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Productivity and profitability of basmati rice (*Oryza sativa*) at farmer's field under optimal nutrient management practices

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ABSTRACT

On farm trials at farmers' field were conducted for two years (2015-17) to evaluate different fertilizer management options *vis-a-vis* farmers practice on Basmati rice (*Oryza sativa* L) (cv. PB-1121) productivity and economics in Rajpura village of Aligarh, UP at two sites having two trials each with distinct soil properties. Results revealed that maximum pooled yield of basmati rice under targeted yield based fertilizer recommendation (TY_{50}) was 4.78 and 4.81 t/ha higher by 33% at site –I and 40% at site-II over farmer practice (FP). From the results, it can be inferred that, around 30-40% basmati rice yield could be increased with targeted yield based fertilizer recommendation. Moreover, the net profits at site-I & II were ₹23486/ha and ₹30905/ha, respectively higher with targeted yield based fertilizer recommendation (TY_{50}), over farmer's practices (FP). The significant improvement in available nitrogen, phosphorus and potassium was noticed at both sites under targeted yield based fertilizer recommendation in post-harvest soil after two years of trials. The soil microbial biomass carbon and dehydrogenase activity of soil were also enhanced under targeted yield based fertilizer management (TY_{50}) as compared to other fertilizer options studied.

Key words: Basmati rice, Fertilizer management options, Net profit, Soil biological properties Soil fertility

In India, rice (*Oryza sativa* L.) is one of the most important staple food crops in terms of area, production as well as consumer preference. India is the second largest producer and consumer of rice in the world, it covers an area of 43.7 million ha (mha) with production of 112.9 million tonnes (mt) during 2017-18 (GOI 2018). Among different varieties of rice grown throughout the globe, Basmati is one of the unique specialty rice varieties from the Indian subcontinent. These are highly prized in the international market for its unique grain, cooking and eating quality. In India, basmati rice is primarily grown in the Indo-Gangetic region of north-western region, which is earmarked as the Geographical Indication (GI) for basmati rice by Government of India in 2016. The total basmati rice produced during *kharif* 2016 was 6.16 mt and only variety of basmati rice PB-1121 contributed 4.39 mt (~68%) (Singh *et al.* 2018). But, continued use of imbalanced fertilizers over the years in paddy field without application of potassium and/or disproportionate application of nutrients, *i.e.* without taking the consideration of nutrients demands of crops based upon soil nutrient status and yield target, have resulted decline in productivity as well as quality of produce accompanied with deterioration of fertility status of soil.

Development of appropriate nutrient management techniques is necessary to maintain the productivity of 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 micronutrients; these have considerably decreased the productivity. After the harvest of rice and wheat, a negative balance of nutrients has been commonly observed. Presently applications of secondary (S) and micronutrients (Zn, Fe and B) have become as essential as N and P. Therefore, appropriate and target yield based fertilizer management is urgently required to enhance the productivity of Basmati rice because the mounting population pressure puts up a challenge and great threat to food security of India. In view of the above mentioned facts, present investigation was undertaken to achieve

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attainable yield and profits from rice crop through improved fertilizer management options.

MATERIALS AND METHODS

Farmers' participatory field trials were established at two sites having two trials each in Rajpura village of Aligarh district of Uttar Pradesh, which comes under Indo-Gangetic plain of India. The experiments were conducted on basmati rice (var. PB-1121) with four treatments, i.e. control, farmers' practice (FP), recommended dose of fertilizer (RDF) and targeted yield based fertilizer recommendation (TY_{50}) and data was collected from three points in each treatment. The climate of experiment sites is semi-arid, with annual rainfall about 1000 mm, rice and pearl millet based cropping systems are most prevalent in the area. The experimental soils are sandy loam in texture having pH 7.84 - 8.72, EC 0.24 - 0.28 dS/m, organic carbon 2.2- 5.5 g/kg, available N 139-188 kg/ha, available $P_2O_5$19.5-73.8 kg/ha available K 116-446 kg/ha, available S 7.90-12.80 kg/ha, DTPA- extractable Zn 0.75-1.32 mg/kg, Fe 5.44-8.21 mg/kg, Mn 2.52- 4.67 mg/kg, Cu 0.72-1.24 mg/kg and available B 0.45-0.68 mg/kg. The urea, diammonium phosphate (DAP) and muriate of potash (MOP) were used to supply of N, P and K nutrients, respectively. The micronutrients were not applied to the trials, as the concentration of these elements was adequate. Nutrient doses for different treatments of rice were 80 kg N + 58 kg P_2O_5/ha for Farmer's practices (FP), 120 kg N + 60 kg P_2O_5 + 40 kg K_2O/ha for state fertilizer recommendations (GR) and, 168 kg N + 35 kg P_2O_5 + 80 kg K_2O/ha at site-1 and 176 kg N + 0 kg P_2O_5 + 56 kg K_2O/ha at site-II for targeted yield based fertilizer application (TY_{50}) (average of two trials at each sites).The amount of fertilizer/nutrients for targeted yield of rice 5.0 tonnes/ha were calculated by using equations of fertilizer prescription developed by Division of Soil Science and Agricultural Chemistry, ICAR-IARI, New Delhi.

Nutrients as per fertilizer options were applied in rice crop in which full dose of P & K as basal and N in three split doses after transplanting of rice. Seedling of rice was transplanted in the 1^{st} fortnight of July and crop grown with recommended cultural practices. The test crops were harvested at maturity, i.e. second week of November in the both the year and data on grain yield were recorded as per standard procedure. The post-harvest soil samples were collected from experimental trials (treated plots), 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 $CaCl_2$ extractable-S (Williams and Steinbergs 1959). The available micronutrients (Zn, Fe, Cu and Mn) in soil were extracted by DTPA method (Lindsay and Norvell 1978) and determined on atomic absorption spectrophotometer. Hot water extractable boron was determined by colorimeter methods (Berger and Truog 1939). Dehydrogenase activity (DHA) was determined using the reduction of 2, 3, 5-triphenyltetrazolium chloride (3%) method (Klein *et al.* 1971), soil microbial biomass carbon (SMBC) was estimated through chloroform fumigation method (Vance *et al.* 1987). The economics of various treatments was computed on the basis of prevailing market price of inputs (fertilizers) and produces (rice grain). The fertilizer response rate was calculated as grain production/amount of applied nutrients.

RESULTS AND DISCUSSION

Yields

Experimental data revealed that, the grain yield of rice ranged 2.42 - 4.88 t/ha at site-I and 2.62 - 4.91 t/ha at site-II during 2015-16 (Table 1). Similarly, it ranged from 2.52 - 4.91 t/ha and 2.82 - 4.88 t/ha at site I & II respectively, during 2016-17. In both the sites, lowest averaged rice yield was recorded under control (2.62 t/ha) in site-I and 2.79 t/ha in site-II in year 2015-16. Under farmers' practice 3.28 – 3.67 t/ha rice yield was obtained during both the cropping season, where they generally used only urea and DAP as nutrient supply option and neglect MOP application in rice. The maximum pooled yield of rice under targeted yield approach (TY_{50}) was 4.78 & 4.81 t/ha at site I & II,

Table 1 Effect of different fertilizer management practices on rice yield and fertilizer response (two years data)

	Treatment	Yield (t/ha)					Yield response over control (t/ha)	Increase over control (%)	Increase over FP (%)	Fertilizers response rate (kg grain/kg nutrient)
		2015-16		2016-17		Pooled				
		Range	Mean	Range	Mean					
Site I	Control	2.42-2.82	2.62	2.52-2.64	2.58	2.60	--	--	--	--
	FP	3.54-3.67	3.61	3.64-3.49	3.57	3.59	0.99	37.9	--	7.14
	RDF	3.94-4.12	4.03	3.93-4.03	4.01	4.02	1.42	54.6	12.1	6.45
	TY_{50}	4.78-4.88	4.83	4.54-4.91	4.73	4.78	2.18	83.8	33.3	7.12
Site II	Control	2.62-2.95	2.79	2.82-2.92	2.87	2.83	--	--	--	--
	FP	3.28-3.51	3.40	3.43-3.51	3.47	3.43	0.60	21.3	--	4.38
	RDF	4.22-4.34	4.28	4.26-4.42	4.34	4.31	1.48	52.3	25.6	6.74
	TY_{50}	4.65-4.91	4.78	4.81-4.88	4.85	4.81	1.98	70.1	40.2	8.45

respectively and it increased by 84% and 70% over control and by 33% at site –I and 40% at site-II over FP. Increased yield of rice under TY_{50} may be due to balanced used of fertilizer based on soil test under targeted yield approach (STCR). Maximum yield response of fertilizer was recorded 2.18 and 1.98 t/ha under TY_{50} in site-I and Site-II, respectively over control, while it was minimum, i.e. 0.99 t/ha in site-I and 0.60 t/ha in site-II with farmer practices (FP). However, recommended fertilizer application (RDF) increased rice yield by 0.43 and 0.88 tonne/ha at site I & II, respectively over FP. The state fertilizer recommendation gave similar response in term of yield (1.42 and 1.48 t/ha at site-I& II, respectively) at both the experimental sites. From these results, it can be inferred that, around 30-40% rice yield could be increased with targeted yield approach (TY_{50}). Moreover, highest fertilizer response rate in rice was recorded in FP treatments (7.14 kg grain/kg nutrients) at site-I, which was similar to TY_{50} treatment (7.12 kg grain/kg nutrient), this may be due to higher application of nitrogen and phosphatic fertilizers (urea & DAP) as per requirement of crop and very low available N & P status in soil. Whereas, the fertilizer response rate at site-II was highest (8.45 kg grain/kg nutrient) in TY_{50} treatment and lowest (4.38 kg grain/kg nutrient) in FP treatment. This might be because of balanced use of fertilizer based on soil test.

Economics

The maximum gross returns of ₹ 109830/ha and ₹ 110720/ha with targeted yield based fertilizer recommendation (TY_{50}) treatment was obtained from rice at site I and II respectively. Whereas minimum gross return were ₹ 59780/ha and ₹ 65075/ha in site-I and site-II, respectively under control treatments (Table 2). Highest net profit from rice crop at both sites was recorded (₹ 42447 and ₹ 41122/ha) under targeted yield (TY_{50}) followed by recommended dose of fertilizer (RDF) ₹ 272812 (site-1) and ₹ 28697 (site-II), while farmers practices (FP) recorded minimum net profit (₹ 10216 to ₹ 18961). This may be due to unbalanced used of fertilizers, which gave low yield as well as rationally high cost of fertilizers. It could be inferred that the net income of farmers in rice growing area is about 2-3 times higher by adoption of targeted yield based fertilizer recommendation (TY_{50}). The net profit at site-I & II was recorded ₹ 23486/ha and ₹ 30905/ha respectively with targeted yield approach fertilizer management, over farmer's practices.

Fertility status

There was no marked difference in soil pH due to various nutrient management practices and recorded in the range of 8.78- 8.95 at site-I and 8.40-8.59 at site-II. No significant change was observed in soluble salt content (EC)

Table 2 Economics of different fertilizer management practices (means of two year)

	Treatment	Average grain yield (t/ha)	Gross income (₹/ha)	Extra income over control (₹/ha)	Cost of fertilizers (₹/ha)	Net profit over control (₹/ha)
Site I	Control	2.58	59780	--	---	--
	FP	3.57	82435	22655	3694.0	18961
	RDF	4.01	92450	32670	5388.4	27282
	TY_{50}	4.73	109830	50050	7603.1	42447
Site II	Control	2.87	65075			
	FP	3.47	78985	13910	3694.0	10216
	RDF	4.34	99160	34085	5388.4	28697
	TY_{50}	4.85	110720	45645	4523.5	41122

Table 3 Fertility status of post-harvest soil of rice under different fertilizer practices (after two year)

	Treatment	pH	EC	OC	Available macronutrients (kg/ha)				Available micronutrients (ppm)				
					N	P	K	S	Zn	Cu	Fe	Mn	B
Site I	Control	8.80	0.25	0.36	183	12.6	276	23.4	0.35	1.90	15.2	1.54	0.70
	FP	8.78	0.25	0.36	189	14.5	282	23.0	0.36	1.99	15.9	1.63	0.71
	RDF	8.95	0.24	0.37	195	16.4	298	24.2	0.38	2.02	16.4	1.61	0.72
	TY_{50}	8.87	0.25	0.37	206	17.2	312	23.9	0.39	2.12	17.3	1.65	0.78
	LSD(5%)	NS	NS	NS	6	0.6	18	NS	NS	NS	NS	NS	NS
Site II	Control	8.40	0.17	0.35	225	27.3	163	22.4	0.48	0.75	7.45	0.95	0.68
	FP	8.50	0.19	0.35	235	28.9	174	21.1	0.46	0.79	7.22	0.96	0.71
	RDF	8.54	0.20	0.36	244	32.4	183	21.8	0.48	0.81	7.48	0.99	0.72
	TY_{50}	8.59	0.21	0.36	252	36.3	191	20.8	0.51	0.82	7.63	1.05	0.75
	LSD(5%)	NS	NS	NS	7	1.5	12	NS	NS	NS	NS	NS	NS

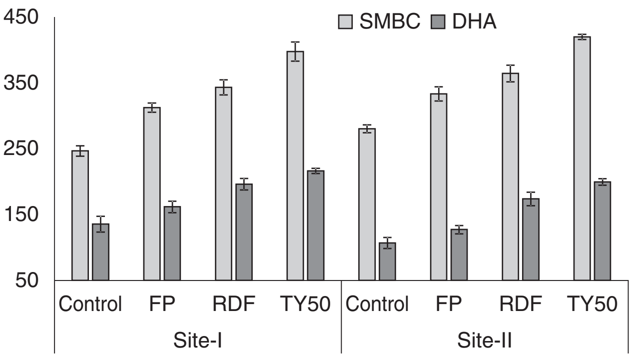

Fig 1 Soil microbial biomass carbon (SMBC) (mg C/kg soil) and dehydrogenase activities (µg TPFg/soil/24 hr) of post-harvest soil of rice at farmers' field under different fertilizer management options.

in the soil. Use of different nutrient management practices did not cause any marked change in the organic carbon (SOC) content. However, the organic carbon content at both sites ranged from 0.36-0.37% & 0.35-0.36%, respectively. It can be inferred the soil chemical properties do not change by nutrient management practices (Table 3). Available nitrogen content exhibited marked differences at all the experimental sites due to various nutrient management options. The average highest available nitrogen content at site-I was recorded under targeted yield approach (206 kg/ha) followed by RDF (195 kg/ha) and farmers' practice (FP) (189 kg/ha), the lowest available nitrogen content was recorded in control (183 kg/ha). However, at site –II it ranged between 225 (control) and 252 kg/ha (TY_{50}). The significant enhancement in available nitrogen was noticed at both sites with fertilizer management options. Available P status of post-harvest soil recorded significant variation due to treatments (Table 3). Significant highest available P content of 17.2 kg/ha was recorded in targeted yield approach treatment at site-I while it was 36.3 kg/ha at site–II.Treatment TY_{50} was followed by RDF and FP in that sequence at both the sites. The lowest available P content of 12.6 kg/ha was observed under control at site-I and it was 27.3 kg/ha at site-II. Application of targeted yield based fertilizers option (TY_{50}) showed buildup of available potassium content in post-harvest soil. Available K ranged from 276-312 kg/ha and 163-191 kg/ha at site-I & II, respectively. Available S content was not significantly affected by different fertilizer options. DTP extractable micronutrients such as Zn, Cu, Fe and Mn were not significantly changed due to different fertilizer managements options in post-harvest soil. Highest Zn, Cu, Fe and Mn were recorded in targeted yield approach fertilizer management, while lowest was in the control treatment in both site of trials (Table 3). Hot water extractable boron in post-harvest soil ranged from 0.70-0.78 mg/kg and 0.68-0.75 mg/kg at studied site-1 and II, respectively. Soil microbial biomass indicates soil biological processes, including organic matter degradation, mineralization and nutrient recycling. Results indicated that, soil microbial biomass carbon (SMBC) in post-harvest soil ranged from 246 to 397 mg C/kg dry soil at site-1, while it ranged from 280 to 419 mg C/kg dry soil at site-II (Fig 1). After two year of trials, application of fertilizer under targeted yield approach increased SMBC by 61 and 49% over control at site I and II respectively, however it was 27 and 25% over FP treatments at site I and II respectively. This increase may be attributed to increase in microbial population due to optimum ratio of nutrients supply, which provide ambient condition for enhancing the microbial population and/or microbial biomass of soil. The SMBC and DHA were highest in targeted yield based fertilizer management and lowest in control at both sites of the study. The DHA of site-I ranged from 106 to 199 µg TPF/gsoil/24 hr, while it was ranged from 131 to 216 µg TPF/gsoil/24 hr at site-II. DHA of targeted yield approach (TY_{50}) increased over FP by 61 and 49% at site-I and II, respectively, while the increment over control was 56 and 34% at site I and II respectively, while the increment was only 15 and 10% over RDF treatment at site I and II respectively. Our finding is in the line of other studies which showed that application of targeted yield based fertilizer increased SMBC and DHA under barley crop of site specific nutrient management (Sharma *et al.* 2016; Kumar *et al.* 2018).

From the study, it can be concluded that targeted yield based fertilizer application increased the grain yield and net profits from the basmati rice as compared to the state recommendation of fertilizers. Besides, with such fertilizer management, soil fertility status and microbial activity also improved with the adoption of targeted yield based fertilizer application in basmati rice. Hence, higher yield as well as net profit of basmati rice with targeted yield based fertilizer option over other fertilizer management options, clearly indicated that the urgent need of balanced fertilizer application is required is required to achieve doubling farmer's income and food security.

REFERENCES

Berger K C and Truog E. 1939. Boron determination in soils and plants. *Industrial & Engineering Chemistry Analytical Edition* **11:** 540–544.

GOI. 2019.Pocket book of agricultural statistics. Department of Agriculture, Cooperation & Farmers Welfare, Government of India, New Delhi, pp 1-135.

Hanway J J and Heidal H. 1952. Soil analysis methods as used in Iowa State College. *Agriculture Bulletin* **57**: 1–13.

Jackson M L. 1973. *Soil Chemical Analysis.* Prentice Hall of India Pvt Ltd, New Delhi.

Klein D A, Loh T C and Goulding R L. 1971. A rapid procedure to evaluate dehydrogenase activity of soils low in organic matter. *Soil Biology and Biochemistry* **3:** 385-387.

Kumar S, Sharma A, Sharma V K, Rosin K G and Kumar D. 2018. Enhancement of apple (*Malus domestica*) productivity and soil health through organic fertilization and bio-inoculants under north-western Himalayan region of India. *Indian Journal of Agricultural Sciences* **88**(9): 1463-1468

Lindsay W I and Norvell W A. 1978. Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal* **42**: 421–48.

Olsen S R, Cole C V, Watanabe F S and Dean L A. 1954. Estimation of available phosphorous in soils by extraction with sodium bicarbonate. Circular US Departmant of Agriculture, Washington DC.

Sharma V K, Pandey R N, Kumar S, Chobhe K A and Chandra S. 2016. Soil test crop response based fertilizer recommendations under integrated nutrient management for higher productivity of pearl millet (*Pennisetum glaucum*) and wheat (*Triticum aestivum*) under long term experiment. *Indian Journal of Agricultural Sciences* **86** (8): 1016–23.

Singh V, Singh A K, Mohapatra T, Krishnan G and Ellur R K. 2018. Pusa Basmati 1121 – a rice variety with exceptional kernel elongation and volume expansion after cooking. *Rice* **11**:19.

Subbiah B V and Asija G L. 1956. A rapid procedure for the available nitrogen in soils. *Current Science* **25:** 259–60.

Vance E D, Brookes P C and Jenkinson D S. 1987. An extraction method for measuring soil microbial biomass carbon. *Soil Biology and Biochemistry* **19:** 703–707.