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Influence of Zinc and Boron Application on Growth and Yield of French bean (*Phaseolus vulgaris* L.)

Rachamallu Yogitha Reddy [a++*], Biswarup Mehera [b#] and Mallela Nikitha Rani [a†]

[a] *Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Naini, Prayagraj-211007 (U.P.) , India.*
[b] *Naini Agricultural Institute, India.*

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

This study was conducted with the aim of investigating the response of boron and its interaction in maximizing the growth and yield performance of French beans. A field experiment was conducted during *Rabi* 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P), India. To find out the influence of Zinc and Boron on the growth and yield attributes of French bean. The experiment was laid out in Randomized Block Design with ten treatments including control each replicated thrice based on one year of experimentation. The application of Zinc 45 kg/ha^{-1} + Boron 0.5% @ 15 DAS, recorded significantly higher Plant height (44.00 cm), Plant dry weight (29.31 g/plant). Significantly maximum pods/plant (17.40), Seeds/pod (7.00), Seed index (44.04 g), Seed yield (1.37 t/ha), stover yield (3.21 t/ha) were recorded with the treatment of Zinc 45 kg/ha^{-1} + Boron 0.5% @ 15 DAS.

[++] *M.Sc Student;*
[#] *Dean;*
[†] *M.Sc Agronomy;*
**Corresponding author: E-mail: yogitharachamallu@gmail.com;*

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1. INTRODUCTION

"Kidney beans are the young, immature fruits of various types of kidney beans (*Phaseolus vulgaris*), but the immature or young pods of pole beans (*Phaseolus coccineus*), fava beans (Sesquipedal`s), and hyacinth beans (*Lablab purpureus*) are also used. increase. Kidney beans are known by many common names, including broad bean (French: haricot vert), kidney bean (although most modern varieties are "stringless"), broad bean, or simply snaps" [1]. In the Philippines, it is also called 'baguio bean' or 'habithuela' to distinguish it from the 1-meter-long bean [2]. Unlike many other types of beans, green beans are harvested and consumed in pods before the bean seeds within them are fully mature. A similar practice is to harvest and consume immature pea pods, as is done with sugar snap peas and field peas.

"More than 130 varieties (cultivars) of edible legumes are known. In home gardens, there are many varieties of green beans that are grown specifically for green pods, chosen for their juiciness and flavor, and there are many of them. Beans with different pod colors (green, purple, red, striped) are collectively known as snap beans, while green beans are predominantly green. Shapes range from the thin 'fillet' type to the wide 'Romano' type and the more common type in betwee" [3]. The three most common types of kidney beans (*Phaseolus vulgaris*) species are round and flat. Stringless beans or bush beans, lacking the tough fibrous threads running the length of the pod. Runner beans belong to another species, kidney beans. Green beans sometimes have purple pods instead of green pods that turn green when cooked. Green beans with yellow pods are also called wax beans. Wax bean varieties usually have a bushy or dwarf form.

"Zinc is an essential micronutrient required by all living organisms and plays several important roles in life, growth and development. It plays an important role in the normal physiological activities of growth and development" [4,5]. "Zinc is an essential trace metal that has a structural role in protein regulation as an enzymatic cofactor" [6] and is involved in several enzymes involved in numerous processes such as DNA replication, protein synthesis, and lipid metabolism. "It is acts as a cofactor for In addition, zinc plays an important role in many plant metabolic processes, including enzymatic activity, photosynthesis, chlorophyll synthesis, and other biochemical functions" [7]. Zinc is the second most abundant trace element required by all living organisms. It occurs as a divalent cation (Zn2+) and has no redox activity under physiological conditions. This explains the performance of Zn in different physiological roles in different biological activities. Due to the high zinc content, a single application significantly reduced the yield of bean roots. There are several examples showing that the application of zinc fertilizers or zinc-enriched NPK fertilizers to crops not only improves productivity, but also improves plant zinc concentrations in grains. Zinc is involved in the formation of auxin and activation of dehydrogenase enzymes. Stabilization of the ribosomal fraction. Zinc deficiency is now listed as a major risk factor for human health and mortality worldwide.

"Boron (B) is a micronutrient essential for the growth and health of all crops. It is a component of plant cell walls and reproductive structures. It is a mobile nutrient in the soil, meaning it can easily move through the soil. Boron is one of the essential micronutrients required for normal growth of most plants. Boron is required for proper development and differentiation of tissues and also helps reduce infertility and malformations of the reproductive organs" [8]. "Boron aids in normal plant growth, nitrogen uptake from soil, sugar mobilization, cell wall synthesis, root elongation, and nucleic acid synthesis. Boron improves grain and straw yield, nutrient content, nutrient intake and quality in legume crops. Boron deficiency limits the production of legumes" [9]. Given the importance of phosphorus and boron, this study was conducted with the aim of investigating the response of boron and its interaction in maximizing the growth and yield performance of French beans.

2. MATERIALS AND METHODS

The experiment conducted to know the Influence of Zinc and Boron application on the growth and yield of French Bean (*Phaseolus vulgaris* L.) was carried out at the Crop Research Farm of Sam Higginbottom University, Prayagraj, Uttar Pradesh in 2022. The soil was sandy loam in texture, medium in available nitrogen (238.12 kg/ha), low in Phosphorous (38.3 kg/ha^{-1}), and medium in potassium (244.8 kg/ha^{-1}). The experiment was laid out in an RBD consisting of ten treatments including Control with 3 replications, *viz.,* The treatments which are T_1: Zinc 15 kg/ha^{-1} + Boron 0.5% @ 15 DAS, T_2: Zinc 15 kg/ha^{-1} + Boron 0.6% @ 25 DAS, T_3: Zinc 15 kg/ha^{-1} + Boron 0.7% @ 55 DAS, T_4: Zinc 30 kg/ha^{-1} + Boron 0.5% @ 15 DAS, T_5: Zinc 30 kg/ha^{-1} + Boron 0.6% @ 25 DAS, T_6: Zinc 30 kg/ha^{-1} + Boron 0.7% @ 55 DAS, T_7: Zinc 45 kg/ha^{-1} + Boron 0.5% @ 15 DAS, T_8: Zinc 45 kg/ha^{-1} + Boron 0.6% @ 25 DAS, T_9: Zinc 45 kg/ha^{-1} + Boron 0.7% @ 55 DAS, T_{10}: Control are used. The French bean seeds were sown at a spacing of 35 cm x 10 cm with a seed rate of 50 – 75 kg/ha^{-1}, growth-like plant height and dry weight and yield-attributing characteristics, such as the number of seeds per pod, have considerably increased. The yield contributing characters such as the number of pods per plant, number of seeds per pod, seed yield, and stover yield were recorded at the time of harvest and averages were calculated and the data were statistically analyzed using the ANOVA technique in Randomized Block design.

3. RESULTS AND DISCUSSION

3.1 Influence of Zinc and Boron on the Growth of French bean

The perusal of the data of growth attributes recorded at growth stage, is presented in Table 1.

Plant Height: At 80 DAS, there was a significant difference among the treatments. However, the highest plant height (44.00 cm) was recorded with the application of Zinc 45 kg/ha^{-1} + Boron 0.5%@15 DAS, whereas the minimum plant height (36.90 cm) was recorded with the treatment Control 120:60:50 (N:P: K) kg/ha^{-1} and Zinc 30 kg/ha^{-1} + Boron 0.5% @ 15 DAS (33.30 cm), Zinc 15 kg/ha^{-1} + Boron 0.5% @ 15 DAS (32.97 cm) were statistically at par with T7. This might be due to the quick availability of boron to crop during the entire growing season. Boron plays an important role in tissue differentiation and carbohydrate metabolism. It is also a constituent of cell membrane and essential for cell division, and maintenance of conducting tissue with regulatory effect on other element. Similar results were shown by Alam et al*.* [10].

Plant Dry Weight: highest dry weight (29.31 g) was recorded with the application of Zinc 45 kg/ha^{-1} + Boron 0.6% @ 15 DAS, whereas the minimum plant dry weight (24.65 g) was recorded with the treatment Control 120:60:50 (N:P: K) kg/ha^{-1} and Zinc 30kg/ha^{-1} + Boron 0.5% @ 15 DAS (29.05 g) was statistically at par with T7. This might be due to the quick availability of boron to crop during the entire growing season. “Boron plays an important role in tissue differentiation and carbohydrate metabolism. It is also a constituent of the cell membrane and essential for cell division, and maintenance of conducting tissue with a regulatory effect on another element” [11].

3.2 Influence of Zinc and Boron on Yield Attributes of French bean

Number of Pods/Plants: The perusal of the data of the number of Pods/plants recorded at harvest, is presented in Table 2. The data reveals that there was a significant effect among different treatments on the Number of Pods/plants.

The maximum number of Pods/plant (17.40) was recorded with the treatment of the application of Zinc 45 kg/ha^{-1} + Boron 0.5% @ 15 DAS over all the treatments, and the minimum was recorded in Control 120:60:50 (N:P: K) kg/ha^{-1} (10.00). However, the treatments Zinc 30 kg/ha^{-1} + Boron 0.5% @ 15 DAS (17.07), and Zinc 15 kg/ha^{-1} + Boron 0.5% @15 DAS (16.80) which was found to be statistically at par with T7. This might be due to “the role of zinc in the production of biomass and that iron is necessary for chlorophyll synthesis and has many essential roles in plant growth and development” [12].

The number of Seeds/Pod: Significantly Maximum Number of seeds/pods (7.00) was recorded with the treatment of the application of Zinc 45 kg/ha^{-1} + Boron 0.5% @ 15 DAS over all the treatments, and the minimum was recorded in Control 120:60:50 (N:P: K) kg/ha^{-1} (4.07). However, the treatments Zinc 30 kg/ha^{-1} + Boron 0.5% @ 15 DAS (6.00), and Zinc 15 kg/ha^{-1} + Boron 0.5% @ 15 DAS (6.40) which was found to be statistically at par with T7. “The improvement might be due to an increase in the germination percentage of seed inside the pod and may be due to boron making stigma receptive and sticky and making pollen grain fertile and enhancing the pollination. Thus, increased fruit setting reduces the sterility of the flowers and the number of grains per pod increases” [13].

Table 1. Influence of zinc and boron on growth parameters of French bean

Treatments	Plant height (cm)	Plant Dry Weight (g/plant)
Zinc 15 kg/ha + Boron 0.5% at 15 DAS	42.37	27.89
Zinc 15 kg/ha + Boron 0.6% at 25 DAS	38.40	27.19
Zinc 15 kg/ha + Boron 0.7% at 55 DAS	37.40	26.89
Zinc 30 kg/ha + Boron 0.5% at 15 DAS	43.40	29.05
Zinc 30 kg/ha + Boron 0.6% at 25 DAS	38.40	27.52
Zinc 30 kg/ha + Boron 0.7% at 55 DAS	37.45	27.01
Zinc 45 kg/ha + Boron 0.5% at 15 DAS	44.00	29.31
Zinc 45 kg/ha + Boron 0.6% at 25 DAS	40.80	27.80
Zinc 45 kg/ha + Boron 0.7% at 55 DAS	38.03	27.10
Control (RDF) 120:60:50 Kg NPK/ha	36.90	24.65
Sem (±)	0.41	0.23
CD (p=0.05)	1.24	0.69

Table 2. Influence of zinc and boron on yield parameters of French bean

Treatments	Pods/plant (No)	Seeds/pod (No)	Seed index (g)	Seed yield (t/ha)	Stover yield (t/ha)
Zinc 15 kg/ha + Boron 0.5% at 15 DAS	16.80	6.40	42.56	1.32	3.19
Zinc 15 kg/ha + Boron 0.6% at 25 DAS	12.00	5.07	38.97	1.29	3.16
Zinc 15 kg/ha + Boron 0.7% at 55 DAS	11.00	3.93	35.78	1.26	3.05
Zinc 30 kg/ha + Boron 0.5% at15 DAS	17.07	6.60	43.85	1.33	3.20
Zinc 30 kg/ha + Boron 0.6% at 25 DAS	14.00	4.93	40.78	1.31	3.17
Zinc 30 kg/ha + Boron 0.7% at 55 DAS	10.00	3.93	36.99	1.27	3.08
Zinc 45 kg/ha + Boron 0.5% at 15 DAS	17.40	7.00	44.04	1.37	3.21
Zinc 45 kg/ha + Boron 0.6% at 25 DAS	16.00	6.00	41.18	1.31	3.18
Zinc 45 kg/ha + Boron 0.7% at 55 DAS	11.00	3.93	38.25	1.28	3.09
Control (RDF) 120:60:50 Kg NPK/ha	10.00	4.07	33.90	1.22	2.95
Sem (±)	0.50	0.13	0.68	0.01	0.03
CD (p=0.05)	1.49	0.39	2.03	0.03	0.02

Seed Index (g): Highest seed index (44.04 g) was recorded with the treatment of the application of Zinc 45 kg/ha^{-1} + Boron 0.5% @ 15 DAS over all the treatments and the minimum was recorded in Control 120:60:50 (N:P: K) kg/ha^{-1} (33.90 g). However, the treatments Zinc 30 kg/ha^{-1} + Boron 0.5% @ 15 DAS (43.85 g), Zinc 15 kg/ha + Boron 0.5% @ 15 DAS (42.56 g) which was found to be statistically at par with T7. This improvement in the test weight of green gram may be due to boron, which affects cell division, carbohydrate metabolism, sugar and starch formation, which increased the size and weight of the grain. Similar results were reported by Padbhushan and Kumar [14].

Seed Yield (t/ha): Significantly Maximum seed yield (1.37 t/ha) was recorded with the treatment of the application of Zinc 45 kg/ha + Boron 0.5%@15 DAS over all the treatments, and the minimum was recorded in Control 120:60:50 (N:P:K) kg/ha (1.22 t/ha). However, the treatments Zinc 30kg/ha + Boron 0.5%@15 DAS (1.34 t/ha), Zinc 15 kg/ha + Boron 0.5%@15 DAS (1.33 t/ha) which was found to be statistically at par with T7. "Yield enhancement meets plant needs through increased assimilation and translocation of photosynthesis from leaves to seeds, increased boron to the process of somatic to reproductive tissue differentiation, meristematic activity and flower development. may be due to the B application associated with The original strain gained weight and produced more flowers and a higher seed yield" [15].

Stover Yield (t/ha): Significantly Maximum stover yield (3.21 t/ha) was recorded with the treatment of the application of Zinc 45 kg/ha^{-1} + Boron 0.5%@15 DAS over all the treatments, and the minimum was recorded in Control 120:60:50 (N:P:K) kg/ha^{-1} (2.95 t/ha). However, the treatments Zinc 30 kg/ha^{-1} + Boron 0.5%@15 DAS (3.20 t/ha^{-1}), Zinc 15 kg/ha^{-1} + Boron 0.5%@15 DAS (3.19 t/ha^{-1}) which was found to be statistically at par with T7.

4. CONCLUSION

It is concluded that the application of Zinc 45kg/ha^{-1} + Boron 0.5% at 15DAS recorded higher seed yield as compared to other treatments and was found suitable for obtaining higher yield in French beans.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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