



Effect of organic v/s chemical nutrient packages on productivity, economics and physical status of soil in rice (*Oryza sativa*) – potato (*Solanum tuberosum*) cropping system in Chhattisgarh

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Received: February 2009

ABSTRACT

Field experiments were conducted at Raipur in *Inceptisols* between 2003-04 and 2007-08 to compare organic, integrated and chemical fertilizer nutrient inputs packages in scented rice (*Oryza sativa* L.) – potato (*Solanum tuberosum* L.) a high value cropping system. Seven different nutrient treatments, 5 of them having use of organic inputs and 1 each having integrated (50% through fertilizers and 50% through organic nutrients) and 100% through fertilizers were studied in RBD with 3 replications. Organic transition effect in which decline in yield from 1 to 3 years and again increase in yield was noticeable in rice under organic nutrient inputs packages. These treatments followed a steady increase and registered 20 to 50% more yield at the end of study compared to first year yield *i.e.* 2003-04. However, effect of different organic inputs packages on potato tuber yield was not stable over the years. Total productivity in terms of rice equivalent yield of the system (13.36 tonne/ha) and total net return (Rs 92,634/kg) was highest with chemical fertilizer treatment closely followed by integrated inputs use. 100% N (1/3 each from cowdung manure, *neem* cake and composed crop residue) appreciably increased the organic carbon (6.3 g/kg) over initial value (5.8 g/kg). However, availability of P and K did not show any perceptible change after completion of five cropping cycles under organic as well as integrated nutrient approaches.

Key words: Compost, Cropping systems, Farmyard manure, Potato, Productivity

The global consumers are showing inclination towards health cautiousness with their day-to-day diet. Food crops grown using organic inputs having less or no chemicals are being preferred over conventionally produced food by the end users. Food material produced organically has got its place in food market in developed and developing countries. Organic food as is self explanatory needs large quantity of organic manures to supply nutrients in soil but on the contrary, there is a serious decline in organic matter in Indian soils particularly in tropical regions under the influence of arid, semi-arid and sub-humid climate. Application of organic manure not only improves the soil organic carbon for sustaining the soil physical quality but also increases the soil N. However, N-use efficiency is very low particularly in rice and it is difficult to sustain in the soil system due to volatilization, leaching and denitrification losses. Hence, N is the element to be first thrust in sense of organic farming (Magar, 2004). The replacement of external inputs *viz.*,

chemical fertilizers by farm-derived organic inputs normally leads to a reduction in variable input costs under organic management. In Chhattisgarh, by virtue of using less quantity of chemical fertilizers and pesticides and dependency upon naturally available sources of nutrients, organic food could provide better vistas towards high remuneration with premium price in market with inherent lesser cost advantage. Therefore, an experiment was conducted to evaluate different organic inputs; nutrients sources and to compare the chemical and integrated treatments in rice- potato system.

MATERIAL AND METHODS

Field experiment was conducted on rice-potato cropping system under irrigated conditions between 2003-04 and 2007-08 at Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh under All India Coordinated Research Project on Cropping Systems. The soil was silty clay (*Inceptisols*) in texture and neutral in reaction, medium in organic carbon (5.8 g/kg), low in available N (168 kg/ha), medium in available P (17.4 kg/ha) and high in available K (270 kg/ha). Bulk density of the soil before starting of experiment was 1.66 Mg/m³ at 0-7 cm soil

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depth. Seven treatments, having five different organic nutrient inputs packages and one each of integrated and chemical fertilizer treatment *viz.*, T₁: integrated- 50% recommended dose of fertilizer (RDF) + 50% N $\frac{1}{3}$ each from cowdung manure (CDM) + neem cake (NC) + composted crop residues (CCR)- T₂: 100% N ($\frac{1}{3}$ each from CDM + NC + CCR); T₃: T₂ + green manuring in rice + intercropping of raddish in potato; T₄: T₂ + deep summer ploughing (DSP); T₅: 50% N ($\frac{1}{3}$ each from CDM + NC + CCR) + *Azospirillum*. + phosphorus solubilizing bacteria (PSB); T₆: T₂ + *Azospirillum* + PSB and T₇: RDF were tested in randomized block design replicated thrice with a plot size of 10.0 m x 4.1 m. Bunds of 50 cm height were made between replications and individual plots to check the outflow of nutrients and reduce the border effect. Under the treatment T₃, green manuring was done *in situ* with *Sesbania aculeata* (1.6 tonne/ha dry weight having 2.4 to 2.5% N) in different years. RDF for rice crop was 80-22.0-25.2 kg N-P-K/ha and to potato was 150-35.2-83.3 kg N-P-K/ha. Nitrogen, P and K content (%) of different organic manures on dry weight basis were 0.5, 0.37 and 0.80 in CDM; 5.0, 1.0 and 1.25 in NC and 0.5, 0.5 and 0.75 in CCR respectively. The full dose of P and K and half of the fertilizer N was applied as basal. The remaining quantity of N was given at tillering and panicle initiation stage to rice and at earthing of potato *i.e.* 25 and 50 days after germination. Nitrogen was given as urea, CDM, NC and CCR, as per treatment requirement as basal dose. In organic treatments, P requirement was supplemented through rock phosphate (23% P₂O₅ grade) after adjusting the quantity of P supplied through manures. Basmati rice 'Kasturi' was grown during *kharif* and potato 'Kufri Chipsona' for first 2 years and 'Kufri Badshah' for rest of the 3 years was sown in *rabi* in rice- potato cropping sequence. Transplanting of rice at spacing of 20 cm x 10 cm was done from 15 to 25 July and harvested in last week of October every year to facilitate the planting of well sprouted seed tuber of 30 to 40 g potato in rows 60 cm apart during the first fortnight of November. The total rainfall received during *kharif* (July to October) was 1,335, 690, 1,290, 930 and 746 mm and during *rabi* (November to March) was 84, 115, 159, 22 and 44 mm in 2003-04, 2004-05, 2005-06, 2006-07 and 2007-08, respectively. The experiments were conducted under assured irrigation facilities and need based irrigations were applied to rice and potato, as per recommended practice. Farm gate price of rice was taken Rs 11,000/t and Rs 6,000/t considered for potato and radish. Due to yearly variation in price of crops, the cost of cultivation and net return of ending year *i.e.* 2007-08 was only presented in the study and calculated on the basis of 25% premium price to organic produce where organic manure was added.

RESULTS AND DISCUSSION

Rice yield and yield attributes

At the end of fifth crop cycle, the soil fertility under integrated nutrient package (50% RDF + 50% organic sources) and 100% organic package ($\frac{1}{3}$ N each from CDM + NC + CCR) was developed to provide available nutrients to harvest a comparable crop yield of rice nearer to chemical fertilizer treatment *i.e.* RDF (Table 1). Highest grain yield of rice was recorded in chemical fertilizer treatment when compared with all the treatments having organic nutrient packages in all years. Among organic nutrient supply packages, promising rice yield was obtained only after 2 crop cycles in the treatments, where 100% N was given through CDM + NC + CCR either followed by green manuring (T₃) or deep summer ploughing (T₄) due to greater availability of nutrients in soil, improved soil environment and higher root penetration leading to better absorption of moisture and nutrients. Besides N, GM also added other nutrients. Whereas, yield advantage of rice by applying *Azospirillum*, rock phosphate and PSB with reducing N by 50% (through CDM) was only observed after fourth organic crop cycle. Reduction in recommended dose of N even blended with organic manures failed to sustain productivity of rice (Roul *et al.*, 2006). Soil nutrient status build-up in an organic system takes a long time, due to slow mineralization and release of nutrients from organic sources. Similar results of gradual increase in grain yield with the use of organics over a period of time was also observed by Surekha (2007). Yield attributes of rice *viz.* panicles/m², grains/panicle and test weight followed similar fashion and higher values of these yield parameters were recorded in chemical fertilizer treatment *i.e.* 100% RDF and integrated nutrient package (50% RDF + 50% organic sources).

Potato tuber yield and yield attributes

It is a common belief that "after a transition period of 2 to 3 years from conventional to organic sources of nutrients, organic farming sustains yields when compared with using chemical fertilizers" but it was not found realistic in potato. The effect of different organic nutrient packages was not consistent on tuber yield over the years as obtained in chemical or integrated approaches (Table 1). At the end of fifth crop cycle, balanced inorganic fertilization and integrated nutrient management have sustained crop yields on long-term basis (Dwivedi *et al.*, 2002). Maximum potato tuber yield obtained with the treatment where, 100% RDF was applied and followed by integrated treatment (50% chemical + 50% organic source). Since, potato is one of the heavy feeder crops, the yield of integrated and chemical nutrients were higher than the organic treatments as organic inputs release the nutrients slowly. How-

Table 1. Productivity of rice, potato tuber, total productivity (TP) in terms of rice equivalent yield and economics of rice-potato cropping system as influenced by different organic, integrated, and chemical fertilizers packages

Treatment	Rice yield (tonnes/ha)				Potato tuber yield (tonne/ha)				System analysis kh+rb (2007-08)					
	2003-04	2004-05	2005-06	2006-07	2007-08	2003-04	2004-05	2005-06	2006-07	2007-08	TP (t/ha)	Cost of cultivation (Rs/ha)	Total NR (Rs/ha)	B:C ratio
T ₁ : 50% RDF + 50% N (1/3 each from CDM + NC + CCR)	2.92	4.10	3.47	3.50	4.28	9.11	14.36	19.25	20.43	15.91	12.93	67,635	74,595	1.10
T ₂ : 100% N (1/3 each from CDM + NC + CCR)	2.86	3.41	3.51	3.58	3.66	8.39	13.17	16.33	16.26	13.36	10.94	77,921	72,504	0.93
T ₃ : T ₂ + GM in rice and intercrop of radish in potato*	2.71	3.32	3.62	3.87	4.03	6.46 (5.33+1.13)	15.80 (11.92+3.88)	15.82 (11.55+4.27)	15.95 (12.45+3.50)	12.62 (9.35+3.27)	10.92	80,804	69,346	0.86
T ₄ : T ₂ + DSP	2.78	3.13	3.71	3.92	3.37	8.83	13.87	16.64	18.04	14.04	11.24	79,704	74,846	0.94
T ₅ : 50% N (CDM) + <i>Azospirillum</i> + RP + PSB	2.44	2.74	2.81	2.99	3.58	6.52	12.20	14.83	13.53	11.36	9.56	65,493	65,957	1.01
T ₆ : T ₂ + <i>Azospirillum</i> + PSB	2.25	3.22	3.45	3.49	4.03	9.07	14.25	15.95	17.60	14.56	11.97	78,144	86,444	1.11
T ₇ : RDF	3.06	3.85	3.97	4.13	4.10	9.80	15.66	18.58	19.93	16.98	13.36	54,326	92,634	1.71
SEm±	0.12	0.21	0.20	0.22	0.0	0.17	0.83	0.62	0.55	0.21				
CD (P = 0.05)	0.35	0.62	0.58	0.67	0.12	0.54	2.56	1.85	1.73	0.84				

* Figures in parenthesis show potato tuber yield + potato equivalent yield of radish CDM, cow dung manure; NC, neem cake; CCR, composted crop residue; GM, green manure; RP, rock phosphate; PSB, phosphorus solubilizing bacteria and DSP, deep summer ploughing.

ever, at the end of experimentation, cumulative effect of organic sources was noticeable. Among organic approaches, the tuber yield obtained from some organic inputs treatment was improved as compared to preceding years., Treatments having summer ploughing with 100% N, 1/3 each from CDM + NC + CCR (T₄) and CDM + NC + CCR blended with *Azospirillum* + PSB (T₆) produced significantly higher tuber yield (14.04 and 14.56 tonne/ha, respectively) than other organic treatments (Table 1). Use of organic manures (T₄) and *Azospirillum* + PSB (T₆) helped in increasing nutrient use efficiency and achieved good harvest of potato tubers by reducing the cost of cultivation. Microbes in rhizosphere of crops provide benefits to crops through better nutrient availability by way of mineralization of organic N, atmospheric N-fixation or solubilizing fixed mineral forms of P and other nutrients (Hegde *et al.*, 2007). Application of 100% N (1/3 each from CDM + NC + CCR) + intercropping with radish produced lowest tuber weight/plant (116, 181 and 185 g/plant) and resulted in lowest tuber yield due to the competition by the component crop (radish) for the nutrient during all the years (Table 1 and 2).

Total productivity

The total productivity in terms of rice equivalent yield of *khari* and *rabi* crops and economics of rice-potato system was calculated by assigning 25% premium price to organically grown treatments *i.e.* T₂ to T₆ over inorganic/integrated treatment on the basis of prevailing prices for 2007-08. The highest total productivity (13.36 tonne/ha) was obtained under chemical nutrient package (100% RDF) closely followed by integrated treatment (12.93 tonne/ha) while, 50% N (1/3 each CDM + NC + CCR) + *Azospirillum* + RP + PSB (9.56 t/ha) remained the lowest one. Highest total net return (Rs 92,634/ ha) and B:C ratio (1.71) was also obtained with the application of RDF. The effect of organic manures combined with inorganic fertilizers on both rice and potato was prominent when compared with organic manure alone (Singh and Kushwah, 2006). Organic nutrient packages failed to register higher net return even though the premium prices was given to them due to more cost of cultivation involved on weeding, arrangement and transportation of bulky manures etc. The lowest net return was recorded with 50% N (CDM + NC + CCR) + *Azospirillum* + RP + PSB. However, lowest B:C ratio (0.86) was calculated in that treatment where, 100% N was given through CDM + NC + CCR either followed by green manuring (rice) or intercropped with radish in potato due to highest cost of cultivation incurred (Table 1).

Physico-chemical properties

Bulk density of soil remained unaffected due to application of different organic and chemical nutrient packages. However, it was slightly higher in 100% RDF (1.43 Mg/m³) when compared with organic treatments. Organic carbon (OC) in soils is considered as an indicator of N-supplying capacity of soils. It could help in an efficient and judicious use of fertilizer N and a substantial proportion of N utilized by rice is derived from mineralizing soil organic matter (Sahrawat, 2006). The OC ranged from 6.0 to 6.5 g/kg of soil under various organic and chemical nutrient treatments (Table 2). It remained higher in organic treatment with 100% N (1/3 each from CDM + NC + CCR and in RDF. Electrical conductivity (EC) and pH ranged from 0.21 to 0.24 dS/m and 7.29 to 7.50 under various organic & chemical fertilizer treatments respectively.

After completion of fifth crop cycle in 2007-08, appli-

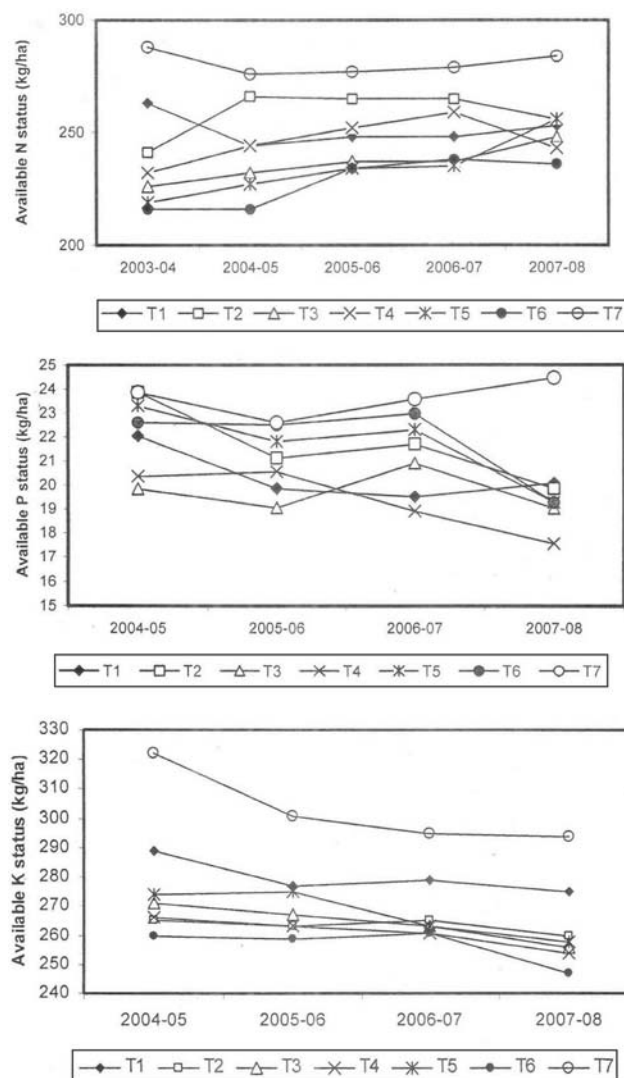
cation of chemical fertilizer source of nutrients *i.e.* RDF recorded the highest N (284 kg/ha) as well as P and K status. High availability of N, P and K nutrients was also found in organic treatments *i.e.* under CDM + NC + CCR. Built-up of N status of organic nutrient packages pooled and averaged over five years of experimentation followed an increasing trend over the years. Available phosphorus content remained high (24.46 kg/ha) in chemical source of nutrient *i.e.* RDF. Amongst various organic sources of nutrients, application of 100% N supplied 1/3 each from CDM + NC + CCR + *Azospirillum* + PSB stood second (20.1 kg/ha) after RDF. However the lowest available soil phosphorus status (17.55 kg/ha) was recorded under organic treatment having 100% N through CDM + NC + CCR + deep summer ploughing. Available P continuously decreased with use of organic nutrient package. If the organic treatments are averaged, the content is less after 5

Table 2. Yield attributes of rice and potato as influenced by different organic, integrated, and chemical fertilizers package

Treatment	Rice									Potato		
	Panicle/m ²			Test weight (g)			Grains/panicle (No.)			Tuber weight (g/plant)		
	2003-04	2005-06	2007-08	2003-04	2005-06	2007-08	2003-04	2005-06	2007-08	2003-04	2005-06	2007-08
T ₁ : 50% RDF + 50% N (1/3 each from CDM + NC + CCR)	310	325	336	21.7	21.2	22.4	91.5	96.2	98.6	163	311	264
T ₂ : 100% N (1/3 each from CDM + NC + CCR)	310	322	323	21.1	21.2	20.9	90.2	92.3	94.8	146	281	234
T ₃ : T ₂ + GM in rice and intercrop of radish in potato	302	326	335	21.5	21.4	22.1	87.3	93.0	98.0	116	181	185
T ₄ : T ₂ + DSP	303	334	317	21.1	20.8	21.3	94.3	89.3	92.7	151	262	243
T ₅ : 50% N (CDM) + <i>Azospirillum</i> + RP + PSB	295	310	315	19.6	20.3	21.2	87.1	93.3	91.3	108	253	215
T ₆ : T ₂ + <i>Azospirillum</i> + PSB	275	316	330	19.4	20.9	21.8	79.6	95.3	94.7	166	279	255
T ₇ : RDF	316	342	339	21.0	21.3	22.1	92.7	95.7	98.3	167	294	275
SEm±	2	6	4	0.1	0.3	0.3	2.5	2.6	2.2	7	6	5
CD (P = 0.05)	7	18	13	0.3	1.1	0.9	7.4	7.7	6.8	21	19	14

Table 3. Organic carbon, soil physical properties and available nutrient content in soil as affected by different nutrient packages after completion of 5th cycle (2007-08)

Treatment	Organic carbon (g/kg)	Bulk density (Mg/m ³)	EC (dS/m)	pH	Available nutrient (kg/ha)		
					N	P	K
T ₁ : 50% RDF + 50% N (1/3 each from CDM + NC + CCR)	6.1	1.39	0.21	7.36	253	20.1	275
T ₂ : 100% N (1/3 each from CDM + NC + CCR)	6.3	1.35	0.21	7.38	256	19.8	260
T ₃ : T ₂ + GM in rice and intercrop of radish in potato	6.0	1.39	0.24	7.29	248	19.0	256
T ₄ : T ₂ + DSP	6.2	1.35	0.22	7.39	243	17.5	254
T ₅ : 50% N (CDM) + <i>Azospirillum</i> + RP + PSB	6.0	1.37	0.24	7.40	256	19.3	258
T ₆ : T ₂ + <i>Azospirillum</i> + PSB	6.1	1.39	0.23	7.40	236	19.3	247
T ₇ : RDF	6.5	1.43	0.23	7.50	284	24.5	294
SEm±	0.01	0.01	0.01	0.06	5	1.0	7
CD (P = 0.05)	0.03	0.04	0.03	NS	16	3.0	18
Initial	5.8	1.66			169	17.4	274



T₁: 50% RDF + 50% N $\frac{1}{3}$ each from CDM + NC + CCR, T₂: 100% N ($\frac{1}{3}$ each from CDM + NC + CCR), T₃: T₂ + GM in rice and intercrop of raddish in potato, T₄: T₂ + DSP, T₅: 50% N (CDM) + *Azospirillum* + RP + PSB, T₆: T₂ + *Azospirillum* + PSB, T₇: RDF

Fig. 1. Available N, P and K status of soil as affected by different organic, integrated, and chemical fertilizers packages

years when compared with initiation of study (Fig. 1). Available potassium content in soil ranged from 247 to 294 kg/ha. It remained higher in RDF followed by integrated treatment and was lower in 100% organic (CDM + NC + CCR) + *Azospirillum* + PSB. Amongst the various sources of organic nutrients, application of 100% N ($\frac{1}{3}$

each from CDM + NC + CCR) recorded higher status (260 kg/ha) of available K in soil. Potassium content followed a decreasing trend over the years under inorganic as well as organic treatments and was somewhat stable under integrated treatment (Fig. 1).

Consequently application of organic sources of the nutrients had their considerable role to affect the productivity of scented rice-potato cropping sequence when compared with integration of organic and inorganic nutrients and fertilizer alone. Steady increase in rice productivity, build-up of organic carbon and soil N can be achieved over the years. In rice, 100% N ($\frac{1}{3}$ each from CDM + NC + CCR) either with green manuring or supplemented with *Azospirillum* + PSB could be a promising combination for obtaining profitable yield. In potato, organic treatments failed to register any noticeable increase in yield over the years because of heavy consumption of potassium by potato and organic sources might have not replenished that amount of potassium in the soil to fulfill the requirement of potato.

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