



Maximizing rice (*Oryza sativa*) and wheat (*Triticum aestivum*) productivity and profitability using improved nutrient management practices

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ABSTRACT

On farm trials were conducted for two year to evaluate the effect of soil test based site specific nutrient management (SSNM) *vis-a-vis* other farmers practice on rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.) productivity in villages of Ghaziabad (Uttar Pradesh) and Faridabad (Haryana). Results revealed that the SSNM led to significant increase in grain yield of rice and wheat crops in both the years as compared to the state recommended NPK fertilizer treatment and farmers practices. On an average, SSNM increased the grain yield of rice crop by 19.9% and 14.9% at Partapur and Badarpur said, respectively, over farmers practice. The corresponding increases in grain yield of wheat at Kumbhawas and Badarpur said were 13.9% and 15.4 %. The maximum net profits of ₹ 9 401/ha and ₹ 12 100/ha were obtained from rice under SSNM at Badarpur Said and Partapur, respectively. In wheat crop, the highest net profits of ₹ 6 346/ ha at Badarpur said and ₹ 4 346/ha at Kumbhawas were recorded under SSNM. The lowest yield and net profits from both the crops were obtained with farmers practices. The physicochemical properties (pH, EC and organic carbon) do not get deteriorated due to various nutrient management practices. Available major (NPK), secondary (S) and micronutrients (Zn and B) exhibited significant differences due to treatment variations. SSNM proved significantly superior in respect of buildup of these nutrients in soil.

Key words: Fertilizer practices, Productivity, Rice, Soil fertility, SSNM, Wheat

In India, the rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.) are dominant across the Indo-Gangetic plains and in the Himalayan foothills. Approximately 10.5 million ha land under these crops contributes about 25% of total food grain production in India. About 33% of India's rice and 42% of wheat is grown, consuming nearly 65% of the total fertilizers used in the country.

Rice and wheat crops have been reported to show the sign of productivity decline and major cause of this decline has been attributed to imbalanced use of plant nutrients which has adversely impacted the physico-chemical and biological properties of soils (Singh *et al.* 2012, Sharma *et al.* 2015). Development of appropriate nutrient management techniques is necessary to maintain the productivity of rice and wheat crops because the burgeoning population pressure puts up a challenge and great threat to food security of India.

Fertilizers played the pivotal role in boosting crop production. The loss of soil health due to imbalanced fertilizer use coupled with large mining of nutrients under intensive cropping system posed a threat to the sustainability of our farming system. Due to intensive cultivation the Indian soils

have become deficient in most of the macro and micro-nutrients; these have considerably decreased the productivity. After the harvest of rice and wheat, a negative balance of nutrients has been commonly observed presently application of secondary (S) and micronutrients (Zn, Fe and B) has become as essential as N and P. In view of the above mentioned facts, present investigation was undertaken to achieve attainable yield and profits from rice and wheat crops through improved nutrient management practices.

MATERIALS AND METHODS

The on farm multi-location trials at farmers' fields of NCR Delhi were conducted in three villages, viz. Partapur (Ghaziabad, UP), Badarpur Said (Faridabad, Haryana) and Kumbhawash (Gurgaon, Haryana), during 2010-11 and 2011-12 to evaluate the performance of the site specific nutrient management (SSNM) with other fertilizer practices used by the farmers for rice and wheat crops. The experimental soils sandy loam in texture having pH (7.20-8.60), EC (0.14-0.50 dS/m), organic carbon (1.7- 6.1 g/kg), available N (98-212 kg/ha), available P₂O₅ (39.0-98.5 kg/ha) available K (122-285 kg/ha), available S (10.7-23.7 kg/ha), DTPA- extractable Zn (0.78-2.4 mg/kg), Fe (4.96-9.20 mg/kg), Mn (4.44-9.60 mg/kg) and Cu (0.68-1.48 mg/kg) and available B (0.22-0.30 mg/kg).

Out of 16 experiments, eight experiments with wheat

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Table 1 Effect of different fertilizer options on rice yield (mean of two years)

Village	Treatment	Grain yield (tonnes/ha)		Response over FP (tonnes/ha)		% increase over FP
		Range	Mean	Range	Mean	
Partapur (4)*cv. PB-1121 (Sugandh 4)	FP	4.25-4.56	4.43			
	SR	4.55-4.90	4.73	0.20-0.40	0.30	6.77
	SSNM	5.04-5.52	5.31	0.70-1.00	0.85	19.9
Badarpur Said (4)*cv. PB-1121 (Sugandh 4)	FP	4.60-4.80	4.71			
	SR	4.90-5.34	5.11	0.25-0.50	0.36	8.49
	SSNM	5.22-5.65	5.41	0.50-0.85	0.69	14.9

*No. of experiments.

var. HD 2733 and HD 2967, and rest eight experiments with rice var. PB 1121 (Sugandh-4) were conducted with three fertilizer use practices, i.e. Farmer's practices (80 kg N + 58 kg P₂O₅/ha for rice and wheat crop), State fertilizer recommendations (100 kg N + 60 kg P₂O₅ + 40 kg K₂O + 10 kg Zn SO₄/ha for rice and 125 kg N + 62.5 kg P₂O₅ + 30 kg K₂O + 25 kg Zn SO₄/ha for wheat) and site specific nutrient management (SSNM) (120 kg N + 30 kg P₂O₅ + 40 kg K₂O + 25 kg Zn SO₄/ha for rice and 150 kg N + 62.5 kg P₂O₅ + 60 kg K₂O + 25 kg ZnSO₄ + 10 kg borax + 40 kg S/ha for wheat). Nutrient (Fertilizers) as per fertilizer practices/treatments was applied in each crop (Table 4). Sowing of wheat crop was done in the month of November and rice was transplanted in the month of July with recommended seed rate and cultural practices of each crop were followed as usually except fertilizers application. The test crops were harvested at maturity and data on grain yield were recorded. The post harvest soil samples were drawn from all the fields, and analyzed for pH, electrical conductivity (Jackson 1973), organic carbon (Walkley and Black 1934). Soil samples were also analyzed for available nitrogen (Subbiah and Asija 1956), available phosphorus (Olsen *et al.* 1954), available potassium (Hanway and Heidal 1952) and CaCl₂ extractable-S (Williams and Steinbergs 1959). The available micronutrients (Zn, Fe, Cu and Mn) in soil were extracted by DTPA (Lindsay and Norvell 1978) and determined on atomic absorption spectrophotometer. Hot water extractable boron was determined by colorimeter methods (Berger and Truog 1939). The economics of various treatments was computed on the basis of prevailing market price of inputs and produces.

RESULTS AND DISCUSSION

Yields

The fertilizer option for rice crop was evaluated at farmer's field in two villages. In both the villages rice yields were lowest under FP, which were on an average 4.43 tonnes/ha in Partapur and 4.71 tonnes/ha in Badarpur Said (Table 1). The use of fertilizers as per State Recommendation (SR) increased rice yield by 0.20 - 0.40 tonne/ha and 0.25 - 0.50 tonne/ha in these villages, respectively as compared to FP. The data (Table 1) indicated higher yield of rice with the application of soil based fertilizer under SSNM. The highest grain yield of rice (5.41 tonnes/ha) was recorded with SSNM

based fertilizer application in Badarpur Said. It showed the SSNM proved distinctly superior to other fertilizer options, i.e. FP and SR. Compared to FP, grain yields of rice under SSNM were higher by 0.70-1.00 tonne/ha (mean 0.85 tonne/ha) in Partapur and by 0.50 and 0.85 tonne/ha (mean 0.69 tonne/ha) in Badarpur Said. As per nutrient requirement of the crop under SSNM was balanced and it indicated that fertilizer dose for wheat requirement under SR and FP was not sufficient. Sharma and Singhal (2014) reported highest yield (55.1 q/ha) of rice along with higher profit per rupee spent on fertilizer (4.5) under soil test based fertilizer recommendation for targeted yield as compared to general fertilizer recommendation and farmers practices.

Averaged across field trials, wheat grain yield in Kumbhawas village was lowest under farmers practice (FP), which was increased by 0.58 - 0.81 tonne/ha (mean 0.72 tonne/ha) with SSNM treatment (Table 2). The use of fertilizer as per state recommendation (SR) increased wheat yield by 0.29 - 0.54 tonnes/ha (mean 0.41 tonne/ha) and 0.28 - 0.40 tonne/ha (mean 0.33 tonnes/ha) in Kumbhawas and Badarpur said villages, respectively as compared to farmers practice (FP). It showed that SSNM proved distinctly better option (Gupta *et al.* 2009, Hada *et al.* 2013). Thus field trials revealed the possibility of enhancing the productivity of agricultural land by adopting soil test based SSNM. Among wheat varieties, the highest grain yield of wheat cv. HD 2967 (6.34 to 6.42 tonnes/ha) was recorded with SSNM based fertilizer application, which was comparatively higher than wheat variety cv. 2733 (5.63 to 5.81 tonnes/ha) in Badarpur Said village. These yield differences in both wheat varieties may be due to genetic character or potential yield of wheat varieties. In general, the SSNM treatments at all farmers' field produced higher grain yields of rice and wheat as compared to state recommendation and farmers practice. Therefore balanced dose of fertilizers as per requirement on the basis of soil test based fertilizer should be applied. It was evident from the data (Table 1 and 2) that the use of nutrients based on soil test in rice increased the grain yield by 12.6 and 5.0% at Partapur and Badarpur Said respectively over state fertilizer recommendation. Similarly in wheat, yield was increased by 5.6, 7.1 and 9.6% in Kumbhawas (wheat cv. 2733), Badarpur Said (wheat cv. 2733) and Badarpur Said (wheat cv. 2967) over state fertilizer recommendation, similar results were reported by Pathak (2014) in rice.

Table 2 Effect of different fertilizer options on wheat yield (mean of two years)

Village	Treatment	Grain yield (tonnes/ha)		Response over FP (tonnes/ha)		% increase over FP
		Range	Mean	Range	Mean	
Kumbhawas (4)* cv. HD 2733	FP	4.91-5.33	5.15			
	SR	5.45-5.62	5.56	0.29-0.54	0.41	8.0
	SSNM	5.72-6.03	5.87	0.58-0.81	0.72	13.9
Badarpur Said (2)* cv. HD 2733	FP	4.91-5.03	4.97			
	SR	5.24-5.43	5.34	0.33-0.40	0.37	7.44
	SSNM	5.63-5.81	5.72	0.72-0.78	0.75	15.1
Badarpur Said (2)* cv. HD 2967	FP	5.44-5.62	5.53			
	SR	5.72-5.91	5.82	0.28-0.29	0.29	5.2
	SSNM	6.34-6.42	6.38	0.80-0.90	0.85	15.4

*No. of experiments.

Economics

Data (Table 3) indicated that maximum gross returns of ₹ 81 150.0/ha and ₹ 70 180.0/ha were obtained from rice and wheat with soil test based SSNM in Badarpur Said, respectively. On the other hand, minimum gross returns of ₹ 66 450.0/ha in rice and ₹ 54 670.0/ha in wheat were obtained with farmer practice. The maximum net profit of ₹ 12 100.0/ha in rice and ₹ 6 346.0/ha in wheat was obtained with soil test based SSNM fertilizer practice in Partapur and Badarpur Said, respectively, over farmers practice. The fertilizer practice SSNM in Kumbhawas and Badarpur Said (wheat cv. 2733) fetched the net profit of ₹ 4 916.0/ha and ₹ 5 246.0/ha, respectively.

Table 3 Average yield and economics of fertilizer of the different fertilizer practices (mean of two year)

Villages	Fertilizer practices	Average grain yield (t/ha)*	Gross income (₹/ha)	Cost of fertilizer	Net profit over FP(₹/ha)
<i>Rice crop</i>					
Partapur (4)	FP	4.43	66450	2236	
	SR	4.73	70950	3230	3506
	SSNM	5.31	79650	3335	12100
Badarpur Said (4)	FP	4.71	70650	2236	
	SR	5.11	76650	3230	5006
	SSNM	5.41	81150	3335	9401
<i>Wheat crop</i>					
Kumbhawas (4)	FP	5.15	56650	2236	
	SR	5.56	61160	4020	2726
	SSNM	5.87	64570	5240	4916
Badarpur Said (2) cv. HD 2733	FP	4.97	54670	2236	
	SR	5.34	58740	4020	2286
	SSNM	5.72	62920	5240	5246
Badarpur Said (2) cv. HD 2967	FP	5.53	60830	2236	
	SR	5.82	64020	4020	1406
	SSNM	6.38	70180	5240	6346

*Average of experiments. Price taken for calculation: Rice seed rate ₹ 15 000/t, Wheat seed rate ₹ 11 000/t. Fertilizer cost: N @ ₹ 12/kg, P₂O₅ @ ₹ 22/kg, K₂O @ ₹ 9/kg, S @ ₹ 17/kg, Zn @ ₹ 35/kg B @ ₹ 25/kg.

It may be due higher grain yield of wheat with this fertilizer practice. The minimum net profit of ₹ 3 506.0/ha in rice and ₹ 1 406.0/ha in wheat was obtained with state fertilizer recommendation (Gupta *et al.* 2009).

Soil fertility

There was no marked difference in soil pH due to various nutrient management practices. There was also no marked difference in soluble salt content (EC) in the soil due to various treatments. It can be inferred that soil chemical properties do not get deteriorated by nutrient management practices (Table 4). Use of different nutrient management practices did not cause any marked change in the organic carbon (SOC) content. However the maximum amount of soil organic carbon in post harvest soil was noted with SSNM at all the experimental soils.

Available nitrogen content exhibited marked differences at all the experimental sites of the both the crops due to various nutrient management practices. The highest available nitrogen contents were obtained under SSNM followed by state recommendation (SR) and farmers practice (FP). The lowest available nitrogen content was recorded in FP. Available Phosphorus status recorded significant variation due to treatment variations (Table 4). Highest available P content of 44.0 kg/ha was recorded in SSNM treatment at Badarpur Said site. Treatment SSNM was followed by SR and FP in that sequence. The lowest available P content of 17.4 kg/ha was observed under FP at Kumbhawas site. Application of SSNM showed marked higher available potassium status. The lowest available potassium was recorded in FP treatment at Kumbhawas site. Available S content was not affected by variations in the treatments. Lowest and highest contents of DTPA-Zn in post harvest soil were recorded under FP and SSNM, respectively. This increase in available Zn in post harvest soil may be attributed to increase amount of applied Zn to the soil. Available Fe content in post harvest soil was not affected markedly by various nutrient management practices. However status of available Fe was higher under SSNM. The status of Mn and Cu in post harvest soil did not vary markedly with various nutrient management practices. The soil samples collected

Table 4 Fertility status of post harvest soil under different fertilizer practices (mean of all experimental site)

Fertilizer practices	pH	EC (dS/m)	OC (g/kg)	Available nutrients (kg/ha)				Available micro-nutrients (mg/kg)				
				N	P	K	S	Zn	Cu	Mn	Fe	B
<i>Rice (Partapur village)</i>												
FP	8.32	0.20	3.9	205	29.5	185	17.5	0.75	0.45	4.45	5.20	0.18
SR	8.39	0.21	4.1	218	35.0	192	18.9	0.79	0.46	4.60	5.80	0.19
SSNM	8.40	0.20	4.3	230	41.0	203	20.6	0.86	0.48	4.75	6.15	0.18
<i>Rice (Badarpur Said village)</i>												
FP	7.70	0.29	4.1	190	32.0	170	18.0	0.65	0.39	5.70	5.60	0.20
SR	7.69	0.31	4.5	205	37.5	182	20.0	0.78	0.41	5.90	5.90	0.20
SSNM	7.72	0.31	5.0	222	44.0	200	20.0	0.74	0.42	6.00	6.15	0.22
<i>Wheat (Badarpur Said village)</i>												
FP	7.90	0.29	4.3	155	33.5	145	14.7	0.80	0.62	6.20	7.40	0.24
SR	7.93	0.30	4.4	175	38.0	170	16.8	0.91	0.65	6.30	7.50	0.26
SSNM	7.95	0.33	4.9	190	40.3	189	19.0	1.02	0.64	6.31	7.52	0.28
<i>Wheat (Kumbhawas village)</i>												
FP	7.20	0.14	3.1	150	17.4	112	18.0	0.78	0.82	4.14	4.96	0.22
SR	7.22	0.15	3.5	165	21.0	135	20.0	1.00	0.80	4.27	5.10	0.24
SSNM	7.21	0.15	3.9	180	26.4	150	24.0	1.15	0.81	4.40	5.17	0.26

after harvest of wheat contained relatively higher amounts of sulphur and boron as both these elements were applied in wheat crop.

Based on the results of on farm trials, it may be concluded that site-specific nutrient management (SSNM) increased the grain yield and net profits from the rice and wheat as compared to the state recommendation of fertilizers. Variability introduced due to treatments was reflected in the available nutrient status of the post harvest soil. Higher yield of rice and wheat with SSNM approach over SR and FP clearly indicated that the site and crop specific balanced fertilizer in addition to maintain food security will also help in sustaining soil and environment health due to improved nutrient use efficiency.

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