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Pankaj Singh
Asstt Professor, Soil Science, RPCAU, Pusa, Bihar, India

Sanjay Tiwari
Assoc Professor, Soil Science, RPCAU, Pusa, Bihar, India

Sanjay Kr Singh
Asstt Professor, Soil Science, TCA, Dholi, RPCAU, Pusa, Bihar, India

Rajesh Kr Pal
MSc Ag Scholar, Soil Science, RPCAU, Pusa, Bihar, India

Correspondence
Pankaj Singh
Asstt Professor, Soil Science, RPCAU, Pusa, Bihar, India

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Sustainable rice production with nutrient expert as a tool for site specific nutrient management

Pankaj Singh, Sanjay Tiwari, Sanjay Kr Singh and Rajesh Kr Pal

Abstract
To overcome the bottleneck of conventional blanket fertilizer recommendation there is need of site specific knowledge of crop nutrient requirements, indigenous nutrient supply, and recovery efficiency of applied fertilizer which emphasizes 'feeding' rice with nutrients as and when needed so as to enable the farmers to fill up the gap between the nutrient needs of a high yielding crop and the nutrient supply occurring from indigenous sources such as crop residue and manures. The SSNM approach was evaluated during kharif 2017 at RPCAU, Pusa, Bihar with Nutrient Expert (NE) software, a computer based decision tool for rapidly providing recommendation to farmers in presence or absence of soil testing data. The treatments were replicated thrice and arranged in randomized block design. The treatments included - Recommended fertilizer dose (T1); SSNM based on nutrient expert (T2); SSNM based on LCC/Green Seeker (50% Nitrogen as basal and rest 50% based on LCC or Green Seeker(T3); T2 minus N (T4); T2 minus P (T5); T2 minus K (T6) and Absolute control without NPK (T7). The experimental soil was calcareous in nature with pH - 8.4, organic carbon - 0.6%, available N- 192.5 kg ha^{-1}, available-P_2O_5 31.2 kg ha^{-1}, available- K_2O 202.8 kg ha^{-1} and DTPA- Zn 0.41 $mgkg^{-1}$.The results indicated that, nutrient expert treatment recorded significantly higher grain yields (5.3 t ha^{-1}) as compared to recommended fertilizer (4.9 t ha^{-1}). The panicles m^{-2} and 000'grain weight were significant and both, nutrient expert and agronomic recommendation were at par to each other. Significantly higher nutrient uptake was recorded under nutrient expert and similarly, the availability of nitrogen and potassium in post-harvest soil was significantly higher under nutrient expert as compared to all other treatments. Therefore, fertilizer recommendations based on soil supply potentials *i.e.*, site specific nutrient management (SSNM) through the use of nutrient expert helped in realizing better yields.

Keywords: rice production, specific nutrient management

Introduction

Rice is the most important food crop of India and contributes nearly 41% to the total food grain production. Rice is grown under diverse agro-ecological conditions, in a variety of soils ranking first in the use of land at > 43 million (M) ha, water resources (> 50% irrigation water), and inputs (38 to 40% of fertilizers and 17 to 18% of pesticides) among the cultivated crops in India. Projections compiled by the Directorate of Rice Research (2011) showed the demand for rice is expected to rise between 107 to 156 Million tonne by 2030 over the current production of 43 Million tonne (FAI, 2014). Future gains in rice yield will be largely driven by knowledge intensive crop and soil management as compared to the germplasm driven yield gains.

The conventional blanket fertilizer recommendation causes loss of valuable inputs due to imbalanced use of fertilizers and low fertilizer use efficiency. To overcome this bottleneck there is need of site specific knowledge of crop nutrient requirements, indigenous nutrient supply, and recovery efficiency of applied fertilizer. The site specific nutrient management (SSNM) approach emphasizes 'feeding' rice with nutrients as and when needed and to enable the farmers to fill up the gap between the nutrient needs of a high yielding crop and the nutrient supply occurring from indigenous sources such as amendments, crop residue and manures. The SSNM approach aims to specifically apply nutrients at optimal rates and times to achieve high nutrient use efficiency for better yields in rice crop leading to higher returns per unit of input invested. Adynamic nutrient management tool, the Nutrient Expert® (NE) for rice (India), can generate farm specific fertilizer recommendation for rice. The tool is based on the site-specific nutrient management (SSNM) principles (Pampolino *et al.*, 2012) [6] and utilizes information of the growing environment to provide balanced fertilizer recommendations for rice that are tailored for a particular location, cropping system, rice ecology, season, and farmer resource availability.

Materials and Methods

Field experiment was conducted at the agricultural farm of RPCAU, Pusa during kharif season of 2017. The experimental soil was sandy loam in texture, slightly alkaline with pH 8.5, organic carbon 6.1 g kg^{-1}, available N - 195.1 kg ha^{-1}, available P_2O_5- 31.2 kg ha^{-1} and available - K_2O 199.8 kg ha^{-1}. The experimental treatments constructed with three replications arranged in a randomized block design. The absolute control treatment was totally free from the application of N, P and K. The land was prepared 20 days before transplanting of rice seedlings. All the treatments were applied at the time of transplanting. The RDF treatment was N - 120 kg ha^{-1}, P_2O_5– 60kg ha^{-1}, K_2O- 40kg $ha^{-1}$and $ZnSO_4$- 25kg ha^{-1}.NE software was used for calculation of dose of N, P and K for SSNM treatment based on NE. Accordingly, the nitrogen dose was split into 25, 68 and 39 kg ha^{-1}at transplanting, panicle initiation and heading stages respectively. The P_2O_5 was applied @ 27 kg ha^{-1}at transplanting while K_2O was split into two doses of 30 and 32 kg ha^{-1}at transplanting and PI stages respectively. Under the treatment SSNM based on LCC, nitrogen was applied half basal at transplanting (65 kg ha^{-1}). The minus N, minus P and minus K plots were based on NE treatment. Zinc Sulphate was applied @ 25 kg ha^{-1} in all treatments except Absolute Control. The source of nutrients was Neem Coated Urea (NCU), Single Super Phosphate (SSP) and Muriate of Potash (MOP). The rice nursery was sown on 7th June, 2017. Twenty two days old rice seedlings of RAU 1476-4-1 were used for transplanting. Only two seedlings were transplanted per hill on 4th July, 2017with a spacing of 20 cm (RxR) and 15cm (PxP). The crop was harvested on 27th October 2017. Post-harvest soil samples were analyzed for Organic carbon (Walkley & Black, 1934) [1]; available N (Subbiah and Asija, 1956) [4]; P (Olsen *et al*., 1954) [3] & K (Jackson, 1973) [2] and plant samples were analyzed for N, P and K by standard method (Jackson, 1973) [2]. The treatments included: Recommended fertilizer of that region(T_1); SSNM based on nutrient expert (T_2); SSNM based on LCC/Green Seeker (50% Nitrogen as basal and rest 50% based on LCC or Green Seeker(T_3); T_2 minus N (T_4); T_2 minus P (T_5); T_2 minus K (T_6); Absolute control without NPK (T_7) and Farmers' fertilizer Practice (T8). The experimental soil was calcareous in nature with pH - 8.4, organic carbon - 0.6%, available N- 192.5 kg ha^{-1}, available-P_2O_5 31.2 kg ha^{-1}, available - K_2O 202.8 kg ha^{-1} and DTPA- Zn 0.41 $mgkg^{-1}$.

Results and Discussion

Yield attributes and yield

The application of site specific nutrient management (SSNM) resulted in significant variation in yield components and yield of rice (Table-1). Significantly higher filled grains per panicle, panicles m^{-2}, 000'grain weight, grain and straw yield were obtained with the application of SSNM based on nutrient expert (NE). The maximum filled grains per panicle and thousand grain weight was recorded in the treatment SSNM based on nutrient expert while higher panicles m^{-2} was obtained in RDF (Kumar *et al*., 2018). The highest grain and straw yields of 5.32 and 6.52t ha^{-1} respectively were found under treatment SSNM based on nutrient expert. The filled grains per panicle (122) under SSNM with nutrient expert was significantly higher while RDF and farmer practice were at par to each other indicating that farmer practice was as good as recommended dose (RDF). The panicles m^{-2}under RDF (245), SSNM with NE (241) and LCC (220) were at par to each other and significantly higher as compared to farmer's fertilizer practice (198) which might be due to better utilization of fertilizer applied under SSNM approach. The 000' grain weight under RDF (19.54g) and SSNM with nutrient expert (19.79 g) were at par to each other while SSNM with LCC(19.25 g) and FFP(19.12 g) were at par to RDF indicating that even though with higher dose of fertilizer the RDF could not perform better than farmer practice.

The grain yield recorded significantly higher values (5.32 t ha^{-1}) under SSNM which nutrient expert over all other treatments while straw yield was at par with RDF. Further, it was observed that grain yield under SSNM with LCC (4.87t ha^{-1}) was at par with RDF (4.92 t ha^{-1}) which indicates that with proper timing and quantity of N application, less P application and split application of K as compared to RDF could result in equivalent yields. The straw yield (5.80 t ha^{-1}) under farmer practice was significantly lower as compared to SSNM with LCC (6.15 t ha^{-1}) but was at par to each other in grain yield.

Nitrogen Uptake

The grain and straw uptake (Table-2) of 63.09 and 39.33 kg ha^{-1}respectively under SSNM with nutrient expert was significantly higher overall other treatments. The increase might be due to higher dry matter production and nutrient concentration. Also the splitting of N & K dose as per need of crop under the treatment might have caused higher N uptake by grain and straw. The application based on LCC resulted in nitrogen up take of 56.54 and 35.90 kg $ha^{-1}$by grain and straw respectively was at par with RDF (57.17 and 36.19 kg ha^{-1}) the farmer fertilizer practice resulted in significantly lower and uptake 51.42 and 33.83 kg ha^{-1}respectively by grain and straw as compared to RDF and SSNM based on Nutrient Expert as well as SSNM based on LCC.

Residual Soil Fertility

The organic carbon of post-harvest soil (Table- 2) varied significantly under the influence of SSNM. RDF and SSNM based on LCC recorded 6.9 gram per kg organic carbon which was at par with SSNM based on Nutrient Expert (7.5 g kg^{-1}). The farmer's practice recorded 6.5 g kg^{-1} organic carbon which was at par with RDF and SSNM with LCC. Significantly higher organic carbon recorded in SSNM with Nutrient Expert might be due to splitting of N & K as per the need of crop during the cropping season.

The available and K_2O were significantly influence by SSNM while available P_2O_5 was non-significant. The highest values recorded for available N & K were to 224.5 kg $ha^{-1}$and 222.7 kg ha^{-1} respectively. The available N under RDF (213.8 kg ha^{-1}) and SSNM with LCC (213.9 kg ha^{-1}) were at par to each other whereas, farmer practice recorded significantly lower available N. The available K_2O under RDF and SSNM with Nutrient Expert were at par to each other while farmer practice recorded significantly lower availability but was at par to RDF.

Therefore, it may be concluded that fertilizer recommendations based on soil supply potentials coupled with plant requirements *i.e.*, site specific nutrient management (SSNM) through the use of nutrient expert helped in realizing better yields from balanced nutrient management thereby, reducing the cost by avoiding excess fertilization which would keep the soil healthy for a longer period of time.

Table 1: Effect of SSNM on yield and yield attributes

Treatments	Filled Grains Panicle^{-1}	Panicles m^{-2}	000'Grain wt. (g)	Grain Yield (t ha^{-1})	Straw Yield (t ha^{-1})
RDF	108	245	19.54	4.92	6.24
SSNM on Nut. Exp.	122	241	19.79	5.32	6.52
SSNM on LCC	114	220	19.25	4.87	6.15
SSNM minus N	103	201	18.98	4.21	5.48
SSNM minus P	109	209	19.05	4.71	6.07
SSNM minus K	97	202	18.93	4.76	5.91
Absolute Control	84	141	18.73	3.81	5.37
FFP	102	186	19.12	4.66	5.70
CD (0.05)	11.2	45.0	0.46	0.22	0.28
CV (%)	6.08	12.3	1.37	0.003	0.003

Table 2: N-uptake, organic carbon and availability of nutrients as influenced by SSNM

Treatments	Grain N uptake (Kg ha^{-1})	Straw N uptake (Kg ha^{-1})	Org. Carbon (%)	Av – N (Kg ha^{-1})	Av – P (Kg ha^{-1})	Av – K (Kg ha^{-1})
RDF	57.17	36.19	0.69	213.8	35.6	211.7
SSNM on Nut. Exp.	63.09	39.33	0.75	224.5	39.1	222.7
SSNM on LCC	56.54	35.90	0.69	213.9	33.7	205.7
SSNM minus N	41.25	29.93	0.61	199.8	33.0	211.6
SSNM minus P	53.50	34.81	0.67	210.3	30.7	200.3
SSNM minus K	53.03	32.89	0.63	203.8	34.8	195.5
Absolute Control	34.48	23.82	0.55	190.8	27.6	181.3
FFP	51.42	33.83	0.68	213.6	33.2	203.3
CD (0.05)	4.43	2.98	0.059	9.91	NS	13.8
CV (%)	0.048	0.051	5.11	2.68	15.39	3.84

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