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Productivity and Economics of rice – wheat cropping system as influenced by organic manures and fertilizer management under irrigated conditions

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ABSTRACT
A field experiment was conducted during *kharif* and *rabi* seasons of 2003-04 and 2004-05 at J.V. College, Baraut, Baghpat (U.P.), to study the influence of organic manures and fertilizer management on productivity and economics of rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.) cropping system under irrigated conditions of Western Uttar Pradesh. Incorporation of organic manures i.e., FYM, PM and FYM + PM had similar favourable effects on yield and yield attributes of rice over control during both the seasons. Organic manures increased the mean grain yield of rice by 16.1 to 18.8%. Fertilizer N application increased grain and straw yields of rice up to 120 kg/ha. However, the difference between 80 and 120 kg N/ha were not marked. The residual fertility left after rice due to organic manures had significant influence on grain and straw yields of wheat. Application of P along with N to preceding rice produced more grain yield of wheat than control. The mean increase in grain yield of wheat due to NP application was 15.8% over control. Combined use of FYM + PM fetched higher mean net returns of Rs. 14,795 in rice cultivation. Application of 120 kg N/ha fetched the maximum mean net returns of Rs. 17,380/ha.

Key words : Rice, Wheat, Nitrogen, Phosphorus, Zink, Poultry manure, farmyard manure, yield

INTRODUCTION

Rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.) are the principal food crops of the world. Rice-wheat sequential cropping being an important cropping system plays a significant role in food security of India. This system has gained popularity in Uttar Pradesh, Bihar, Punjab and Haryana which at present occupies nearly 10 million ha area. Growing of two cereal crops in a year involves heavy removal of plant nutrients which leads to poor soil fertility. Continuous use of only chemical fertilizers in rice-wheat system resulted in the decline in the yield potential of the crops of this cropping system and also deteriorated physico-chemical properties of soil (Das *et al.,* 2003). Therefore, it is desirable to increase the productivity and reduce the cost of cultivation in rice-wheat cropping through integration of organic and inorganic sources of nutrients. Keeping this in view, the present investigation was undertaken to evaluate the integrated nutrient supply on the productivity of rice and wheat in rice-wheat system.

MATERIALS AND METHODS

The field experiment was conducted during the kharif and rabi seasons of 2003-04 and 2004-05 at the research farm of J. V. College, Baraut, Baghpat (U.P.). The soil was sandy clay loam, having pH 7.3 (soil : Solution ratio 1:2.5), organic carbon 0.54% total kjeldahl N 0.058% and 22.8 and 270.4 kg/ha available P and K respectively. The treatments comprised 4 organic manures (No organic manure, farm yard manure, poultry manure and farmyard manure + poultry manure) and 6 fertilizer treatments (0, 40, 80, 120 kg N, N 20 P60 and N120 P60 Zn 25 kg/ha). The experiment was laid out in split-plot design keeping the organic manures in the main plot and fertilizer treatments in subplots, using 3 replications. FYM, PM and FYM + PM were applied @ the rate of 10.0, 3.0 and 5.0 + 1.5 tonnes/ha, respectively. Seedlings of 27 days of 'Pusa Basmati-1' rice were transplanted, keeping 2 seedlings/hill on 13 and 11 July in 2003 and 2004 under puddled conditions. All organics were applied on dry weight basis 3 weeks before transplanting. The N content in 2 organic manures was analysed 0.50 and 1.81% in FYM and PM respectively. The nitrogen treatments were imposed in 2 equal splits, half at the time of transplanting and the remaining half at 35 DAT. Total amount of P and Zn were applied at the time of transplanting. The sources of N, P and Zn were prilled urea, single super phosphate and Zinc sulphate, respectively. All other operations were performed as per recommendations of the crop. The data on various yield attributes, grain and straw yields were recorded under various treatments. Rice crop was harvested in the second week of November in both the years and grain yield was reported at 14% moisture. The gross and net plot size was 5m x 3m and 4m x 2.5m, respectively. Wheat crop was sown during the succeeding *rabi* (winter) season. A uniform dose of N (50 kg/ha) was applied to wheat crop. Statistical analysis of data was carried out using standard analysis of variance (Cochran and Cox, 1957). The significance was tested by 't; test and critical difference (CD, P = 0.05) was calculated to compare the differences of treatment means.

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RESULTS AND DISCUSSION

Effect of organic manures

Rice responded well to organic manures incorporation during both the seasons. Maximum plant height was recorded with FYM + PM followed by PM and FYM. All organic manures recorded more plant height than the control (Table 1). Significant higher values of yield attributes, viz., effective tillers/hill, panicle length, grains/panicle and 1000-grain weight, were recorded with organic manures over control. However, the differences among organic manures were not significant in either years of study. It showed that under the organic manures, the crop enjoyed a better nutritional environment and was reflected in the yield attributes as well. Similar increase in growth and yield attributes of rice and other crops due to incorporation of organic manure reported by (Singh *et al.*, 1998).

Significantly higher mean grain yield of rice was obtained with FYM, PM and FYM + PM, with a yield increase of 16.1, 17.7 and 18.8% over control, respectively (Table 3). Least mean grain yield of 36.1 q/ha was recorded under no organic manures during the study. The corresponding increase in mean straw yield under FYM, PM and FYM + PM was 10.9, 11.8 and 14.8% respectively, over control. However, among the organic manures, none was found superior than other during both the seasons. Such favourable response of organic manure on yield was the result of increased availability of nutrients which in turn must have improved synthesis and translocation of metabolites to various reproductive structures of the plant. Similar increases in yield of rice and other crops due to FYM (Thakur and Kanwar, 1994) and PM (Singh *et al.*, 1998) incorporation have been reported.

Effect of fertilizer nitrogen

Fertilizer nitrogen showed a favourable influence on growth and yield attributes (plant height, effective tillers/hill, Panicle length and 1000-grain weight) up to 80 kg N/ha (Table 1). Fertilizer treatments applied to rice indicated a significant increase in plant height of rice due to each successive dose of 40 kg N/ha up to 120 kg N/ha in 2003, while in 2004 each successive dose of 40 kg N/ha up to 80 kg/ha resulted in a significant increase in plant height of rice. Fertilizer treatments, applied to rice observed a significant improvement in 1000-

Table 1 : Growth and yield attributes of rice as influenced by organic manures and fertilize treatments

Treatment	Plant height at harvest (cm)		Effective tillers/hill		Panicle length (cm)		Grains/panicle		1000-grain weight (g)	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
Organic manure										
Control	90.4	93.1	5.7	7.0	25.7	27.4	68.6	70.8	21.0	21.7
FYM	96.8	97.9	6.4	7.8	27.6	28.4	84.8	89.7	21.8	22.8
PM	98.6	98.9	6.6	8.0	28.2	28.6	86.3	90.1	22.0	23.3
FYM + PM	99.4	99.6	6.7	8.2	27.6	29.0	87.8	92.6	22.0	23.00
CD at 5%	4.08	NS	0.35	0.93	1.21	NS	4.01	7.62	0.35	0.94
Fertilizer treatment (kg ha^{-1})										
N_0	81.2	88.0	4.4	5.6	24.6	26.8	52.4	58.6	20.5	21.5
N_{40}	93.6	98.6	6.0	7.3	27.0	27.8	71.1	73.7	21.3	22.0
N_{80}	97.0	103.4	6.6	8.4	27.9	28.7	87.2	89.6	22.0	22.9
N_{120}	100.9	97.8	6.9	8.4	27.9	29.1	91.4	97.4	22.2	23.4
N_{120} P_{60}	102.3	98.9	7.2	8.3	28.1	28.8	94.5	97.9	22.5	23.0
N_{120} P_{60} Zn_{25}	102.6	97.7	7.3	8.5	28.3	29.2	94.9	97.7	21.9	23.3
CD at 5%	3.75	4.24	0.44	2.06	2.08	NS	4.12	7.11	0.61	1.46

Table 2 : Growth and yield attributes of wheat as influenced by organic manures and fertilize treatments in preceding rice

Treatment	Plant height at 80 DAS (cm)		Effective tillers/m row length		Length of spike (cm)		Number of grains/spike		1000-grain weight (g)	
	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05
Organic manure										
Control	43.8	43.8	77.0	81.2	8.81	9.64	35.8	36.4	40.9	41.4
FYM	46.6	46.6	82.5	86.4	9.36	9.93	37.4	38.6	41.2	41.6
PM	47.4	47.4	82.7	87.1	9.62	9.85	38.2	40.5	41.4	41.7
FYM + PM	48.5	48.5	87.2	89.5	9.62	9.78	37.6	39.6	41.0	41.6
CD at 5%	2.21	2.21	3.57	4.33	0.45	NS	1.39	2.14	NS	NS
Fertilizer treatment (kg ha^{-1})										
N_0	42.8	52.7	70.9	78.4	8.67	9.39	33.6	34.5	40.5	41.1
N_{40}	45.3	54.6	78.2	83.6	8.90	9.74	37.1	38.7	40.9	41.4
N_{80}	45.1	54.8	85.3	84.3	9.48	9.88	38.0	39.6	41.2	41.8
N_{120}	47.9	56.9	91.9	90.7	9.59	9.90	38.0	40.0	41.2	41.7
N_{120} P_{60}	49.4	58.8	83.3	89.4	9.70	9.90	38.2	40.3	41.3	41.9
N_{120} P_{60} Zn_{25}	49.3	58.8	85.0	89.3	6.65	9.84	38.8	39.8	41.4	41.9
CD at 5%	2.40	3.07	6.32	8.37	0.49	0.35	2.51	3.22	NS	NS

grain weight with each increase in N level up to 80 kg N/ha. The beneficial effect of nitrogen on growth and yield attributes of rice has also been reported by Gangaiah and Prasad (1999).

There was a significant increase in grain and straw yields of rice with each successive dose of 40 kg N/ha up to 80 kg N/ha during both the seasons (Table 3). Phosphorus and Zinc application along with N in both the years of study significantly increased grain yield of rice over 40 kg N/ha. There was no marked favourable effect of further increase in nitrogen level up to 120 kg N/ha. Application of NPZn recorded the highest grain and straw yields of wheat during both the seasons. The improvement in yield and yield attributes of rice with N application might be due to better growth and development. Similar increase in yield and yield attributes by nitrogen have been reported by Brindra *et al.* (2001).

Residual fertility

In wheat, the plant height of wheat was significantly influenced by organic manures applied in preceding rice during both the years. Incorporation of organic manures had a significant influence on effective tillers/m row length as compared to control (Table 2). Effective tillers were the highest in FYM + PM incorporated plots during both the seasons. Data showed that organic manure had a significant influence on length of spike of wheat in 2003-04 only. However, organic manures failed to cause significant effect of the test weight of wheat crop over control. Incorporation of organic manures in preceding rice had a significant influence on number of grains/spike of wheat during both the seasons. FYM, PM and their combined application improved the organic carbon content in the soil which was favourable in supplying the plant nutrient for longer period

Table 3 : Grain and straw yields of rice and wheat as influenced by organic manures and fertilizer treatments

Treatment	Rice				Wheat			
	Grain yield (q/ha)		Straw yield (q/ha)		Grain yield (q/ha)		Straw yield (q/ha)	
	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05
Organic manure								
Control	35.2	36.9	67.4	69.7	30.0	33.7	43.6	54.2
FYM	40.9	42.9	73.3	78.9	33.1	37.8	48.8	58.4
PM	41.2	43.7	73.6	79.7	33.4	38.1	48.4	58.2
FYM + PM	41.7	44.1	75.7	81.8	33.5	38.3	48.2	58.8
CD at 5%	1.87	2.98	2.43	3.84	2.66	3.22	2.73	NS
Fertilizer treatment (kg ha^{-1})								
N_0	27.5	29.2	51.4	56.2	29.6	33.2	42.9	53.2
N_{40}	37.7	38.9	71.8	73.7	31.7	36.7	46.9	57.4
N_{80}	42.1	44.9	76.3	80.9	32.7	36.8	47.2	57.0
N_{120}	43.3	46.1	77.3	83.5	33.0	37.5	47.7	58.0
N_{120} P_{60}	44.1	46.2	78.6	84.4	33.9	38.9	49.2	59.4
N_{120} P_{60} Zn_{25}	44.3	46.5	79.8	86.5	34.0	38.9	49.7	59.4
CD at 5%	3.29	3.89	4.42	4.96	3.45	3.79	4.61	3.79

Table 4 : Net income (Rs/ha) from 1 ha of rice, wheat and rice + wheat as affected by Organic manures and fertilizer treatments

Treatment	Rice		Wheat		Rice + Wheat	
	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05
Organic manure						
Control	12720	13247	18818	23081	31538	36328
FYM	14230	15361	21827	26545	36057	41906
PM	13590	14833	21984	26697	35574	41530
FYM + PM	14135	15375	21877	27015	36012	42390
Fertilizer treatment (kg ha^{-1})						
N_0	6885	8145	18454	22561	25339	30706
N_{40}	14033	14824	20594	25641	34627	40465
N_{80}	16443	17364	21224	25625	37667	42989
N_{120}	16742	18017	21532	26273	38274	44290
N_{120} P_{60}	16020	17160	22446	27449	38466	44609
N_{120} P_{60} Zn_{25}	15635	16801	22543	27449	38178	44250

for butter growth and development of succeeding wheat corp. The results further confirms the view of Kalia *et al.* (2004). The residual effect of organic manures had significant influence on grain and straw yields of wheat as compared to control (Table 3). In general, the impact of the residual N due to FYM and PM alone or combined use of FYM + PM applied to rice, was more pronounced during 2004-05.

The residual effect of fertilizer N applied to rice had a significant influence on growth and yield parameters of wheat only at 120 kg N/ ha, NP and NPZn treated plots (Table 2). Residual effect of NP and NPZn was more pronounced than other level of N in most of yield attributing characters. All the fertilizer treatments being on par produced more number of grains/spike in wheat than control in both the seasons. However, test weight of wheat was not significantly influenced by residual fertility due to fertilizer applied in preceding rice crop. Application of P along with N resulted in a significant increase in grain and straw yields of wheat over control in both the years (Table 3). The mean increase in grain yield of wheat due to NPZn level was 15.8% over control. Grain and straw yields of wheat was appreciably more in 2004-05 as compared to 2003-04 season which could be ascribed to cumulative residual effects of the fertilizer NP and NPZn. Similar increase in grain and straw yields of wheat due to residual effect of P applied to rice and other crops were obtained by Singh *et al.* (1998) and Singh & Ghosh (1999).

Economics

Based on two seasons, combined use of FYM + PM was more profitable with a net return of Rs. 14,795/ha in rice cultivation. The corresponding value of net returns was Rs. 12,983/ha under control (Table 4). The net income increased with increase in N level up to 120 kg N/ha which gave the highest mean net income (Rs. 17,380/ha) from rice cultivations. Residual fertility of fertilizer treatment (NP) applied to rice recorded the highest mean net returns (Rs. 41,214/ ha), whereas no N recorded the lowest net returns (Rs. 28,022/ha) in rice-wheat cropping system. The results obtained are in close conformity with the findings of Ghosh *et al.* (2003). Hence application of FYM + PM along with the N fertilization is efficient in increasing the yield and for better returns in rice-wheat cropping system.

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