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Effect of organic nitrogen nutrition on yield, quality, nutrient uptake and economics of rice (*Oryza sativa*)—table pea (*Pisum sativum* var. *hortense*) — onion (*Allium cepa*) cropping sequence*

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The post-green revolution problems, presently threatening the sustainability of Indian agriculture as a whole and raising a serious concern about national food security include: stagnation or even decline in production and productivity growth rates of major crops, deterioration of soil fertility, decline in factor productivity, low diversity of production systems and increasing production costs, leaving agriculture as an economically non-viable enterprise. It is due to these problems that the echo of sustainable and eco-friendly agriculture, viz organic farming became louder (Saini and Pandey 2009). Use of organic manures have been found to be promising in arresting the decline in productivity through correction of deficiency of secondary and micronutrients and its beneficial influence on the physical and biological properties of soil. Use of high analysis chemical fertilizers in imbalanced and indiscriminate manner had developed many problems like decline of soil organic matter, increase in salinity, sodicity, soil pollutant and hazards of pests and diseases (Chakraborti and Singh 2004). Continuous use of inorganic fertilizers has brought loss of vital soil fauna and flora. Organic production systems, maintained and improved the soil health through stimulating the activity of soil organisms and organic manures are also helpful in alleviating the increasing incidence or deficiency of secondary and micronutrients and is capable of sustaining crop productivity. Organic manures modifies the soil physical behaviour and increases the efficiency of applied nutrients (Pandey *et al*. 2007). Regular application of organics in amounts sufficient to meet the requirements of crops not only results in increasing crop yield but also improve soil fertility and organic matter content (Ramesh *et al*. 2008). Use of organic manures to meet the nutrient requirement of crops would be an inevitable practice in the years to come for sustainable agriculture, hence organic matter should be replenished by adding organic manures. Therefore, the present study was conducted to find out the effect of various organic manures on yield, quality and nutrient uptake by rice (*Oryza sativa* L.)—tablepea (*Pisum sativum* L. var *hortense*)—onion (*Allium cepa* L.) cropping sequence and to explore the possibility of improving the productivity, profitability and sustainability of the above sequence by supply of nutrients through organic source.

A field experiment was conducted during 2003–05 at Varanasi, Uttar Pradesh with rice–table pea–onion cropping sequence during rainy, winter and summer seasons. The soil was sandy clay loam in texture with *p*H 7.12, 0.45% organic carbon and 180.5, 18.2 and 202.4 kg/ha available N, P and K respectively. The experiment was carried out in randomized block design in fixed plots lay out replicated with 10 treatment combinations involving 3 sources of organic manures, viz farmyard manure, vermicompost and poultry manure adopting 3 different rates, ie 100, 125 and 150% of recommended nitrogen dose and 100% recommended nitrogen dose through urea (control). The organic manures were applied as per their nutrient content on oven dry weight basis. The farmyard manure, vermicompost and poultry manure contained 0.50, 2.30 and 2.80% N, 0.20, 0.75 and 2.20% P_2O_5 and 0.50, 1.23 and 1.30% K_2O, respectively. Organic manures were applied as per treatment at sowing and mixed thoroughly in 15 cm top soil layer. In control treatment, recommended nitrogen dose through urea was drilled 10 cm deep and 5 cm away from the seed or seedling. The 'Pusa Sugandha 3' rice, early 'Apoorva' table pea and 'Pusa Red' onion were transplanted/sown at 20 cm × 10 cm, 30 cm × 10 cm and 20 cm × 10 cm, respectively. Protein content in rice and table pea grain was estimated through NIR by taking whole grain under near infrared waves.

*Short note

Based on complete PhD thesis of the first author submitted to BHU, Varanasi during 2006

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Pungency (%) in onion was computed by Allyl-propyl-disulphide content in onion bulb determined as pyruvic acid and using formula suggested by Hort and Fisher (1970). The yield data were recorded and converted into rice equivalent and system productivity was calculated on the basis of inputs used during the investigation period and prevailing market prices of rice, table pea and onion for inorganic treatment (T_{10}) while premium prices were assigned to organically grown treatments (T_1 to T_9).

Pooled data of 2 years revealed that the system productivity of rice–table pea–onion sequence in terms of rice-equivalent yield was highest with the application of poultry manure @ 150% recommended nitrogen dose than other treatments. In general, the production of grain, pod and bulb of rice, table pea and onion were higher with application of organic manures, respectively (Table 1). Among organic nutrient supply, higher application rate of each manure augmented system productivity of which poultry manure was best, closely followed by vermicompost. This is due to greater availability of nutrients in soil, improved soil physical condition and higher total uptake of nutrients because of better root penetration leading to better absorption of nutrients and moisture. Thus higher rates over recommended nitrogen dose favourably influenced plant growth and development characters which ultimately resulted in higher yields.

Pooled economic evaluation in terms of monetary returns showed that all the organic nitrogen nutrition treatments gave higher net returns and benefit : cost ratio than control (Table 1), indicating that organic nitrogen management is a productive and remunerative practice, while 100% recommended nitrogen dose through urea was found least economical. The highest system productivity in terms of rice equivalent yield (311.67 tonne/ha) was obtained under poultry manure applied @ 150% recommended nitrogen dose, closely followed by poultry manure applied @ 125% (299.78 tonne/ha) and 100% (294.92 tonne/ha), respectively. Maximum net returns of ₹ 130 799/ha with 1.49 benefit : cost ratio was obtained when crops were fertilized with 150% recommended nitrogen dose through poultry manure . It was followed by (₹ 1 30 517/ha and 1.72 benefit : cost ratio) 100% recommended nitrogen dose applied as poultry manure . The benefit : cost ratio reduced with increase in the rate of manure application is an indicative of the fact that additional productivity obtained due to increased manorial dose over the recommended nitrogen dose and the value of additional product/ha were not proportionately increased.

Nitrogen, phosphorus and potassium uptake by the system was highest with 150% recommended nitrogen dose applied as poultry manure (T_9) over 100% recommended nitrogen dose through urea (T_{10}) (Table 1) which could be ascribed to the increase in the available nitrogen, phosphorus and potassium contents in soil resulting from the increased availability of nutrients through organic sources, particularly poultry manure and it was followed by vermicompost and farmyard manure (Biswas and Narayanasamy 1998).

Soil physical parameters, viz bulk density and water stable aggregates did not show any profound effect due to addition of organic materials (Table 2). The values of chemical properties of soil like organic carbon, available N, P and K increased significantly from initial stage and over the control treatment on the completion of 2-year cycle of rice–table pea–onion sequence. The maximum organic carbon build-up was accured (0.54%) when 150% recommended nitrogen dose

Table 1 Effect of organic nitrogen nutrition on the productivity, total NPK uptake, rice equivalent yield (REY) and economics of rice–table pea–onion cropping sequence (pooled data over 2 years)

Treatment	Yield(tonnes/ha)			Net returns (Rs/ha)	Cost of cultivation (Rs/ha)	Benefit : cost ratio	Rice equivalent yield	Total uptake of system(kg/ha)		
	Rice grain	Table pea green pod	Onion bulb					N	P	K
T_1, 100% RND as FYM	4.38	4.621	23.93	97 749	75 917	1.29	2 479.7	183.49	59.28	222.53
T_2, 125% RND as FYM	4.45	4.789	24.53	96 602	81 917	1.18	2 543.9	187.96	61.69	229.53
T_3, 150% RND as FYM	4.68	5.095	25.06	96 846	87 917	1.10	2 637.5	195.08	63.45	231.71
T_4, 100% RND as VM	4.75	5.465	25.46	114 198	75 917	1.50	2 714.5	198.70	64.90	238.65
T_5, 125% RND as VM	5.08	5.981	25.92	116 451	81 920	1.42	2 839.4	205.67	67.10	244.81
T_6, 150% RND as VM	5.20	6.371	26.22	116 038	87 917	1.32	2 917.8	209.53	68.79	252.01
T_7, 100% RND as PM	5.22	6.469	26.50	130 517	75 917	1.72	2 949.2	217.43	70.87	260.63
T_8, 125% RND as PM	5.40	6.656	26.62	128 233	81 920	1.56	2 997.8	222.07	72.45	270.99
T_9, 150% RND as PM	5.80	7.072	27.08	130 799	87 917	1.49	3 116.7	231.28	74.98	286.81
T_{10}, 100% RND through urea	4.13	3.703	23.63	49 494	54 522	0.91	2 200.8	174.54	57.15	209.55
CD (*P*=0.05)	0.363	0.588	1.17					4.50	1.14	12.04

RND, Recommended nitrogen dose; FYM, farmyard manure; VM, vermicompost; PM, poultry manure

Charges of input used (₹/kg): Urea 5.00, FYM 0.50, VM 3.00, PM 3.00

Selling price (₹/kg) of organic produce: Rice grain 6.50, table pea pod 8.00, onion bulb 4.00, rice and table pea straw 1.00

Selling price (₹/kg) of inorganic produce: Rice grain 5.00, table pea pod 5.00, onion bulb 3.00, rice and table pea straw 0.50

Table 2 Parameters as influenced by organic nitrogen nutrition at the end of 2- year cycle of rice–table pea–onion sequence

Treatment	Soil physical parameters			Soil chemical parameters				Soil biological parameters		
	Bulk density (g/cc)	Porosity (%)	Water stable aggregates (%)	Organic carbon (%)	Available nutrient (kg/ha)			Bacteria ($\times10^3$)	Fungi ($\times10^3$)	Actinomycetes ($\times10^3$)
					N	P	K			
T_1, 100% RND as FYM	1.36	40.32	18.01	0.44	184.34	24.43	154.41	62.82	22.50	33.73
T_2, 125% RND as FYM	1.37	40.38	18.18	0.45	185.46	24.61	154.87	63.63	23.03	34.74
T_3, 150% RND as FYM	1.39	41.34	18.20	0.46	186.72	25.44	155.44	66.92	24.00	35.43
T_4, 100% RND as VM	1.38	40.30	18.01	0.47	187.73	26.52	157.42	72.34	25.31	36.25
T_5, 125% RND as VM	1.40	40.36	18.20	0.48	189.44	27.82	158.84	77.94	27.94	37.44
T_6, 150% RND as VM	1.41	41.18	18.50	0.49	189.95	28.00	160.42	78.65	28.63	43.18
T_7, 100% RND as PM	1.39	40.20	18.04	0.50	190.44	28.42	161.72	79.54	29.45	46.94
T_8, 125% RND as PM	1.41	40.22	18.32	0.52	191.43	28.84	162.43	80.44	32.11	54.46
T_9, 150% RND as PM	1.42	40.95	18.65	0.54	192.98	29.43	164.12	82.45	37.82	58.23
T_{10}, 100% RND through urea	1.35	40.02	18.00	0.40	178.95	22.44	152.44	41.85	11.49	33.44
Initial	1.35	40.00	18.00	0.38	178.43	22.41	151.24	41.45	11.25	32.41
CD (*P*=0.05)	NS	0.86	NS	0.12	9.78	0.56	8.94			

was supplied through poultry manure (T_9), while the least value (0.40%) was noticed with the 100% recommended nitrogen dose through urea (T_{10}). The organic carbon of the soil increased over its initial status (0.38%) under nitrogen supply through organic sources. The nutrient status of the experimental site was also affected significantly by the application of different organic manures along with their varying rates. Results clearly indicated improved fertility status of soil due to increased values of available N, P and K in all organic treatments over its initial value as well as control. Application of organic manures with increased rate enhanced soil fertility over their lower doses. At the end of 2-year cycle, 150% recommended nitrogen dose applied as poultry manure maintained higher values of organic carbon and available N, P and K. Next best treatments in this respect were also found when poultry manure applied with reduced rates of 125% and 100% recommended nitrogen dose, respectively. Continuous application of organic manures in sufficient quantities have been reported to improve the soil organic carbon and available N, P and K in soil, thereby sustaining the soil health (Tiwari *et al*. 2002).

Soil biological properties showed improvement in the soil microbial counts over its initial values at the end of 2-year cropping sequence due to supplementation of organic sources. Poultry manure applied @ 150% recommended nitrogen dose was best which lead into higher counts of bacteria (82.45×10^3), fungi (37.82×10^3) and actinomycetes (58.23×10^3), closely followed by the treatments where poultry manure was applied with reduced rates (T_8 and T_7), respectively. The control treatment (T_{10}) had relatively lower values of soil microbial count than the organic treatments. The favourable effect of organics on soil biological properties is a proven fact which helped in providing ideal conditions and presumably increased the microbial activity because of the available high organic matter. Hati *et al*. (2001) and Shanmei *et al*. (2002) also reported favourable effect of organic manures on soil biological properties. These results are in conformity with the findings of Bohra (2005).

SUMMARY

A field experiment was conducted during 2003–05 to study the effect of various sources (farmyard manure, vermicompost and poultry manure) and rates of organic manures (100, 125 and 150% recommended nitrogen dose) on yield, quality of produce, soil quality and economics of rice (*Oryza sativa* L.) – table pea (*Pisum sativum* L. var. *hortense*) – onion (*Allium cepa* L.) cropping sequence. Poultry manure @ 150% recommended nitrogen dose gave higher grain yield (5.79 tonne/ha) of rice, green pod yield (7.07 tonne/ha) of table pea and bulb yield (27.08 tonne/ha) of onion. Application of poultry manure resulted improved values of soil organic carbon, NPK uptake and soil biological properties compared to varying doses of vermicompost and farmyard manure and over the control. Physical properties of soil, viz bulk density and water stable aggregates were not affected due to nitrogen management through organic sources. Economic analysis revealed that the highest rice equivalent yield and maximum net profit (₹ 130 799/ha) from rice–table pea–onion sequence were recorded with the application of 150% recommended nitrogen dose through poultry manure.

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