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Effect of Boron and Zinc on Growth and Yield of Cowpea (*Vigna ungiculata* L.) in Gwalior Region of Madhya Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during the rainy (*kharif*) season of 2024 at Crop Research Centre-1 (CRC-1) of ITM University Gwalior, Madhya Pradesh, to evaluate the effect of boron and zinc on Growth and Yield of Cowpea (*Vigna unguiculata* L.) in Gwalior region of Madhya Pradesh. Ten treatments, *viz*., T_1-Control, T_2-5 kg $ZnSO_4$ as Basal application (BA), T_3-5 kg $ZnSO_4$ +0.5% $ZnSO_4$ as Foliar spray (FS) at 25 DAS, T_4-5kg $ZnSO_4$ +0.5% $ZnSO_4$ +0.2% Solubor as (FS) at 45 DAS, T_5-7.5kg $ZnSO_4$ as (BA), T_6-7.5kg $ZnSO_4$ +0.5% $ZnSO_4$ as (FS) at 25 DAS, T_7-7.5kg $ZnSO_4$ +0.5% $ZnSO_4$ +0.2% Solubor as (FS) at 45 DAS, T_8-10 kg $ZnSO_4$ as (BA), T_9-10 kg $ZnSO_4$ +0.5%

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$ZnSO_4$ as (FS) at 25 DAS, T_{10}-10kg $ZnSO_4$ +0.5% $ZnSO_4$ +0.2% Solubor as (FS) at 45 DAS were tested in a randomized block design with 3 replications. The growth, yield attributes and yield of cowpea were significantly influenced by the different treatments. Resulted that growth parameters (*viz.,* plant height (cm), number of branches per plant^{-1}, leaf area index, dry matter accumulation (g m^{-2} area), yield attributes (*viz.,* no. of pods plant^{-1}, pod length, no. of seeds pod^{-1}), yield (*viz.,* seed (1390 kg ha^{-1}), biological (3475 kg ha^{-1}), harvest index (40.0%) increased through the basal application of 10 kg $ZnSO_4$ and foliar application of $ZnSO_4$ @ 0.5% at 25 DAS + Solubor @ 0.2% at 45 DAS (T_{10}) while, the lowest was found in control (T_1).

Keywords: Cowpea; zinc; boron; growth; yield attributes and yield.

1. INTRODUCTION

"Cowpea (*Vigna unguiculata* L.) is a widely grown and utilized as seed, used for pulses, vegetables, and fodder. It is a poor man's meat. It contains high protein" (Ng and Marechal, 1985). "Cowpea is a versatile seed legume commonly grown in dry and semi-arid regions" (Singh et al., 2012). 24.8% protein, 63.6% carbohydrate, 1.9% fat, 6.3% fiber, 7.4 ppm thiamine, 4.2 ppm riboflavin, and 28.1 ppm niacin are all present in ripe cowpea seeds (Ahlawat and Shivkumar 2005). A good crop of cowpea in India yields about 12–15 quintals of seed and 50–60 quintals of stover per hectare. The yield of cowpea in Madhya Pradesh is 5.30–5.87 quintals per hectare.

Zinc is required by several enzyme systems, auxin and protein synthesis, seed development, and maturity rate, all of which are either directly or indirectly involved. Zinc is thought to increase RNA synthesis, which is required for protein creation. Zinc is not transported within the facility. "More than half of the world's population eats micro nutrients in concentrations lower than their daily minimum needs. Zn is also a trace element that is regarded critical since it has antioxidant characteristics and is essential for healthy growth, immune system development, enzyme activation, and neuro behavioral development (Ahmad et al., 2009). A shortage of Zn in the die can lead to major health problems such as stunted development in children, increased sickness susceptibility, poor birth outcomes, and damage to the brain and immune system. Boron is a mineral that plants require for optimum growth. Boron modulates plant hormones and encourages proper growth. Boron enhances flower output and retention, pollen tube elongation and germination, and seed and fruit development" (Ng and Marechal 1985). It is a component of plant cell walls and reproductive structures. It is a mobile nutrient in the soil. It promotes the passage of sugar or energy into plant growth areas, as well as pollination and seed set. Boron is also required for effective nitrogen fixation and nodulation in bean plants.

2. MATERIALS AND METHODS

A field experiment was conducted to assess the responses of cowpea (*Vigna unguiculata* L.) to B and Zn application at the Crop Research Centre (CRC-1) (26°8′51″N latitude and 78°11′18″E longitude) of college, of ITM University, Gwalior, Madhya Pradesh, India during *kharif* season of 2024. The soil of experimental was sandy loamy in texture, alkaline in reaction (pH 7.81) with organic carbon (OC) content 0.34g kg^{-1}, available nitrogen (N) 148.5 kg ha^{-1}, available phosphorus 14 kg P_2O_5 ha^{-1}, available potassium (K) 287 kg K_2O ha^{-1}, available B 1.25 ppm and DTPA-extracted Zn 0.78 ppm. The field experiment was conducted in randomized block design (RBD) with ten treatments *viz*., T_1-Control, T_2-5 kg $ZnSO_4$ as Basal application (BA), T_3-5 kg $ZnSO_4$ +0.5% $ZnSO_4$ as Foliar spray (FS) at 25 DAS, T_4-5kg $ZnSO_4$ +0.5% $ZnSO_4$ +0.2% Solubor as (FS) at 45 DAS, T_5-7.5kg $ZnSO_4$ as (BA), T_6-7.5kg $ZnSO_4$ +0.5% $ZnSO_4$ as (FS) at 25 DAS, T_7-7.5kg $ZnSO_4$ +0.5% $ZnSO_4$ +0.2% Solubor as (FS) at 45 DAS, T_8-10 kg $ZnSO_4$ as (BA), T_9-10 kg $ZnSO_4$ +0.5% $ZnSO_4$ as (FS) at 25 DAS, T_{10}-10kg $ZnSO_4$ +0.5% $ZnSO_4$ +0.2% Solubor as (FS) at 45 DAS and 3 times replicateed. Recommended dose of fertilizer (RDF) was applied @ 20: 50: 20 (N: P_2O_5: K_2O kg ha^{-1}) as fertilizer grade urea, single super phosphate (SSP) and Muriate of potash (MOP), respectively. The cowpea crop variety, "Gomati" was sown on 22nd July 2024 in well prepared flat bed at 30 cm row to row and 10 cm plant to plant spacing. The matured pods of seeds were harvested during 14th October of 2024.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

The data presented in (Table 1) observed that the growth of the plants was affected by the treatments. The highest plant height (77.0) was

Table 1. Effect of zinc and boron nutrition on growth parameters

Treatments	Plant Height (cm)	No. of Branches Plant^{-1}	Leaf area index	Dry matter accumulation (g m^{-2})
T_1	65.5	8.06	3.53	267
T_2	66.6	8.13	3.68	276
T_3	68.2	8.53	3.86	291
T_4	69.0	8.56	3.93	307
T_5	67.5	8.43	3.76	283
T_6	72.0	9.06	4.18	323
T_7	73.5	9.53	4.26	343
T_8	70.1	8.63	4.10	315
T_9	75.1	10.1	4.33	338
T_{10}	77.0	10.7	4.46	345
SEm±	2.18	0.42	0.19	12.1
CD (P=0.05)	6.53	1.26	0.58	36.3

Table 2. Effect of zinc and boron nutrition on yield attributes and yield

Treatments	No. of pods/plant	Pod length (cm)	No. of seeds/pod	seed yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index %
T_1	24.3	21.0	10.9	1042	2862	37.0
T_2	26.8	23.0	11.6	1079	2913	37.0
T_3	27.3	26.4	14.1	1157	3097	37.4
T_4	28.4	27.3	14.5	1178	3144	37.5
T_5	27.0	24.6	13.7	1142	3052	37.4
T_6	29.4	30.2	15.2	1199	3237	37.0
T_7	30.5	32.4	15.7	1250	3312	37.7
T_8	29.3	28.0	15.0	1194	3195	37.4
T_9	31.6	33.0	16.8	1319	3429	38.5
T_{10}	32.3	33.4	17.7	1390	3475	40.0
SEm±	1.48	1.80	1.06	48.0	54.2	1.76
CD (P=0.05)	4.43	5.40	3.17	143	163	NS

observed in the treatment T_{10}-10kg $ZnSO_4$ +0.5% $ZnSO_4$ +0.2% Solubor as (FS) at 45 DAS and found at par with T_9-10 kg $ZnSO_4$ +0.5% $ZnSO_4$ as (FS) at 25 DAS (75.1), T_7-7.5kg $ZnSO_4$ +0.5% $ZnSO_4$ +0.2% Solubor as (FS) at 45 DAS (73.5) and T_6-7.5kg $ZnSO_4$ +0.5% $ZnSO_4$ as (FS) at 25 DAS (72.0). However, the minimum plant height was observed at T_1-Control. "The reported positive effect of application of Zinc on an enhanced height of the plant and branching in pulses mainly attributed to increase of branch development by the auxins, whereas Zn application ultimately expanded the availability of other nutrients and increased the translocation of photo assimilates" which is similar as reported by (Ravichandra et al., 2015; El- Afifi et al., 2016; Upadhyay and Anita Singh, 2016; Debnath et al., 2018 and Hamouda et al., 2018). The application of boron has improved maximum plant height. Boron is important for root and shoot growth, chlorophyll synthesis and nitrogen utilization as well as improved translocation of photosynthesis characters and eventually resulted in increased in plant height.

3.2 Yield Attributes and Yield

According to the yield characteristics data (Table 2) was collected and analyzed at harvest, The mean no.of pods plant^{-1} was influenced significantly due to different treatments. The higher no.of pods plant^{-1} (32.3) was recorded with T_{10}-10kg $ZnSO_4$ +0.5% $ZnSO_4$ +0.2% Solubor as (FS) at 45 DAS and it was found at par (31.6) with T_9-10 kg $ZnSO_4$ +0.5% $ZnSO_4$ as (FS) at 25 DAS, T_7-7.5kg $ZnSO_4$ +0.5% $ZnSO_4$ +0.2% Solubor as (FS) at 45 DAS (30.5), T_6-7.5kg $ZnSO_4$ +0.5% $ZnSO_4$ as (FS) at 25 DAS (29.4), T_8-10 kg $ZnSO_4$ as (BA) (29.3) and T_4-5kg $ZnSO_4$ +0.5% $ZnSO_4$ +0.2% Solubor as (FS) at 45 DAS (28.4). While lowest was found in T_1-Control. The mean pod length was influenced significantly due to different treatments. The higher PL (33.4) was observed in T_{10}-10kg

$ZnSO_4$ +0.5% $ZnSO_4$ +0.2% Solubor as (FS) at 45 DAS and it was found at par (33.0) with T_9-10 kg $ZnSO_4$ +0.5% $ZnSO_4$ as (FS) at 25 DAS, T_7-7.5kg $ZnSO_4$ +0.5% $ZnSO_4$ +0.2% Solubor as (FS) at 45 DAS (32.4), T_6-7.5kg $ZnSO_4$ +0.5% $ZnSO_4$ as (FS) at 25 DAS (30.2) and T_8-10 kg $ZnSO_4$ as (BA) (28.0). While lowest was found in T_1-Control.

The mean no.of seeds pod^{-1} was influenced significantly due to different treatments. The higher no.of seeds pod^{-1} was observed in T_{10}-10kg $ZnSO_4$ +0.5% $ZnSO_4$ +0.2% Solubor as (FS) at 45 DAS (17.7) and it was found at par with T_9-10 kg $ZnSO_4$ +0.5% $ZnSO_4$ as (FS) at 25 DAS (16.8), T_7-7.5kg $ZnSO_4$ +0.5% $ZnSO_4$ +0.2% Solubor as (FS) at 45 DAS (15.7), T_6-7.5kg $ZnSO_4$ +0.5% $ZnSO_4$ as (FS) at 25 DAS (15.2), T_8-10 kg $ZnSO_4$ as (BA) (15.0) and T_4-5kg $ZnSO_4$ +0.5% $ZnSO_4$ +0.2% Solubor as (FS) at 45 DAS (14.5). While lowest was found in T_1-Control. The seed yield influenced significantly due to different treatments. The maximum seed yield (1390 kg ha^{-1}) observed with the application of T_{10}-10kg $ZnSO_4$ +0.5% $ZnSO_4$ +0.2% Solubor as (FS) at 45 DAS which was significantly superior over rest of the treatments. However, it was at par with the treatment of T_9-10 kg $ZnSO_4$ +0.5% $ZnSO_4$ as (FS) at 25 DAS (1319 kg ha^{-1}) and T_7-7.5kg $ZnSO_4$ +0.5% $ZnSO_4$ +0.2% Solubor as (FS) at 45 DAS (1250 kg ha^{-1}). The lower was recorded in T_1-Control. "The probable reason for increasing yield attributes and yield (*viz*.,no.of pods per plant, pod length and no.of seeds pod^{-1}, seed yield, biological yield and harvest index is due to application of 30 kg/ha zinc plays a very important role in the metabolism of the plant process by influencing the activity of growth enzymes as well as it is involved in carbohydrate metabolism, maintenance of the integrity of cellular membranes, protein synthesis, and regulation of auxin synthesis and pollen formation" as described by Khan et al. (2019); Aboyeji et al. (2019); Chakirwa et al. (2020); Hamouda et al (2018); Vinodkumar et al. (2020) and Verma and Joy Dawson (2019)).

The biological yield influenced significantly due to different treatments. The maximum biological yield (3475 kg ha^{-1}) was observed in T_{10}-10kg $ZnSO_4$ +0.5% $ZnSO_4$ +0.2% Solubor as (FS) at 45 DAS which was significantly superior over rest of the treatments. However, it was at par with the treatment of T_9-10 kg $ZnSO_4$ +0.5% $ZnSO_4$ as (FS) at 25 DAS (3429 kg ha^{-1}) and T_7-7.5kg $ZnSO_4$ +0.5% $ZnSO_4$ +0.2% Solubor as (FS) at 45 DAS (3312 kg ha^{-1}). The lower biological yield was recorded in T_1-Control. However, close examination of data indicates that Zn and B gave synergistic effect on the biological yield. The information showed that the various treatments had imperceptible impact on the harvest index. The higher harvest index was recorded with the application of T_{10}-10kg $ZnSO_4$ +0.5% $ZnSO_4$ +0.2% Solubor as (FS) at 45 DAS (40.0 %) which was found at par with T_9-10 kg $ZnSO_4$ +0.5% $ZnSO_4$ as (FS) at 25 DAS (38.5 %). The lower harvest index was recorded in T_1-Control.

4. CONCLUSION

It can be concluded that the basal application of $ZnSO_4$ @ 10 kg/ha with foliar application of $ZnSO_4$ & Solubor @ 0.5% & 0.2% respectively (T_{10}), recorded higher growth parameters and yield of cowpea, which was also found statistically *at par* with treatment T_9.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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