J. Farm Sci., 34(4): (404-409) 2021

RESEARCH PAPER

Growth and yield of chickpea (*Cicer arietinum* L.) and soil fertility as influenced by micronutrients and bio-fertilisers in vertisols

DEEPA BASAPPA AJJANNAVAR, VIDYAVATHI G. YADAHALLI, I. M. SARAWAD AND S. B. PATIL

Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vijayapura - 586 101
University of Agricultural Sciences, Dharwad - 580 005 (Karnataka), India
E-mails: deepabajjannavar1997@gmail.com, vidyavathisac@gmail.com

(*Received: October, 2021 ; Accepted: December, 2021*)

Abstract: A field experiment to assess the effect of micronutrients and bio-fertilizers on growth and yield of chick pea and soil fertility in vertisols was conducted at College of Agriculture, Vijayapura during *rabi* 2020-21. The experiment was laid out in a randomized complete block design with nine treatments and three replications. Apart from the recommended dose of fertilizers (10:25:00: N: P_2O_5:K_2O kg ha^{-1}), the treatments included the application of iron sulphate @10 kgha^{-1} (19% Fe and 10.5%S), zinc sulphate @10 kg ha^{-1} (21% Zn and 10% S), borax @ 10 kg ha^{-1} (11.34% B) and sodium molybdate @ 1.0 g kg^{-1} seeds in various combinations along with RDF. The effects of these treatments on growth, yield, dehydrogenase activity and quality of chickpea were studied. The application of different micronutrients and biofertilizers in combinations with RDF resulted in significant increase in growth and yield of chickpea over RDF alone. Among the different treatments, the treatment which received RDF + *Rhizobium* + PSB (@ 1250 g ha^{-1}) + $FeSO_4$ @ 10 kg ha^{-1} +$ZnSO_4$@ 10 kg ha^{-1} +Borax @ 10 kg ha^{-1} + Sodium molybdate @ 1.0 g kg^{-1} seeds (T_8) resulted in maximum plant height (32.10 cm), number of branches per plant (12.74), total dry matter accumulation at flowering (12.60), at pod filling (22.57) and at harvest (25.56 g plant^{-1}), grain yield (1591.4), straw yield (1350 kg ha^{-1}) and harvest index (0.54). The treatment also resulted in higher uptake of major (N, P, K and S) and micronutrients (Zn, Fe, Cu and Mn) by chickpea. Significantly higher crude protein content in seeds was observed and similarly higher available macronutrients and DTPA extractable Fe and Zn status in soil after harvest of the crop noticed. Thus, the combined application of RDF (10:25:00: N: P_2O_5:K_2O kg ha^{-1}) + *Rhizobium* + PSB (@ 1250 g ha^{-1}) + FeSO4 @ 10 kg ha^{-1} +$ZnSO_4$@ 10 kg ha^{-1} +Borax @ 10 kg ha^{-1} + Sodium molybdate @ 1.0 g kg^{-1} seeds, found optimum for higher productivity of chickpea in vertisols.

Key words: Borax, Chickpea, Sodium molybdate, Zinc

Introduction

Pulses constitute an important dietary ingredient of the oriental food due to their high protein content. Pulses have long standing history of being soil fertility restorer, thus play a vital role in sustainable agriculture. Chickpea (*Cicer arietinum* L.) is the most important ancient pulse crop being traditionally grown during *rabi* in India and cultivated mainly in semi-arid regions of the world. Chickpea belongs to the Leguminaceae family; is the highest protein yielding grain legume next to groundnut and soybean. The malic and oxalic acids present in green leaves are very useful for recovering from intestinal disorder. In India, pulses cover an area of 10.56 million hectares with an annual production of 11.23 million tonnes, and productivity of about 1063 kg ha^{-1} (Anon., 2018). Karnataka is one of the major chickpea producing states in the country. In Karnataka, it is grown in *rabi* season over an area of 946 thousand ha with an annual production of 715.00 thousand tones, having an average productivity of 757 kg ha^{-1} (Anon., 2015).

Micronutrients are essential for the normal growth of plants. Deficiencies of micronutrients drastically affect the growth, metabolism and reproductive phase in plants, animal and human beings. Molybdenum activates several enzymes like catalase, peroxidase and polyphenol oxidase, which is required by nitrogen fixing organisms like *Azotobacter, Clostridium, Nostoc, Anabaena*. Being aconstituent of the hydrogenase enzyme, helps in enzymatic transfer of electrons for reduction of nitrogen. Zinc plays a role in the detoxification of superoxide radicals, membrane integrity as well as synthesis of protein and phytoharmones like IAA. Considerable yield losses due to iron deficiency may occur when susceptible genotypes are grown on calcareous soils with high pH. Boron regulates transport of sugars through membranes, cell division, cell development, and metabolism. A continuous supply of boron is important for adequate plant growth and optimum yields. Boron is trace element that can be applied to soil as well as foliar.

Bio-fertilizers are carrier based preparations containing beneficial microorganisms in a viable state intended for seed or soil application to improve soil fertility and plant growth by increasing the number and biological activity of beneficial microorganisms in the rhizosphere. They improve soil fertility levels by fixing atmospheric nitrogen, solubilizing insoluble soil phosphates and releasing plant growth substances in the soil (Venkatashwarlu, 2008). Some important inoculants are rhizobium, azotobacter, arbuscular mycorrhiza (AM), blue green algae, azolla, phosphate solubilizing bacterial (PSB) inoculants etc. Rhizobium inoculants are widely used as biofertilizer to enhance chickpea growth and yield as they fix atmospheric nitrogen symbiotically.

Material and methods

A field experiment to assess the effect of micronutrients and bio-fertilizers on growth and yield of chickpea and soil fertility in vertisols under dry land canditions was carried out at College of Agriculture, Vijayapura during *rabi* 2020-21. Vijayapura is situated in the Northern Dry Zone (Zone-3) of Karnataka. Geographically, it is located in the northern part of the state at 16^0 49'N latitude and 75^0 43' E longitude and at an altitude of 593.8 m above the mean sea level. The soil is black; clayey in texture with 7.2, 18.3, 15.3 and 59.2 per cent of coarse sand, fine sand, silt and clay, respectively. The soil pH is estimated by Potentiometric method (Sparks, 1996) and it is alkaline in reaction (pH 8.33) and electrical conductivity of soil is estimated by Conductometric method (Sparks, 1996) and is low in soluble salts (0.38 dS m^{-1}). The soil low in organic carbon (3.90 g kg^{-1}) and available N (209.0) and medium in available P (14.00), while it was high in available K (340) and sulphur (14.0 kg ha^{-1}). The free calcium carbonate content was 13.4 per cent. The DTPA extractable micronutrient content *viz*., zinc, iron, copper and manganese was 0.2, 1.6, 0.6 and 6.1 mg kg^{-1}, respectively .The content of Zn and Fe in soil was below the critical limits.

The experiment was laid out in randomized complete block design (RCBD) design with nine treatments and three replications. The RDF @10: 25: 0 kg N:P_2O_5: K_2O ha^{-1} was applied to all the treatments. Iron, zinc and Borax were applied to soil as per treatments through ferrous sulphate ($FeSO_4.7H_2O$) containing 19 percent Fe and 10.5 percent S, zinc sulphate ($ZnSO_4.7\ H_2O$) containing 21 per cent Zn and 10 percent S and, boron applied through borax $Na_2[B_4O_5(OH)_4].8H_2O$ (11.34%B). Iron sulphate and zinc sulphate were chelated with vermicompost at 1:1 ratio for 15 days before sowing. *Rhizobium,* phosphate solubilizing bacteria (PSB) and sodium molybdate were seed treated. Treatments included were, T_1: RDF (10: 25: 0 kg N:P_2O: K_2O ha^{-1}), T_2:T_1+*Rhizobium* + PSB (@ 1250 g ha^{-1} each), T_3: T_2 + $FeSO_4$@ 10 kg ha^{-1} ,T_4: T_2 + $ZnSO_4$@ 10 kg ha^{-1} ,T_5: T_2 + Borax @10 kg ha^{-1} T_6 : T_2 + Sodium Molybdate @ 1.0 g kg^{-1} seeds,T_7 : T_2 + $FeSO_4$ @ 10 kg ha^{-1} + $ZnSO_4$ @ 10 kg ha^{-1} + Borax @ 10 kg ha^{-1} ,T_8: T_2 + $FeSO_4$ @ 10 kg ha^{-1} + $ZnSO_4$ @ 10 kg ha^{-1} + Borax @ 10 kg ha^{-1} + Sodium molybdate @ 1.0 g kg^{-1} seeds and T_9 : $FeSO_4$ @ 10 kg ha^{-1} + $ZnSO_4$ @ 10 kg ha^{-1} + Borax @ 10 kg ha^{-1} + Sodium molybdate @ 1.0 g kg^{-1} seeds.

Recommended dose of nitrogen (10 kg N ha^{-1}) and phosphorus (25 kg P_2O_5 ha^{-1}) was applied through urea and DAP. The entire quantity of fertilizer was applied as basal dose. The soil samples after the harvest of the crop were analyzed for various chemical properties as mentioned by Page *et al*. (1982).The data collected from the experiment during the crop growth period was subjected to statistical analysis.

Results and discussion

Effect on growth parameters of chickpea

The treatment which received RDF + *Rhizobium* + PSB + $FeSO_4$ @ 10 kg ha^{-1} + $ZnSO_4$ @ 10 kg ha^{-1} + Borax @ 10 kg ha^{-1} + Sodium molybdate @ 1.0g kg^{-1} seeds (T_8) recorded significantly higher plant height (32.10 cm), number of branches per plant (12.74) and root nodules per plant(17.55) and was superior over all the treatments except treatment receiving RDF + *Rhizobium* + PSB + $FeSO_4$ @ 10 kg ha^{-1} + $ZnSO_4$ @ 10 kg ha^{-1} + Borax @ 10 kg ha^{-1} (T_7). The lower plant height (16.30 cm), number of branches per plant (10.58) and root nodules per plant (12.28) was recorded in the treatment which received RDF alone (T_1) and data are presented in Table 1. The increase in the growth parameters might be due to continuous supply of chelated micronutrients along with bio-fertilizers. This provides a way for balanced nutrition throughout the growth period of crop. The rhizobium helps in fixation of atmospheric nitrogen in nodules containing aspergine and gluts a thiamin, which results in an increase in the production of protein, carbohydrate and starch for higher dry matter accumulation and more branches per plant. Zinc and iron play vital role in photosynthesis, assimilation and translocation of photosynthates from source (leaves) to sink (panicle). The seed treatment with sodium molybdate also helps for the nitrogen fixation; it increases number of nodules per plant which results in greater increase in number of branches per plant, which ultimately increase the yield of crop (Valenciano *et al*., 2010). Boron is essential for root and shoots growth, flower fertility and Mo being nutrient for nodule forming bacteria, therefore, increased nodulation resulting in increased number of branches per plant, number of nodules per plant and dry nodule weight at 45 DAS (Movalia *et al.* 2020).The results obtained were in accordance with the study of Kumar *et al.* (2020).

Effect on yield parameters of chickpea

The treatment receiving RDF + *Rhizobium* + PSB + $FeSO_4$ @ 10 kg ha^{-1} +$ZnSO_4$@ 10 kg ha^{-1} +Borax @ 10 kg ha^{-1} + Sodium molybdate @ 1.0 g kg^{-1} seeds (T_8) recorded significantly higher test weight of 100 seeds (25.36 g) and was superior over all the treatments except treatment receiving RDF + *Rhizobium* + PSB+ $FeSO_4$ @ 10 kg ha^{-1} +$ZnSO_4$@ 10 kg ha^{-1} +Borax @ 10 kg ha^{-1} (T_7). The lower test weight of 100 seeds (19.22 g) was recorded in the treatment which received RDF alone (T_1) and data are presented in Table 1.The better growth and development of the crop observed in the present study could be due to more supply of micronutrients in the deficient soil, which 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 also reported by Biradar (2015) in chickpea. Significantly higher grain and haulm yield (1591and 1350 kg ha^{-1}, respectively) was noticed in the treatment which received RDF + *Rhizobium* + PSB+ $FeSO_4$ @ 10 kg ha^{-1} +$ZnSO_4$@ 10 kg ha^{-1} +Borax @ 10 kg ha^{-1} + Sodium molybdate @ 1.0 g kg^{-1} seeds (T_8) and was superior over all the treatments except treatment which received RDF + *Rhizobium* + PSB+ $FeSO_4$@ 10 kg ha^{-1} +$ZnSO_4$@ 10 kg ha^{-1} +Borax @ 10 kg ha^{-1} (T_7). The lower grain yield and haulm yield (1088 kg ha^{-1} and 1058 kg ha^{-1}, respectively) was recorded in the treatment which received RDF alone (T_1) and are presented in Table 1. The increase in seed yield with rhizobium and PSB treatments may be due to more nitrogen availability through increased nitrogen fixation, higher number of pods per plant, seeds per pod and yield attributes via higher photosynthetic rate and their translocation to sink, which contribute for higher

Table 1. Influence of different micronutrients and bio-fertilizers on growth, yield parameters and economics of chickpea

Treatments	Plant height (cm)	Number of branches plant^{-1}	Number of root nodules plant^{-1}	Test weight of 100 seeds (g)	Grain yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Net returns (Rs. ha^{-1})	BC Ratio
T_1 - RDF (10: 25: 0 kg N: P_2O_5: K_2Oha^{-1})	16.30	10.58	12.28	19.22	1088	1058	27734	2.30
T_2 - *Rhizobium* + PSB (@ 1250 g ha^{-1})	20.30	11.06	12.85	20.11	1216	1137	33235	2.54
T_3 - T_2 + $FeSO_4$ @ 10 kg ha^{-1}	24.30	11.40	13.45	20.52	1291	1162	36100	2.63
T_4 - T_2 + $ZnSO_4$ @ 10 kg ha^{-1}	22.10	11.23	13.23	20.13	1280	1152	35346	2.58
T_5 - T_2 +Borax @ 10 kg ha^{-1}	18.60	10.78	12.73	19.49	1200	1112	31333	2.38
T_6 - T_2 +Sodium molybdate @ 1.0 g kg^{-1} seeds	26.40	11.43	15.73	20.85	1347	1176	39075	2.81
T_7 - T_2 +$FeSO_4$ @ 10 kg ha^{-1} +$ZnSO_4$ @ 10 kg ha^{-1} + Borax @ 10 kg ha^{-1}	30.00	11.74	13.75	23.31	1450	1212	41322	2.72
T_8 - T_2 +$FeSO_4$ @ 10 kg ha^{-1} +$ZnSO_4$ @ 10 kg ha^{-1} +Borax @ 10 kg ha^{-1} + Sodium molybdate @ 1.0 g kg^{-1} seeds	32.10	12.74	17.55	25.36	1591	1350	47616	2.98
T_9 - $FeSO_4$ @ 10 kg ha^{-1} + $ZnSO_4$ @ 10 kg ha^{-1} + Borax @ 10 kg ha^{-1} + Sodium molybdate @ 1.0 g kg^{-1} seeds	28.60	11.57	16.03	22.67	1361	1188	37520	2.57
S.Em.±	0.76	0.39	0.65	0.91	48.45	45.86	3220	0.07
C. D. (P = 0.05)	2.29	1.16	1.95	2.73	145.27	137.50	9656	0.22

seed yield in chickpea. These results were in close conformity with the findings of Das *et al.* (2012) and revealed that the treatment with 0.5 kg Na_2MoO_4 ha^{-1} + Rhizobium gave the highest plant dry weight of 4.22, 9.12 and 11.35 g plant^{-1} at 45, 75 and 120 DAS, respectively also highest grain yield of 2977 kg ha^{-1} and straw yield (7111 kg ha^{-1}) was recorded due to inoculation with Rhizobium + 10 kg Borax ha^{-1} in chickpea and Kumari *et al.* (2019) in chickpea revealed that highest grain yield and stover yield where *Rhizobium* was applied along with micronutrients *i.e.* RDF + *Rhizo.* + Zn (20 kg ha^{-1}) + B (0.5 kg ha^{-1}) + Mo (1 kg ha^{-1}).

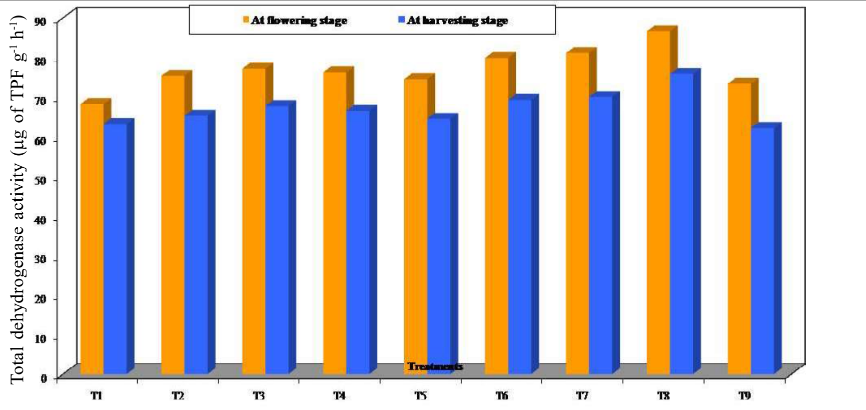
Significantly higher net returns (47616 Rs. ha^{-1}) was noticed in the treatment which received RDF + *Rhizobium* + PSB+ $FeSO_4$ @ 10 kg ha^{-1} +$ZnSO_4$@ 10 kg ha^{-1} +Borax @ 10 kg ha^{-1} + Sodium molybdate @ 1.0 g kg^{-1} seeds (T_8) and was superior over all the treatments except treatment which received RDF + *Rhizobium* + PSB+ $FeSO_4$ @ 10 kg ha^{-1} +$ZnSO_4$@ 10 kg ha^{-1} +Borax @ 10 kg ha^{-1} (T_7). The lower net returns (27734 Rs. ha^{-1}) was recorded in the treatment which received RDF alone (T_1) and are presented in Table 1. Similarly, significantly higher BC ratio (2.98) noticed in the treatment which received RDF + *Rhizobium* + PSB+ $FeSO_4$ @ 10 kg ha^{-1} +$ZnSO_4$@ 10 kg ha^{-1} +Borax @ 10 kg ha^{-1}) + Sodium molybdate @ 1.0 g kg^{-1} seeds (T_8) followed by the treatment which received RDF + *Rhizobium* + PSB + $FeSO_4$ @ 10 kg ha^{-1} +$ZnSO_4$@ 10 kg ha^{-1} +Borax @ 10 kg ha^{-1} (2.81) (T_9). The lower B:C ratio (2.30) was recorded in the RDF alone (T_1).The higher the yield, the higher the gross return and net return, hence B:C will be higher.

Effect on dehydrogenase activity of soil at different growth stages of chickpea

The treatment which received RDF + *Rhizobium* + PSB + $FeSO_4$@ 10 kg ha^{-1} +$ZnSO_4$@ 10 kg ha^{-1} + Borax @ 10 kg ha^{-1} + Sodium molybdate @ 1.0 g kg^{-1} seeds (T_8) resulted in significantly higher total dehydrogenase activity of soil at flowering and harvesting (86.61 ug of TPF g^{-1} h^{-1} and 75.86 ug of TPF g^{-1} h^{-1}, respectively)and was superior over all the treatments except treatment receiving RDF + *Rhizobium* + PSB +$FeSO_4$@ 10 kg ha^{-1} +$ZnSO_4$@ 10 kg ha^{-1} +Borax @ 10 kg ha^{-1} (T_7). The lower total dehydrogenase activity of soil (68.22 ug of TPF g^{-1} h^{-1} and 63.18 ug of TPF g^{-1}h^{-1}, respectively) was recorded in the treatment which received RDF alone (T_1) and are represented in Fig.1. The addition of trace metals like zinc to soil might influence microbial proliferation and enzyme activity, possibly leading to an increase in the rates of biochemical process in the soil environment. Dehydrogenase activity in the chickpea rhizosphere increased significantly at vegetative stage due to rhizosphere effects (only plant growth) and inoculation. The greatest relative increase was due to combination of rhizosphere effects and microbial inoculation. The results obtained were in accordance with the findings of Apoorva *et al.* (2018) reported that the highest dehydrogenase activity with RDF + soil application of bio zinc@30 kg ha^{-1}, in rice crop.

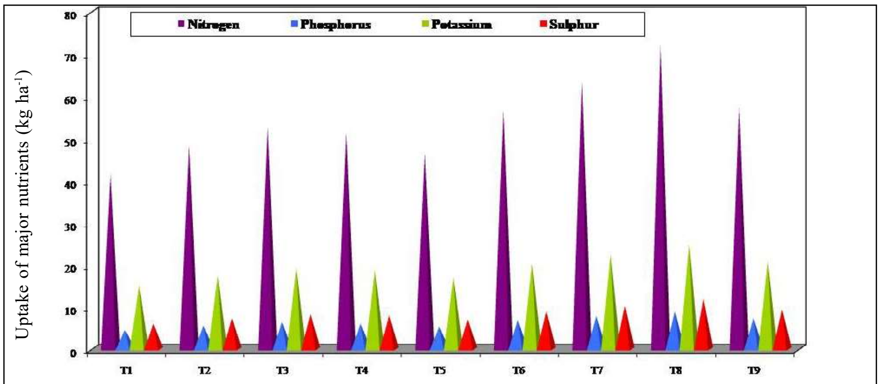
Macro nutrient uptake by chickpea (N, P, K and S)

The treatment which received RDF + *Rhizobium* + PSB+ $FeSO_4$@ 10 kg ha^{-1} +$ZnSO_4$@ 10 kg ha^{-1} +Borax @ 10 kg ha^{-1} + Sodium molybdate @ 1.0 g kg^{-1} seeds (T_8) recorded significantly



T_1-RDF (10:25:0 kg NPK ha^{-1})
T_2- *Rhizobium* + PSB @ 1250 g ha^{-1}
T_3-T_2+$FeSO_4$ @ 10 kg ha^{-1}
T_4-T_2=$ZnSO_4$ @10 kg ha^{-1}
T_5-T_2+ Borax@10 kg ha^{-1}
T_6-T_2 + Sodium molydbate @ 1.0g kg^{-1} seeds
T_7-T_2+ $FeSO_4$+$ZnSO_4$ + Borax (@10 kg ha^{-1} each)
T_8-T_2+ $FeSO_4$+$ZnSO_4$+Borax (@10 kg ha^{-1} each) + Sodium molybdate @ 1.0 g kg^{-1} seeds
T_9-$FeSO_4$+$ZnSO_4$+Borax (@10 kg ha^{-1} each) + Sodium molybdate @ 1.0g kg^{-1} seeds

Fig. 1: Influence of different micronutrients and bio-fertilizers on dehydrogenase activity of soil at different growth stages of chickpea



T_1- RDF (10:25:0 kg NPK ha^{-1})
T_2- *Rhizobium* + PSB @ 1250 g ha^{-1}
T_3- T_2+$FeSO_4$ @ 10 kg ha^{-1}
T_4- T_2+$ZnSO_4$ @ 10 kg ha^{-1}
T_5-T_2 + Borax @10 kg ha^{-1}
T_6-T_2 + Sodium molydbate @ 1.0 g kg^{-1} seeds
T_7-T_2 + $FeSO_4$+$ZnSO_4$ + Borax (@10 kg ha^{-1} each)
T_8- T_2+$FeSO_4$+$ZnSO_4$+Borax (@10 kg ha^{-1} each) + Sodium molybdate @ 1.0 g kg^{-1} seeds
T_9- $FeSO_4$+$ZnSO_4$+Borax (@10 kg ha^{-1} each) + Sodium molybdate @ 1.0 g kg^{-1} seeds

Fig. 2: Influence of different micronutrients and bio-fertilizers on macro nutrient uptake by chickpea at harvest

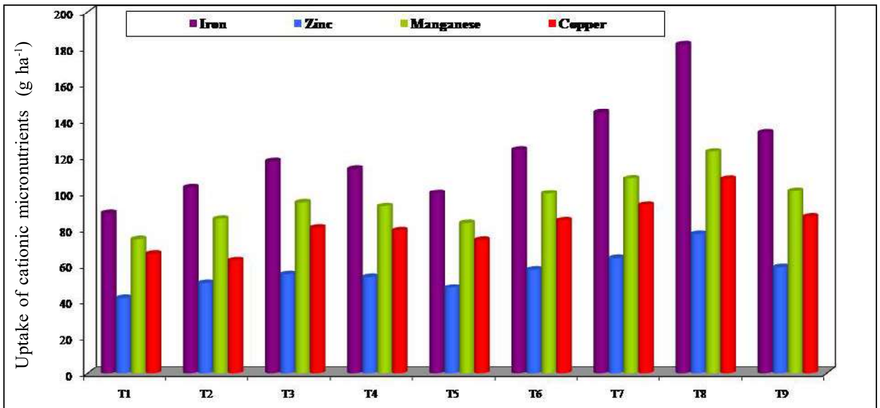
higher nitrogen (N) uptake (55.40 and 16.55), phosphorus (P) uptake (4.76 and 4.13) potassium (K) uptake (9.37 and 15.43) and sulphur (S) uptake (7.07 and 4.77 kg ha^{-1}, respectively) by chickpea seed and straw and was superior over all the treatments except treatment receiving RDF + *Rhizobium* + PSB+ $FeSO_4$@ 10 kg ha^{-1} +$ZnSO_4$@ 10 kg ha^{-1} +Borax @ 10 kg ha^{-1} (T_7). The lower nitrogen uptake by chickpea seed and straw (32.67 and 8.66 kg ha^{-1}, respectively), phosphorus uptake in chickpea seed and straw (2.38 and 2.16 kg ha^{-1}, respectively), potassium uptake in chickpea seed and straw (5.32 and 9.67 kg ha^{-1}, respectively) and sulphur uptake in chickpea seed and straw (3.81 and 2.17 kg ha^{-1}, respectively) was recorded in the treatment which received RDF alone (T_1) and are depicted in Fig. 2. Similar trend of result was obtained with total uptake of nitrogen, phosphorus, potassium and sulphur by the crop. An increase in uptake of macronutrients might be due to increased N uptake at harvest, attributed to the synergistic effect between iron and nitrogen as well as zinc and nitrogen. Since iron absorbed by plants is involved in the biosynthesis of chlorophyll, which intern stimulates greater N demand by plants leading to enhanced N uptake (Balai *et al*., 2017). Greater availability and uptake of phosphorus due to additive effects of these PSB bio-fertilizers in improving nutritional environment enhanced the growth in terms of branches and dry matter, photosynthetic area, production of assimilates and their translocation to reproductive structures, thereby increasing the yield attributes and ultimately, yield of the crop. An increase in the uptake of potassium may be attributed to the synergetic effect between iron and potassium and also to the increase in dry matter production due to the application of iron, zinc and balanced nutrition with each other. Similar findings were reported by Tiwari *et al*. (2018) in lentil they reported that the highest uptake of N and P in lentil.

Micronutrient uptake by chickpea (Fe, Zn, Mn and Cu)

Significantly higher iron (Fe) uptake by chickpea seed and straw (110.22 and 71.77 g ha^{-1}, respectively), zinc (Zn) uptake by chickpea seed and straw (47.59 and 29.62 g ha^{-1}, respectively), manganese (Mn) uptake by chickpea seed and straw (45.79 and 76.38 g ha^{-1}, respectively) and copper (Cu) uptake by chickpea seed and straw (44.61 and 63.02 g ha^{-1}, respectively) was recorded in the treatment which received RDF + *Rhizobium* + PSB+ $FeSO_4$@ 10 kg ha^{-1}+$ZnSO_4$@ 10 kg ha^{-1}+Borax @ 10 kg ha^{-1}+ Sodium molybdate @ 1.0 g kg^{-1} seed (T_8) and followed by the treatment which received RDF + *Rhizobium* + PSB+ $FeSO_4$@ 10 kg ha^{-1}+$ZnSO_4$@ 10 kg ha^{-1}+Borax @ 10 kg ha^{-1} (T_7) and lower iron uptake in chickpea seed and straw (68.63 and 20 g ha^{-1}, respectively), zinc uptake by chickpea seed and straw (23.63 and 18.18 g ha^{-1}, respectively), manganese uptake by chickpea seed and straw (24.38 and 49.49 g ha^{-1}, respectively) and copper uptake in chickpea seed and straw (27.57 and 38.50 g ha^{-1}, respectively) in (T_1) and it was represented in Fig. 3. Uptake of any nutrient is the function of its content and dry matter production of the crop. The uptake of iron by chickpea increased due to the increased availability of iron due to chelation effect as it is applied after chelation with vermicompost. As a result, fixation of iron reduced in soils and its availability of iron to plants increased. Due to this the uptake of iron increased. It was also due to the synergetic effect between iron and zinc in plants and higher dry matter production .The results obtained were in accordance with the findings of Singh *et al.* (2004) who revealed that content and uptake of Fe, Mo,

Table 2. Influence of different micronutrients and bio-fertilizers on soil available nutrients and DTPA extractable micronutrients (Fe and Zn) in soil after the harvest of chickpea crop.

Treatments		Available nutrients (kg ha^{-1})				DTPA -micronutrients (mg kg^{-1})	
		N	P	K	S	Fe	Zn
T_1-	RDF (10: 25: 0 kg N: P_2O_5: K_2Oha^{-1})	210.5	15.8	348.0	15.48	2.06	0.30
T_2-	*Rhizobium* + PSB (@ 1250 g ha^{-1})	215.0	16.1	357.0	16.38	2.25	0.34
T_3-	T_2 + $FeSO_4$ @ 10 kg ha^{-1}	219.9	16.7	363.0	17.75	2.85	0.39
T_4-	T_2 + $ZnSO_4$ @ 10 kg ha^{-1}	218.1	16.2	359.0	17.35	2.35	0.41
T_5-	T_2 +Borax @ 10 kg ha^{-1}	213.0	16.0	355.0	16.35	2.12	0.32
T_6 -	T_2 +Sodium molybdate @ 1.0 g kg^{-1} seeds	226.1	17.7	369.0	17.89	2.55	0.38
T_7 -	T_2 +$FeSO_4$ @ 10 kg ha^{-1} +$ZnSO_4$ @ 10 kg ha^{-1} + Borax @ 10 kg ha^{-1}	227.1	17.8	388.0	19.65	3.00	0.49
T_8-	T_2 +$FeSO_4$ @ 10 kg ha^{-1} +$ZnSO_4$@ 10 kg ha^{-1} +Borax @ 10 kg ha^{-1} + Sodium molybdate @ 1.0 g kg^{-1} seeds	233.1	20.0	397.0	21.92	3.21	0.51
T_9-	$FeSO_4$ @ 10 kg ha^{-1} + $ZnSO_4$ @ 10 kg ha^{-1} + Borax @ 10 kg ha^{-1} + Sodium molybdate @ 1.0 g kg^{-1} seeds	226.2	14.9	374.0	18.77	2.91	0.44
S.Em.±		2.0	0.8	10.80	0.77	0.07	0.02
C. D. (*P* = 0.05)		6.1	2.5	NS	2.33	0.21	0.06



T_1-RDF (10:25:0 kg NPK ha^{-1})
T_2-*Rhizobium* + PSB @ 1250 gha^{-1}
T_3-T_2+$FeSO_4$ @ 10 kg ha^{-1}
T_4- T_2+$ZnSO_4$ @ 10 kg ha^{-1}
T_5-T_2+ Borax@10 kg ha^{-1}
T_5-T_2 + Sodium molydbate @ 1.0g kg^{-1} seeds
T_7-T_2+ $FeSO_4$+$ZnSO_4$ + Borax (@10 kg ha^{-1} each)
T_8- T_2+$FeSO_4$+$ZnSO_4$+Borax (@10 kg ha^{-1} each) + Sodium molybdate @ 1.0 g kg^{-1} seeds
T_9-$FeSO_4$+$ZnSO_4$+Borax (@10 kg ha^{-1} each) + Sodium molybdate@ 1.0g kg^{-1} seeds

Fig. 3. Influence of different micronutrients and bio fertilizers on micro nutrient uptake by chickpea at harvest

Zn, N and P irrespective of Rhizobium increased significantly with the addition of micronutrients individually or in combination over the control in chickpea. Jobner and Rathod *et al.* (2020) revealed that higher zinc, boron, copper, Manganese and Iron in seed and haulm recorded with POP + foliar spray of Zn as $ZnSO_4$ @ 0.5 % + B as Solubor @ 0.2 % and the lowest was found in control with chickpea.

Available nutrient status of soil at harvest

The treatment which received RDF + *Rhizobium* + PSB+ $FeSO_4$@ 10 kg ha^{-1} +$ZnSO_4$@ 10 kg ha^{-1} +Borax @ 10 kg ha^{-1} + Sodium molybdate @ 1.0 g kg^{-1} seeds (T_8) recorded significantly higher available nitrogen, phosphorus and sulphur of soil (233.13, 20.0 and 21.92 kg ha^{-1}, respectively)and was superior over all the treatments except treatment receiving RDF + *Rhizobium* + PSB + $FeSO_4$@ 10 kg ha^{-1} +$ZnSO_4$@ 10 kg ha^{-1} + Borax @ 10 kg ha^{-1} (T_7). The lower available nitrogen, phosphorus and sulphur of soil (210.55, 15.8 and 15.48kg ha^{-1}, respectively) were recorded in RDF alone (T_1).

The treatment which received RDF + *Rhizobium* + PSB + $FeSO_4$ @ 10 kg ha^{-1} + $ZnSO_4$@ 10 kg ha^{-1} +Borax @ 10 kg ha^{-1} + Sodium molybdate @ 1.0 g kg^{-1} seeds (T_8) resulted in numerically higher soil available potassium (397.0kgha^{-1}). Followed by RDF + *Rhizobium* + PSB+ $FeSO_4$ @ 10 kg ha^{-1} +$ZnSO_4$@ 10 kg ha^{-1} +Borax @ 10 kg ha^{-1}(T_7). The lower potassium of soil (348.0 kg ha^{-1}) was recorded in the treatment which received RDF alone (T_1) and data are presented in Table 2.

The RDF + *Rhizobium* + PSB+ $FeSO_4$ @ 10 kg ha^{-1} +$ZnSO_4$@ 10 kg ha^{-1} +Borax @ 10 kg ha^{-1} + Sodium molybdate @ 1.0 g kg^{-1} seeds (T_8) resulted in significantly higher DTPA extractable Fe (3.21) and Zn (0.51 mg kg^{-1}) in soil and was superior over all the treatments except treatment receiving RDF + *Rhizobium* + PSB + $FeSO_4$@ 10 kg ha^{-1} +$ZnSO_4$@ 10 kg ha^{-1} +Borax @ 10 kg ha^{-1} (T_7). The lower DTPA extractable Fe and Zn of soil (2.06 and 0.30 mg kg^{-1},respectively) was recorded in the treatment RDF alone (T_1) and data are presented in Table 2. This may be due to the application of higher doses of chelated iron and zinc to the soils deficient in iron and zinc (Kuldeep 2016) The results obtained were in accordance with the findings of Tagore *et al*. (2013) reported in chickpea.

Conclusion

The study revealed that application of RDF(10:25:00: N: P_2O_5:K_2O kg ha^{-1}) + *Rhizobium* + PSB (@ 1250 g ha^{-1}) + $FeSO_4$ @ 10 kg ha^{-1} +$ZnSO_4$@ 10 kg ha^{-1} +Borax @ 10 kg ha^{-1} + Sodium Molybdate @ 1.0 g kg^{-1} seed, recorded significantly higher growth, yield, quality and nutrient uptake by chickpea crop in vertisols.

References

Anonymous, 2015, Project Coordinators Report (2014-1 5) of AICRP on Chickpea. Kanpur, *PP*.32

Anonymous, 2018, Agricultural statistics at a glance, 2018, Government of India, Ministry of Agriculture and Farmers Welfare, Department of Agriculture, Cooperation and Farmers Welfare, Directorate of Economics and Statistics.

Apoorva M R, Rao P C, Padmaja G and Reddy R S, 2018, Activity of Soil Urease, Phosphatase and Dehydrogenase as Influenced by Various Sources of Zinc in Rice (*Oryza sativa* L). *International Journal of Current Microbiology and Applied Sciences*, 7 (1): 2319-7706.

Bera A K, Pramanik K and Panda D, (2013), Response of biofertilizers and homobrassinoloids on growth, relative water content and yield of lentil. *Journal of Crop and Weed*, 9: 84-90.

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

Das S, Pareek N, Raverkar K P, Chandra R and Kaustav A, 2012, Effectiveness of micronutrient application and Rhizobium inoculation on growth and yield of Chickpea. *International Journal of Agriculture, Environment and Biotechnology,* 5(4) :445-452.

Kuldeep, 2016, Effect of iron and zinc nutrition on growth, yield and quality of chickpea. *M. Sc. (Agri.) Thesis, University of Agricultural Sciences,* Junagadh (India).

Kumar S, Kumar V, Kumar T and Basker O P, 2020, Effect of Organic and Inorganic Nutrient Combinations on Yield and Economics of Black Gram (*Vigna mungo* L.). *International Journal of Current Microbiology and Applied Sciences,* 9(8): 3366-3371.

Kumari N, Mondal S, Mahapatra P, Meetei T T and Devi Y B, 2019, Effect of Biofertilizer and Micronutrients on yield of chickpea. *International Journal of Current Microbiology and Applied Sciences*, 8(1): 2389- 2397.

Movalia J, Donga S and Parmar K B, 2020, Effect of boron and molybdenum on summer green gram (*Vigna radiata* L.) (GM-4) under medium black calcareous soils. Proceedings of the National Conference on Innovations in Biological Sciences (NCIBS).

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.

Rathod S, Channakeshava S, Basavaraja B and Shashidhara K S, 2020, Effect of soil and foliar application of zinc and Boron on growth, yield and micro nutrient uptake of Chickpea. *Journal of Pharmacognosy and Phytochemistry*, 9(4): 3356-3360.

Sparks, 1996, Methods of Soil Analysis Part - 3: Chemical Methods. *Soil Science Society of America,* Pp: 78-98.

Tagore G S, Namdeo S L, Sharma S K and Kumar N, 2013, Effect of rhizobium and phosphate solubilizing bacterial inoculants on symbiotic traits, nodule leghemoglobin, and yield of chickpea. *International Journal of Agron*omy, 8, 581-627.

Tiwari A K, Prakas V, Ahmad A and Singh R P, 2018, Effect of Biofertilizers and Micronutrients on Nutrient Uptake, Growth, Yield and Yield Attributes of Lentil (*Lens culinaris* L.). *International Journal of Current Microbiology and Applied Sciences*, 7(2): 319-706.

Valenciano J B, Boto J B and Marcelo V, 2010, Response of chickpea (*Cicer arietinum* L.) yield to zinc, boron and molybdenum application under pot conditions. *Spanish Journal of Agricultural Research*, 8(3): 797-807

Venkatashwarlu B, 2008, Role of bio-fertilizers in organic farming: Organic farming in rain fed agriculture: Central institute for dry land agriculture. Hyderabad. 4(8): 85-95.