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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD, NUTRIENT UPTAKE AND NUTRIENT BALANCE IN RICE-WHEAT SYSTEM

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Abstract

A fixed plot field experiment was carried out for three years from 1994-95 to 1996-97 with rice (cv. Sujata) - wheat (cv. UP-262) cropping system in silty loam calcareous soil with moderate water holding capacity, low in available N and K_2O, medium in organic carbon content and available P_2O_5 having alkaline reaction (pH-8.3) at the Research Farm of Rajendra Agricultural University, Bihar Pusa (Samstipur). The experiment was laid out in split plot design having three replications. Three organic treatments viz. F_0-no organics, F_1-Farm yard manure (FYM) @ 6.5 t/ha dry matter and F_2-Green manuring through Sesbania rostrata @ 2.85 t/ha dry matter either alone or in combination with four graded levels of N, P_2O_5 and K_2O (control D_0-Control; D_1-50%; D_2-75% and D_3-100% of the recommended fertilizer i.e. 120:60:40 kg N: P_2O_5 K_2O/ha) were applied as per treatments in main-plot (rice) and inorganic fertilizer treatments *viz.* M_0-control, M_1-50%, M_2-75% and M_3-100% recommended NPK were allotted randomly in sub-plot for wheat. The results revealed that organic and inorganic nutrient sources when applied alone or in combinations, significantly increased yields and NPK-uptake as compared to unmanured and unfertilized control. Application of FYM produced rice grain yield to the tune of 41.5 q/ha which was statistically at par with GM (40.6 q/ha). Similar pattern was also observed in straw yield also. The minimum yield of rice grain (20.0 q/ha) was recorded with F_0D_0 and maximum (51.1 q/ha) with F_1D_3. Average grain yield due to FYM + 50% of recommended NPK (41.3 q/ha) was comparable with the sole application of 100% recommended NPK (42.8 q/ha). Similarly, grain yield of F_0 D_2 (39.22 q/ha) was found to be statistically at par with F_2D_1 (35.17 q/ha). Residual effect of FYM and 100% recommended NPK applied to rice either alone or in combination has discernible variation on the succeeding wheat crop in respect of yields and uptake. Direct application of fertilizers to wheat linearly increased yield and uptake. Positive balance of NPK was observed when recommended dose of NPK through inorganic fertilizer was applied along with FYM.

Key words: INM, Rice-wheat system, Nutrient uptake and balance

Profit motivated conversion of green revolution in to greed revolution with scant regard to prudent use of natural resources affected both soil and water quality and had brought about the fatigue in the sustainability of rice-wheat system. Declining crop and factor productivity have been cited as the evidences of fragility of rice-wheat system. Among the factors responsible for declining factor productivity, imprudent use of fertilizer (imbalance use of NPK without organic manures) ranks first. Balanced fertilization, integrated nutrient management and *in situ* nutrient recycling are the key, which impart sustainability. Keeping the above in view, an experiment was conducted to address non-sustainability indicators viz. decline in yield and low factor productively.

Materials and Methods

A field experiment was conducted in fixed plots at RAU, Pusa, Bihar research farm for three consecutive years during 1994-95 to 1996-97 to study the effect of integrated nutrient management (farm yard manure, green and inorganic fertilizer) on yield, nutrient uptake and nutrient balance after completion of third cycle of rice-wheat system (1996-97). The experiment was laid out in split-plot design with kharif (rice) treatments in main plots and rabi (wheat) treatments in sub-plots and replicated thrice. The main plot treatments comprised of organic (control: F_0, FYM-F_1 and GM in situ - F_2) and inorganic fertilizer (control-D_0-control, D_1-50% D_2-75% and D_3-100% of the recommended fertilizer i.e. 120:60:40 kg N: P_2O_5 :K_2O/ha). Twenty-six days old rice seedlings were transplanted during second fortnight of July in all the three year of experimentation. The experimental soil was silty loam in texture and alkaline (pH 8.2) in reaction, and was low in available N (243.4 lg/ha) and available K_2O (100.7 kg/ha) and medium in organic carbon (0.65%) and available P_2O_5 (42.9 kg/ha). The bulk density, total porosity, water-holding capacity and field capacity were 1.42 Mg/m^3, 46.42%, 29.9% and 20.7%, respectively. FYM @ 10/t/ha was applied about one

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month before transplanting. Seeds of *Sesbania rostrata* as green manuring @ 60 kg seed/ha were sown 45 days before transplanting and incorporated *in situ* at the time of transplanting. The amount of green matter added through green manure was 10.4 t/ha (2.85 t dry matter/ha). The NPK content of FYM (6.5 t/ha on dry-weight basis) was 1.32, 0.34 and 0.39% respectively. However, NPK content of *Sesbania rostrata* was 2.31, 0.34 and 2.2% respectively. Amount of nutrients i.e., N, P and K added through FYM and GM was 85.8, 22.1, 25.4 and 65.8, 9.9, 62.7 kg/ha, respectively, Twelve main plots were further divided in to four sub plots each, in which *rabi* treatments *viz.*, control (M_0) 50% (M_1) 75% (M_2) and (M_3)100% of recommended NPK (120 N: 60 P_2O_5: 40 K_2O) were applied to wheat crop. Balance sheet of soil available N, P_2O_5 and K_2O was calculated by considering the amount added and nutrient removed (uptake).

Results and Discussion

Grain and straw yield

The interactive effects of organic and inorganic sources of nutrients on grain and straw yields of rice were found to be significant (Table 1). Without applying organic manures (F_0), fertilizer responded significantly upto D_1 i.e. 50% of the recommended NPK, however, with F_1 (FYM @ 10 t/ha) fertilizer response was significant to the extent of 100% of the recommended NPK i.e. D_3 and such increases were observed only up to 75% of the recommended NPK (D_2) with F_2 i.e green manuring. The organic and organic combination F_1 D3 (FYM with recommended dose of NPK produced the highest grain yield (51.1 q/ha) and the lowest was recorded with control i.e. F_0D_0 (20.0 q/ha). It is interesting to note here that the rice grain yield at F_0D_3 (42.8q/ha) was statistically at par with F_1D_1 (41.3 q/ha). In other words, the applied FYM contributed to the extent of 50% of the recommended NPK (equivalent of 60 kg N, 30 kg P_2O_5 and 20 kg K_2O/ha) whereas such contribution by green manuring was of the order of 25% of the recommended dose (equivalent to 30 kg N, 15 kg P_2O_5 and 10 kg K_2O/ha). It is in accordance with the findings of Yadav *et al.* (1992). With F_0 (No organic control) there was significant increase in straw yield up to an application of 100% NPK (D_3) whereas in case of F_1 (FYM and F_2 (GM) it was upto 50% (D_1) and 75% (D_2) NPK respectively.

Grain of wheat without any organics i.e. F0 (27.1 q ha) applied to rice was significantly lower as compared to both F_1 (40.2 q/ha) and F_2 (35.2 q/ha). Similarly the later i.e. F_2 was significantly inferior to F_1. This again brings out the fact that organic manuring results in to saving of considerable quantity of required inorganic fertilizers. As far as inorganic fertilizer given directly to wheat crop was concerned, it showed highly significantly influence on grain yield of wheat. The decreasing trend of grain yield was observed in the order of M_3 (43.7 q/ha), M_2 (37.9 q/ha), M_1 (35.2q/ha) and M_0 (19.9 q/ha).

Table 2. Grain and straw yield (q/ha) of wheat as affected by different treatments under R-W system

Treatment	Grain yield	Straw yield
Organies to Rice		

Table 1. Interaction effect of integrated nutrient management on grain and straw yield of rice under Rice - Wheat System

Treatment	Grain yield (q/ha)					Straw yield (q/ha)				
	D_0	D_1	D_2	D_3	Mean	D_0	D_1	D_2	D_3	Mean
F_0	20.0	35.3	39.3	42.8	34.5	32.6	40.4	44.0	59.8	44.7
F_1	28.8	41.3	44.6	51.1	41.5	34.9	62.0	62.6	67.7	56.8
F_2	31.5	35.1	47.8	47.8	40.6	39.5	41.7	53.1	59.7	48.5
Mean	26.9	37.2	43.9	49.3	-	35.7	48.0	53.9	62.4	-

Particulars	C.D. at 5%	C.D. at 5%
Organic manures (F)	2.5	3.8
Inorganic fertilizer (D)	2.9	4.5
Interation (F x D)	5.0	7.7

F_0	27.1	47.8
F_1	40.2	46.7
F_2	35.1	47.0
C.D. at 0.5%	3.2	NS
Inorganic to Rice		
D_0	30.3	42.4
D_1	32.8	44.2
D_2	35.1	49.8
D_3	38.5	52.2
C.D. at 0.5%	1.4	2.8
Inorganic to wheat		
M_0	19.9	19.0
M_1	35.2	48.7
M_2	37.9	57.2
M_3	43.7	63.8
C.D. at 0.5%	1.5	2.8

Nutrient Uptake

The organic treatments have significant positive effect on N, P & K uptake. The maximum N uptake (114.50 kg/ha) was recorded in FYM treated plot (64.8 kg/ha grain and 49.7 kg/ha in straw) and on an average these values were 65.5 and 24.1 per cent higher than that of control and green manuring respectively (Table 3). Similar treatments as in case o f P and K. Inorganic fertilizer treatments exerted significant influence on total N-uptake. Among the various levels N, P and K fertilizers the uptake value increased with increasing level of fertilizers i.e. up to D_3. The total nitrogen uptake in rice was found in the order of D_3 (128.9 kg/ha) > D_2 (102.9 kg/ha) > D_1 (82.2 kg/ha) > D_0 (54.0 kg /ha). Similar was the trend with regard to uptake of P and K.

The results with respects to N, P and K uptake in wheat revealed that uptake of NPK were significantly affected by residual effect of organic manures recorded significantly higher uptake of N (115.6 and 98.9 kg/ha), P (15.8 and 14.4 kg/ha) and K (68.9 and 63.6 kg/ha) respectively in comparison to control. NPK uptake in control treatment was 76.8, 12.6 and 56.8 kg/ha respectively. The total uptake value of N (48.8 kg/ha) P (7.0 kg/ha) & K (30.5 kg/ha) at M_0 (control, linearly increased up to M_3 level of fertilizer and maximum uptake values of N (130.2 kg/ha), P (18.8 kg/ha) and K (83.6 kg/ha) was recorded at M_3 level of fertilizer application to wheat.

Appartment balance sheet of nutrients

The final status of soil available N, P_2O_5 and K_2O were appreciably affected by different treatments as compared to initial status of soil available N, P_2O_5 and K_2O were observed in unfertilized plots (Table 5).

The N, P_2O_5 and K_2O status of the soil after the completion of R-W sequence was -6.0, 3.0 and -10.0 kg/ha respectively in control plots ($F_0D_0M_0$). Plots received only FYM ($F_1D_0M_0$) had negative balance of N (-2.0 kg/ha) and K_2O (-5.0 kg/ha) but positive balance with respect to P_2O_5 (1.0 kg/ha) was noticed. As far as nutrient balance

Table 3. Effect of organic manures (F) and inorganic fertilizer (D) on total (Grain + Straw) NPK uptake (Kg/ha) in Rice-wheat system

Treatment	Rice			Wheat		
	Nitrogen	Phosphorus	Potash	Nitrogen	Phosphorus	Potash
Organic manures to rice (F)						
F_0	69.20	12.30	59.70	76.8	12.6	56.8
F_1	114.50	18.30	78.10	115.6	15.8	68.9
F_2	92.30	15.20	67.10	98.9	14.4	63.6
C.D. (0.5)	7.60	1.80	5.50	15.7	1.2	4.3
Inorganic fertilizer (D) to rice						
D_0	54.00	9.30	47.00	75.7	12.6	49.2
D_1	82.00	14.00	65.00	89.1	13.5	59.3
D_2	102.90	17.30	74.60	104.3	14.9	66.9
D_3	128.90	20.40	86.80	119.4	16.1	77
C.D. (0.05)	8.50	2.00	6.70	4.8	0.7	3.4
Inogranic fertilizers to wheat (M)						
M_0	-	-	-	48.8	7	30.5
M_1	-	-	-	98	14.7	64.8
M_2	-	-	-	111.5	16.6	73.5
M3	-	-	-	130.2	18.8	83.6
C.D. (0.05)	-	-	-	4.8	0.7	3.4

with the application of GM alone to rice was concerned, almost similar trend as in case of control was recorded. N, P_2O_5 and K_2O status after completion of R-W sequence in GM plot was of the order of -4.0, 0.5 & -4.0 kg/ha respectively. Narang *et al.* (1990) also reported that green manure contributed about 60 kg/ha to rice but showed no residual effect on succeeding crop. Both sets of inorganic fertilizer applied to rice and wheat showed the similar pattern on balance sheet of soil available N, P_2O_5 and K_2O however the magnitude of positive balance was slightly different and its was higher when higher dose of NPK fertilizer were applied to wheat. Maximum positive balance of NPK was observed when NPK was applied in combination with FYM.

Build-up soil fertility status in FYM treated plots may be due to addition of higher levels of organic matter probably by the mineralization of organic leading to availability of essential nutrients (Maskina et al. 1988). The increment in soil available P under FYM treatments may be due to the mineralization of organic matter accompanied by the released of appreciable quantities of CO_2 which when dissolved in water, forms carbonic acid which is capable of decomposing certain primary minerals and consequently this happens in calcareous soil else by which there was an increase in P_2O_5 availability. The reasons for beneficial effect of FYM on the available K_2O may be due to reduction of potassium fixation and more release of potassium Hussain *et al.* (1995) and Diekmann *et al.* (1996).

It may thus be concluded that combined application of organic manures such as FYM & Green manuring of *Dhaincha* with inorganic fertilizers (NPK) proved superior in respect of growth yield, profitability & soil health in rice-wheat cropping system in comparison to inorganic fertilizer alone.

Table 4. Interaction effect of differents treatments (F x D x M) on apparent balance sheet of soil available N, P_2O_5 and K_2O after completion of third rice-wheat sequeace

Treatment	F0					F1					F2				
	D_0	D_1	D_2	D_3	Mean	D_0	D_1	D_2	D_3	Mean	D_0	D_1	D_2	D_3	Mean
Soil available N (kg/ha)															
M_0	-6.0	-2.2	-0.5	1.2	-1.88	-2.0	-1.0	-1.0	1.0	-0.75	-4.0	-2.0	-1.5	1.1	-1.6
M_1	-2.5	0.75	1.4	2.0	0.42	1.0	1.5	2.0	2.0	1.63	-1.5	1.0	2.0	2.5	1.0
M_2	0.5	1.10	1.9	3.0	1.63	1.5	2.5	3.5	3.5	2.75	2.0	2.5	3.0	3.0	2.6
M_3	-1.5	2.5	2.85	4.0	2.71	3.0	4.5	5.0	6.0	4.63	3.0	4.0	4.5	5.0	4.1
Mean	-1.63	0.54	1.41	2.55	-	0.88	1.88	2.38	3.13	-	-0.13	1.38	2.0	2.90	-
Soil available P_2O_5 (kg/ha)															
M_0	-3.0	-1.0	0.5	1.5	-0.75	1.0	1.5	3.0	4.0	2.38	-0.5	1.0	2.5	3.0	1.5
M_1	-1.0	1.5	2.0	4.0	1.63	3.5	4.5	5.0	6.5	4.88	2.0	3.0	5.0	6.0	4.0
M_2	2.5	4.0	5.0	6.5	4.50	5.0	6.5	7.5	8.5	6.88	3.0	5.0	7.0	8.0	5.7
M_3	4.0	6.0	7.0	7.75	6.19	6.0	8.0	8.5	10.0	8.13	4.0	6.0	8.0	9.0	6.7
Mean	0.63	2.63	3.83	4.94	-	3.88	5.13	6.0	7.35	-	2.21	3.7	5.6	6.50	-
Soil available K_2O (kg/ha)															
M_0	-10.0	-7.5	-5.0	-4.0	-6.63	-5.0	-3.0	-2.80	-1.90	-3.18	-4.0	-2.0	-1.5	-1.0	-2.1
M_1	-8.0	-5.0	-4.0	-3.5	-5.13	-3.40	-2.0	1.38	2.69	-0.33	-2.5	-1.0	-0.5	0.5	-0.8
M_2	-7.6	-4.10	-3.50	-3.10	-4.58	-2.50	1.0	3.75	4.0	1.56	1.50	+2.0	2.5	4.20	2.5
M1	-5.7	-3.20	-3.0	-2.85	-3.69	-1.0	2.5	4.90	5.50	2.98	2.25	3.0	4.0	6.0	3.8
Mean	-7.83	-4.95	-3.88	-3.36	-	-2.98	-0.38	1.81	2.57	-	-0.69	0.50	1.1	2.43	-

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