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Effect of zinc and iron nutrition on productivity and profitability of chickpea (*Cicer arietinum* L.) in Central India

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ABSTRACT

A field experiment was conducted during *rabi* season of 2018-19 and 2019-20 to assess the effect of foliar spray of zinc and iron on yield and economics of chickpea (*Cicer arietinum* L.). Yield attributes *viz.*, number of pods/plant, number of grains/plant, 1000 seed weight and grain weight per plant were obtained significantly higher under 25 kg $ZnSO_4$ through soil application. Seed yield (1617 kg/ha), stover yield (4128 kg/ha), gross returns (₹ 86524/ha) and net returns (₹ 61370/ha) were recorded significantly superior under 25kg $ZnSO_4$ through soil application. However, application of 25kg $ZnSO_4$ through soil application gave 328 kg/ha (25.44%) higher seed yield, ₹ 18551/ha (27.29%) greater gross returns and ₹ 15794/ha (34.65%) more net returns over the control. While the Benefit: Cost ratio was obtained significantly higher (3.48) under 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ spray at flower initiation stage followed by 25kg $ZnSO_4$ through soil application (3.43), harvest index was significantly superior under (33.32%) 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ spray at flower and pod initiation stage.

Key words: Chickpea, Economics, Foliar fertilization, Iron, Soil application, Yield, Zinc

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the third important pulse crop in the world after french bean (*Phaseolus vulgaris* L.) and field peas (*Pisum sativum* L.) (FAO, 2019). In India, it is grown in area of 9.55 million ha, production of 9.94 million tonnes with productivity of 1041 kg/ha during 2018 - 19 (Anonymous, 2020). The productivity of chickpea in India is low as compare to production potential of crop. However, quality of seed is also impaired due to deficiency of several micronutrients.

In Indian soil, the deficiencies of micronutrients are exhibited in vast area due to use of strait fertilizer, less or no use of organic manure and intensive cultivation practices. The farmers generally do not use micro-nutrients which drastically reduces crop yield. Singh (2008) reported that 49% of soils in India are potentially deficit in Zn, 12% in Fe, 5% in Mn, 3% in copper (Cu), 33% in boron (B) and 11% in molybdenum (Mo). Zinc plays a very important role in plant metabolism by influencing the activities of hydrogenase and carbonic anhydrase, stabilization of ribosomal fraction and synthesis of cytochrome (Tisdale *et al.*, 1984). Zinc activated plant enzymes are involved in carbohydrate metabolism, regulation of auxin synthesis, protein synthesis and pollen formation (Marschner, 1995). It is associated with water uptake and water regulation and is helpful in reproduction of plants. Zinc applications either through soil or foliar application also increase the zinc content in shoot (Abbas and Zaynab, 2010). However, significantly higher grain yield and net returns of chickpea were found in Zn addition at 5 kg/ha as basal and foliar application of Zn 0.5% than that of control and water spray, respectively (Yadav *et al.*, 2020). Application of Zn enhanced quality and yields of chickpea (Khan *et al*., 2003). Nandan *et al*. (2018) observed highest gross returns, net returns and B: C ratio of chickpea under treatment RDF + Zn (0.5%) and Fe (0.5%) through foliar application, which was followed by RDF + seed treatment + Soil application of Zn @ 25 kg/ha. However, zinc application had significantly positive effect on all growth attributes and yield parameters of chickpea with the levels of zinc up to 2.5 kg ha^{-1} (Kuldeep *et al*., 2018). Soil or foliar applications of $ZnSO_4$ improves the Zn content in chickpea plant (Pal *et al*., 2019).

Iron has an essential role in the synthesis and maintenance of chlorophyll in plants, nucleic acid metabolism, photosynthesis, nitrogen fixation and uptake mechanism (Kim and Rees, 1992). It plays a significant role in plants and serves as a component of many vital enzymes such as cytochrome of electron transport chain. Iron translocated from roots to shoots as a ferric- citrate chelate form and is transported to activily growing shoot regions. Kumar *et al*. (2009) showed that application of iron fertilizer increased the grain yield of chickpea by 17.3% over the control. However,yield attributing characters *viz*. pods/ plant, seed/ plant, test weight and seed yields was found maximum in treatment RDF (20:50:20) + 0.5% $ZnSO_4$ and 0.1% $FeSO_4$ through foliar application in pre flowering and pod development stage followed by RDF (20:50:20) + Soil application of $ZnSO_4$ @ 25 kg/ha at basal compared to other treatment (Banjara and Majgahe, 2019). Significant improvement in yield *viz*., seed, stover and biological yields was observed with the increasing levels of iron up to 4.0 kg Fe/ ha over control and 2.0 kg Fe/ ha (Kuldeep *et al*., 2018).

In view of these facts, the present investigation was carried out to find out the appropriate dose and time of zinc and iron nutrition on chickpea under Kymore Plateau region of Madhya Pradesh .

MATERIAL AND METHODS

The field experiment was conducted at Agriculture farm of the Mahatma Gandhi Chitrakoot GramodayaVishwavidyalaya, Chitrakoot, Satna (M.P.) during *rabi* season of 2018-19 and 2019-20. The farm is situated under Kymore Plateau of Northern Madhya Pradesh (25^0 10′ N latitude, 80^0 32′E longitude and 190-210 meter above mean sea level). The total mean annual rainfall of Chitrakoot is 950 mm while, the crop was received 100 mm and 264 mm rainfall during two respective crop season. The soil of experimental field was sandy loam with neutral pH (7.48 and 7.67), low organic carbon (0.26% and 0.50%) and available nitrogen (185.4 and 215.65 kg/ha), medium to high available phosphorus (23.23 and 42.76 kg/ha), medium available potassium (146.43 and 245.25 kg/ha), Zn 1.009 and 1.075 ppm and Fe 5.56 and 5.78 ppm during two consecutive years.

The experiment consisted of 8 treatments *viz.* T_1: control, T_2: 0.5% $ZnSO_4$ spray at flower initiation stage, T_3: 0.5% $ZnSO_4$ spray at flower and pod initiation stage, T_4: 0.5% $FeSO_4$ spray at flower initiation stage, T_5: 0.5% $FeSO_4$ spray at flower and pod initiation stage, T_6: 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ spray at flower initiation stage, T_7: 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ spray at flower and pod initiation stage, T_8: 25 kg $ZnSO_4$ through soil application. The experiment was replicated thrice in Randomized Block Design. Recommended dose of fertilizers (RDF) *viz.* 20:40:20 kg N: P_2O_5: K_2O/ha, wassupplied through DAP and muriate of potashas basal in the furrows in all treatments. Foliar application of zinc and iron was given through zinc sulphate heptahydrate ($ZnSO_4.7H_2O$) and iron sulphate heptahydrate ($FeSO_4.7H_2O$) at pre flowering and pod formation stage as per treatment. Chickpea *cv.* JG-14 was sown in rows 30 cm apart on 19th November, 2018 and 16th October, 2019 using a seed rate of 100 kg/ha. The plant to plant spacing was maintained at 5 cm by thinning at 20 DAS. The crop was grown as per recommended package and practices and harvested on 23rd March, 2019 and 20th March, 2020. The important yield attributes and yield were recorded at appropriate time as per standard procedure. The economics of treatment was calculated as per prevailing market price of the area. Experimental data related to each character was statistically analysed as per procedure of analysis of variance and significance was tested by "F" test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effect on yield attributes

Yield attributes *viz.*, pods per plant recorded as significantly higher under T_8through soil application (44.33) followed by T_7spray at flower and pod initiation stage (42.47). However, grains per pod (1.53) and 1000 seed weight (207.83 g) were significantly maximum under 25 kg $ZnSO_4$ through soil application (T_8) followed by T_3spray at flower and pod initiation stage (1.51 ; 207.67 g) (Table 1). Similarly, grain weight/plant was significant superior in all foliar and basal application of $ZnSO_4$ and $FeSO_4$ followed by T_4spray at flower initiation stage (13.19 g/plant). This might be due to more supply of available zinc to plants either through addition into soil or foliar spray leading to higher photosynthesis rate, translocation and assimilation of metabolism in the sink which ultimately increased number of pods/plant, 1000 seed weight and grains

Table 1. Effect of zinc and iron nutrition on yield attributes of chickpea (Pooled for 2 years)

Treatment	Yield attributes			
	Pods/ plant	Grains/ pod	1000-seed weight (g)	Grain weight/ plant (g)
T_1 Control	36.40	1.35	198.67	11.70
T_2 0.5% $ZnSO_4$ spray at FI	38.67	1.45	201.50	12.66
T_3 0.5% $ZnSO_4$ spray at FI & PI	37.88	1.51	207.67	12.20
T_4 0.5% $FeSO_4$ spray at FI	41.30	1.38	201.83	13.19
T_5 0.5% $FeSO_4$ spray at FI & PI	37.10	1.36	196.67	11.81
T_6 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ spray at FI	38.70	1.45	202.33	12.01
T_7 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ spray at FI & PI	42.47	1.43	205.83	13.00
T_8 25 kg $ZnSO_4$ through soil application	44.33	1.53	207.83	13.20
SEm±	1.97	0.06	3.65	0.52
CD (P = 0.05)	5.66	**0.18**	**10.47**	**1.49**

FI: Flower initiation; PI: Pod initiation per pod. The findings are in agreement with results of Ram *et al.* (2002), Valenciano *et al.*(2010), Usman *et al.*(2014) and Soni and Kushwaha (2020).

Effect on Yield

Seed yield (1617 kg/ha) and stover yield (4128 kg/ha) were recorded significantly superior under 25 kg $ZnSO_4$ through soil application (T_8) and 0.5% $ZnSO_4$ + 0.5%$FeSO_4$ spray at flower and pod initiation stage (T_7) over rest of the treatment except T_6which exhibits to be statistically at par (Table 2). Application of 25 kg $ZnSO_4$ through soil application obtained 135 kg (10.47%), 178 kg (13.80%), 136 kg (10.55%), 140 kg (10.86%), 226 kg (17.53%), 268 kg (20.79%) and 328 kg (25.44%) more seed yield over control, 0.5% $ZnSO_4$ spray at flower initiation stage, 0.5% $ZnSO_4$ spray at flower and pod initiation stage, 0.5% $FeSO_4$ spray at flower initiation stage, 0.5% $FeSO_4$ spray at flower and pod initiation stage, 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ spray at flower initiation stage, 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ spray at flower and pod initiation stage. This could be ascribed due to higher yield attributes of chickpea. The increase in supply of available zinc to plants through addition to the soil improved the starch formation, growth promoting substance like auxin, seed maturation and production which resulted in greater grain and stover yield. Similar results were also reported by Kushwaha (1999), Kanasa *et al.*(2008) and Paramesh *et al.*(2014). Patel *et al.* (2012) found that application of zinc sulphate @ 25 kg/ha significantly increased growth and yield of chickpea.Harvest index of chickpea was significantly increased due to foliar application ofzinc and iron than basal application. It was significantly higher in 0.5% $ZnSO_4$ spray at flower and pod initiation stage (T_3). While lowest harvest index was found in basal application of 25 kg $ZnSO_4$/ha. This was due to more increase in grain yield as compared to stover yield.

Table 2. Effect of zinc and iron nutrition on yield and harvest index of chickpea (Pooled for 2 years).

Treatment	Yield		Harvest index (%)
	Seed (kg/ha)	Stover (kg/ha)	
T_1 Control	1289	2755	32.12
T_2 0.5% $ZnSO_4$ spray at FI	1427	3200	31.73
T_3 0.5% $ZnSO_4$ spray at FI & PI	1467	3219	32.32
T_4 0.5% $FeSO_4$ spray at FI	1425	3711	29.00
T_5 0.5% $FeSO_4$ spray at FI & PI	1429	3245	32.10
T_6 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ spray at FI	1515	3497	30.30
T_7 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ spray at FI & PI	1557	3793	30.03
T_8 25 kg $ZnSO_4$ through soil application	1617	4128	28.70
SE m±	51	264	1.35
CD (P = 0.05)	**147**	**756**	**3.86**

FI: Flower initiation; PI: Pod initiation

Effect on economics

The cost of cultivation varied with treatment and was maximum under T_8. It was due to higher cost of $ZnSO_4$ applied as basal. Net returns (₹ 61370/ha) and gross returns (₹ 86524 /ha) obtained were significantly higher under application of 25 kg $ZnSO_4$ through soil application (T_8) followed by 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ spray at flower and pod initiation stage (Table 3). Application of 25 kg $ZnSO_4$ through soil application gave ₹ 15794/ha (34.65%) higher net returns and ₹18551/ha (27.29%) more gross returns than control. This could be ascribed due to higher value of grain and stover yield as compared to cost of cultivation of concerning treatments. These results were supported with the findings of Patel *et al.,* (2011) and Gowda *et al.,*(2014). Significantly higher benefit: cost ratio was obtained under 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ spray at flower initiation closely followed by 25 kg $ZnSO_4$ through soil application. This could be associated due to lower cost of cultivation in T_6- 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ spray at flower initiation stage. The moderate benefit: cost ratio was obtained under T_8- 25 kg $ZnSO_4$ through soil application was due to greater gross returns with higher cost of cultivation of applied $ZnSO_4$. These returns are agreement with findings of Nandan *et al.*(2018).

Table 3. Effect ofzinc and iron on economics of chickpea (Pooled for 2 years).

Treatment	Economics			
	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C
T_1 Control	22396	67973	45576	3.02
T_2 0.5% $ZnSO_4$ spray at FI	23157	75504	52346	3.26
T_3 0.5% $ZnSO_4$ spray at FI & PI	23917	77476	53559	3.24
T_4 0.5% $FeSO_4$ spray at FI	23063	76434	53371	3.31
T_5 0.5% $FeSO_4$ spray at FI & PI	23731	75591	51859	3.18
T_6 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ spray at FI	23141	80667	57525	3.48
T_7 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ spray at FI & PI	24427	82918	58491	3.39
T_8 25 kg $ZnSO_4$ through soil application	25154	86524	61370	3.43
SE m±	-	2529	2554	0.10
CD (P = 0.05)	**-**	**7247**	**7319**	**0.28**

FI: Flower initiation; PI: Pod initiation

CONCLUSION

Thus it can be concluded that basal application of $ZnSO_4$ @ 25 kg /ha as well as foliar application 0.5% $ZnSO_4$ + 0.5% $FeSO_4$ at FI or FI & PI in chickpea were found equally and most productive and profitable treatment for Kymore Plateau of Madhya Pradesh .

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