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SM Fulmali
Assistant Professor, KSK College of Agriculture, Beed, Murshadpur, Maharashtra, India

RA Jadhav
Assistant Professor, KSK College of Agriculture, Beed, Murshadpur, Maharashtra, India

MS Deshmukh
Associate Professor, Department of Soil Science & Agricultural Chemistry, VNMKV, Parbhani, Maharashtra, India

Correspondence
SM Fulmali
Assistant Professor, KSK College of Agriculture, Beed, Murshadpur, Maharashtra, India

Studies on use of potassium and zinc on quality and yield of Chickpea

SM Fulmali, RA Jadhav and MS Deshmukh

Abstract
A field experiment was planned and conducted during *Rabi* 2015-16 to evaluate the "Studies on use of potassium and zinc on yield and nutrient uptake by chickpea". The experiment was conducted the Departmental Research Farm of Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The experiment was laid out in Randomized Block Design with three replications. There were eight treatments comprising of K and zinc levels viz; T_1- Absolute control, T_2- Only RDF through soil (25:50:00 NPK 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}+25 kg $ZnSO_4$ ha^{-1}, T_7- RDF + 30 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ ha^{-1}, T_8- RDF + 45 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ ha^{-1}.
The results indicated that, the application of RDF + 30 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1} improved growth, quality parameters and increased grain and straw yield. Soil fertility status (available N, P, K, and S), micronutrients and plant nutrient concentration were higher in the treatments receiving potassium and zinc supplementation. The total uptake of nutrients was significantly increased with application of potassium and zinc @; RDF + 30 kg K_2O ha^{-1} and RDF + 30 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}. The uptake of N, P, K and zinc was increased due to K application and maximum uptake of these nutrients was noticed in the treatments receiving K and Zn in combinations. Available N and P status at various growth stages of chickpea were found to be increased at pod development stage and thereafter, N and P available status was decreased. The plant nutrient concentration studied in the present investigation was enhanced due to K and Zn application over absolute control. Thus, the maximum gross monetary returns, net monetary returns and monetary benefits were observed in treatment receiving RDF + 30 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1} with 1.74 B: C ratio. These findings indicate requirement of K and Zn to chickpea.

Keywords: micronutrients, quality, yield, uptake.

Introduction
Chickpea (*Cicer arietinum* L.) is the crop belongs to legume family and third most important pulse crop in the world after dry bean and dry peels. India is the largest producer and importer of the leguminous crops. Amongst the leguminous crops, chickpea occupies an important position due to its nutritious value (17-23% protein) in large vegetarian population of the country. India is the largest chickpea producer as well as consumer in the world (Kumar *et al*. 2014). Area under chickpea production in India during 2013-14 was 10.22 million ha; total production is 9.88 million tones and yield recorded up to 967 kg ha^{-1}.
Potassium is the third major element taken up by the plant and absorbed in larger amount as compared to other minerals except nitrogen. It has utmost importance for imparting drought and disease resistance and has synergistic effect with nitrogen and phosphorus (Das, 1999). It is not a constituent of organic structures, but regulates enzymatic activities (over 60 enzymes required by K for activation), translocation of photosynthesis (Mengel & Krikby, 1987) and considerably improves seed yield of chickpea if applied as a fertilizer (Samiullah & Khan, 2003, Singh *et al*., 1994, Verma, 1994). Keeping in view, the importance of potash for plants, the present study was carried out to investigate the growth, yield and quality on response of chickpea to different levels of potash.
Zinc (Zn), an essential micronutrient, not only enhances the crop productivity but also improves the quality of crop produce through its involvement in various physiological and biochemical reactions like synthesis of auxin or indole acetic acid (a growth-promoting hormone in plants), nucleic acids, and proteins. Zinc helps in utilization of nitrogen (N) and phosphorous (P) in plants and also maintains the semi-permeability of cell membrane. The important enzymes activated by Zn in plants are carbonic anhydrase, ribonuclease, and a number of dehydrogenases (Ohki 1976; Vallee and Wacker 1970; Takaki and Kushizaki 1970; Mengel and Kirkby 1996).
So taking into consideration, the importance of potassium and zinc in chickpea productivity, the research project entitled, "Studies on use of potassium and zinc on yield and nutrient

uptake by Chickpea" was undertaken at Departmental Research Farm of Soil Science and Agricultural Chemistry, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during 2015-16 with following objective:

To study the effect of potassium and zinc on yield and quality of chickpea.

Material and Methods

Experimental details

The field experiment was carried out using chickpea crop (Var. Akash) in *Rabi* season during years 2015-16 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 eight (8) 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}.

Details of experiment

1.	Plot size	4.5 x 3.6 m^2
2.	Crop Spacing	45 x 10 cm
3.	Method of sowing	Line sowing
4.	Date of sowing	5th October, 2015
5.	Date of harvesting	31st January, 2016

Treatment details

T_1	:Absolute Control (No Fertilizers)
T_2	:RDF only (25:50 kg N, P_2O_5 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} + 25 Kg $ZnSO_4$ ha^{-1}
T_7	: RDF + 30 Kg K_2O ha^{-1} + 25 Kg $ZnSO_4$ ha^{-1}
T_8	RDF + 45 Kg K_2O ha^{-1} + 25 Kg $ZnSO_4$ ha^{-1}

Biometric observations

Biometric observation includes plant height, number of branches, number of flowers and pods $plant^{-1}$ was recorded at different critical growth stages (flowering, pod development and harvest) of chickpea.

Quality parameter

Protein content

It was determined by multiplying the per cent of N in grain sample by constant factor 6.25 as described by AOAC. (1975) [3].

Grain yield and Straw yield

The grain and straw yield of both the crops was recorded separately from each net plot and converted on per hectare basis.

Economics in terms of chickpea

Economics of cultivation was worked out as per the following formulae.

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

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.

Statistical analysis

The results obtained were statistically analyzed and appropriately interpreted as per the methods described in "Statistical method for Agricultural Workers" by Panse and Sukhatme (1967). Appropriate standard error (S.E.) critical differences (C.D.) at 5 per cent levels were worked out for interpretation of result.

Results and Discussion

The various aspects of chickpea such as yield, quality as influenced by application of potassium and zinc have been studied and the findings are presented and discussed in this chapter under following heads..

Nutrient status of the experimental soil.

The soil analysis of the experimental plot was carried out before the establishment of field experiment and at harvest stage of the crop. The data thereof presented in Table 1. The experimental soil was fine, smectitic calcareous, Iso hyperthermic Typic Haplusterts. It was alkaline in reaction (pH 7.52), safe in soluble salt concentration (EC 0.22 dSm^{-1}) and low in organic carbon content (0.30 %). The free calcium carbonate was 5.20 per cent.

Table 1: Soil properties of the experimental soil before sowing and after harvest of crop

Treatments		pH	EC (dSm^{-1})	Organic carbon (%)	$CaCO_3$ (%)
Before sowing					
Initial		7.52	0.22	0.30	5.20
After harvest					
T_1	Absolute Control	7.44	0.21	0.33	5.13
T_2	Only RDF (25:50 NP kg ha^{-1})	7.40	0.23	0.32	5.20
T_3	RDF+ 15 kg K_2O ha^{-1}	7.52	0.24	0.35	5.30
T_4	RDF+ 30 kg K_2O ha^{-1}	7.57	0.22	0.32	5.33
T_5	RDF +45 kg K_2O ha^{-1}	7.45	0.25	0.35	5.47
T_6	RDF+ 15 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}	7.41	0.24	0.33	5.30
T_7	RDF+ 30 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}	7.52	0.22	0.35	5.27
T_8	RDF +45 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}	7.43	0.23	0.36	5.37
SEm (±)		0.07	0.01	0.01	0.08
CD at 5%		NS	NS	NS	NS
Grand mean		7.47	0.23	0.34	5.30

After harvest of the crop, it was observed that pH, electrical conductivity, organic carbon and calcium carbonate content of soil was not influenced significantly due to administration of various treatments. However, there was numerical increase or decrease in these parameters. The fine texture and alkaline soil reaction of the experimental soils is due to basaltic alluvial parent material of fine crystalline extrusive rock. The slight increase in organic carbon of some treatments might be due to the addition of crop residues remains after harvest of previous crop such as roots and shaded leaves. The similar results have been observed by Keram and Singh (2014) in wheat crop.

Effect of potassium and zinc on plant height, number of branches, number of pods at various growth stages.

Plant height (cm)

Table 2: Effect of potassium and zinc on plant height (cm)

Treatments	Treatment details	Plant Height (cm)		
		Flowering	Pod development	Harvesting
T_1	Absolute Control	22.33	37.53	50.53
T_2	Only RDF (25:50 NP kg ha^{-1})	25.20	38.27	51.40
T_3	RDF+ 15 kg K_2O ha^{-1}	26.73	40.73	53.13
T_4	RDF+ 30 kg K_2O ha^{-1}	28.67	41.20	55.93
T_5	RDF +45 kg K_2O ha^{-1}	29.67	42.67	54.13
T_6	RDF+ 15 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	30.27	43.00	57.67
T_7	RDF+ 30 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	32.17	46.20	60.13
T_8	RDF +45 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	30.00	42.67	56.73
SEm (±)		0.98	1.28	1.29
CD at 5%		2.95	3.87	3.89
Grand mean		28.13	41.53	54.96

The data presented in Table 2 revealed that, the plant height at flowering, pod development and harvesting stage was varied from 22.33 cm to 32.17 cm, 37.53 to 46.20 cm and 50.53 to 60.13 cm with an average of 28.13 cm, 41.53 cm and 54.96 cm, respectively. The maximum plant height was observed in treatment T_7 (RDF+ 30 kg K_2O ha^{-1}+ 25 kg $ZnSO_4$ ha^{-1}) which was followed by T_6 (RDF+15 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ ha^{-1}) and T_8 (RDF + 45 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ ha^{-1}) and minimum plant height was noticed in treatment T_1 i.e. absolute control at all the growth stages of crop. However, treatment T_7, T_6 and T_8 were at par with each other and they were significantly superior over rest of the treatments. Similar results have been reported by Ali *et al.* (2007) [2] and Sohu *et al.* (2015).

Number of branches

Table 3: Effect of potassium and zinc on number of branches.

Treatments	Treatment details	No. of branches		
		Flowering	Pod development	Harvesting
T_1	Absolute Control	6.13	8.13	9.13
T_2	Only RDF (25:50 NP kg ha^{-1})	6.80	9.07	10.07
T_3	RDF+ 15 kg K_2O ha^{-1}	6.67	9.47	10.73
T_4	RDF+ 30 kg K_2O ha^{-1}	7.07	10.07	11.13
T_5	RDF +45 kg K_2O ha^{-1}	7.13	10.20	11.20
T_6	RDF+ 15 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	7.20	10.73	11.80
T_7	RDF+ 30 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	7.33	11.20	12.53
T_8	RDF +45 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	7.20	10.87	12.07
SEm (±)		0.250	0.230	0.262
CD at 5%		NS	0.695	0.790
Grand mean		6.94	9.96	11.08

The data on mean number of branches per plant are presented in Table 3, which showed the number of branches per plant was influenced by application of potassium and zinc on chickpea. Number of branches per plant at flowering, pod development and harvesting stage was varied from 6.13 to 7.33, 8.13 to 11.20 and 9.13 to 12.53 with an average of 6.94, 9.96 and 11.08, respectively. Number of branches per plant at flowering stage was found non-significant. The maximum number of branches was observed in treatment T_7 (RDF+ 30 kg K_2O ha^{-1}+ 25 kg $ZnSO_4$ ha^{-1}) which was followed by T_8 (RDF+45 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ ha^{-1}) and T_6 (RDF + 15 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ ha^{-1}). The minimum number of branches was observed in treatment T_1 i.e. absolute control at pod development and harvesting stage of crop. However, treatment T_7, T_8 and T_6 were at par with each other and they were significantly superior over rest of the treatments. Similar results have also been reported by Ali *et al.* (2007) [2] and Buriro *et al.* (2015).

Number of flowers and pods.

Table 4: Effect of potassium and zinc on number of flowers and pods.

Treatments	Treatment details	Crop growth stages		
		Flowering (No. of flowers)	pod development (No. of pods)	Harvesting (No. of pods)
T_1	Absolute Control	65.87	38.33	54.53
T_2	Only RDF (25:50 NP kg ha^{-1})	74.13	40.68	55.87
T_3	RDF+15 kg K_2O ha^{-1}	74.87	42.55	57.67

T_4	RDF+30 kg K_2O ha^{-1}	82.20	45.87	60.53
T_5	RDF+45 kg K_2O ha^{-1}	80.53	43.47	59.40
T_6	RDF + 15 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}	84.67	47.47	63.80
T_7	RDF+ 30 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}	80.27	50.73	66.87
T_8	RDF +45 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}	99.07	46.73	61.87
SEm (±)		1.87	1.39	1.66
CD at 5%		5.65	4.20	5.03
Grand mean		80.20	44.48	60.07

The data presented in Table 4 indicated that, the number of flowers was in the range of 65.87 to 99.07 under varying treatments with an average of 80.20 at flowering stage of the crop. The maximum number of flowers was recorded in treatment T_8 (99.07) which were found significantly higher than rest of the treatments. Further scruiting of the data showed that, 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 + 25 kg $ZnSO_4$ ha^{-1} (T_7) followed by treatment T_6 (RDF + 15 kg K_2O + 25 kg $ZnSO_4$ ha^{-1}) and T_8 (RDF + 45 kg K_2O + 25 kg $ZnSO_4$ ha^{-1}). The maximum number of flowers and pods were recorded in treatment receiving RDF + 30 kg K_2O + 25 kg $ZnSO_4$ ha^{-1} (T_7). This might be due to the favorable influence of optimum potash and zinc on metabolism and biological activity and its stimulatory effects on growth of plant. Similar findings were observed by Thalooth *et al*. (2006), Ali *et al.* (2007) [2] and Sohu *et al.* (2015).

Effect of potassium and zinc on grain yield and straw yield of chickpea.

The data presented in Table 5 revealed that, the application of potassium and zinc with recommended dose of N and P (25 kg N and 50 kg P_2O_5 ha^{-1}) to chickpea recorded increase in grain yield.

Table 5: Effect of potassium and zinc on grain yield and straw yield.

Treatments	Treatment details	Grain yield (qha^{-1})	Straw yield (qha^{-1})
T_1	Absolute Control	9.25	20.37
T_2	Only RDF (25:50 NP kg ha^{-1})	10.18	22.22
T_3	RDF+ 15 kg K_2O ha^{-1}	11.41	24.07
T_4	RDF+ 30 kg K_2O ha^{-1}	14.50	30.86
T_5	RDF +45 kg K_2O ha^{-1}	13.27	28.39
T_6	RDF+ 15 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}	15.12	32.09
T_7	RDF+ 30 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}	16.35	34.56
T_8	RDF +45 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}	14.19	30.24
SEm (±)		0.70	1.43
CD at 5%		2.13	4.31
Grand mean		13.04	27.85

The grain yield of chickpea was ranged from (9.25 to 16.35 q ha^{-1}) and treatment T_4 comprises recommended dose of N and P with 30 kg K_20 ha^{-1} obtained higher (14.50 q ha^{-1}) grain yield and showed significant increase over absolute control. Further addition of zinc to growing media enhanced the chickpea grain and straw yield. The chickpea crop receiving RDF+30 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}(T_7) recorded the highest grain yield (16.35 q ha^{-1}) and at par with treatment T_6 (RDF + 15 kg K_2O + 25 kg $ZnSO_4$ ha^{-1}). The straw yield was in the range of 20.37 to 34.56 q ha^{-1} and maximum straw yield was observed in treatment T_7 (RDF+30 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}) which was significantly superior over absolute control but at par with rest of the treatments excluding T_2 and T3, respectively. 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 reported by Jat *et al*. (2013) [6], Patil and Dhonde (2009), Khrogamy and Farnia (2009), Buriro *et al.* (2015) and Ali *et al.* (2007) [2].

Effect of potassium and zinc on quality of chickpea.

The data presented in Table 6 revealed that, the test weight (100 seed weight) was in the range of 21.71 to 24.83 and maximum test weight was observed in treatment T_7 (RDF+ 30 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}) and it was at par with treatment T_6 (RDF+ 15 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}), T_4 (RDF+ 30 kg K_2O ha^{-1}) and T_8 (RDF+ 45 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}). However, said treatment showed significantly superior in test weight over rest of the treatments. The similar findings were recorded by Sohu *et al.* (2015).

The protein content was in the range of 18.86 to 21.08 per cent and maximum protein content was observed in treatment T_8 (RDF +45 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ ha^{-1}) followed by treatment T_7 (RDF+ 30 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}) and T_6 (RDF+ 15 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}). As potash has synergistic effect on N and K uptake, facilitates protein synthesis and activates different enzymes. Therefore, protein content increased significantly with increase in K levels. The results were statistically non-significant. Results are in confirmation with earlier observations reported by Selvaraj *et al.* (2014), Kumar *et al.* (2014), Ali *et al.* (2007) [2], Chavan *et al.* (2012) and Habbasha *et al*. (2013).

Table 6: Effect of potassium and zinc on test weight (gm) and protein content (%)

Treatments	Treatment details	Test Weight (gm)	Protein Content (%)
T_1	Absolute Control	21.71	18.86
T_2	Only RDF (25:50 NP kg ha^{-1})	22.82	19.37
T_3	RDF+ 15 kg K_2O ha^{-1}	23.06	19.81
T_4	RDF+ 30 kg K_2O ha^{-1}	23.42	20.12
T_5	RDF +45 kg K_2O ha^{-1}	22.35	20.50
T_6	RDF+ 15 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}	24.22	20.81
T_7	RDF+ 30 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}	24.83	20.92
T_8	RDF +45 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}	23.38	21.08
SEm (±)		0.58	0.56
CD at 5%		1.75	NS
Grand mean		23.22	20.18

Summary and Conclusion

A field experiment was planned and conducted during *Rabi* 2015-16 to evaluate the "Studies on use of potassium and zinc on yield by chickpea". The field 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. There were eight treatments comprising of K levels and zinc *viz*., T_1- Absolute control, T_2- Only RDF through soil (25:50:00 NPK kg ha^{-1}), T_3 –RDF + 15 kgK_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}+25 kg $ZnSO_4ha^{-1}$, T_7- RDF + 30 kg K_2O ha^{-1} + 25 kg $ZnSO_4ha^{-1}$, T_8- RDF+45 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ ha^{-1}.

The data in respect of plant growth, yield, soil nutrient status, plant nutrient concentration was collected, tabulated, analyzed statistically, presented, interpreted and discussed in previous chapters. These results are summarized in this chapter and conclusions were drawn. Number of flowers and no. of pods found to be increased due to application of 30 kg K_2O and 25 kg $ZnSO_4$ ha^{-1} to chickpea. Application of recommended dose of N and P with 30 kg K_20 ha^{-1} produced 14.50 q ha^{-1} chickpea grain yield and showed significant increase over absolute control. Further addition of zinc to growing media enhanced the chickpea yield. The chickpea crop receiving 30 K_2O ha^{-1} with 25 kg $ZnSO_4$ ha^{-1} recorded the highest grain yield (16.35 q ha^{-1}) and found at par with RDF + 15 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ ha^{-1} (T_6). The straw yield was in the range of 20.37 to 34.56 q ha^{-1} and maximum (34.56 q ha^{-1}) was recorded in treatment RDF+30 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1} (T_7). Chickpea protein content and seed test weight was improved due to inclusion of K and Zn in fertilizer recommendation schedule.

From the results summarized above following conclusion can be drawn

Application of RDF + 30 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1} improved growth and quality parameters increased grain yield and straw yield.

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