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Effect of Foliar Application of Boron and Soil Application of Zinc Levels on Growth and Yield of Cowpea (*Vigna unguiculata*)

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Abstract
The field experiment was conducted during *kharif*, 2020 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of the experiment plot was sandy loam in texture, nearly neutral in soil reaction with a pH (7.21), low in organic carbon (0.536%), available N (163.42 kg/ha), available P (21.96 kg/ha) and available K (256.48 kg/ha). The treatments consist of soil application of boron (1 kg/ha, 2 kg/ha and 3 kg/ha) and foliar application of zinc (10 kg/ha, 20 kg/ha and 30 kg/ha). The experiment was laid out in randomized block design which consist of 10 treatments and were replicated thrice. The results revealed that maximum plant height was recorded significantly higher *viz*. 84.54 cm, number of branches/plant (4.20), number of root nodules/plant (24.32), maximum dry weight (16.30 g), number of pods/plant (9.07), number of seeds/pod (10.67), 100 seeds weight (130.73 g), seed yield (814.13 kg/ha), stover yield (1257.40 kg/ha) and harvest index (39.47%) were recorded with foliar application of Boron 3 kg/ha (foliar) + Zinc 30 kg/ha (soil application). Whereas, crop growth rate was recorded maximum in Boron 3 kg/ha (foliar) + Zinc 20kg/ha (soil application) and relative growth rate was in (foliar) Boron 3 kg/ha + (soil application) Zinc 10 kg/ha.

Keywords: Boron, cowpea, foliar application, soil application, yield, zinc

Introduction
Cowpea (*Vigna unguiculata* L.) commonly known as "Lobia" is a pulse, fodder and green manure crop. Cowpea is one of the oldest pulse crop in Asian and African tropics. Being rich in protein and containing many other nutrients it is known as vegetable meat. It is poor man's protein source and considered one of the most ancient human food sources and has probably been used as a crop plant since neolithic times. The seeds represent a chief source of proteins and carbohydrates. Cowpea seeds are a nutrition component in the human diet as well as a nutritious livestock feed. The protein in seeds of cowpea is rich in lysine and tryptophan amino acids compared to cereal grains. The mature cowpea seed contains protein (24.8%), carbohydrate (63.6%), fat (1.9%), fiber (6.3%), thiamine (7.4 ppm), riboflavin (4.2 ppm) and niacin (28.1 ppm) (Ahlawat and Shivkumar, 2005) [2].

Application of micronutrient fertilizers through soil application is the most efficient and economical method of getting these nutrients into the crops. The amount of nutrient required is much higher compared to foliar application. In many cases, aerial spray of nutrients is preferred and gives quicker and better results than the soil application. Foliar feeding practice would be more useful in early maturing short duration crops, where the soil applied fertilizer may not become fully available before maturity of crop (Somla Naik *et al*. 2018) [18].

Legume crops required more amount of boron compared to most field crops as boron plays vital role in proper development of reproductive organs. Its deficiency leads to sterility in plants by malformation of reproductive tissues affecting pollen germination, resulting in increased flower drop and reduced fruit set (Subasinghe *et al*. 2003) [19]. Boron is one of the mineral nutrients required for normal plant growth. The most important functions of boron in plants are thought to be its structural role in cell wall development, cell division, seed development and stimulation or inhibition of specific metabolic pathways for sugar transport and hormone development (Ahmed *et al*. 2009) [3]. Boron also plays an important role in production of any crop in terms of yield, quality and control of some diseases. Zinc being essential nutrient plays a significant role in stomata regulation and reducing the tensions of less water by creating ionic balance in plants system and is involved in various physiological processes such as synthesis of protein and carbohydrates.

Similarly, B application improves growth, and enhances stress tolerance in plants and improves grain production. Boron and Zinc are the essential plant micronutrients and their importance for crop productivity is similar to that of major nutrients. Both play an important role in the basic plant functions like photosynthesis, proteins and chlorophyll synthesis.

Materials and Methods

The experiment was conducted during the *kharif* season of 2020 at the Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj (U.P.). The Crop Research Farm is situated at 25.57o N latitude, 87.19o E longitude and at an altitude of 98 m above mean sea level. This area is situated on the right side of the river *Yamuna* and by the opposite side of Prayagraj City. All the facilities required for cultivation of crop were available. The experiment consists of soil application of boron (1 kg/ha, 2 kg/ha and 3 kg/ha) and foliar application of zinc (10 kg/ha, 20 kg/ha and 30 kg/ha). The treatment combinations which are T1: Boron 1 kg/ha + Zinc 10 kg/ha, T2: Boron 1 kg/ha + Zinc 20 kg/ha, T3: Boron 1 kg/ha + Zinc 30 kg/ha, T4: Boron 2 kg/ha + Zinc 10 kg/ha, T5: Boron 2 kg/ha + Zinc 20 kg/ha, T6: Boron 2 kg/ha + Zinc 30 kg/ha, T7: Boron 3 kg/ha + Zinc 10 kg/ha, T8: Boron 3 kg/ha + Zinc 20 kg/ha, T9: Boron 3 kg/ha + Zinc 30 kg/ha, T10: Control (RDF 20:40:20). The soil of the experimental field constituting a part of central gangetic alluvium and is neutral and deep. Pre-sowing soil samples were taken from a depth of 15 cm with the help of an auger which were tried in randomized block design replicated thrice. The composite samples were used for the chemical and mechanical analysis. The soil was sandy loam in texture, low in organic carbon (0.536%) and medium in available nitrogen (163.42 kg/ha), low in phosphorus (21.96 kg/ha) and high in potassium (256.48 kg/ha). The recommended dose of fertilizers (RDF) used in the experiment are 20 kg N, 40 kg P2O5 and 20 kg K2O/ha were supplied in all plots as basal doses. The nutrient sources were Urea, DAP and MOP. Whereas, based on the treatment combinations Zinc (ZnSO4) is supplied to the plots as basal wherever required as soil application and boron is supplied at 35 and 45 DAS as foliar spray. Irrigation was based on the necessity and as per the time of sowing. The growth parameters *viz*. plant height, number of branches/plant, number of nodules/plant, dry weight/plant, crop growth rate and relative growth rate was recorded at harvest. The yield parameters *viz*. number of pods/plant, number of seeds/plant, 100 seeds weight, grain yield, stover yield and harvest index were recorded with standard process of observation. The data was statistically analyzed using analysis of variance (Anova) as applicable to Randomized Block Design (Gomez and Gomez, 1984).

Result and Discussion

Growth Parameters

Data presented in Table 1 indicated that the significantly maximum plant height (84.54 cm), branches/plant (4.20), number of nodules/plant (24.32) was recorded at harvest in those plots which are treated with Boron 3 kg/ha + Zinc 30 kg/ha. Whereas, with Boron 2 kg/ha + Zinc 30 kg/ha in growth parameter plant height (81.91 cm), branches/plant (3.97), number of nodules/plant (23.11) was found statistically at par with Boron 3 kg/ha + Zinc 30 kg/ha. The best obtained results were found with effect of zinc or boron might be attributed to the favourable influence of them on plant metabolism and biological process activity and their stimulating effect on photosynthetic pigments and enzyme activity which in turn encourage vegetative growth. The reported positive effect of application of Zinc on an enhanced height of the plant and branching in pulses mainly attributed to promotion of bud and branch development by the auxins whereas Zn application ultimately increased the availability of other nutrients and accelerated the translocation of photo assimilates. Similar results were 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 [17, 8, 20, 7, 10]. And dry weight was recorded significantly higher with Boron 3 kg/ha + Zinc 30 kg/ha and remaining all other treatments was shown statistically on par to treatments treated with Boron 3 kg/ha + Zinc 30 kg/ha. Dry weight was increased significantly with increasing levels of zinc at 30 kg ZnSO4. There is no any statically difference between the treatments for crop growth rate
and relative growth rate. whereas, highest crop growth rate of (5.70 g/m2/day) was recorded at harvest in those plots which are treated with Boron 3 kg/ha + Zinc 10 kg/ha. The dry matter yield increase in the Zn treatments over the control suggests that Zn was one of the limiting nutrients in the soils. This indicates that, at this level, the soil Zn was further improved with better Zn nutrition leading to high dry matter production which in turn increases CGR. These results are in agreement with the findings of Evangeline Marngar and Joy Dawson, 2017; Monu Kumar *et al.*, 2019; Rajana Praveena *et al*., 2018; Lal Babu Singh *et al.*, 2015 and Barbara M. Humtsoe *et al.*, 2018 [9, 14, 15, 12, 4].

Highest relative growth rate of (0.137 g/g/day) was recorded at harvest in those plots which are treated with Boron 3 kg/ha + Zinc 10 kg/ha. The application of micronutrients on growth of cowpea, in terms of dry matter and crop growth rate can be interpreted in terms of the metabolic function of micronutrients in the plant which ultimately increases the relative growth rate. These results are in agreement with the findings of Ram Pratap, 2006; Moghazy *et al.*, 2014 and Lal Babu Singh *et al.*, 2015 [16, 13, 12].

Table 1: Effect of foliar application of boron and soil application of zinc levels of cowpea at harvest

S. No.	Treatments	Plant height (cm)	Branches/plant	Root nodules/plant	Dry weight (g/plant)	CGR (g/m2/day) (45-60 DAS)	RGR (g/g/day) (45-60 DAS)
T1	Boron 1 kg/ha + Zinc 10 kg/ha	72.91	3.40	13.42	14.07	4.67	0.0103
T2	Boron 1 kg/ha + Zinc 20 kg/ha	76.88	3.60	15.97	14.60	4.52	0.0097
T3	Boron 1 kg/ha + Zinc 30 kg/ha	79.84	3.87	20.97	15.37	5.55	0.0123
T4	Boron 2 kg/ha + Zinc 10 kg/ha	74.95	3.47	15.43	14.35	4.93	0.0113
T5	Boron 2 kg/ha + Zinc 20 kg/ha	77.81	3.67	17.30	15.10	5.56	0.0110
T6	Boron 2 kg/ha + Zinc 30 kg/ha	81.91	3.97	23.11	16.13	5.04	0.0100
T7	Boron 3 kg/ha + Zinc 10 kg/ha	78.98	3.67	19.43	15.13	5.48	0.0137
T8	Boron 3 kg/ha + Zinc 20 kg/ha	81.10	3.87	21.40	15.63	5.70	0.0113
T9	Boron 3 kg/ha + Zinc 30 kg/ha	84.54	4.20	24.32	16.30	4.70	0.0087
T10	Control (RDF 20:40:20)	70.65	3.07	10.88	12.83	4.44	0.0117

	S.Em±	0.91	0.08	1.13	0.65	1.03	0.0023
	CD (P=0.05)	2.70	0.23	3.36	1.94	-	-

Yield and Yield Attributes

Data presented in Table 2, indicated that the maximum number of pods/plant (9.07), number of seed/pod (10.67), 100 seeds weight (130.73 g), higher seed yield (814.13 kg/ha), higher stover yield (1257.40 kg/ha) and maximum harvest index (39.47%) was recorded significantly with Boron 3 kg/ha + Zinc 30 kg/ha. In yield parameters, number of pods/plant (8.80), seeds/pod (10.23), 100 seeds weight (130.47 g), seed yield (810.33 kg/ha), stover yield (1250.60 kg/ha) and harvest index (39.29%) was recorded with Boron 2 kg/ha + Zinc 30 kg/ha which was statistically at par with Boron 3 kg/ha + Zinc 30 kg/ha. The probable reason for increasing yield attributes like number of pods per plant, 1000 seed weight, grain yield, stover 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. It also converts ammonia to nitrate in crops which contribute to yield. The positive effect application of 3 kg/ha boron may be due to key role in plant metabolism and in the synthesis of nucleic acid. Boron is a required for many physiological processes and plant growth, also adequate nutrition is a critical for increase yields and quality of crops. These results are in conformatory with the work of Abid Khan *et al.* (2019) [1]; Christopher Aboyeji *et al.* (2019) [6]; Hamouda *et al.* (2018) [10]; Vinodkumar *et al.* (2020) [21]; Chakirwa *et al. (*2020) [5] and Hemkalyan Verma and Joy Dawson (2019) [11].

Table 2: Effect of foliar application of boron and soil application of zinc levels on yield attributes and yield of cowpea at harvest

S. No.	Treatments	Pods/plant	Seeds/pod	100 seeds weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
T1	Boron 1 kg/ha + Zinc 10 kg/ha	6.60	7.20	123.27	524.53	983.73	34.77
T2	Boron 1 kg/ha + Zinc 20 kg/ha	7.13	7.73	125.07	553.10	1066.60	34.14
T3	Boron 1 kg/ha + Zinc 30 kg/ha	7.87	9.07	128.27	654.60	1127.20	36.73
T4	Boron 2 kg/ha + Zinc 10 kg/ha	6.87	7.47	124.87	534.67	1017.37	34.46
T5	Boron 2 kg/ha + Zinc 20 kg/ha	7.27	7.87	126.77	564.67	1150.77	32.91
T6	Boron 2 kg/ha + Zinc 30 kg/ha	8.80	10.23	130.47	810.33	1250.60	39.29
T7	Boron 3 kg/ha + Zinc 10 kg/ha	7.53	8.60	127.07	582.53	1090.57	34.81
T8	Boron 3 kg/ha + Zinc 20 kg/ha	8.33	9.27	129.07	710.53	1157.93	38.02
T9	Boron 3 kg/ha + Zinc 30 kg/ha	9.07	10.67	130.73	814.13	1257.40	39.47
T10	Control (20:40:20)	6.20	6.93	121.47	482.67	891.03	35.13
	S.Em (±)	0.11	0.19	0.26	1.87	2.63	0.07
	CD (5%)	0.33	0.56	0.76	5.55	7.83	0.22

Conclusion

Study suggested that the maximum plant height (84.54 cm), number of branches/plant (4.20), number of root nodules/plant (24.32), dry weight (16.30 g), number of pods/plant (9.07), number of seeds/pod (10.67), 100 seeds weight (130.73 g), seed yield (814.13 kg/ha), stover yield (1,257.40 kg/ha) and harvest index (39.47%) were recorded significantly higher with foliar application of Boron 3 kg/ha (foliar) + Zinc 30 kg/ha (soil application). Whereas, crop growth rate was recorded maximum in Boron 3 kg/ha (foliar) + Zinc 20kg/ha (soil application) and relative growth rate was in (foliar) Boron 3 kg/ha + (soil application) Zinc 10 kg/ha.

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