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Profitability of high value crops with organic nitrogen sources under rice (*Oryza sativa*) based cropping sequence

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ABSTRACT

A field experiment was conducted during 2005-06 and 2006-07 at Campus Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi to identify a suitable high value cropping sequence with organic nitrogen sources under rice (*Oryza sativa* L.) based cropping system. The experiment was laid out in split plot design with three replications. Seven rice based cropping sequences, viz. rice-potato-onion; rice-green pea-onion; rice-potato-cowpea (green pod); rice-green pea-cowpea; rice-rajmash (green pod)-onion; rice-rajmash-cowpea and rice-maize (green cob)-cowpea were assigned to main plots and three organic treatments (control; 100% RDN through organic manure along with biofertilizers and 100% RDN through organic manure alone) were allocated to sub plots. Among the cropping sequences, rice-potato-onion gave the highest rice grain equivalent yield (35.57 tonnes/ha), maximum net return (₹ 268 656/ha), profitability (₹ 738/ha/day) and labour employment generation (469 man days/ha/year). However rice yield and soil fertility status was not significantly affected by cropping sequences. Application of 100% recommended dose of through organic manure along with biofertilizers (*Azotobacte*r and PSB) had the highest rice equivalent grain yield (35.31 tonnes/ha), production efficiency (96.74 kg/ha/day), net monetary return (₹ 292 454/ha), profitability (₹ 803/ha/day) and labour employment generation (419 man days/ha/year). Inclusion of pulses in sequence with proved superior due to its viable favorable effect on soil fertility. Thus organic nitrogen nutrition with biofertilizers had the highest rice equivalent grain yield, production efficiency, net monetary return and profitability.

Key words: Cropping sequence, Organic farming, Profitability, Rice, System productivity

Increased consumer awareness of food safety issues and environmental concerns has contributed to the growth in organic farming over the last few years. With increasing health consciousness and concern for environment, organic farming systems have been drawing attention of the people all over the world almost for the past three decades. Demand for organic products, especially in developed countries, has been increasing by leaps and bounds (Prasad and Gill 2009). Furthermore, 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 and deterioration of soil fertility (Saini and Pandey 2009). There has been a growing public concern about adverse impacts of pesticides and chemical fertilizers on the environment and on the safety and quality of food. Organic manures can be used to promote the healthy population of beneficial organisms in the soil. Biofertilizers, on the other hand are cost-effective and renewable source of plant nutrients to supplement the parts of chemical fertilizers (Jaipaul *et al*. 2011). In addition to these organic sources besides supplying nutrients also make unavailable sources of elemental nitrogen, bound phosphates and micro nutrients into available form in order to facilitate the plants to absorb the nutrients. Therefore, farmers can in turn, get good remuneration from the organically produced crops and vegetables due to their heavy demands in domestic, national as well as international markets which may help country in earning some foreign exchange. These evidences suggest that the use of organic manures and biofertilizers could be a key factor for achieving more remuneration and maintaining soil fertility. Keeping these facts in view the present investigation was carried out.

MATERIALS AND METHODS

A field experiment was conducted during 2005-06 and 2006-07 at Campus Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The

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geographical co-ordinates of experimental field are 25°18" N latitude and 83°3' E longitude and an altitude of 129.93 meters above mean sea level. The soil was sandy clay loam in the texture with pH 7.4, moderately fertile, being low in organic carbon (0.45%), and available nitrogen (185.5 kg/ha) and medium in available phosphorus (20.35 kg/ha) and potassium (210.32 kg/ha). The amount of total rainfall received during the period of investigation was 721.5 mm, major part of which was received in the month of August during experimentation. The maximum temperature of 44.1°C during the experimentation was recorded in the month of June whereas the lowest minimum temperature remained 7.4°C in December. The highest maximum relative humidity was 92 per cent in July and the minimum relative humidity remained 14 per cent in April. The average duration of bright sunshine day during the course of investigation was 7.5 hours. The range of maximum and minimum mean weekly bright sunshine duration was 9.5 to 1.9 hours during the period of investigation. The experiment on rice based high value cropping sequences with organic N nutrition treatments was laid out in split plot design with three replications. Seven rice based cropping sequences rice-potato-onion; rice-green pea-onion; rice-potato-cowpea (green pod); rice-green pea-cowpea; rice-rajmash (green pod)-onion; rice-rajmash-cowpea and rice-maize (green cob)-cowpea were assigned to main plots and three organic treatments, viz. control (no application of any source of nutrients), 100% recommended dose of nitrogen (100% RDN) through organic manure (1/3 farmyard manure+1/3 vermicompost +1/3 poultry manure) alone and 100% RDN through organic manure [(1/3 farmyard manure+1/3 vermicompost +1/3 poultry manure) along with bio-fertilizer (*Azotobacter* + phosphate solubilizing bacteria)] were allocated to sub plots.

With a view to avoid the mixing of soil in different treatments, individual plots were thoroughly prepared by power tiller in each season. Cultivation practices were followed as per standard recommendation for each crop. Variety HUBR 2-1 of rice, Kufri Badshah of potato, Early Apoorva of green pea, Pioneer Hybrid (X 3342) of maize, HUR 137 of rajmash, Agrifound Light Red of onion and Tokito Hybrid of cowpea were used in this experiment. Properly decomposed organic manures were applied at 15 days before sowing the crops. The seed was inoculated with biofertilizers (*Azotobacte*r + PSB) and sown as per treatment. Rice grain equivalent yield and economics were calculated considering the prevailing market prices rice grain (₹ 1 078/q), potato (₹ 880/q), green pea (₹ 1 320/q), rajmash (₹ 1 540/q), maize (₹ 660/q), onion (₹ 880/q) and cowpea (₹ 1 760/q) were considered. The system productivity was calculated by dividing the total rice equivalent yield of the system by 365. Profitability in kg of ₹/ha day was worked out by dividing the average net return over years by 365. Soil was analyzed at initial stage and after completion of the studies to monitor the changes in nutrient status due to different treatments. Data of both years were pooled and subjected to analysis of variance (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Economic yield of crops in sequences

Data on economic yield of each crops under treatment of various cropping sequence and organic are shown in Table 1 (average value) that application of 100% recommended dose of nitrogen through organic manure along with biofertilizers recorded lowest to highest economic yield of rice grain (4.35 to 4.55 tonnes/ha) during rainy season; potato tuber (26.78 to 27.88 tonne/ha), green pea (4.91 to 5.45 tonnes/ha), rajmash (8.79 to 8.83 tonnes/ha) and maize (19.55 tonnes/ha) during winter season and onion (26.52 to 27.09 tonnes/ha) and cowpea (9.09 to 9.49 tonnes/ha) during summer season, respectively. Similarly, next highest economic yield was found under application of 100% recommended dose of nitrogen through organic manure alone. However, lowest yield was recorded under control plot (no application of any sources of nutrients.) during investigation. Further, statistically analyzed data of different are given in Table 2.

Rice grain yield

Data on yield of rice as affected by different treatments are presented in Table 2. Yield of rice did not differ significantly under different cropping sequences. In organic treatment application of 100% RDN through organic manure along with biofertilizers recorded the highest grain yield (4.43 tonnes/ha). This might be due to better availability of nutrients through superimposition of organic manure along with biofertilizers. It was also observed that plant well supplied with nitrogen, senescence of flag leaf was delayed and respiratory losses were low. Besides fixing non-symbiotic atmospheric nitrogen by *Azotobacter* in soil it also produced growth promoting substances which improved seed germination and growth of extended root system. Whereas PSB in the rhizosphere of rice rendered insoluble soil phosphate available to plants due to secretion of organic acids (Gaur 2006).

Potato equivalent yield of winter season crops

The maximum potato equivalent yield (20.45 tonnes/ha) was recorded (Table 2) under sequence rice-potato-cowpea which was significantly higher than that of the other sequences followed by sequence rice-potato-onion (19.62 tonnes/ha) which remained statistically at par among them and significantly superior to others. It may be emphasized here that potato equivalent yield of crops is the function of market price along with yield of particular crop. The potato itself produced higher economic yield and this accompanied with better market value as a result of potato equivalent yield were higher as compared to other sequences. Nitrogen application through organic manures along with bio-fertilizers brought about significant improvement in potato equivalent yield (16.22 tonnes/ha) over rest of the treatments. Nitrogen application through organic manures alone significantly augmented the potato equivalent yield (14.15 tonnes/ha) compared to that of control (6.26 tonnes/

Table 1 Effect of different treatments on economic yield of each crop in all crop sequences

Crops	2005-06			2006-07			Pooled		
	Control	OM	OM + BF	Control	OM	OM + BF	Control	OM	OM + BF
Sequence I: Rice-Potato-Onion									
Rice	3.32	4.29	4.41	3.26	4.20	4.30	3.29	4.25	4.35
Potato	8.98	22.34	25.99	9.05	23.43	27.57	9.02	22.89	26.78
Onion	6.30	24.62	25.73	6.35	25.86	27.31	6.33	25.24	26.52
Sequence II: Rice-Green pea-Onion									
Rice	3.36	4.28	4.36	3.31	4.26	4.36	3.34	4.27	4.36
Green pea	1.83	4.55	5.24	1.96	4.98	5.66	1.89	4.77	5.45
Onion	6.78	24.89	26.44	6.82	26.11	27.93	6.80	25.50	27.19
Sequence III: Rice-Potato-Cowpea									
Rice	3.51	4.33	4.41	3.40	4.28	4.35	3.46	4.30	4.38
Potato	9.55	22.51	27.23	9.50	23.63	28.53	9.52	23.07	27.88
Cowpea	3.64	8.18	8.93	3.81	8.90	9.78	3.73	8.54	9.36
Sequence IV: Rice-Green pea-Cowpea									
Rice	3.56	4.29	4.42	3.51	4.22	4.37	3.53	4.26	4.39
Green pea	1.71	4.16	4.66	1.80	4.52	5.15	1.75	4.34	4.91
Cowpea	3.12	7.83	9.02	3.24	8.57	9.96	3.18	8.20	9.49
Sequence V: Rice-Rajmash-Onion									
Rice	3.52	4.39	4.51	3.50	4.45	4.48	3.51	4.42	4.50
Rajmash	3.56	7.94	8.39	3.63	8.73	9.19	3.60	8.34	8.79
Onion	6.73	24.60	26.27	6.73	25.84	27.92	6.73	25.22	27.09
Sequence VI: Rice-Rajmash-Cowpea									
Rice	3.52	4.48	4.56	3.51	4.41	4.53	3.51	4.45	4.55
Rajmash	3.57	7.92	8.40	3.65	8.75	9.26	3.61	8.34	8.83
Cowpea	3.30	8.04	8.86	3.42	8.78	9.73	3.36	8.41	9.29
Sequence VII: Rice-Maize-Cowpea									
Rice	3.62	4.46	4.54	3.62	4.43	4.43	3.62	4.44	4.49
Maize	11.73	18.46	19.01	11.62	19.22	20.09	11.68	18.84	19.55
Cowpea	3.49	7.92	8.68	3.61	8.65	9.50	3.55	8.29	9.09

Table 2 Effect of cropping sequences and organic treatment on equivalent yield and production efficiency of system (Pooled data of 2 years)

Treatment	Rice yield (tonnes/ha)	Potato equivalent yield (tonnes/ha)	Onion equivalent yield (tonnes/ha)	Rice grain equivalent yield of potato (tonnes/ha)	Rice grain equivalent yield of onion (tonnes/ha)	Rice Grain equivalent yield of system (tonnes/ha)	Production efficiency (kg/ha/day)
Cropping sequence							
Rice-Potato-Onion	3.95	19.62	19.12	16.02	15.61	35.57	97.46
Rice-Green pea-Onion	3.98	5.81	19.50	4.75	15.92	24.65	67.54
Rice-Potato-Cowpea	4.04	20.45	14.01	16.69	11.43	32.17	88.13
Rice- Green pea -Cowpea	4.06	5.27	13.50	4.30	11.02	19.38	53.11
Rice-Rajmash - Onion	4.15	12.10	19.33	9.88	15.78	29.81	81.67
Rice-Rajmash-Cowpea	4.16	11.78	13.77	9.62	11.24	25.02	68.54
Rice-Maize-Cowpea	4.19	10.42	14.00	8.51	11.43	24.12	66.09
SEm±	0.11	0.62	0.41	0.51	0.33	0.49	1.32
CD (P=0.05)	NS	1.92	1.26	1.57	1.03	1.50	4.09
Organic Treatment							
Control	3.46	6.26	6.78	5.11	5.54	14.11	38.66
100% RDN through OM*	4.34	14.15	20.13	11.55	16.43	32.32	88.55
100% RDN through OM+ BF**	4.43	16.22	21.62	13.24	17.65	35.31	96.74
SEm±	0.05	0.28	0.21	0.23	0.17	0.28	0.77
CD (P=0.05)	0.15	0.80	0.61	0.65	0.49	0.81	2.23

*Organic manure, ** Biofertilizers

ha). Nitrogen application through organic manures significantly augmented the potato equivalent yield due to the continuous raising of organic potato bio-dynamically on the same site which improved tuber production by enrichment of soil fertility.

Onion equivalent yield of summer season crops

The maximum onion equivalent yield (19.50 tonnes/ha) was recorded (Table 2) under sequence rice-green pea-onion which was significantly higher than that of the other sequences followed by sequence rice-rajmash-onion and sequence rice-potato-onion which remained statistically at par among them and significantly superior to others. The onion itself produced higher economic yield due to inclusion of legume as previous crop and this accompanied with better market value as a result of onion equivalent yield were higher compared to other sequences. Application of 100% recommended dose of nitrogen through organic manures along with bio-fertilizers brought about significant improvement in onion equivalent yield (21.62 tonnes/ha) over rest of the treatments. Further nitrogen application through organic manures significantly augmented the onion equivalent yield. 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 (Meena *et al.* 2010).

Rice grain equivalent yield of system

Different crop sequences differed significantly in respect of rice grain equivalent yield (RGEY). The maximum rice grain equivalent yield (35.57 tonnes/ha) was recorded under rice-potato-onion system followed by rice-potato-cowpea and rice-rajmash-onion sequence which remained statistically at par among them and significantly superior to others. Beside higher production potential of potato as well as onion and better market price were instrumental for attaining higher rice grain equivalent yield by this sequence (Sharma *et al*. 2004, Saroch *et al*. 2005 and Yadav *et al*. 2005). Application of 100% recommended dose of nitrogen through organic manures along with biofertilizers brought about significant improvement in rice grain equivalent yield (35.31 tonnes/ha) over rest of the treatments, viz.100% RDN through organic manure alone (32.32 tonnes/ha) and control (14.11 tonnes/ha). Rice grain equivalent yield is directly associated with the yield of respective crops in the sequence and organic manure alone or along with biofertilizers enhanced the yield potential of crops which ultimately increased the rice equivalent yield of the sequence. (Debjani *et al.* 2009)

Data showed significant interaction effect between crop sequences and organic treatment on rice equivalent yield (Fig 1). Application of recommended dose of nitrogen(120 kg N/ha) through organic manures resulted in significant increase in rice equivalent yield over control in all crop sequences while application of nitrogen through organic manures along with biofertilizers proved its superiority

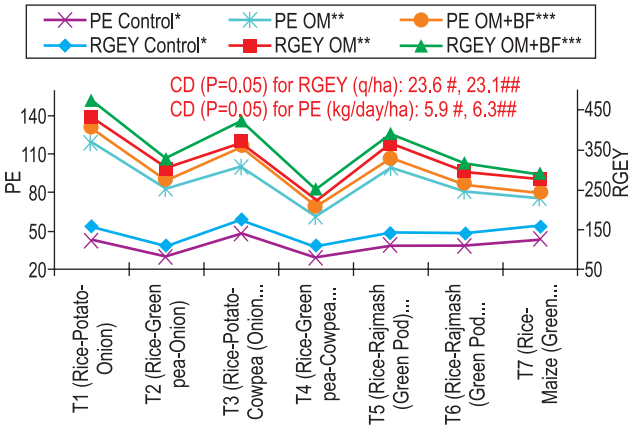

Fig 1 Interaction effect between cropping sequence and organic treatment on rice grain equivalent yield and production efficiency of the system [***:** No application **: 100% RDN through organic manures as (1/3 FYM + 1/3 Poultry Manure (PM) + 1/3 Vermicompost), *****:**100 % RDN through organic manures as (1/3 FYM + 1/3 Poultry Manure + 1/3 Vermicompost + Azotobacter + PSB, #: Two organic treatment means at the same cropping sequence treatment, ##: Two cropping sequence means at same or different organic treatments, PE: Production efficiency(kg/day/ha), RGEY: Rice grain equivalent yield(q/ha)]

over application of nitrogen through organic manures alone in sequence rice-potato-onion and rice-potato-cowpea.

System production efficiency

Data on production efficiency of the system as affected by various cropping sequences and organic nitrogen treatments of two years experimentation are presented in Table 2. Citation of data revealed that sequence rice-potato-onion had recorded significantly maximum production efficiency (97.46 kg/ha/day) to rest of the treatments. Amongst various organic treatments, application of 100% recommended dose of nitrogen through organic manures along with bio-fertilizers recorded significantly higher production efficiency (96.74 kg/ha/day) of the system followed by nitrogen application through organic manure alone (88.55 kg/ha/day). Similarly, organic manure alone had recorded significantly higher production efficiency of the system over control (38.66 kg/ha/day).

Data showed significant interaction effect between crop sequences and manuring on production efficiency of the system (Fig 1). Application of 100% recommended dose of nitrogen through organic manures resulted in significant increase in production efficiency of the system over control in all crop sequences while application of 100% recommended dose of nitrogen through organic manures along with biofertilizers proved its superiority over application of nitrogen through organic manures alone in rice-potato-onion and rice-potato-cowpea sequence.

System economics

The maximum gross return (₹ 388 474/ha), net return (₹ 268 656/ha) and profitability (₹ 738/ha) were recorded

Table 3 Effect of different treatments on system economics and fertility status of rice based cropping sequence (Pooled data of 2 years)

Treatment	System economics						Fertility status		
	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C ratio	Profitability (₹/ha)	Employment generation (man days)	Available NPK (kg/ha) after two years		
							N	P	K
Cropping sequence									
Rice-Potato-Onion	119 818	388 474	268 656	2.24	738	469.00	185.79	19.94	205.13
Rice-Green pea-Onion	89 453	271 691	182 238	2.04	502	439.33	193.33	21.74	218.43
Rice-Potato-Cowpea	96 958	348 822	251 865	2.60	691	401.33	190.28	21.14	212.79
Rice-Green pea-Cowpea	66 594	207 931	141 338	2.12	387	371.67	192.58	21.58	216.62
Rice-Rajmash-Onion	95 366	306 613	211 247	2.22	579	445.00	191.11	20.98	212.79
Rice-Rajmash-Cowpea	72 506	257 739	185 233	2.55	507	377.33	192.75	22.01	220.48
Rice-Maize-Cowpea	72 506	250 391	177 885	2.45	487	359.33	189.14	21.80	210.87
SEm±		1 382	1 522		4		5.41	0.60	6.06
CD (P=0.05)		4 258	4 690		13		NS	NS	NS
Organic treatment									
Control	73 122	129 049	55 927	0.76	154	389.86	177.23	19.70	201.35
100% RDN through OM*	94 392	353 924	259 531	2.75	711	418.14	196.98	22.06	219.46
100% RDN through OM+BF**	95 286	387 740	292 454	3.07	803	419.00	197.92	22.17	220.81
SEm±		966	1 044		2		2.48	0.28	2.77
CD (P=0.05)		2 798	3 024		7		7.13	0.80	7.98
						Initial value	185.50	20.35	210.32

*Organic manure, ** Biofertilizers

under sequence rice-potato-onion (Table 3) which was significantly higher than that of the other sequences followed by rice-potato-cowpea and rice-rajmash-onion sequence which remained statistically at par among them and significantly superior to others. This was mainly due to higher production potential of potato accompanied with good monetary return from onion (Sharma *et al*. 2004; Singh and Bohra 2009). However, the benefit cost ratio (2.6) was highest in the sequence rice-potato-cowpea. Highest values of cost of cultivation (₹ 95 286), gross return (₹ 387 740) net return (₹ 292 454), B:C ratio (3.07) and profitability (₹ 803/ha) were recorded with the application of 100% recommended dose of nitrogen through organic manures along with biofertilizers. This was mainly due to higher productivity without proportionate increase in cost of cultivation.

Employment generation

A close examination of the data (Table 3) clearly indicated that in general, sequences involving rice-potato-onion employed more man days. The higher labour requirements under rice-potato-onion were mainly due to potato and onion crops which are labour intensive regarding cultural practices. Maximum employment generation was recorded under rice-potato-onion (469 man days/ha/year) followed by sequence rice-rajmash-onion (445 man days/ha/year) and rice-green pea-onion (439 man days/ha/year). Therefore, the higher labour requirement of sequential cropping with 300% intensity indicates the potential for more employment generation. Similar views were also expressed by Newaj and Yadav (1992). Amongst various organic treatments, application of 100% of recommended dose of nitrogen through organic manures along with biofertilizers recorded highest (419 man days/ha/year) followed by 100% RDN through organic manure alone (418 man days/ha/year). This was due to more labour required for seed treatment with biofertilizers. Similarly, organic manure alone had recorded higher employment generation of over control (390 man days/ha/year).

Soil fertility

Data on nutrient status affected by different treatments are presented in Table 3. Different cropping sequences did not differ significantly with respect to status of major nutrients (N, P, and K). However, maximum improvement in this respect was observed where pulse crops were incorporated in the sequence. Similarly, Mubarak and Singh (2011) reported that inclusion of legumes pulses in the system have definite positive effect of nitrogen status in soil. Among organic treatment, application of either organic manure alone or with biofertilizers significantly improved soil available nutrients status under study and the highest value (197.92 kg N/ha, 22.17 kg P/ha and 220.81 kg K/ha) was associated with the 100% RDN through organic manure along with biofertilizers over initial status (185.50 kg N/ha, 20.35 kg P/ha and 210.32 kg K/ha). Due to addition of large quantity of bulky organic manure, process of mineralization through soil microorganism might be enhanced in plenty

amount of available organic food in soil. Consequently nutrient availability of organic field may be increased. Further, soil organic matter is known to serve as soil conditioner, nutrient source, and substrate for microbial activity as well as it generated essential plant nutrients, organic matter decomposition produces legends capable of complexing nutrient elements. Complexed elements remain more available to plant roots because complexion shields them against immobilization in soils (Yadav and Kumar 2009).

It can be concluded that rice-potato-onion was observed as the most intensive, stable and profitable high value cropping sequence with application of 100% recommended dose of nitrogen through organic sources with biofertilizers for identical to Varanasi ecosystem.

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