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INTEGRATED EFFECT OF ORGANICS AND INORGANIC FERTILIZERSON FERTILIZER USE EFFICIENCY, NUTRIENT UPTAKE AND PRODUCTIVITY OF RICE UNDER RICE-WHEAT CROPPING SYSTEM

Sanjay Tiwari, S. Kumar and S.B. Pandey
Department of Soil Science, RAU, Pusa, Bihar

ABSTRACT

An investigation was undertaken to assess the impact of conjoint use of organics and chemical fertilizers on crop production, nutrients uptake by rice and fertilizer use efficiency under rice-wheat cropping system. Rice was grown in a field experiment during kharif season of 1999-2000 at Rajendra Agricultural University, Pusa, Bihar (Samastipur) with treatments of five organic manures *viz.*, Dhaincha (GM), Urd (GL), FYM, straw and weedy fallow in the main plot and five levels of fertilizers, (control, 50 % PK, 50% NPK, 100% PK and 100% NPK of recommended dose) in sub plots of split plot design. The results indicated that organic and inorganic nutrient sources when applied alone or in combinations, increased the crop yield, the N, P and K uptake by rice and the fertilizer use efficiency as compared to weedy fallow and unfertilized control treatments. The Dhaincha (GM) + 100 % NPK treatment combination produced the highest grain and straw yield (53.24 and 69.85 q/ha), respectively. The uptake of N, P and K by rice were highest under this treatment while the highest N, P and K use efficiency were recorded in the treatment containing Dhaincha (GM) and 50% NPK treatment combination.* ***Key words : Rice, organic manures, nutrient uptake, fertilizer use efficiency.***

A noticeable and gradual decline in productivity in many of the intensively cultrvated areas is being observed. The yield decline has been attributed to soil degradation through nutrient depletion and loss of soil quality. The sustainability of crop production system in future will mainly depend to a large measure on the adequacy and balanced supply of nutrients. In recent years, integrated use of inorganic fertilizers with bulky organic manures, green manuring and farm products like straw have emerged as an issue of vital importance and renewed interest. Organic materials provide considerable amounts of macro and micro nutrients. The beneficial role of organic matter in improving the physical, chemical and microbiological properties of soil is well recognised (Bellaki and Badhur, 1994).

There is need to improve environmental conditions and to reduce the cost of crop production led to focus the attention of research workers on recycling of organic materials. Organic manures are not regarded as alternative or substitution for chemical fertilizers (Susma Kumari, *et al.* 1989), It is likely that mixing of organic manures with chemical fertilizers in certain proportion might prove more advantageous then the addition of either of them separately. The objective of the present study is to develop a suitable integrated nutrient supply system in a rice-wheat cropping system involving both organic manures and inorganic fertilizer nutrients.

MATERIALS AND METHODS

The experiment was conducted during kharif season of 1999-2000 at Rajendra Agricultural University, Bihar. The experimental soil was of sandy loam in texture having pH 8.5, organic carbon (OC) 0.51 per cent and it contained 200.32, 14.46 and 96.18 kg/ha soil of available N ($KMnO_4$.-N), P (Olsen-P) and K (neutral normal NH_4OAC-K), respectively. The experiment was started with 25 treatment combinations of five organic sources [Dhaincha (GM), Urd (GL), Farm Yard Manure (FYM), straw and weedy follow] and five levels of inorganic fertilizers [0% NPK, 50% PK, 50% NPK, 100% PK and 100% NPK of recommended dose (N : P : K ::120 : 60 : 40 kg/ha,) respectively in split plot design with three replications in 8 m^2 plot for each treatment. The sources of NPK were urea, single super phosphate and muriate of potash, respectively. Organic manure additions were made 10-15 days before puddling/ transplanting of rice. Dhaincha green manure was chopped into small pieces spread uniformly on the soil surface of required plots and incorporated into the soil (0-15 cm) with spades. After this, soil of each plot was irrigated to its field capacity and and finally puddled. At the end of kharif 1999 session, plant and soil samples were collected and analyzed. The plant samples were analyzed for total-N, P and K content (Jackson 1973) and uptake were calculated. The apparent nutrient use efficiency was worked out as follows :

Table-1 : Influence of organic and inorganic fertilizer on the yield of rice in rice-wheat cropping system.

Inorganic fertilizer level	Grain yield (q/ha)						Straw yield (q/ha)					
	Organic sources						Organic sources					
	Dhaincha (GM)	Urd (GL)	FYM	Straw	Weedy fallow	Mean	Dhaincha (GM)	Urd (GL)	FYM	Straw	Weedy fallow	Mean
Control	31.36	28.73	30.60	25.72	21.41	27.56	38.98	34.72	37.02	34.37	31.25	35.27
50% PK	34.29	31.92	33.58	27.29	25.60	30.54	43.03	39.97	40.72	38.84	33.76	29.27
50% NPK	44.07	36.76	43.48	34.66	30.86	38.04	59.02	46.44	56.02	43.22	39.26	48.93
100% PK	36.53	32.81	35.67	29.89	28.37	32.63	47.66	41.81	46.71	40.19	35.06	42.29
100% PK	53.24	43.29	52.57	40.65	34.94	44.94	69.85	59.34	68.31	57.50	50.23	61.05
Mean	39.90	34.70	39.26	31.64	28.22		51.71	44.45	49.83	42.83	37.91	
Source		S.Em.±		CD at 5%			S.Em.±		CD at 5%			
Organic manures (M)		0.89		2.90			0.89		2.91			
Inorganic fertilizers (S)		0.56		1.62			0.58		1.63			
Interaction (M×S)		1.44		NS			1.45		4.36			

$$\text{Apparent nutrient use efficiency (\%)} = \frac{\text{Uptake in treated plot - uptake in control plot}}{\text{Fertilizer dose}} \quad 100$$

RESULTS AND DISCUSSION

Grain and straw yield of rice : The grain and straw yield of rice (Table-1) varied from 21.41 to 53.24 q/ha and 31.25 to 69.85 q/ha, respectively as influenced by different treatment combinations. The grain and straw yield of rice were significantly influenced by different organic sources. The maximum grain and straw yield (39.90 q/ha) and (51.71 q/ha) were recorded in dhaincha (GM) treatment and were at par with FYM treatment (39.26 q/ha) and (49.83 q/ha), but superior over Urd (GL) (34.700 g/ha) and (44.45 q/ha), straw (31.64 q/ha) and 42.83 q/ha) and weedy fallow (28.22 q/ha) and (37.90 q/ha). Thus, the effect of organic manures on grain as well as straw yield of rice were in the order : dhaincha (GM) = FYM > urd >straw > weedy fallow. The impact of chemical fertilizers was found significant in improving the grain and straw yield of rice from 27.56 q/ha and 35.27 q/ha in control to 44.94 q/ha and 61.5 q/ha in 100 % NPK treatment. The effect of NPK with respect to grain and straw yield of rice can be shown by following order: 100% NPK > 50% NPK > 100% PK= 50% PK>control.

The significant interaction effect of organics and the fertilizers on straw yield indicated the beneficial effects of application of GM, FYM and Urd (GL) on different levels of NPK. The maximum grain and straw yield (53.24 q/ha and 69.85 q/ha), respectively of rice were recorded with dhaincha (GM) and 100 % NPK combination. The effects of Dhaincha (GM) and FYM treatments in combination with inorganic fertilizers at all the levels of inorganic fertilizers were similar. Thus, this results indicate that 100% NPK in combination with green manuring or application of FYM improved grain and straw yield of rice because of the balanced dose of fertilization through chemical fertilizer and inherited amount of organic sources by incorporation of dhaincha (GM) of FYM. These results were in conformity with findings to Pandey *et al.* (1993) and Bhagat ef al. (1995).

Nutrient Uptake

N-uptake : The uptake of nutrients by rice is presented in Table-2. It could be observed that the N uptake in rice increased markedly with increasing levels of applied NPK. It was observed that the increase in N uptake by rice was very well pronounced in 100 per cent NPK treatment. Organic manure application, irrespective of the source increased the N uptake over weedy follow treatment. Among the organic manures, Dhaincha green manuring (GL) recorded the highest value of N uptake (75.12 kg/ha). The maximum N uptake (112.27 kg/ha) by rice was observed in the treatment containing dhaincha (GM) combined with 100 per cent NPK and followed by FYM, Urd (GL) at the same level of NPK. Nambiar (1994) reported that heavy withdrawal of nutrients from soils and its success depend largely upon the external application of nutrients commensurate with the nutrient uptake.

P-uptake : Addition of different sources of organics markedly increased the P uptake over weedy follow treatment. Among the organics, the treatment containing dhaincha (GM) recorded higher P uptake (15.01 kg/ha) followed by FYM, Urd (GL) and Straw.

Table-2 : Influence of organic and inorganic fertilizer on nutrients uptake by rice crop in rice-wheat cropping system.

Inorganic fertilizer level	N-uptake (Kg/ha) by rice crop						P-uptake (kg/ha) by rice crop						K-uptake (kg/ha) by rice crop					
	Organic sources						Organic sources						Organic sources					
	Dhain-cha (GM)	Urd (GL)	FYM	Straw	Weedy fallow	Mean	Dhaincha (GM)	Urd (GL)	FYM	Straw	Weedy fallow	Mean	Dhain-cha (GM)	Urd (GL)	FYM	Straw	Weedy fallow	Mean
Control	29.88	26.19	30.02	23.19	148.82	25.63	10.06	8.75	9.45	7.78	6.32	8.47	64.39	50.43	60.48	52.17	43.30	51.15
50% PK	31.86	27.67	33.21	24.72	22.33	27.96	11.54	10.33	11.03	8.79	7.47	9.84	73.38	63.24	69.61	62.46	48.10	63.39
50% NPK	50.68	40.52	49.13	36.90	31.24	41.69	16.80	12.98	16.17	11.66	9.82	13.48	106.73	76.11	98.60	73.75	57.48	82.53
100% PK	33.34	29.29	32.25	27.38	24.48	29.35	14.41	11.80	13.85	10.24	8.96	11.85	92.18	71.80	87.74	71.61	55.14	75.69
100% PK	66.65	51.08	61.43	44.71	36.38	52.05	22.33	16.95	21.27	15.19	12.82	17.69	144.90	106.47	137.78	106.65	79.95	115.35
Mean	42.48	34.95	41.21	31.38	26.65		15.01	12.16	14.35	10.73	9.08		96.32	73.61	91.04	73.33	56.79	
Source			S.Em.±		CD at 5%			S.Em.±		CD at 5%				S.Em.±		CD at 5%		
Organic manures (M)			0.68		2.22			0.18		0.58				0.89		2.91		
Inorganic fertilizers (S)			0.65		1.86			0.17		0.49				0.90		2.59		
Interaction (M×S)			1.47		4.33			0.38		1.14				2.02		5.93		

Table-3 : Influence of organic and inorganic fertilizer on the fertilizer use efficiency by rice in rice-wheat cropping system.

Inorganic fertilizer level	Apparent N-recovery (%)						Apparent P-recovery (%)						Apparent K-recovery (%)					
	Organic sources						Organic sources						Organic sources					
	Dhaincha (GM)	Urd (GL)	FYM	Straw	Weedy fallow	Mean	Dhaincha (GM)	Urd (GL)	FYM	Straw	Weedy fallow	Mean	Dhaincha (GM)	Urd (GL)	FYM	Straw	Weedy fallow	Mean
50% NPK	48.46	28.72	44.00	26.50	20.45	33.62	22.50	14.10	22.40	12.93	11.66	16.72	201.70	128.40	190.60	107.90	70.90	141.90
100% NPK	41.97	27.73	36.96	25.47	20.24	30.47	20.30	13.66	19.70	12.35	10.83	15.37	201.27	140.10	195.75	136.20	91.62	152.98
50% PK							4.96	5.26	5.27	3.36	3.83	4.54	44.95	65.05	45.60	51.45	24.00	46.21
100% NPK							7.26	5.08	7.33	4.10	4.40	5.63	69.47	53.42	68.15	48.60	29.60	53.86
Mean	45.22						13.75	9.52	13.67	8.18	7.68		131.85	96.94	125.02	86.04	54.03	

Similarly under mineral fertilizer treatments, significantly higher P uptake in rice (17.69 kg/ha) was recorded with 100 per cent NPK treatment. The order or superiority of treatments with regards to their P-uptake can be presented in the following order : 50 per cent NPK > 100 per cent PK > 50 per cent PK > control. The positive impact of conjoint use of organics with fertilizers on P uptake in rice plant was highest (22.23 kg/ha) in case of 100 per cent NPK dhaincha (GM) combination. The effect of GM and FYM on P uptake by rice, at all the levels of NPK fertilizer combination were statistically similar with each other. Increase in P uptake may be due to the decomposition of GM, FYM, Urd (GL), straw released more organic anions and hydroxy acids. These acids helped in complexing or chelating i.e. Fe^{+++}, Al^{+++} and Ca^{++} and preventing their reactions with phosphate ions to form insoluble phosphate and thus, more phosphours might have been available to the plants (Bindra and Thakur, 1996).

K-uptake : The increase in K uptake by rice consequent upon addition of various levels of chemical fertilizer was more over control. Addition of dhaincha (GM) recorded higher K uptake (96.32 kg/ha) which was followed by FYM (91.04 kg/ha) Urd (GL) (73.61 kg/ha), straw (73.33 kg/ha) and weedy fallow (56.79 kg/ha). As far as integrated approach is concerned, integration effects between organic sources and inorganic fertilizers on K uptake in rice were found to be statistically significant. The highest K uptake (144.90 kg/ha) was recorded with dhaincha (GM) + 100 NPK treatment combination and the lowest (43.30 kg/ha) were recorded under weedy fallow + control treatment combination in rice. Thus, it may be concluded that addition of GM, FYM, Urd (GL) and straw with chemical fertilizers enhanced nutrient uptake by making temporary linkage with a part of nutrient elements and prevent them from leaching and other losses. These nutrients get

released slowly in later period of crop lice and then were made use by the crop plants (Greenland, 1971).

Fertilizer use efficiency

Apparent N-recovery : A perusal of data presented in the Table-3 indicated that, per cent apparent recovery of N, P and K in rice were higher at lower level of fertilizer (50% NPK) than that of the higher level of 100% K. At lower fertilizer level, combined use of dhaincha (GM), FYM, Urd (GL) and straw resulted in maximum use efficiency of nutrients for rice crop. The lower recovery of applied nitrogen by rice might be due to the greater loss of N under flooded conditions, Nitrogen use efficiency at lower level (50%NPK) for rice was 33.62 per cent which decreased to 30.47 per cent at 100 per cent NPK. Nitrogen use efficiency increased to 45.22, 40.48, 28.22 and 25.98 per cent over weedy fallow (20.34 %) with the addition of dhaincha (GM), FYM, Urd (GL) and straw, respectively. These results were also in strict accordance with the findings reported by Dwivedi (1997) in Bihar soils.

Apparent P-recovery : Apparent P-recovery in rice ranged from 3.36 to 22.50 per cent in different treatment combinations. Phosphorus recovery at 50 % NPK in rice was 16.72 per cent which decreased to 15.37, 5.63, and 4.54 per cent at 100% NPK, 50% PK and 100% PK, respectively. Incorporation of dhaincha (GM), FYM, Urd (GL) and Straw increase the apparent P-recovery from 7.68 to 13.75, 13.67, 9.52 and 8.18 per cent respectively,s in rice. This may be due to retardation of the phosphorus transformation process by organic matter added through compost and crop residue and thus rendering more of applied phosphorus available to plant. Swamp (2002) also made similar observation.

Apparent K-recovery : The maximum apparent K-recovery by rice was recorded as 201.70 per cent in GM + 50% NPK treatment combination whereas, it was minimum as 24.00 per cent Under weedy fallow + 50% PK treatment combination. Under mineral fertilizer treatment, highest apparent K-recover y in rice (152.98%) was recorded with 100% NPK treatment. The order of superiority of treatments with regards to their K-recovery can be presented in the following order : 100% NPK > 50% NPK. >100 % PK > 50% PK. The impact of various organics with regards to K-recovery by rice may be shown in the following order : GM (131.85%) > FYM (125.02%) > Urd ((96.74%) > straw (86.04) > weedy fallow (54.03%). The apparent K-recovery by rice was found exceptionally high. It is thus seen that in most of the cases, per cent utilization of K exceed in those application through mineral fertilizer. The utilization efficiency in excess of applied K indicates that a large fraction of non-exchangeable –K also appears to contribute towards plant uptake of K. The results are in conformity with these reported by (Pandey *et al.* 2004).

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