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INTEGRATED NUTRIENT MANAGEMENT IN RICE AND WHEAT CROP IN RICE- WHEAT CROPPING SYSTEM IN LOWLANDS

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ABSTRACT

A field experiment was conducted during 2004-05 to 2006-07 at the Ghagharaghat, Bahraich (U.P.) to study the effect of combined use of inorganic fertilisers with organic manure, or bio-fertilisers on yields, nutrient uptake by rice and wheat and soil fertility. The yield of rice and wheat recorded with 100% NPK + 5t FYM ha^{-1} or 75% NPK +5t FYM ha^{-1} was on par but significantly higher over rest of the treatments. The per cent increase in grain yield due to 100% NPK + 5 t FYM ha^{-1} was to the tune of 9.6 and 8.3 in rice and wheat, respectively over 100% NPK. Increasing fertiliser dose from 50% to 100% NPK increased significantly the grain and straw yield of both crops. Application of 15 t FYM ha^{-1} increased the grain yield of rice by 24.6% and wheat by 17.5% over farmer practice. Application of 100% NPK + 5 t FYM ha^{-1} recorded the highest monetary efficiency (Rs 86.06 ha^{-1} day^{-1}) and net return (Rs. 42060 ha^{-1}), system productivity (26.5 kg grain ha^{-1} day^{-1}) and stability yield index (0.99), however benefit: cost ratio being highest (1.36) with 75% NPK + 5t FYM ha^{-1}. The uptake of N (73.6 and 91.6 kg ha^{-1}), P(27.9 and 18.9 kg ha^{-1}) and K(125.7 and 109.3 kg ha^{-1}) by rice and wheat, respectively was maximum with 100% NPK +5t FYM ha^{-1} followed by 75% NPK + 5t FYM ha^{-1}. The content of organic carbon, available P and K in soil was improved with combined use of fertilizers as compared to 100% NPK; however, magnitude of increase was higher in 15 t FYM ha^{-1}.

Keywords: Integrated nutrient management, rice-wheat cropping system, lowlands

INTRODUCTION

Rice-wheat cropping system plays an important role in food security of India. Cereal – cereal system like rice – wheat is fertility exhaustive. It removes higher amount of plant nutrients resulted in decline of soil organic carbon and deteriorated soil health (*Singh et al., 2011*). At present, higher cost of inorganic fertilizers, growing ecological concern, and conservation of energy have created considerable interest for the use of organic manure like FYM and bio- fertilizer as source of plant nutrients and also in integrated nutrient management system. Application of FYM or bio-fertilizer alongwith inorganic fertilizer for efficient growth of crop arrest the decline in organic carbon and also bridge up the gap between potential and actual yield of rice - wheat system. Further use of organic manure and biofertilizer had favourable effect on physico- chemical and biological properties of soil due to supply of macro and micronutrients to the crop. Recycling of organic sources of nutrients has become inevitable to sustain crop productivity and soil health. It is, therefore, necessary to judicious use of organic resources of nutrients (organic manure or bio-fertilisers) with inorganic fertilisers to improve the productivity of rice – wheat cropping system and soil fertility (Mundra *et al.* 2003, and Singh, 2008). An attempt was, thus, made to study the effect of integrated use of fertilisers with farmyard manure or bio fertilisers like, *Azotobacter* + PSB on rice – wheat cropping system in rainfed lowlands.

MATERIALS AND METHODS

A field experiment was conducted during 2004-05 to 2006-07 at the Crop Research Station, Ghagharaghat, Bahraich (U.P.). The soil of experimental site was sandy- loam having pH 8.1, organic carbon 4.2 g kg^{-1}, available N 184, P_2O_5 19.6 and K_2O 179 kg ha$^{-1.}$ The eight treatments comprised of ; farmers practice (40 kg N ha^{-1} + 2 t FYM ha^{-1}), 100% NPK – 120 N + 60 P_2O_5 + 40 K_2O kg ha^{-1}, 100% NPK + 5 t FYM ha^{-1}, 75% NPK + 5 t FYM ha^{-1}, 50% NPK + 5 t FYM ha^{-1}, 100% NPK + Azotobacter + PSB, 75% NPK + Azotobacter + PSB, 50% NPK + Azotobacter + PSB, and 15 t FYM ha^{-1} were tested in randomized block design with four replications on both crops. The required quantity of Azotobacter (2 kg ha^{-1}) and PSB (5 kg ha^{-1}) was mixed in soil as per treatment before sowing, while farmyard manure (N 0.5%, P_2O_5 0.3% and K_2O 0.4%) was applied in the respective treatments 25 days before sowing of both crops. The quantity of 50, 75 and 100% NPK was supplied through inorganic fertilizers. The half quantity of nitrogen as urea, full

dose of P as single superphosphate and K as muriate of potash was applied at sowing. Rest amount of N was applied in two splits as top dressed at tillering and panicle initiation stage in rice, and after first and second irrigation in wheat. Twenty five days old seedlings of rice variety "NDR 359" were transplanted at 20 x 15 cm spacing using 2-3 seedlings hill^{-1} on 12 July in all the years. During rabi season wheat variety "HUW 234" was sown on 18 December in 2004 and 20 December in 2005 and 2006 in rows at 20 cm apart using 125 kg seed ha^{-1}. The five panicles/spikes from each plot were selected randomly, and used to collect data pertaining to yield attributes on both crops. At harvest of both crops, grain and straw yields were recorded. The grain and straw samples were analysed for N content by micro kjeldahl method. Phosphorus and K were estimated in diacid (HNO_3:$HClO_4$) extract by vanadomolybdate yellow colour method (Jackson, 1973) and flame photometer, respectively. A composite soil sample collected before start and after harvest of the crop was analyzed for organic carbon, available P, K and pH using standard methods (Jackson, 1973).

RESULTS AND DISCUSSION

Yield attributes

Application of 15 t FYM^{-1} or integrated use with inorganic fertilizers tended to influence significantly the yield attributes of rice and wheat as compared to farmer practice. Increase in level of NPK from 75% to 100% either with FYM or azotobacter + PSB, the increase was higher in yield attributes as compared to 100% NPK (Table 1). The increase may be attributed to mineralization of FYM or through soubilization of nutrients from native source during the process of decomposition. Integrated nutrient management had beneficial effect on yield attributes, the maximum value of all yield attributes of rice and wheat were recorded under treatment receiving 100% NPK + 5 t FYM ha^{-1} followed by 75% NPK + 5 t FYM ha^{-1} as compared to 100% NPK. The better crop growth with combined use of nutrient may be attributed to improvement in physico-chemical and biological properties of soil which maintained continuous supply of nutrient to crop. Similar higher values of yield attributes with combined use of inorganics + organic source of nutrients was reported by Davari and Sharma (2010).

Table 1: Yield attributes, system productivity and stability index as affected by different treatments (mean of 3 years)

Treatments	Yield attributes of rice				Yield attributes of wheat				System productivity kg grain ha^{-1} day^{-1}	Stability yield index
	Panicle / m^2	Grains/ panicle	Test wt (g)	Panicle length (cm)	Spike/ m^2	Grains/ Spike	Test wt (g)	Spike length (cm)		
Farmers Practice	220	42.5	23.7	20.9	195	28.6	38.9	7.9	20.26	0.68
100% NPK	248	54.3	24.9	22.8	283	38.3	41.0	8.6	24.11	0.90
100% NPK + 5t FYM ha^{-1}	274	61.2	25.3	24.7	312	48.9	41.8	9.7	26.47	0.99
75% NPK + 5t FYM ha^{-1}	268	58.6	25.0	24.4	299	40.2	39.7	8.9	25.90	0.97
50% NPK + 5t FYM ha^{-1}	240	50.7	24.2	21.6	261	33.6	37.6	8.1	20.90	0.79
100% NPK + Azoto. + PSB	254	56.6	25.0	24.5	301	45.6	40.8	9.4	24.71	0.93
75% NPK + Azoto. + PSB	240	54.1	24.9	23.9	278	36.3	38.9	8.5	24.17	0.91
50% NPK + Azoto. + PSB	228	48.5	24.3	22.2	250	30.8	35.8	8.0	20.29	0.76
15t FYM ha^{-1}	224	51.3	24.4	22.4	256	31.7	38.5	8.2	21.79	0.82
CD (P=0.05)	23	8	3	1.7	12	4	1.2	0.4	1.41	0.075

Yield

The mean increase in yield due to 15 t FYM ha^{-1}, over farmer practice was 19.7% in rice and 14.9% in wheat crop. Application of 100% NPK + 5t FYM ha^{-1} was on par with 75% NPK + 5 t FYM ha^{-1} but produced significantly higher grain and straw yields of rice (33.76 and 50.50 q ha^{-1}), and wheat (37.72 and 52.69 qha^{-1}), respectively over rest of treatments (Table 2). This might be due to immediate and quick supply of plant nutrients through chemicals for crop growth and steady supply of plant nutrient by organics throughout growing period. The FYM released nutrients following decomposition and mineralization that would have increased the availability of plant nutrients at later stage and brought improvement in physical, chemical and biological properties of soil. As a result the fertility status of soil might have increased and thus increasing the absorption of plant nutrients. Similar results on productivity of rice and wheat were recorded by Kumari *et al.* (2010) and Davari and Sharma (2010) and Jaga and Tripathi (2011).

Table 2: Yields and economics of rice – wheat system as affected by different treatments (mean of three years)

Treatments	Yields (q ha^{-1})				Cost (Rs ha^{-1})	Gross income (Rs ha^{-1})	Net income (Rs ha^{-1})	Benefit : Cost ratio	Monetary efficiency (Rs ha^{-1} day^{-1})
	Rice		Wheat						
	Grain	Straw	Grain	Straw					
Farmers Practice	22.40	31.76	26.32	44.30	28649	50442	21843	0.76	59.24
100% NPK	30.50	46.80	34.60	48.06	29096	66710	37614	1.29	78.48
100% NPK + 5t FYM ha^{-1}	33.76	50.50	37.72	52.69	31096	73156	42060	1.35	86.06
75% NPK + 5t FYM ha^{-1}	32.73	49.96	37.20	52.78	30427	71741	41314	1.36	84.40
50% NPK + 5t FYM ha^{-1}	28.50	43.43	28.18	47.91	29758	58408	28650	0.96	68.71
100% NPK+Azoto. + PSB	30.83	46.76	35.90	51.18	30646	68538	37892	1.24	80.63
75% NPK + Azoto. + PSB	29.76	45.40	35.51	52.68	29977	67290	37313	1.24	79.16
50% NPK + Azoto. + PSB	26.93	40.66	27.87	46.94	29308	56549	27241	0.93	66.52
15t FYM ha^{-1}	27.91	42.50	30.94	49.30	30421	60733	30312	1.00	71.45
CD (P= 0.05)	1.42	1.53	2.03	2.95	-	-	-	-	2.41

Cost (Rs/q): Rice, G: 850, S-50, Wheat: G: 1000, S: 80

Application of 100%, 75% and 50% NPK with 5 t FYM ha^{-1} resulted in significantly higher grain and straw yields as compared to azotobacter + PSB treatment (Table 2). This could be attributed to higher nutrient supply by FYM in conjunction with inorganic fertilizers which helped to maintain the optimum nutrient status in the soil as compared to 100% or 75% NPK with azotobacter + PSB with inorganic treatments. Both crop received 100% NPK produced significantly higher yield over 50% NPK + 5t FYM ha^{-1} or 50% NPK + Azotobacter + PSB, or 15 t FYM ha^{-1} alone. This could be attributed to lower values of yield attributes due to addition of inadequate dose of plant nutrients under these treatments. Application of 15 t FYM ha^{-1} gave significantly higher stability index and system productivity over farmer practice. Combined use of 75% NPK + 5 t FYM ha^{-1} or azotobacter + PSB improved system productivity, and stability index of rice – wheat system as compared to 100% NPK. The highest values of (26.5 kg grain ha^{-1} day^{-1} and 0.99) system productivity and stability index, respectively were recorded with 100% NPK + 5 t FYM ha$^{-1.}$ This could be attributed to higher grain yield of both crops with above treatments.

Table 3: Nutrient uptake (kg ha^{-1}) by rice and wheat in rice-wheat cropping system (mean of three years) and soil fertility after harvest

Treatments	Uptake of nutrient (kg ha^{-1})						Soil fertility		
	Rice			Wheat					
	N	P	K	N	P	K	Org. carbon (g kg^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
Farmers Practice	45.8	15.8	78.0	62.3	13.6	76.0	4.4	19.1	178.5
100% NPK	65.8	24.5	113.9	84.0	17.9	100.3	4.5	19.7	179.7
100% NPK + 5t FYM ha^{-1}	73.6	27.9	125.7	91.6	18.8	109.3	5.3	20.9	183.2
75% NPK + 5t FYM ha^{-1}	71.0	26.7	122.2	90.5	18.9	107.8	5.0	21.6	182.7
50% NPK + 5t FYM ha^{-1}	61.1	22.1	105.5	70.2	14.9	83.2	4.7	21.0	181.2
100% NPK +Azoto.+ PSB	68.2	25.8	114.9	87.2	17.9	104.1	4.6	21.6	182.4
75% NPK + Azoto.+ PSB	63.8	24.3	110.6	86.2	18.4	102.6	4.5	21.2	181.7
50% NPK + Azoto. + PSB	56.9	20.6	99.0	67.6	14.4	80.8	4.4	21.0	180.9
15t FYM ha^{-1}	62.9	25.6	105.4	75.4	16.0	89.7	5.7	22.5	185.7
Initial Soil fertility	-	-	-	-	-	-	4.5	19.8	180.9
CD (P=0.05)	1.2	0.8	1.2	2.2	0.5	3.7	-	-	-

Economics

Monetary efficiency (86.06 Rs ha^{-1} day^{-1}) and net return (Rs 42060 ha^{-1}) were highest with 100 % NPK + 5 t FYM ha^{-1} followed by 75% NPK + 5 t FYM ha^{-1}, however, benefit: cost ratio was highest (1.36) with 75% NPK + 5t FYM ha^{-1} because of lower cost incurred as compared to 100% NPK + 5t FYM ha^{-1}. Integrated nutrient supply gave higher gross income, net income, benefit: cost ratio and monetary efficiency as compared to inorganics with

Azotobacter + PSB. This was mainly due to higher yield with former treatment with less cost involved as compard to later treatment. Similar higher B: C ratio with 75% NPK + 5 t FYM ha^{-1} + azotobacter as compared to 100% NPK was recorded by Jaga and Tripathi (2011).

Nutrient uptake

The uptake of nutrients by rice and wheat was maximum with 100% NPK + 5 t FYM ha^{-1} followed by 75% NPK + 5 t FYM ha^{-1} (Table 3). The higher grain and straw yield and sustained availability of plant nutrient with 100% NPK +5 t FYM ha^{-1} enhanced higher uptake of nutrient by both crops. Similar higher nutrient uptake by rice with integrated use of inorganic + organic manure has been reported by Kumari *et al.* (2010) and Jaga and Tripathi (2011). Application of 15 t FYM ha^{-1} alone depleted higher amount of NPK by rice and wheat as compared to farmers practice owing to higher yields and continuous availability of plant nutrient to rice and wheat crop. Application of 100% NPK failed to improve the uptake of NPK over 100% or 75% NPK along with + 5 t FYM ha^{-1} because of lower yield with former treatment. Application 75% NPK + azotobacter + PSB recorded significantly higher uptake of nutrients as compared to 100% NPK which may due to the fixation of nutrients and better assimilation.

Soil fertility

All integrated nutrient management practices improved soil fertility as compared to farmers practice**.** The content of organic carbon, available P and K was improved with fertilizers + FYM as compared to 100 % NPK alone. Mundra et al. (2003) and Kumari *et al.* (2010) also reported the higher values of nutrients with combined use of fertilizers + FYM to both rice and wheat separately. Application of 15 t FYM ha^{-1} resulted in the higher values of organic carbon, available P and K (5.7g kg^{-1}, 22.5 kg ha^{-1} and 185.7 kg ha^{-1}) as compared to rest of the treatments. This was due to better soil health in terms of physical, chemical and biological properties owing to continuous addition of organic matter in soil. Among the INM practices, application of 100% NPK + 5 t FYM ha^{-1} recorded the highest value of organic carbon (5.3 g kg^{-1}), available P (21.9 $kgha^{-1}$) and K (183.2 kg ha^{-1}) followed by 75% NPK + 5 t FYM ha^{-1}. Mundra *et al.* (2003) and Kumari *et al.* (2010) reported higher values of organic carbon and available P and K under integrated nutrient management system.

It is concluded that rice-wheat sequence in rainfed lowland situation, application of 100% or 75% recommended dose of NPK along with 5 t FYM ha^{-1} is imperative for higher productivity and sustaining soil health.

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