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Organic farming package for rice-potato cropping system

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Abstract
Field experiments were conducted at Research Farm, Krishi Nagar, JNKVV, Jabalpur (M.P.), between the year 2003-04 and 2009-10 under irrigated production system to compare organic, integrated and chemical fertilizer inputs packages in scented rice (*Oryza sativa* L.) –Potato (*Solanum tuberosum*) a high value cropping system. The present investigation has been started since the *kharif* season of the year 2003-04 under the AICRP on Integrated Farming System. Seven different nutrient treatments, 6 of them using organic inputs (FYM, vermicompost, rock phosphate neem cake, green manure and bio-inoculants) and 1 each having integrated (50% NPK through fertilizers + 50% N through FYM) and 100% NPK through fertilizers + Zn as per soil test values were studied in RBD with 3 replications. In organic treatment decline in yield was observed since 2003-04 to 2006-07 and again increases in yield was noticeable in rice. These treatments followed a steady increase and registered 20 to 50% more yield at the end of study compare to first years. Effect of different organic input packages on potato tuber yield was not stable over the years. Total productivity of scented rice-potato cropping system in terms of rice equivalent yield of the system (78.48 q/ha/day) and total net returns (Rs/ 64554) was highest in chemical treatments closely followed by integrated input use. Long term use of organic manures like FYM, vermicompost, neem cake, composed crop residue appreciably increased the organic carbon (7.50g/kg) over initial value (6.40g/kg). Integration of the organic and inorganic inputs significantly increased the availability of N, P and K in soil over chemical treatment alone.

Keywords: organic farming, rice-potato, FYM, vermicomopst

Introduction
Modern agricultural farming practices, along with irrational use of chemical inputs over the past four decades have resulted in not only loss of natural habitat balance and soil health but have also caused many hazards like soil erosion, decreased groundwater level, soil salinization, pollution (Reddy 2010) [29] due to fertilizers and pesticides, genetic erosion, ill effects on environment, reduced food quality and increased the cost of cultivation, rendering the farmer poorer year by year (Ram, 2003) [25]. Therefore the apparent contradiction of our necessity for nutritional security on one hand and environmental sustainability on the other makes it inevitable to restore to the organic or eco-farming system, as it appear to be possible option to meet both these objectives ((Mishra and Nayak, 2004) [20]. Organic farming is to be possible alternative of farming system for sustainable agriculture production to ensure food security for increasing population of human being and livestock in future (Swaminathan 2011). Organic farming implies a farming system that primarily aims at cultivating land and raising crops under ecologically favourable conditions. The use of locally available agro-inputs in agriculture by avoiding or minimizing the use of synthetically compound of agro-chemicals appears to be one of the probable options to sustain the agricultural productivity (Satheesh, 2008) [33]. Addition of different organic materials increased the organic carbon and slightly decreased in soil pH (Pandey *et al*., 2009) [24]. Organic manures are store house of several plant nutrients and act as a good soil conditioner. The FYM has always been one of the principal means of replenishing soil losses (Albert, 2000) [3]. It supplies soil organic matter (SOM) which is an indicator of life, soil health and even its production capacity (Rupela, 2007) [31]. In rice growing areas, organically produced scented rice has better scope to obtained better market price as well as good export opportunity. Demand of aromatic rice may be further enhanced if grown under organic farming system (Mani, 2004) [19]. In the long run, organic farming offers more advantages compared to conventional farming. (Julia *et al* 2008) [9].
Cultivation of both crop components under scented rice-potato cropping sequence under organic farming situation appears to be one of the remunerative cropping systems in rice growing pockets of M.P. because of its high market value in the domestic markets and in export potential. Choudhary *et al*. (2001) reported more productivity by replacing wheat in existing system with vegetables like potato.

Keeping these views in mind an experiment was conducted to evaluate productivity of scented rice-potato system under different organic and inorganic sources and to compare the chemical and integrated treatments.

Material and Method

A field experiment was conducted on rice-potato cropping system under irrigated conditions between 2003-04 and 2008-09 at Jawaharlal Krishi Vishwavidyalaya, Jabalpur, Madhya Pradesh under All India Coordinated Research Project on Cropping System. The soil of the experimental field was sandy clay loam in texture, neutral in the reaction (pH 7.2), normal in OC (7.0 m/kg); analyzing low in available N (210 kg/ha), available P (8.8 kg/ha); and medium in available K (370 kg/ha). The eight treatment consisted with T_1 – 50%N through fertilizers + 50% N through FYM, T_2 - 1/3 N through each of FYM, T_3 - T_2+Intercropping of Isabgol in potato, T_4 - T_2 + Agronomic practices of weed control, T_5 - T_2 + BGA+Rock phosphate + PSB, T_6 - T_2 + *Azospirillium* +PSB, T_7 - 100% NPK through fertilizers +Zn as per soil test values and T_8 - T_2 + Green manuring in rice only were tested in randomized block design with unreplicated treatments, different years were taken as a replication with a plot size of 6.0m x 35.0m. Bunds of 50 cm height were made between plots to check the outflow of nutrients and reduce the border effect. Under the treatment T_8 green manuring was done insitu with sunhemp (*Crotalaria juncea*) (1.6 tonnes/ha dry weight having 2.4 to 2.5% N). RDF for rice crop was 120 - 60 - 40 kg N-P-K/ha and to potato was 120-100-100 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 FYM; 5.0,1.0 and 1.25 in neem cake and 0.5,1.20, 0.90 in vermicompost respectively. The full dose of P an 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 earthing of potato i.e. 25 and 50 days after germination. Nitrogen was given as urea, FYM, NC and VC, as per treatment requirement as basal dose. In organic treatments, P requirement was supplemented through rock phosphate (23% P_2O_5 grade) adjusting the quantity P supplied through manures. Basmati rice 'Sungandha-3' was grown during *kharif* and potato 'Kufri Sinduri' was sown in *Rabi* in rice-potato cropping sequences. Transplanting of rice at spacing of 20 cm X 10 cm was done done on 25 July 2009 and harvested on November 16, 2009 in well prepared seed bed with planting geometry of 60.0cm x 15.0cm. The experiment were conducted under assured irrigation facilities and need based irrigation were applied to rice and potato, as per recommended practices. Data on growth, yield component, yield and economics were recorded. Soil and plant samples were taken and analyzed as per standard procedure N, P and K contents of samples were analysed by Nessler's reagent colorimetric method (Linder, 1944) for nitrogen, Ammonium vanadomolybdo phosphoric acid yellow colour method (Jackson, 1973) [8] for phosphorus and flame photometer method (Khanna *et al.*, 1971) [13] for potassium, respectively. Record of all inputs and outputs was maintained so as to work out the economics of the system. Price of Rs. 1500/q for inorganic and 2000/q for organic rice and 400 q/ha for inorganic potato and 700/q for organic potato. For comparison between crop sequence the yield of all crops were converted into rice- equivalents on price basis (Manjunath *et al*. 2004). The profitability of the system was calculated by dividing the net returns ha- 1 in a sequence by 365 days.

Due to yearly variation in price of crops, the cost of cultivation and net returns of ending year i.e. 2009-10 was only presented in the study and calculated on the basis of 25% premium price to organic produce where organic manure was added.

Result and Discussion

Rice yield and yield attributes: At the end of the seventh crop cycle, Data pertaining to grain yields in quintal per hectare as influenced by various treatments during consecutive years (2003-04 to 2009-10) are presented in Table 1. It is evident from the data that, grain yield of rice cv. Sugandha-3 significantly varied due to effect of various treatments. Based on 7 years mean grain yield data, the highest grain yield (36.31 q/ha) was obtained under T_7 -100% NPK through fertilizers + Zn as per soil test values (STV) chemical fertilizers treatment was significantly superior over rest of the treatments. Among organic nutrient supply packages, INM-T_1 was the next best treatment with the grain yield of 33.02 q/ha. Under organic nutrient management followed by agronomic practices of weed control treatments T_4 (27.31 q/ha) and Intercropping of isabgol in potato (T_3), T_5 (27.33 q/ha) were next to it in this regard and Intercropping of isabgol in potato (T_3) due to greater availability of nutrients in soil, improved soil environment and higher root proliferation leading to better absorption of moisture. Treatment T_8 produced the lowest grain yield (26.46 q/ha) among all the treatment but differences between T_2, T_3, T_4, T_5 and T_6, and T_8 were not significant. Soil nutrients status build-up in an organic system takes a long time, due to slow mineralization and releases of nutrients from organic sources. Several workers have also emphasized from their studies on rice-based cropping at different locations that rice yields reduced with the use of organic nutrition over chemical nutrition during early years even upto 5-6 years (Kar, 2004; Chettri *et al.*, 2004, Khanda *et al.*, 2005;) [10, 5, 13].

Potato Tuber Yield: Balanced inorganic fertilization and integrated nutrient management have sustained crop yields on long run basis. Since potato is one of the heavy feeder crops, the yield of integrated and chemical nutrients were higher than the organic inputs releases the nutrients slowly. 100% N through fertilizers + Zn as per soil test values (T_7) and integrated nutrient management having 50% N through fertilizers + 50% N through FYM (T_1). Both these treatments were significantly superior to the rest of all the treatments receiving organic nutrient managements (Table 2) and gave the yield 74.04 q/ha and 62.61 q/ha respectively. Among organic nutrient management use of 100% organic manure with intercropping of Isabgol (T_3) helped to increase the mean potato tuber yield due to additional cost of Isabgol (59.94 q/ha) than other organic treatments (Table 2). Agronomic practices of weed control (T_4) and use of *Azospirillum* + PSB (T_6) and BGA + rock phosphate (T_5) 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 nutrient. Application of 100% organic manures with green manuring in rice (T_8) produced the lowest tuber yields (60.50 q/ha). These results also corroborated with the findings of several research workers (Chettri *et al.*, 2004; Singh *et al.*, 2004; Kar, 2004; Biswait and Mondal, 2005) [5, 10, 36] from various locations.

Total Productivity: Total productivity of rice-potato cropping system under different treatments was determined in terms of REY. The economic values of both crop components are different in market. Therefore the market value of potato yield was used to convert into rice yield on the basis of existing market value of both crops. The total productivity of entire rice-potato system was significantly more with inorganic nutrient management as per STV (78.48 q/ha/yr) closely followed by integrated treatments (68.94 q/ha/yr) while, application of 100% organic with green manuring in rice produced the lowest REY (60.39 q/ha/yr) among all the nutrient management treatments, because this was the first year of introducing green manuring in T8. In previous years T_8 was similar as T_2 as dummy plot. Highest total net returns (Rs. 64554/ha) and B:C ratio was also obtained with the application of chemical fertilizers. Organic nutrient package failed to register higher net returns even through the premium price was given to them due to more cost of cultivation involved on weeding, arrangement and transportation of bulky manures etc. Yields may decline significantly, atleast during the initial years of conversion, until the natural soil tilth and fertility are sufficiently restored. But, after that, they may stabilize at a comparably, lower or even higher levels, depending on the efficacy of organic management and the quality of organic fertilizers applied (Kasturi, 2007) [11]. The lowest net returns was recorded with the application of 100% organic manures with green manuring in rice (T_8). However, lowest B:C ratio (1.71) was calculated in same treatments (Table 3). Application of 100% organic manures with intercropping of Isabgol in potato (T_3) produced higher net returns (Rs. 6437/ha) and B:C ratio (1.88) because of additional yield of Isabgol as a high value crop. However, organic farming may be remunerative by growing high value crops as already found in case of including Isabgolas an intercrop with potato. These results are in close conformity with the findings of, Kumar *et al*., (2002) [17] and Bishwajit and mandel (2005).

Physico-Chemical Properties: Organic carbon (OC) in soil 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) [32]. The OC ranged from 6.5 to 7.5 g/kg of soil under various organic and chemical nutrients treatments. (Table 4). The OC and N contents showed remarkable improvement due to the effects of organic nutrient management over their initial status. It remained higher in organic treatment with 100% N through each of FYM, vermicompost and neem cake with the application of BGA + rock phosphate + PSB. Electrical conductivity (EC) and pH ranged from 0.35 to 0.39ds/m and 7.0 to 7.50 ds/m under various organic and chemical fertilizer treatments respectively. After completion of seventh crop cycle in 2009-10, application of organic sources of nutrients recorded the highest N as well as P and K status. Organically treated plots continuously to both crops for seventh years under a fixed rice-potato system attributed to enhance the OC and N contents of soil agreeing with the findings of Murali and Shetty (2000) [21].

Application of 100% organic manures through each of FYM, VC and NC with the inclusion of BGA + rock phosphate + PSB built up of N status of organic nutrient package pooled and averaged over seven years of experimentation followed an increasing trend over years. Available phosphorus content remained high (10.2 kg/ha) in 100% organic treatments i.e. 1/3rd N through each of FYM, VC and NEOC. (Murali and Shetty, 2000; Singh *et al.*, 2004) [21, 36] has also mentioned that balanced nutrition to crop through organic as well as inorganic sources found helpful to maintain the P and K content of soil. Available potassium content in soil ranged from 328 to 382 kg/ha. It remained higher with the application of 100% organic manures with the inclusion of BGA + rock phosphate + PSB. Consequently application of organic sources of the nutrients had their considerable role to affect the productivity of scented rice-potato cropping sequences when compared with integration of organic and inorganic nutrients and fertilizer alone.

Uptake of Nutrients

Organically cultivated soils are relatively better attuned to withstand water stress and nutrient loss. (Alam and Wani, 2003). The total uptake of major nutrients (NPK) was recorded maximum with the application of 100% NPK through fertilizer + Zn as per STV because of increased availability of these nutrients at all critical stages owing to higher yields in both the crops under rice-potato system as per STV had shown removal of maximum quantity of N (200 kg/ha), P (25 kg/ha) and K (315 kg/ha). The INM treatments to both crops was next to it with removal of 190, 20 and 300 kg N, P and K, respectively, when quantity of NPK fertilizers proportionally reduced by substituting organic manures equivalent to rest proportion of N. All organic nutrient management removed lesser quantity of N, P and K than the former two nutrient management treatments, mainly because of lesser yields. The organic nutrient management supplemented with intercropping of Isabgol with potato produced additional yield of Isabgol without declining the yield of potato resulted in numerically higher uptake of major (NPK) nutrients over only organic nutrient management treated plot (Murali and Shetty, 2000; Singh *et al.*, 2004; Khanda *et al.*, 2005) [21, 15, 36].

Table 1: Mean rice grain yield (q/ha) under different nutrient management treatments during 7 consecutive years (2003-04 to 2009-10)

T. No.	Treatment	Rice grain yield (q/ha)							Mean
		Year							
		03-04	04-05	05-06	06-07	07-08	08-09	09-10	
T_1	50% NPK through fertilizers + 50% N through FYM	44.73	42.77	30.39	19.61	23.11	38.09	32.5	33.02
T_2	1/3 N through each of FYM, vermicompostand neem cake	37.99	28.34	24.57	14.7	21.5	28.09	30.23	26.49
T_3	T_2+Intercropping of Isabgol in potato	39.82	28.55	23.34	15.32	22.13	31.42	30.5	27.30
T_4	T_2+ Agronomic practices of weed control	42.89	27.79	24.45	14.09	21.71	29.05	31.2	27.31
T_5	T_2 + BGA + Rock phosphate + PSB	44.11	29.1	24.05	14.09	22.93	27.14	29.9	27.33
T_6	T_2 + *Azospirillium* +PSB	39.21	28.4	25.43	15.07	22.43	30	28.8	27.05
T_7	100% NPK through fertilizers +Zn as per soil test values	50.24	40.16	32.41	26.29	27.62	42.85	34.6	36.31
T_8	T_2+ Green manuring with Sunhemp	38.6	28.64	24.43	15.32	21.64	27.62	29	26.46
	Mean	42.20	31.72	26.13	16.81	22.88	31.78	30.84	

	Treatment	Years
SEM +	0.81	0.76
CD at 5%	2.33	2.18

Table 2: Mean rice equivalent yield (q/ha/year) under different nutrient management treatments during 7 consecutive years (2003-04 to 2009-10)

T. No.	Treatment	Rice equivalent yield (q/ha/year)							Mean
		Years							
		03-04	04-05	05-06	06-07	07-08	08-09	09-10	
T_1	50% NPK through fertilizers + 50% N through FYM	87.86	86.27	77.76	42.15	56.12	67.93	64.48	68.94
T_2	1/3 N through each of FYM, vermicompost and neem cake	84	69.83	60.35	30.39	50.57	64.24	67.74	61.02
T_3	T_2+Intercropping of Isabgol in potato	89.26	75.92	66.14	36.08	56.37	73.19	72.64	67.09
T_4	T_2+ Agronomic practices of weed control	90.61	68.48	60.23	29.99	52.45	71.48	68.82	63.15
T_5	T_2 + BGA+Rock phosphate + PSB	87.32	71.09	60.54	29.49	49.99	68.41	66.83	61.95
T_6	T_2 + *Azospirillium* +PSB	85.52	68.67	62.62	30.12	51.91	70.21	65.92	62.14
T_7	100% NPK through fertilizers +Zn as per soil test values	102.03	91.3	81.21	62.45	66.72	78.4	67.22	78.48
T_8	T_2+ Green manuring with Sunhemp	86.54	70.19	60.57	29.29	50.22	60.7	65.25	60.39
	Mean	89.14	75.22	66.18	36.25	54.29	69.32	67.36	

Cost of organic rice and potato and inorganic rice and potato is Rs. 2000, 700, 1500 and 400 /, respectively.

Treatment	Years	
SEM +	1.70	1.60
CD at 5%	4.85	4.53

Table 3: Mean marketable tuber yield (q/ha) of potato under different nutrient management treatments during 7 consecutive years (2003-04 to 2009-10)

T. No.	Treatment	Mean marketable tuber yield (q/ha)							Mean
		Years							
		03-04	04-05	05-06	06-07	07-08	08-09	09-10	
T_1	50% NPK through fertilizers + 50% N through FYM	161.76	163.16	178	84.56	123.8	111.91	119.93	134.73
T_2	1/3 N through each of FYM, vermicompost and neem cake	131.13	118.26	102	44.72	82.86	103.05	106.93	98.42
T_3	T_2+Intercropping of Isabgol in potato	140.93	(114.58+ 1.43)135	(105 + 1.19) 122	(42.90+1.1 4) 59.18	(76.18+1 .5) 97.6	(99.05+1.) 119.05	(100.12+1. 4)120.12	113.41
T_4	T_2+ Agronomic practices of weed control	136.03	115.98	102	45.34	87.62	120.95	107.23	102.16
T_5	T_2 + BGA+Rock phosphate + PSB	123.16	119.68	104	43.89	77.14	117.62	105.27	98.68
T_6	T_2 + *Azospirillium* +PSB	132.97	114.78	106	42.92	84.02	114.62	105.8	100.16
T_7	100% NPK through fertilizers +Zn as per soil test values	194.24	191.79	183	135.62	146.66	133.34	121.97	158.09
T_8	T_2+ Green manuring with Sunhemp	136.64	118.43	103	39.82	81.46	94.28	107.25	97.27
	Mean	144.61	134.64	125.00	62.01	97.65	114.35	111.81	

Treatment	Years	
SEm +	4.86	4.54
CD at 5%	13.81	12.92

Table 4: Total NPK uptake by rice-potato sequence as under different nutrient management during 2009-10

T. No.	Treatment	Uptake (kg/ha)		
		N	P	K
T_1	50% NPK through fertilizers + 50% N through FYM	190	20	300
T_2	1/3 N through each of FYM, vermicompostand neem cake	155	18.1	280
T_3	T_2+Intercropping of Isabgol in potato	140	17.5	238
T_4	T_2 + Agronomic practices of weed control	135	16.1	225
T_5	T_3 + BGA+Rock phosphate + PSB	140	16.6	230
T_6	T_3 + *Azospirillium* +PSB	131	16.7	220
T_7	100% NPK through fertilizers +Zn as per soil test values	200	25	315
T_8	T_2 + Green manuring with Sunhemp	139	17.0	218

Table 5: Changes in soil-properties due to different treatments upto end of 2009-10 over their initial status

T. No.	Treatment	pH	EC (dS/m)	OC (g/kg)	Available nutrient (kg/ha)		
					N	P	K
	***Initial soil status**	**7.2**	**0.36**	**6.4**	**210**	**8.8**	**370**
T_1	50% NPK through fertilizers + 50% N through FYM	7.4	0.37	6.9	235	8.2	328
T_2	1/3 N through each of FYM, vermicompostand neem cake	7.3	0.38	7.2	240	10.2	376
T_3	T_2+Intercropping of Isabgol in potato	7.0	0.35	7.0	220	8.9	391
T_4	T_2 + Agronomic practices of weed control	7.2	0.36	6.8	232	8.5	380
T_5	T_2 + BGA+Rock phosphate + PSB	7.1	0.39	7.5	243	9.5	399
T_6	T_2 + *Azospirillium* +PSB	7.3	0.39	7.3	239	9.1	389
T_7	100% NPK through fertilizers +Zn as per soil test values	7.5	0.36	6.5	210	8.0	382
T_8	T_2 + Green manuring with Sunhemp	7.1	0.38	7.2	238	8.9	385

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