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Studies on use of Potassium and Zinc on Nutrient Uptake by Chickpea

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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, 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 were 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 were 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. Potassium availability was decreased from flowering to harvesting stage, and sulfur availability increased till the harvesting. In respect of micronutrients, no specific trend was noted. However, the application of zinc to chickpea maintained the higher Zn availability throughout the crop growth period. 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: Nutrient uptake, Chick pea, Micronutrients.

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.
In general, the productivity of pulse crop often constrained by imbalanced and insufficient supply of nutrients to plant. In balanced proportion and uses of fertilizers in appropriate quantities is absolutely essential for good productivity of crops in general and chickpea in particular. Pulses are the second most important group of crops after cereals. India, China, Brazil, Canada, Myanmar and Australia are major pulse producing countries with relative share of 25 %, 10 %, 5 %, and 4%, respectively. India ranks first in production of chickpea in world contributing 25-28 per cent world's total crop production. Low productivity of chickpea

in India is mainly attributed to improper and inadequate nutritional supply to plant. Use of fertilizers in appropriate quantities and in balanced proportion is absolutely essential for good productivity of crop. During green revolution high yielding varieties introduced to meet the demand of food for growing population resulted in the depletion of soil nutrients status.

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 objectives:

1. To study the effect of potassium and zinc on soil nutrient availability to chickpea.
2. To study the effect of potassium and zinc application on nutrient uptake at various growth stages 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

Soil analysis

Soil samples were collected before sowing, at flowering, at pod formation and at harvest stage of crop at 0-20 cm depth from each treated plot. Soil was air dried, ground with wooden mortar and pestle and sieved through 2 mm sieve. The sieved samples were stored in polythene bags with proper labeling for further analysis. These soil samples were subjected to various chemical estimations as per the methods given below.

Soil Reaction (pH)

pH was determined in (1:2.5) soil water suspension using digital pH meter described by Jackson (1973).

Electrical conductivity

Electrical conductivity was determined in (1:2.5) soil water suspension by using conductivity bridge meter described by Jackson (1973).

Organic carbon

Organic carbon was determined by Walkley and Black method (1934).

Calcium Carbonate

Calcium Carbonate was determined by rapid titration method as suggested by (Jackson, 1973).

Available Nitrogen

Available N was determined by alkaline potassium permanganate method as described by Subbiah and Asija (1956).

Available Phosphorus

Available Phosphorus was extracted from the soil with 0.5 M sodium bicarbonate (pH 8.5) as an extractant and measured colorimetrically by using 420 nm wave length as described by Olsen *et al*. (1954).

Available Potassium

Available Potassium was determined by using neutral normal ammonium acetate as an extractant and was measured on flame photometer (Piper, 1966).

Available Sulphur

It was determined by using turbidimetry method and measured on spectrophotometer as described by Chopra and Kanwar (1976).

Micronutrients (Zn, Fe, Mn and Cu)

Zn, Fe, Mn and Cu were determined by using DTPA extract as described by Lindsay and Norvell (1978).

Uptake of nutrients

Nutrient uptake i.e. uptake of N, P, K, S, Fe, Zn, Cu, Mn was calculated by considering grain and dry matter yield at harvest in particular plot in relation to concentration of the particular nutrient in respective plot using the following formula.

$$\text{Uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (\%) X (Grain/dry matter yield (kg ha}^{-1}\text{)}}{100}$$

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.

Result and Discussion

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 4.1. 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 nutrient uptake of N, P, K, S, Zn, Fe, Cu and Mn at various growth stages of chickpea.

Table 2: Effect of potassium and zinc on N uptake (kg ha^{-1}) at various growth stages

Treatments	Treatment details	N uptake (kg ha^{-1})			
		Flowering	Pod Development	Harvesting	Grain
T_1	Absolute Control	35.70	38.72	42.80	26.75
T_2	Only RDF (25:50 NP kg ha^{-1})	45.78	55.66	53.00	31.55
T_3	RDF+ 15 kg K_2O ha^{-1}	51.42	61.68	62.35	36.17
T_4	RDF+ 30 kg K_2O ha^{-1}	83.41	89.26	85.67	46.69
T_5	RDF +45 kg K_2O ha^{-1}	83.77	87.70	77.54	43.53
T_6	RDF+ 15 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	89.92	97.37	96.55	50.16
T_7	RDF+ 30 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	101.59	109.63	106.41	55.93
T_8	RDF +45 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	91.23	101.65	88.91	48.96
SEm (±)		3.93	4.50	3.65	2.37
CD at 5%		11.86	13.57	11.01	7.16
Grand mean		72.85	80.21	76.65	42.47

The data presented in Table 2 revealed that, the plant N uptake was ranged from 35.70 to 101.59 kg ha^{-1}, 38.72 to 109.63 kg ha^{-1} and 42.80 to 106.41 kg ha^{-1} at flowering, pod development and harvesting stage and grain N uptake was in the range from 26.75 to 55.93 kg ha^{-1} respectively. The treatment T_7 (RDF+ 30 kg K_2O ha^{-1}+25 kg $ZnSO_4$ kg ha^{-1}) had maximum value (101.59 kg ha^{-1}) at flowering, (109.63 kg ha^{-1}) pod development and (106.41) at harvesting stage and it was at par with treatment T_8 (RDF +45 kg K_2O ha^{-1}+25 $ZnSO_4$ ha^{-1}) and T_6 (RDF+ 15 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ ha^{-1}) over absolute control and in only RDF treatment (T_2). In grain, treatment T_7 (RDF+ 30 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}) (55.93 kg ha^{-1}) recorded maximum uptake of N and found to be at par with treatment 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 it was significantly superior over control and only RDF. Kherawat *et al*. (2013), Singh and Singh (1994), Chavan *et al.* (2012) and Keram and Singh (2014) supported these findings.

P uptake

Table 3: Effect of potassium and zinc on P uptake (kg ha^{-1}) at various growth stages

Treatments	Treatment details	P uptake (kg ha^{-1})			
		Flowering	Pod Development	Harvesting	Grain
T_1	Absolute Control	5.29	5.92	9.14	4.56
T_2	Only RDF (25:50 NP kg ha^{-1})	6.10	9.19	10.87	5.49
T_3	RDF+ 15 kg K_2O ha^{-1}	6.65	13.08	12.49	6.62
T_4	RDF+ 30 kg K_2O ha^{-1}	10.47	20.62	16.06	8.40
T_5	RDF +45 kg K_2O ha^{-1}	10.56	18.61	15.39	8.62
T_6	RDF+ 15 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	10.99	18.80	17.32	9.82
T_7	RDF+ 30 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	11.56	18.71	18.98	10.95
T_8	RDF +45 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	11.30	17.06	16.93	8.37
SEm (±)		0.44	0.78	0.70	0.43
CD at 5%		1.34	2.35	2.12	1.30
Grand mean		9.11	15.25	14.65	7.85

The data presented in Table 3 revealed that, the significant increase in P uptake by chickpea with application of potassium alone or in combination with zinc over control and only RDF. The P uptake was in the range from 5.29 to 11.56 kg ha^{-1}, 5.92 to 20.62 kg ha^{-1} and 9.14 to 18.98 kg ha^{-1} at flowering, pod development and harvesting stage and grain P uptake was in the range from 4.56 to 10.95 kg ha^{-1} respectively. The highest P uptake in plant was noticed in treatment T_7 (RDF+ 30 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ ha^{-1}) and at par with treatment T_8 (RDF +45 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}), T_6 (RDF+ 15 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ ha^{-1}), T_5 (RDF+ 45 kg K_2O ha^{-1}) and T_4 (RDF+ 30 kg K_2O ha^{-1}) at flowering stage. The highest P uptake in plant was noticed in treatment T_4 (RDF+ 30 kg K_2O ha^{-1}) and at par with treatment 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}), and T_5 (RDF+ 45 kg K_2O ha^{-1}) at pod development stage. The highest P uptake in plant was noticed in treatment T_7 (RDF+ 30 kg K_2O + 25 kg $ZnSO_4$ ha^{-1}) and at par with treatment T_6 (RDF+ 15 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}) and T_4 (RDF+ 30 kg K_2Oha^{-1}) at harvesting stage. The highest P uptake in grain recorded with treatment T_7 (RDF+ 30 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ ha^{-1}) and at par with treatment T_6 (RDF+ 15 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ ha^{-1}) which was significantly superior over control and only RDF. Similar trend was noticed by Kherawat *et al*. (2013), Joshi *et al*. (1974), Chavan *et al.* (2012) and Keram and Singh (2014).

K uptake

Table 4: Effect of potassium and zinc on K uptake (kg ha^{-1}) at various growth stages

Treat Ments	Treatment details	K uptake (kg ha^{-1})			
		Flowering	Pod Development	Harvesting	Grain
T_1	Absolute Control	24.38	28.70	31.58	6.11
T_2	Only RDF (25:50 NP kg ha^{-1})	28.99	37.52	36.89	7.42
T_3	RDF+ 15 kg K_2O ha^{-1}	32.12	41.64	41.47	8.90
T_4	RDF+ 30 kg K_2O ha^{-1}	53.06	64.50	56.49	12.90
T_5	RDF +45 kg K_2O ha^{-1}	57.72	66.34	61.86	12.60
T_6	RDF+ 15 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	51.75	62.02	56.18	12.19
T_7	RDF+ 30 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	54.58	66.66	74.34	13.40
T_8	RDF +45 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	53.08	71.88	69.86	14.75
SEm (±)		1.55	1.96	1.91	0.65
CD at 5%		4.68	5.92	5.75	1.97
Grand mean		44.46	54.91	53.58	11.04

The data presented in Table 4 revealed that, the K uptake was influenced due to K and Zn application. The K uptake in plant was ranged between 24.38 to 57.72 kg ha^{-1}, 28.70 to 71.88 kg ha^{-1} and 31.58 to 74.34 kg ha^{-1} at flowering, pod development and at harvest stage of crop. The K uptake in grain ranged from 6.11 to 14.75 88 kg ha^{-1}. At flowering stage, the maximum uptake of K (57.72 kg ha^{-1}) was in treatment T_5 (RDF + 45 kg K_2O ha^{-1}) and it was at par with treatment 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}) and T_4 (RDF+ 30 kg K_2Oha^{-1}).At pod development stage, the maximum uptake of K (71.88 kg ha^{-1}) was noted with treatment T_8 (RDF +45 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}) and it was at par with treatment T_7 (RDF+ 30 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}) and T_5 (RDF + 45 kg K_2O ha^{-1}). At harvesting stage, the maximum uptake of K (74.34 kg ha^{-1}) was observed in treatment T_7 (RDF+ 30 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}) and was at par with T_8 (RDF +45 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}). In grain, the maximum K uptake was observed (14.75 kg ha^{-1}) in treatment T_8 (RDF +45 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}) which showed its significancy over rest of the treatments excluding T_4 (RDF+ 30 kg K_2Oha^{-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}) and T_7 (RDF+ 30 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}). Results are inconformity with the findings of Kherawat *et al*. (2013), Brar *et al*. (2010), Jat *et al*. (2013), Chavan *et al.* (2012) and Keram and Singh (2014).

S uptake

The data presented in Table 5 indicated that, the S uptake in plant varied from 9.26 to 23.49 kg ha^{-1}, 8.88 to 26.36 kg ha^{-1} and 7.73 to 17.61 kg ha^{-1} at flowering, pod development and harvest of the crop and in grain it was varied from 10.63 to 23.21 kg ha^{-1} respectively. The treatment T_7 (RDF +30 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}) recorded the highest S uptake and it was at par with 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}) at flowering, pod development and harvesting stage and similar type of results noticed in grain S uptake.

Table 5: Effect of potassium and zinc on S uptake (kg ha^{-1})

Treatments	Treatment details	S uptake (kg ha^{-1})			
		Flowering	Pod Development	Harvesting	Grain
T_1	Absolute Control	9.26	8.88	7.73	10.63
T_2	Only RDF (25:50 NP kg ha^{-1})	10.89	14.66	8.88	13.54
T_3	RDF+ 15 kg K_2O ha^{-1}	12.39	16.02	10.10	15.29
T_4	RDF+ 30 kg K_2O ha^{-1}	21.29	22.87	13.87	20.58
T_5	RDF +45 kg K_2O ha^{-1}	21.82	22.19	13.62	19.24
T_6	RDF+ 15 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	22.33	25.57	16.36	22.22
T_7	RDF+ 30 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	23.49	26.36	17.61	23.21
T_8	RDF +45 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	22.85	21.78	17.24	21.29
SE±(m)		0.50	0.62	0.50	0.73
C.D.		1.52	1.86	1.50	2.20
Grand mean		18.04	19.79	13.18	18.25

Zn uptake

The data presented in Table 5 revealed that, the Zn uptake in plant was ranged between 860.12 to 3154.94 mg ha^{-1}, 1333.99 to 3532.16 mg ha^{-1}, and 1639.63 to 3810.35 mg 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} + 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}) and T_8 (RDF +45 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}) at flowering and pod development stage. The maximum uptake of Zn was recorded (3810.35 mg ha^{-1}) in treatment T_7 (RDF + 30 kg K_2O ha^{-1} + 25 kg $ZnSO_4$ 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 389.04 to 1148.72 mg ha^{-1} and treatment T_7 (RDF + 30 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}) showed maximum Zn uptake (1148.72 gm ha^{-1}) and at par with treatment 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}) and it was significantly superior over rest of treatments. Similar trends were noticed by Bahmanyar and Poshtamosari *et al*. (2006), Pandey and Gautam (2009), Chavan *et al.* (2012) and Keram and Singh (2014).

Table 6: Effect of potassium and zinc on Zn uptake (mg ha^{-1}) at various growth stages

Treatments	Treatment details	Zinc uptake (mg ha^{-1})			
		Flowering	Pod development	Harvesting	Grain
T1	Absolute Control	860.12	1333.99	1639.63	389.04
T2	Only RDF (25:50 NP kg ha^{-1})	1104.04	1927.03	1898.15	445.01
T3	RDF+ 15 kg K_2O ha^{-1}	1291.94	2045.73	2167.25	621.81
T4	RDF+ 30 kg K_2O ha^{-1}	2169.73	2890.85	2774.77	762.76
T5	RDF +45 kg K_2O ha^{-1}	2649.98	2838.31	2710.79	774.67
T6	RDF+ 15 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	3007.02	3288.25	3093.18	947.03
T7	RDF+ 30 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	3154.94	3532.16	3810.35	1148.72
T8	RDF +45 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	2936.21	3283.95	3030.56	967.35
SEm (±)		84.31	141.81	154.23	68.21
CD at 5%		254.54	428.15	465.65	205.94
Grand mean		2146.75	2642.53	2640.59	757.05

Thus from the uptake studies, it was noted that, there was increase in N,P,K and Zinc uptake due to application of K and zinc. The potassium application enhances the movement of N and P which might have contributed to high N and P uptake. Further application of zinc had additive effect on nutrient uptake. It was seen here that, zinc had not played any negative role in uptake of phosphorus, which confirms that, at lower level, zinc and phosphorus shows synergistic effects. Many research workers also supported to these findings.

Fe uptake

Table 7: Effect of potassium and zinc on Fe uptake (mg ha^{-1})

Treatments	Treatment details	Fe uptake (mg ha^{-1})			
		Flowering	Pod Development	Harvesting	Grain
T1	Absolute Control	457.32	836.92	760.21	147.37
T2	Only RDF (25:50 NP kg ha^{-1})	614.28	1157.35	893.21	185.06
T3	RDF+ 15 kg K_2O ha^{-1}	741.09	1368.46	1021.60	248.55
T4	RDF+ 30 kg K_2O ha^{-1}	1665.78	2071.34	1816.41	360.90
T5	RDF +45 kg K_2O ha^{-1}	1278.33	1930.00	1436.91	401.39
T6	RDF+ 15 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	1066.92	2120.97	1531.85	493.36
T7	RDF+ 30 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	1849.21	2166.55	2255.03	691.72
T8	RDF +45 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	1240.35	2083.91	1647.67	507.72
SE±(m)		81.76	81.84	97.03	19.89
C.D.		246.86	247.10	292.96	60.05
Grand mean		1114.16	1716.94	1420.36	379.51

The data presented in Table 7 indicated that, the Fe uptake in plant varied from 457.32 to 1849.21 mg ha^{-1}, 836.92 to 2166.55 mg $ha^{-1}$and 760.21 to 2255.03 mg ha^{-1} at flowering, pod development and harvest of the crop and in grain it was varied from 147.37 to 691.72 mg ha^{-1} respectively. The treatment T_7 (RDF +30 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}) recorded the highest Fe uptake and at par with 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}) and T_8 (RDF +45kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}) at pod development stage. The treatment T_7 (RDF +30 kg K_2O ha^{-1}+25 kg $ZnSO_4$ 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.

Cu uptake

The data presented in Table 8 indicated that, the Cu uptake in plant varied from 285.31 to 1469.40 mg ha^{-1}, 336.71 to 1927.69 mg ha^{-1} and 327.29 to 1582.26 mg ha^{-1} at flowering, pod development and harvest stage of the crop and in grain it was varied from 95.60 to 422.16 mg ha^{-1} respectively. The treatment T_7 (RDF +30 kg K_2O ha^{-1}+25 kg $ZnSO_4$ 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 8: Effect of potassium and zinc on Cu uptake (mg ha^{-1})

Treatments	Treatment details	Cu uptake (mg ha^{-1})			
		Flowering	Pod Development	Harvesting	Grain
T_1	Absolute Control	285.31	336.71	327.29	95.60
T_2	Only RDF (25:50 NP kg ha^{-1})	368.39	413.27	399.62	119.26
T_3	RDF+ 15 kg K_2O ha^{-1}	509.65	966.42	588.85	164.95
T_4	RDF+ 30 kg K_2O ha^{-1}	1330.65	1416.81	1258.01	216.85
T_5	RDF +45 kg K_2O ha^{-1}	897.67	1445.21	916.83	214.34
T_6	RDF+ 15 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	953.63	1583.49	1081.01	275.65
T_7	RDF+ 30 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	1469.40	1927.69	1582.26	422.16
T_8	RDF +45 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	1121.80	1589.72	922.98	279.42
SE±(m)		50.73	61.81	44.90	12.06
C.D.		153.17	186.62	135.57	36.40
Grand mean		867.06	1209.92	884.61	223.53

Mn uptake

The data presented in Table 9 indicated that, the Mn uptake in plant varied from 262.67 to 1472.31 mg ha^{-1}, 341.23 to 2234.59 mg $ha^{-1}$and 318.46 to 1724.90 mg ha^{-1} at flowering, pod development and at harvest stage of the crop and the grain Mn uptake varied from 149.57 to 748.85 mg ha^{-1} respectively. The treatment T_7 (RDF +30 kg K_2O ha^{-1}+25 kg $ZnSO_4$ 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 9: Effect of potassium and zinc on Mn uptake (mg ha^{-1})

Treatments	Treatment details	Mn uptake (mg ha^{-1})			
		Flowering	Pod Development	Harvesting	Grain
T_1	Absolute Control	262.67	341.23	318.46	149.57
T_2	Only RDF (25:50 NP kg ha^{-1})	470.89	568.79	384.50	177.57
T_3	RDF+ 15 kg K_2O ha^{-1}	566.37	918.39	893.58	235.97
T_4	RDF+ 30 kg K_2O ha^{-1}	931.37	1997.29	1463.44	316.88
T_5	RDF +45 kg K_2O ha^{-1}	916.94	1599.06	1270.33	404.79
T_6	RDF+ 15 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	1047.25	1818.75	1235.30	535.88
T_7	RDF+ 30 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	1472.31	2234.59	1724.90	748.85
T_8	RDF +45 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	1071.95	2029.35	1279.18	519.88
SE±(m)		33.02	55.33	54.53	9.79
C.D.		99.70	167.04	164.63	29.55
Grand mean		842.47	1438.43	1071.21	386.17

Economics of chickpea

The economics in respect of chickpea production with selected prescribed treatment schedule was computed considering the cost of cultivation, gross monetary return, net monetary return and benefit cost ratio. The prevailing market results for inputs and market prices of sale of product were used for calculating the cost of cultivation. The data thereof are presented in Table 10. The highest gross monetary return, net monetary return and benefit cost ratio were recorded with treatment T_7 (RDF + 30 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}) followed by 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}). The benefit cost ratio varied in range from 1.02 to 1.74 respectively. The maximum benefit cost ratio (1.74) was recorded with treatment T_7 (RDF + 30 kg K_2O ha^{-1}+25 kg $ZnSO_4$ ha^{-1}).

Table 10: Effect of potassium and zinc on economics of chickpea

Treatments	Treatment details	Cost of Cultivation(Rs.)	Gross monetary return (Rs.)	Net monetary return (Rs.)	B:C Ratio
T_1	Absolute Control	25535	51810	26275	1.02
T_2	Only RDF (25:50 NP kg ha^{-1})	27305	56920	29615	1.08
T_3	RDF+ 15 kg K_2O ha^{-1}	28961	63380	34419	1.18
T_4	RDF+ 30 kg K_2O ha^{-1}	29863	80680	50817	1.70
T_5	RDF +45 kg K_2O ha^{-1}	30188	73860	43672	1.44
T_6	RDF+ 15 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	32452	84085	51633	1.59
T_7	RDF+ 30 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	33082	90855	57773	1.74
T_8	RDF +45 kg K_2O ha^{-1} +25 kg $ZnSO_4$ ha^{-1}	33285	78975	45690	1.37

Conclusions

The initial soil fertility status showed that, soils were alkaline in reaction, safe in soluble salt, calcareous in nature and low in organic carbon content. The available N and P status was low. The experimental soil was high in available K content and deficient in zinc.

The data in respect of plant growth, yield, soil nutrient status, plant nutrient concentration and uptake of nutrient 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).

The plant nutrient concentration studied in the present investigation enhanced due to K and Zn application over absolute control. This suggested balance nutrition is a need of hour.

- Soil fertility status (available N, P, K, and S) and micronutrients, and plant nutrient concentration were higher in the treatment receiving potassium. The total uptake nutrients 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. Maximum uptake of these nutrients were noticed in the treatment receiving K and Zn in combinations.

“Even under high potassium content of soil for pulses in general and chickpea in particular it is essential to include potassium in fertilizer application schedule in the Vertisols of Marathwada region.**”**

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