



Effect of organic farming on productivity, soil health and economics of rice (*Oryza sativa*)–wheat (*Triticum aestivum*) system

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ABSTRACT

A study was done from 2003 -2008 at Kumarganj, Faizabad to assess the impact of organic manures on performance of (*Oryza sativa* L.)–wheat (*Triticum aestivum* (L.) Fiori & Paol.) system. Among different organic farming treatments, incorporation of crop residues in both the crops + green manuring + phosphorus solubilising microbes (PSM) + poultry manure (PM) 5 t/ha + neem cake 0.2 t/ha, resulted in highest values of growth and yield components, yield and net return. This treatment gave 16.1, 16.6, 13.1, 13.1 and 44.5 % higher yield of rice and 19.7, 17.0, 14.5, 7.5 and 26.8% higher yield of wheat over T_1 , T_2 , T_3 , T_4 (organics) and T_6 (inorganics) respectively. Maximum amount of balance or un-utilized NPK was computed with inorganics treatment (T_6). All the organic farming treatments improved soil health as evident by increased organic carbon and reduction in soil pH. Highest values of organic carbon (0.64%) after 5 years of experimentation was recorded with wheat residues + FYM 10 t/ha + 0.2 t/ha neem cake in rice and rice residue + pressmud 10 t/ha in wheat (T_3). Treatment with crop residue + green manuring + poultry manure 5 t/ha + PSM + neem–cake 0.2 t/ha also proved most remunerative and gave 15.46, 16.08, 14.17, 8.87 and 36.48 x 10³ Rs/ha higher net return over T_1 , T_2 , T_3 , T_4 and T_6 , respectively. Highest benefit: cost ratio (1.60) was also recorded with this treatment.

Key words: Economics, Organic farming, Productivity, Rice, Soil fertility, Wheat

In India, (*Oryza sativa* L.)–wheat (*Triticum aestivum* (L.) Fiori & Paol.) is the dominant cropping system across the Indo-Gangetic plains and in the Himalayan foot-hills. Approximately 10.5 m ha area under this system contributed to 25% total food grain production of India. Results of long-term experiments conducted at Faizabad (Kumar *et al.*, 2007) and other places in the country (Swaroop, 2002) have shown decline or stagnation in the productivity of this system. The decline in organic matter content and associated changes in nutrient availability and physical properties of soil seem to be closely related with this. The deficiencies of secondary and micro-nutrients are also affecting the performance of this region in newer areas (Chakraborti and Singh, 2004). Organic farming is a production system which favours maximum use of organic materials, crop residues, animal excreta, legumes, on and off farm organic wastes, growth regulators, bio-pesticide etc. and discourage use of synthetically produced agro-inputs for maintaining soil health, productivity and pest management under the conditions of sustainable natural resources and healthy environment. Use of organic manures have been found to be promising in arresting the decline in productivity through correction of deficiencies of secondary and micro-nutrients and its

beneficial influence on the physical and biological properties of soil (Kumar and Tripathi, 1999). An experiment was, therefore, planned to find out the effect of different organic farming modules on productivity, soil health and economics of rice-wheat system.

MATERIALS AND METHODS

An experiment was conducted at N.D. University of Agriculture and Technology, Kumarganj, Faizabad, Uttar Pradesh (25°.43'N and 82°.8'E), from 2003 to 2008. The climate of the area is sub-humid to sub-tropical. The soil is alluvial having silty loam texture and taxonomically classified as typic ustrochrept with 0.42% organic carbon, 8.13 soil pH and 0.22 dS/m electrical conductivity. The treatments consisted of *in situ* incorporation of wheat straw (WS) + green manuring (GM) + pressmud (PRM) @ 7.5 t/ha in rice and *in situ* incorporation of rice straw (RS) + PRM @ 5 t/ha + phosphate solubilising microbes (PSM) + *Azotobacter* (T_1), *in situ* incorporation of WS + GM + FYM 10 t/ha in rice and *in situ* incorporation of RS + FYM @ 5 t/ha + PSM + *Azospirillum* in wheat (T_2), *in situ* incorporation of WS + FYM @ 10 t/ha in rice and *in situ* incorporation of RS + PRM @ 10 t/ha + PSM in wheat (T_3), *insitu* incorporation of WS + PRM @ 5t/ha

+FYM @ 5 t/ha + PSM in rice and *in situ* incorporation of RS + FYM @ 10 t/ha + PSM in wheat (T_4), *in situ* incorporation of WS / RS + GM + poultry manure (PM) @ 5 t/ha + PSM in rice and wheat (T_5). Data on recommended dose of fertilizer 120:26.4:33.3 in rice and 120:26.4:50 N:P:K kg/ha in wheat were taken from side plot where green manures were not applied for last 5 years (T_6). Neem cake @ 0.2 t/ha was applied in all organic treatments (T_1 to T_5) in rice as well as in wheat. The chemical composition (% N:P₂O₅:K₂O:S) of different manures ranged from: 0.45-0.56:0.21-0.28:0.41-0.51: - (FYM); 5.1-5.5:1.2-1.6:2.2-2.6:- (PM); 0.05-0.07:0.02-0.04:0.6-0.9:- (RS); 0.10-0.16:0.06-0.08:0.8-1.0:- (WS) and - : - : -:18.4-21.2 (PRM) respectively.

Experiment was conducted in randomized block design with 4 replications. Rice 'Sarjoo-52' was transplanted on 10 July at 20 cm x 10 cm spacing and wheat 'HP1744' was sown on 17 December with a seed rate of 125 kg/ha. All the organic materials were applied 1 week before transplanting/sowing. Crops were irrigated as and when required. Plant protection was done with the use of neem oil, solution of crushed garlic and detergent soap extract. Trichocard (*Trichogramma* sp.) were used after 20 days of transplanting to next 6 weeks to control rice stem borer. Weeds were controlled by hand weeding. Crop was harvested at its full maturity and threshed in respective plots. All the organic materials were incorporated in the same field as in the treatment. Data on growth, yield components, yield and economics were recorded. Soil and plant samples were taken and analyzed as per standard procedure. Record of all inputs and outputs was maintained so as to work out the economics of the system. Price of Rs 6,500/t of rice and Rs 10,000/t of wheat grain were used. For organic produce, 25% higher price of the above were used.

RESULTS AND DISCUSSION

Growth and yield components

It is evident that growth and yield components of rice and wheat were not affected to the level of significance during first year. The tallest plant and highest dry matter production of rice and wheat were recorded with the treatment *in situ* incorporation of wheat/rice straw + GM + PM @ 5t/ha + PSM (T_5) followed by *in situ* incorporation of WS + GM + FYM @ 10 t/ha in rice and *in situ* incorporation of RS + FYM @ 5 t/ha + PSM + *Azospirillum* in wheat (T_2) and *in situ* incorporation of WS + FYM @ 10 t/ha in rice and *in situ* incorporation of RS + PM @ 10t/ha + PSM (T_3) in wheat. Length of the panicle, number of grains/spike and test weight in rice and test weight in wheat were not altered by different treatments during fifth year (2007-08). The values of all the components were higher in T_5 as compared to other treatments (Table 1).

Yield

Data (Table 2) revealed that grain yield of rice was not affected significantly due to various organic farming treatments in the first year. From second year onwards, *in situ* incorporation of WS/RS + GM + PM @ 5 t/ha + PSM (T_5) gave highest yield which was significantly superior over all other treatments during all the years except 2007-08 in which treatment T_4 which was *in situ* incorporation of WS + PRM @ 5 t/ha + FYM @ 5 t/ha + PSM in rice and *in situ* incorporation of RS + FYM @ 10 t/ha + PSM in wheat, was at par with T_5 . Considering the mean of the 5 year's data, the grain yield under T_5 was 16.1, 16.6, 13.1, 13.1 and 44.5% higher over T_1 , T_2 , T_3 , T_4 , and T_6 , respectively. Higher growth and higher values of yield components due to higher concentration and fast release of nutrients in poultry manure might have resulted in higher grain yield under this treatment. Mankotia (2007) also reported higher yield of rice due to *in situ* GM with *dhaincha*, sunnhemp, soybean, cowpea and with application of FYM. Similar trend was also noted in the yield of straw. Values of harvest index were not altered too much due to different treatments.

The differences in grain yield of wheat were also not significant during first year. Similar to rice, highest yield of wheat was also obtained from T_5 during all the years of experimentation. On the basis of mean yield, T_5 (incorporation of RS + GM + PM @ 5 t/ha + PSM) gave 19.7, 17.0, 14.5, 7.5 and 26.8% higher grain yield of wheat over T_1 , T_2 , T_3 , T_4 and T_6 , respectively. In all the years, the differences between T_1 , T_2 , T_3 , and T_4 were not-significant. However, during 2007-08, all the respective treatments except T_1 gave higher yield than T_6 (recommended N:P:K). A similar trend was noted in straw yield. Values of harvest index were not altered much due to different treatments. The highest yield under organic treatments was mainly due to accumulation of nutrients over years and improvement in physico-chemical properties of soil. The highest yield of wheat under T_5 (incorporation of RS + GM + PM @ 5 t/ha + PSM) was mainly due to higher nutrient content and, comparatively fast release of nutrients. Besides supplying nutrients, organic manures have also solubilizing effect on fixed form of other nutrients and therefore, improve the productivity of soil (Sinha, 1981). Singh and Singh (2005) also reported 29.9, 18.8, 35.5 and 15.2% increase in yield owing to FYM application at 15 t/ha and vermin-compost at 7.5, 10 and 15 t/ha, respectively over no organic manure. Yadav (2005) also reported similar results. Saxena and Yadav (1998) concluded that green manuring of green gram as a whole or after picking of pods resulted in higher yield of rice and wheat grown in sequence. Kumar *et al.* (2007) also recorded higher yield of rice-wheat with the use of organic

manures. They also reported that bio-fertilizers have added advantage in wheat production.

Nutrient balance sheet

Data on addition, depletion and balance of nutrient under different organic farming modules are given in Table 3. It is evident that maximum addition of N and P was done in T₅, whereas highest K was added in T₁. Depletion of all N, P and K was computed highest in T₅. High-

est balance or unutilized fraction of N was noted in T₆ (inorganics) closely followed by T₁, the values being 11.26 and 11.04 kg N/ha, respectively. A lowest value of N balance of 54.2 kg/ha was recorded in T₃. Maximum balance of P (59.0 kg P/ha) was noted in T₅, whereas it was lowest (5.2 kg P/ha) in T₂. Maximum balance of K was recorded in T₁ (307.8 kg K/ha) followed by T₄. Negative balance of K was recorded in T₆ (inorganics). The highest depletion of nutrients in T₅ was due to highest

Table 1. Effect of organic farming on growth and yield components of rice and wheat at harvest stage

Treatment	Rice						Wheat					
	Plant height (cm)	Dry weight (g/hill)	No.of shoots/hill	Length of panicle (cm)	No.of filled grains/panicle	Test weight (g)	Plant height (cm)	Dry weight (g/m row)	No.of shoots (m row)	No.of grains/spike	Grain weigh/spike	Test weight (g)
2003-04												
T ₁	96.6	35.2	8.6	21.9	114.6	23.5	62.6	129.2	50.4	34.6	1.6	32.9
T ₂	96.3	33.0	8.0	21.7	121.5	24.3	58.1	138.5	53.6	34.9	1.5	30.6
T ₃	94.0	31.0	7.6	21.6	122.9	24.2	58.0	144.2	56.0	38.3	1.9	34.7
T ₄	95.8	31.0	7.7	21.5	120.7	24.9	60.1	141.0	53.6	36.6	1.8	34.9
T ₅	100.8	36.0	8.0	22.0	123.1	24.4	69.2	146.3	52.0	33.3	1.7	36.8
SEm±	2.2	1.7	0.3	0.2	2.8	0.5	3.9	5.7	1.9	1.8	0.1	2.3
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
2007-08												
T ₁	94.0	50.2	8.2	21.9	116.0	23.5	66.4	134.0	55.2	34.0	1.9	43.0
T ₂	96.0	54.6	8.6	21.7	114.5	23.3	63.2	138.6	56.4	36.0	2.0	42.8
T ₃	98.0	52.0	8.2	21.7	116.8	24.2	64.1	146.8	58.1	33.1	2.0	42.6
T ₄	99.2	51.8	7.8	21.5	120.0	24.6	65.1	145.0	61.2	34.0	2.1	44.1
T ₅	103.6	56.0	9.0	22.0	124.2	24.4	71.8	151.2	63.2	41.2	2.7	44.8
SEm±	2.0	0.7	0.2	0.2	1.9	0.4	2.3	2.8	1.9	1.9	0.2	0.8
CD (P=0.05)	4.8	1.8	0.4	NS	5.8	NS	6.4	7.8	5.2	5.8	0.4	NS

Table 2. Yield (t/ha) of rice and wheat and economics (x 10³ Rs/ha) rice-wheat system under different organic farming modules

Treatment	Grain yield						Straw yield (t/ha)*	Harvest index *	Cost of cultivation*	Net income*	Net B:C ratio*
	2003-04	2004-05	2005-06	2006-07	2007-08	Mean					
Rice											
T ₁	4.22	4.99	4.92	5.01	5.20	4.78	7.17	39.96	35.90	42.19	1.18
T ₂	4.27	4.92	4.85	4.99	5.30	4.76	6.64	41.77	37.55	41.57	1.11
T ₃	4.25	4.98	5.24	5.18	5.42	4.91	7.27	40.35	35.72	43.48	1.22
T ₄	4.35	5.14	5.15	5.02	5.46	4.91	6.93	41.53	36.09	48.68	1.35
T ₅	4.59	5.77	5.92	5.96	5.86	5.56	9.55	36.81	35.97	57.65	1.60
T ₆				4.06	3.64	3.85	5.86	39.55	34.25	23.84	0.70
SEm±	0.13	0.18	0.20	0.19	0.14						
CD (P=0.05)	NS	0.52	0.61	0.55	0.42						
Wheat											
T ₁	2.70	3.15	3.38	3.01	3.42	3.13	3.58	46.56			
T ₂	2.84	3.31	3.40	3.28	3.61	3.21	4.08	44.64			
T ₃	2.97	3.68	3.41	3.14	3.62	3.36	4.03	45.46			
T ₄	2.87	3.74	3.81	3.61	3.88	3.58	4.11	46.45			
T ₅	2.62	4.03	4.30	3.98	4.31	3.85	4.67	45.15			
T ₆				3.21	2.86	3.04	3.78	44.55			
SEm±	0.14	0.17	0.29	0.22	0.17						
CD (P=0.05)	NS	0.57	0.64	0.63	0.56						

*Mean

Table 3. Balance sheet (mean) of nutrients and soil properties in rice-wheat system under organic farming

Treatment	Total addition (kg/ha)			Total depletion (kg/ha)			Balance (kg/ha)			Soil properties		
	N	P	K	N	P	K	N	P	K	Organic carbon (%)	pH	EC
T ₁	285	75	536	175	31	167	110	19.4	307.8	0.57	7.68	0.50
T ₂	271	42	210	173	31	165	98	5.2	37.5	0.60	7.65	0.50
T ₃	240	54	243	186	34	178	54	8.8	54.2	0.60	7.79	0.53
T ₄	250	70	374	187	37	174	63	14.5	166.7	0.62	7.61	0.51
T ₅	308	176	279	219	42	216	89	59.0	52.5	0.68	7.54	0.48
T ₆	280	120	100	167	29	163	113	40.0	-52.5	0.38	8.10	0.56
Initial value							166	12.2	215	0.42	8.13	0.22

yield of grain and straw recorded under this treatment. Maximum balance or loss of N in T₆ was mainly due to leaching and volatilization of N fertilizers. Several other workers have reported that N use efficiency in rice ranged from 30 to 91 % only (Prasad, 1998 ; Tandon, 1980). Negative balance of K was under T₆ was met from the release of K from its non-exchangeable pool of the soil to meet the demand of crop. These results corroborate with Sharma and Mishra (1987).

Soil health

Data on soil properties as influenced by different treatments showed that organic carbon content increased to a great extent with the addition of different organic manures (Table 3). Highest value of organic carbon (0.64%) was recorded in T₃ where in addition to crop residues FYM was applied @ 10 t/ha. Slight decrease (0.37%) in organic carbon content was recorded in T₆ (recommended NPK) against the initial value of 0.42%. Organic carbon content in T₁, T₂, T₄ and T₅ ranged from 0.51 to 0.57%. Slight reduction in pH was recorded in the treatment with chemical fertilizers (T₆).

There was no much variation in the values of EC after rice, but was higher after wheat. Highest value of EC was recorded in T₆ where only chemical fertilizer applied. Better growth of crops due to availability of nutrients and better physical condition enhanced root biomass leading to accumulation of more organic residues. Kumar *et al.* (2007) also reported improvement in soil organic carbon content and decrease in soil pH due to addition of organic manures. Yaduvanshi (2003) and Patil *et al.* (2003) also reported similar trends.

Economics

Economics is the ultimate deciding factor to adopt a practice by the farmers. Total cost of cultivation under different treatments varied from 34.25 to 37.55 x 10³ Rs/ha. Highest net return of 57.65 x 10³ Rs/ha was recorded in the treatment of *in situ* incorporation of WS / RS + GM + PM @ 5 t/ha + PSM (T₃) in both the crops, rice

and wheat (Table 2). This treatment gave 15.46, 16.08, 14.47, 8.97 and 33.81 x 10³ Rs/ha higher net profit over T₁, T₂, T₃, T₄ and T₆, respectively. Lowest net income of 23.84 x 10³ Rs/ha was recorded in the treatment with chemical fertilizer (T₆). Net B:C ratio was computed highest (1.60) in treatment T₅ and lowest under the treatment with chemical fertilizer (T₆). The higher returns under organic farming when compared with chemical fertilizers was mainly due to better soil health resulted in better plant growth, yield components, yield and higher prices of organic produce. Sarma *et al.* (2007) also reported that by integration of FYM and *Azotobacter* with N, productivity and monetary returns of wheat can be increased by maintaining or improving soil fertility.

From the results of the 5 year experimentation on organic farming and discussion it may be concluded that *in situ* decomposition of wheat / rice residues + green manuring + poultry manure @ 5 t/ha + phosphate solubilizing microbes is the most remunerative organic farming treatment and may be recommended for adoption by the farmers.

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