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Influence of potassium and zinc application on quality and micro nutrient uptake of red gram under Vertisol

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Abstract
A field experiment was conducted during *Kharif* season 2016-17 to studies on effect of graded levels of potassium and zinc on growth, yield, nutrient uptake and quality of pigeon pea at experimental farm, Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The experiment was laid out on Vertisols with eight treatments replicated three times in randomized block design. The initial soil fertility status showed that soils were slightly alkaline in soil reaction, safe in soluble salt, low in organic carbon content and calcareous in nature. The highest test weight and seed protein content was recorded by application of 30 kg potassium with 15 kg zinc along with RDF. The K application shows synergistic effects on other nutrients (Fe, Zn, Cu, Mn) uptake. Soil fertility was found to be improved due to application of potassium and zinc to pigeon pea.

Keywords: potassium, zinc, quality, micro nutrient uptake, red gram

1. Introduction

Pigeon pea is one of the important pulse crops of India and 91 per cent of the world's pigeon pea is produced in India. The productivity of pigeon pea in India (799 kg ha^{-1}) is far below the average productivity (848 kg ha^{-1}) of world. In India, it occupies an area of about 4.09 million hectares producing 3.27 million tonnes with an average productivity of 799 kg per hectare (Anon, 2010) [2]. Pigeon pea is normally cultivated during *kharif* season. It is the second most important pulse crop next to chickpea, covering an area of around 4.42 m ha (occupying about 14.5% of area under pulses) and production of 2.86 MT contributing to 16% of total pulse production. (Sameer *et al*., 2014) [10].

Potassium is a key nutrient in the plants tolerance to stresses such as high / low temperatures, drought, and disease and pest occurrences. It has a critical role to play in osmo-regulation-regulation of water use in plants. Osmo-regulation maintains high cell turgor pressure which affects cell elongation for growth and most importantly regulates the opening and closing of the stomata which affect transpirational cooling and carbon dioxide uptake for photosynthesis. Zinc is a major metal component and activator of several enzymes involved in metabolic activities and biochemical pathways. It is a functional, structural or regulatory co-factor of a large number of enzymes. It is required in a large number of enzymes and plays an essential role in DNA transcription.

To realize this extent of annual growth rate, application of micro-nutrients including Zn is needed to negate hidden hunger for such nutrients. Several parts of the pulse growing regions of the country are deficient in Zn status. Zn not only increases the yield, but also improves the quality of the produce (Singh *et. al*., 2011) [11].

2. Material and methods

A field experiment was conducted during *kharif* season 2016-2017 to study effect of graded levels of potassium and zinc on growth, yield, nutrient uptake and quality of pigeon pea at Research Farm of Soil Science and Agricultural Chemistry, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani.

2.1 Details of field experiment

The representative soil samples were collected plot wise to assess the initial soil fertility status of experimental plot. The experiment was laid out in a randomized block design with 8 treatments and 3 replications. The plot size was 5.4 m. x 4.2 m. and the recommended spacing of 90 cm x 20 cm was adopted. The recommended dose of fertilizer was 25:50 kg N and P_2O_5 ha^{-1}. The RDF, K_2O and zinc fertilizers were applied through soil application at the time of sowing of pigeon pea. Fertilizers were applied as per the treatment, through Urea, Diammonium phosphate, Muriate of potash and zinc sulphate prior to sowing of pigeon pea. The treatment comprised of:

Table 1

T_1: Absolute control
T_2: Only RDF (25:50 N and P_2O_5 kg ha^{-1})
T_3: T4:RDF + 15 kg K_2O ha^{-1}
T_4: RDF + 30 kg K_2O ha^{-1}
T_5: RDF + 45 kg K_2O ha^{-1}
T_6: RDF + 15 kg K_2O ha^{-1} + 15 Kg Zn ha^{-1}
T_7: RDF + 30 kg K_2O ha^{-1} + 15 Kg Zn ha^{-1}
T_8: RDF + 45 kg K_2O ha^{-1} + 15 Kg Zn ha^{-1}

Recommended Dose of Fertilizer (RDF) = 25: 50:00 kg ha^{-1} N: P_2O_5:K_2O.

Dose of $ZnSO_4$ @ 15 kg ha^{-1} applied in treatment of T_6 to T_8.

2.2 Quality parameters
2.2.1 Protein content
The nitrogen content from the grain samples was estimated by Micro-kjeldhal's method (AOAC, 1975) and N content was multiplied by 6.25 to get percent crude protein.

2.2.2 Test weight
The weight of 100 seeds of pigeon pea from each net plot was recorded and designated as test weight of pigeon pea.

2.3 Uptake of nutrients
Nutrient uptake i.e. uptake of N, P and K was calculated by considering grain and dry matter yield at harvest in particular treatment plot in relation to concentration of the particular nutrient in respective treatment plot using the formula.

$$\text{Uptake (g ha}^{-1}) = \frac{\text{Nutrient concentration (ppm) X Dry matter yield (kg ha}^{-1})}{1000}$$

3. Results and Discussion
3.1 Effect of potassium and zinc on quality parameters of pigeon pea.
3.1 Quality parameters
3.1.1 Test weight
The test weight and protein content of pigeon pea under graded levels of potassium and zinc application are presented in table 1

The data revealed the significant increase in test weight due to application of graded levels of potassium and zinc. The highest test weight was obtained (90.67 g) by the application of RDF + 30 kg K_2O ha^{-1} + 15 kg Zn ha^{-1} which is significantly higher over control (82.00 g), RDF (85.67 g) and RDF + 15 kg K_2O ha^{-1} (87.17 g). The higher levels of K supplied sufficient K to plants which initiated maximum translocation of photosynthates to fruiting zone. Similar findings were also reported by Thesiya *et al.* (2013) [12] and Jadeja *et al.* (2016) [7].

Table 1: Effect of levels of potassium and zinc on test weight and protein content

Treatments		Quality parameters	
		Test weight (g)	Protein content (%)
T_1	Absolute control	82.00	17.55
T_2	Only RDF (25:50 N and P_2O_5 kg ha^{-1})	85.67	17.76
T_3	RDF + 15 kg K_2O ha^{-1}	87.00	17.60
T_4	RDF + 30 kg K_2O ha^{-1}	86.83	17.25
T_5	RDF + 45 kg K_2O ha^{-1}	87.17	18.58
T_6	RDF + 15 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	90.00	20.90
T_7	RDF + 30 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	90.67	21.63
T_8	RDF + 45 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	87.33	20.14
Grand Mean		87.08	18.93
SEm (±)		0.93	0.67
CD at 5%		2.31	1.67

3.1.2 Protein content
The data revealed that protein content showed some amount of variation among different treatments (Table 1). The treatment T_7 (RDF + 30 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}) recorded highest protein content (RDF + 30 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}), followed by treatment T_6 (RDF + 15 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}) (21.63 %) and T_8 (RDF + kg K_2O ha^{-1} + 15 kg Zn ha^{-1}) (20.14 %). The lowest protein content was observed in control T_1 (17.75 %). Improved K supply is commonly associated with improved protein content in pulse grains, N fixation and water use efficiency. As potash has synergistic effect on N and K uptake, it also facilitates protein synthesis and activates different enzymes. Therefore, protein content increased significantly with increase in K levels. Potassium involved in physiological and biochemical functions of plant growth i.e. enzyme activation and protein synthesis and its application in legumes might have improved the nitrogen use efficiency which leads to increase the protein content of the crop. Similar results were also reported by Patil (2002) [9], Farhad *et al.* (2010) [5], Chavan *et al.* (2012) [4] and Habbasha *et al.* (2014) [6].

3.2 Effect of potassium and zinc on nutrient uptake of Fe, Mn, Zn and Cu at critical growth stages of pigeon pea.
3.1 Fe uptake
The data presented in table 2 indicated that, the Fe uptake in plant varied from 291.51 to 530.55 g ha^{-1}, 244.64 to 653.44 g $ha^{-1}$and 158.26 to 310.55 g ha^{-1} at flowering, pod development and harvest of the crop and in grain it was varied from 46.96 to 220.98 g ha^{-1} respectively. The treatment T_7 (RDF +30 kg K_2O ha^{-1}+ 15 kg Zn ha^{-1}) recorded the highest Fe uptake and at par with T_6 (RDF+ 15 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}) and T_8 (RDF +45kg K_2O ha^{-1} + 15 kg Zn ha^{-1}) at pod development stage. The treatment T_7 (RDF +30 kg K_2O ha^{-1}+ 15 kg Zn ha^{-1}) recorded the highest Fe uptake and significantly superior over rest of the treatments. As far as the grain Fe uptake, similar results were noticed.

Table 2: Effect of graded levels of potassium and zinc on Fe uptake at various growth stages

Treatments		Fe uptake (g ha^{-1})			
		Flowering	**Pod development**	**Harvesting**	**Seed**
T_1	Absolute control	291.51	244.64	158.26	46.96
T_2	Only RDF (25:50 N and P_2O_5 kg ha^{-1})	314.95	318.22	230.64	101.06
T_3	RDF + 15 kg K_2O ha^{-1}	356.48	358.09	234.16	82.63
T_4	RDF + 30 kg K_2O ha^{-1}	376.15	493.04	215.90	114.92
T_5	RDF + 45 kg K_2O ha^{-1}	351.49	358.43	209.87	122.73
T_6	RDF + 15 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	512.79	633.28	301.19	204.82
T_7	RDF + 30 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	530.55	653.44	310.55	220.98
T_8	RDF + 45 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	487.41	627.69	283.40	180.61
Grand Mean		402.68	460.86	243.00	134.33
SEm (±)		8.58	8.85	6.93	9.30
% CD at 5		21.36	21.37	17.26	23.15

3.2 Zn uptake
The data presented in fig. 1 revealed that, the Zn uptake in plant was ranged between 185.64 to 407.44 g ha^{-1}, 200.76 to 553.66 g ha^{-1}, and 121.83 to 268.91 g ha^{-1} at flowering, pod development and at harvest stage respectively.

The maximum uptake of Zn was recorded in treatment T_7 (RDF + 30 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}) and it was at par with treatment T_6 (RDF+ 15 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}) and T_8 (RDF +45 kg K_2O ha^{-1}+ 15 kg Zn ha^{-1}) at flowering and pod development stage. The maximum uptake of Zn was recorded (268.91 g ha^{-1}) in treatment T_7 (RDF + 30 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}) at harvest stage and was significantly superior over rest of the treatments. With the addition of Zinc to growing media there was significant increase in zinc uptake in both the treatments. In case of grain, the Zn uptake was ranged from 34.14 to 65.95 g ha^{-1} and treatment T_7 (RDF + 30 kg K_2O ha^{-1}+ 15 kg Zn ha^{-1}) showed maximum Zn uptake (49.82 g ha^{-1}) and at par with treatment T_6 (RDF+ 15 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}) and T_8 (RDF+ 45 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}) and it was significantly superior over rest of treatments. Similar trends were noticed by Bahmanyar and Poshtamosari *et al.* (2006) [3], Chavan *et al.* (2012) [4] and Keram and Singh (2014) [10].

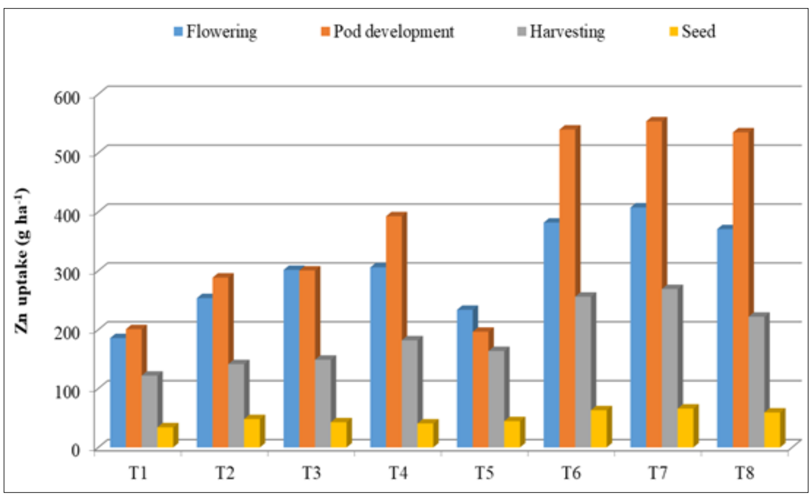

Fig 1: Effect of graded levels of potassium and zinc on Zn uptake (g ha^{-1})

3.3 Mn uptake
The data presented in table 3 indicated that, the Mn uptake in plant varied from 294.35 to 484.95 g ha^{-1}, 282.39 to 683.66 g $ha^{-1}$and 181.25 to 390.05 g ha^{-1} at flowering, pod development and at harvest stage of the crop and the grain Mn uptake varied from 77.65 to 244.70 g ha^{-1} respectively. The treatment T_7 (RDF +30 kg K_2O ha^{-1}15 kg Zn ha^{-1}) recorded the highest Mn uptake and significantly superior over rest of treatments at all the growth stages. Similar results were noticed in Mn uptake of grain.

Table 3: Effect of graded levels of potassium and zinc on Mn uptake at various growth stages

Treatment		Mn uptake (g ha^{-1})			
		Flowering	**Pod development**	**Harvesting**	**Seed**
T_1	Absolute control	294.35	282.39	181.25	77.65
T_2	Only RDF (25:50 N and P_2O_5 kg ha^{-1})	327.48	328.70	222.12	123.85
T_3	RDF + 15 kg K_2O ha^{-1}	399.17	392.19	224.41	105.75
T_4	RDF + 30 kg K_2O ha^{-1}	422.28	485.11	295.24	149.09
T_5	RDF + 45 kg K_2O ha^{-1}	378.69	336.80	238.54	151.88
T_6	RDF + 15 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	472.02	677.24	379.60	227.10

T_7	RDF + 30 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	484.95	683.66	390.05	244.70
T_8	RDF + 45 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	454.63	666.59	366.63	195.90
Grand Mean		404.20	481.59	287.23	159.49
SEm (±)		7.32	8.21	5.81	20.87
CD at 5%		18.24	20.45	14.46	51.96

3.4 Cu uptake

The data presented in table 4 indicated that, the Cu uptake in plant varied from 119.98 to 272.29 g ha^{-1}, 111.31 to 367.12 g ha^{-1} and 89.41 to 208.88 g ha^{-1} at flowering, pod development and harvest stage of the crop and in grain it was varied from 14.94 to 30.74 g ha^{-1} respectively. The treatment T_7 (RDF +30 kg K_2O ha^{-1}+ 15 kg Zn ha^{-1}) recorded the highest Cu uptake over rest of treatments at flowering, pod development and harvesting stage. Similar results were noticed in grain Cu uptake.

Table 4: Effect of graded levels of potassium and zinc on Cu uptake at various growth stages

Treatments		Cu uptake (g ha^{-1})			
		Flowering	**Pod development**	**Harvesting**	**Seed**
T_1	Absolute control	119.98	111.31	89.41	14.94
T_2	Only RDF (25:50 N and P_2O_5 kg ha^{-1})	170.55	161.33	102.34	22.02
T_3	RDF + 15 kg K_2O ha^{-1}	185.24	186.15	128.76	18.80
T_4	RDF + 30 kg K_2O ha^{-1}	193.41	196.70	148.11	17.89
T_5	RDF + 45 kg K_2O ha^{-1}	144.55	126.03	146.49	23.21
T_6	RDF + 15 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	248.16	337.49	194.13	27.06
T_7	RDF + 30 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	272.29	367.12	208.88	30.74
T_8	RDF + 45 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	240.89	331.21	177.43	30.59
Grand Mean		196.88	227.17	149.44	23.16
SEm (±)		12.35	17.58	12.43	2.47
CD at 5%		30.75	43.77	30.95	6.15

4. Conclusion

Application of 30 kg potassium with 15 kg zinc in recommended dose of pigeon pea (25:50 kg N and P_2O_5 ha^{-1}) significantly enhanced quality and nutrient uptake (Fe, Mn, Zn and Cu) at growth stages of pigeon pea.

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