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Effect of potassium management on soil fertility of basmati rice (*Oryza sativa* L.) in intensive cropping system of Western Uttar Pradesh

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Abstract
A field experiment was conducted during *Kharif* season 2015 at Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.). Twelve treatments comprising 100% NP, 100% NPK, 100% NP + 125% K, 100% NP + 150% K, 125% NPK, 150% NPK, 100% NP + Crop residue, 100% NP + FYM, 100% NP + SPM, SSNM, SSNM-K and SSNM+K were replicated thrice in a randomized block design. The data on growth, yield and its contributing traits were calculated on plot area basis (15 m^2), whereas content and uptake of nutrients at various stages along with available N, P, K, S, Zn, B and Fe as well as availability at surface, sub surface and potassium dynamics was recorded as per the standard procedure. The experimental results revealed that Application of SPM along with the recommended dose of N, P improved organic carbon of soil. Therefore, application of 150 % RDF (100:60:60 kg NPK) proved to be better for achieving higher yield and maintaining the nutrient status of soil. Although the yield was high in 150% NPK but it did not differ from SSNM therefore. The practice of SSNM is found better for sustainability of crop yield and soil health.

Keywords: SSNM, potassium dynamics, SPM (Sulfonated press Mud)

Introduction
Rice (*Oryza sativa* L.) is a member of Poaceae, formerly called Gramineae family and one of the most important food crops in the world forms the staple diet of 2.7 billion people. It is grown in all the continents except Antarctica, occupying 150 million ha, producing 573 million tones paddy with an average productivity of 3.83 tones ha^{-1}. Cultivation of rice is of immense importance to food security of Asia, where more than 90% of the global rice is produced and consumed. India is the second largest consumer and producer of rice in world after China. The area, production and productivity of India is 43.42 m ha, 105.24 mt and 24.23 qha^{-1}, respectively, Uttar Pradesh is the 2^{nd} largest rice growing state only after West Bengal in the country, in which rice is grown over an area of 58.6 lakh hectares with the production of 144.1 lakh tonnes and the productivity is 2460 kg ha^{-1}. Total rice cultivated area in Meerut is 14514 ha, production 39362 tonnes and productivity 2710 kg ha^{-1} (Anonymous, 2015) [1]. Demand for rice is growing every year and it is estimated that by 2025 AD the requirement would be 140 million tonnes to sustain present food self-sufficiency and to meet future food requirements, Site Specific Nutrient Management (SSNM) is an approach to feeding rice with nutrients ‘as and when needed’. The application and management of nutrients are dynamically adjusted to crop needs of the location and season. The SSNM approach aims to increase farmers profit through increased yield of rice per unit of applied fertilizer and reduced disease and insect damage. The features of Site Specific Nutrient Management are optimal use of existing indigenous nutrient source such as crop residues and major application of Nitrogen (N), Phosphorous (P) and Potassium (K) fertilizer is adjusted to the location and season specific need of the crop. In rice cultivation, the farmers are giving much attention only to N fertilization and very often P and K applications are carried out at minimal level, mostly missing K fertilization. This practice of imbalance and inadequate fertilizer application affects the soil productivity in general and particularly depletes the essential nutrients.
Potassium is the third essential plant nutrient along with N and P. Potassium enhances production of protein and thus, improves the efficiency of fertilizer nitrogen. Potassium is essential for making plant more resistant to lodging, Deficiency system appears on younger leaves and finally plant can die (Tiwari, 2000) [13].

Potassic fertilizers should be applied at the rate giving the highest grain yield to produce the best combination of yield and quality of aromatic rice. At higher K rates, grains had a stronger aroma, whiter and glassier appearance but less softness. Thus, poor nutrient management due to lack of proper and balanced use of chemical fertilizers including micronutrients is one of the factor responsible for low yields and poor grain quality of Basmati rice. The picture of crop responses to potassium in India has been changing with time. Starting with early reports of substantial responses to potassium only in potato and groundnut, first lateritic soil were universally reported to be deficient in potassium and then potassium application was considered necessary for obtaining high yields in many other parts of the country. Crop responses to potassium were more in light textured soils and under humid conditions.

Materials and Methods

This research was conducted at Crop Research Centre (CRC) of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.) during the kharif season of 2015, which is located at a latitude of 29^0 40′ N and longitude of 77^0 42′ E and at an altitude of 237 m amsl. Meerut lies in the spirit of Western Uttar Pradesh and has semi-arid to sub-tropical climate and variety of rice was Pusa Basmati 1509. The experiment was laid in randomized block design (RBD) with twelve treatments comprising 100% NP(T_1), 100% NPK(T_2), 100% NP+125% K(T_3), 100% NP+150% K(T_4), 125% NPK(T_5), 150% NPK(T_6), 100% NP + Crop residue(T_7), 100% NP+FYM(T_8), 100% NP + SPM(T_9), SSNM(T_{10}), SSNM-K(1_{11}) and SSNM + K(T_{12}) and three replication. The size of each plot was 5×3 m ^{2}. All recommended package of practices were followed during the experiment. The weather data for the experimental period recorded at the meteorological observatory of SVPUA&T, Meerut during the crop growing season. Soil samples from a depth of 0-15 cm were collected from each plot of the experiment prior to transplanting and a composite sample was drawn for determining its physical and chemical properties of soils are BD (Mgm^{-3}) 1.41, textural class sandy loam soil, O.C (4.00 g kg^{-1}), pH (8.03), EC (dS m^{-1}) 0.29, Available N (kg ha^{-1}) 202.0, Available P (kg ha^{-1}) 14.25, Available K (kg ha^{-1}) 195.0. The data on, soil nutrients status was recorded as per the standard procedure. The data obtained were subjected to statistical analysis as outlined by (Gomez and Gomez, 1984) [4]. The treatment differences were tested by using "F" test and critical differences (at 5% probability).

Soil sampling and analysis

Soil samples were collected from each plot of the experimental field at depths of 0-15 cm and 15-30 cm, and soil samples were analysed in the laboratory of the department of soil science at Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut. Available nitrogen in the soil was determined (Subbiah and Asija, 1956) [12], available phosphorus in the soil (Olsen *et al.*, 1954) [8], available potassium in the soil was extracted using 1N neutral ammonium acetate as an extractant (Hanway and Heidel, 1952) [5], and non-exchangeable potassium in the soil was extracted using 1N nitric acid as an extractant (Haylock *et al.*, 1956) [6], and K in the extract was determined (Systronic).

Result and Discussion

Fertility status of soil under different fertility levels

Available nitrogen in soil (kg ha^{-1})

Available nitrogen was affected significantly by different treatments. Available nitrogen at 0-15 cm under different treatments varied from 203.14 to 210.11 kg ha^{-1} and at 15-30 cm 130.54 to 149.45 kg ha^{-1} at tillering stage, 201.53 to 208.71 kg ha^{-1} (0-15cm) and at 15-30 cm 126.04 to 146.54 kg ha^{-1} at Panicle Initiation (P/I/) stage and 196.80 to 206.54 kg ha^{-1} (0-15cm) and at 15-30 cm 121.54 to 141.54 kg ha^{-1} at harvest. Maximum available nitrogen at 0-15cm and 15-30 cm was recorded in 150% NPK (T_6) at tillering, panicle initiation and at harvest stage, respectively. Availability of nitrogen differ significantly in T_{10} as compared to RDF. Availability of nitrogen under different treatments decline with depth at all the growth stages. After harvesting the slight variation was observed in soil availability of nutrients N, P, and K, and availability improved over their initial value. Available NPK and micronutrients decline with the advancement of crop age and reached to minimum at harvest stage probably due to increase absorption of available nutrients with growth and development and possible losses. Moreover, maximum N was observed with the application of 150% RDF alone at all the stages might be due to excess application of N under this treatment T_6 (Table 1.)

Table 1: Effect of different fertility levels on available nitrogen at various stage

Treatment	Available nitrogen (kg ha^{-1}) in surface and sub surface soil					
	Tillering		Panicle initiation		Harvest	
	0-15	15-30	0-15	15-30	0-15	15-30
T_1	203.14	130.54	201.53	126.04	196.58	121.54
T_2	203.56	132.42	202.41	130.95	198.87	126.45
T_3	204.58	132.82	202.79	132.24	200.42	127.74
T_4	204.60	133.42	203.49	134.92	201.32	130.42
T_5	207.51	137.45	206.89	136.54	203.77	131.54
T_6	210.11	149.45	208.71	146.54	206.54	141.54
T_7	206.49	145.56	204.54	132.62	198.67	127.56
T_8	208.55	137.87	206.56	137.06	201.76	129.23
T_9	206.64	138.65	201.88	133.24	198.27	130.54
T_{10}	207.46	138.25	206.84	134.50	202.62	128.84
T_{11}	205.43	134.34	202.13	133.54	199.72	121.56
T_{12}	206.42	140.35	203.87	136.56	200.35	125.24
SEm ±	0.97	2.16	0.73	1.51	0.82	11.15
CD=0.05	2.87	6.39	2.15	4.46	2.43	N.S

Available phosphorus in soil (kg ha^{-1})

Available phosphorus recorded in soil at 0-15 and 15-30 cm depth under different treatments at different stages and results reveal that available phosphorus at 0-15cm differ from 13.72 to 18.45 kg ha^{-1} and at 15-30 cm differ from 6.24 to 9.56 kg ha^{-1} at tillering stage, 13.62 to 17.95 kg ha^{-1} (0-15 cm), at 15-30 cm 4.25-7.25 kg ha^{-1} at P.I and 13.30 to 16.61 (0-15 cm), at 15-30 cm 3.50to 6.89 kg ha^{-1} at harvesting stage. Maximum availability of phosphorus at 0-15 cm and 15-30 cm at different stages with the application of 150% NPK (T_6). Availability of P did not increase due to adoption of SSNM and decline with depth. at all the growth stages were also noticed. Phosphorus availability was also higher with the application of 150% NPK (T_6) than rest of the treatments. Present finding are in conformity with the reports of other investigators (Pal *et al*. 2008) [9] and (Kumar *et al*. 2015) [7] (Table 2).

Table 2: Effect of different fertility levels on available phosphorous at various stages.

Treatment	Available phosphorus (kg ha^{-1}) in surface and sub surface soil					
	Tillering		Panicle initiation		Harvesting	
	0-15	15-30	0-15	15-30	0-15	15-30
T_1	13.72	6.24	13.62	4.25	13.30	3.50
T_2	14.47	6.50	13.86	4.50	13.52	3.56
T_3	14.67	6.54	14.07	4.56	13.73	3.57
T_4	14.87	6.58	14.19	5.10	13.84	4.10
T_5	16.91	7.89	15.88	6.23	14.40	5.20
T_6	18.45	9.56	17.95	7.25	16.61	6.89
T_7	16.72	6.59	15.62	4.53	14.38	3.59
T_8	16.92	7.21	16.61	5.21	14.39	3.89
T_9	16.09	6.58	15.43	4.54	14.51	3.99
T_{10}	15.52	6.93	16.48	4.75	13.28	3.58
T_{11}	14.87	6.85	13.94	4.45	13.61	3.44
T_{12}	15.24	7.21	15.13	5.23	14.00	3.85
SEm ±	0.83	0.92	0.89	1.32	0.76	0.89
CD=0.05	2.45	N.S	2.61	N.S	2.23	N.S

Available potassium in soil (kg ha^{-1})

Available potassium recorded in soil at 0-15 and 15-30 cm depth under different treatments at different stages and results reveal that available potassium at 0-15 cm depth differ from 200.45 to 222.18 kgha^{-1} and at 15-30 cm 98.57 to 105.45 kg ha^{-1} at tillering stage, 196.20 to 217.88 kg ha^{-1} (0-15 cm) and at 15-30 cm 97.57 to 104.45 kg ha^{-1} at P.I, 193.17 to 212.78 kg ha^{-1} (0-15cm) and at 15-30 cm 96.57 to 100.75 kg ha^{-1} at harvesting stage of surface soil and sub surface soil . Maximum availability of potassium was noticed at different stages with the application of 150% NPK (T_6). Availability of Potassium increase significantly due to adoption of SSNM over RDF and decline with depth at all the growth stages. Higher available K observed with the application of 150% RDF NPK was significantly higher than the treatments except T_3, T_4, T_5, T_6 T_{10} and T_{12}. Additional application of potassium exhibits significant effect on availability of potassium. (Table 3.)

Potassium dynamics in soil (mg kg^{-1})

In potassium dynamics water soluble K varies from 13.45 to 19.45 mg kg^{-1}, exchangeable K from 76.04 to 97.26 mgkg^{-1} and non- exchangeable K from 1520.16 to 2195.20 ppm. Nearly 1:5 ratio was found between solution and exchangeable K. Nearly 1:22 ratio was found between exchangeable and non-exchangeable K. (Table 3.). Higher available K observed with the application of 150% RDF NPK was significantly higher than the treatments except T_3, T_4, T_5, T_6 T_{10} and T_{12}.

Table 3: Effect of different fertility levels on available potassium and Potassium dynamics at various stages.

Treatment	Available potassium (kg ha^{-1}) in surface and sub surface soil						Tillering			Harvesting		
	Tillering		Panicle initiation		Harvesting		Water soluble K (mg kg^{-1})	Exchange-able K (mg kg^{-1})	Non-Exchange-able K (mg kg^{-1})	Water soluble K (mg kg^{-1})	Exchange-able K (mg kg^{-1})	Non Exchange-able K (mg kg^{-1})
	0-15	15-30	0-15	15-30	0-15	15-30						
T_1	200.45	98.57	196.20	97.57	193.17	96.57	13.45	76.04	1520.16	14.66	71.58	1408.37
T_2	210.87	100.77	206.80	99.77	201.59	99.27	16.94	77.20	1630.72	16.20	73.80	1620.72
T_3	216.75	101.92	212.68	100.27	207.47	99.77	16.93	79.83	1697.92	16.20	76.42	1686.13
T_4	222.07	100.54	217.67	98.54	212.78	97.51	17.84	81.30	1792.00	17.10	77.90	1764.08
T_5	216.89	103.13	214.88	100.24	207.88	99.21	18.39	78.44	1845.76	17.63	75.17	1817.84
T_6	222.18	105.45	217.88	104.45	212.79	100.75	19.34	76.23	1895.04	18.52	76.47	1883.25
T_7	209.87	103.70	206.08	101.70	200.86	100.45	16.86	74.51	1531.55	16.14	73.53	1499.76
T_8	206.04	101.27	204.58	96.27	199.55	95.32	17.47	74.84	1541.12	16.92	72.16	1513.20
T_9	209.56	105.32	205.23	100.04	200.20	96.05	18.71	78.32	1542.91	17.87	71.51	1531.12
T_{10}	216.58	102.24	214.22	101.25	208.86	100.26	18.37	96.69	1759.74	17.71	75.53	1747.95
T_{11}	202.17	99.27	200.90	94.57	197.13	98.57	16.24	90.25	1482.88	15.84	72.16	1471.09
T_{12}	217.86	101.90	215.88	101.85	211.88	100.26	19.45	97.26	2195.20	18.90	72.69	1981.81
SEm ±	2.46	14.64	2..51	12..54	2.46	15.34	0.27	0.82	22.82	0.37	1.08	24.55
CD=0.05	7.25	N.S	7.40	N.S	7.25	N.S	0.85	2.45	68.45	1.10	3.24	73.62

Additional application of potassium exhibits significant effect on availability of potassium. (Dash *et al.* 2014) [3] revealed that combined application of NPK with S, B and Zn maintained soil fertility. Omission of N, P or K from the fertilizer scheduled reduced the soil fertility and deteriorates soil quality. Supply of potassium to plant is very much depend on level of non-exchangeable potassium in soil. Exchangeable potassium and non-exchangeable potassium increase with the application of 150% of RDF NPK (T_6). This form of potassium decline with advancement of crop growth. Ratio of this form about 1:20. Non-exchangeable K fraction is released when the level of soil solution and exchangeable K are decreased by plant uptake and leaching. Increase in exchangeable K due to the application of organic manure might be attributed to the release of K to the available pool of the soil besides the reduction of K fixation. (Saleque *et al.*, 1991) [10]. The need of fertilizer K depends upon the management of rice straw which contains 80 to 85% of the K in a rice crop. It also depends on K contained in irrigation water and the K-supplying capacity of the soil, which are typically not known by farmers. Asian rice farmers are often not applying sufficient fertilizer K to balance the K removed in harvested grain and straw. The production of rice consequently relies on the extraction and depletion of K from soil reserves (Buresh *et al.*, 2008) [2].

Conclusion

On the basis of the experiment, it is concluded that nutrient management in rice through potassium and its positive effect on soil nutrient status, despite the fact that potassium has a better response after investigation and it is possible to make recommendations for rice crop with different level of potassium as fertiliser. The application of potassium in a balanced manner improves the quality of produce while also maintaining soil health and the K level in the soil

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