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Effect of graded levels of potassium and zinc on growth, yield and quality of pigeon pea

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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 results clearly indicated that various growth and yield parameters like plant height, leaf area, number of pods, seed yield and dry matter yield was increased due to application of potassium and zinc. The highest test weight and seed protein content was recorded by application of 30 kg potassium with 15 kg zinc along with RDF.
Key words: *Potassium, Zinc, Growth, Yield, Quality and Pigeon pea*

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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 [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. [17].

Among the three essential nutrient required by plants, one of them is potassium. Potassium is a most abundant element in soils but its content in them varies widely. Hence its native supplies in soils need to be supplemented at places with potassium fertilizer for successful crop production. Potassium exits in soils in structural, non-exchangeable and water soluble forms [19]. Potassium is an essential element for plant growth and is an extremely dynamic ion in plant and soil system. As an ion, potassium is highly mobile in the plant system but only moderately mobile in the soil system. Just like humans require a balanced diet with appropriate amounts of carbohydrates, proteins, vitamins, minerals, fats and water, plants to require conditions of balanced nutrition.

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. Other functions of zinc include catalyzing the process of oxidation in plant cell and is vital for the transformation of carbohydrates; and influencing the formation of chlorophyll and auxins, the growth promoting compounds [12].

MATERIAL AND METHODS

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.

Fertilizer application schedule

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.

Seed and sowing

The seed of pigeon pea variety BSMR - 736 was sown in *kharif* by dibbling at distance 90 cm x 20 cm, gap filling was done 10 days after sowing to maintain plant population. Schedule of cultural operations were carried out as per recommendation.

RESULTS AND DISCUSSION

Plant height (cm)

The data on plant height of pigeon pea at critical growth stages as influenced by graded levels of potassium and zinc are presented in table 1.

Plant height showed significant differences due to the effect of graded levels of potassium and zinc at critical growth stages. The data presented in table 1 revealed that, the plant height at flowering, pod development and harvesting stage was varied from 162.87 cm to 184.87 cm, 169.73 to 190.67 cm and 172.47 to 192.93 cm with an average of 173.78 cm, 180.78 cm and 184.74 cm respectively. The plant height was significantly highest in treatment T_8 (RDF + 45 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}) which was followed by treatment T_5 (RDF + 30 kg K_2O ha^{-1}) and T_7 (RDF + 30 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}). However, lower value of plant height was noticed in treatment T_1 i.e. absolute control at all the growth stages of crop. Treatment T_4, T_5 T_6 and T_7 were at par with each other and they were significantly superior over rest of the treatments. Similar results have been reported by Saritha *et al.* [18], Suryapani *et al.* [21] and Reddy *et al.* [16].

Table 1. Effect of graded levels of potassium and zinc on plant height at critical growth stages

Treatments		Plant height (cm)		
		Flowering	Pod development	Harvesting
T_1	Absolute control	162.87	169.73	172.47
T_2	Only RDF (25:50 N and P_2O_5 kg ha^{-1})	166.20	171.93	174.27
T_3	RDF + 15 kg K_2O ha^{-1}	172.07	177.40	179.53
T_4	RDF + 30 kg K_2O ha^{-1}	175.67	180.60	183.47
T_5	RDF + 45 kg K_2O ha^{-1}	179.47	187.67	192.07
T_6	RDF + 15 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	170.33	183.93	186.93
T_7	RDF + 30 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	178.73	184.33	188.27
T_8	RDF + 45 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	184.87	190.67	192.93
Grand Mean		173.78	180.78	184.74
SEm (±)		3.22	3.12	3.30
CD at 5%		8.02	7.77	8.23

Number of flowers and pods

The data pertaining to the effect of graded levels of potassium and zinc on number of flowers and pods per plant is presented in table 2.

Table 2. Effect of graded levels of potassium and zinc on number of flowers and pods per plant

Treatments		Number of flowers	Number of pods per plant	
		Flowering	Pod development	Harvesting
T_1	Absolute control	104.56	151.67	153.83
T_2	Only RDF (25:50 N and P_2O_5 kg ha^{-1})	128.78	170.00	160.83
T_3	RDF + 15 kg K_2O ha^{-1}	131.67	158.56	198.00
T_4	RDF + 30 kg K_2O ha^{-1}	134.00	203.67	196.17
T_5	RDF + 45 kg K_2O ha^{-1}	129.78	204.33	170.83
T_6	RDF + 15 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	144.22	209.22	216.17
T_7	RDF + 30 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	145.00	214.22	216.67
T_8	RDF + 45 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	117.67	205.11	210.50
Grand Mean		129.46	189.60	190.38
SEm (±)		3.61	3.01	4.37
CD at 5%		9.00	7.49	10.89

The data presented in table 2 indicated that, the number of flowers was range from 104.56 to 145.00 with an average of 129.46 at flowering stage of the crop. The maximum number of flowers was noticed in treatment T_7 (145.00) which were found significantly higher than rest of the treatments. Further, number of pods at pod development and harvesting stage were influenced significantly due to treatments administrated. The maximum number of pods were observed in the treatment receiving RDF + 30 kg K_2O + 15 kg Zn ha^{-1} (T_7) followed by treatment T_6 (RDF + 15 kg K_2O + 15 kg Zn ha^{-1}) and T_8 (RDF + 45 kg K_2O + 15 kg Zn ha^{-1}). The maximum number of flowers and pods were noticed in treatment receiving RDF + 30 kg K_2O + 15 kg Zn ha^{-1} (T_7). This might be due to the favorable influence of optimum potash and zinc in metabolism and biological activity and its stimulatory effects on growth of plant. Similar findings were observed by Thalooth *et al*. [22], Ali *et al.* [1], and Shrikantbabu *et al.* [20].

Leaf area

The effect of graded levels of potassium and zinc application on leaf area at critical growth stages of pigeon pea is presented table 3

Table 3 Effect of graded levels of potassium and zinc on leaf area at critical growth stages

Treatments		Leaf area (cm^2)		
		Flowering	Pod development	Harvesting
T_1	Absolute control	47.80	49.39	53.21
T_2	Only RDF (25:50 N and P_2O_5 kg ha^{-1})	52.33	53.95	54.51
T_3	RDF + 15 kg K_2O ha^{-1}	56.40	52.88	54.20
T_4	RDF + 30 kg K_2O ha^{-1}	54.80	54.18	54.67
T_5	RDF + 45 kg K_2O ha^{-1}	56.77	54.85	55.45
T_6	RDF + 15 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	58.70	61.47	62.79
T_7	RDF + 30 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	61.13	60.49	60.91
T_8	RDF + 45 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	62.93	65.63	66.22
Grand Mean		56.36	56.61	57.75
SEm (±)		1.76	1.36	1.33
CD at 5%		4.39	3.38	3.31

Leaf area showed increasing tendency up to harvesting stage. Application of increasing levels of potassium recorded significantly higher leaf area over control (T_1) and only RDF (T_2) i.e. without K at flowering, pod development and harvesting stage. The application of RDF + 30 kg K_2O ha^{-1} + 15 kg Zn ha^{-1} (T_8) showed the maximum leaf area in flowering stage (62.93 cm^2), pod development stage (65.63 cm^2) and at harvesting stage (66.22 cm^2). The lowest leaf area was observed in control T_1 (47.80, 49.39 and 53.51 cm^2) at flowering, pod development and harvesting stage, respectively. Treatment T_7, T_6 and T_5 were found to be statistically fallowed by with each other. These result obtained that the inclusion of potassium in recommended dose (N and P) has synergistic effects. The increase in leaf area per plant with increasing age up to harvest stage was observed in investigation due to application of potassium and zinc was in accordance with the findings reported by Puste and Jana [15]., Saritha *et al.* [18] and Mondal *et al.* [10].

Effect of potassium and zinc on grain yield of pigeon pea

Table 4. Effect of graded levels of potassium and zinc on economic yield of pigeon pea

Treatments		Economic yield	
		g plant^{-1}	kg ha^{-1}
T_1	Absolute control	16.48	916.45
T_2	Only RDF (25:50 N and P_2O_5 kg ha^{-1})	18.61	1034.86
T_3	RDF + 15 kg K_2O ha^{-1}	26.14	1453.37
T_4	RDF + 30 kg K_2O ha^{-1}	27.41	1523.98
T_5	RDF + 45 kg K_2O ha^{-1}	28.25	1571.05
T_6	RDF + 15 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	30.58	1700.50
T_7	RDF + 30 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	31.59	1756.77
T_8	RDF + 45 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	30.81	1713.00
Grand Mean		26.23	1458.75
SEm (±)		0.42	23.51
CD at 5%		1.05	58.54

The data on economic yield of pigeon pea under graded levels of potassium and zinc is presented in table 4.

The grain yield was lowest (916.45 kg ha^{-1}) in control plot (T_1) while yield was improved in nutrient added plots. Potassium application showed significant increase in grain yield of pigeon pea in all the treatments over control (T_1) and only RDF (T_2). The highest yield was obtained by the application of T_7 -RDF + 30 K_2O kg ha^{-1} + 15 kg Zn ha^{-1} (1756.77 kg ha^{-1}) fallowed by with T_8 -RDF + 45 K_2O kg ha^{-1} (1713.00 kg ha^{-1}) and T_6 -RDF + 15 kg K_2O ha^{-1} + 15 kg Zn ha^{-1} (1700.50 kg ha^{-1}) an agronomic efficiency based on this 15 kg ha^{-1} K_2O showed highest agronomic efficiency 7.46 kg^{-1} which were found to be statistically at par with each other. The one year data showed that application of 15 kg or 30 kg or 45 kg K_2O ha^{-1} recorded statistically at par on grain yield. The application of graded levels of potassium with recommended dose of N and P_2O_5 (25:50 kg ha^{-1}) recorded increase in yield. Treatment T_7 comprises RDF with 30 kg K_2O and 15 kg Zn ha^{-1} fertilizer produced 1756.77 kg ha^{-1} grain yield which was found to be statistically at par with all the treatments receiving potassium. However, it is significantly superior over absolute control (T_1) and only RDF (T_2). Addition of potassium 30 kg K_2O ha^{-1}+ 15 kg Zn ha^{-1} recorded significant improvement in yield and all parameters contributing grain yield, biomass yield and quality. The grain yield of pigeon pea further increased with soil application of zinc sulphate. The positive effect of K on crop yield might also be due to its requirement in carbohydrate synthesis and translocation of photosynthesis and also may be due to improved yield attributing characters, shoot growth and nodulation. This may be due fact that potassium and zinc are reported to enhance the absorption of native as well as added major nutrient such as N and P which might have been attributed to improvement in yield. Similar findings were also observed by Jat *et al*. [8], Mukundgowda *et al*.,[11], Patil and Dhonde [14] Khrogamy and Farnia [9], Buriro *et al.* [3] and Ali *et al.* [1].

Dry matter yield

The data on dry matter production as influenced by graded levels of potassium and zinc application at critical growth stages is presented in table 5.

Table 5 Effect of graded levels of potassium and zinc on dry matter production

Treatments		Dry matter (kg ha^{-1})		
		Flowering	Pod development	Harvesting
T_1	Absolute control	4593.70	5640.74	6525.57
T_2	Only RDF (25:50 N and P_2O_5 kg ha^{-1})	4921.48	6005.19	7098.77
T_3	RDF + 15 kg K_2O ha^{-1}	5519.26	6912.78	7547.03
T_4	RDF + 30 kg K_2O ha^{-1}	5690.74	7814.81	6834.22
T_5	RDF + 45 kg K_2O ha^{-1}	5379.45	6138.33	7583.77
T_6	RDF + 15 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	6151.56	9844.08	7782.19
T_7	RDF + 30 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	6249.63	9957.04	7950.74
T_8	RDF + 45 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}	5878.70	9771.59	7697.94
Grand Mean		5548.07	7760.57	7377.53
SEm (±)		58.4086	93.75	106.75
CD at 5%		145.463	233.48	265.86

The results revealed that various levels of potassium application resulted in increase in mean dry matter yield with advancement in crop growth stages i.e. from flowering (5548.07 kg ha^{-1}) to harvest (7377.53 kg ha^{-1}). The mean dry matter was found to be highest due to application of RDF + 30 kg K_2O ha^{-1} + 15 kg Zn ha^{-1} (T_7) (6249.63, 9957.04, 7950.74 kg ha^{-1}) which was significantly higher than other treatments at all growth stages. The lowest dry matter production was observed in control T_1 (4593.70, 5640.74, 6525.57 kg ha^{-1}) at flowering, pod development and harvesting stage, respectively. At all the growth stages, 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}) were found to be statistically at par with each other. This is due to effect of K nutrition on cell elongation and turgor potential in leaves. These results are in compliance with the findings of Buriro *et al.* [3].

Effect of potassium and zinc on quality parameters of pigeon pea.

Test weight

The test weight and protein content of pigeon pea under graded levels of potassium and zinc application are presented in table 6.

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*. [23] and Jadeja *et al.* [7].

Table 6 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

Protein content

The data revealed that protein content showed some amount of variation among different treatments (Table 6). 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 [14], Farhad *et al.* [5], Chavan *et al.* [4] and Habbasha *et al*. [6].

SUMMARY

The yield parameters like number of pods per plant, economic yield and dry matter yield were at higher magnitude when pigeon pea received T_7 - RDF + 30 kg K_2O ha^{-1} + 15 kg Zn ha^{-1} followed by application of 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^{-}, which was significantly higher over control and application of RDF i.e. only N and P.

The highest grain yield of pigeon pea was obtained by application of T_7 - RDF + 30 kg K_2O ha^{-1} + 15 kg Zn ha^{-1} which was statistically at par with application of 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}.

The highest seed protein content and test weight was recorded by application of T_7 - RDF + 30 kg K_2O ha^{-1} + 15 kg Zn ha^{-1} followed by application of T_6 - RDF + 15 kg K_2O ha^{-1} + 15 kg Zn ha^{-1}.

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 growth, yield and quality of pigeon pea.

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