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Effect of soil and foliar application of zinc and Boron on growth, yield and micro nutrient uptake of Chickpea

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Abstract
A field experiment was conducted during *Rabi* 2017 at KVK K, Hassan to study the effect of soil and foliar application of zinc and boron on growth, yield and micro nutrient uptake of chickpea with twelve treatments and replicated thrice using RCBD. Results revealed that significantly higher plant height (42.46 cm), number of branches (6.19), total biomass (1944 kg ha^{-1}) and seed yield (1262 Kg ha^{-1}) was recorded with POP + foliar application of Zn as $ZnSO_4$ @ 0.5% + B as Solubor @ 0.2% (T_{11}) and on par with POP + soil application of $ZnSO_4$ @ 15 kg ha^{-1} + Solubor @ 5 kg ha^{-1} (T_{12}) and POP (T_2). Higher zinc (15.14 mg/kg &14.07 mg/kg), boron (18.18 mg/kg& 15.39 mg/kg), copper (15.21 mg/kg &11.18 mg/kg), Manganese (42.43 mg/kg &35.58 mg/kg) and Iron (86.81 &70.89 mg/kg) in seed and haulm recorded in T_{11} (POP+ foliar spray of Zn as $ZnSO_4$ @ 0.5% + B as Solubor @ 0.2%) and the lowest was found in control (T_1). Significantly higher uptake of zinc, boron, copper, manganese and iron was recorded in T_{11}treatment and lowest uptake of nutrient recorded in control.

Keywords: Foliar spray, zinc, boron, yield, micronutrient uptake, chickpea

Introduction
The biggest challenge for India is its ever increasing population and to match it with food production. By 2025, India's food grain requirement to feed the estimated population of 1,400 million will be 300 million tonnes (FAO, 2010). In India, the arable land is limited and we have exceeded the carrying capacity of the land. Because of limited land area, there is need to increase the productivity.

Chickpea (*Cicer arietinum* L.) is the most important ancient pulse crop being traditionally grown during rabi in India and cultivated mainly in semi-arid and warm temperate regions of world where the temperature is 20-30^0 C (Reddy, 2009). Chickpea belongs to the Leguminaceae family. It contains 22.25 per cent protein which is almost three times more than that of cereals. Chickpea is the highest protein yielding grain legume. The crop has the capacity to fix 140 kg N ha^{-1} in a growing season (Rupela and Saxena, 1987) [6]. 100 g of chickpea seeds provide 360 calories of energy, 5.2 g fat, 2.2 g minerals and 55 g carbohydrates. The malic and oxalic acid present in green leaves are very useful for recovering from intestinal disorder.

Zinc (Zn) is the main micronutrient limiting chickpea productivity, boron (B) may cause yield losses of up to 100% (Ahlawat et al. 2007) [2] and molybdenum (Mo) presents low availability in acidic soils. With the exception of Mo, micronutrient availability is greatest in the very slightly-to-medium acid range. In general, each tonne of chickpea grain removes 38 g of Zn, and it has been estimated that 35 g of B and 1.5 g of Mo are also removed from the soil (Ahlawat et al. 2007) [2].

Zinc deficiency leads to reduction of stem elongation, auxin activities, protein synthesis, flowering and fruit development and also growth period is prolonged resulting in delayed maturity (Tandon, 2009) [10]. boron plays an important role in new cell development in meristemetic tissues, proper pollination and fruit or seed formation and nodule formation in legumes (Verma *et al.*, 2004) [11]. It is also involved in translocation of sugars, synthesis of amino acid, protein, carbohydrate metabolism and movement of N, P, starch and sugar (Marschner, 1986). Although B deficiency limits chickpea productivity less than Zn deficiency (Ahlawat et al. 2007) [2], it has been shown to have a significant limiting effect on chickpea yield in some regions with acid soil conditions (Srivastava et al. 1997) [9]. B application is most important when B concentration in soil is below 0.3 mg kg^{-1} (Ahlawat et al. 2007) [2], and crop response to B application is higher in chickpea than in some cereals.

B deficiency causes flower drop and, consequently, poor poding in chickpeas (Srivastava et al. 1997) [9].

In this context the present investigation has been carriedout to study the Effect of soil and foliar application of zinc and boron on growth, yield and micronutrient uptake by chickpea with following objectives.

1. To study the effect of different levels of application of Zinc and Boron on growth and yield of chickpea.
2. To study the effect different methods and levels of application of zinc and boron on micronutrient uptake by chickpea
3. To study the effect of different levels and methods of zinc and boron on availability of micronutrient in soil.

Material and methods:

A field experiment was conducted during *Rabi* season of 2017 to study the "Effect of different methods of application of zinc and boron on growth, yield and micro nutrient uptake of chickpea (*Cicer arietinum* L.)". Initial soil samples were collected from the field and analyzed for physical and chemical properties. Soil samples were collected using core sampler. Soil samples collected from the experimental sites were dried under shade, mixed thoroughly and gently ground with wooden pestle and mortar without breaking the primary particles and passed through 2 mm sieve. Available Nitrogen was determined by micro Kjeldhal method, Subbaiah and Asija (1956) [7], available phosphorus was determined by Brays–I method, Brays and Kurtz (1945) [3] and potassium was determined using flame photometer as outlined by Piper (1966) [5]. Micro nutrients were analyzed by making suitable dilution of di-acid extract, the samples were fed to the atomic absorption spectrophotometer using appropriate hallow cathode lamp. The 2 mm sieved samples were thoroughly mixed and analyzed for pH, electrical conductivity and available nutrients status (N, P, and K). The soil was sandy loam in texture with neutral in soil reaction (7.4), normal electrical conductivity (0.37 dSm^{-1}), and medium in organic carbon (0.48 per cent) content. The soil was medium in available nitrogen (312.55 Kg ha^{-1}) medium in available P_2O_5 (39.76 Kg ha^{-1}) and medium in available K_2O (176.45 Kg ha^{-1}). DTPA extractable zinc was deficient (0.40 mg kg^{-1}) and hot water soluble boron was also deficient (0.36 mg kg^{-1}).

Seed yield and total biomass of the chickpea crop was recorded at harvest. Grain and straw samples were collected separately from each plot soon after the harvest of the crop. The samples were initially air-dried cut in to pieces and then oven dried at 70^0 C for overnight, later grounded in willey mill to powder and stored. The powdered grain and straw samples drawn at harvest from each treatment in each replication were analysed for various parameters.

Treatment details: The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. RDF: Recommended dose of fertilizer for chickpea (25:50:25 kg ha^{-1} NPK): FYM: Farm Yard Manure @ 7.5 t ha^{-1}, Seed treatment with rhizobium and PSB common for all the treatments, foliar spray of Zinc and Boron was taken at 45 days after sowing and Urea spray @ 2 per cent was common for all the treatments. The experiment comprised of twelve treatments. The treatment details are T_1: Absolute control (foliar water spray), T_2: POP (RDF + FYM + Bio fertilizers), T_3: Farmers practice (2 bags of DAP), T_4: POP+ soil application of $ZnSO_4$ @ 15 kg ha^{-1}, T_5: POP + soil application of Solubor @ 5 kg ha^{-1}, T_6: POP + foliar application of Zn as $ZnSO_4$ @ 0.25%, T_7: POP + foliar application of Zn as $ZnSO_4$ @ 0.5%, T_8: POP+ foliar application of B as Solubor @ 0.1%, T_9: POP + foliar application of B as Solubor @ 0.2%, T_{10}: POP+ foliar application of Zn as $ZnSO_4$ @ 0.25% + B as Solubor @ 0.1%, T_{11}: POP + foliar application of Zn as $ZnSO_4$ @ 0.5% + B as Solubor @ 0.2% and T_{12}: POP+ soil application of $ZnSO_4$ @ 15 kg ha^{-1} + Solubor @ 5 kg ha^{-1}. Source of zinc was zinc sulphate and boron was solubor.

Results and Discussion:

Effect of different levels and methods of application of zinc and boron on growth parameters of chickpea at harvest (Table-1) : At harvest significantly higher plant height (42.46 cm) was recorded in treatment T_{11} ((POP+foliar application of zinc as Zn SO4 @ 0.25%+ B as solubor @0.1%).and it was on par with T_{10}(42.06 cm), T6 (41.16 cm), T7 (41.16 cm) and absolute control (26.99 cm). Significantly higher number of branches (6.19) was recorded in treatment T_{11}(POP+foliar application of zinc as Zn SO4 @ 0.25%+ B as solubor @0.1%) and was on par with T_{10} (5.92), T9 (4.66), T6 (4.95) and T7(5.35).

Total biomass: The total biomass of chickpea differed significantly due to soil and foliar application of zinc and boron. Significantly higher total biomass production recorded in T11 (POP+foliar application of zinc as Zn SO4 @ 0.25%+ B as solubor @0.1%) 1944 kg/ha followed by treatmentT_{10} (1910 kg/ha) and T7 (1864 kg/ha).Significantly lower biomass (1115 kg/ha) was recorded in T1(control).

Number of nodules per plant differed significantly due to soil and foliar application of zinc and boron to chickpea(Table 2). Significantly higher number of nodules (30.22) recorded in treatment T11(POP+foliar application of zinc as Zn SO4 @ 0.25%+ B as solubor @0.1%) and was on par with T10 (29.58) and T7 (28.64). Lowest number of nodules per plant recorded in control (12.17).

Increase in growth parameters like plant height, number of branches, number of nodules per plant and total biomass was attributed to soil and foliar application of zinc and boron which favoured synthesis of tryptophan and auxin growth harmones which in turn increased growth parameters of chickpea. Similar results were also recorded by Singh *et al.*, (1998).

Yield and yield parameters of chickpea (Table 2): Yield parameters like number of pods per plant and 100 seed weight differed significantly due to application of soil and foliar application of zinc and boron. Significantly higher number of pods per plant were recorded (33.21) in treatment T11(POP+ foliar application of zinc as Zn SO4 @ 0.25%+ B as solubor @0.1%). It was on par with T7 (31.24) and T10 (31.69). The lowest number of pods per plant was recorded (20.18) in Control.

Micronutrient content in grain and straw of Chickpea (Table 3): Boron content in seed and straw of chickpea at harvest influenced by application of zinc and boron. Significantly higher boron content in seed (18.18 mg/kg) and haulm (15.39 mg/kg) recorded at harvest by application of (POP + foliar application of zinc as Zn SO4 @ 0.25%+ B as solubor @0.1%) and it was on par with application of (T10) POP + foliar application of ZnSO4 @ 0.25% +B as solubor@0.1 (17.26 mg/kg and 14.55 mg/kg in grain and haulm respectively). The lowest boron content of 12.66 mg/kg and 10.15 mg/kg was recorded in seed and haulm respectively.

Significantly higher zinc content in seed (15.14 mg/kg) and haulm (14.07 mg/kg) recorded in T11(POP+foliar application of zinc as Zn SO4 @ 0.25%+ B as solubor @0.1%) and was on par with T10, T7 and T6. However lower zinc content of 12.94 mg/kg in seed and 12.24 mg/kg in haulm was noticed in control (T1). As regard to iron content, highest iron content of 86.81 mg/kg in seed and 70.89 mg/kg in haulm was recorded in T11 (POP + foliar application of zinc as Zn SO4 @ 0.25%+ B as solubor @ 0.1%) and lowest iron content of 83.63 mg/kg and 68.14 mg/kg in seed and haulm was recorded.

The highest Manganese content of 42.43 mg/kg and 35.58 mg /kg in seed and haulm was recorded in T11 (POP+foliar application of zinc as Zn SO4 @ 0.25%+ B as solubor @0.1%) and lowest manganese content of 40.24 mg/kg and 33.48 mg/kg was recorded in seed and haulm respectively in treatment T1 (Control).

The copper content of seed and haulm differed significantly due to application of zinc and boron. Significantly higher copper content of 15.21mg/kg in seed and 11.18 mg/kg in haulm was recorded in treatment T11 (POP+ foliar application of zinc as Zn SO4 @ 0.25%+ B as solubor @0.1%).

Higher zinc, boron, manganese iron and copper content in seed and haulm was attributed to soil and foliar application of Zn and boron. Application of zinc and boron increased physiological activity and enzymatic activity of plant which in turn increased growth and development of plant through this uptake of other nutrient also increased for physiological requirement of nutrients for the plant. Similar results were also recorded by Sahrawat *et al* (2008) [8].

Effect of different levels and methods of application of zinc and boron on micronutrient uptake of seed and haulm of chickpea (Table 4).

Zinc and boron uptake (Table 4) by grain and straw of chickpea was significantly higher (287.02 and 334.39g/ha respectively) in T11 treatment (POP+ foliar application of zinc as Zn SO4 @ 0.25%+ B as solubor @0.1%). It was on par with T10 treatment which consist of POP + foliar application of Zn as ZnSO4 @ 0.25%+ B solubor @ 0.1%(274.32 and 310.86 g/ha) respectively. Significantly lower zinc and boron uptake by chickpea (141.83 and 132.37 g/ha) was recorded in T1. Application of zinc sulphate significantly increased zinc uptake in grain and straw when applied alone or with solubor. Similar results were also recorded by Farshid Aref (2011) [4].

Highest uptake of Iron (Table 5) was recorded in Treatment T11 (1579.01g/ha) and lower uptake of iron (878.26g/ha) was recorded in control (T1).

Highest total uptake of Manganese (778.12 g/ha) was recorded (Table 5) in the treatment T11 (POP+foliar application of zinc as Zn SO4 @ 0.25%+ B as solubor @0.1%). Lower manganese uptake of 425.02 g/ha recorded in the treatment T1 (Control).

Highest uptake of Copper (268.20g/ha) was recorded (Table 5) in the treatment T11 (POP+foliar application of zinc as Zn SO4 @ 0.25%+ B as solubor @0.1%). Lower copper uptake of 133.9 g/ha was recorded in treatment T1(Control).

Iron uptake of grain and straw was significantly higher over other treatment attributed to application of zinc sulphate with solubor in all levels increased the Fe uptake by the crop.

100 Seed weight (g): Significantly higher 100 seed weight was recorded in T11 (POP+foliar application of zinc as Zn SO4 @ 0.25%+ B as solubor @0.1%) and was on par with T1, T2, T3,T4 and T5 treatments. However lower seed weight of 22.17 g was recorded in control.

Seed yield (kg/ha): Seed yield varied significantly due to soil and foliar application of zinc and boron to chickpea. Higher seed yield (1262 kg/ha) was recorded with T11 (POP + foliar application of zinc as Zn SO4 @ 0.25%+ B as solubor @0.1%) and was on par with T10 (1216 kg/ha) treatment (POP + foliar application of Zn as ZnSO4 @ 0.5%+ Boron as solubor @ 0.1%) and T7 (1207 kg/ha) treatment (POP+ foliar application of Zn as ZnSO4 @ 0.5%). The lower seed yield of 765 kg/ha was recorded with Control.

The increase in growth, yield and yield parameters of chickpea was attributed due to combined application of soil and foliar application of zinc and boron. Zinc which serves as energy source for synthesis of auxin and stimulates metabolic activities and enzymatic activities in plant. Boron is involved in cell wall development, cell distribution root and shoot elongation of plants and pollen tube germination which might have contributed to better growth. Similar results were also recorded by Ali and Mishra (2001) [1].

Table 1: Effect of soil and foliar application of zinc and boron on growth parameters of chickpea.

Treatments	Plant height (cm)	Number of branches per plant
T1: Absolute control	26.99	3.00
T2: POP(RDF+ FYM+ Biofertilizer)	32.08	3.59
T3: Farmers Practice(2 bags of DAP	27.88	3.32
T4: POP+ Soil application of Zn SO4 @15 kg/ha	38.17	4.07
T5: POP + soil application of Zn as ZnSO4 @ 5 kg/ha	36.48	3.83
T6: POP+ foliar application of Zn as Zn SO4 @0.25%	41.16	4.95
T7: POP + foliar application of Zn as Zn SO4 @ 0.5%	41.56	5.35
T8: POP+ Foliar application of B as Solubor @0.1%	39.77	4.31
T9: POP+ foliar application of B as Solubor @ 0.2%	40.60	4.66
T10: POP + foliar application of Zn as Zn SO4 @0.25% + B as solubor @ 0.1%	42.06	5.92
T11: POP+ foliar application of Zn as Zn SO4 @ 0.5% + B as solubor @0.2%	42.46	6.19
T12: POP + soil application of ZnSO4 @ 15 kg/ha + solubor @ 5kg/ha	37.77	4.50
S Em±	1.41	0.14
CD @ 5%	4.12	0.42

Table 2: Effect of soil and foliar application of zinc and boron on yield parameters of chickpea.

Treatments	No. Pods/plant	100 seed weight (g)	No. Nodules/plant
T1: Absolute control	20.18	22.17	12.17
T2: POP(RDF+ FYM+ Bio fertilizer)	24.41	22.81	18.37
T3: Farmers Practice(2 bags of DAP	21.61	22.40	14.06
T4: POP+ Soil application of Zn SO4 @15 kg/ha	27.34	23.47	19.24
T5: POP + soil application of Zn as ZnSO4 @ 5 kg/ha	25.89	23.16	18.85
T6: POP+ foliar application of Zn as Zn SO4 @0.25%	30.19	24.61	26.04
T7: POP + foliar application of Zn as Zn SO4 @ 0.5%	31.24	24.92	28.64
T8: POP+ Foliar application of B as Solubor @0.1%	28.14	23.89	22.79
T9: POP+ foliar application of B as Solubor @ 0.2%	29.32	24.13	24.10
T10: POP + foliar application of Zn as Zn SO4 @0.25% + B as solubor @ 0.1%	31.69	25.19	29.58
T11: POP+ foliar application of Zn as Zn SO4 @ 0.5% + B as solubor @0.2%	33.21	25.62	30.22
T12: POP + soil application of ZnSO4 @ 15 kg/ha + solubor @ 5kg/ha	28.25	24.70	22.38
SEm±	0.91	0.71	1.42
CD @ 5%	2.67	2.09	4.17

Table 3: Effect of soil and foliar application of zinc and boron on seed and haulm yield of chickpea.

Treatments	Seed yield (kg/ha)	Haulm yield (Kg/ha)
T1: Absolute control	765	1115
T2: POP(RDF+ FYM+ Bio fertilizer)	1064	1587
T3: Farmers Practice(2 bags of DAP	861	1291
T4: POP+ Soil application of Zn SO4 @15 kg/ha	1100	1668
T5: POP + soil application of Zn as ZnSO4 @ 5 kg/ha	1080	1618
T6: POP+ foliar application of Zn as Zn SO4 @0.25%	1172	1798
T7: POP + foliar application of Zn as Zn SO4 @ 0.5%	1207	1864
T8: POP+ Foliar application of B as Solubor @0.1%	1117	1717
T9: POP+ foliar application of B as Solubor @ 0.2%	1150	1754
T10: POP + foliar application of Zn as Zn SO4 @0.25% + B as solubor @ 0.1%	1216	1910
T11: POP+ foliar application of Zn as Zn SO4 @ 0.5% + B as solubor @0.2%	1262	1944
T12: POP + soil application of ZnSO4 @ 15 kg/ha + solubor @ 5kg/ha	1129	1695
SEm±	45	80.08
CD @ 5%	132	234.87

Table 4: Effect of soil and foliar application of zinc and boron on Boron and Zinc uptake by chickpea.

Treatments	Total B uptake (g/ha)	Total Zinc uptake (g/ha)
T1: Absolute control	132.37	141.83
T2: POP(RDF+ FYM+ Bio fertilizer)	199.79	198.53
T3: Farmers Practice(2 bags of DAP	157.60	163.75
T4: POP+ Soil application of Zn SO4 @15 kg/ha	226.59	219.36
T5: POP + soil application of Zn as ZnSO4 @ 5 kg/ha	210.42	210.57
T6: POP+ foliar application of Zn as Zn SO4 @0.25%	269.23	246.14
T7: POP + foliar application of Zn as Zn SO4 @ 0.5%	286.84	259.78
T8: POP+ Foliar application of B as Solubor @0.1%	240.71	228.19
T9: POP+ foliar application of B as Solubor @ 0.2%	257.70	235.01
T10: POP + foliar application of Zn as Zn SO4 @0.25% + B as solubor @ 0.1%	310.86	274.32
T11: POP+ foliar application of Zn as Zn SO4 @ 0.5% + B as solubor @0.2%	334.39	287.02
T12: POP + soil application of ZnSO4 @ 15 kg/ha + solubor @ 5kg/ha	238.63	225.65
SEm±	17.38	11.65
CD @ 5%	50.99	34.18

Table 5: Effect of soil and foliar application of zinc and boron on total Iron, Copper and Manganese uptake by chickpea.

Treatments	Total Fe uptake (g/ha)	Total Cu uptake (g/ha)	Total Mn uptake (g/ha)
T1: Absolute control	878.26	133.90	425.02
T2: POP(RDF+ FYM+ Bio fertilizer)	1264.02	195.30	610.51
T3: Farmers Practice(2 bags of DAP	1024.51	156.31	492.80
T4: POP+ Soil application of Zn SO4 @15 kg/ha	1335.83	210.79	647.24
T5: POP + soil application of Zn as ZnSO4 @ 5 kg/ha	1293.86	202.31	625.93
T6: POP+ foliar application of Zn as Zn SO4 @0.25%	1449.26	237.63	709.68
T7: POP + foliar application of Zn as Zn SO4 @ 0.5%	1504.94	250.19	738.04
T8: POP+ Foliar application of B as Solubor @0.1%	1375.43	219.56	668.72
T9: POP+ foliar application of B as Solubor @ 0.2%	1410.52	228.44	687.31
T10: POP + foliar application of Zn as Zn SO4 @0.25% + B as solubor @ 0.1%	1542.45	259.17	758.26
T11: POP+ foliar application of Zn as Zn SO4 @ 0.5% + B as solubor @0.2%	1579.01	268.20	778.12
T12: POP + soil application of ZnSO4 @ 15 kg/ha + solubor @ 5kg/ha	1360.59	216.35	660.47
SEm±	71.85	19.56	46.31
CD @ 5%	210.74	NS	NS

Conclusion: Application of NPK as per the recommended dosage along with Foliar application of zinc and boron @ 0.5 percent and 0.2 percent respectively increased the yield yield parameters by 36 percent and grain yield increased by 18 percent over recommended practice with application of only NPK fertilizers. The uptake of micronutrients (Fe, Mn, Zn and B) followed similar trend due to foliar application of zinc and boron along with NPK application as per the recommended dose.

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