



## Performance of basmati rice (*Oryza sativa*)-based cropping systems under different modes of nutrient management

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### ABSTRACT

Field experiments were carried out during 2006–08 to study the response of basmati rice (*Oryza sativa* L.)-based cropping systems to different modes of nutrient management. The system productivity was the highest with basmati rice–vegetable pea (*Pisum sativum* L.) (4.40 tonnes/ha) during 2006–07 and basmati rice–wheat (*Triticum aestivum* L. emend. Fiori & Paol.) (4.36 tonnes/ha) during 2007–08. These two cropping systems were significantly better than the basmati rice–lentil (*Lens esculenta* M.) and basmati rice–*Brassica napus* during each year of study. Comparison of different nutrient management showed that the grain yield of rice with inorganic nutrient management was significantly highest (3.55 tonnes/ha) in 2006–07, while in 2007–08 it was at par with organic nutrient management, the system productivity in terms of rice equivalent yield was also 37.0 and 5.0% higher with inorganic nutrient management over the organic nutrient management in 2006–07 and 2007–08, respectively. Soil organic carbon was 13.0% higher with organic nutrient management (0.907%) than the inorganic nutrient management (0.803%). Available potassium was also significantly higher with organic nutrient management after harvest of winter (*rabi*) season crops. However, available nitrogen and phosphorus were recorded significantly higher with integrated nutrient management at harvest of both rice and *rabi* crops. The available sulphur remained the highest with inorganic nutrient management during both the seasons. Improvement in soil organic carbon, available N, P, K and S was higher under basmati rice–lentil cropping system during the both seasons.

**Key words:** Cropping system, Fertility balance, Nutrient management, Rice, Rice equivalent yield

Rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L. emend. Fiori & Paol.) are the staple food crops of India. However, both being cereals are exhaustive in nature. Rapid spread of rice–wheat system in India, has caused an eclipse on sustainability and profitability of soil as well as crop productivity in long run. With growing concern about the human health, soil quality and environmental safety, need has been felt to rethink over the existing agricultural practices, especially the nutrient management. Further, in order to meet the foodgrain requirement of the population, sustainability of crop productivity at higher level, especially in developing countries like ours is the need of the hour. In this context, low external input sustainable agriculture largely focusing on agricultural practices such as green manuring, recycling crop residues and animal manure and inclusion of legumes in rotation are important (Paikaray *et al.* 2002). Thus there is need to diversify this system with high value input efficient crops (legumes and oilseeds) to make the system more

remunerative and sustainable. This prompted us to take up study on nutrient management under basmati rice-based cropping systems.

### MATERIALS AND METHODS

Field experiments were carried out in organic farming block at Breeder Seed Production Centre of the University at Pantnagar (29°N latitude, 79°29'E longitude and 243.8 m above mean sea level). Soil was silty clay loam. Chemical analysis of soil revealed that it was neutral in reaction (7.3), high in organic carbon (0.81%), medium in available phosphorus (20.60 kg/ha) and low in available nitrogen (254 kg/ha) and potassium (153 kg/ha). The experiment consisted of 4 basmati rice-based cropping systems [Basmati rice ('Pusa Basmati 1')–wheat ('PBW 343'), B. rice–lentil ('Pant-L 406') B. rice–vegetable pea ('Arkel') and B. rice–*Brassica napus* ('GSL 1')] under organic (organic NM), inorganic (inorganic NM) and integrated (INM) mode of nutrient management. Under organic mode, *Sesbania* green manure was grown before rice and subsequent *rabi* crops were grown with farmyard manure (20 tonnes/ha for wheat and *B. napus* and 10 tonnes/ha for lentil and vegetable pea). Under

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inorganic mode of nutrient management crops were fertilized with recommended dose of fertilizers as rice, wheat and *B. napus* (120:60:40 kg/ha N:P<sub>2</sub>O<sub>5</sub>:K<sub>2</sub>O) and lentil and vegetable pea (25:60:40 kg/ha N:P<sub>2</sub>O<sub>5</sub>:K<sub>2</sub>O), while for integrated nutrient management practice, the rice was taken with green manure plus half of recommended fertilizers and *rabi* crops with half of farmyard manure dose plus half of recommended fertilizers. Under inorganic mode N, P and K were supplied through urea, single superphosphate and muriate of potash, respectively. Experiment was conducted in strip-plot design with three horizontal strip treatments consisting organic, inorganic and integrated mode of nutrient management and four vertical strips have cropping system treatments. Fertility balance was calculated by subtracting the amount of nutrient taken up by the crop from the amount applied to the soil (Raghuwanshi *et al.* 1991). In organic plots, the pests were managed, using organic products only (pheromone traps and *Trichoderma* powder), while in inorganic and integrated NM, through inorganic products. All the crops were raised with recommended package of practices.

## RESULTS AND DISCUSSION

### Rice and rice equivalent yield

The grain yield of basmati rice (Table 1) due to nutrient management practices was affected significantly in 2006–07, during which the inorganic nutrient management recorded significantly the highest grain yield (3.55 tonnes/ha). Grain yield did not differ significantly between organic nutrient management (2.45 tonnes/ha) and integrated nutrient

Table 1 Rice and rice equivalent yield (tonnes/ha) under different cropping systems and nutrient management practices

Treatment	Rice			Total (Rice equivalent yield)		
	2006–07	2007–08	Mean	2006–07	2007–08	Mean
<i>Nutrient management practices</i>						
Organic NM	2.45	2.96	2.71	3.45	3.99	3.72
Inorganic NM	3.55	2.90	3.22	4.71	4.20	4.46
INM	2.85	2.87	2.86	3.98	4.06	4.02
SEm±	0.13	0.05		0.15	0.05	
CD (P=0.05)	0.54	NS		0.59	NS	
<i>Cropping systems</i>						
Basmati rice–wheat	2.95	2.84	2.90	4.35	4.36	4.35
Basmati rice–lentil	3.06	3.02	3.04	3.79	3.95	3.87
Basmati rice–veg.pea	2.86	2.83	2.84	4.40	4.30	4.35
Basmati rice– <i>B. napus</i>	2.92	2.94	2.93	3.64	3.72	3.68
SEm±	0.09	0.02		0.08	0.02	
CD (P=0.05)	NS	0.09		0.27	0.09	

management practice (2.85 tonnes/ha). In 2007–08, all nutrient management practices gave statistically at par grain yield from 2.87 tonnes/ha (integrated nutrient management) to 2.96 tonnes/ha (organic nutrient management). During this year, the insects damage, especially due to shoot borer in organic mode was relatively less as compared to inorganic and integrated nutrient management mode. Higher grain yield with inorganic mode might be due to better nutrient availability and less infestation of bacterial leaf blight. These findings are in accordance with Mankotia *et al.* (2008). The increased grain yield during second year of present investigation under organic mode (green manuring) indicates the nutrient build-up in the soil, as well as favourable effect on other soil properties. Among preceding crops in 2007–08, again the grain yield was significantly highest after lentil which was at par with *B. napus*, but significantly superior than vegetable pea and wheat. The grain yield of rice was maintained after all the *rabi* crops, barring wheat, after which it showed a declining trend. The legumes improve the physical and chemical properties of soil that favour the better growth and ultimately the yield of succeeding crop (Saha *et al.* 1999).

Rice-equivalent yield of cropping system was significantly higher with inorganic nutrient management (4.71 tonnes/ha) than the other nutrient management practices in 2006–07. All the winter crops gave higher rice equivalent yield (Table 2) under inorganic mode of nutrient management. The poor response of *rabi* crops under organic mode contrary to rice may be justified taking into account the climatic conditions of respective growing season. The mineralization of organic matter chiefly is a function of temperature, since during *rabi* season, the temperature remains low and so may be the nutrient release. This might have caused such variation. The rice equivalent yield of the whole system was the highest with inorganic mode of nutrient supply, however, significantly higher only in 2006–07. The higher rice equivalent yields of systems with inorganic mode are in accordance with the findings of Patra *et al.* (2000). The yield variation among nutrient management practices got narrowed during second

Table 2 Rice equivalent yield (tonnes/ha) of *rabi* crops under different nutrient management practices

Treatment	Organic NM		Inorganic NM		Integrated NM	
	2006–07	2007–08	2006–07	2007–08	2006–07	2007–08
Basmati rice–wheat	1.27	1.23	1.49	1.73	1.44	1.57
Basmati rice–lentil	0.67	0.82	0.76	1.03	0.75	0.95
Basmati rice–veg.pea	1.45	1.36	1.59	1.56	1.55	1.48
Basmati rice– <i>B. napus</i>	0.59	0.71	0.80	0.86	0.76	0.76

Table 3 Soil fertility status at the end (second year) of experiment under different cropping systems and nutrient management practices

Treatment	Organic carbon (%)		Nitrogen (kg/ha)		Phosphours (kg/ha)		Potasium (kg/ha)		Sulphur (kg/ha)	
	Rice	Rabi crops	Rice	Rabi crops	Rice	Rabi crops	Rice	Rabi crops	Rice	Rabi crops
<i>Nutrient management practices</i>										
Organic NM	0.876	0.907	260.9	264.3	23.67	26.12	156.4	163.3	25.40	26.69
Inorganic NM	0.796	0.803	252.9	254.7	23.85	26.36	154.9	156.0	27.20	28.30
INM	0.842	0.887	262.8	267.8	23.99	26.83	157.5	158.1	26.20	26.96
SEm±	0.011	0.012	0.96	1.69	0.49	0.97	1.10	1.26	0.61	0.31
CD (P=0.05)	0.043	0.048	3.77	6.62	NS	NS	NS	4.95	NS	1.24
<i>Cropping systems</i>										
Basmati rice-wheat	0.839	0.814	257.2	260.1	23.12	25.60	151.8	157.9	26.18	26.76
Basmati rice-lentil	0.857	0.923	260.4	268.6	24.49	27.76	160.1	164.0	27.11	28.93
Basmati rice-veg.pea	0.829	0.903	260.0	263.4	24.38	26.54	159.2	157.7	26.40	28.85
Basmati rice- <i>B. napus</i>	0.827	0.820	257.9	256.8	23.35	25.83	153.8	157.0	25.38	24.73
SEm±	0.008	0.014	1.27	1.52	0.62	0.61	1.26	1.12	0.57	0.69
CD (P=0.05)	NS	0.050	NS	5.27	NS	NS	4.34	3.86	NS	2.39

year which suggests the soil fertility build-up under organic and integrated modes of nutrient management.

#### Soil fertility

The soil organic carbon and available N were affected significantly due to nutrient management practices (Table 3). Organic mode of nutrient supply recorded significantly higher soil organic carbon, whereas available N, P and K were favoured by integrated nutrient management. The inorganic mode of nutrient management had the lowest values of these parameters. Due to preceding crops the available K was affected significantly (Table 3). All the soil fertility indicators were the highest in rotation with lentil. The lentil being a leguminous crop owing to its N-fixation capability and addition of root biomass (low C:N ratio) have caused such improvement.

At harvest of *rabi* crops, the soil organic carbon, available N, P, K and S were affected significantly due to nutrient management practices except, P (Table 3). Organic nutrient management recorded the highest organic carbon and available potash, while with integrated nutrient management the available N and P. However, the available sulphur was the highest with inorganic nutrient management. The reasons cited for such changes at rice harvest might also have been responsible for this trend. At harvest of *rabi* crops too, the highest values of soil organic carbon, available N, P, K and S were recorded with lentil, generally it was followed by vegetable pea. The beneficial effect of legumes on soil fertility are in conformity with Kumar and Kumaraswamy (2003) who also stated that inclusion of legumes in cropping system recorded the higher available potassium content.

#### Fertility balance

Except potassium with inorganic and integrated nutrient management a positive balance for the all the nutrients was

observed under different nutrient management practices (Table 4). Significantly highest nitrogen and phosphorus balance was observed due to integrated nutrient management after two years of the study. The nitrogen balance was significantly higher with organic nutrient management as compared to inorganic nutrient management. However, for phosphorus it observed *vice versa*. Relatively lower uptake under these treatments might have caused positive balance. The potassium balance was recorded significantly higher with organic nutrient management (111.13 kg/ha). The inorganic nutrient management and integrated nutrient management recorded negative balance. The lowest negative balance was recorded with basmati rice-*B. napus* cropping system (-34.56 kg/ha). The inorganic nutrient management recorded significantly highest balance of sulphur. Among cropping

Table 4 Fertility balance at the end of experiment under different cropping systems and nutrient management practices

Treatment	Nitrogen (kg/ha)	Phosphours (kg/ha)	Potassium (kg/ha)	Sulphur (kg/ha)
<i>Nutrient management practices</i>				
Organic NM	174.0	41.33	111.13	26.94
Inorganic NM	138.3	58.93	-357.90	151.04
INM	288.3	69.13	-0.31	99.87
SEm±	5.30	1.42	13.89	0.38
CD (P=0.05)	20.81	5.57	54.55	1.50
<i>Cropping systems</i>				
Basmati rice-wheat	221.5	62.13	-130.98	96.28
Basmati rice-lentil	124.8	43.41	-86.84	90.90
Basmati rice- veg.pea	167.2	62.22	-77.06	90.06
Basmati rice- <i>B. napus</i>	287.3	58.09	-34.56	93.23
SEm±	4.12	0.43	4.74	0.75
CD (P=0.05)	14.27	1.49	16.41	2.60

system it was significantly higher with basmati rice– wheat. The sulphur balance was recorded significantly higher with basmati rice– wheat cropping systems. Among cropping systems the *B. napus* with rice recorded significantly higher positive balance of nitrogen as compared to other crops. However, for phosphorus, a positive balance was found with vegetable pea.

Rice and *rabi* crops performed better under inorganic nutrient management however, soil quality was better with integrated and organic nutrient management, which is needed imparting sustainability to crop production.

#### REFERENCES

- Kumar S P S and Kumaraswamy K. 2003. Soil potassium as affected by long term application of fertilizers and cropping with rice on an alfisol. *Indian Agriculture* **47**(1&2): 121–4.
- Mankotia B S, Shekhar J, Thakur R C and Negi S C. 2008. Effect of organic and inorganic sources of nutrients on rice (*Oryza sativa*)- wheat (*Triticum aestivum*) cropping system. *Indian Journal of Agronomy* **53**(1): 32–6.
- Paikray R K, Mahapatra B S and Sharma G L. 2002. Effect of organic and inorganic sources of nitrogen on productivity and soil fertility under rice (*Oryza sativa*)-wheat (*Triticum aestivum*) crop sequence. *Indian Journal of Agricultural Sciences* **72**(8): 445–48.
- Patra A K, Nayak B C and Mishra M M. 2000. Integrated nutrient management in rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system. *Indian Journal of Agronomy* **45**(3): 453–7.
- Raghuwanshi R K S, Umat R, Nema M L and Dubey D D. 1991. Balance sheet of nitrogen, phosphorus and potash in soil as influenced by wheat (*Triticum eastivum*) based crop sequence. *Indian Journal of Agronomy* **33**(3): 322–5.
- Saha A K, Saha N and Pal S K. 2001. Influence of farmyard manure and fertilizer phosphorus on transformation of inorganic phosphates and its uptake by wheat. *Indian Agriculture* **44**(3&4): 185–91.