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Potassium fractions affected by split application of potassium in rice (*Oryza* spp.) in calcareous soil of North Bihar

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Abstract

A field experiment was conducted in calcareous soil (medium in available K) in split-plot design with two rice varieties (Inbred and Hybrid) in main plot and six combinations of potassium management [control, NP(-K); NP+K(100 % basal); NP+K(50% basal + 50% tillering); NP+K(50% basal + 50% panicle) and NP+K(50% basal + 25% tillering + 25% panicle)] in sub-plot at Experimental Farm, RPCAU, Pusa, Samastipur, during *kharif* – 2017. Post-harvest surface soil samples were analyzed for different forms of potassium (available K, water soluble K, exchangeable K, non-exchangeable K, lattice Kand total K). Water soluble potassium was significantly higher in treatments receiving potassium in split application than treatment receiving total potassium as basal. All the fraction of potassium was highest in treatment receiving potassium in split.

Keywords: Potassium fractions, split application, North Bihar

Introduction

Rice (*Oryza* spp.), a major crop cultivated in at least 95 countries across the globe in an area of 163.5 million hectares (m ha) with an annual production of 758.9 million tons (mt) and average productivity of 4641.5 kg ha^{-1} (FAO Stat, 2017) [2]. In India, rice is cultivated in 42.5 m ha with production of 165.3 mt and productivity of 3632.9 kg ha^{-1} (FAO Stat, 2017) [2]. Global demand of milled rice is estimated to increase from 496 million tons in 2020 to 555 million tons in 2035 as the global population increases (Tuong and Bouman, 2002) [12].

Potassium is required by plants in large quantities, equal to or more than N, and plays a key role in many metabolic processes in the plant. Sufficient K supply is important for crop yield as well as product quality (Pettigrew, 2008 and Zorb *et al*., 2014) [8, 14]. Potassium is less mobile in soils because of the strong affinity with exchange sites of clays. Exchangeable K and non-exchangeable K can thereby significantly depleted and contribute to a substantial proportion of plant uptake. Agronomically, the demand for K largely varies with plant species and cultivars and productivity. K in soils can be divided into immediately available, readily available, slowly available, and relatively unavailable K, which are also termed as water-soluble, exchangeable, non-exchangeable, and mineral K, respectively (Martin and Sparks, 1985) [6]. The distribution of K forms in the soil. According to Horra *et al*., 1998 [4] application K fertilizers increases labile forms of K and changes the quantity-intensity parameters of K in soils. Therefore, knowledge about distribution of potassium fractions in soil and time of application is important for effective use of K fertilizer.

Material & Method

The experimental farm of Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar (India) is located at 25^0 94'N latitude, 85^0 67'E longitude and an altitude of 52.3 meter above mean sea level. The climate is sub-tropical having three distinct seasons *i.e.* rainy (mid June to September), winter (October-February) and summer (March to mid June). The total rainfall received during the cropping season (*Kharif*-2017) was 941.2 mm. The mean monthly maximum and minimum temperature during the cropping season varied between 28.7 ^{0}C to 35.1 ^{0}C and 15.3 ^{0}C to 26.7 ^{0}C, respectively. The surface soil samples (0-15 cm) were collected from the experimental field with the help of auger prior to experimentation as per standard procedures. The soil of experimental site was alkaline in reaction, normal in salinity, medium in organic carbon and available K content. The experiment was conducted in split plot design to evaluate the effect of split application of potassic fertilizer in inbred and hybrid rice. The experimental design was split plot with two varieties (inbred-*Sugandha 5* and hybrid-*Arize 6444*) as main plot and six different rate and time of application of potassium [Control (unfertilized, NP (-K), NP + K (100% as basal), NP + K (50% as basal + 50% at tillering), NP + K (50% basal + 50% panicle), NP + K (50 % basal + 25% tillering + 25 % panicle)] as sub plot. The dose of NPK, based on Nutrient Expert tool for inbred and hybrid rice was 108:23:46 and 123:39:65 kg ha^{-1}, respectively. Sources of N, P and K were urea, DAP and MOP, respectively. The content of water soluble K in soils was determined by extracting the soils with distilled water in the 1: 5:: soil: water ratio and shaken for half an hour. Then the K in the filtrate was estimated with the help of flame photometer (Systronics flame photometer 128) as described by USSLS (1954). The available-K of soils was estimated with the help of flame photometer in the aliquot obtained by equilibrating the soils with the extractant in the 1: 5:: soil : 1*N* neutral Ammonium Acetate for five minutes as per method by Hanway and Heidel (1952) [3]. HNO_3 or Non-Exchangeable K was measured by method given by Wood and De Turk, 1941. Lattice K was determined by subtracting the amount of non-exchangeable K from total K.The total-K was determined in soil by digesting the soil with H_2SO_4, $HClO_4$ and HF mixture in platinum crucible at 220-225 °C using flame photometer by following the standard method of Jackson (1973) [5]. The data were statistically analyzed online (http://14.139.232.166/opstat/ default.asp) using analysis of variance technique (ANOVA) in split-plot design (Sheoran *et al.*, 1998) [10]. The significance of the treatment means was tested at 5 % ($P \leq 0.05$) level of probability.

Result and Discussion

Available and Water soluble K

Available K in post-harvest soil was non-significantly affected by variety and potassium fertilization (Table 1). The mean available K in post-harvest soil ranged from 75.76 and 83.18 mg kg^{-1} in NP(-K) and K treated plots with three split doses (50% basal+ 25% tillering +25% panicle), respectively. The highest mean available K content (83.18 mg kg^{-1}) was observed in the treatment receiving K in three splits as 50% basal + 25% tillering + 25% panicle.

Water soluble K in post-harvest soil increased significantly in potassium treated plots over NP(-K) and control plots and varied from 15.64 to 19.88 mg kg^{-1}in NP(-K) and K treated plots with three split doses (50% basal+ 25% tillering +25% panicle), respectively (Table 1). The highest available K content (19.88 mg kg^{-1}) was observed in the treatment receiving K in three splits (50% basal + 25% tillering + 25% panicle) followed by treatments receiving K as 50% basal + 50% panicle, 50% basal + 50% tillering, 100% basal, control and NP(-K). Water soluble K (18.49 mg kg^{-1}) in post-harvest soil in inbred rice grown plot was 6.3% higher than hybrid rice (17.39 mg kg^{-1}) grown plot. The interaction effect between variety and K fertilization was not significant.

Split application of K leads greater availability of K and lowers the transformation of potassium into non-exchangeable pool which regulated the continuous growth of cells and tissues (Mehdi *et al.*, 2007, Wani *et al.*, 2014) [7, 13]. Thippeswamy *et al.* (1995) [11] reported that among different fractions of K, available K fraction increased with increase in K doses and split application of K also increased the available K fraction in red soils of Bangalore. Increasing levels of either fertilizers or lantana incorporation increased the available K content significantly and consistently (Sharma *et al.*, 2013) [9] The water soluble K is subjected to removal by crops as well as prone to leaching under the influence of high rainfall intensity, thus, its content in present soil were the lowest among all the K fractions (Sharma *et al.*, 2013) [9].

Table 1: Effect of K fertilization on available and water soluble K (mg kg^{-1}) in post-harvest soil

Treatment	Available K			Water soluble K		
	Inbred	**Hybrid**	**Mean**	**Inbred**	**Hybrid**	**Mean**
Control	76.52	76.10	76.31	15.85	15.90	15.88
NP(-K)	75.44	76.08	75.76	15.77	15.52	15.64
NP + K 100% Basal	79.49	78.76	79.12	18.20	17.88	18.04
NP + K (50% Basal + 50% Tillering)	81.05	80.41	80.73	20.03	18.00	19.02
NP + K (50% Basal + 50% Panicle)	81.62	82.13	81.87	20.20	18.15	19.18
NP + K (50% Basal + 25% Tillering + 25% Panicle)	83.38	82.98	83.18	20.88	18.87	19.88
Mean	79.58	79.41		18.49	17.39	
	SE(m) ±	CD(P=0.05)	CV	SE(m) ±	CD(P=0.05)	CV
V	0.81	NS	8.78	0.15	0.88	6.89
K	2.85	NS		0.50	1.48	
V X K	4.03	NS		0.71	NS	

Exchangeable and Non-Exchangeable K

The changes in exchangeable and non-exchangeable K in post-harvest soil was non-significantly affected by variety and potassium application (Table 2). Also, the interaction effect of variety and potassium fertilization on exchangeable K was not significant. The mean exchangeable K content in post-harvest soil ranged from 60.12 to 63.31 (mg kg^{-1}) in control and the treatment receiving potassium in three splits (50% basal + 25% tillering + 25% panicle), respectively.

The increase in mean non-exchangeable K content due to application of potassic fertilizers was not significant and ranged from 984.96 to 1007.64 mg kg^{-1} in NP(-K) and the treatment receiving potassium in two splits (50% basal + 50% tillering), respectively.

Verma *et al.*, 1994 reported that the dominance of non-exchangeable K in the soils can be ascribed to abundance of K-fixing minerals such as illite and chlorite. Since water soluble K is subjected to removal by crops as well as prone to leaching under the influence of high rainfall intensity, its contents in present soil were the lowest among all the three fractions

Lattice and Total K

The changes in lattice and total K in post-harvest soil was non-significantly affected by variety and application of potassium and interaction between variety and split application of potassium (Table 3). The average lattice K content varied from 13414.6 to 13719.2 mg kg^{-1} in treatment receiving NP (-K) and three split applications of K (50% basal + 25% tillering + 25% panicle), respectively.

The average total K content in post-harvest soil due to application of potassium varied from 14399.6 to 14726.7 mg kg^{-1} in the treatment receiving NP(-K) and K in three splits (50% basal + 25% tillering + 25% panicle), respectively.

Bharat (2002) [1] reported that lattice and total K in calcareous soil at Pusa, Bihar 5799 to 9243 and 12199 to 13599 mg kg^{-1} respectively under different cropping system.

Table 2: Effect of K fertilization on exchangeable and non-exchangeable K (mg kg^{-1}) in Post-harvest soil

Treatment	Exchangeable K			Non-Exchangeable K		
	Inbred	Hybrid	Mean	Inbred	Hybrid	Mean
Control	60.67	60.20	60.43	988.08	983.76	985.92
NP(-K)	59.67	60.56	60.12	988.56	981.36	984.96
NP + K 100% Basal	61.29	60.88	61.08	997.92	990.96	994.44
NP + K (50% Basal + 50% Tillering)	61.01	62.41	61.71	1006.56	1005.60	1006.08
NP + K (50% Basal + 50% Panicle)	61.42	63.98	62.70	1008.72	1006.56	1007.64
NP + K (50% Basal + 25% Tillering + 25% Panicle)	62.50	64.12	63.31	1010.16	1004.88	1007.52
Mean	61.09	62.02		1000.00	995.52	
	SE(m) ±	CD (P=0.05)	CV	SE(m) ±	CD (P=0.05)	CV
V	0.83	NS	11.11	14.99	NS	8.92
K	2.79	NS		36.33	NS	
V X K	3.94	NS		51.38	NS	

Table 3: Effect of K fertilization on lattice and total K (mg kg^{-1}) in post-harvest soil

Treatment	Lattice K			Total K		
	Inbred	Hybrid	Mean	Inbred	Hybrid	Mean
Control	13427.75	13427.91	13427.83	14415.83	14411.67	14413.75
NP(-K)	13418.11	13411.14	13414.62	14406.67	14392.50	14399.58
NP + K 100% Basal	13699.58	13654.87	13677.23	14697.50	14645.83	14671.67
NP + K (50% Basal + 50% Tillering)	13773.44	13651.07	13712.25	14780.00	14656.67	14718.33
NP + K (50% Basal + 50% Panicle)	13739.61	13685.11	13712.36	14748.33	14691.67	14720.00
NP + K (50% Basal + 25% Tillering + 25% Panicle)	13734.84	13703.45	13719.15	14745.00	14708.33	14726.67
Mean	13632.22	13588.92		14632.22	14584.44	
	SE(m) ±	CD (P=0.05)	CV	SE(m) ±	CD (P=0.05)	CV
V	90.92	NS	6.95	99.31	NS	6.41
K	386.38	NS		382.06	NS	
V X K	546.42	NS		540.32	NS	

V= Variety, K= Potassium

Conclusion

Availability of water soluble potassium increases with split application of potassic fertilizer.

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