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Influence of zinc and iron foliar nutrition to Chickpea (*Cicer arietinum* L.) crop on growth, yield and nutrient uptake characteristics and its economics

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Abstract
A field experiment was conducted at a farmer's field in Yattingudda village, (Dharwad district) to study the foliar nutrition of chickpea (*Cicer arietinum* L.) with zinc and iron on growth, yield, nutrient uptake and economics 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, significantly higher plant height (41.67 cm), number of branches (21.52), dry matter production plant^{-1} (22.95 g) at harvest, seed yield (18.21 q ha^{-1}), haulm yield (25.14 q ha^{-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 (11.94 kg ha^{-1}) zinc (146.38 g ha^{-1}) and iron (449.16 g ha^{-1}) were recorded with RPP + foliar spray of $ZnSO_4$. $7H_2O$ and $FeSO_4.7H_2O$ @ 0.5% at the time of pre flowering, flowering and pod setting (T_9). Similarly highest gross returns, net returns and B:C ratio was recorded in treatment (T_9) compared to control (RPP).

Keywords: Chickpea, foliar spray, $ZnSO_4$. $7H_2O$ and $FeSO_4.7H_2O$

Introduction

Legumes play a vital role in diet and nutrition from the beginning of Indian civilization as well as in the daily diets of a wide spectrum of people across the globe. Pulses are the seeds of legume plants, but not all pulses are legumes. Pulses are special because they have distinct health benefits apart from other legumes and also, they are good sources of protein and other nutrients like carbohydrates, vitamins and minerals. In addition to being good for health they are also good for the soil as they are nitrogen fixing crops. India is the largest producer as well as consumer of pulses in the world. The per capita availability of pulses is 42 g per day. In India total area under pulse cultivation is 29.15 million hectares with a production and productivity of 22.07 million tonnes and 757 kg ha^{-1}, respectively (Anon., 2019) [1]. 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) [1].

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. Chickpea is widely regarded as a zinc-deficiency-sensitive crop. Zinc deficiency has an effect on plant-water relationships, such as stomatal closure and reduced transpiration. Zinc deficient plants appear stunted, size of leaflets reduces and delayed crop maturity. The younger leaves turn a pale green colour first, then a reddish-brown discoloration appears on the leaflet margins and the lower part of the stem. The upper portion of the leaflet becomes bronzed and necrotic (Kumar and Sharma, 2013) [11]. Iron acts as a co-factor for various enzymes performing basic functions in human body. Inadequate supply of iron leads to disability, anaemia and stunted mental growth (Sheftela, 2011) [18]. Its malnutrition may be reduced by enhancing the bio-available iron content through iron supplementation and food fortification (Rana *et al*., 2012) [13]. 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 biofortification) (White and Broadley, 2005) [22] 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) [3]. Hence, the present investigation was undertaken to study Biofortification of chickpea (*Cicer arietinum* L.) through foliar spray of zinc sulphate and iron sulphate on growth, yield, quality and nutrient uptake of chickpea in Vertisol.

Material and Methods

A field experiment was conducted during *rabi*, 2020 at farmer's field at Yattingudda village, Dharwad district 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}), medium 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 experiment was carried out by adopting RCBD with nine treatments replicated thrice. The treatments were, T_1: Recommended package of practice (control), T_2: RPP + foliar spray of 0.25% each 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% each 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% each 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% each of $ZnSO_4.\ 7H_2O$ and $FeSO_4.\ 7H_2O$ at pre flowering + flowering + pod setting, T_6: RPP + foliar spray of 0.5% each of $ZnSO_4.\ 7H_2O$ and $FeSO_4.\ 7H_2O$ at pre flowering, T_7: RPP + foliar spray of 0.5% each of $ZnSO_4.\ 7H_2O$ and $FeSO_4.\ 7H_2O$ at flowering, T_8: RPP + foliar spray of 0.5% each of $ZnSO_4.\ 7H_2O$ and $FeSO_4.\ 7H_2O$ at pod setting, T_9: RPP + foliar spray of 0.5% each of $ZnSO_4.\ 7H_2O$ and $FeSO_4.\ 7H_2O$ at pre flowering + flowering + pod setting.

Methodology followed for recording observations

Growth and Yield and yield parameters

- **Plant height (cm):** The plant height was measured from the base of the plant up to top of fully opened top leaf. The height of five tagged plants was measured and average was recorded as plant height.
- **Number of branches per plant:** The total number of branches per plant was counted in five tagged plants and their average was taken as the number of branches per plant.
- **Number of effective nodules per plant:** Five plants in each plot were uprooted carefully at 45 DAS without damaging the roots and were dipped gently in a bucket containing water to remove the soil particles and then nodules were detached and dissected to check the pink colour which was indication of effective root nodule. The effective nodules were counted from each plant and their average was taken as effective nodules per plant.
- **Dry matter production per plant (g):** Five randomly selected plants were uprooted carefully at 30 DAS, 60 DAS and at harvest. Then, the plants were chopped into small pieces after removing roots to enable complete drying and air dried for two days, then oven dried at 65°C to get constant weight. The oven dry weight of dry matter was recorded and their average was taken to record dry matter production per plant.
- **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 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

Economics

- Net returns per ha (₹) = Gross returns per ha (₹) - Cost of cultivation per ha (₹)
- Benefit: Cost (ratio) = $\frac{\text{Gross returns (₹ ha}^{-1}\text{)}}{\text{Cost of cultivation (₹ ha}^{-1}\text{)}}$

Results and Discussion

Growth parameters: growth parameters of chickpea were differed significantly due to foliar application of zinc and iron sulphate. At harvest significantly higher in plant height (41.67 cm), number of branches (21.52), dry matter (22.95 g $plant^{-1}$) and effective root nodules (34.56 per plant) were recorded in RPP + foliar spray of 0.5% each of $ZnSO_4.\ 7H_2O$ and $FeSO_4.$

$7H_2O$ at pre-flowering, flowering and pod setting (T_9). This increasing trend in growth parameters might be due to the increased availability of zinc and iron to deficient soil through foliar application of zinc sulphate and iron sulphate, the process of its absorption and translocation in the plant. Similar results were found by Gowthami and Ananda (2015) [6], Saini and Singh (2017) [15] and Vinod *et al*. (2020) [21]

Yield and 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 2). 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) [19], Ramaprasad *et al*. (2017) and Yashona *et al*. (2020) [23]

Table 1: Plant height (cm) and number of branches (plant^{-1}) at different growth stages of chickpea as influenced by foliar spray of zinc and iron

Treatments	plant height (cm)			total number of branches			Dry matter (g plant^{-1})			Effective root nodules (per plant)
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest	
T_1	16.68	28.05	37.63	2.36	10.33	18.20	0.38	4.83	18.40	27.36
T_2	17.54	30.76	38.82	2.79	11.47	19.53	0.35	5.72	20.97	30.00
T_3	16.90	29.89	38.14	2.53	10.80	19.26	0.36	5.33	19.31	30.04
T_4	18.70	29.69	37.88	2.93	10.66	19.38	0.43	5.06	19.13	29.67
T_5	17.86	32.52	40.92	2.30	12.00	21.33	0.38	7.00	22.14	32.10
T_6	18.16	31.16	39.27	2.28	11.84	20.20	0.46	6.56	21.37	33.85
T_7	19.12	30.94	39.50	2.57	11.00	20.00	0.40	6.27	20.89	31.99
T_8	17.80	30.07	38.11	2.96	10.82	19.46	0.39	5.58	19.26	29.87
T_9	18.31	33.68	41.67	2.46	12.50	21.52	0.44	7.29	22.95	34.56
S.Em ±	0.63	0.73	0.45	0.18	0.25	0.42	0.09	0.24	0.40	0.45
CD (0.05)	NS	2.21	1.35	NS	0.74	1.27	NS	0.73	1.22	1.36

NS=Non significant

Table 2: Yield and yield parameters of chickpea as influenced by foliar spray of zinc and iron

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	29.57	8.68	19.10	16.11	22.53
T_2	34.92	10.08	21.024	17.01	23.39
T_3	32.96	9.61	20.856	16.90	22.96
T_4	31.76	9.01	20.47	16.24	22.50
T_5	36.06	11.48	23.04	17.74	24.39
T_6	35.24	11.08	22.15	17.29	23.90
T_7	34.72	10.20	21.96	17.06	23.74
T_8	32.09	9.53	20.70	16.59	22.59
T_9	37.62	11.89	23.96	18.21	25.14
S.Em ±	0.78	0.28	0.42	0.19	0.36
CD (0.05)	2.35	0.85	1.27	0.58	1.10

NS=Non significant

Quality parameters

Significantly higher crude protein content (24.12 per cent), zinc content in seed (41.12 mg kg^{-1}) and iron content in seed (134.25 mg kg^{-1}) were recorded in treatment (T_9) that received RPP + foliar spray of 0.5 per cent each of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pre flowering, flowering and pod setting. 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 protein. Similar findings were recorded by Balai *et al.* (2017) [4] and Sanjay (2017) [16].

Higher zinc and iron content in seeds 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. Similar findings were reported Kayan *et al*. (2015) [10] and Heidarian *et al*. (2011) [8].

Table 3: Quality of chickpea as influenced by foliar spray of zinc and iron

Treatments	Protein content (%)	Zinc content in seeds (mg kg^{-1})	Iron content in seeds (mg kg^{-1})
T_1	22.10	34.77	96.37
T_2	23.19	36.70	109.60
T_3	23.13	36.54	107.03
T_4	22.78	36.40	106.15
T_5	23.90	40.63	132.90
T_6	23.63	38.03	113.19
T_7	23.38	37.34	110.87
T_8	23.25	37.16	108.43
T_9	24.12	41.12	134.25
S.Em ±	0.10	0.20	0.57
CD (0.05)	0.34	0.61	1.69

NS=Non significant

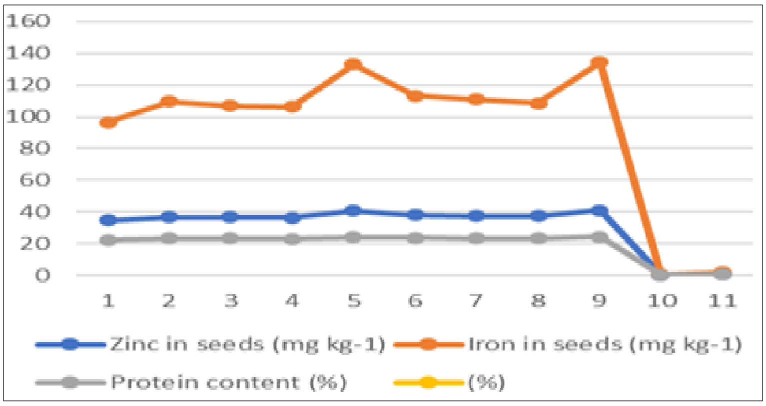

Fig 1: Foliar application of zinc and iron on zinc, iron and protein content in chickpea seeds.

Nutrient uptake

Significantly higher uptake of nitrogen (90.39 kg ha^{-1}), phosphorus (11.03 kg ha^{-1}), potassium (48.89 kg ha^{-1}), sulphur (11.94 kg 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% each of $ZnSO_4 . 7H_2O$ and $FeSO_4 . 7H_2O$ at pre flowering, flowering and pod setting over the other treatments (Table 4). This might be due to foliar application zinc and iron at critical stages such as pre flowering, flowering and pod setting that 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. These results are in conformity with the findings of Das *et al*. (2012) [5], Gupta and Sahu (2012) [7] and Santosh *et al*. (2020) [17].

Table 4: Nutrient uptake of chickpea as influenced by foliar spray of zinc and iron

Treatments	N	P	K	S	Zn	Fe
	kg ha^{-1}				g ha^{-1}	
T_1	67.64	8.20	37.78	7.67	110.80	294.12
T_2	80.23	9.15	41.33	9.23	122.96	344.78
T_3	79.86	9.01	40.81	8.48	118.25	335.25
T_4	76.55	8.91	40.74	8.40	115.52	321.57
T_5	87.47	10.32	46.52	10.96	139.00	429.20
T_6	84.19	9.72	44.40	10.34	130.53	367.01
T_7	81.95	9.25	43.84	9.38	126.80	357.93
T_8	80.00	9.08	42.35	9.30	121.79	339.63
T_9	90.68	11.06	48.89	11.80	146.29	449.17
S.Em ±	0.77	0.21	1.05	0.28	2.46	6.69
CD (0.05)	2.34	0.80	3.13	0.85	7.39	20.05

NS=Non significant

Table 5: Nutrient uptake of chickpea as influenced by foliar spray of zinc and iron

Treatments	Cost of cultivation	Gross return	Net return	B:C ratio
	₹/ha			
T_1	35057	72495	37438	2.07
T_2	35627	76545	40919	2.15
T_3	35627	76050	40423	2.13
T_4	35627	73080	37453	2.05
T_5	36942	79830	42885	2.16
T_6	35787	77805	42018	2.17
T_7	35787	76770	40983	2.15
T_8	35787	74655	38868	2.09
T_9	37137	81943	44807	2.21

Economics

Among the treatments, highest gross income (₹ 81943), net return (₹ 44807) and B:C ratio (2.21) were recorded with RPP + foliar spray of 0.5% each of $ZnSO_4$. $7H_2O$ and $FeSO_4$. $7H_2O$ at pre flowering, flowering and pod setting when compare to rest of the treatment (Table 5). That might be due to an increased seed and haulm yield as a result of better utilization of foliar applied zinc and iron. The requirement and amount incurred for foliar spray was comparatively less than soil application. Similar findings were reported by Jat *et al*. (2014) [9] and Bahure *et al*. (2016) [2].

From this investigation it can be concluded 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 growth parameters, number of pods plant^{-1}, pod weight per plant, 100-seed weight, seed yield, haulm yield, uptake of nutrients and economics by chickpea over other treatments.

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