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Influence of iron and zinc on yield, quality of chickpea and status of iron and zinc in post harvest soil

C. Pooja* and I.M. Sarawad

Department of Soil Science and Agricultural Chemistry, College of Agriculture,
Vijayapur University of Agricultural Sciences, Dharwad-580 005, Karnataka, India.
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ABSTRACT

Chickpea (*Cicer arietinum* L.) is the most important and ancient pulse crop being traditionally grown during *rabi* season and cultivated mainly in semi-arid regions. The content of iron and zinc in the soil of Regional Agricultural Research Station (RARS) is below the critical level. A field experiment to study the effect of iron and zinc nutrition on growth, yield and nutrient uptake by chickpea conducted in the vertisols of the Regional Agricultural Research Station (RARS), Vijayapur during *rabi* 2017-18. The experiment was laid out in randomized complete block design with ten treatments and three replications. The treatments included RPP (Recommended package of practice) and application of iron @ 2, 4 and 6 kg ha^{-1} and zinc @ 2, 3 and 4 kg ha^{-1} in combinations along with RPP (RDF (Recommended dose of fertilizer) @ 10:25:00:: N : P_2O_5 : K_2O kg ha^{-1}). The results of the experiment revealed that, the application of iron and zinc in combinations resulted in significant increase in growth, yield and nutrient uptake by chickpea over RPP alone. Among the different treatments RPP + 6 kg Fe ha^{-1} + 4 kg Zn ha^{-1} was resulted in the maximum test weight (28.28 g), seed (2065.4 kg ha^{-1}) and straw (1734.9 kg ha^{-1}) yield. Similarly, higher protein content, uptake of nutrients (Fe and Zn) by the crop and residual iron and zinc status in soil were recorded due to the application of RPP + 6 kg Fe ha^{-1} + 4 kg Zn ha^{-1}. These results were at par with the application of RPP + 6 kg Fe ha^{-1} + 3 kg Zn ha^{-1} and lower values were recorded in the treatment that received RPP alone. Finally it could be concluded that the application of fertilizers containing iron and zinc helpeds to improve crop yield, protein content and nutrient uptake by chickpea crop and residual soil fertility in terms of iron and zinc.

Key words: Chickpea, Iron, Protein, Uptake, Yield, Zinc.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the most important and ancient pulse crop being traditionally grown during *rabi* season in India and cultivated mainly in semi-arid regions of the world. Chickpea belongs to the family Leguminaceae. Chickpea seeds contain higher protein content (21-23 %) next to groundnut and soybean. India is the largest chickpea producer and consumer in the world (Majumdar, 2011). India stands first in area and production in the world, with an area of 8.35 million hectares, production of 7.17 million tonnes and productivity of 859 kg per hectare during 2015-16. Karnataka is one of the major chickpea producing states in India with an area of 1.37 million hectare with an annual production of 0.9 million tonnes and with an average productivity of 654 kg per hectare during 2015-16 (Anonymous, 2017). In Karnataka it is mainly grown in Dharwad, Belagavi, Vijayapur, Bagalkote, and Bidar districts during *rabi* season under both rainfed and irrigated condition.

Zinc plays a role in the detoxification of superoxide radicals, membrane integrity as well as synthesis of protein and phytoharmones like IAA. Chickpea is generally considered as a sensitive crop to zinc deficiency. Zinc deficiency affects plant-water relationships, including stomatal closure and decrease transpiration in plants. Zinc deficient plants appear stunted and have fewer branches. The size reduction of leaflets and delayed crop maturity are common. The younger leaves become pale green first then a reddish brown discoloration appears on margins on margins of leaflets and on the lower part of the stem. In the later stage the upper portion of the leaflet turns bronzed and necrotic (Kumar and Sharma, 2013). Iron plays a crucial role in redox system in cell and various enzymes. Dicotyledonous and grami- neaceous plants have different strategies to acquire iron (Marschner, 2012). Chickpea genotypes vary in their sensitivity to iron deficiency. Considerable yield losses due to iron deficiency chlorosis may occur when susceptible genotypes are grown on calcareous soils with high pH. Iron deficiency generally results in stunted growth. Plants display deficiency symptom first on younger leaves. Younger leaves turn bright yellow and then white, while older leaves remain dark green and healthy. As symptom advances white necrotic area develop on the distal half of the leaflets in younger leaves. In the later stage, the white necrotic areas get enlarged and the leaves wither and die. Eventually, the uppermost leaves die or they become white and drop off.

*Corresponding author's e-mail: poojac795@gmail.com

The deficiency of micronutrients is observed in most of the soils of northern dry zone of Karnataka. The contents of iron and zinc in the soil of Regional Agricultural Research Station (RARS) Vijayapur were 3.09 mg Fe kg^{-1} and 0.54 mg Zn kg^{-1}, respectively (Biradar, 2015). Hence, this experiment was carried out to know the effect of iron and zinc on yield and quality of chickpea.

MATERIALS AND METHODS

A field experiment to study the effect of iron and zinc nutrition on growth, yield and nutrient uptake by chickpea conducted in the vertisols of the Regional Agricultural Research Station (RARS), Vijayapur during *rabi* 2017-18. Regional Agricultural Research Station (RARS), Vijayapur under Northern Dry Zone of Karnataka (Zone 3), situated at 16°49' N latitude and 75°43' E longitude and at an altitude of 593.8 m above the mean sea level. The soil is black clayey in texture with 25.5, 15.2, and 59.3 per cent sand, silt and clay, respectively. The soil was alkaline in reaction (pH 8.36) and low in soluble salts (0.38 dS m^{-1}). The soil was low in organic carbon (3.4 g kg^{-1}) and available nitrogen (220 kg ha^{-1}) and medium in available P (15.80 kg ha^{-1}), while it was high in K (559 kg ha^{-1}) and high in sulphur (15.10 kg ha^{-1}). The free calcium carbonate content was 20.5 percent. The DTPA extractable micronutrient content *viz.,* zinc, iron, copper and manganese were 0.42, 2.52, 1.12 and 8.2 mg kg^{-1}, respectively (Biradar, N. S., 2015). The content of Zn and Fe in soil was below the critical limit. The experiment was laid out in randomized complete block design with ten treatments and three replications including RPP, application of iron @ 2, 4, 6 kg ha^{-1} and zinc @ 2, 3, 4 kg ha^{-1} in combinations. RPP (RDF @ 10:25:00::N:P_2O_5:K_2O kg ha^{-1} was applied to all the treatments. Sulphur in all the treatments was balanced through application of gypsum ($CaSO_4$. $2H_2O$). Fe and Zn were applied through $FeSO_4$. $7H_2O$ (19%Fe) and $ZnSO_4.7H_2O$(21%Zn), respectively. $FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$ were chelated with vermi-compost at 1:1 ratio for 15 days before sowing. Treatments included were, T_1 : RPP, T_2 : RPP + 2 kg Fe ha^{-1} + 2 kg Zn ha^{-1}, T_3 : RPP + 2 kg Fe ha^{-1} + 3 kg Zn ha^{-1}, T_4 : RPP + 2 kg Fe ha^{-1} + 4 kg Zn ha^{-1}, T_5 : RPP + 4 kg Fe ha^{-1} + 2 kg Zn ha^{-1}, T_6 : RPP + 4 kg Fe ha^{-1} + 3 kg Zn ha^{-1} T_7 : RPP + 4 kg Fe ha^{-1} + 4 kg Zn ha^{-1} T_8 : RPP + 6 kg Fe ha^{-1} + 2 kg Zn ha^{-1} T_9 : RPP + 6 kg Fe ha^{-1} + 3 kg Zn ha^{-1} and T_{10} : RPP + 6 kg Fe ha^{-1} + 4 kg Zn ha^{-1}. After the onset of monsoon seeds were sown in the plot by dibbling 2-3 chickpea seeds (JG-11) per hill at the spacing of 30 cm × 10 cm. Then the thinning and gap filling operations were done at the right time to maintain optimum plant population. Recommended dose of nitrogen (10 kg N ha^{-1}) and phosphorus (25 kg P_2O_5 ka^{-1}) were applied through urea and DAP. The entire quantity of fertilizer was applied as basal dose. The observations recorded were test weight (100- seed weight), seed and straw yield. The protein content in seed was determined as mentioned by AOAC, (1984). The seed and straw samples were analysed in laboratory to determine Fe and Zn content as mentioned by Piper, (1966) then the uptake of macro and micro nutrients were calculated. Finally the total uptake of nutrients by chickpea crop was computed. The soil samples after the harvest of crop were analysed for iron and zinc content as mentioned by Page *et al.,* (1982).

RESULTS AND DISCUSSIONS

Yield parameters

Test weight: The higher test weight (28.28 g) was recorded in the treatment with RPP + 6 kg Fe ha^{-1} + 4 kg Zn ha^{-1}. The lower test weight (20.57 g) was recorded in the treatment with RPP alone (Table 1). The better growth and development of the crop observed in the present study could be due to more supply of iron and zinc in the deficient soil increased the supply of nutrients and assimilates to seed which ultimately gained more weight and increase in 100 seed weight. Kuldeep (2016) reported that application of iron and zinc each @ 6kg ha^{-1} resulted in maximum seed index in chickpea. Similar findings were reported by Singh and Hiremath (1990) in mungbean.

Table 1: Effect of iron and zinc application on test weight, seed and straw yield of chickpea.

Treatments	Test weight(100 - seed weight) (g)	Seed yield(kg ha^{-1})	Straw yield(kg ha^{-1})
T_1: RPP*	20.57	1436	1206
T_2: RPP+ 2 kg Fe ha^{-1} + 2 kg Zn ha^{-1}	22.38	1595	1339
T_3: RPP+ 2 kg Fe ha^{-1} + 3 kg Zn ha^{-1}	22.65	1611	1353
T_4: RPP+ 2 kg Fe ha^{-1} + 4 kg Zn ha^{-1}	23.09	1635	1373
T_5 :RPP+ 4 kg Fe ha^{-1} + 2 kg Zn ha^{-1}	23.48	1667	1400
T_6 :RPP+ 4 kg Fe ha^{-1} + 3 kg Zn ha^{-1}	23.60	1683	1414
T_7 :RPP+ 4 kg Fe ha^{-1} + 4 kg Zn ha^{-1}	23.94	1729	1453
T_8 :RPP+ 6 kg Fe ha^{-1} + 2 kg Zn ha^{-1}	25.84	1886	1584
T_9 :RPP+ 6 kg Fe ha^{-1} + 3 kg Zn ha^{-1}	27.99	2040	1719
T_{10} :RPP+ 6 kg Fe ha^{-1} + 4 kg Zn ha^{-1}	28.28	2065	1735
SEm±	0.6	50.7	42.2
CD (*P* =0.05)	1.7	150.2	125.4

*****RPP- Recommended package of practices.

Seed and straw yield: Higher seed (2065 kg ha^{-1}) and straw (1734 kg ha^{-1}) yield was recorded in the treatment which received RPP + 6 kg Fe ha^{-1} + 4 kg Zn ha^{-1}. The lower seed yield (1436 kg ha^{-1}) was recorded in the treatment which received RPP alone (Table 1). The increase in yield is due to application of ferrous sulphate in crop reduced the Fe deficiency and also increased the chlorophyll content in plant leaves and ultimately enhanced crop yield (Goos and Johnson, 2000). Application of Zn favoured better root growth and development of sink size (number of pods plant^{-1}) and ultimately higher seed yield (Kareti *et al.*, 2017). Combined application of micronutrients increased haulm yield due to increase in photosynthetic rate and there by increased dry matter production and translocation from source to sink (Krishnamurthy *et al.*, 1973). Singh *et al*. (2004) reported 85 per cent higher seed yield and higher straw over control in chickpea due to application of ferrous sulphate @ 50 kg ha^{-1} and zinc sulphate @ 25 kg ha^{-1}. Similar finding were also reported by Prasad and Sharma (2015) in blackgram.

Crude protein content (%): The maximum crude protein in chickpea seed (24.15 %) was recorded in the treatment with RPP + 6 kg Fe ha^{-1} + 4 kg Zn ha^{-1} and the lower crude protein in chickpea seed (19.67 %) was recorded in the treatment 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. It helps in conversion of amino acids to high quality protein. As iron and zinc helps in the translocation of N to grain resulted in increased protein content in grain. (Hemn, 2013). Balai *et al*. (2017) reported increased protein content in seed with the soil application of increasing levels of zinc. Krishna (1995) also reported a significant positive effect of zinc treatment on crude protein content in the seeds of mungbean. Similar findings were reported by Singh *et al.* (2006) in french bean, Duraisamy and Mani (2001) in horse gram and Sanjay (2017) in pigeon pea.

Uptake of iron and zinc by chickpea crop at harvest: The uptake of iron and zinc by chickpea crop was significantly influenced by the soil application of iron and zinc in combination (Table 3). The maximum uptake of iron (458.86 g ha^{-1}) and zinc (203.35 g ha^{-1}) by chickpea crop was found in the treatment which received RPP + 6 kg Fe

Table 2: Effect of iron and zinc application on nitrogen content and crude protein content of chickpea seed.

Treatments	Nitrogen content in grain (%)	Crude protein (%)
T_1: RPP*	3.15	19.67
T_2: RPP+ 2 kg Fe ha^{-1} + 2 kg Zn ha^{-1}	3.31	20.70
T_3: RPP+ 2 kg Fe ha^{-1} + 3 kg Zn ha^{-1}	3.36	21.00
T_4: RPP+ 2 kg Fe ha^{-1} + 4 kg Zn ha^{-1}	3.38	21.14
T_5 :RPP+ 4 kg Fe ha^{-1} + 2 kg Zn ha^{-1}	3.46	21.60
T_6 :RPP+ 4 kg Fe ha^{-1} + 3 kg Zn ha^{-1}	3.51	21.97
T_7 :RPP+ 4 kg Fe ha^{-1} + 4 kg Zn ha^{-1}	3.54	22.10
T_8 :RPP+ 6 kg Fe ha^{-1} + 2 kg Zn ha^{-1}	3.68	23.00
T_9 :RPP+ 6 kg Fe ha^{-1} + 3 kg Zn ha^{-1}	3.83	23.97
T_{10} :RPP+ 6 kg Fe ha^{-1} + 4 kg Zn ha^{-1}	3.86	24.15
S.Em. ±	0.014	0.025
CD (*P* =0.05)	0.12	0.75

*RPP- Recommended package of practices.

Table 3: Effect of iron and zinc application on uptake of cationic micronutrients by chickpea crop.

Treatments	Uptake of cationic micronutrients (g ha^{-1})	
	Fe uptake	Zn uptake
T_1: RPP*	197.99	91.60
T_2: RPP+ 2 kg Fe ha^{-1} + 2 kg Zn ha^{-1}	244.30	109.79
T_3: RPP+ 2 kg Fe ha^{-1} + 3 kg Zn ha^{-1}	255.71	115.36
T_4: RPP+ 2 kg Fe ha^{-1} + 4 kg Zn ha^{-1}	272.92	124.96
T_5 :RPP+ 4 kg Fe ha^{-1} + 2 kg Zn ha^{-1}	295.13	130.91
T_6 :RPP+ 4 kg Fe ha^{-1} + 3 kg Zn ha^{-1}	309.89	138.40
T_7 :RPP+ 4 kg Fe ha^{-1} + 4 kg Zn ha^{-1}	332.26	149.19
T_8 :RPP+ 6 kg Fe ha^{-1} + 2 kg Zn ha^{-1}	384.47	171.36
T_9 :RPP+ 6 kg Fe ha^{-1} + 3 kg Zn ha^{-1}	443.35	195.80
T_{10} :RPP+ 6 kg Fe ha^{-1} + 4 kg Zn ha^{-1}	458.86	203.35
S.Em. ±	3.78	1.72
CD (*P* =0.05)	9.16	5.10

*RPP- Recommended package of practice

Table 4: Available micronutrient status of soil after harvest of crop as influenced by iron and zinc application.

Treatments	Available micronutrients (mg kg^{-1})	
	Fe	Zn
T_1: RPP*	2.42	0.39
T_2: RPP+ 2 kg Fe ha^{-1} + 2 kg Zn ha^{-1}	2.82	0.43
T_3: RPP+ 2 kg Fe ha^{-1} + 3 kg Zn ha^{-1}	2.96	0.45
T_4: RPP+ 2 kg Fe ha^{-1} + 4 kg Zn ha^{-1}	3.23	0.47
T_5 :RPP+ 4 kg Fe ha^{-1} + 2 kg Zn ha^{-1}	3.53	0.49
T_6 :RPP+ 4 kg Fe ha^{-1} + 3 kg Zn ha^{-1}	3.76	0.51
T_7 :RPP+ 4 kg Fe ha^{-1} + 4 kg Zn ha^{-1}	3.93	0.54
T_8 :RPP+ 6 kg Fe ha^{-1} + 2 kg Zn ha^{-1}	4.30	0.58
T_9 :RPP+ 6 kg Fe ha^{-1} + 3 kg Zn ha^{-1}	4.63	0.62
T_{10} :RPP+ 6 kg Fe ha^{-1} + 4 kg Zn ha^{-1}	4.83	0.64
S.Em. ±	0.088	0.01
C.D. (P =0.05)	0.26	0.03

*RPP- Recommended package of practices. NS - Non significant

ha^{-1} + 4 kg Zn ha^{-1}. The minimum uptake of iron and zinc by chickpea was recorded in the treatment which received RPP alone. This may be due to the increased availability of micronutrients applied because of chelation effect as it is applied after chelation with vermicompost. It was also due to the synergetic effect between iron and zinc in plants and higher dry matter production. Singh *et al*. (2004) reported that the application of ferrous sulphate @ 50 kg ha^{-1}, sodium molybdate @ 1 kg ha^{-1} and zinc sulphate @ 25 kg ha^{-1} has recorded higher Zn uptake (0.060 kg ha^{-1}) which was significantly higher over control. Similar findings were reported by Gupta and Sahu (2012).

Available iron and zinc status in soil after harvest of crop: The application of iron and zinc to soil in combination showed significant difference in DTPA-extractable iron and zinc content in soil after harvest of crop. The higher DTPA-extractable iron (4.83 mg kg^{-1}) and zinc (0.64 mg kg^{-1}) were found in the treatment which received RPP + 6 kg Fe ha^{-1} + 4 kg Zn ha^{-1} and lower DTPA-extractable iron (2.42 mg kg^{-1}) and zinc (0.39 mg kg^{-1}) were recorded in the treatment which received RPP alone (Table 4). This is due to the application of higher doses of chelated iron and zinc to the soil deficient in iron and zinc. Balai *et al*. (2017), Kuldeep (2016) and Karajanagi (2013) also reported the similar results.

CONCLUSION

The results of field experiment revealed that, the application of iron and zinc in combinations resulted in significant increase in yield, protein content and iron and zinc uptake by chickpea over RPP alone and it also recorded higher residual iron and zinc content in soil. The significantly higher results were recorded in the treatment which received RPP + 6 kg Fe ha^{-1} + 4 kg Zn ha^{-1}. Finally it can be concluded that the application of fertilizers containing iron and zinc helps to increase crop yield and nutrient uptake by chickpea and also improves iron and zinc status in soil after crop harvest.

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