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Agronomic Response of Pigeonpea to Potassium and Zinc Nutrition

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ABSTRACT

A field experiment entitled "Productivity and quality of redgram as influenced by potassium and zinc nutrition" was carried out during *kharif*, 2014-15 on sandy loam soils of dryland farm of S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University. In redgram at harvest, the tallest plants (255.0 cm), with the highest dry matter production (7893 kg ha^{-1}) and largest leaf area index (1.55) were recorded with foliar application of 1% KNO_3 + 0.2% $ZnSO_4$ at flower bud initiation and pod formation stage along with RDF, which was significantly superior over the rest of the nutrient management practices but the leaf area was however comparable with foliar application of 1% KNO_3 once at flower bud initiation or at flower bud initiation and pod formation stage along with RDF, foliar application of $ZnSO_4$ @ 0.2% at flower bud initiation, twice at flower bud initiation at pod formation stage along with RDF and foliar application of 1% KNO_3 + 0.2% $ZnSO_4$ at flower bud initiation stage along with RDF. Foliar application of 1% KNO_3 + 0.2% $ZnSO_4$ at flower bud initiation and pod formation stage along with RDF took significantly lesser number of days to 50% flowering. The highest number of pod bearing branches $plant^{-1}$ (17.6) were recorded with soil application of 50 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ ha^{-1} along with RDF. Foliar application of 1% KNO_3 + 0.2% $ZnSO_4$ at flower bud initiation and pod formation stage along with RDF recorded significantly higher number of pods $branch^{-1}$, number of seeds $pod^{-1}$and hundred seed weight. which was superior over the rest of the treatments. The foliar application of 1% KNO_3 + 0.2% $ZnSO_4$ at flower bud initiation and pod formation stage along with RDF recorded the highest seed, stalk and harvest index in pigeonpea than the rest of the nutrient management practices.

Key words: *Growth parameters, Pigeonpea , Yield attributes, Yield.*

Redgram is an important pulse crop In India, which occupies an area of about 3.89 M ha producing of 3.02 M tand with an average productivity of 776 kg ha^{-1}. In Andhra Pradesh, redgram is cultivated over an area of 4.8 lakh ha with annual production of 2.5 lakh tonnes with a productivity of 524 kg ha^{-1} (Ministry of Agriculture and Co-operation, 2014). The lower yield of pigeonpea in India is mainly attributed to its cultivation on poor soils with inadequate and imbalanced nutrient application. Among pulses, pigeonpea is one of the important pulse crops as a major source of protein in the diets of large section of vegetarian population in the developing countries in general and India, in particular. Even though India has the largest area under pulses in the world, the average productivity is very low and the production is not sufficient to meet the population requirement. Potassium is a key nutrient in plants which imports tolerance to stress such as temperature, drought and pest resistance. It not only enhances the biological nitrogen fixation, but also improves the protein content, water use in the plants (osmoregulation). Under intensive cropping without K fertilization, leads to depletion of potassium from the soil. Factors which can lead to potassium deficiency are leaching in sandy soils, irrigation water with high sodium content and where high rates of Ca and Mg are added through the irrigation water or through fertilization. Foliar application of macro nutrients particularly potassium can help the plants to recover from temporary stress caused by biotic and abiotic factors (Nasri *et al.,* 2011). Among the micronutrients, zinc deficiency is the most common deficiency prevalent in the world (Alloway, 2004). Zinc deficiency in Indian soils is expected to increase from 42 per cent in 1970 to 63 per cent by 2025 due to continuous depletion of soil fertility. Application of zinc improved the yield appreciably and foliar application of zinc is more economical in pulses. The present experiment was, therefore, planned to study the effect of potassium and zinc on growth, yield attributes and yield of pigeon pea.

MATERIAL AND METHODS

A field experiment was carriedout during *kharif*, 2014 at S.V. Agricultural College, dryland farm, Tirupati, which is geographically situated at 13.5°N latitude and 79.5°E longitude. The experimental soil was sandy loam in texture, neutral in reaction (pH 6.9), low in organic carbon (0.4%), available nitrogen (210.0 kg ha^{-1}), available phosphorus (14.2 kg ha^{-1}), available potassium (144.4 kg ha^{-1}) and zinc (1.07 kg ha^{-1}). The experiment was laidout in randomized block design and replicated thrice with ten treatments. The treatments consisted of ten nutrient management practices *viz.,* application of

Recommended Dose of Fertilizers (RDF) (20-50-0 kg N, P_2O_5 and K_2O ha^{-1}), soil application of K_2O and $ZnSO_4$ alone and in combination along with RDF, foliar application of 1% KNO_3 and 0.2% $ZnSO_4$ once or twice alone and in combination along with RDF. The crop was soon with a spacing of 120x20cm. 600 l of spray fluid was used for spraying in the morning time. (Table 1). The redgram variety used in the present experiment was TRG-38, by adopting seed rate of 5 kg ha^{-1} and the crop was harvested on 11-02-2015.

RESULTS AND DISCUSSION

Plant height, leaf area index and dry matter production of redgram at harvest was significantly influenced by soil and foliar application of potassium and zinc (Table 1). At harvest, the tallest plants (255.0 cm), with the highest dry matter production (7893 kg ha^{-1}) were produced with foliar application of 1% KNO_3 + 0.2% $ZnSO_4$ at flower bud initiation and pod formation stage along with RDF (T_{10}), which was significantly superior over the rest of the nutrient management practices. The highest plant height associated (T_{10}) might be due to role of nutrients in various physiological and biochemical processes contributing to the growth of the meristematic region (Cakmak *et al*., 1989), zinc is involved in the biosynthesis of plant hormones by activating tryptophan, which is a precussor of indole acetic acid, which inturn promotes the vertical growth. Higher dry matter production was associated with (T_{10}) might be due to the significant role of potassium in better root and shoot development, which increased N, P, K and Zn uptake and inturn increased dry matter production (Chavan *et al.,* 2012), Potassium works as a co-factor or activator of several enzymes involved in protein and carbohydrate metabolism thereby it enhances the efficiency of leaf in manufacturing sugars and starch (Beg *et al.,* 2013). The improvement in dry matter production with application of zinc was due to the fact that zinc is an essential component of several enzymes and plays an important role in nitrogen metabolism and higher uptake of nitrogen in plants, resulting in increased aminoacid and protein synthesis in plant cell causing better growth. The foliar application of potassium and zinc was more effective due to its higher uptake efficiency compared to soil application as they helps in increased photosynthetic efficiency by delaying the leaf senescence (Puniya *et al.,* 2013). The next best treatment was foliar application of 1% KNO_3 + 0.2% $ZnSO_4$ at flower bud initiation stage along with RDF (T_9) and soil application of 50 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ ha^{-1} along with RDF (T_4), which were comparable among themselves. The shortest plants (177.0 cm), with the lowest dry matter production (3986 kg ha^{-1}) was observed in plots where no potash was applied (20-50-0 kg NPK ha^{-1}) *i.e.* recommended dose of fertilizers. This might be due to the fact that high root to shoot ratio was associated with potassium uptake (Yang *et al.,* 2004).

At harvest, the maximum leaf area index (1.55) was recorded with foliar application of 1% KNO_3 + $ZnSO_4$ @ 0.2% at flower bud initiation and pod formation stage along with RDF (T_{10}), which was however comparable with foliar application of 1% KNO_3 once at flower bud initiation or at flower bud initiation and pod formation stage along with RDF (T_5 and T_6), foliar application of $ZnSO_4$ @ 0.2% at flower bud initiation, twice at flower bud initiation at pod formation stage along with RDF (T_7 and T_8) and foliar application of 1% KNO_3 + 0.2% $ZnSO_4$ at flower bud initiation stage along with RDF (T_9). Higher LAI at harvest with foliar application of potassium and zinc at flower bud initiation and pod formation stage along with RDF (T_{10}) was due to better absorption and translocation of foliar applied nutrients leading to delayed senescence and abscission. Foliar application of nutrients at the hour of need enable the plants to maintain higher chlorophyll content, leaf area per plant, leaf area index and decreasing the rate of senescence (Zayed *et al*., 2011). As zinc is involved in the synthesis of IAA, which is a component of various enzymes, such as carbonic anhydrase and alcoholic dehydrogenase, which have a suggestive role in chlorophyll formation, photosynthesis and metabolic reactions in plants leading to high LAI. The lowest leaf area index (0.71) was associated with application of recommended dose of fertilizers alone (T_1).

Foliar application of 1% KNO_3 + 0.2% $ZnSO_4$ at flower bud initiation and pod formation stage along with RDF (T_{10}) took significantly lesser number of days to 50% flowering (148), which was however comparable with foliar application of potassium and zinc individually/ in combination at flower bud initiation and pod formation stage along with RDF (T_5,T_6,T_7,T_8 and T_9). These nutrient management practices were significantly superior over soil application of 50 kg K_2O ha^{-1} along with RDF or 25 kg $ZnSO_4$ ha^{-1} along with RDF (T_2 and T_3) and soil application of 50 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ ha^{-1} along with RDF (T_4).The supplementation of potassium through foliar spray might have resulted in transport of assimilates thereby better nutrient balance in the plants leading to activation of enzymes responsible for increased flowering . Similar results were also reported by Singh and Singh, (2013). Foliar application of zinc helps in better absorption of zinc which promotes the translocation of synthesized carbohydrates to reproductive parts, causing early bloom with bold seeds.

The delayed flowering with soil application of potassium and zinc might be due to the fact that K and

Table 1. Plant height (cm) Leaf area index , Dry matter production (kg ha^{-1}) at harvest and Days to 50 per cent flowering of redgram as influenced by soil and foliar application of potassium and zinc

Treatments	Plant height (cm)	Leaf area index	Dry matter production (kg ha^{-1})	Days to 50 per cent flowering
T_1: Recommended dose of fertilizers (RDF) (20-50-0 kg N, P_2O_5 and K_2O ha^{-1})	177.0	0.71	3986	162
T_2: T_1 + Soil application of 50 kg K_2O ha^{-1}	211.9	0.82	5800	161
T_3: T_1 + Soil application of 25 kg $ZnSO_4$ ha^{-1}	215.8	0.78	5400	160
T_4: T_1 + Soil application of 50 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ ha^{-1}	234.0	0.83	6820	157
T_5: T_1 + Foliar application of KNO_3 @ 1% at flower bud initiation stage	193.9	1.51	4930	151
T_6: T_1 + Foliar application of KNO_3 @ 1% at flower bud initiation and pod formation stage	195.3	1.48	5097	151
T_7: T_1 + Foliar application of $ZnSO_4$ @ 0.2% at flower bud initiation stage	195.9	1.52	4900	152
T_8: T_1 + Foliar application of $ZnSO_4$ @ 0.2% at flower bud initiation and pod formation stage	217.0	1.41	5437	153
T_9: T_1 + Foliar application of 1% KNO_3 + 0.2% $ZnSO_4$ at flower bud initiation stage	237.0	1.39	6655	150
T_{10}: T_1 + Foliar application of 1% KNO_3 + 0.2% $ZnSO_4$ at flower bud initiation and pod formation stage	255.0	1.55	7893	148
SEm±	5.65	0.073	272.52	1.6
CD(P=0.05)	16.6	0.21	803.9	4.6

Table 2. Number of pod bearing branches plant^{-1}, pods branch^{-1}, Number of seeds pod^{-1} and Hundred seed weight (g) in redgram as influenced by soil and foliar application of potassium and zinc

Treatments	Number of pod bearing branches plant^{-1}	Number of pods branch^{-1}	Number of seeds pod^{-1}	Hundred seed weight(g)
T_1: Recommended dose of fertilizers (RDF) (20-50-0 kg N, P_2O_5 and K_2O ha^{-1})	12.1	9.2	3.10	10.3
T_2: T_1 + Soil application of 50 kg K_2O ha^{-1}	15.6	14.7	3.90	11.8
T_3: T_1 + Soil application of 25 kg $ZnSO_4$ ha^{-1}	15.5	15.3	3.96	11.9
T_4: T_1 + Soil application of 50 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ ha^{-1}	17.6	18.1	4.07	13.0
T_5: T_1 + Foliar application of KNO_3 @ 1% at flower bud initiation	12.5	11.5	3.26	11.0
T_6: T_1 + Foliar application of KNO_3 @ 1% at flower bud initiation and pod formation stage	12.9	13.8	3.82	11.7
T_7: T_1 + Foliar application of $ZnSO_4$ @ 0.2% at flower bud initiation	13.1	11.7	3.38	11.1
T_8: T_1 + Foliar application of $ZnSO_4$ @ 0.2% at flower bud initiation and pod formation stage	13.0	15.7	4.01	12.1
T_9: T_1 + Foliar application of 1% KNO_3 + 0.2% $ZnSO_4$ at flower bud initiation stage	13.3	18.0	4.12	12.8
T_{10}: T_1 + Foliar application of 1% KNO_3 + 0.2% $ZnSO_4$ at flower bud initiation and pod formation stage	13.2	20.4	4.56	13.7
SEm±	0.52	0.68	0.15	0.21
CD(P=0.05)	1.5	2	0.4	0.6

Table 3. Seed yield, stalk yield (kg ha^{-1}) and harvest index of redgram as influenced by soil and foliar application of potassium and zinc

Treatments	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Harvest index (%)
T_1: Recommended dose of fertilizers (RDF) (20-50-0 kg N, P_2O_5 and K_2O ha^{-1})	680	2403	22.05
T_2: T_1 + Soil application of 50 kg K_2O ha^{-1}	1052	3649	22.38
T_3: T_1 + Soil application of 25 kg $ZnSO_4$ ha^{-1}	1065	3752	22.11
T_4: T_1 + Soil application of 50 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ ha^{-1}	1304	4531	22.35
T_5: T_1 + Foliar application of KNO_3 @ 1% at flower bud initiation stage	800	2848	21.93
T_6: T_1 + Foliar application of KNO_3 @ 1% at flower bud initiation and pod formation stage	1045	3613	22.43
T_7: T_1 + Foliar application of $ZnSO_4$ @ 0.2% at flower bud initiation stage	887	3133	22.07
T_8: T_1 + Foliar application of $ZnSO_4$ @ 0.2% at flower bud initiation and pod formation stage	1123	3888	22.42
T_9: T_1 + Foliar application of 1% KNO_3 + 0.2% $ZnSO_4$ at flower bud initiation stage	1257	4332	22.49
T_{10}: T_1 + Foliar application of 1% KNO_3 + 0.2% $ZnSO_4$ at flower bud initiation and pod formation stage	1478	5007	22.8
SEm±	39.8	259.3	-
CD(P=0.05)	117	764	-

Zn absorbed by roots may not be sufficient to meet the needs of crop at flowering and pod formation stages. In redgram the peak absorption of potassium occurs from flowering to early pod development, any deficiency of potassium during this period can result in delayed blooming without obvious foliar symptoms.

Yield attributes

The highest number of pod bearing branches plant^{-1} (17.6) were recorded with soil application of 50 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ ha^{-1} along with RDF (T_4), which was significantly superior over the rest of the nutrient management practices (Table 2).. The next best treatment was soil application of 50 kg K_2O ha^{-1} along with RDF (T_2), which was however comparable with soil application of 25 kg $ZnSO_4$ ha^{-1} along with RDF (T_3). This might be attributed to the favourable influence of these nutrients on metabolism and its stimulating effect on photosynthetic pigments and enzymes which inturn encourage the number of branches plant^{-1} (Michail *et al.,* 2004). Zinc is a constituent of number of zinc finger proteins, which forms a structural motif of DNA binding region of the transcriptional regulatory proteins and plays an important role in reproductive development (Gamsjaeger *et al.,* 2007).The lowest number of pod bearing branches plant^{-1} (12.1) were recorded with application of recommended dose of fertilizers (T_1), which was in parity with foliar application of potassium and zinc alone/ in combination at flower bud initiation and pod formation stages once or twice (T_5,T_6,T_7,T_8,T_9 and T_{10}). This might be due to the fact that number of pod bearing branches plant^{-1} was already formed by the time of imposing the foliar treatments *i.e.* at 130 DAS.

Foliar application of 1% KNO_3 + 0.2% $ZnSO_4$ at flower bud initiation and pod formation stage along with RDF (T_{10}) recorded significantly higher number of pods branch^{-1}, number of seeds pod^{-1}and higher hundred seed weight, which was superior over the rest of the treatments (Table 2). This might ascribed due to the role of potassium in enhancing the availability of other nutrients, carbohydrates redistribution and increased transportation of photosynthates, from source to sink and starch synthesis and consequently the enhanced partioning of photosynthates towards newly formed sink. (Hussain *et al.,* 2011). The increase in number of pods branch^{-1} and seeds pod^{-1} was due to the role of zinc on reproductive organs, such as stamens and pollen, which increases the number of flowers that can fertile well and as a result, more number of pods branch^{-1} (Seifinadergholi *et al*., 2011). The higher hundred seed weight might be due to role of zinc in effective absorption of nutrients by plants and translocation of assimilates more efficiently for development of grains by proper filling as foliar application is a better way for supplying optimum nutrition for crop to complete its reproductive phases (Puniya *et al.,* 2013). Soil application of 50 kg K_2O+ 25 kg of $ZnSO_4$ ha^{-1} along with RDF (T_4) and foliar application of 1% KNO_3 + 0.2% $ZnSO_4$ at flower bud initiation stage along with RDF (T_9) were the next best treatments, which were comparable with each other. The lowest number of pods branch^{-1} (9.2) seeds pod^{-1} (3.1) was recorded with application of recommended dose of fertilizers (T_1). This might be due to physiological effects of zinc deficiency in pollen function, fertilization and reproductive development of plants (Pandey *et al*., 2010).

Yield

The yield of redgram was significantly influenced by soil and foliar nutrition of potassium and zinc. The highest seed and stalk yield of redgram was recorded with foliar application of 1% KNO_3 + 0.2% $ZnSO_4$ at flower bud initiation and pod formation stage along with RDF, which were significantly superior over the rest of the nutrient management practices tried (Table 3). The superiority of foliar nutrition in this nutrient management practice might be due to coincidence of foliar application with peak nutrient requirement of the crop, moreoverpeak absorption of potassium occurs from flowering to early pod development, any deficiency of potassium during this period can result in yield loss without obvious foliar symptoms. The quantity of nutrients absorbed due to soil application of potassium and zinc may not be sufficient to meet the crop demands at pod development stage. Supplementing the nutrients through foliage at flowering and pod formation stages might have resulted in better nutrient uptake and thereby regaining the photosynthetic efficiency of the plant at post anthesis period resulted in increased yield attributes and seed yield of redgram (Reddy *et al.,* 1991). Soil application of 50 kg K_2O + 25 kg $ZnSO_4$ ha^{-1}along with RDF and foliar application of 1% KNO_3 + 0.2% $ZnSO_4$ at flower bud initiation stage along with RDF were the next best nutrient management practices, which were comparable with each other. Application of recommended dose of fertilizers alone (20-50-0 kg N, P_2O_5 and K_20 ha^{-1}) recorded the lowest seed and stalk yield due to deficiency of potassium and zinc as the experimental soils, which are poor in available potassium (144.4 kg ha^{-1}) and available zinc (1.07 kg ha^{-1}). Similar results were also reported by Nalini *et al*. (2013) in blackgram.

The highest harvest index in redgram was recorded with foliar application of 1% KNO_3 + 0.2% $ZnSO_4$ at flower bud initiation and pod formation stage along with RDF. This might be due to better absorption and translocation of all the nutrients in balanced proportion leading to increased partitioning of photosynthates from source to developing seed, where foliar application coincides with the peak crop nutrient demand and thereby maintainance of better source-sink relationship. The lowest harvest index was recorded with application of recommended dose of fertilizers due to poor source-sink relationship.

CONCLUSION

Application of Recommended dose of fertilizers (RDF) (20-50-0 kg N, P_2O_5 and K_2O ha^{-1}) along with foliar application of 1% KNO_3 + 0.2% $ZnSO_4$ at flower bud initiation and pod formation stage recorded the highest stature of growth parameters like plant height, leaf area index and dry matter production of redgram at harvest and yield attributes *viz* number of pod bearing branches plant^{-1} number of pods branch^{-1}, number of seeds pod^{-1}, hundred seed weight and seed a yield of redgram, which were significantly superior over the rest of the nutrient management practices tried.

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