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NUTRITIONAL QUALITY AND NUTRIENT USE EFFICIENCY OF PIGEONPEA AS INFLUENCED BY POTASSIUM AND SULPHUR

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ABSTRACT

A field experiment was conducted during *kharif* season of 2014-15 to study the response of potassium and sulphur on nutritional quality and nutrient use efficiency in pigeonpea .The experiment was laid out in a factorial randomized block design replicated thrice. The treatment comprised of four levels of potassium viz., K_0-no potassium, K_{15}-15 kg ha^{-1}, K_{30}-30 kg ha^{-1} and K_{45}-45 kg ha^{-1} potassium and three levels of sulphur viz., S_{10}- 10 kg ha^{-1}, S_{20}- 20 kg ha^{-1}, and S_{30}- 30 kg ha^{-1} sulphur. The grain yield of pigeonpea 11.05 q ha^{-1} was significantly increased with the application of 30 kg K_2O ha^{-1} along with recommended dose of N_{25} and P_{50} kg ha^{-1} and significantly increased in yield of pigeonpea 10.80 q ha^{-1} under 20 kg S ha^{-1} along with recommended dose of N_{25} and P_{50} kg ha^{-1}. Maximum protein content was obtained with the application of 45 kg K_2O and 30 kg S ha^{-1} individually having 20.60 and 22.22 %, respectively. Methionine (1.163 mg 100 g^{-1}) and cysteine (1.360 mg 100 g^{-1}) content in pigeonpea increased with the combination of K_{45} S_{20} for methionine and K_{45} S_{30} for cysteine along with the application of 25 kg N and 50 kg P ha^{-1}. Nutrient use efficiency of N, P and K was observed maximum with the application at 30 kg ha^{-1}.Significantly highest grain yield of pigeonpea 11.78 q ha^{-1} was obtained with the interaction of K_{45} S_{20} and it found at par with K_{45} S_{10} , K_{30} S_{20} , K_{30} S_{30} and K_{15} S_{30}. Interaction effect between potassium and sulphur was found significant with respect to methionine, cysteine, calcium and magnesium content in pigeonpea. Maximum total uptake of N (105.67 kg ha^{-1}) in pigeonpea was obtained with combined application of 20 kg S and 45 kg K_2O ha^{-1}.

(Key words: Nutritional quality, nutrient use efficiency, potassium, sulphur, pigeonpea)

INTRODUCTION

Pigeonpea crop is generally cultivated as intercrop with cotton, soybean, sorghum and others. Farmers applied fertilizers to main crop and pigeonpea remains under fertilized. Now a days with increasing demand and prices of pigeonpea, it has been taken as a sole crop with N and P fertilization @ 25 : 50 : 00 kg ha^{-1}.Unlike these nutrients, potassium does not directly participated in formation of a bio molecule, however, it is involved in all processes needed to sustain the plant life. Potassium nutrition is associated with grain quality including the protein. Effective response to K application sets in when levels of potassium satisfies the potassium hunger in soil (Ravichandran and Sriramchandrasekharan, 2011). Inadequate sulphur content (less than 10 ppm) cannot provide sufficient sulphur to meet crop demand resulting in suboptimal yield and quality. Optimum supply of sulphur improves yield and quality of pulse grain. The sulphur use efficiency was observed higher at application 35 kg S ha^{-1} in pigeonpea- groundnut intercropping system (Jat and Ahalawat, 2010). In view of the above the present study was carried out to understand the nutrient use efficiency and quality of pigeonpea.

MATERIALS AND METHODS

Field experiment was conducted during *kharif* season of 2014-15 at Agronomy farm, College of Agriculture, Nagpur in a factorial randomized block design replicated thrice. The pigeonpea variety PKV-Tara was sown by drilling method. The treatment consisted of four levels of potassium viz., K_0- no potassium, K_{15}-15 kg ha^{-1}, K_{30}- 30 kg ha^{-1} and K_{45}- 45 kg ha^{-1} potassium, and three levels of sulphur viz., S_{10}- 10 kg ha^{-1}, S_{20}- 20 kg ha^{-1}, and S_{30}- 30 kg ha^{-1} sulphur. The recommended dose (25 : 50 kg NP hectare^{-1}) was applied to all the treatments. The rainfall distribution during the cropping season was normal and means annual precipitation was 938.4 mm within 37 rainy days. The crop was rainfed during its whole cropping period. The source of fertilizer was Muriate of potash, Bentonite sulphur, Urea and DAP. The soil of the experimental site was clayey, slightly alkaline in reaction and medium in organic carbon and low in available N and P and high in available K. The available sulphur in soil was at critical level of 10.2 mg kg^{-1}.

Treatment wise separate grain and straw samples were collected for analysis of different parameters. Nitrogen was determined using Kjeldahl's method (Piper, 1966). Phosphorus was estimated using vanodo molybdate yellow colour method (Jackson,1973). Potassium was estimated from

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diacid extact using flamephotometer (Jackson, 1973). Calcium was determined by EDTA method and magnesium was determined by ammonium phosphate method (Jackson, 1973). Protein % was estimated using nitrogen content in grain multiplied with the factor 6.25 (Piper, 1966). Methionine and cysteine was determined using calorimetric (Tsai, 1972). Protein yield was calculated using the formula, grain yield (q ha^{-1}) x protein %. Nutrient use efficiency was estimated using the formula, nutrient uptake of fertilizer plot – nutrient uptake of control plot x 100 / fertilizer applied in kg ha^{-1}. Total uptake of nutrient (kg ha^{-1}) was calculated by concentration of nutrient % x yield of grain and straw, q ha^{-1}.

RESULTS AND DISCUSSION

Grain yield of pigeonpea (q ha^{-1})

The results indicated that (Table1), the grain yield of pigeonpea was significantly influenced due to application of levels of potassium and sulphur along with the application of RDF (25 kg N and 50 kg P_2O_5 ha^{-1}). More grain yield of pigeonpea (11.05 q ha^{-1}) was obtained with the application of 30 kg K_2O ha^{-1} along with RDF (25 kg N and 50 kg P_2O_5 ha^{-1}) which was found at par with the level of 45 kg K_2O ha^{1} indicating the response of potassium to pigeonpea. The increase in the grain yield of pigeonpea may be ascribed to the effect of balanced used of NPK, encourages the root development at plant, enzyme transformation and metabolic process, greatest transport of sugar and starch synthesis. Potassium applied @ 15, 30 and 45 kg ha^{-1} resulted significant increase in the grain yield of pigeonpea to the tune of 5.13, 14.66 and 14.11 per cent, respectively over no use of potassium.

Interaction effect between the potassium and sulphur resulted significant on grain yield of pigeonpea (Table1). The highest yield of pigeonpea 11.78 q ha^{-1} was recorded with combined application of K_{45} S_{20} and it found at par with K_{45} S_{10} , K_{30} S_{20} , K_{30} S_{30} and K_{15} S_{30}. The data further indicated that the application of different levels of sulphur with no use of potassium resulted lower yield. The data was also observed that the combined application of high level of sulphur and potassium caused antagonistic effect on grain yield of pigeonpea. There was an increase in yield by 14.09 and 18.80 per cent with the application of K_{45} S_{20} and K_{45} S_{10} over the application of K_{15} S_{20} and K_{15} S_{10}, respectively. Umesh *et al.* (2013) revealed that increased quantity of N application from 25 to 50 kg ha^{-1}, P from 50 to 100 kg ha^{-1} and K from 25 to 75 kg ha^{-1} increased grain yield of pigeonpea to the extent of 34, 22 and 20 %, respectively. They also reported that the application of 10 kg S ha^{-1} was significantly improved the pigeonpea grain yield (12%) as compared to no use of sulphur.

Significantly increase in yield of pigeonpea (10.80 q ha^{-1}) under 20 kg S ha^{-1} and it was found at par with 30 kg S ha^{-1}. Maximum increase in grain yield was 7.87 per cent due to application of 20 kg S ha^{-1} over 10 kg S ha^{-1} applied. Deshbharat *et al.*(2010) reported that the grain yield (11.18 q ha^{-1}) was significantly increased upto 20 kg S ha^{-1}.Higher rates of sulphur application caused antagonistic effect.The results revealed that the straw yield of pigeonpea was obtained highest (48.07 q ha^{-1}) under higher level of K_{45} S_{30} along with 25 kg N and 50 kg P_2O_5 ha^{-1}. This was an increase in straw yield of pigeonpea by 21.99 per cent over sulphur applied at 30 kg ha^{-1} with no use of potassium.

Total uptake of nutrients

The total uptake of N increased by 5.09, 18.02, and 19.00 per cent with the application of 15, 30 and 45 kg K_2O ha^{-1}, respectively over no supply of potassium. This increased in nitrogen uptake might be due to increase in content and yield, the favorable effect of balanced nutrient fertilizer on N uptake might be owing to better nutritional environment in plant and significant effect on root formation. Singh and Singh *et al.* (2012) obtained total uptake of nitrogen (177.2 kg ha^{-1}) by pigeonpea with the use of N-30, P-15, K-40, S-30 fertilizer applied. The application of 30 kg S ha^{-1} gave higher total uptake of nitrogen (95.55 kg ha^{-1})and significantly superior over rest of the levels of sulphur.

Interaction effect of potassium in combination with sulphur found significant with respect to uptake of nitrogen. The maximum total uptake of N in pigeonpea (105.67 kg ha^{-1}) was obtained with the application of 20 kg S and 45 kg K_2O ha^{-1} and found at par with 30 kg K_2O + sulphur applied @10, 20 or 30 kg ha^{-1}. The increase in total uptake of pigeonpea would be attributed to the higher in coupled with improvement in nutrient concentration of grain and non grain parts. Umesh *et al.* (2013) recorded total uptake of nitrogen 102.5 kg ha^{-1}, with the use of N-37.5, P-75, K-25, S-10 and zinc-12.5 kg ha^{-1}.

Highest total uptake of P (31.24 kg ha^{-1}) was observed with 45 kg K_2O ha^{-1}along with RDF which was found at par with 30 kg K_2O ha^{-1}. It is well documented that the total phosphorus uptake by crop dependence on dry matter accumulation and concentration of phosphorus in the plant part and increased availability of phosphorus in the soil due to solubilization of the added phosphorus by phosphorus solubalizer through the production of organic acid. Increase in potassium from 0 to 45 kg ha^{-1} increase the uptake by 15.42 per cent. Singh and Singh (2012) recorded 26.8 kg ha^{-1} total phosphorus uptake with the use of N -30, P-75, K-40 and S-30 and were found at par with N-30, P-50, K-40 and S-30.Total uptake of phosphorus was significantly increased by increase in levels of sulphur. Interaction effect of potassium and sulphur found non-significant with respect to uptake of phosphorus.Sathe *et al.*(2011) also recorded maximum uptake of P(13.81 kg ha^{-1}) with 100% RD of P_2O_5 through fertilizer and PSB which was significantly superior over 75 and 50 % RDF and PSB.

The total uptake of K was significantly increased with the increasing level of potassium and sulphur. The maximum value of total uptake of potassium (72.02 kg ha^{-1}) was observed with 45 kg K_2O ha^{-1}along with RDF which was found at par with 30 kg K_2O ha^{-1}. There was an increased the total uptake of potassium by 10.73, 24.06 and 25.15 %

with the application of 15, 30 and 45 kg K ha^{-1}, respectively over no use of potassium. Kumar *et al.* (2013) revealed that uptake of N, P and K increased with the application of NPK and S. The application of S @ 30 kg S ha^{-1} enhanced the total uptake of K. Interaction effect of potassium and sulphur exhibited non significant on total uptake of potassium.

Nutritional quality parameter of pigeonpea

Protein content (%)

The results obtained in respect to protein content in grains of pigeonpea as influenced by different levels of potassium and sulphur are presented in table 2.The protein content of pigeonpea grains significantly increased over the control. The protein content varied from 19.51 to 20.60 % with minimum under no use of K_2O and maximum with 45 kg K_2O ha^{-1}. This increase in grain protein content might be due to enhanced nutrient use efficiency as a consequence of increased potassium application. Maximum protein content was obtained with the application of 45 kg K_2O and 30 kg S ha^{-1}individually having 20.60 and 22.22 % respectively. In respect to potassium maximum increase in protein content was 5.29 % due to application of potassium @ 45 kg ha^{-1}. Interaction effect of K and S exhibited non significant on protein content. Mallesha *et al.* (2014) reported that the protein content in pigeonpea grains recorded 18.08 to 19.1% with the use of inorganic fertilizer @ 25:50:50 kg ha^{-1} along with different rates of foliar spray of water soluble (19:19:19) fertilizer.From the data (Table 2), the protein yield varied from 183.97 to 226.19 kg ha^{-1} with the application of 0 to 45 kg K_2O ha^{-1}. This increase in protein yield was mainly due to higher grain yield. Protein yield was minimum under combination of K_0S_{10} kg ha^{-1}(179.67 kg ha^{-1}) and maximum under combination of $K_{30}S_{30}$ kg ha^{-1}(227.50 kg ha^{-1}).Balpande *et al.(*2016) reported an increase in protein yield by 8.01 per cent with the application of 45 kg K_2O ha^{-1} over the application of potassium applied @ 15 kg ha^{-1}.

Sulphur containing amino acids (Methionine and cysteine)

The data in respect of sulphur containing amino acid i.e. methionine and cysteine content are summarized in table 3. It was observed that nutritional quality characters showed increasing trend with increasing level of nutrients being lowest in no use of potassium and higher at 45 kg K_2O ha^{-1} (1.154 mg 100 g^{-1}) and 20 kg S ha^{-1} (1.136 mg 100 g^{-1}).

The methionine content in pigeonpea grain was varied from 1.100 to 1.154 mg 100 g^{-1}. Maximum methionine content was noticed under 45 K_2O ha^{-1}. The cysteine content in pigeonpea grain was ranged from 1.244 to 1.340 mg 100 g^{-1}.There was an increase the cysteine content by 4.16 to 7.10% due to application of potassium 15 to 45 kg ha^{-1} over no use of potassium. Potassium acts as an activator of several enzymes of phosphorylation and protein synthesis. It is essential for activating the enzymes concerned in the synthesis of polypeptides from amino acid, potassium also helps in the synthesis of sugar and starch, therefore addition of potassium caused increase in protein methionine and cysteine content in the present investigation.

Interaction effect exhibited significant with respect to methionine content in pigeonpea grain. Methionine content increased from 1.063 to 1.163 mg 100 g^{-1} with the combine application of K and S along with recommended dose of N 25 and P 50 kg ha^{-1}. Methionine content in pigeonpea was more with the combination of high dose of potassium and various doses of sulphur along with the application of N and P. The nutritional quality character showed increasing trend with increasing level of nutrient being lowest in no use of potassium and higher at 45 kg K_2O ha^{-1}(1.340 mg 100 g^{-1}) and 20 kg S ha^{-1}(1.316 mg 100 g^{-1}). The cysteine content was increased with the high doses of application of potassium and sulphur applied, while its content reflected less with minimum doses of potassium. It varied from 1.230 to 1.360 %.

Concentration of Calcium and Magnesium

Interaction between potassium and sulphur level was significant on Ca content in grain (Table 4). Maximum Ca content (0.876%) was obtained with the use of $K_{3O}S_{30}$ and found at par with K_{30} $S_{20.}$. The content of calcium was influenced significantly by the application of potassium up to 30 kg K_2O ha^{-1} but after that, the content and uptake get decreased. This might be possible due to antagonistic effect between K and Ca. The significantly highest content of calcium in grain (0.868%) was associated with the treatment consisting 30 kg K_2O ha^{-1}. The treatment 45 kg K_2O ha^{-1} for Ca content in grain (0.868 %) found at par with the treatment 30 kg K_2O ha^{-1}. Calcium in plant is essential to cell wall membrane structure and permeability. Ca^{++} is important to N metabolism, protein formation and translocation of carbohydrate and nutrients. The significantly maximum content of calcium in grain (0.818%) of pigeonpea was obtained with the treatment consisting S 20 kg ha^{-1} and it was found at par with S 30 kg ha^{-1}.

Significantly highest content of magnesium in grain (1.525%) was associated with the treatment applied @ 30 kg K_2O ha^{-1}. The sulphur application up to 10 kg ha^{-1} was found to be significant for Mg content in grain (1.538%), than the other two treatments of 20 and 30 kg S ha^{-1}. Interaction effect was found significant with respect to magnesium content of pigeonpea.

Nutrient use efficiency

From the data (Table 5), the nutrient use efficiency of nitrogen, phosphorus and potassium varied from 29.94 to 61.30 %, 14.14 to 19.57 % and 40.62 to 56.6 %, respectively with the application of 0 to 45 kg K ha^{-1}. The maximum nutrient use efficiency of N, P and K was noted with the application of 30 kg ha^{-1}. The use efficiency of applied nitrogen, phosphorus and potassium in Indian soil are 30 to 50 %, 15 to 20 % and 70 to 80 %, respectively .Fertilizer use efficiency vary widely in grain yield rarely exceed 50 to 60 % and can be low as 20 %, 10 to 30 % for phosphorus (Swarup, 2002). Best management practice for achieving optimum

Table 1. Effect of potassium and sulphur on grain and straw yield (q ha^{-1}) of pigeonpea

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
Levels of potassium kg ha^{-1}		
K_0	9.43	37.06
K_{15}	9.94	39.62
K_{30}	11.05	45.07
K_{45}	10.98	46.46
SE (m)±	0.28	0.60
CD at 5 %	0.84	1.78
Levels of sulphur kg ha^{-1}		
S_{10}	9.94	41.18
S_{20}	10.80	42.07
S_{30}	10.31	42.91
SE (m)±	0.25	0.53
CD at 5 %	0.71	--

Interaction (potassium x sulphur)

	K_0	K_{15}	K_{30}	K_{45}	K_0	K_{15}	K_{30}	K_{45}
S_{10}	8.50	9.20	10.71	11.33	36.19	39.15	44.12	45.27
S_{20}	10.07	10.12	11.22	11.78	37.48	40.44	44.31	46.05
S_{30}	9.72	10.48	11.22	9.83	37.50	39.28	46.79	48.07
SE (m)±		0.490				1.05		
CD at 5 %		1.435				--		

Table 2. Effect of potassium and sulphur on protein content (%) and protein yield (kg ha^{-1}) of pigeonpea

Treatments	Protein (%)	Protein yield (kg ha^{-1})
Levels of potassium kg ha^{-1}		
K_0	19.51	183.97
K_{15}	19.85	197.31
K_{30}	20.40	225.42
K_{45}	20.60	226.19
SE (m)±	0.17	---
CD at 5 %	0.50	---
Levels of Sulphur kg ha^{-1}		
S_{10}	19.90	197.81
S_{20}	20.09	216.19
S_{30}	22.22	208.46
SE (m)±	0.14	---
CD at 5 %	0.42	---

Interaction (potassium xsulphur)	K_0	K_{15}	K_{30}	K_{45}	K_0	K_{15}	K_{30}	K_{45}
S_{10}	19.815	19.685	20.435	20.685	179.67	181.07	218.81	226.30
S_{20}	19.565	19.565	20.296	20.500	196.77	197.94	227.45	227.32
S_{30}	19.471	20.065	20.875	21.185	189.24	210.03	227.50	208.88
SE (m)±		0.29				---		
CD at 5 %		---				---		

Table 3. Effect of K and S on sulphur containing amino acid in pigeonpea

Treatments	Methionine (mg 100 g)				Cysteine (mg 100 g)			
Levels of potassium kg ha^{-1}								
K_0	1.100				1.244			
K_{15}	1.120				1.298			
K_{30}	1.118				1.306			
K_{45}	1.154				1.340			
SE (m)±	0.003				0.010			
CD at 5 %	0.011				0.0295			
Levels of Sulphur kg ha^{-1}								
S_{10}	1.101				1.281			
S_{20}	1.136				1.316			
S_{30}	1.131				1.286			
SE (m)±	0.016				0.041			
CD at 5 %	0.047				0.122			
Interaction (potassium x sulphur)								
	K_0	K_{15}	K_{30}	K_{45}	K_0	K_{15}	K_{30}	K_{45}
S_{10}	1.063	1.113	1.090	1.150	1.240	1.290	1.286	1.340
S_{20}	1.090	1.136	1.136	1.163	1.263	1.310	1.343	1.320
S_{30}	1.146	1.110	1.130	1.150	1.230	1.266	1.290	1.360
SE (m) ±	0.0067				0.0170			
CD at 5 %	0.0195				0.0514			

Table 4. Effect of potassium and sulphur on concentration of calcium and magnesium (%) of pigeonpea

Treatments	Ca content grain (%)				Mg content grain (%)			
Levels of potassium kg ha^{-1}								
K_0	0.746				1.443			
K_{15}	0.786				1.454			
K_{30}	0.868				1.525			
K_{45}	0.858				1.502			
SE (m) ±	0.0003				0.013			
CD at 5 %	0.001				0.039			
Levels of Sulphur kg ha^{-1}								
S_{10}	0.813				1.538			
S_{20}	0.818				1.476			
S_{30}	0.816				1.436			
SE (m) ±	0.0006				0.055			
CD at 5 %	0.0020				0.161			
Interaction (potassium x sulphur)	K_0	K_{15}	K_{30}	K_{45}	K_0	K_{15}	K_{30}	K_{45}
S_{10}	0.746	0.786	0.863	0.856	1.550	1.560	1.593	1.440
S_{20}	0.750	0.786	0.866	0.860	1.320	1.473	1.520	1.593
S_{30}	0.743	0.786	0.876	0.860	1.460	1.330	1.463	1.473
SE (m) ±	0.003				0.023			
CD at 5 %	0.011				0.009			

Table 5. Nutrients use efficiency by pigeonpea as affected by different levels of potassium

Treatments	N	P	K
K0 (0 kg K_20 ha^{-1})	---	---	---
K_{15} (15 kg K_20 ha^{-1})	29.94	14.14	42.54
K_{30} (30 kg K_20 ha^{-1})	61.3	19.57	56.6
K_{45} (45 kg K_20 ha^{-1})	43.58	14.74	40.62

Table 6. Response of potassium over recommended dose of N and P (25:50:0 kg ha^{-1})

Treatments	Grain yield	Response over NP	
		kg grain kg^{-1} K	Per cent
K0 (0 kg K_20 ha^{-1})	943	-------	------
K_{15} (15 kg K_20 ha^{-1})	994	3.40	5.13
K_{30} (30 kg K_20 ha^{-1})	1105	5.40	14.66
K_{45} (45 kg K_20 ha^{-1})	1098	3.44	14.11
		kg grain kg^{-1} S	Per cent
S_{10} (10 kg S ha^{-1})	994	------	-------
S_{20} (20 kg S ha^{-1})	1079	4.25	7.87
S_{30} (30 kg S ha^{-1})	1032	1.27	3.68

Table 7. Effect of potassium and sulphur on total uptake of N, P and K of pigeonpea (kg ha^{-1})

Treatments	N uptake kg ha^{-1}	P uptake kg ha^{-1}	K uptake kg ha^{-1}
Levels of potassium kg ha^{-1}			
K_0	83.65	24.50	53.90
K_{15}	88.14	26.63	60.38
K_{30}	102.14	30.37	70.98
K_{45}	103.26	31.24	72.02
SE (m)±	0.97	0.44	1.16
CD at 5 %	2.85	1.28	3.40
Levels of Sulphur kg ha^{-1}			
S_{10}	92.78	27.67	61.69
S_{20}	92.84	27.95	64.65
S_{30}	95.55	28.92	66.61
SE (m)±	0.84	0.38	1.00
CD at 5 %	2.46	1.12	2.98

Interaction (potassium x sulphur)	K_0	K_{15}	K_{30}	K_{45}	K_0	K_{15}	K_{30}	K_{45}	K_0	K_{15}	K_{30}	K_{45}
S_{10}	78.61	84.55	102.07	104.14	23.25	26.13	29.94	31.39	52.09	55.63	67.74	71.31
S_{20}	85.59	88.01	102.72	105.67	24.98	26.11	29.91	30.81	54.23	61.54	70.87	71.98
S_{30}	84.98	89.20	102.35	102.59	25.27	27.65	31.26	31.53	55.40	63.96	74.33	72.78
SE (m)±			1.68			0.759				2.01		
CD at 5 %			4.94			---				----		

nutrient use efficiency is applied the nitrogen at right rate, at right time and in right place.

Response of potassium on NP doses

With respect to response of application of potassium and sulphur produced 5.40 kg grain and 4.25 kg grain, respectively due to application of 1 kg potassium or sulphur (Table 6). Response of potassium over the nitrogen and phosphorus was in the ranged between 3.40 to 5.40 kg grain kg^{-1} K, where as response of sulphur over nitrogen and phosphorus recorded 1.27 to 4.25 kg grain kg^{-1} S. This was an increase in 14.66 % response over NP with the use of 30 kg K ha^{-1} and 7.87 % with the use of 30 kg S ha^{-1}.Tiwari *et al*. (2012) reported that efficiency of potassium varied from 5.07 to 6.7 kg kg^{-1} of potassium in pigeonpea with maximum application of 60 kg ha^{-1}.

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