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Influence of various sources and doses of potassium nutrient on growth, yield and quality 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. (India) to evaluate the Potassium management for basmati rice (*Oryza sativa* L.) in intensive cropping system of Western Uttar Pradesh. The soil of the experimental field was well drained, sandy loam in texture, alkaline in reaction (pH 8.03), low in available nitrogen, medium in available phosphorus and available potassium with an electrical conductivity 0.29dSm$^{-1.}$ 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 in rhizosphere as well as potassium dynamics was recorded as per the standard procedure. The experimental results revealed that significant difference was found in growth attributes and yield attributing traits and also difference was found in uptake of nitrogen, phosphorus and potassium in rice. Among the different treatments uptake were maximum with the application of 150% NPK. However S, Zn, B and Fe uptake was highest in SSNM (Site Specific Nutrient Management) + K (Potassium). 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, quality and soil health.

Keywords: basmati rice (*Oryza Sativa* L.), integrated nutrients management, intensive cropping system

Introduction
Rice (*Oryza sativa* L.) 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. The area, production and productivity of India is 43.42 m ha, 105.24 mt and 24.23 qha^{-1}, respectively. (Anonymous, 2015). Uttar Pradesh is the 2nd 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). Pusa Basmati-1509 was developed in 2013 and has been ranked the best among the Basmati varieties. The rice-potato-maize is a dominant cropping sequence being followed in western Uttar Pradesh. Potassium is the third essential plant nutrient along with N and P. Its availability to plants depends upon the concentration of K in soil solution and on exchange sites. Potassium is essential for enzyme activation, charge balance and osmotic regulation in plants. It is present in cation form in plant cell to maintain ionic balance and up to 10% of plant dry matter is made up of K (Marschner, 1995) [4]. Its ease of access to plants depends upon its status in soil solution, exchangeable K and rate of exchange of K from exchangeable form to soil solution form (Wakeel, 2013) [13]. Specific functions that occur in cytoplasm require small amount of potassium while a major portion (90%) of K is present in vacuole where it acts as an osmotic contributing to extension growth of plants (Wakeel, *et al.*, 2010 & 2011) [14]. High K contents in plant tissue increase its resistant to sudden environmental

variations like temperature stress, rain in late season, cold and frost (Cakmak, 2005) [2]. Potassium accumulation in the plant tissue also decreases damage to plant in response to osmotic stress and physiological burdens (Rajkumara, 2008) [5]. Deficiency system appears on younger leaves and finally plant can die (Tiwari, 2000) [12]. Thus poor nutrient management due to lack of proper and imbalanced use of chemical fertilizers including micronutrients is one of the factor responsible for low yields and poor grain quality of basmati rice. Balance site specific nutrient management (SSNM) in combination with micronutrients will not only break the yield barrier (Kumar, *et al.*, 2015) [3] but also improved the quality of rice grain such as crude protein, zinc and iron content in grain. Supply of plant nutrients in balanced and sufficient quantity is essential to sustain its productivity on long-term basis. Plants require potassium (K) in large quantity. Decline in crop productivity due to lack of K supply was reported even in K rich soils (Srinivasarao, *et al*. 2011 and Singh and Wanjari, 2012) [11, 9]. Therefore, keeping these facts in mind, the present study was formulated to find out the optimum dose of potassium fertilizer to obtain maximum growth and yield and best quality of basmati rice (*Oryza sativa* L.) in intensive cropping system of Western Uttar Pradesh.

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 latitude of 29^0 40′ N and longitude of 77^0 42′ E and at an altitude of 237 meter above mean sea level (MSL). Meerut lies in the heart of Western Uttar Pradesh and has semi-arid to sub-tropical climate. The experiment was laid in randomized block design (RBD) with 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 and three replication. The size of each plot was 5X3 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.Observed related to growth parameter viz. plant height, number of tillers. Dry matter accumulation was recorded by selecting five hills randomly from observation row of each plot. Test weight (g) one thousand filled grains from each plot samples were counted and weighed on electronic balance and their weight was expressed in grams. Quality of rice determined by amount of content changed over RDF (recommended dose of fertilizer) in the form of protein, zinc and iron.

Results and Discussion

It was found that maximum plant height was recorded with the application 150% NPK (T_6) that was significantly higher than the other treatments except T_5, T_{10} and T_{12}. Neither the deletion of potassium from RDF NPK nor the addition of super optimal level of potassium results any significant effect over 100% NPK. Plant height differs significantly due to additional application of 25 and 50% NPK over 100% NPK. Number of tillers differs from 51.15 to 62.87. Maximum number of tillers 62.87 recorded in T_6 was significantly higher than the treatments except T_5, T_{10}, T_{11} and T_{12}. It was because experimental soil was deficient in nitrogen, therefore when additional application of nitrogen was applied, it responded in term of taller plant, more number of effective tillers. Nitrogen is an integral part of chlorophyll, it stimulates chlorophyll synthesis hence it accelerate rate of assimilation (photosynthesis) which finally results improvement in grain quality in term of protein content, similar results have been reported by Singh, *et al.* (1999) [8]. Organic sources did not result any significant effect on growth parameter. Nutrient application on SSNM based in various treatments produce significantly higher number of tillers in T_{10} than T_2. Since the soil was deficit in nitrogen, recommended dose of nitrogen was not enough to fulfill the requirement of nitrogen for growth therefore the response of plant height and number of tillers to additional application of nitrogen over recommended dose is well accepted. Balance application of nutrients to the plants. SSNM practice showed positive and favorable effect on improving almost all the growth attributes of rice varieties (Shanker, et *al.*, 2014) [7].

The Grain yield differs from 24.0 to 42.76 q ha^{-1}. Maximum grain yield 42.76 qha^{-1} produced with the application of 150% NPK (T_6) that was significantly higher than the treatments except T_5, T_{10}, T_{11} and T_{12} (Table1). A significant effect reduction of 25% in grain yield was noticed due to skipping of potassium from RDF. Significant increase in grain yield was noticed due to super optimal application of potassium or NPK over RDF.fig.1.

At harvest rice straw yield differ from 36.11 to 64.14 q ha^{-1}. The highest straw yield 64.14 q ha^{-1} recorded with the application 150% NPK (T_6) was significantly higher than the treatment except T_5, T_{10} and T_{12}. Straw yield decline significantly due to deletion of K from RDF NPK while, a significant increase was noticed due to super optimal application of potassium.

Straw yield also differ significantly due to additional application of 25 and 50% NPK. Straw yield reduced due to addition of crop residue while no effect was noticed of FYM and SPM. A significant variation in T_2 and T_{10} was noticed. Nutrient application on SSNM base produce significantly higher straw yield than T_2 where RDF NPK was applied. Harvest index which is a ratio of grain yield to biological yield was highest in the T_5 treatment with the application of 125% NPK while minimum 38.75 in case T_2 where 100% NPK was applied. Organic sources did not result any significant effect on grain and straw yield. Grain yield differ significantly among T_2 to T_{10}. Nutrient application on SSNM based produce significantly higher grain yield than RDF. The extra yield of rice had found through SSNM over farmer Practice (Singh, *et al*., 2008) [10]. Balance site specific nutrient management in combination with micronutrients which break the yield barrier which is similarly reported by Kumar, *et al.* (2015) [3]. SSNM strategies significantly improved the grain yields of rice and wheat reported by Regmia, *et al.* (2006) [6].

It is also clear from the table that the applications of balanced fertilization through SSNM practice; the protein, zinc and iron content of rice grain increased. Much more variation in zinc and iron content over RDF was found in T_{10} where SSNM was applied. Percentage change over RDF in crude protein due to application of different nutrient combinations ranged from 2.34 to 12.28 per cent. Variation due to application of different nutrient combinations in Zn & Fe content was 0.82

to 36.57 and 7.16 to 51.09 per cent respectively, rice quality in respect of crude protein decline due to deletion of potassium from RDF. Grain quality improved due to additional application of potassium over RDF and additional application of NPK over RDF. Grain quality decline in respect of crude protein with the application of organic sources however, an improvement was noticed by adoption of SSNM.

Table 1: Effect of different fertility levels on growth, yield and yield attributing character of basmati rice at harvest stage.

Treatments	Plant height (cm)	No. of tillers Per meter row length.	No. of grains per panicle	Test weight (g)	Grain yield (qha^{-1})	Straw Yield (qha^{-1})	HI (%)
100%NP	81.76	51.15	70.23	28.45	24.00	36.11	39.93
100%NPK	82.88	53.25	71.45	29.45	32.00	49.67	38.75
100%NP+125%K	83.67	55.58	73.42	30.15	38.71	58.15	40.01
100%NP+150%K	84.25	56.22	75.25	30.56	39.51	59.25	40.01
125%NPK	85.35	59.57	76.61	30.24	40.76	61.54	40.08
150%NPK	86.83.86	62.87	77.12	31.42	42.76	64.14	40.00
100%NP+CR	82.68	55.12	72.24	30.12	29.21	43.80	39.95
100%NP+FYM	83.68	55.14	73.35	30.16	32.77	49.15	40.020
100%NP+SPM	82.38	56.21	73.19	30.00	32.33	48.49	40.00
SSNM	85.87	60.12	76.62	31.86	42.40	63.81	39.92
SSNM-K	82.43	59.23	74.12	30.23	40.10	60.15	40.00
SSNM+K	84.76	60.58	76.89	32.85	42.16	63.99	39.99
SEm ±	0.71	1.26	0.28	1.19	0.99	1.11	-
CD = 0.05	2.10	3.71	0.83	N.S.	2.94	3.29	-

Note: RDF NPK (100:60:60), SSNM (100:60:60:25:30:5) CR (Crop residue), SPM (Sulfonated pressmud) 10 t ha^{-1}, FYM (Farm yard manure) 10 t ha^{-1}, H.I (Harvest index).

Table 2: Effect of different doses of potassium fertilizer on grain quality of basmati rice over RDF.

Treatments	Percent change over RDF		
	Crude protein	Zinc	Iron
100%NP	-3.51	-3.56	-7.92
100%NPK	0.00	0.00	0.00
100%NP+125%K	2.34	7.15	10.61
100%NP+150%K	5.26	4.01	21.51
125%NPK	8.19	9.14	26.36
150%NPK	12.28	7.61	23.48
100%NP+CR	-2.92	0.82	18.21
100%NP+FYM	-1.17	1.20	14.93
100%NP+SPM	0.00	14.98	7.16
SSNM	7.02	35.61	42.53
SSNM-K	3.51	29.42	39.28
SSNM+K	7.60	36.57	51.09

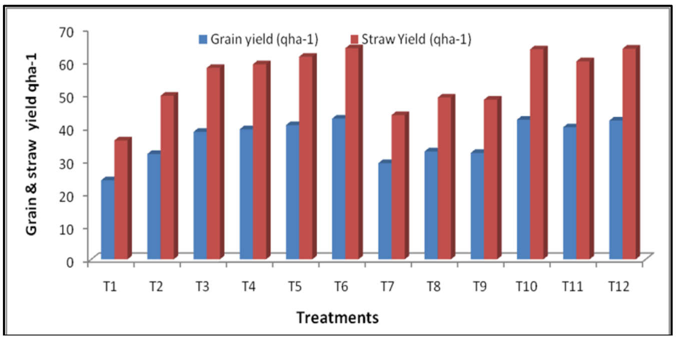

Fig 1: Effect of different fertility levels on grain and straw yield of basmati rice at harvest stage

Conclusions

On the basis of one year experiment it can be concluded that nutrient management for basmati rice through site specific nutrient management can be best option in terms of crop productivity, soil fertility and economic feasibility, although it will require further investigation before making any recommendation. Application of potassium in balanced manner improves the quality of produce and maintains the K level in soil under the intensive cropping system of Western Uttar Pradesh.

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