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.

Received: 04-02-2019 Accepted: 11-03-2019

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, 3 and 4 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 : P₂O₅ : K₂O 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 helped 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 phytohormones 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. Dicotyledinous 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:K) was applied to all the treatments. The soil samples after the harvest of crop were analysed for iron and zinc content as mentioned by Page, (1982). 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\(^{-1}\)) and available K at the site (559 kg ha\(^{-1}\)).

**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 @ 6 kg 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
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), Kuldeepsingh (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.

**REFERENCES**

Anonymous, (2017). Agricultural Statistics at a Glance 2016, Department of Agriculture, Cooperation and Farmers Welfare, Directorate of Economics and Statistics, pp. 109-111.

AOAC. (1984). Official Methods for Analysis of the Association of Official Analytical Chemists. 14th edition. Arlington, VA, p. 1141.

Balai, K., Jajoria, M., Verma, R., Deewan, P. and Bairwa, S. K. (2017). Nutrient content, uptake, quality of chickpea and fertility status of soil as influenced by fertilization of phosphorus and zinc. Journal of Pharmacognosy and Phytochemistry, 6(1): 392-398.

Biradar, N. S., (2015). Studies on iron and ferrous sulphate application on growth and yield of *rabi* sorghum and chickpea intercrops in a *vertisol*. M. Sc. (Agri.) Thesis. Univ. Agric. Sci, Dharwad, Karnataka (India).

Duraisamy, P. and Mani, A.K. (2001). Effect of iron and molybdenum on yield and nutrition of horse gram in red loamy sand soil. Mysore J. Agric. Sci. 35: 26-31.

Goos, R.J. and Johnson, B.E. (2000). A comparison of three methods for reducing iron deficiency chlorosis in soybean. Agron. J. 92: 1135-1139.

Gupta, S.C. and Sahu, S. (2012). Response of chickpea to micronutrients and bio fertilizers in *vertisol*, Legume Res, 35 (3): 248 – 251.

Hemn, O.S. (2013). Effect of foliar fertilization of Fe, B and Zn on nutrient concentration and seed protein of cowpea (*Vigna unguiculata*). J. Agri. Vet. Sci. 6: 42-46.

Karajanagi, M. S. (2013). Response of chickpea (*Cicer arietinum L.*) TO identified micronutrients constraints under *vertisol* of malaprabha command area in Karnataka, M. Sc. (Agri.) Thesis. Univ. Agric. Sci. Dharwad, Karnataka (India).

Kareti, Siva, S., Krishna, S. and George, P.J. (2017). Effect of levels of phosphorus and zinc on growth and yield of *Kabuli* chickpea (*Cicer kabulium L*.), J. Pharmacognosy and Phytochemistry. 6(4): 1013-1016.
Krishna, S. (1995). Effect of sulphur and zinc application on yield, S and Zn uptake and protein content of mung (greengram). *Legume Res.* **18**: 89–92.

Krishnamurthy, K., Bommegouda, A., Ragunath, G., Rajashekhar, B.G., Venugopal, N., *et al.* (1973). Investigation on the structure of yield in cereals (maize and sorghum). *Final Tech. Report of PL 480 Project*. p. 373.

Kukleop (2016). Effect of iron and zinc nutrition on growth, yield and quality of chickpea. *M. Sc. (Agri.) Thesis*, Univ. Agric. Sci. Junagadh (India).

Kumar, P. and Sharma, M.K. (2013). Nutrient Deficiencies of Field Crops: Guide to Diagnosis and Management. Research Building Sirohi Department of Agriculture Government of Rajasthan, Rajasthan, India. pp. 189-191.

Majumdar, D.K. (2011). Pulse crop production – Principles and Technologies. PHI Learning Private Limited, New Delhi, India.

Marschner, P. (2012). *Mineral Nutrition of Higher Plants*, Academic Press, UK, pp. 191-243.

Page, A.L., Miller, R.H. and Keeney, D.R. (1982). *Methods of Soil Analysis*. Part 2- Chemical and Microbiological Properties. 2nd Edition. Agronomy No. 9 Part 2. ASA, SSSA, Madison, Wisconsin, USA.

Piper, C.S. (1966). *Soil and Plant Analysis*, Inter-science Publishers, Inc., New York. pp. 368.

Prasad, S.D. and Sharma, S.K. (2015). Effect of organic and inorganic sources of nutrients on yield and economics of blackgram (*Vigna mungo* L.) grown during kharif season. *Agric. Res.* **52(3)**: 991-95.

Sanjay, T.S. (2017). Studies on effect of graded levels of potassium and zinc on growth, yield, nutrient uptake and quality of pigeon pea. *M. Sc. (Agri.) Thesis*, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (India).

Singh, B.G. and Hiremath, S.M. (1990), Effect of zinc fertilization on physiological aspects of mungbean. *J. Maharashtra Agric. Univ.* **15(2)**: 176-78.

Singh, C.K., Sharanappa and Rakesh Kumar. (2006). Effect of phosphorus, zinc, sulphur and bioinoculants on yield and economics of cowpea. *Mysore J. Agril. Sci.* **40(1)**: 138-141.

Singh, U. and Yadav, D. S. (2004). Response of green gram to sulphur and zinc. *Ann. Agric. Res.* **25(3)**: 463-464.