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RESEARCH PAPER

Effect of foliar spray of zinc sulphate and iron sulphate on yield, quality and nutrient uptake of chickpea (*Cicer arietinum* L.) in Vertisols

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Abstract: A field experiment was conducted at farmer's field in Yattingudda village (Dharwad district) to study the Biofortification of zinc sulphate and iron sulphate though foliar spray on yield, quality and nutrient uptake of chickpea *(Cicer arietinum* L.*)* in *Vertisol* during *rabi* 2020. The experiment was laid out in Randomized Complete Block design (RCBD) with nine treatments and three replications combination with different levels of zinc sulphate and iron sulphate. The results revealed that, among the different treatments, foliar spray of $ZnSO_4$. $7H_2O$ and $FeSO_4$.$7H_2O$ @ 0.5% at the time of pre flowering, flowering and pod setting along with recommended package of practices recorded the significantly higher number of pods plant^{-1} (37.62), pod weight per plant (11.89 g plant^{-1}), 100 seed weight (23.96g), seed yield (18.21 q ha^{-1}) and haulm yield (25.14 q ha^{-1}). This treatment also recorded significantly higher crude protein content (24.12 per cent), zinc content (41.12 mg kg^{-1}), iron content (134.25 mg kg^{-1}) and also higher uptake of nitrogen (90.39 kg ha^{-1}), phosphorus (11.03 kg ha^{-1}), potassium (48.89 kg ha^{-1}), sulphur (11.94kg ha^{-1}) zinc (146.38 g ha^{-1}) and iron (449.16 g ha^{-1}).

Key words: Chickpea, Iron Sulphate, Nutrient uptake, Seed yield, Zinc sulphate

Introduction

Chickpea (*Cicer arietinum* L.) is the most important pulse crop in India during the *rabi* season. It is the second most important pulse crop which ranks next to pigeon pea. Chickpea, is valued for its nutritious seeds, which are rich in protein (18-22%), fat (4-20%), and carbohydrates (52-70%). Karnataka contributes significantly to the production of pulses in India, which ranks fourth in pulses cultivation. Among all the pulses grown in Karnataka, chickpea is cultivated in an average area of 6.05 lakh ha with a production and productivity of 17.30 lakh tones and 937.19 kg ha^{-1} (Anon., 2019).

Zinc is an essential nutrient for plant and human health and about two billion people worldwide are at the risk of Zn deficiency. In India, Zinc is now considered as the fourth most important yield limiting nutrient after Nitrogen, Phosphrous and Potassium respectively. Deficiency of Zn in the soil leads to the dietary malnutrition and health problems in human and animals. Presently half of the world population is affected with Zn deficiency (5,657) and therefore, it comes second only after iron. In India, about 25 per cent of the population is suffering from Zn-related problems and nearly half of the Indian children under the age of 5 are small due to the Zn deficiency. Zinc plays a significant role in various enzymatic and physiological activities of plants. It stabilizes the structure of membranes and cellular components and catalysis the process of oxidation in plant cells. It is vital for transformation of carbohydrates and regulates the sugar, increases the source of energy for production of chlorophyll, aids in formation of auxins which produce more plant cells and more dry matter, that in turn will be stored in seed as a sink and promotes absorption of water and also plays a role in detoxification of superoxide radicals membrane integrity as well as synthesis of protein and phytohormones like indole acetic acid (Kumar and Sharma, 2013).

Iron is another essential micronutrient for the cell's redox system and a variety of enzymes. Iron absorption strategies differ among dicotyledonous and graminaceous plants (Marschner, 2012). The sensitivity of chickpea genotypes to iron deficiency varies *i.e*., when sensitive genotypes are planted on calcareous soils with high pH, yield losses due to iron deficiency might be observed. Iron deficiency generally results in stunted growth followed by poor nodulation, less leg hemoglobin production and reduced Nitrogenase activity. Iron deficiency is a common nutritional condition that affects 2.5 to 5 billion people worldwide (Yip, 2002), with poor households and pre-school children suffering the most and as a result there is high need for iron.

Iron acts as a co-factor for various enzymes performing basic functions in human body. Inadequate supply of iron leads to disability, anemia and stunted mental growth (Sheftela, 2011). Its malnutrition may be reduced by enhancing the bio-available iron content through iron supplementation and food fortification (Rana *et al*., 2012). These efforts frequently are costly and difficult to maintain on a daily basis, especially in underdeveloped countries. As a result, it seems that crop fortification with iron content would be the most cost-effective way to address the hidden hunger of iron.

Biofortification is a process aims to increase the bio availability of vital minerals in economic parts of the crop either through agronomic intervention or plant breeding (genetic bio-fortification) (White and Broadley, 2005) The most effective method of biofortification is plant breeding, but it takes very long duration to come up with an outcome compared to micronutrient biofortification which takes only the cropping period for fortification and further it improves the soil fertility status by supplying these micronutrients (Bajiya and Yadav, 2017). Hence, the present investigation was undertaken to assess the effect of foliar spray of Zinc and Iron sulphates on growth, grain yield, quality and nutrients uptake of chickpea crop in Vertisols.

Material and methods

Field experiment was conducted during *rabi*, 2020 at farmer's field at Yattingudda village, Dharwad district it is situated at Northern Transitional Zone (Zone 8) of Karnataka. The experimental soil was calcareous, clay in texture with ($pH_{2.5}$: 8.20), low in salt content (EC: 0.27 dS m^{-1}), low in organic carbon (4.90 g kg^{-1}) and slightly high in calcium carbonate content (6.12 per cent). The soil was low in available nitrogen (N) (264 kg ha^{-1}), medium in available phosphorus (P_2O_5) (29.0 kg ha^{-1}), medium in available potassium (K_2O) (319.0 kg ha^{-1}), high in available sulphur (SO_4-S) (34.30 kg ha^{-1}) and deficient zinc (0.40 mg kg^{-1}) and iron (2.90 mg kg^{-1}).

The treatments were, T_1: Recommended package of practice (control), T_2: RPP + foliar spray of 0.25% of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pre flowering (On 45th DAS after sowing), T_3: RPP + foliar spray of 0.25% of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at flowering (On 60th DAS after sowing), T_4: RPP + foliar spray of 0.25% of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pod setting (On 75th DAS after sowing), T_5: RPP + foliar spray of 0.25% of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pre flowering + flowering + pod setting, T_6: RPP + foliar spray of 0.5% of $ZnSO_4.7H_2O$ and $FeSO_4$. $7H_2O$ at pre flowering, T_7: RPP + foliar spray of 0.5% of $ZnSO_4.7H_2O$ and $FeSO_4$. $7H_2O$ at flowering, T_8: RPP + foliar spray of 0.5% of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pod setting, T_9: RPP + foliar spray of 0.5% of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pre flowering + flowering + pod setting, treatments laid out in RCBD with three replications $FeSO_4$. $7H_2O$ at pre flowering + flowering + pod setting.

Methodology followed for recording observations

Yield and yield parameters:

Number of pods per plant: The pods of five tagged plants from each plot were removed, air dried, counted, their average was taken and expressed as number of pods per plant.

100 Seed weight (g): 100 randomly selected seeds will be taken from net plot yield and weighed.

Seed weight per plant (g plant^{-1}): The seeds of five tagged plants were separated from the pods and their average was taken and expressed as seed weight per plant.

Seed yield per hectare (q ha^{-1}): At physiological maturity, plants from the net plot area were harvested. The produce was threshed to separate the seeds after drying. The yield per hectare was calculated on the basis of total weight of the seeds harvested in net plot area.

Haulm yield per hectare (q ha^{-1}): After separation of seeds, the haulm was dried. The haulm yield for each net plot area was recorded.

Quality parameters:

Crude protein content (%): The protein content was obtained by multiplying per cent nitrogen content of seeds with a factor 6.25 (Sadasivam and Manickam, 1996).

Iron and zinc concentration in seed and haulm (mg kg^{-1}): After digestion with diacid mixture, iron and zinc contents in the plant digest were determined using atomic absorption spectrophotometer (Tandon, 1998).

Uptake of nutrients: The nutrient concentration after chemical analysis was multiplied with biomass yield at

Table 1. Effect of foliar application of zinc and iron sulphate on yield parameters of chickpea

Treatments	No. of pods plant^{-1}	Seed weight plant^{-1} (g)	100 seed weight (g)	Seed yield (q ha^{-1})	Haulm yield (q ha^{-1})
T_1 - RPP	29.57	8.68	19.10	16.11	22.53
T_2 - RPP + foliar spray of 0.25 % of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pre flowering.	34.92	10.08	21.024	17.01	23.39
T_3 - RPP + foliar spray of 0.25 % of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at flowering.	32.96	9.61	20.856	16.90	22.96
T_4 - RPP + foliar spray of 0.25 % of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pod setting.	31.76	9.01	20.47	16.24	22.50
T_5 - RPP + foliar spray of 0.25 % of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pre flowering + flowering + pod setting.	36.06	11.48	23.04	17.74	24.39
T_6 - RPP + foliar spray of 0.5 % of $ZnSO_4$. $7H_2O$ and $FeSO_4.7H_2O$ at pre flowering.	35.24	11.08	22.15	17.29	23.90
T_7 - RPP + foliar spray of 0.5 % of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at flowering.	34.72	10.20	21.96	17.06	23.74
T_8 - RPP + foliar spray of 0.5 % of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pod setting.	32.09	9.53	20.70	16.59	22.59
T_9 - RPP + foliar spray of 0.5 % of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pre flowering + flowering + pod setting.	37.62	11.89	23.96	18.21	25.14
S.Em±	0.78	0.28	0.42	0.19	0.36
C.D (0.05)	2.35	0.85	1.27	0.58	1.10

*RPP (Recommended Package of Practices): FYM 5t, N: P_2O_5: K_2O (25: 50: 0) kg ha^{-1}

harvest to obtain uptake of respective nutrient as per the formulas given below.

Nutrient uptake (kg ha^{-1}) = [Nutrient concentration (%) × Biomass yield (kg ha^{-1})] / 100

Nutrient uptake (g ha^{-1}) = [Nutrient concentration (mg kg^{-1}) × Biomass yield (kg ha^{-1})] / 1000

Results and discussion

Yield parameters

Results obtained from present experiment indicated that the foliar application of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ @ 0.5% at the time of pre-flowering, flowering and pod setting recorded significantly higher number of pods $plant^{-1}$(37.62), pod weight per plant (11.89 g $plant^{-1}$), 100-seed weight (23.96 g), seed yield (18.21 q ha^{-1}) and haulm yield (25.14 q ha^{-1}) of chickpea over other treatments. The lowest number of pods $plant^{-1}$ (29.57), pod weight per plant (8.68 g $plant^{-1}$), test weight (19.10 g), seed yield (16.11 q ha^{-1}) and haulm yield (22.53 q ha^{-1}) were recorded in treatment (T_1) that received RPP alone (Table 1). The increasing in the yield and yield attributes might be due to foliar application of micronutrients directly absorbed by plants thereby increasing the metabolism of the plants resulting in increased synthesis of photosynthetic products. These micronutrients also helped in efficiently transferring photosynthetic products from source to sink, thereby increasing seed weight in pods ultimately resulting in higher seed yield. Similar findings were reported by Shivanand *et al.* (2017) in soyabean and Hussien *et al.* (2018) in lentil.

Quality parameters

Higher crude protein in chickpea seed (24.12 per cent) was recorded in the treatment (T_9) with RPP + foliar spray of 0.5% of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pre-flowering, flowering and pod setting. The lower crude protein in chickpea seed (22.10%) was recorded in the treatment (T_1) with RPP alone (Table 2). Increase in crude protein content could be attributed to iron and sulphur role in the enzyme activities and amino acids synthesis and it helps in conversion of amino acids to high quality crude protein. As iron and zinc helps in the translocation of nitrogen to grain that resulted in increased protein content in grain (Hemn, 2013). Nandan *et al.* (2018) reported significantly higher protein content in chickpea with (RDF+ Zn 0.5% and Fe 0.05%) over the control.

Significantly higher zinc content in seeds (41.12 mg kg^{-1}) and iron content in seeds (134.25 mg kg^{-1}) were recorded treatment with RPP + foliar spray of 0.5% of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pre flowering, flowering and pod setting over the control. This might be due to foliar application of zinc and iron which was directly observed by the chickpea and also due to the mobilization of the micronutrient from the leaves, stems to the seed and zinc and iron spray helps in increasing the micronutrients in edible parts. Kayan *et al.* (2015) reported that foliar spray of 0.6% $ZnSO_4$ in chickpea before flowering resulted in greater zinc content (21.75 per cent) in seeds over the control. Hidoto *et al.* (2017) in chickpea also reported the similar findings.

Uptake of nutrients and available soil nutrients status after harvest of chickpea

Significantly higher uptake of nitrogen (90.39 kg ha^{-1}), phosphorus (11.03 kg ha^{-1}), potassium (48.89 kg ha^{-1}), sulphur (11.94kg ha^{-1}) zinc (146.38 g ha^{-1}) and iron (449.16 g ha^{-1}) by chickpea was observed with the application of RPP + foliar spray of 0.5% of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pre flowering, flowering and pod setting over the other treatments (Table 3). This might be due to foliar application of zinc and iron at critical stages such as pre flowering, flowering and pod setting that

Table 2. Effect of foliar application of zinc and iron sulphate on protein content, zinc content and iron content of chickpea seeds

	Treatments	Crude Protein (%)	Zinc (mg kg^{-1})	Iron(mg kg^{-1})
T_1-	RPP	22.10	34.77	96.37
T_2-	RPP + foliar spray of 0.25% of $ZnSO_4$. $7H_2O$ and $FeSO_4$ $7H_2O$ at pre flowering.	23.19	36.70	109.60
T_3-	RPP + foliar spray of 0.25% of $ZnSO_4$. $7H_2O$ and $FeSO_4$.$7H_2O$ at flowering.	23.13	36.54	107.03
T_4 -	RPP + foliar spray of 0.25% of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pod setting.	22.78	36.40	106.15
T_5-	RPP + foliar spray of 0.25% of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pre flowering + flowering + pod setting.	23.90	40.63	132.90
T_6-	RPP + foliar spray of 0.5% of $ZnSO_4$. $7H_2O$ and $FeSO_4$.$7H_2O$ at pre flowering.	23.63	38.03	113.19
T_7-	RPP + foliar spray of 0.5% of $ZnSO_4$. $7H_2O$ and $FeSO_4$.$7H_2O$ at flowering.	23.38	37.34	110.87
T_8-	RPP + foliar spray of 0.5% of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pod setting.	23.25	37.16	108.43
T_9-	RPP + foliar spray of 0.5% of $ZnSO_4$. $7H_2O$ and $FeSO_4$ $7H_2O$ at pre flowering + flowering + pod setting.	24.12	41.12	134.25
S. E.m ±		0.10	0.20	0.57
C. D (0.05)		0.34	0.61	1.69

*RPP (Recommended Package of Practices): FYM 5t, N: P_2O_5: K_2O (25: 50: 0) kg ha^{-1}

Table 3. Effect of foliar application of zinc sulphate and iron sulphate on nutrient uptake of chickpea

Treatments		N	P	K	S	Zn	Fe
		kg ha^{-1}				g ha^{-1}	
T_1-	RPP	67.64	8.20	37.78	7.67	110.80	294.12
T_2 -	RPP + foliar spray of 0.25% of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pre flowering.	80.23	9.15	41.33	9.23	122.96	344.78
T_3-	RPP + foliar spray of 0.25% of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at flowering.	79.86	9.01	40.81	8.48	118.25	335.25
T_4-	RPP + foliar spray of 0.25% of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pod setting.	76.55	8.91	40.74	8.40	115.52	321.57
T_5-	RPP + foliar spray of 0.25% of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pre flowering + flowering + pod setting.	87.47	10.32	46.52	10.96	139.00	429.20
T_6-	RPP + foliar spray of 0.5% of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pre flowering.	84.19	9.72	44.40	10.34	130.53	367.01
T_7-	RPP + foliar spray of 0.5% of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at flowering.	81.95	9.25	43.84	9.38	126.80	357.93
T_8-	RPP + foliar spray of 0.5% of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pod setting.	80.00	9.08	42.35	9.30	121.79	339.63
T_9-	RPP + foliar spray of 0.5% of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pre flowering + flowering + pod setting.	90.68	11.06	48.89	11.80	146.29	449.17
S. E.m±		0.77	0.21	1.05	0.28	2.46	6.69
C. D (0.05)		2.34	0.80	3.13	0.85	7.39	20.05

*RPP (Recommended Package of Practices): FYM 5t, N: P_2O_5: K_2O (25: 50: 0) kg ha^{-1}

Table 4. Effect of foliar application of zinc and iron sulphate on nutrients in soil after harvest of chickpea

Treatments		N	P_2O_5	K_2O	SO_4-S	Fe	Zn
		kg ha^{-1}				mg kg^{-1}	
T_1-	RPP	245	43.09	247.00	23.68	2.83	0.39
T_2-	RPP + foliar spray of 0.25% of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pre flowering.	238	41.02	242.00	22.14	2.57	0.34
T_3-	RPP + foliar spray of 0.25% of $ZnSO_4$. $7H_2O$ and $FeSO_4$.$7H_2O$ at flowering.	239	40.60	242.00	22.91	2.62	0.36
T_4-	RPP + foliar spray of 0.25% of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pod setting.	241	41.61	245.00	23.00	2.73	0.37
T_5-	RPP + foliar spray of 0.25% of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pre flowering + flowering + pod setting.	232	38.69	236.00	20.65	2.43	0.30
T_6-	RPP + foliar spray of 0.5% of $ZnSO_4$. $7H_2O$ and $FeSO_4$.$7H_2O$ at pre flowering.	236	39.23	238.00	20.98	2.48	0.31
T_7-	RPP + foliar spray of 0.5% of $ZnSO_4$. $7H_2O$ and $FeSO_4$.$7H_2O$ at flowering.	237	39.50	240.00	21.86	2.50	0.32
T_8-	RPP + foliar spray of 0.5% of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pod setting.	238	40.68	240.00	21.97	2.54	0.33
T_9-	RPP + foliar spray of 0.5% of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pre flowering + flowering + pod setting	229	37.54	234.00	20.14	2.40	0.28
Initial		264	29.00	319.00	34.30	2.90	0.40
S. E.m±		1.67	0.50	1.32	0.19	0.08	0.01
C. D (0.05)		5.03	1.6	3.94	0.58	0.23	0.04

*RPP (Recommended Package of Practices): FYM 5t, N: P_2O_5: K_2O (25: 50: 0) kg ha^{-1}

might have increased the transfer of photosynthetic products from source to sink, resulting in higher N, P, K, S, Zn and Fe uptake by chickpea. Similar findings were reported by Das *et al*. (2012) in chickpea and Santosh *et al*. (2020) reported that significantly higher zinc (15.14 mg kg^{-1} and 14.07 mg kg^{-1} and iron (86.81 and 70.89 mg kg^{-1}) in seed and haulm of chickpea was recorded in (POP + foliar spray of $ZnSO_4$ @ 0.5% + B as Solubor @ 0.2%).

Foliar application of zinc and iron to chickpea showed significant difference in available soil nutrients after harvest of the crop. The higher available nitrogen (245 kg ha^{-1}), phosphorus (43.09 kg ha^{-1}), potassium (246 kg ha^{-1}), sulphur (23.68 kg ha^{-1}), zinc (0.39 mg kg^{-1}) and iron (2.83 mg kg^{-1}) were reported in control (T_1) that received only RPP (Table 4). This was because of very low dry matter yield in these treatments that resulted in lower uptake of nutrients from the soil and lower available nutrients were observed in treatment which receiving $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ @ 0.5% at the time of pre flowering, flowering and pod setting. This is due to highest seed and biomass yield leading to greater removal of nutrients from the soil (Balai *et al.,* 2017).

Conclusion

It was concluded that the foliar application of zinc sulphate and iron sulphate each @ 0.5% at the time of pre flowering, flowering and pod setting recorded optimum for higher grain yield of chickpea with higher crude protein, Zn, Fe content in the seeds.

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