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Integrated plant nutrient supply in rice (*Oryza sativa*)–wheat (*Ttriticum aestivum*) system

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ABSTRACT

A field experiment was conducted at Karnal during 2005–07 to evaluate the effect of 13 different combinations of integrated plant nutrient supply including crop residues, farmyard manure, pressmud, neem-coated urea and biofertilizers on productivity and soil health of rice (*Oryza sativa* L.)–wheat (*Triticum aestivum* L. emend Fiori & Paol.) system under integrated nutrient supply. Growth and yield attributes of rice, viz tillers/m^2, panicle length, number of grains/panicle and 1 000-grain weight were statistically similar under organic, inorganic and integrated plant nutrient supply. The number of days to heading was significantly less with the 100% organic application. Although the highest system productivity (9.88 tonnes/ha) was observed in treatment 100% inorganic nutrient supply to rice–125% inorganic nutrient supply wheat but taking soil fertility improvement in consideration, the treatments, viz 75% inorganic to rice–100% inorganic+25% through farmyard manure in wheat (9.22 tonnes/ha), 75% inorganic + 50% through farmyard manure in rice–100% inorganic + biofertilizer in wheat (9.36 tonnes/ha), 50% inorganic + 50% through pressmud in rice–100% inorganic in wheat (9.39 tonnes/ha), 50% inorganic + 50% through farmyard manure to rice–50% inorganic + 50% through farmyard manure + biofertilizer in wheat (9.13 t/ha), 75% neem-coated urea in rice–100% neem coated urea + 25% through rice residue in wheat (9.08 tonnes/ha) were found significantly superior than 100% organic supply through farmyard manure in rice–wheat (6.82 tonnes/ha) and at par with 100% recommended inorganic nutrient supply in rice–wheat (9.43 tonnes/ha). Slight improvement in organic carbon status was observed in all treatments even in conventional cropping of rice–wheat system. NPK balance sheet shows that nitrogen (4–206 kg/ha) and phosphorus (20.6–185.0 kg/ha) have the positive balance, whereas K shows highly negative balance (–130 to –416 kg/ha). K balance was less negative (–130 to –405 kg/ha) where organic source of nutrient was applied in parts or full.

Key words: Integrated nutrient supply, Nutrient balance, Rice–wheat system, Soil fertility

Rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L. emend. Fiori & Paol.) are high fertilizer responsive and input exhaustive, and the nutrient uptake often exceed replenishment through fertilizers and manures causing soil fertility deterioration in many parts of Indo-Gangetic plains leading to decline in factor productivity. Continuous cropping of these crops without adequate restorative practices may pose threats to the sustainability of system causing nutrient depletion at an alarming rate which is one of the major forms of soil degradation. High-yielding varieties draw heavy amount of plant nutrients from soil and imbalanced and indiscriminate use of chemical fertilizers resulted in deterioration of soil health (Yadav and Kumar 2009). Nutrient management based on eco-friendly principles of balanced fertilization not only enhances the fertilizer-use efficiency but also helps to sustain the rice and wheat productivity. Integrated plant nutrient supply is an important and promising component for sustainable productivity of these crops and to restore soil fertility. The aim is to integrate natural and man-made sources of plant nutrients supply so as to increase crop productivity in an efficient and environmentally favourable manner without diminishing soil's inherent capacity of plant nutrient supply. This integration approach helps to restore soil fertility (Mankotia 2007). In the present study, different combinations of integrated plant nutrient supply including crop residues, farmyard manure, pressmud, neem-coated urea and biofertilizers were studied in rice and wheat and their residual effect on succeeding crop.

MATERIALS AND METHODS

A field experiment was conducted at research farm of Directorate of Wheat Research, Karnal for 2 years during 2005–07. The experimental soil was sandy clay loam in texture (22% clay), low in organic carbon (0.36%) and available N (139 kg/ha), medium in available P (17.6 kg/ha)

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and K (151 kg/ha). Electrical conductivity and *p*H were 0.273 dS/m and 7.8, respectively. Thirteen combinations of nutrient supply, viz 100% recommended dose in the form of inorganic fertilizer (T_1), 100% inorganic to rice–125% inorganic to wheat (T_2), 75% inorganic to rice–100% inorganic + 25% through farmyard manure in wheat (T_3), 75% inorganic + 25% through farmyard manure in rice–75% inorganic + biofertilizer in wheat (T_4), 75% inorganic + 25% through farmyard manure to rice–100% inorganic+ biofertilizer to wheat (T_5), 75% inorganic + 50% through farmyard manure in rice–100% inorganic + biofertilizer in wheat (T_6), 50% inorganic+50% through farmyard manure in rice –75% inorganic + biofertilizer in wheat (T_7), 50% inorganic + 50% through farmyard manure in rice –100% inorganic in wheat (T_8), 50% inorganic + 50% through press mud in rice –100% inorganic in wheat (T_9), 50% inorganic + 50% through farmyard manure in rice –50% inorganic+50% through farmyard manure + biofertilizer in wheat (T_{10}), 75% through neem-coated urea in rice –100% through neem-coated urea in wheat (T_{11}), 75% through neem-coated urea to rice –100% through neem-coated urea + 25% through rice residue in wheat (T_{12}), 100% through farmyard manure in rice and wheat (T_{13}) were tested in randomized block design. The treatment of neem-coated urea (slow-solubilizing fertilizer) and 100% organic were included in rice and wheat. Recommended doses of N, P and K were 150, 60 and 40 kg/ha, respectively. Full dose of P and K were applied as basal. Organic forms of nitrogen and neem-coated urea were applied as basal and inorganic form of nitrogen were applied as 1/3 basal and 2/3 at tillering stage in rice and wheat. Irrigation was applied on the basis of critical physiological stages of different crops. 'PBW 343' wheat and 'HKR 47' rice were sown in the experiment. The observations on important characters, viz plant height, number of ear/m^2, 1 000-grain weight, biomass and grain yield were recorded. Nutrient estimation of grain and straw samples was done as per methods described under AOAC. Balance sheet was calculated by subtracting removal of nutrient from nutrient applied.

RESULTS AND DISCUSSION

Growth and yield

The plant height of wheat was statistically similar among all the integrated nutrient supply treatments and also similar with recommended doses of inorganic fertilizer but significantly lower plant height was recorded with 100%

Table 1 Effect of integrated nutrient supply on plant growth and yield attributes of wheat and rice

Treatment		Wheat				Rice				
Rice	Wheat	Plant height (cm)	Ears/m^2	Grains /ear	1000 grains weight, g	Days to heading	Tillers/ m^2	Panicle length, cm	Grains/ panicle	1000 grains weight, g
100% rec. inorganic	100% rec. inorganic	90.0	351.7	38.3	47.8	62.5	338	27.15	122	26.4
100% rec. inorganic	125% rec. inorganic	90.0	355.0	38.5	47.2	63	344	27.8	123.5	27.0
75% rec. inorganic	100% rec. inorganic + 25% *th. FYM	90.7	361.7	39.6	47.1	61	330	27	119	27.0
75% rec. inorganic + 25% th. FYM	75% rec. inorganic + biofertilizer	87.3	333.3	37.0	47.2	65	342	27.4	116	26.5
75% rec. inorganic + 25% th. FYM	100% rec. inorganic + biofertilizer	87.3	383.3	39.0	47.8	67	326	27.8	120.5	27.1
75% rec. inorganic + 50% th. FYM	100% rec. inorganic + biofertilizer	88.0	380.0	39.2	46.4	66	326	27.15	117	26.5
50% rec. inorganic + 50% th. FYM	75% rec. inorganic + biofertilizer	87.7	336.7	37.4	48.2	66	320	27.5	116.5	26.7
50% rec. inorganic + 50% th. FYM	100% rec. inorganic	90.3	328.3	38.0	47.0	65	315	27.15	117	26.8
50% rec. inorganic + 50% th. pressmud	100% rec. inorganic	86.7	355.0	38.5	47.1	67	341	26.9	121	26.4
50% rec. inorganic +	50% rec. inorganic + 50% th. FYM + biofertilizer	86.3	308.3	36.8	49.4	68	335	26.5	114	26.8
75% th. neem-coated urea	100% th. neem-coated urea	86.7	351.7	39.0	47.6	61	334	28.1	122	26.8
75% th. neem-coated urea	100% th. neem-coated urea + 25% th. rice residue	89.0	353.3	39.3	46.8	65	337	28.0	120	27.7
100% th. FYM	100% th. FYM	74.0	191.7	33.0	47.2	59	333	26.65	120.5	26.5
CD (*P*=0.05)		5.30	80.09	2.91	NS	6.74	NS	NS	NS	NS

FYM, Farmyard manure; Rec., recommended dose of inorganic fertilizers (NPK 150:60:40); *th., through

Table 2 Effect of integrated plant nutrient supply on yield and productivity of rice and wheat (tonnes/ha)

Treatment		Wheat						Rice						System's productivity
		Grain yield			Straw yield			Grain yield			Straw yield			Mean of 2 years
Rice	Wheat	2005–06	2006–07	Pooled	2005–06	2006–07	Pooled	2005–06	2006–07	Pooled	2005–06	2006–07	Pooled	
100% rec. inorganic	100% rec. inorganic	4.76	4.41	4.58	6.45	6.74	6.59	7.05	6.71	6.88	12.3	12.7	12.5	9.43
100% rec. inorganic	125% rec. inorganic	5.01	4.78	4.89	6.82	6.64	6.73	7.01	7.13	7.07	12.5	13.0	12.7	9.88
75% rec. inorganic	100% rec. inorganic + 25% *th. FYM	4.34	4.14	4.24	6.03	6.11	6.07	7.29	6.83	7.06	11.6	12.7	12.1	9.22
75% rec. inorganic + 25% th. FYM	75% rec. inorganic + biofertilizer	4.45	3.74	4.10	6.18	5.70	5.94	6.49	6.73	6.61	10.9	12.2	11.6	8.76
75% rec. inorganic + 25% th. FYM	100% rec. inorganic + biofertilizer	4.64	3.95	4.29	6.40	5.65	6.02	7.40	6.85	7.13	12.0	12.3	12.2	9.32
75% rec. inorganic + 50% th. FYM	100% rec. inorganic + biofertiliser	4.78	4.04	4.41	6.50	7.07	6.78	7.15	6.87	7.01	12.5	12.6	12.6	9.36
50% rec. inorganic + 50% th. FYM	75% rec. inorganic + biofertilizer	3.61	3.90	3.75	5.64	6.29	5.97	6.94	7.03	6.99	12.3	12.7	12.5	8.68
50% rec. inorganic + 50% th. FYM	100% rec. inorganic	4.78	4.38	4.58	6.53	6.42	6.48	7.05	6.90	6.97	11.8	12.8	12.3	9.50
50% rec. inorganic + 50% th. pressmud	100% rec. inorganic	4.73	4.28	4.51	6.48	6.55	6.52	6.94	6.87	6.91	12.1	12.7	12.4	9.39
50% rec. inorganic + 50% th. FYM	50% rec. inorganic + 50% th. FYM + biofertilizer	4.76	3.74	4.25	6.39	5.82	6.11	7.08	6.76	6.92	12.1	12.3	12.2	9.13
75% th. neem-coated urea	100% th. neem-coated urea	5.00	3.77	4.39	6.36	5.83	6.09	5.90	6.90	6.40	11.0	12.1	11.6	8.91
75% th. neem-coated urea	100% th. neem-coated urea + 25% th. rice residue	5.09	4.05	4.57	6.45	6.90	6.57	5.69	7.10	6.39	10.8	11.7	11.2	9.08
100% th. FYM	100% th. FYM	2.47	2.49	2.48	2.83	2.80	2.80	5.63	6.67	6.15	10.2	10.8	10.5	6.82
CD (P=0.05)		0.49	0.52	0.67	0.65	0.76	0.91	0.55	NS	NS	1.25	NS	NS	0.91

organic nutrient application through farmyard manure. Similarly, ears/m^2 and number of grains/ear were at par among all the treatments except 100% organic fertilizer application. 1 000-grain weight of wheat remained unaffected by organic, inorganic or integrated fertilizer application. Growth and yield attributes of rice tillers/m^2, panicle length, number of grains/panicle and 1 000-grain weight were statistically similar under organic, inorganic and integrated plant nutrient supply. The number of days to heading was significantly less with the 100% organic nutrient application through farmyard manure as compared to inorganic or integrated application of nutrients (Table 1).

Rice productivity was the highest (7.13 tonnes/ha) in the treatment where 75% N supplied through inorganic source and 25% through farmyard manure in rice–100% through inorganic sources+ biofertilizer applied in wheat (Table 2). The treatments, like 100% –125% through inorganic source to wheat and rice, 75% inorganic in rice –100% inorganic + 25% through farmyard manure in wheat, 75% inorganic + 50% through farmyard manure in rice –100% inorganic + biofertilizer in wheat, 50% inorganic + 50% through farmyard manure in rice –75% inorganic + biofertilizer in wheat, 50% inorganic + 50% through farmyard manure in rice –100% inorganic in wheat, 50% inorganic + 50% through pressmud in rice –100% inorganic in wheat, 50% inorganic + 50% through farmyard manure in rice –50% inorganic + 50% through farmyard manure + biofertilizer in wheat were at par with the highest yield treatment (75% N inorganic source and 25% through farmyard manure in rice–100% through inorganic sources + biofertilizer in wheat). Wheat productivity was higher in the treatments where 100 and 125% of inorganic N was applied in rice and wheat and it was at par with 100% inorganic in wheat - 100% inorganic in rice, 50% inorganic + 50 through farmyard manure in rice–100% inorganic in wheat, 75% neem-coated urea in rice–100% neem-coated urea + 25% through rice residues in wheat. The lowest yield in both the crops (2.48 t/ha wheat and 6.15 t/ha rice) was recorded in the treatment where 100% of nutrients were applied through organic source, ie farmyard manure. Wheat yield was comparatively higher in the treatments where 50% of N was applied through organic source (pressmud or farmyard manure) in rice, irrespective of wheat treatments. System(rice–wheat) productivity was at par under 100% inorganic in rice and wheat, 100% inorganic in rice–125% inorganic in wheat, 75% inorganic in rice –100% inorganic + 25% through farmyard manure in wheat, 75% inorganic + 25% through farmyard manure in rice –100% inorganic + biofertilizer in wheat, 75% inorganic + 50% through farmyard manure in rice –100% inorganic + biofertilizer in wheat, 50% inorganic + 50% through farmyard manure in rice –100% inorganic in wheat, 50% inorganic + 50% through pressmud in rice –100% inorganic in wheat,

Table 3 Balance sheet of N, P and K after 2 years of rice – wheat cropping

Treatment		N (kg/ha)			P (kg/ha)			K (kg/ha)		
Rice	Wheat	Applied	Removal	Balance	Applied	Removal	Balance	Applied	Removal	Balance
100% rec. inorganic	100% rec. inorganic	600	490	110	240	122.4	117.6	160	544	–384
100% rec. inorganic	125% rec. inorganic	676	498	178	240	128.8	111.2	160	576	–416
75% rec. inorganic	100% rec. inorganic + 25% *th. FYM	600	482	118	240	126.0	114.0	160	565	–405
75% rec. inorganic + 25% th. FYM	75% rec. inorganic + biofertilizer	526	464	62	256	125.2	130.8	190	530	–340
75% rec. inorganic + 25% th. FYM	100% rec. inorganic + biofertilizer	600	512	88	272	117.6	154.4	220	532	–312
75% rec. inorganic + 50% th. FYM	100% rec. inorganic + biofertilizer	676	484	192	272	125.6	146.4	220	554	–334
50% rec. inorganic + 50% th. FYM	75% rec. inorganic + biofertilizer	600	526	74	252	125.0	127.0	220	550	–330
50% rec. inorganic + 50% th. FYM	100% rec. inorganic	600	503	97	240	122.0	118.0	160	554	–394
50% rec. inorganic + 50% th. pressmud	100% rec. inorganic	600	460	140	304	119.0	185.0	280	530	–250
50% rec. inorganic + 50% th. FYM	50% rec. inorganic + 50% th. FYM + biofertilizer	526	478	48	240	124.0	116.0	160	522	–362
75% th. neem-coated urea	100% th. neem-coated urea	526	522	4	240	127.6	112.4	160	566	–406
75% th. neem-coated urea	100% th. neem-coated urea+25% th. rice residue	600	538	62	260	130.2	129.8	220	580	–360
100% th. FYM	100% th. FYM	600	394	206	128	107.4	20.6	300	430	–130

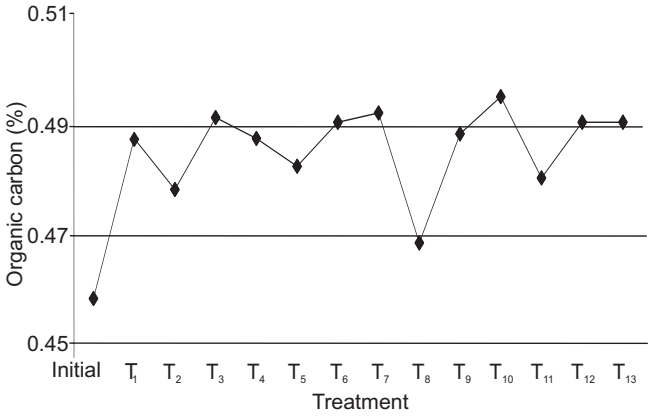

Fig 1 Effect of integrated use of fertilizers on soil organic carbon status

50% inorganic + 50% through farmyard manure in rice – 50% inorganic + 50% through farmyard manure + biofertilizer in wheat, 75% neem-coated urea in rice–100% neem coated urea + 25% through rice residue in wheat and significantly higher as compared to remaining treatments. Yadav and Kumar (2009) also reported that substitution of 50% N through farmyard manure and *Sesbania* green manuring to rice gave equal or more yields than 100% NPK fertilizers alone. A positive residual response to farmyard manure was observed on wheat yield. Combined application of urea and farmyard manure showed superiority over recommended fertilizer application as reported by Chaudhary and Thakur. (2007). Similar observation was recorded by Mankotia *et al*. (2008) to rice and wheat system. Gill *et al*.(2008) evaluated the effects of different combinations of organic and inorganic fertilizers on a rice–wheat crop rotation and reported saving of 50% chemical fertilizers for same average yield of wheat and rice, if integrated nutrient with green manuring is practised.

Organic carbon and nutrient balance

There was slight improvement in organic carbon status even in conventional cropping of rice–wheat system (Fig 1). NPK balance sheet shows that nitrogen and phosphorus have the positive balance means that adding more nutrients than uptake, whereas potassium shows highly negative balance means applying less nutrients than total uptake of plants (Table 3). K balance was less negative where organic source of nutrient was applied in parts or full. Kumar and Yadav (2009) reported that long-term application of organic plus mineral fertilizer treatments decreased the soil *p*H, electrical conductivity and exchangeable sodium per cent at faster rates and depleted the micronutrients at slower rates as compared to sole application of inorganic fertilizers. Yadav *et al*. (2009) reported that continuous rice–wheat cropping had variable effects on soil fertility, depending on soil type, nutrient application and productivity levels. Integrated nutrient supply generally had beneficial effects on soil fertility.

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