

Original Research Article

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Impact of Split Application of Potassium on Inbred and Hybrid Rice yield and its attributes in Calcareous Soil

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ABSTRACT

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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 (unfertilized), 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. The results revealed that the growth parameters (plant height, panicle length, number of tillers m⁻², number of panicles m⁻²), grain yield and test weight increased significantly with the application of potassium in three splits (50% basal + 25% tillering + 25% panicle) as compared to the treatment where potassium was applied only as basal dose (recommended practice).

Introduction

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. Potassium (K), one of the essential macronutrients, plays important roles in many fundamental physiological processes in plant cells, including osmoregulation, enzyme activation and ion homeostasis (Clarkson and Hanson, 1980; Marschner, 1986; 1995). Sufficient K supply is required for optimal plant growth and development. Particularly,

K⁺ transport across the cell membrane or the endomembrane is related to the photosynthetic regulation (Carraretto *et al.*, 2013 and Kunz *et al.*, 2014) and is also involved in transport of assimilation products (Mengel, 1980). Thus, sufficient K supply is important for crop yield as well as product quality (Pettigrew, 2008 and Zorb *et al.*, 2014).

Materials and Methods

The experimental plot at Dr. Rajendra Prasad

Central Agricultural University, Pusa, Samastipur, Bihar is located at 25° 94'N latitude, 85° 67'E longitude and an altitude of 52.3 meter above mean sea level. The experimental design used 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 *viz.*, control (unfertilized), NP(-K), NP + K (100% basal), NP + K (50% as basal + 50% at tillering), NP + K (50% as basal + 50% at panicle) and NP + K (50% as basal + 25% at tillering + 25% at panicle) as sub-plot. The dose of NPK, based on Nutrient Expert, a nutrient decision support tool, for inbred and hybrid paddy was 108:23:46 and 123:39:65 kg ha⁻¹, respectively. Sources of N, P and K were urea, DAP and MOP, respectively. Plant height, number of tillers m⁻², the number of productive tillers, panicle length, and test weight (1000 grain weight) were recorded at the time of harvest. Harvest Index was measured by ratio of grain yield and biological yield of crop.

Results and Discussion

Grain and straw yield of rice

Application of potassic fertilizers increased the grain and straw yield significantly over control (unfertilized) and potassium omitted plot (Table 1). The highest grain yield (5.77 t ha⁻¹) was recorded under the treatment receiving three split applications of potassium (50% basal+ 25% tillering +25% panicle) followed by the treatments receiving K as 50% basal + 50% panicle, 50% basal + 50% tillering, 100 % basal, NP(-K), and control. The grain yield of hybrid rice was 30.8% higher than that of inbred rice. The interaction effect between variety and split application of potassium was not significant.

The straw yield (mean) of rice varied from 5.58 to 6.76 t ha⁻¹ in control and K treated plots with three split doses (50% basal+ 25% tillering +25% panicle), respectively (Table

1). Split application of K increased the straw yield over 100% basal application of K, but the increase was not significant. The straw yield of hybrid rice was found to increase significantly over inbred rice. The interaction effect was significant for straw yield between varieties and potassium application.

Increase in yield of rice was might be due to prolonged availability of K in soil. Sivagnanam and Arivazhagan (2009) conducted trial at A.U. Karnataka, and reported that the application of entire K₂O in three split doses gave maximum grain yield in SRI Rice. Verma *et al.* (1979) also found that split applications of K at 105 kg K₂O ha⁻¹ (50% planting + 25% at maximum tillering + 25% at panicle initiation) gave the highest grain yield with cv. Sona in sandy clay loam soil. Ravi and Rao (1992); Thakur *et al.* (1999); Dwivedi *et al.* (2000) and Ali *et al.* (2005) also reported significant increase in paddy yield when potash was applied in splits at different growth stages over a single application as basal.

The increase in straw yield was might be attributed to better plant and vegetative growth characters as a result of higher availability of potassium in case of split applications of potassium (Ahmad *et al.*, 2011). Wani *et al.* (2014); Annadurai *et al.* (2000) reported that split application of K on rice either in two splits (basal and panicle initiation) or three splits (basal, active tillering and panicle initiation) produced higher grain yield. Devasenapathy (1997) reported that application of potassium in split doses enhanced the enzymatic activities, probably caused higher mobilization of nutrients in soil and plant and translocation of photosynthetic in plant system, which ultimately resulted in higher grain and straw yields.

Harvest index and test weight

The increase in harvest index due to

application of potassic fertilizer is given in table 2. The data revealed that the application of potassium increased the harvest index significantly over control. Application of potassium in three splits (50% as basal + 25% at tillering + 25% at panicle) recorded highest harvest index (0.46), followed by K application as 50% basal + 50% panicle, 50% basal + 50% tillering, 100% basal, NP(-K) and control. The differences in harvest index between hybrid and inbred rice was significant and HI of hybrid rice was 12.8% higher than inbred rice.

The interaction effect of variety and potassium fertilization was significant for HI. In inbred, harvest index was non-significantly affected by application of fertilizer without K and control and increased significantly in treatment receiving 100% basal and split application of K. In hybrid rice, harvest index was significantly higher in K omitted plot, basal and split application of potassium than that of control. At same level of potassium, harvest index was not significant in control but potassium omitted, 100% basal and split application of potassium was significantly higher in hybrid than that of inbred.

Amal *et al.* (2011) reported that non-significant effects on HI due to split application of potassium. But in present study, split application of potassium significantly increased the HI over control that might be due to improved translocation of photosynthates (Marschner, 1995) in terms of higher grain yield than straw yield. An increase in grain yield can be achieved by increasing the harvest index, which indicates the partitioning of assimilation products to grain, and/or total biomass production (Evans, 1993 and Richards, 2000). Peng *et al.* (2000) reported that the increasing trend in yield of rice cultivars released by the IRRI before 1980 was mainly due to the improvement in HI, while an increase in total biomass was

associated with yield trends for cultivars released after 1980. The authors also suggested that further increases in rice yield potential would likely occur through increasing biomass production rather than increasing HI.

The mean test weight of the rice varied from 20.41 to 22.41g in control and K treated plots with three split doses (50% basal+ 25% tillering +25% panicle), respectively (Table 2). Treatment receiving potassium as 100% basal and split applications showed significantly higher test weight than that of NP(-K) application and control. Test weight was highest in treatment receiving potassium in three splits which was 9.8% higher than control. The differences in test weight between hybrid and inbred rice was not significant. Potassium application in splits doses improved plant growth and facilitates quick transportation of nutrients and assimilates towards grain, which increases 1000 grain weight (g) (Marschner, 1995). The present findings are in confirmation with Khan *et al.* (2015). They reported that the rice plant ultimately proved more beneficial and resulted in a significant increase in 1000 grain weight which ultimately resulted in maximum paddy yield. This increase in 1000 grain weight was might be due to continuous supply of K to the crop during crop growth stages.

Plant height and panicle length

Plant height increased significantly by application of potassium over no potassium application and control (Table 3). The maximum plant height (120.65 cm) was observed in treatment receiving three split applications of potassium followed by two split, 100% basal, NP(-K) and control. The plant height of hybrid rice (116.16 cm) was significantly higher than inbred rice (112.71cm).

Table.1 Effect of K fertilization on grain and straw yield of rice

Treatment	Grain yield (t ha ⁻¹)			Straw yield (t ha ⁻¹)		
	Inbred	Hybrid	Mean	Inbred	Hybrid	Mean
Control	2.40	3.34	2.87	4.72	6.44	5.58
NP(-K)	3.58	4.63	4.11	6.23	6.06	6.14
NP + K 100% Basal	4.01	5.51	4.76	6.39	7.01	6.70
NP + K (50% Basal + 50% Tillering)	4.63	5.72	5.18	6.40	7.32	6.86
NP + K (50% Basal + 50% Panicle)	4.65	6.17	5.41	6.51	7.13	6.82
NP + K (50% Basal + 25% Tillering + 25% Panicle)	5.04	6.50	5.77	6.49	7.04	6.76
Mean	4.05	5.31		6.12	6.84	
	SE(m) ±	CD (P=0.05)	CV	SE(m) ±	CD (P=0.05)	CV
V	0.05	0.31	6.59	0.085	0.52	6.15
K	0.13	0.37		0.163	0.48	
V X K	0.18	NS		0.230	0.80	

V= Variety, K= Potassium

Table.2 Effect of K fertilization on harvest index (HI) and test weight of the rice

Treatment	HI			Test weight		
	Inbred	Hybrid	Mean	Inbred	Hybrid	Mean
Control	0.34	0.34	0.34	20.22	20.61	20.41
NP(-K)	0.36	0.43	0.40	20.66	20.92	20.79
NP + K 100% Basal	0.39	0.44	0.41	21.16	21.82	21.49
NP + K (50% Basal + 50% Tillering)	0.42	0.44	0.43	21.55	22.37	21.96
NP + K (50% Basal + 50% Panicle)	0.42	0.46	0.44	21.76	22.51	22.14
NP + K (50% Basal + 25% Tillering + 25% Panicle)	0.44	0.48	0.46	22.02	22.81	22.41
Mean	0.39	0.43		21.23	21.84	
	SE(m) ±	CD (P=0.05)	CV	SE(m) ±	CD (P=0.05)	CV
V	0.001	0.01	3.23	0.103	NS	3.03
K	0.006	0.02		0.266	0.78	
V X K	0.009	0.03		0.376	NS	

V= Variety, K= Potassium

Table.3 Effect of K fertilization on plant height and panicle length of rice plant

Treatment	Plant height (cm)			Panicle length (cm)		
	Inbred	Hybrid	Mean	Inbred	Hybrid	Mean
Control	103.80	104.27	104.03	25.07	25.98	25.53
NP(-K)	108.87	106.30	107.58	26.40	26.82	26.61
NP + K 100% Basal	113.97	117.57	115.77	26.62	27.22	26.92
NP + K (50% Basal + 50% Tillering)	115.33	122.20	118.77	26.70	27.44	27.07
NP + K (50% Basal + 50% Panicle)	117.07	122.53	119.80	26.75	27.54	27.15
NP + K (50% Basal + 25% Tillering + 25% Panicle)	117.23	124.07	120.65	27.48	27.57	27.53
Mean	112.71	116.16		26.50	27.10	
	SE(m) ±	CD (P=0.05)	CV	SE(m) ±	CD (P=0.05)	CV
V	0.24	1.43	5.56	0.12	NS	2.44
K	2.59	7.66		0.27	0.79	
V X K	3.67	NS		0.38	NS	

V=Variety, K=Potassium

Table.4 Effect of K fertilization on number of panicles and tillers m⁻²

Treatment	No. of panicles m ⁻²			No. of tillers m ⁻²		
	Inbred	Hybrid	Mean	Inbred	Hybrid	Mean
Control	166.83	184.33	175.58	193.67	204.17	198.92
NP(-K)	187.83	219.33	203.58	228.67	243.83	236.25
NP + K 100% Basal	230.42	249.67	240.04	259.58	267.17	263.38
NP + K (50% Basal + 50% Tillering)	240.33	256.67	248.50	264.83	288.17	276.50
NP + K (50% Basal + 50% Panicle)	245.00	264.83	254.92	270.67	277.67	274.17
NP + K (50% Basal + 25% Tillering + 25% Panicle)	248.50	276.50	262.50	273.00	298.67	285.83
Mean	219.82	241.89		248.40	263.28	
	SE(m) ±	CD (P=0.05)	CV	SE(m) ±	CD (P=0.05)	CV
V	1.62	9.84	5.03	4.65	NS	4.86
K	4.74	13.98		5.07	14.97	
V X K	6.70	NS		7.17	NS	

V= Variety, K= Potassium

The same trend exhibited in respect of all the other crop characters due to split application of K. Ghosh *et al.* (1982), Ram and Prasad (1985), Narang *et al.* (1997), and Nannabatcha *et al.* (1985) also reported the similar results in plant height with the three split applications of potassium. Bansal *et al.* (2001) reported increased plant height, when potassium applied in splits as compared to 100 % as basal. Krishnappa *et al.* (2006) suggested that potassium applied in split dressings were more effective in increasing the plant height than when applied at sowing time. Plant height was higher with the split application of potassium as compared to single basal application (Wani *et al.*, 2014).

The panicle length (27.53cm) observed under three split applications of potassium (50% basal +25% at tillering +25% at panicle) was significantly higher than NP(-K) and control but it was at par with treatment receiving K as 100% basal and two split applications (50% basal + 50% tillering, 50% basal + 50% panicle). The increase in panicle length between rice varieties and interaction effect between varieties and K application for panicle length was not significant (Table 3). The rice plant ultimately proved more beneficial and resulted in a significant increase in panicle length, number of grains per panicle and ultimately resulted in maximum paddy yield. The increment in panicle length may be due to continuous supply of K to the crop during crop growth stages (Manzoor *et al.*, 2008).

Number of panicles and tillers m⁻²

The number of panicle (mean) m⁻² was found to vary from 175.58 to 262.50 in control and K treated plots with three split doses (50% basal+ 25% tillering +25% panicle), respectively (Table 4). Potassium fertilization increased the panicle number significantly over NP (-K) and control. Application of potassium in three splits (50% as basal + 25% at tillering + 25% at panicle) recorded maximum no. of panicles

m⁻², which was 3.3,5.7, 9.4, 28.9 and 49.5% higher from the treatment receiving K as 50% basal + 50% panicle, 50% basal + 50% tillering, 100% basal, NP(-K) and control. The increase in panicle length in hybrid rice was significantly higher than inbred rice. The increase in number of panicles m⁻² was might be due to increase in potash uptake efficiency when applied in split application.

The number of tillers (mean) m⁻² was found to vary from 198.92 to 285.83 in control and K treated plots with three split doses (50% basal+ 25% tillering +25% panicle), respectively (Table 4). Application of potassium in three splits (50% basal + 25% tillering + 25% panicle) recorded maximum number of tillers m⁻², which was 3.4, 4.3, 8.5, 21.0 and 43.7% higher than the treatment receiving K as 50% basal + 50% tillering, 50% basal + 50% panicle, 100% basal, NP(-K) and control, respectively. The increase in number of tillers between rice varieties and interaction effect between varieties and K application was not significant.

Number of tillers m⁻² was higher with the split application of potassium as compared to single basal application (Wani *et al.*, 2014). Mutanal (1997) reported that split application of potassium (50 % basal + 25 % tillering + 25 % panicle) increased number of tillers compared to the basal application of potassium. Krishnappa *et al.* (1990) observed maximum number of tillers m⁻² with the split application of potassium than with the basal application. Though there was numerical increase in tillers due to split application, the difference in increase was not significant.

Maximum improvement in the growth parameters (plant height, number of tillers m⁻²), yield attributes (panicle length and test weight), and grain yield of rice crop was recorded under three split doses of K (50% basal + 25% tillering + 25% panicle) as compared to two splits and basal application.

Harvest index was also highest in the treatment with three split doses of K as compared to two splits or basal.

The hybrid rice performed better compared to inbred variety in respect of growth, yield attributes and yield. Thus, it can be concluded that synchronization of split applications of potassium (50% basal + 50% panicle or 50% basal + 25% tillering + 25% panicle) with nitrogen can result in significantly higher yield of rice compared to basal application.

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