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Effect of varying levels of potassium and zinc on yield, yield attributes, quality of pigeon pea (*Cajanus cajan* L. Millsp.)

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Abstract
A field experiment was conducted at research farm, Department of soil science and Agricultural Chemistry, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani University to study effect of application of varying levels of potassium and zinc on productivity, nutrient uptake and quality parameters of pigeon pea during 2017-2018.Highest seed and stover yield of pigeon pea was recorded with the combined application of 30 kg K_2o + 15 kg $Znso_4$ ha^{-1} along with recommended dose of NPK fertilizers (RDF) and was at par with application of RDF + 15 kg K_2o +15 kg $Znso_4$ ha^{-1}, RDF + 45 kg K_2o ha^{-1} + 15 kg $Znso_4ha^{-1}$ was significantly superior over RDF and other treatment. Higher levels of K and Zn along with RDF also recorded higher growth and yield attributes at harvest viz., protein content, test weight, straw and seed yield of pigeon pea.

Keywords: pigeon pea, zinc, potassium, productivity, protein

Introduction

Pigeon pea (*Cajanus cajan* L. Millsp.) is one of the most important pulse crop of India and 91 per cent of world's pigeon pea is produced in India. The crop is extensively grown in dry land Maharashtra (Marathwada region) Karanataka, Madhya Pradesh, Andra Pradesh and Gujarat, etc. Area, production, productivity, of pigeon pea in India is the 3.96 m ha, 2.56 million tonnes, and 646 kg ha^{-1} respectively during the year 2015-2016. Maharashtra and Karanataka have higheast area (1.23 m ha, 0.65 m ha) respectively and production (0.55 million tonnes, 0.24 million tonnes) respectively. Delhi and Bihar have highest productivity 3522 kg ha^{-1} and 1577 kg ha^{-1} respectively whereas in case of Maharashtra 450 kg / ha during the year 2015-2016. India, China, Brazil, Canada, Myanmar and Australia are major pulse producing countries with relative share of 25%, 10%, 5%, 5%, and 4% respectively.

Beginning of 19th century, potassium has been recognized as an essential element and a major nutrient for plant growth and required in large quantities. It ranks the third most important limiting nutrient next to nitrogen and phosphorus in crop production. It is a soft and silvery metallic element of group I (formerly IA) of the periodic table. Over 95 to 97 % world's potash is used in Agriculture. About 85% potassium movement in soil is by diffusion through the water films found around soil particles. As diffusion is relatively a slow process, potash fertilization is needed to maintain high levels of exchangeable potassium. Rapid plant growth and uptake deplete potassium from soil and around the root surface. The soil potassium reserves are depleted and crop yields found to be reduced. It is reported that, high clay Vertisol suppose to be having very high potassium content now responding for K application, which shows that, the K content has been depleted. (Ranade, 2011) [16].

Pigeon pea is a rich source of proteins i.e. about 22 per cent, lysine, riboflavin, thiamine, niacin and iron. Pigeon pea was longer duration coupled with heavy incidence of pests during flowering and pod formation stage which highly affect on the productivity of pigeon pea. 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 dry land and predominantly sown as intercrop with cotton, sorghum and soybean in most of the parts of Maharashtra. Pigeon pea being photosensitive, highly branching and in determinant growth habit responds very well to spacing. Only water soluble potassium is presence to leading from surface soil however, when water soluble potassium containing fertilizers, manures, crop residue applied to soil, it is likely that much of potassium will be as both exchangeable and non exchangeable potassium in surface and subsurface soil layers.

The function of potassium in plant metabolism is different from that of other major nutrients. The later become part of the plant structure, whereas potassium largely remains as an ion in the cells and sap and helps to control the water intake and metabolism of the plant. Some of the specific effects of potassium are to increase root growth and improve drought resistance. (Ranade, 2011) [16].

Zinc is one of the seventh plant micronutrient, involved in many enzymatic activities of the plant. It functions generally as a metal activator of enzymes. It is reported that, zinc improves crop productivity almost as much as major nutrients. Besides increasing crop yield, it increases the crude protein content, amino acids, energy value and total lipid in chickpea, soybean, black gram etc. Zinc deficiency is wide spread, in Marathwada region and it varies between 62 to 89 %. The Zn plays very important role in plant metabolism by influencing the activities of hydrogenise and carbonic anhydrate, stabilization of ribosomal fractions and synthesis of cytochrome. Plant enzymes activated by Zn are involved in carbohydrate metabolism, maintenance of the integrity of cellular membranes, protein synthesis, regulation of auxin synthesis and pollen formation. The regulation and maintenance of the gene expression required for the tolerance of environmental stresses in plants are Zn dependent. Its deficiency resulted in development of abnormalities in plants which become visible as deficiency symptoms such as stunted growth, chlorosis and smaller leaves, spikelet sterility. Zn deficiency can also adversely affect the quality of harvested products, plants susceptibility to injury by high light or temperature intensity and infection by fungal diseases can also increase. Zinc seems to affect the capacity for water uptake and transport in plants and also reduce the adverse effects of short periods of heat and salt stress. As Zn is required for the synthesis of tryptophan which is a precursor of IAA, it also had an active role in production of an essential growth hormone auxin. The Zn is required for integrity of cellular membranes to preserve the structural orientation of macromolecules and iron transport systems.

Materials and Methods

A field experiment was conducted during *kharif* season 2017-2018 to study the influence of varying levels of potassium and zinc on yield attributes and soil nutrient dynamics in pigeon pea at Research Farm, Department of Soil Science and Agricultural Chemistry, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The soil of the experimental site is alkaline having pH (7.81) with organic carbon (OC) content (4.73 g kg^{-1}) with calcium carbonate ($CaCO_3$) content (55.03 g kg^{-1}) and low in available N (201.25 kg ha^{-1}) and phosphorous (P_2O_5) content (7.39 kg ha^{-1}) and available potassium (K_2O) content (704.27 kg ha^{-1}) and available iron content (4.01 mg kg^{-1}) and available zinc content (0.19 mg kg^{-1}) and available manganese content (2.15 mg kg^{-1}) and available copper content (0.85 mg kg^{-1}).

The experiment was counducted in randomized block design with plot size of 5.4×4.2m^2 and 8 treatments were T_1: Absolute control (No fertilizer), T_2: Only RDF (25:50 N and P_2O_5 kg ha^{-1}), T_3: 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 $ZnSO_4ha^{-1}$, T_7: RDF + 30 kg K_2O ha^{-1} + 15 Kg $ZnSO_4ha^{-1}$, T_8: RDF + 45 kg K_2O ha^{-1} + 15 Kg $ZnSO_4ha^{-1}$. Pigeon pea variety BSMR – 736 was sown in rows 90 cm and plant 20 cm. Application of K and Zn at sowing. One irrigation at the time of flowering were provided. The RDF viz., 25: 50 kg ha^{-1} N, P_2O_5, was applied to pigeon pea during the following kharif season.

All yield attributes were recorded at harvest to assess the contribution to yield. The field observations on test weight, protein content, seed and straw yield were recorded. The five randomly selected plants from each plot were uprooted and cleaned. Seeds of five sampled were counted and expressed as seeds per sample. 1000 seed were counted from the lot, weighed and expressed as 1000 seed weigh. The seed and straw yields were recorded plot-wise after threashing of the produce. The N content in pigeon pea seed sample was determined by Kjeldahl method and protein content was obtained by multiplying with a factor of 6.25.

Results and Discussion

Protein content and test weight

Protein content in pigeon pea was ranged from 17.68 to 22.18. The treatment T_7 (RDF + 30 kg K_2O ha^{-1} + 15 kg $ZnSO_4$ ha^{-1}) recorded highest (22.18) protein content followed by treatment T_6 (RDF + 15 kg K_2O ha^{-1} + 15 kg $ZnSO_4$ ha^{-1}) 21.25 % and T_8 (RDF + 45kg K_2O ha^{-1} + 15 kg $ZnSO_4$ ha^{-1}) 21.06 %. The lowest protein content was observed in control T_1 17.68 %. 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 *et al.* (2002) [13], Farhad *et al.* (2010) [7], Chavan *et al.* (2012) [5], Habbasha *et al*. (2014) [8], Chavan *et al*. (2013) [6], Ayub *et al*. (2012) [2].

Table 1: Influence of varying levels of potassium and zinc on test weight and protein content of pigeon pea.

Treatments		Quality Parameters	
		Test weight (g)	Protein content (%)
T_1	Absolute control	80.00	17.68
T_2	Only RDF (25:50 N and P_2O_5 kg ha^{-1})	82.17	17.81
T_3	RDF + 15 kg K_2O ha^{-1}	85.28	17.93
T_4	RDF +30 kg K_2O ha^{-1}	84.42	18.12
T_5	RDF + 45 kg K_2O ha^{-1}	85.39	18.93
T_6	RDF + 15 kg K_2O ha^{-1} + 15 kg $ZnSO_4$ ha^{-1}	91.23	21.25
T_7	RDF + 30 kg K_2O ha^{-1} + 15 kg $ZnSO_4$ ha^{-1}	91.79	22.18
T_8	RDF + 45 kg K_2O ha^{-1} + 15 kg $ZnSO_4$ ha^{-1}	85.64	21.06
Grand Mean		85.74	19.38
Sem		2.34	1.41
CD at 5 %		7.12	NS

The data presented in (Table 1) revealed the significant increase in test weight was due to application of influence of varying levels potassium and zinc. The treatment T_7 (RDF + 30 kg K_2O ha^{-1} + 15 kg $ZnSO_4$ ha^{-1}) recorded highest test weight 91.79 g, followed by treatment T_6 (91.23 g) and T_8 (85.64 g). The lowest protein content was observed in control T_1 (80 g). The higher levels of K supplied to plants initiated maximum translocation of photosynthesis to fruiting zone. Similar findings were also reported by Reddy *et al.* (2007), Jadeja *et al.* (2016) [9].

Table 2: Influence of varying levels of potassium and zinc on seed and straw yield (kg ha^{-1}) of pigeon pea

	Treatments	Seed Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})	Total Biomass (kg ha^{-1})
T_1	Absolute control	881.75	1782	2666.75
T_2	Only RDF (25:50 N and P_2O_5 kg ha^{-1})	1058.62	2180	3238.62
T_3	RDF + 15 kg K_2O ha^{-1}	1190.39	2330	3520.39
T_4	RDF + 30 kg K_2O ha^{-1}	1322.81	2460	3782.81
T_5	RDF + 45 kg K_2O ha^{-1}	1543.48	2510	4053.48
T_6	RDF + 15 kg K_2O ha^{-1} + 15 kg $ZnSO_4$ ha^{-1}	1587.24	2580	4167.24
T_7	RDF + 30 kg K_2O ha^{-1} + 15 kg $ZnSO_4$ ha^{-1}	1675.56	2680	4355.56
T_8	RDF + 45 kg K_2O ha^{-1} + 15 kg $ZnSO_4$ ha^{-1}	1631.67	2450	4081.67
Grand mean		1361.44	2372	
SEm (±)		15.05	82.83	
CD at 5%		45.62	251	

Seed yield

The data pertaining to seed and straw yield presented in (Table 2) and fig. 1 indicated that, there was significant increase in seed and straw yield of pigeon pea with recommended dose of fertilizer along with potassium and zinc. The seed yield was found to be highest with the application of RDF + 30 kg K_2O ha^{-1} + 15 kg $ZnSO_4$ ha^{-1} which was significantly superior over other treatments. The lowest seed yield was observed in control (881.75 kg ha^{-1}). The treatment T_6 RDF + 15 kg K_2O ha^{-1} + 15 kg $ZnSO_4$ ha^{-1} and T_8 RDF + 45 kg K_2O ha^{-1} + 15 kg $ZnSO_4$ ha^{-1} were found to be statistically at par with each other. This was due to the influence of potassium nutrition on cell elongation and turgor potential in leaves. These results are in compliance with the findings of Sonawane *et al*. (2015) [18].

The seed yield of pigeon pea further increased with the 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. Similar results are in compliance with the findings of Jat *et al*. (2013), Mukundgowda *et al*. (2015) [12], Patil and Dhonde (2009) [14], and Ali *et al.* (2007) [1], Buriro *et al.* (2015) [4].

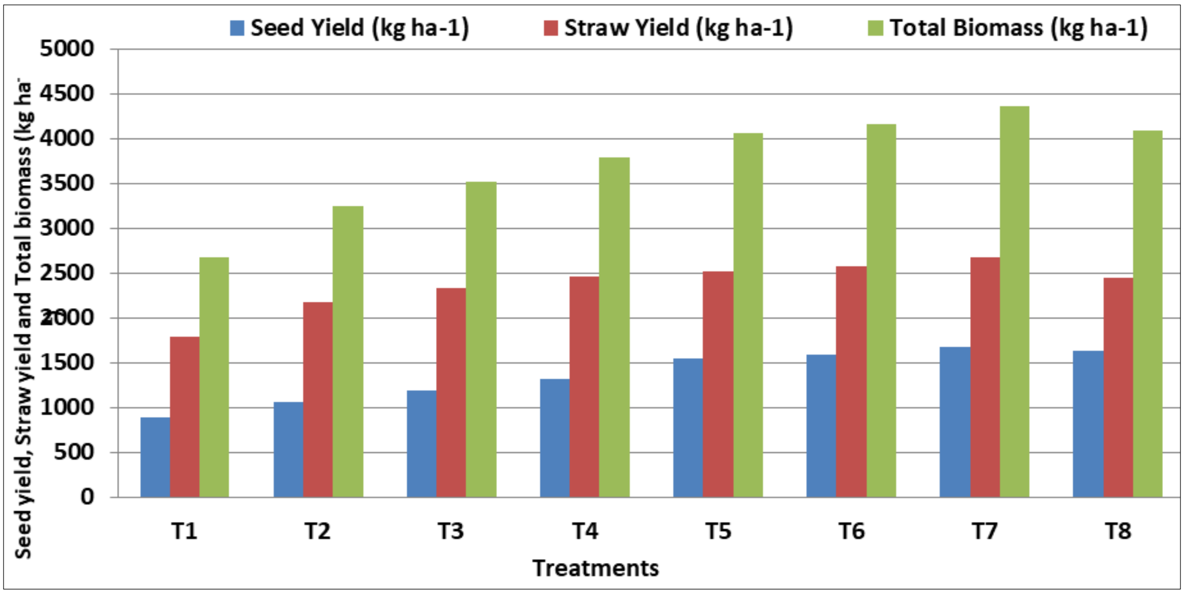

Fig 1: Influence of varying levels of potassium and Zinc on seed and straw yield.

Straw yield

The straw yield was noticed maximum with the application of RDF + 30 kg K_2O ha^{-1} + 15 kg $ZnSO_4$ ha^{-1}, (2680 kg ha^{-1}) which was significantly higher than other treatments and lowest straw yield was obtained in control T_1 (1782 kg ha^{-1}). The treatment T_6 RDF + 15 kg K_2O ha^{-1} + 15 kg $ZnSO_4$ ha^{-1} and T_8 RDF + 45 kg K_2O ha^{-1} + 15 kg $ZnSO_4$ ha^{-1} were found to be statistically at par with each other. Similar results as for the straw yield concern Jat *et al.* (2013) [10], Mukundgowda *et al*. (2015) [12], Patil and Dhonde (2009) [14], Khrogamy and Farnia (2009), Ali *et al.* (2007) [1], Boulbaba *et al.* (2005) [3], Jat *et al.* (2013) [10], Srikanthbabu *et al.* (2012) [17], Purushottam *et al.* (2018) [15].

Total biomass

The total biomass was found to be highest due to application of RDF + 30 kg K_2O ha^{-1} + 15 kg $ZnSO_4$ ha^{-1}, which was significantly higher than other treatments at harvesting stage. The lowest biomass yield was observed in control T_1 (2666.75 kg ha^{-1}). The treatment T_6 RDF + 15 kg K_2O ha^{-1} + 15 kg $ZnSO_4$ ha^{-1} and T_8 RDF + 45 kg K_2O ha^{-1} + 15 kg $ZnSO_4$ ha^{-1} were found to be statistically at par with each other.

The varying levels of potassium and zinc application significantly increased total biomass of pigeon pea. Table 4.1. Highest total biomass of pigeon pea (4355.56) was obtained in treatment T_7 comprises RDF with 30 kg K_2O and 15 kg $ZnSO_4$ ha^{-1} followed by treatment T_8 -RDF + 45 K_2O kg ha^{-1}+ 15 kg $ZnSO_4$ ha^{-1} (4081.67 kg ha^{-1}) and T_6 -RDF + 15 kg K_2O ha^{-1} + 15 kg $ZnSO_4$ ha^{-1} (4167.24 kg ha^{-1}) which were found to be statistically at par with each other. Among different potassium and zinc application, the treatment (T_7) RDF + 30 kg K_2O + 15 kg $ZnSO_4$ ha^{-1} recorded maximum total biomass (4355.56). The minimum biomass production (2666.75) was found in control. Similar results as for the biomass was concern Ayub *et al.* (2012) [2], Thesiya *et al.* (2013) [19].

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