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Response of potassium and micronutrients on nutrient uptake and economics of pigeon pea

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Abstract
A field experiment was planned and conducted during *Kharif* 2016-17 to evaluate the "Potassium management through soil application and foliar sprays in red gram under Vertisols". The experiment was conducted at Departmental Research Farm of Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The experiment was laid out in Randomized Block Design with three replications. The nutrient uptake of pigeon pea was significantly enhanced with the application of potassium and Grade I or Grade II micronutrient along with RDF. Application of RDF + 50 kg K_2O ha^{-1} + Grade I micronutrient showed maximum uptake of N, P, K and micronutrients (Fe, Zn, Mn and Cu) in pigeon pea plant and grain, followed by RDF + 50 kg K_2O ha^{-1} + Grade II micronutrient and RDF + 25 kg K_2O ha^{-1} + Grade II micronutrient. Thus, GMR and NMR was maximum when pigeon pea received RDF + 50 kg K_2O + Grade I micronutrient application followed by RDF + 50 kg K_2O + Grade II micronutrient. Benefit cost ratio (1.82) was higher in treatment RDF + 50 kg K_2O + Grade I micronutrient followed by (1.75) RDF + 50 kg K_2O + Grade II micronutrient.

Keywords: Potassium, micronutrient, uptake, economics pigeon pea

1. Introduction
Pigeon pea (*Cajanuscajan* L. Mill sp.) is one of the most important pulse crop of India and 91 per cent of the world's pigeon pea is produced in India. It is also a important pulse crop of Maharashtra and ranked in second crop area and production after chickpea in India. It is known as red gram, arhar, and tur. It is a long duration crop and suits in different cropping system. It plays a great role in providing protein rich diet and also in improving native soil fertility. Being a drought resistant crop, it is suitable for dryland and predominantly sown as intercrop with cotton, sorghum and soybean in most of the parts of Maharashtra. Area and production under pigeon pea in India is 38.6 million ha^{-1} with production 29.0 million tonnes. In Maharashtra pigeon pea production was 8.7 million tonnes from an area of 12.3 million hectares with the productivity of 706 kg ha^{-1}.While in case of Marathwada region, pigeon pea occupies an area about 5.3 million hectares which produces about 1.3 million tonnes of pigeon pea with an average productivity of 245 kg ha^{-1} (Directorate of Economics and Statistics, New Delhi). It is a rich source of proteins i.e. about 22 per cent, lysine, riboflavin, thiamine, niacin and iron. The productivity of pigeon pea in India (799 kg ha^{-1}) is below the average productivity (848 kg ha^{-1}) of world. In India, it occupies an area of 4.09 million hectares with a production of 3.27 million tonnes with an average productivity of 799 kg ha^{-1}.
Micronutrients like iron, zinc, manganese, copper, molybdenum, cobalt and boron play an important role in increasing legumes yield through their effect on the plant itself, nitrogen fixing symbiotic process and effective use of major and secondary nutrients. However, they are used in lower amounts as compared to macronutrients, such as N, P and K. They have a major role in cell division, development of meristemtic tissues, photosynthesis, respiration and acceleration of plant maturity. In addition, iron (Fe), boron (B), zinc (Zn), copper (Cu), and manganese (Mn) are considered as essential micronutrients for plants and can maintain crop-physiology balance (Salih, 2013) [5]. Iron plays a crucial role in enzyme like cytochrome oxidase, catalase and peroxidase, which participates in oxidation-reduction reactions. Copper is involved in both photosynthesis and respiration. Manganese activates decarboxylase, dehydrogenase and oxidase enzymes. It is also essential for photosynthesis, respiration and nitrogen metabolism. Molybdenum is a key element required by the microorganisms for nitrogen fixation.

2. Material and Methods
2.1. Experimental details
The field experiment was carried out using pigeon pea crop (Var. BSMR-736) in *Kharif* season during years 2016-17 at Research Farm of Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. After completion of preparatory tillage operations, the experiment was laid out in Randomized Block Design comprising ten (10) treatments replicated three (3) times. Recommended dose of fertilizer was applied to the crop which was 25:50:00 kg N and P_2O_5 ha^{-1}. Composition of Grade I micronutrient: Zn - 5%, Fe - 2%, Mn - 1%, B - 1% and Cu-0.5%. Composition of Grade II micronutrient: Zn - 3%, Fe - 2.5%, Mn - 1%, Cu - 1%, B - 0.5%, and Mo - 0.1%.

2.1.1 Details of experiment

1.	Plot size	:	5.4 x 4.2 m^2
2.	Crop Spacing	:	90 x 20 cm
3.	Method of sowing	:	Line sowing
4.	Date of sowing	:	27^{th} June, 2016
5.	Date of harvesting	:	11^{th} January, 2017
6.	Design	:	RBD

2.1.2. Conduct of Experiment
The land of the experimental site was prepared by one ploughing and two harrowings and layout was done. The sowing was carried out on 27^{th} June, 2016 by dibbling method and calculated amount of fertilizers were applied at the time of sowing. Fertilizers were applied as per the treatment, through Urea, Single super phosphate, Muriate of potash, Grade I Micronutrient apply at the time of sowing of Pigeon pea and Grade II micronutrient at the time of flowering. Potassium nitrate (KNO_3) sprays on 60, 90, 120 days after sowing. Two weeding and two hoeing was carried out during the crop growth period of pigeon pea. The crop was harvested at maturity on 11^{st} January, 2017 and plot wise dry matter and grain yield per plot were recorded.

2.2 Observations recorded
2.2.1. Uptake of nutrients
Nutrient uptake i.e. uptake of N, P, K, Fe, Zn, Cu, Mn was calculated by considering grain and dry matter yield at harvest in particular plot in relation to concentration of the particular nutrient in respective plot using the following formula.

$$\text{Macronutrient uptake (kg ha}^{-1}) = \frac{\text{Total dry matter (Kg ha}^{-1}) \text{ X Concentration of element (\%)}}{100}$$

$$\text{Micronutrient uptake (g ha}^{-1}) = \frac{\text{Total dry matter (Kg ha}^{-1}) \text{ X Concentration of element (ppm)}}{10}$$

2.2.2. Economics in terms of pigeon pea
Economics of cultivation was worked out as per the following formulae.

Gross Monetary Returns (GMR) = Yield X Selling price of pigeon pea

Net Monetary Returns (NMR) = GMR – Cost of cultivation

$$\text{Benefit Cost Ratio (B: C Ratio)} = \frac{\text{NMR}}{\text{COC}} \text{ X } 100$$

Where
GMR - Gross monetary return.
NMR - Net monetary return.
B: C - Benefit cost ratio.
COC- Cost of cultivation

3. Results and Discussion
3.1. NPK uptake
The data pertaining to nitrogen, phosphorus and potassium uptake by pigeon pea with respect to graded levels of potassium and micronutrient application are presented in Table 1. The effect of different treatments on N uptake of pigeon pea was found to be enhanced significantly with application of potassium and micronutrient along with RDF. The data shows increased in N uptake by straw and grain was maximum in treatment T_6 (145.53 and 58.68 kg ha^{-1}) receiving RDF + 50 kg K_2O ha^{-1} + Grade I micronutrient, followed by treatment T_8 (134.46 and 55.99 kg ha^{-1}) treated with RDF + 50 kg K_2O ha^{-1} + Grade II micronutrient. The lowest value was noticed in control plot T_1 (75.24 and 27.00 kg ha^{-1}). In presence of potassium, the increase in N uptake could be attributed to enhanced vigour of crop growth with increased utilization and translocation of N in to plant and synergy between N and K in soil system resulting in the enhancement of yield. Similar findings were also reported by Mukundgowda *et al.* (2015) [4].
The P uptake of plant was significantly enhanced due to application of potassium in combination with micronutrient over control and only RDF (Table.1) treatment. The significantly maximum P uptake by pigeon pea crop was recorded at highest level of potassium (50 kg K_2O ha^{-1}) application along with RDF and Grade I micronutrient (T_6) i.e. 28.03 kg ha^{-1} as compared to control (T_1) and only RDF (T_2). The highest P uptake in grain (13.56 kg ha^{-1}) was recorded with treatment T_6 (RDF + 50 kg K_2O ha^{-1} + Grade I micronutrient). Similar trends were also noticed by Kherawat *et al*. (2013) [3], Chavan *et al.* (2012) [2] and Mukundgowda *et al.* (2015) [4].
Like N and P uptake, K uptake was also significantly influenced due to potassium and micronutrient application as presented in Table 1. Data indicated that, application of RDF + 50 kg K_2O ha^{-1} + Grade I micronutrient (T_6) significantly increased the uptake of K in pigeon pea, which was followed by RDF + 50 kg K_2O ha^{-1} + Grade II micronutrient (T_8). The K uptake in plant was ranged between 35.07 to 73.48 kg ha^{-1} and in it was grain ranged from 12.87 to 26.72 kg ha^{-1}. The maximum uptake of K (73.48 kg ha^{-1}) was seen in treatment T_6 (RDF + 50 kg K_2O ha^{-1} + Grade I micronutrient) followed by treatment T_8 (RDF + 50 kg K_2O ha^{-1} + Grade II micronutrient), T_7 (RDF + 25 kg K_2O ha^{-1} + Grade II micronutrient) and T_5 (RDF + 25 kg K_2O ha^{-1} + Grade I micronutrient). In grain, the maximum K uptake (26.72 kg ha^{-1}) was observed in treatment T_6 (RDF + 50 kg K_2O ha^{-1} + Grade I micronutrient) which was significantly superior over rest of the treatments. This might be due to application of higher doses of mineral K with micronutrients favoured higher root and shoot development which might have also increased the K uptake. Results are in conformity with the findings of Chavan *et al.* (2012) [2] and Kherawat *et al.* (2013) [3].

Table 1: Effect of graded levels of potassium and micronutrient application on N, P and K uptake.

Treatments		N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})		
		Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T_1	Absolute control	27.00	75.24	102.24	5.27	9.70	14.97	12.87	35.07	47.94
T_2	Only RDF (25:50 N and P_2O_5 kg ha^{-1})	32.21	84.68	116.89	6.80	13.05	19.85	15.32	40.80	56.12
T_3	RDF + 25 kg K_2O ha^{-1}	38.26	97.26	135.52	7.93	15.40	23.33	17.55	48.37	65.92
T_4	RDF + 50 kg K_2O ha^{-1}	40.13	105.46	145.59	8.47	17.10	25.57	18.55	52.04	70.60
T_5	RDF + 25 kg K_2O ha^{-1} + Grade I micronutrient	44.76	113.97	158.73	9.43	18.99	28.42	19.91	57.61	77.52
T_6	RDF + 50 kg K_2O ha^{-1} + Grade I micronutrient	58.68	145.53	204.21	13.56	28.03	41.59	26.72	73.48	100.19
T_7	RDF + 25 kg K_2O ha^{-1} + Grade II (0.5%) micronutrient	52.80	124.60	177.40	11.50	21.59	33.09	23.77	66.51	90.28
T_8	RDF + 50 kg K_2O ha^{-1} + Grade II (0.5%) micronutrient	55.99	134.46	190.45	12.61	24.52	37.13	25.38	67.12	92.50
T_9	RDF + 25 kg K_2O ha^{-1} + 2% KNO_3	37.77	99.08	136.85	7.77	15.91	23.68	18.53	59.11	77.64
T_{10}	RDF + 50 kg K_2O ha^{-1} + 2% KNO_3	40.08	109.68	149.76	8.28	16.90	25.19	19.80	63.29	83.08
Grand Mean		42.77	108.99	151.76	9.16	18.12	27.28	19.84	56.34	76.18
SEm (±)		0.54	0.21	-	0.47	1.23	-	0.25	1.32	-
CD at 5%		1.61	0.65	-	1.42	3.70	-	0.76	3.96	-

3.2 Micronutrients (Fe, Zn, Mn and Cu uptake)

The data pertaining to uptake of zinc, manganese, copper and iron in plant and seed are presented in Table 2. The uptake of these micronutrients in plant and grain were significantly influenced due to application of potassium and inclusion of Grade I or Grade II micronutrient in fertilizer schedules.

The data indicated that, increasing levels of potassium and micronutrient application produced significant effect on Fe uptake by plant and grain of pigeon pea (Table. 2). The Fe uptake by plant and grain increased from 706.48 to 2205 g ha^{-1} and 315.52 to 864.81 g ha^{-1} at harvesting, respectively. It was noted that application of RDF + 50 kg K_2O kg ha^{-1} + Grade I micronutrient produced maximum uptake of Fe in plant (2205 g ha^{-1}) and seed (864.81 g ha^{-1}). Which was followed by treatment T_8 (RDF + 50 kg K_2O ha^{-1} + Grade II micronutrient), T_7 (RDF + 25 kg K_2O ha^{-1} + Grade II micronutrient) and T_5 (RDF + 25 kg K_2O ha^{-1} + Grade I micronutrient). The increasing Fe uptake may also be attributed due to concentration of Fe in plant and seed. The results are in are in accordance with the findings reported by Balpande *et al*. (2016) [1].

The data also showed that, the increasing the levels of potassium up to 50 kg ha^{-1} with RDF and integration with Grade I or Grade II micronutrient resulted in higher uptake of Zn (Table.6). The application of RDF + 50 kg K_2O ha^{-1} + Grade II micronutrient (T_8) recorded significantly higher Zn uptake in plant followed by T_6 (RDF + 50 kg K_2O ha^{-1} + Grade I micronutrient) i.e. 197.64 g ha^{-1} and 109.95 g ha^{-1}, respectively. Significant highest value of Zn uptake in grain (61.10 g ha^{-1}) was noticed in T_6 (RDF + 50 kg K_2O ha^{-1} + Grade I micronutrient) which was followed by treatment T_8 (RDF + 50 kg K_2O ha^{-1} + Grade II micronutrient) and T_7 (RDF + 25 kg K_2O ha^{-1} + Grade II micronutrient). The Zn increased in grain K, resulted in higher uptake of nutrients. Similar trends were also noticed by Chavan *et al.* (2012) [2].

Table 2: Effect of graded levels of potassium and micronutrient application on micronutrient (Fe, Zn, Mn and Cu) uptake

Treatments		Fe uptake (g ha^{-1})			Zn uptake (g ha^{-1})			Mn uptake (g ha^{-1})			Cu uptake (g ha^{-1})		
		Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T_1	Absolute control	315.52	706.48	1022.00	44.56	96.97	141.53	92.16	198.86	291.01	15.15	52.85	68.00
T_2	Only RDF (25:50 N and P_2O_5 kg ha^{-1})	390.76	772.17	1162.93	55.38	108.70	164.08	110.23	219.15	329.39	17.92	58.73	76.66
T_3	RDF + 25 kg K_2O ha^{-1}	437.74	1094.40	1532.14	58.87	117.55	176.42	126.36	258.63	384.99	20.20	65.94	86.14
T_4	RDF + 50 kg K_2O ha^{-1}	457.79	1662.41	2120.20	66.69	128.98	195.67	134.74	261.25	395.99	22.55	71.08	93.63
T_5	RDF + 25 kg K_2O ha^{-1} + Grade I micronutrient	531.44	1795.52	2326.96	85.76	161.35	247.10	183.84	301.05	484.89	28.25	96.83	125.08
T_6	RDF + 50 kg K_2O ha^{-1} + Grade I micronutrient	684.81	2094.59	2779.40	114.57	194.04	308.61	238.76	334.11	572.87	38.41	118.69	157.10
T_7	RDF + 25 kg K_2O ha^{-1} + Grade II (0.5%) micronutrient	617.95	2095.89	2713.84	99.08	184.47	283.56	181.97	317.65	499.62	29.86	130.68	160.54
T_8	RDF + 50 kg K_2O ha^{-1} + Grade II (0.5%) micronutrient	663.69	2205.79	2869.49	109.95	197.64	307.59	221.49	326.76	548.25	33.88	142.67	176.55
T_9	RDF + 25 kg K_2O ha^{-1} + 2% KNO_3	427.96	1176.37	1604.33	57.60	120.62	178.22	126.14	265.53	391.67	19.74	67.65	87.39
T_{10}	RDF + 50 kg K_2O ha^{-1} + 2% KNO_3	456.41	1417.58	1873.99	66.42	133.62	200.04	134.80	274.17	408.97	20.76	73.69	94.45
Grand Mean		498.41	1502.12	2000.53	75.89	144.39	220.28	155.05	275.72	430.76	24.67	87.88	112.55
SEm (±)		6.37	9.43	-	1.00	0.62	-	2.53	2.13	-	0.39	0.27	-
CD at 5%		19.09	28.05	-	3.02	2.02	-	7.60	6.39	-	1.19	0.81	-

The uptake of Mn by plant and grain of pigeon pea was found to be significantly enhanced with increasing levels of potassium and micronutrient application (Table. 2). Significantly higher uptake in plant (238.76 g ha^{-1}) and grain (334.11 g ha^{-1}) was obtained by the application of RDF + 50 kg K_2O ha^{-1} + Grade I micronutrient (T_6) followed by treatment T_8 (RDF + 50 kg K_2O ha^{-1} + Grade I micronutrient) and T_7 (RDF + 25 kg K_2O ha^{-1} + Grade II micronutrient). The application of potassium helped to enhance the dry matter accumulation which also contributed in higher Mn uptake by pigeon pea. Results are in conformity with the findings of Balpande *et al*. (2016) [1]. Increasing levels of potassium and micronutrient application significantly enhanced uptake of Cu by plant and grain of pigeon pea (Table. 2). The Cu uptake by plant and grain increased from 52.85 to 142.67 g ha^{-1} and 15.15 to 38.41 g ha^{-1} at harvesting with the application of RDF + 50 kg K_2O ha^{-1} + Grade I micronutrient (T_6) over control. Significant increase in biomass production is one of the reasons for better nutrient uptake. Similar results were also reported by Balpande *et al*. (2016) [1].

3.3 Effect of graded levels of potassium and micronutrients on economics of pigeon pea

The economics in respect of pigeon pea production with selected prescribed treatment schedule was computed considering the cost of cultivation, gross monetary return, net

monetary return and benefit cost ratio. The prevailing market results for inputs and market prices of sale of product were used for calculating the cost of cultivation. The data thereof are presented in fig.1.
The highest gross monetary return, net monetary return and benefit cost ratio were recorded with treatment T_6 (RDF + 50 kg K_2O kg ha^{-1} + Grade I micronutrient) followed by T_8 (RDF + 50 kg K_2O ha^{-1} + Grade II micronutrient) and T_7 (RDF + 25 kg K_2O ha^{-1} + Grade II micronutrient). The benefit cost ratio varied in range from 1.33 to 1.82 respectively. The maximum benefit cost ratio (1.82) was recorded with treatment T_6 (RDF + 50 kg K_2O kg ha^{-1} + Grade I micronutrient) followed by T_8 (RDF + 50 kg K_2O ha^{-1} + Grade II micronutrient) and T_7 (RDF + 25 kg K_2O ha^{-1} + Grade II micronutrient).

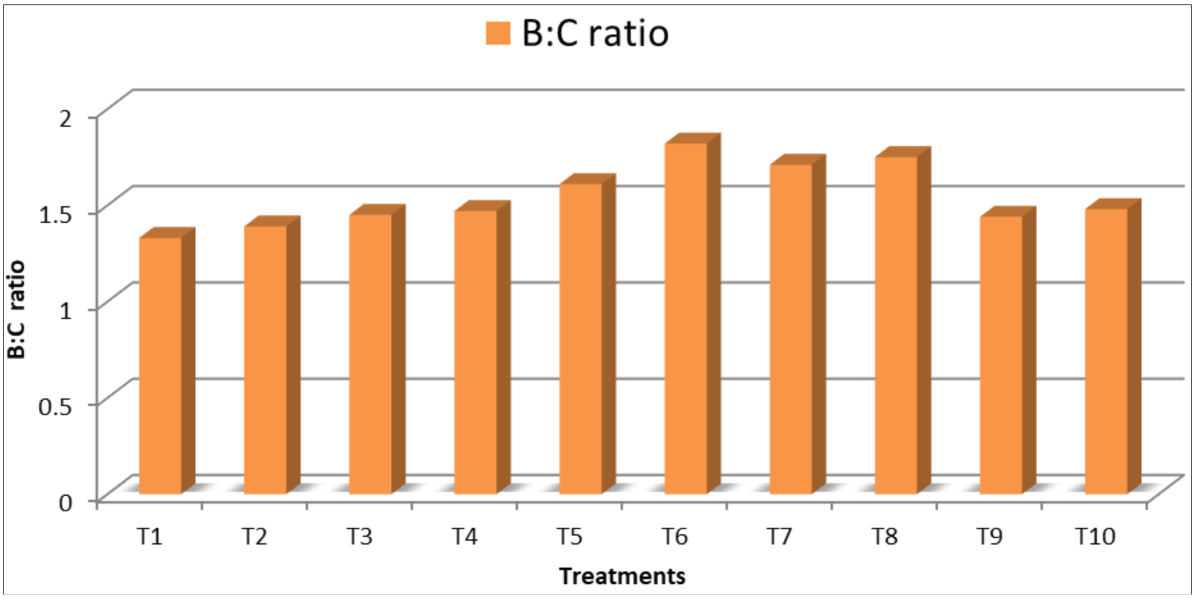

Fig 1: Effect of graded levels of potassium and micronutrients application on economics of red gram

4. Conclusion

Application of 25 or 50 kg potassium with Grade I or Grade II micronutrient in recommended dose of pigeon pea (25:50 kg N and P_2O_5 ha^{-1}) significantly increase uptake of N, P, K, Fe, Zn, Mn, Cu and highest gross monetary return, net monetary return and B:C ratio of pigeon pea.

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