The Andhra Agric. J 59(2):236-241, 2012

Relationship of Forms of Potassium with Its Uptake by Potato Crop in Alfisols of Andhra Pradesh

D Vijaya Lakshmi, G Padmaja and P Chandrasekhar Rao

Department of Soil Science & Agricultural Chemistry, College of Agriculture, Rajendranagar, ANGRAU, Hyderabad- 500 030, Andhra Pradesh

ABSTRACT

A field experiment was conducted on a sandy loam soil during *rabi* season of 2009-10 with four levels of potassium (0, 60, 120 and 180 kg K_2O ha^{-1}) and four levels of nitrogen (0, 60, 120 and 180 kg N ha^{-1}). The soil samples collected at stolonisation, Tuberisation and at harvest stages of potato were analyzed for different forms of K. The simple correlation study indicated that uptake of potassium by potato haulm and roots at stolonisation did not bear relationship with all the potassium forms except water soluble K. However, exchangeable K and 1*N* HNO_3 K played a significant role in meeting K needs at tuberisation stage and at harvest. The non-exchangeable K content found to be significant at harvest stage. The potassium dynamic equilibrium following potassium fertilization shifted towards non-exchangeable K with the advancement of the crop growth.

Key words : Forms of K, K uptake, Potato

Potato produces more drymatter per unit area per unit time as compared to cereals. This high rate of drymatter production results in large amount of nutrient removal per unit time and most of the soils are unable to meet the demand. Hence, nutrient application from external sources through fertilizers becomes essential. Potato production depends on many factors, among them judicious application of N and K plays a vital role. Potato crop is a heavy feeder of soil potassium and the tuber removes 1 to 5 times the amount of nitrogen and 4 to 5 times the amount of phosphate. Potato also acts as an indicator crop for K availability because of its high K requirement (Fageria *et al*., 1997).

Based on availability of K to plants, soil potassium can be classified into three groups *viz*. un available, readily available and slowely available K. The different forms, however, are in dynamic equilibrium with one another and a change in one form results in a change to another form. Potato is a heavy feeder of K and when readily available / exchangeable potassium is removed by crops, more potassium would become exchangeable from non-exchangeable form. Keeping this fact in view, an experiment was conducted to study the relationship between forms potassium and its uptake by potato crop grown in alfisols of Andhra Pradesh.

MATERIAL AND METHODS

A field experiment was conducted on a sandy loam soil (Alfisol) at Collage Farm, College of Agriculture, Rajendranagar, Hyderabad during *rabi* season of 2009-10. The experiment was laid out in randomized block design with factorial concept consisting of sixteen treatment combinations involving four levels of potassium (0, 60, 120 and 180 kg ha^{-1}) and four levels of nitrogen (0, 60, 120 and 180 kg ha^{-1}). Nitrogen and potassium were applied in the form of urea and muriate of potash in 3 splits as per treatment combinations. A basal dose of 60 kg P_2O_5 ha^{-1} was applied in the form of single super phosphate to all the treatmental plots.

The experimental soil was sandy loam in texture, slightly alkaline (7.9 pH) in reaction, non-saline (0.58 dS m^{-1}) and low in organic carbon (3.5 g kg^{-1}). The soil under study was low in available nitrogen (200.7 kg N ha^{-1}) and medium in available phosphorus (32.19 kg P_2O_5 ha^{-1}) and potassium (272.5 kg K_2O ha^{-1}). The soil was analyzed for different fractions (mg kg^{-1}) of potassium. Among the potassium fractions, water soluble K and exchangeable K found to be 9.92 and 72.70 mg kg^{-1}, respectively. The fixed forms of K_2O *viz*., 1*N* HNO_3 extractable K and non-exchangeable K values were 508.20 and 329.50 mg kg^{-1}, respectively.

The soil samples (0-15 cm depth) were collected at stolonisation, tuberisation and harvest stages of potato crop were analyzed for different forms of K. *viz*., water soluble K (1:10 soil: water suspension; Jackson, 1967), available K (neutral normal NH_4OAc; Jackson, 1967) and 1*N* HNO_3 K (Wood and De Turk, 1941). Exchangeable K was

Table 1. Effect of levels of nitrogen, potassium and their interactions on K uptake (kg ha^{-1}) by potato haulm at 30, 60 DAS and at harvest

Levels	Stolonisation (30 DAS)					Tuberisation (60 DAS)					At harvest				
	K_0	K_1	K_2	K_3	Mean	K_0	K_1	K_2	K_3	Mean	K_0	K_1	K_2	K_3	Mean
N_0	2.14	3.34	4.19	4.90	3.64	5.59	8.32	9.45	10.65	8.50	5.17	6.28	7.05	8.15	6.66
N_1	3.63	4.96	5.55	6.42	5.14	9.70	11.75	13.21	14.58	12.31	7.28	8.72	10.50	11.24	9.51
N_2	4.16	4.89	6.94	8.39	6.10	10.88	14.15	16.21	17.24	14.62	8.54	11.15	13.02	13.70	11.60
N_3	4.81	7.62	9.81	10.36	8.15	14.66	16.10	18.30	18.95	17.00	11.80	12.81	14.48	14.91	13.50
Mean	3.68	5.20	6.62	7.52		10.21	12.58	14.29	15.36		8.20	9.74	11.26	12.08	
	S.Ed±		CD (0.05)			S.Ed±		CD (0.05)			S.Ed±		CD (0.05)		
N	0.17		0.34			0.13		0.27			0.13		0.26		
K	0.17		0.34			0.13		0.27			0.13		0.26		
N×K	0.33		0.68			0.27		0.55			0.25		0.51		

Table 2. Effect of levels of nitrogen, potassium and their interactions on K uptake (kg ha^{-1}) by potato tuber at 30, 60 DAS and at harvest

Levels	Stolonisation (30 DAS)					Tuberisation (60 DAS)					At harvest				
	K_0	K_1	K_2	K_3	Mean	K_0	K_1	K_2	K_3	Mean	K_0	K_1	K_2	K_3	Mean
N_0	1.49	2.67	3.37	3.68	2.80	15.72	20.17	22.92	23.95	20.69	27.49	31.28	34.48	37.95	32.80
N_1	2.68	2.98	3.94	4.13	3.43	21.40	23.53	28.48	32.66	26.52	34.19	40.89	42.34	45.70	40.78
N_2	3.29	4.07	4.53	4.93	4.20	26.61	31.36	39.07	41.95	34.75	40.03	45.85	51.97	55.69	48.39
N_3	4.15	4.65	5.44	5.77	5.00	29.52	34.30	40.67	46.87	37.84	47.28	56.23	62.24	64.40	57.53
Mean	2.90	3.59	4.32	4.63		23.31	27.34	32.79	36.36		37.25	43.56	47.76	50.94	
	S.Ed±		CD (0.05)			S.Ed±		CD (0.05)			S.Ed±		CD (0.05)		
N	0.08		0.17			0.74		1.51			0.21		0.43		
K	0.08		0.17			0.74		1.51			0.21		0.43		
N×K	0.17		0.34			1.47		3.01			0.42		0.86		

Table 3. Effect of levels of nitrogen, potassium and their interactions on potassium fractions (mg kg^{-1}) in soil at stolonisation stage

	Water soluble-K					Exchangeable-K				
Levels	K_0	K_1	K_2	K_3	Mean	K_0	K_1	K_2	K_3	Mean
N_0	32.74	34.42	36.75	39.47	35.85	87.26	86.54	89.17	88.30	87.82
N_1	34.06	36.32	38.89	40.74	37.51	88.42	90.95	88.71	88.49	89.14
N_2	36.90	39.91	41.45	43.47	40.43	89.04	89.71	90.92	91.62	90.33
N_3	37.34	41.26	45.68	45.72	42.49	88.24	89.07	89.60	89.47	89.10
Mean	35.26	37.98	40.69	42.35		88.24	89.07	89.60	89.47	
	S.Ed±		CD (0.05)		S.Ed±			CD (0.05)		
N	0.52		1.06		0.15			0.31		
K	0.52		1.06		0.17			0.35		
N×K	1.04		2.16		0.30			N.S.		

	1 N HNO_3 extractable-K					Non – exchangeable K				
Levels	K_0	K_1	K_2	K_3	Mean	K_0	K_1	K_2	K_3	Mean
N_0	507.3	506.2	509.9	509.1	508.1	395.7	395.2	395.9	395.9	395.7
N_1	521.7	521.4	522.2	522.0	521.8	394.1	394.6	395.7	396.8	395.3
N_2	523.5	522.0	524.1	523.6	523.3	395.7	396.3	395.4	395.5	395.7
N_3	533.1	534.3	532.5	535.2	533.8	394.2	393	394.5	394.1	394.0
Mean	521.4	521.0	522.2	522.5		394.9	394.8	395.4	395.6	
	S.Ed±		CD (0.05)		S.Ed±			CD (0.05)		
N	1.44		2.95		0.54			N.S.		
K	1.44		2.95		0.63			N.S.		
N×K	2.89		N.S.		1.09			N.S.		

calculated by subtracting water soluble K from available K while non-exchangeable K was calculated by subtracting available K from 1*N* HNO_3 K. Three representative plant samples were uprooted from each plot at each stage i.e. stolonisation, tuberisation and harvest and these samples were washed with water and tubers separated from haulms. Dry matter production at each stage was worked out on the basis of plant population per hectare. The potassium content was determined in haulms, roots and tubers as per the procedure outlined by Jackson (1967). The relationships between forms of potassium and its uptake at different growth stages of crop were worked out through simple correlation coefficients.

RESULTS AND DISCUSSION

K - uptake

The results on nutrient uptake by potato haulms and tuber revealed that application of different levels of nitrogen, potassium and their interactions significantly increased the K uptake by potato at all the stages of crop growth viz., 30, 60 DAS and at harvest (Table 1&2). The values of K uptake by potato haulm revealed that there was an increase in K uptake upto 60 DAS and decreased at harvest. Potassium uptake by potato tuber increased with the age of the crop and highest uptake was attained at harvest.

The per cent increase in K uptake by potato haulm at K_3 level was 104.1, 50.4 and 47.3 per cent over K_0, at 30, 60 DAS and at harvest, respectively.

Table 4. Effect of levels of nitrogen, potassium and their interactions on potassium fractions (mg kg^{-1}) in soil at tuberisation stage.

	Water soluble-K					Exchangeable-K				
Levels	K_0	K_1	K_2	K_3	Mean	K_0	K_1	K_2	K_3	Mean
N_0	15.14	17.37	18.84	19.89	17.81	81.32	84.68	90.36	95.44	87.95
N_1	21.35	23.55	24.46	25.01	23.59	81.54	86.76	92.05	96.92	89.32
N_2	23.42	25.53	25.01	24.53	24.62	79.65	85.20	96.30	98.86	90.00
N_3	23.36	24.5	26.9	26.25	25.25	79.47	90.86	96.13	97.85	91.08
Mean	20.82	22.74	23.80	23.92		80.50	86.87	93.71	97.27	
		S.Ed±	CD (0.05)		S.Ed±			CD (0.05)		
N		0.65	1.33		0.61			1.25		
K		0.65	1.33		0.61			1.25		
N×K		1.30	2.67		1.22			2.49		

	1 N HNO_3 extractable-K					Non – exchangeable K				
Levels	K_0	K_1	K_2	K_3	Mean	K_0	K_1	K_2	K_3	Mean
N_0	487.0	518.3	538.1	562.9	526.6	317.9	334.8	339.3	343.9	334.0
N_1	490.4	522.9	543.1	563.2	529.9	318.4	333.4	338.1	341.0	332.7
N_2	493.2	523.3	546.6	573.5	534.1	318.8	326.5	323.2	336.3	326.2
N_3	498.6	529.7	547.9	583.0	539.8	316.6	317.8	318.2	343.7	324.1
Mean	492.3	523.6	543.9	570.6		317.9	328.1	329.7	341.2	
		S.Ed±	CD (0.05)		S.Ed±			CD (0.05)		
N		4.03	8.23		4.19			N.S.		
K		4.03	8.23		4.19			8.56		
N×K		8.06	N.S.		8.39			N.S.		

The K uptake by potato tuber at K_3 level increased to an extent of 59.7, 55.9 and 36.6 per cent over K_0, at 30, 60 DAS and at harvest, respectively. The K uptake by potato (haulm + tuber) at harvest showed an increase with increasing levels of nitrogen up to 180 kg N ha^{-1} (N_3) and the over N_0, respectively. Combined application of nitrogen and potassium had synergistic effect on nutrient uptake. Among the combinations, N_3K_3 has recorded higher uptake of K, the per cent increase being 142.8 at harvest, over N_0K_0. The higher uptake at higher N and K levels was due to better absorption of N and K from the fertilizers during the different growth stages of the crop (Chadha *et al*. 2006). Similar results were also reported by Brar and Kaur (2006), Kumar *et al*., (2009) and Sud and Sharma (2002).

Forms of N and K

The contents of different forms of potassium (water soluble K, exchangeable K, 1*N* HNO_3 K and non exchangeable K) at different crop growth stages significantly increased from K_0 to K_3, the increase being 31.57, 161.2, 21.2, 15.4 and 4.3 per cent, respectively (Table 3 to 5). The interaction effect of N×K revealed that there was significant increase in contents of all forms of K in soil at harvest. The results revealed that, higher levels of N and K application increased the N and K fertility status of the soil and supported the nutrient demands of potato. Similar results were reported by Padmaja and Raju, (1998).

Table 5. Effect of levels of nitrogen, potassium and their interactions on potassium fractions (mg kg^{-1}) in soil at harvest

	Water soluble-K					Exchangeable-K				
Levels	K_0	K_1	K_2	K_3	Mean	K_0	K_1	K_2	K_3	Mean
N_0	13.25	17.11	19.04	14.07	15.87	104.4	104.5	104.7	104.8	104.6
N_1	14.46	17.99	18.45	14.18	16.27	105.9	105.6	106.4	108.6	106.6
N_2	15.52	19.20	19.41	19.73	18.46	108.5	108.4	109.4	109.2	108.9
N_3	16.56	19.09	20.72	21.8	19.54	112.4	112.3	113.9	114.1	113.2
Mean	14.95	18.35	19.40	17.45		107.8	107.7	108.6	109.2	
		S.Ed±	CD (0.05)		S.Ed±			CD (0.05)		
N		0.45	0.91		0.32			0.66		
K		0.45	0.91		0.32			0.66		
N×K		0.89	1.82		0.64			1.31		

	1 N HNO_3 extractable-K					Non – exchangeable K				
Levels	K_0	K_1	K_2	K_3	Mean	K_0	K_1	K_2	K_3	Mean
N_0	484.1	487.3	486.0	490.3	486.8	364.7	365.7	366.0	367.6	366.0
N_1	511.0	511.3	514.1	514.0	512.6	380.4	380.5	381.5	381.7	381.0
N_2	516.0	521.7	521.3	520.1	519.8	380.1	383.0	384.1	384.5	382.9
N_3	531.3	534.2	537.0	538.7	535.3	383.2	384.9	386.4	386.6	385.3
Mean	510.6	513.6	514.6	515.8		377.1	378.6	379.5	380.1	
		S.Ed±	CD (0.05)		S.Ed±			CD (0.05)		
N		1.60	3.27		0.72			1.47		
K		1.60	3.27		0.72			1.47		
N×K		3.20	6.56		1.44			2.95		

Table 6. Coefficient of simple correlation between forms of N and K with its uptake of nutrients by potato at different growth stages

Uptake at different crop growth stages		Forms of potassium			
		Water soluble-K	Exchange-able-K	1 N HNO_3 extractable-K	Non – ex-changeable K
Stolonization	Haulm	0.965**	0.562	0.421	-0.332
	Roots	0.963**	0.538	0.496	-0.254
Tuberization	Haulm	0.907**	0.646*	0.649*	0.065
	Tuber	0.831**	0.704*	0.706*	0.127
Harvest	Haulm	0.711*	0.890**	0.894**	0.858**
	Tuber	0.744*	0.912**	0.887**	0.824**

* Significant at 5 percent level ** Significant at 1 percent level

*0.576 – significant at 5 percent level **0.708 – significant at 1 percent level

Correlation studies

Correlation studies revealed that the different forms of potassium contributed to increase in K uptake by potato haulm and tuber at different growth stages (Table 6). It is evident from the table 6 that potassium uptake at stolonisation (haulms+roots) did not bear relation ship with potassium forms except water soluble K. At second stage *i.e*. tuberisation, different forms of potassium except non-exchangeable K, contributed significantly towards potassium uptake. The water soluble K and exchangeable K showed the highest relationship while 1N HNO_3 K showed minimum. At harvest stage, all the forms of potassium exhibited significantly positive relationship with K uptake by potato haulms and tubers. The highest relationship of potassium uptake by potato haulm and tuber at this stage was observed with exchangeable K, the r values being 0.890** and 0.912**, respectively and the minimum r values was showed with water soluble K.

The uptake of potassium by potato haulm and roots at stolonisation did not show the relationship with all the potassium forms except water soluble K. However, exchangeable K and 1*N* HNO_3 K played a significant role in meeting the K needs at tuberisation stage and also at harvest. The non-exchangeable K found to be significant at harvest stage. Correlation studies between potassium form and uptake were also reported by Rao and Subramanian (1991).

The process of transformation of added K into different K fractions is a continuous process since there is an increase in the contents of fractions due to application of fertilizers. The potassium dynamic equilibrium following potassium fertilization shifted towards non-exchangeable K with the advancement of the crop growth.

LITERATURE CITED

Brar M S and Kaur N 2006. Effect of soil and foliar applied potassium and nitrogen on yield of potato (*Solanum tuberosum*) in alluvial soils of Punjab. *Indian Journal Agricultural Research* **76**(12): 740-743.

Chadha S, Rana S S, Rameshwar D and Chaudhary D R 2006. Effect of split doses of N and K and FYM levels on the productivity of seed potato in cold desert regions of Himachal Pradesh. *Potato Journal* 33(1-2): 94-96.

Fageria N K, Baligar V C and Jones CA 1997. *Growth and Mineral Nutrition of Field Crops,* 2nd Edition. Marcel Dekker Inc., Rome.

Jackson M L 1967. *Soil Chemical Analysis*. Prentice Hall Inc.Englewood, Cliffs, New Heresy, U.S.A.

Kumar M, Trehan S P, Jatav MK and Lal S S 2009. Efficacy of potato (*Solanum tuberosum*) cultivars under varying levels of nitrogen and growth duration in Eastern Indo-Gangetic plains. *Indian Journal of Agronomy* 54(1): 63-68.

Padmaja G and Raju A S 1998. Depletion of potassium from Alfisols under two vegetable cropping sequences. *Journal of Research* 26 (2): 42-47.

Rao M H and Subramanian T R 1991. Effect of potassium application on the yield and content of potassium, calcium and magnesium in cabbage, okra, tomato and beet root. *Journal of Potassium Research* 7:190-197.

Sud K C and Sharma R C 2002. Sulphur needs of potato under rainfed conditions in Shimla hills. *In potato, Global Research and Development*, *Volume II*, 889-899.

Wood LK and De Turk E E 1941. The absorption of potassium in soils in non replaceable forms. *Proceedings of Soil Science Society of America* 5: 152-161.

(Received on 25.08.2011 and revised on 08.09.2011)