrients needs by crops. Ranjan and Kothandaraman (1986) reported higher availability of phosphorus to rice from the combined application of rockphosphate and green manure that resulted increased grain yield of rice. Organic manures provided regulated supply of N by releasing it slowly resulting in increased yield of rice and increase in rice equivalent yield (REY) of the system. Similar results were obtained by Sharma (2002).

Nutrient uptake

Total uptake of nutrients (N-P-K) was significantly influenced by cropping system, and nutrient management (Table 4). The highest uptake of nutrients was recorded in rice–wheat system due to higher dry matter production in the system. Increase in nitrogen uptake due to application of FYM+VC+KC, VC+KC, FYM+KC and FYM+VC over control was 44.5%, 44.0%, 43.70% and 41.6% respectively. Similar results were also observed for P and K. The manurial treatment might have improved soil environment, encouraged root proliferation and root surface absorption zone, which in turn, drew more water and nutrients. In addition to the major nutrients from organic sources, the contribution of other macro & micro nutrients for enhancing the crop yield cannot be ruled out.

Physico-chemical properties of soil

The physical properties like bulk density, water holding capacity and organic carbon of soil improved in both cropping systems over the initial value, the highest increase was observed in rice–lentil system (Table 4). Rice–lentil recorded higher organic carbon content, available N, P and K as compared to rice–wheat system after four years of study. The improvement was due to addition of organic matter through root-shoot biomass of crop. Legume in the system increased the availability of several mineral nutrients in the soil, as a result of which soil became rich in

Table 2. Effect of different combinations of organic sources on yield attributes (Pooled data over four years) and yield of wheat/lentil under rice–wheat and rice–lentil cropping system

Treatment	Wheat								Mean
	Yield attributes				Grain yield (t/ha)				
	Effective tillers/m^2	Grains/ spike	1,000–grains wt. (g)	Biological yield (t/ha)	2004-05	2005-06	2006-07	2007-08	
FYM+VC	247	26.0	43.72	5.09	1.89	2.06	2.28	2.19	2.11
FYM+KC	284	26.9	44.40	4.55	1.95	2.15	2.02	2.53	2.16
VC+KC	268	26.6	44.05	5.01	2.10	2.32	2.22	2.42	2.26
FYM+KC+VC	282	26.7	44.13	5.44	2.15	2.30	2.41	2.42	2.32
Control	169	23.5	40.13	2.87	1.23	1.27	1.28	0.87	1.16
SEm±	11.2	0.5	0.43	0.39	0.07	0.08	0.17	0.14	0.12
CD(P=0.05)	35.8	1.7	1.43	1.31	0.20	0.30	0.58	0.47	0.28
Treatment	**Lentil**								**Mean**
	Yield attributes				Grain yield (t/ha)				
	Plant poplation/m^2	Pods/ plant	1,000–grains wt. (g)	Biological yield (t/ha)	2004-05	2005-06	2006-07	2007-08	
FYM+VC	138	42.5	19.27	1.73	0.625	0.632	0.677	0.690	0.66
FYM+KC	148	44.3	19.50	1.83	0.636	0.675	0.709	0.722	0.68
VC+KC	150	44.5	19.53	1.98	0.687	0.722	0.765	0.791	0.74
FYM+KC+VC	198	51.5	20.97	2.18	0.750	0.775	0.837	0.842	0.80
Control	98	33.6	17.40	1.14	0.434	0.440	0.449	0.293	0.40
SEm±	7.1	1.6	0.35	0.072	0.025	0.026	0.028	0.024	0.026
CD (P=0.05)	23.4	5.3	1.17	0.237	0.084	0.087	0.092	0.080	0.086

available N-P-K after harvesting of the pulse crop.

The soil bulk density decreased, while the water holding capacity increased significantly with all the organic manurial treatments. Addition of organic manure in *rabi* crop and *dhaincha* in *kharif* crop and its subsequent decomposition of added organic matter to the soil and thus mass /unit volume of soil reduced and porosity of soil increased resulting in higher water holding capacity of soil. Decrease in bulk density with addition of organic manure and *dhaincha* was also reported by Singh *et al.* (2010).

There was improvement in organic carbon reserve, soil N, P, and K in all the combination of organic manure from their initial values except control. The increase in organic carbon content of the soil with the application of green manure (*Dhaincha*) and organic manure has also reported by Banwasi and Bajpai (2006). The green manure contains

Table 3. Effect of different combinations of organic sources on rice equivalent yield of rice based cropping systems

Treatment	Rice equivalent yield (t/ha)														
	Year														
	2004-05			2005-06			2006-07			2007-08			Pooled		
	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean	C_1	C_2	Mean
FYM+VC	3.94	3.10	3.07	3.40	2.82	3.11	4.15	3.04	3.6	4.39	3.94	4.16	3.91	3.23	3.60
FYM+KC	4.08	3.30	3.69	3.68	3.07	3.38	3.51	3.16	3.33	4.78	4.24	4.51	4.01	3.44	3.73
VC+KC	4.20	3.35	3.78	3.74	3.03	3.39	3.85	2.99	3.41	4.59	4.00	4.29	4.09	3.34	3.72
FYM+KC+VC	4.13	3.28	3.71	3.63	2.85	3.24	3.85	3.43	3.64	4.66	3.68	4.17	4.07	3.34	3.69
Control	2.65	2.35	2.50	2.59	2.08	2.33	1.99	1.71	1.85	2.95	2.35	2.65	2.55	2.12	2.33
Mean	3.80	3.52		3.41	2.77		3.47	2.87		4.27	3.64		3.74	3.09	
SEm± for (S)		0.17			0.21			0.12			0.06			0.05	
CD(P=0.05)		NS			NS			NS			0.40			0.31	
SEm± for (N)		0.05			0.17			0.08			0.13			0.06	
CD (P=0.05)		0.15			0.51			0.23			0.40			0.18	
SEm± for (S&N)		0.37			0.46			0.26			0.14			0.11	
CD (P=0.05)		0.42			NS			0.52			NS			NS	

C_1: Rice–wheat cropping system; C_2: Rice–lentil cropping system; S: Cropping systems; F: Nutrient sources; FYM: Farmyard manure; VC: Vermicompost; KC: Karanj cake; NS: Non significant

Table 4. Effect of different combination of organic sources on economics, nutrient uptake and soil physico–chemical properties of rice– based cropping systems (Pooled data over four years)

Treatment	Cost of cultivation (× 10^3₹/ha)	Net returns (× 10^3₹/ha)	Nutrient uptake (kg/ha/year)			Bulk density (g/cc)	WHC (%)	Organic carbon (%)	Available nutrient (kg/ha)			Microbial population	
			N	P	K				N	P	K	Total fungi (C. fu/g soil)	Total actino-mycetes (C. fu/g soil)
Cropping systems													
Rice–Wheat	22.0	46.0	87.3	17.1	65.3	1.55	41.08	0.43	303.7	45.8	275.5	71.8	76.7
Rice–Lentil	14.4	37.3	71.5	13.0	50.8	1.54	42.05	0.44	304.1	47.9	279.9	73.0	76.3
SEm±			4.2	0.5	2.1	0.015	0.75	0.01	2.6	2.0	5.9	1.87	2.4
CD (P=0.05)			12.6	1.5	6.3	NS	NS	NS	NS	NS	NS	NS	NS
Nutrient sources													
FYM+VC	18.3	46.6	83.8	16.2	60.0	1.51	43.09	0.43	305.3	47.8	280.0	75.8	79.4
FYM+KC	18 .8	47.2	87.4	17.0	64.3	1.54	42.15	0.44	317.6	52.3	286.0	75.6	80.7
VC+KC	20 .7	46.4	87.9	16.6	64.9	1.56	41.89	0.44	318.2	49.8	291.0	76 .0	80.2
FYM+KC+VC	19.3	48.0	88.6	16.7	63.8	1.51	43.17	0.45	321.3	48.8	291.0	76.9	81.0
Control	13 .8	20.1	49.2	8.9	37.1	1.60	39.55	0.39	257.0	35.3	240.0	57.7	62.4
SEm±			3.2	0.9	2.8	0.02	0.68	0.01	5.26	1.9	13.3	2.4	2.8
CD (P=0.05)			9.7	2.8	8.5	0.05	2.03	0.02	15.8	5.7	39.8	7.1	8.4
Initial						1.67	39.42	0.39	305	45	260	48	57

Sale price: Rice: ₹15,000/t, Wheat: ₹11,250/t and Lentil:₹ 25,000/t.
FYM: Farmyard manure; VC: Vermicompost; KC: Karanj cake

two N fractions, one of which undergoes faster decomposition and release N for current crop, while the other mineralizes at slower rate. Enhanced level of organic carbon might be due to latter fraction (Pandian and Perumal 2000). Organic manure helped in the better build up of available N. Since the addition of *Sesbania aculeata* assists in the reduction of pH of flood water and build up the soil fertility. Improvement in the available P status due to the added effect of green manure and organic manure, which would have solublised the Fe-P, Al-P and reductant soluble. The enhancement of available K was might have seen due to appreciable quantity of K released by green manure, which in turn favored the buildup of available K.

Biological properties

Irrespective of cropping system and different combinations of organic nutrient sources, there was sizeable increment in microbial population (total fungi and actinomycetes) from their initial value except control, over time. Decomposition of green manure (*Dhaincha*) and organic manure might have improved the microbial activities leading to increased N fixation and reduced N losses in residue incorporated plots due to the formation of organo–mineral complexes. The increase in available nutrients might be due to solublizing action of certain acids and displacement of phosphate by organic anions formed during the decomposition of organic residues. The organic manure and green manure provides a stable supply of carbon and energy for micro-organism and thus increased microbial population.

Economics

On the basis of four year pooled data, rice-wheat registered ₹8.72 thousands/ha higher net returns as compared to rice–lentil sequence (Table 4). This was due to high yield of wheat in the system. Further all combinations of organic sources registered higher monetary returns over control. Similar findings were earlier reported by Ghanshyam *et al*. (2010).

Thus, it was concluded that continuous in-situ addition of green manuring (*Sesbania aculata*) biomass @ 12 t/ha and rock phosphate @ 250 kg/ha prior to rice in *kharif* season followed by application of any combination of organic sources (FYM, VC and KC) in *rabi* season are best for higher productivity and profitability of rice–wheat cropping system and for improving the soil health.

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