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Effect of potassium levels and its uptake on correlation between tuber yield and yield attributing characters in potato (*Solanum tuberosum* L.) var. KUFRI PUKHRAJ

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ABSTRACT : Field experiment was conducted during winter season of 2009-10 and 2010-11 on potato variety Kufri Pukhraj at farmers' field in participatory mode on sandy loam soils to study the correlation of potassium (K) levels with yield attributing characters and tuber yield in potato (*Solanum tuberosum* L.) var. KUFRI PUKHRAJ. The treatments consisted of 4 graded levels of potassium as MOP (0, 50, 100 and 150 kg K_2O/ ha) at constant dose of nitrogen (150 kg/ha) and phosphorous (60 kg P_2O_5/ ha) in Randomized Block Design with 6 replications. The total tuber yield increased significantly with each increment of potassium dose. The increase in tuber yield was 19, 28 and 32 per cent at 50, 100 and 150 kg K_2O ha^{-1}, respectively over the control. The per cent contribution of large (>75g) grade tuber to the total tuber yield was increased from 33 per cent at 0 kg K_2O/ ha to 43 per cent at100 kg K_2O /ha. The yield of large size tuber increased by 43, 71 and 84 per cent at 50,100 and 150 kg K_2O /ha as compared to no K application. The large (>75g) and medium (25-75g) grade tuber as well as total aggregate tuber number enhanced markedly with each increment in K levels from 0 to 100 kg/ha. The small (<25g) size tuber number decreased with increasing K levels. Different levels of potassium showed increase in K uptake from 83 kg K_2O/ha in control to 149 kg K_2O /ha in potato cv. KUFRI PUKHRAJ. The correlation of average plant height, leaf area index(LAI), tuber yield per plant, average tuber weight per plant, plant population, bulking rate and potassium uptake with tuber yield were found to be positive and significant indicating that simultaneous improvement in all these characters would be possible by improvement in potassium uptake.

KEY WORDS : Potato, Tuber yield, Potassium levels, Potassium uptake

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Potato (*Solanum tuberosum* L.) is one of the most important and widely cultivated vegetable crops of Eastern Indo-Gangetic Plains of India. In this region, Bihar is the 3rd largest potato growing and producing state of India accounting for nearly 9.8 per cent of total potato area and 4.2 per cent of the total potato production in the country. As per the state-wise final estimates of potato for 2007-08 released by the Directorate of Economics & Statistics, Ministry of Agriculture, Govt. of India, New Delhi. Bihar state occupies 152.4 thousand hectare of potato area with an annual production of 1203 thousand tones and 7.89 t ha^{-1} productivity (Anonymous, 2008). The average productivity in the state is below the national average yield of 18.33 t ha^{-1} despite the fact that state is blessed with high fertile soil and good quality water resources, whereas the average productivity of the two neighboring states of Uttar Pradesh and West Bengal is more than 20.0t ha^{-1}. Low use of fertilizers and severe imbalance in the nitrogen(N), phosphorus (P) and K application ratio and unbalanced fertilization in favour of N and lack of potassium application are of the major reasons responsible for low production of potato in the state (Singh, 1999).

Potassium is an important nutritional factor in crop management, which contributes to production of high yields of quality potato. Potato crop demands high level of soil

nutrients due to relatively sparse and shallow root system in relation to yield. The high rate of dry matter production in potato results in large amount of nutrient removed per unit time, which generally most of the soils are not able to supply. A healthy crop of potato removes about 170-230 kg K_2O/ha from soil (Trehan *et al.*, 2008). Response of potato to optimum potassium application in the presence of optimal N and P doses, showed that yield increase was as much as 52q ha^{-1} in alluvial soils with 113 kg K_2O ha^{-1} (Grewal *et al*., 1991). Farmers of Bihar apply very less quantity of potassium fertilizers to potato crop. The current fertilizer rates are insufficient to sustain high potato production and to replenish nutrient removal by the crop (Imas and Bansal,2002).

Potato cultivar Kufri Pukhraj released by the Central Potato Research Institute, Shimla during 1998 is gaining popularity in majority of the districts of Bihar due to its high yielding potential. The information on potassium requirement of this cultivar in different parts of the state is lacking. Therefore, in order to fully exploit the yield potential of potato variety Kufri Pukhraj, it is essential to work out the effect of potassium application on K-uptake and the association among yield and yield contributing characters, since only limited information is available on the related characters. Keeping this in view, the present trail was conducted to study the effect of graded levels of potassium fertilizer on growth, yield, K-uptake and correlation between tuber yield and yield attributing characters in potato variety Kufri Pukhraj.

RESEARCH METHODS

A field experiment was conducted at the six farmer's field in Patna District of Bihar during winter season of 2009-10 and 2010-11 under irrigated condition with potato cultivar Kufri Pukhraj. The soil was sandy loam in texture, neutral in reaction having pH range of 7.1 to 7.3 and having mean organic carbon 0.28 per cent, available N 126 kg/ha, available P 11.0 kg/ha and available K 138 kg/ha. The treatments consisted of 4 graded levels of potassium (0, 50, 100 and 150 kg K_2O ha^{-1}) at constant dose of N (150 kg ha^{-1}) and phosphorous (60 kg P_2O_5 ha^{-1}) in Randomized Block Design with 6 replications. Each treatment was planted in $100m^2$. Full P and K and half of N of potato was applied at the time of planting and rest half N was top dressed at the time of earthing up one month after planting. The sources of N, P and K were urea, single super phosphate and muriate of potash, respectively. Well-sprouted tubers of seed size 50-60 g of Kufri Pukhraj were planted on 07th and 05th November during 2009 and 2010, respectively. The potato crop was dehaulmed at 90 days after planting on 05th and 03rd February during 2010 and 2011, respectively and harvested ten days after dehaulming. Recommended agronomic package of practices were adopted for potato cultivation. During the growth period leaf area index (LAI) was measured with AccuPAR LAI Ceptometer LP-80 at 45 and 60 days after planting (DAP). Yield parameters comprising of aggregate and grade wise tuber yield and tuber number of three grades of tuber namely very small (<25g), medium (25-75g) large (>75gm) size, and average tuber weight as well as economic parameters, gross return, net return and B:C ratio were recorded at harvest. The cost of cultivation was calculated by taking into account the prevailing market price of inputs and the produce. Price of different commodities taken for economics of potato production are, potato seed@ Rs 1000/q, N @ Rs. 10.92/kg, P_2O_5 @ Rs. 21.60/kg, K_2O @ Rs. 7.72/kg, Potato @ Rs. 400/q and other cultivation charge@ Rs. 35000/ha.

The N, P and K content of tuber and haulm of potato was determined by modified Kjeldahl, Vandomolybdate spectro photometry and flame photometer method, respectively as described by Singh *et al*. (2005). The statistical analysis of the mean data of two years was done using standard analysis of variance as per the procedure described by Gomez and Gomez, (1984)

For keeping quality assessment 5kg potato tuber of medium size was stored at ambient temperature. The produce of experiment was kept for storage studies after 15-20 days of curing in heaps after the harvest. The produce was stored for 90 days at ambient temperature. The average maximum and minimum temperature during the period of storage was 39.6 °C and 31.8 °C and the relative humidity was 67 per cent. Periodic observations were recorded on tuber rottage.

RESEARCH FINDINGS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarised under following heads:

Growth parameters:

Plant emergence was not influenced by potassium levels. Plant emergence ranged from 97.5 per cent to 98.8 per cent. Application of potassium had significant effect on plant height, number of leaves per plant, and LAI (Table 1). All the potassium doses promoted plant height and increased the number of leaves per plant and consequently LAI. The maximum plant height and number of leaves were recorded under the highest dose of potassium150 kg K_2O ha^{-1} (Table 1). However, plant height and number of leaver per plant recorded at 100 kg K_2O ha^{-1} was at par with 150 kg K_2O ha^{-1}. Stems/plant is a factor of variety, seed size and its physiological status; hence, stems per hill were not influenced by potassium levels. The tuber bulking rate was increased from 20.8g/m^2/day at 0 kg K_2O ha^{-1} to 30.5g /m^2/day at 100 kg K_2O ha^{-1} at 90 DAP. The maximum total dry matter production was recorded under the highest dose of potassium (150 kg K_2O ha^{-1}). However, total dry matter production recorded at100 Kg K_2O ha^{-1} was at par with 150 Kg K_2O ha^{-1}. Chetri and Thapa (2002) also reported increase in bulking rate and dry matter production due to increase in potassium rate. The lowest value of growth parameters was recorded for crops which received no potassium. Potassium

Table 1 : Growth attributes of potato, tuber bulking rate, average tuber weight, dry matter content, K-uptake and storage behavior at ambient temperature after 90 days storage, as influenced by graded levels of potassium application.(pooled data of two years)

Treatments	Plant height (cm)	Number of leaves per plant	Tuber bulking rate at 90DAP (g/m^2/day)	Average tuber wt (g)	Dry matter content in Tuber (%)	Potassium uptake (kg/ha)			Storage behaviour	
						Tuber	Haulm	Total	Per cent total wt. loss	Per cent rottage loss
K_0	31.2	37.6	20.8	47.3	15.1	54.7	30.6	85.3	35.85	25.44
K_{50}	35.6	42.2	27.6	53.7	15.5	79.4	37.8	117.2	31.99	18.94
K_{100}	38.8	46.4	30.5	57.0	15.9	98.6	41.7	140.3	29.74	16.23
K_{150}	39.4	47.5	31.4	59.8	15.9	105.1	44.8	149.9	27.28	13.92
SEm ±	1.02	1.34	1.3	1.4	0.1	3.1	1.2	4.1	-	-
CD (P=0.05)	3.1	4.1	4.1	4.3	0.2	9.6	3.7	12.5	-	-

K_0 = 0 kg K_2O ha^{-1}, K_{50} = 50 kg K_2O ha^{-1}, K_{100} = 100 kg K_2O ha^{-1} , K_{150} = 150 kg K_2O ha^{-1}

plays a crucial role in the energy status of the plant, translocation and storage of assimilates and maintenance of tissue water relation, aids in photosynthesis and enhances N uptake and protein synthesis resulting in better foliage growth (Marschner, 1995)

Yield parameters and tuber yield:

K application had significant effect on grade wise tuber yield and tuber number as well as total tuber yield and tuber number (Table 2). The large grade and total aggregate tuber yield and tuber number enhanced markedly with each increment in K levels from 0 to 150 kg/ha. The tuber yield increased from 212.8 q ha^{-1} (0 kg K_2O ha^{-1}) to 310.9 q ha^{-1} (150 kg K_2O ha^{-1}). The increase in tuber yield was 19, 28 and 32 per cent at 50, 100 and 150 kg K_2O ha^{-1}, respectively. The potassium application improved the tuber yield by increasing the large grade tuber yield and decreasing the small grade tuber yield. The per cent contribution of large grade tuber to the total tuber yield was increased from 33 per cent at 0 kg K_2O ha^{-1} to 43 per cent at100 kg K_2O ha^{-1}. The yield of large size tuber increased by 43, 71 and 84 per cent at 50,100 and 150 kg K_2O ha^{-1} as compared to no K application. However, the yield and tuber number of large grade tuber as well as total tuber obtained with 150 kg K_2O ha^{-1} was at par with that of 100 kg K_2O ha^{-1}. The increase in K level from 0 to100 kg/ha recorded significant increase in medium grade tuber yield. However, further increase in K dose from 100 kg K_2O ha^{-1} did not enhance the medium grade tuber yield and tuber number any more. The small size tuber yield and number decreased with increasing K levels. Imas and Bansal (2002) and Moinuddin *et al.* (2005)) also observed increase in potato tuber yield due to potassium application upto 120 kg K_2O ha^{-1}. Trehan and Grewal (1990) have reported that rapid bulking potato varieties producing large size tubers respond more to K than the varieties with small size tubers as application of K is known to increase the tuber size. Thus Kufri Pukhraj a high yielding potato variety responded favourably to potassium application.

Increase in total yield and the yield of large tubers due to K fertilization may stem from the stimulating effect of potassium on photosynthesis, phloem loading and translocation as well as synthesis of large molecular weight substances with in storage organs contributing to the rapid bulking of the tubers (Singh, 1999).

The harvest index, average tuber weight and dry matter content in tuber increased with increasing potassium levels up to 100 kg K_2O ha^{-1} (Table 1). At harvest tubers accounted for 73.7 per cent of total dry matter production with 100 kg K_2O ha^{-1}. Sharma and Sood (2002) also reported increase in harvest index and percentage dry matter with K application up to 100 kg K_2O ha^{-1}.

Potassium uptake:

There was significant variation in K-uptake among treatments. The K-uptake increased with increasing levels of potassium application (Table 1) The K-uptake was found to be significant up to100 kg K_2O ha^{-1}, further increase in K-

Table 2 : Grade wise yield, tuber number and economics of potato as influenced by potassium application (pooled data of two years)

Treatments	Grade wise tuber yield (q/ha)				Grade wise tuber population('000 /ha)				Gross return (Rs./ha)	Net return (Rs./ha)	Benefit cost ratio
	>75g	75-25g	<25g	Total	>75g	75-25g	<25g	Total			
K_0	72.1	120.5	20.2	212.8	57.0	197.0	196.0	450.0	85128	14221	1.20
K_{50}	103.3	142.7	17.2	263.2	80.1	232.4	177.5	490.0	105284	33914	1.48
K_{100}	123.3	158.0	12.8	294.0	95.1	268.2	152.7	516.0	117608	45775	1.64
K_{150}	133.0	167.3	10.6	310.9	105.8	279.2	135.4	520.4	124376	52079	1.72
S.E. ±	3.3	4.0	1.3	6.7	4.0	4.4	5.0	5.7	85128	14221	1.20
C.D. (P=0.05)	10.2	12.3	4.1	20.3	12.1	13.4	15.2	17.3	-	-	-

Table 3 : Correlation matrix (r) between yield and yield attributing characters of potato as influenced by potassium uptake

Sr. No.	Parameters	Tuber yield	Plant height	Leaf area index	Bulking rate	No. of tubers/plant	Wt. of tubers/plant	K-uptake	Plant population
1.	Tuber yield	-	0.998*	0.993*	0.997*	0.691	0.987*	0.988*	0.993*
2.	Plant height	-	-	0.995*	0.994*	0.677	0.986*	0.989*	0.889*
3.	Leaf area index	-	-	-	0.985*	0.651	0.990*	0.991*	0.922*
4.	Bulking rate (g/plant/day)	-	-	-	-	0.709*	0.986*	0.975*	0.875*
5.	No. of tubers/plant	-	-	-	-	-	0.903*	0.647	0.521
6.	Wt. of tubers/plant	-	-	-	-	-	-	0.970*	0.928*
7.	K-uptake	-	-	-	-	-	-	-	0.883*
8.	Plant population	-	-	-	-	-	-	-	-

levels, there was no significant increase in K-uptake. The highest total uptake of K (147.65 kg ha^{-1}) was recorded with the application of 150 kg K_2O ha^{-1} which was at par with the K- uptake recorded at 100 kg K_2O ha^{-1}.The lowest K-uptake was in control, where no K was applied. Tuber accounted for 73.3 per cent of total K removed by plants at 100 kg K_2O ha^{-1}. Imas and Bansal (2002) and Moinuddin *et al.* (2005) also observed increase in K-uptake in potato due to potassium application upto 120 kg K_2O ha^{-1}. Potassium uptake varied significantly among different fertility levels, perhaps due to variation in dry matter yield. Higher K content at higher level of K application together with higher dry matter production resulted in higher K uptake, while, potassium enhances N uptake and protein synthesis there by increasing the N uptake (Marschner, 1995).

Economics and keeping quality:

The increase in production due to potassium application increased the gross and net return and the benefit cost ratio (Table 2). Moinuddin *et al* (2005) also reported increased economic return due to potassium application

There was less weight loss and rottage of tubers with potassium application under ordinary storage condition at ambient temperature (Table 1). Potassium enhances storage quality of potato and also extend their self life (Martin-Prevel, 1989). The effect of potassium on self life is, both through slowing of senescence and through decrease of numerous physiological diseases (Martin-Prevel, 1989). Potassium application reduces storage losses of tubers and this was related to reduction in the activity of catalase and peroxidase enzymes (Perrenoud, 1993). Application of K tended to decrease gradually the weight loss of tubers from 20 per cent to 16 per cent (Grewal *et al.*, 1991).

Correlation studies:

The correlation coefficients for different characters combinations are given in Table 3. The correlation of average plant height(0.997), average leaf area index(0.993), bulking rate (0.996) weight of tubers/plant(0.986), K-uptake (0.987) and plant population at harvest(0.883) with yield were found to be positive and significant, which confirms the findings of Moinuddin *et al.* (2005). The significant association was due to significant and positive association of K-uptake with average plant height (0.988), average leaf area index(0.991), bulking rate(0.975) weight of tubers/plant(0.969), plant population at harvest (0.882) and tuber yield (0.987). Therefore, an improvement in any one of these characters with application of K will lead to simultaneous improvement of the other attributes resulting in increased yield.

Conclusion:

Hence it was concluded based on the two year data that potassium application at the rate 100 kg K_2O ha^{-1} as muriate of potash can be economically recommended for cultivation of potato variety Kufri Pukhraj under irrigated condition in the sandy loam soils of the Indo-Gangetic plains of Bihar to obtain higher yield and monetary return.

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