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Effect of Zinc and Boron on Growth, Yield and Economics of Finger Millet (*Eleusine coracana* L.)

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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

A field experiment was conducted during *Kharif* 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P) to evaluate the effect of zinc and boron on growth, yield and economics of finger millet. The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 8.0), low in organic carbon (0.62 %), available N (225 kg/ha), available P (38.2 kg/ha) and available K (240.7 kg/ha). It was a Randomized block design consisting of three levels of zinc (10, 12 and 14 kg/ha) with combination of boron (0.5, 1 and 2 kg/ha), there were 10 treatments, each being replicated thrice. Data was collected from growth and yield parameters and were subjected to analysis of variance method. Results revealed that significant differences such that higher plant height (64.78 cm), maximum number of tillers/hill (6.79), higher plant dry weight (20.25 g), maximum number of fingers/plant (5.52), higher number of seeds/finger (296.52), higher test weight (3.14 g), higher grain yield (2.56 t/ha), higher straw yield (7.79 t/ha), maximum gross returns (110632.00 INR/ha), maximum net returns (74302.00 INR/ha) and maximum Benefit cost ratio (2.04) were recorded in treatment 9 [Zinc (14 Kg/ha) + Boron (2 Kg/ha)]. Zinc 14 kg/ha and boron 2 kg/ha is recommendation for application in finger millet for maximum yields.

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1. INTRODUCTION

"Finger millet is an important small grain crop grown in India and has the pride of place characterized by highest productivity among millets. Finger millet contains methionine, an essential amino acid lacking in the diets of hundreds of millions of the poor who rely mostly on starchy staples. The finger millet contains a low glycemic index and has no gluten, which makes it suitable for diabetics and people with digestive problems" [1]. "They are also recognized for their health beneficial effects, such as anti-diabetic, anti-tumerogenic, atherosclerogenic effects, antioxidant and antimicrobial properties" [2]. Hence, finger millet considered as 'poor man' and also 'rich man crop'. "Moreover, antioxidant properties, and phytochemicals make it easily and slowly digestible and help to control blood glucose levels in diabetes patients very efficiently" [1].

"Globally finger millet covers 90 lakh hectares with the production of 144 lakh tonnes and productivity of 1706 kg/ha. India ranks first in finger millet production with 18.22 lakh tonnes, followed by Niger 16.58 lakh tonnes, Mali 15.73 lakh tonnes. India is major finger millet cultivated country, cultivated in an area with 11.38 lakh hectare, with the production of 18.22 lakh tonnes and productivity of 1650 kg/ha. Total finger millet cultivated area in Uttar Pradesh was about 1.07 lakh hectares with the production of 1.51 lakh tones and productivity of 1402 kg/ha. Among different states of India, Karnataka ranked first both in area of 7.05 lakh hectares and production of 11.88 lakh tonnes, while Tamilnadu recorded the highest productivity of 2013 kg/ha followed by Karnataka 1380 kg/ha" (GOI, 2021).

"The most striking feature, which made finger millet an important dry land crop, is its resilience and ability to withstand adverse weather conditions when grown in soils having poor water holding capacity. It can be grown both under rain fed and irrigated conditions. It is cultivated generally in rain fed conditions as a mixed crop with sorghum, pearl millet and a variety of oilseeds and pulses. Ragi, being a C4 plant is an important grain crop and has a high production potential reaching up to 40 to 50 quintals/ha under optimum conditions" [1].

"The deficiency of Zn and B are 49% and 33% respectively in Indian soils. Among the seven micronutrient elements essential for plant growth, Zn has assumed extensively important place in Indian agriculture" [3]. "Deficiency of zinc occurs in alkaline soils, particularly in calcareous soils. Among the typical common diseases listed due to Zn deficiency is brown leaf spot. Deficiency symptoms of zinc are stunted growth and younger leaves become chlorotic. Zinc deficiency is now recognized as one of the most widespread mineral deficiencies in global human nutrition. Zinc is a component of various enzyme systems. It also plays a vital role in biosynthesis of indole acetic acid (IAA). It helps in formation of nucleic acids and synthesis of proteins. Dietary daily intake of 15 and 12 mg Zn for men and women is recommended adequate, respectively, Zinc deficiency, therefore, disrupts multiple biological functions. Recent intervention trial showed that Zn supplementation decreases the rate of diarrhea and lower respiratory infections, two major causes of child mortality, It is estimated that >90 % coverage with zinc supplementation program to prevent Zn deficiency would reduce child mortality by 5% globally" [4].

"Boron deficiency is an uncommon disorder affecting plants in deficient soils and is often associated with areas of high rainfall and leached soils. Boron may be present but locked up in soils with a high pH, and the deficiency may be worse in wet seasons. The leaves show zigzag appearance and plant height is reduced. Plants are unable to produce panicles if affected by boron deficiency at the panicle formation stage. Finally the yield will be reduced due to poor grain setting. In India, about 33 per cent of soil samples collected all over the country are found to be deficient in boron" [5]. "Boron plays an important role in the physiological process of plants, such as cell elongation, cell division, germination and growth of pollen grains, sugar translocation and movement of growth regulators within the plant, lignin synthesis, cell maturation, meristematic tissue development and protein synthesis" [6]. The need for B application in finger millet is to increase the growth, development and yield of crop. The application of boron also promotes the absorption of nitrogen from soil. Hence, addition of micronutrients in the fertilization schedule is essential in the current scenario of crop production for obtaining economic returns, maintaining soil fertility and improving crop quality which not only helps in achieving food security but also nutritional security. The aim of the experiment was to evaluate the effect of zinc and boron on growth, yield and economics of finger millet.

2. MATERIALS AND METHODS

A field experiment was conducted during *Kharif* 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P) to evaluate the Effect of zinc and boron on growth, yield and economics of finger millet. The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 8.0), low in organic carbon (0.62 %), available N (225 kg/ha), available P (38.2 kg/ha) and available K (240.7 kg/ha). There were 10 treatments, each being replicated thrice and laid out in Randomized Block Design. The treatment combinations were as follows: Treatment 1 [Zinc (10Kg/ha)+Boron (0.5 Kg/ha)], Treatment 2 [Zinc (12Kg/ha)+Boron (0.5 Kg/ha)], Treatment 3 [Zinc (14Kg/ha)+Boron (0.5 Kg/ha)],Treatment 4 [Zinc (10Kg/ha) +Boron (1Kg/ha)], Treatment 5 [Zinc (12 Kg/ha)+Boron (1Kg/ha)], Treatment 6 [Zinc (14 Kg/ha) +Boron (1Kg/ha)], Treatment 7 [Zinc (10 Kg/ha)+Boron (2Kg/ha)], Treatment 8 [Zinc (12 Kg/ha) +Boron (2Kg/ha)], Treatment 9 [Zinc (14 Kg/ha)+Boron (2Kg/ha)], Treatment 10 [Control (RDF) 60:30:30 NPK Kg/ha]. The Data was collected from growth and yield parameters and were subjected to statistically analysis by analysis of variance (ANOVA) method [7].

3. RESULT AND DISCUSSION

3.1 Growth Parameters of Finger millet

Plant height (cm) and Number of tillers/hill: In Table 1 significant differences were registered in plant height, number of tillers per hill such that and higher plant height (64.78 cm) was recorded in treatment 9 [Zinc (14 Kg/ha) + Boron (2Kg/ha)]. This could be due to application of zinc which induces high photosynthetic activity and chlorophyll synthesis which resulted into better vegetative growth namely plant height. Similar results were reported by Mrudhula et al. (2021). The result is complemented with application of boron forming a synergestic effect with nitrogen uptake which in turn enhances vegetative growth and plant height in wheat. Similar result was reported by Singh et al. (2015).

Maximum number of tillers/hill (7.79) was recorded in treatment 9 [Zinc (14 Kg/ha) + Boron (2Kg/ha)]. This could be due to application of zinc and availability of nitrogen which plays a vital role in cell division, where organic sources might have provide available balanced nutrition to the plants especially micronutrients which positively affect number of tillers. Similar result was reported by Singh et al.[8] in rice. The application of boron played significant impact as improved quantity of interception of photosynthetically live radiation and more photosynthesis via way of means of the crop contributed to the building of the cellulose there by enhancing tillers/ hill. Similar result was reported by Srinu et al.[9] in foxtail millet.

Plant Dry weight (g): The same treatment 9 recorded significant and higher plant dry weight of 20.25 g this could be due to zinc which have an impact on the synthesis of various enzymes like carbonic anhydrase, glutamic acid dehydrogenase, some peptidases, auxin synthesis, nitrogen metabolism and several oxidation reduction reactions, stability of RNA and starch formation lead to higher dry matter production, ultimately growth and development of plants. Boron may add to the impact due to leaf expansion which increased the photosynthetic efficiency of the plant and this increased photosynthesis ultimately improved the growth rate of whole crop. Similar result on zinc was reported by Kakarla et al. [10] in pearl millet while in boron by Saleem et al. in wheat.

Crop growth rate (g/m^2/day): Results in Table 1 showed significant differences on crop growth rate where 13.3 g/m^2/day was recorded in treatment 3 [Zinc (14Kg/ha) + Boron (0.5 Kg/ha)]. However, treatment 10 [Control] and 5 [Zinc (12 Kg/ha) + Boron (1Kg/ha)] were statistically at par with the treatment 3. This could be due to solar energy intercepted by plants increases as the leaf area index increases, which could be attributed to improved root development by phosphorus and higher Zn uptake leading to higher photosynthetic efficiency. Similar result was reported by Bhanuprakash et al.[11]in Sorghum and Muhammad et al.[12]in wheat.

Relative growth rate (g/g/day): Highest relative growth rate (0.031 g/g/day) was recorded in treatment 2 [Zinc (12Kg/ha) + Boron (0.5 Kg/ha)], though there was no significant difference among the treatments.

3.2 Yield and Yield Attributes of Finger Millet

Number of fingers/plant and seeds/finger: Results in Table 2 showed significant differences

Table 1. Influence of zinc and boron on growth attributes of finger millet

S.no	Treatments	Plant height (cm)	Number of tillers/plant	Plant Dry Weight (g)	CGR (g/m^2/day) 60-80 DAS	RGR (g/g/day) 60-80 DAS
1	0.5 kg/ha Boron + 10 kg/ha zinc	49.40	5.57	15.46	11.5	0.025
2	0.5 kg/ha Boron + 12 kg/ha zinc	50.25	5.59	16.16	12.2	0.031
3	0.5 kg/ha Boron + 14 kg/ha zinc	52.16	5.90	16.97	13.3	0.030
4	1 kg/ha Boron + 10 kg/ha zinc	53.45	5.69	17.42	12.3	0.027
5	1 kg/ha Boron + 12 kg/ha zinc	54.58	5.99	18.04	12.4	0.028
6	1 kg/ha Boron + 14 kg/ha zinc	57.16	6.11	18.47	11.8	0.024
7	2 kg/ha Boron + 10 kg/ha zinc	59.32	6.36	18.97	10.4	0.027
8	2 kg/ha Boron + 12 kg/ha zinc	61.40	6.31	19.65	11.8	0.022
9	2 kg/ha Boron + 14 kg/ha zinc	64.78	6.79	20.25	11.3	0.022
10	Control	52.14	5.54	17.60	12.8	0.024
	F-Test	S	S	S	S	NS
	SEm(±)	0.74	0.24	0.38	0.42	0.003
	CD (p=0.05)	2.21	0.71	1.12	1.24	--

Table 2. Influence of zinc and boron on yield attributes of finger millet

S.no	Treatments	Number of seeds/finger	Number of fingers/plant	Test Weight (g)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest Index (%)
1	0.5 kg/ha Boron + 10 kg/ha zinc	259.67	4.43	2.41	1.70	5.70	31.15
2	0.5 kg/ha Boron + 12 kg/ha zinc	265.65	4.97	2.33	1.85	5.69	31.76
3	0.5 kg/ha Boron + 14 kg/ha zinc	271.29	5.00	2.54	2.07	6.03	31.32
4	1 kg/ha Boron + 10 kg/ha zinc	263.32	5.18	2.56	2.19	6.53	30.46
5	1 kg/ha Boron + 12 kg/ha zinc	276.11	5.22	2.51	2.27	6.79	30.18
6	1 kg/ha Boron + 14 kg/ha zinc	283.51	5.26	2.60	2.36	6.88	30.53
7	2 kg/ha Boron + 10 kg/ha zinc	273.11	5.28	2.80	2.49	7.16	30.41
8	2 kg/ha Boron + 12 kg/ha zinc	289.32	5.49	3.04	2.72	7.35	30.40
9	2 kg/ha Boron + 14 kg/ha zinc	296.52	5.52	3.14	2.90	7.79	30.00
10	Control	262.23	4.95	2.15	1.96	5.93	28.58
	F-Test	S	S	NS	S	S	NS
	SEm(±)	3.28	0.25	0.16	0.19	0.16	0.91
	CD (p=0.05)	9.74	0.75	--	0.56	0.48	--

Table 3. Effect of zinc and boron application on economics of finger millet

S.no	Treatments	Cost of cultivation (INR/ha)	Gross returns (INR/ha)	Net returns (INR/ha)	B:C ratio
1	0.5 kg/ha Boron + 10 kg/ha zinc	34330.00	65760.00	31430.00	0.91
2	0.5 kg/ha Boron + 12 kg/ha zinc	34730.00	71152.00	36422.00	1.04
3	0.5 kg/ha Boron + 14 kg/ha zinc	35130.00	79344.00	44214.00	1.25
4	1 kg/ha Boron + 10 kg/ha zinc	34730.00	80104.00	45374.00	1.30
5	1 kg/ha Boron + 12 kg/ha zinc	35130.00	83912.00	48782.00	1.38
6	1 kg/ha Boron + 14 kg/ha zinc	35530.00	89744.00	54214.00	1.52
7	2 kg/ha Boron + 10 kg/ha zinc	35530.00	95368.00	59838.00	1.68
8	2 kg/ha Boron + 12 kg/ha zinc	35930.00	103800.00	67870.00	1.88
9	2 kg/ha Boron + 14 kg/ha zinc	36330.00	110632.00	74302.00	2.04
10	Control	31930.00	64864.00	32934.00	1.03

in number of fingers per plant such that maximum number of fingers (5.25) was recorded in Treatment 9 including treatments 8 [Zinc (12 Kg/ha) + Boron (2Kg/ha)] and 7 [Zinc (10 Kg/ha)+ Boron (2Kg/ha). This is attributed to adequate supply of zinc which increased the availability and uptake of other essential nutrients. Similar results were reported by Khan et al.[13]in rice. Boron promotes plant physiological functions especially during plant reproductive hence improved plant growth parameters. Similar result was reported by Saleem et al. [12] in rice. High number of seeds/finger (296.52) was recorded in Treatment 9 and 8 [Zinc (12 Kg/ha) + Boron (2Kg/ha). This is attributed to zinc which acts as an activator of enzymes in plants and is directly involved in the biosynthesis of auxin and boron known to contribute to grain formation and reduction in sterility. Similar results were reported by Mahmoud et al. [14] in sorghum.

Test weight (g) and seed yield (t/ha): Results in Table 2 showed no significant differences in test weight and seed yield. However highest test weight (3.14 g) was recorded in treatment 9 and significant and higher seed yield (2.90 t/ha) was recorded in the same treatment. Treatments 8 [Zinc (12 Kg/ha) +Boron (2Kg/ha)] and 7 [Zinc (10 Kg/ha)+Boron (2Kg/ha)] were statistically at par with 9. This could be due to catalytic or stimulatory effect on most of the physiological and metabolic process of plants participation of Zn in biosynthesis while boron promoted pollen tube germination. Similar result was reported by Mandal et al.[15] in rice and Shankar et al.[6] in finger millet respectively.

Stover yield (t/ha) and harvest index (%): Significant differences (Table 2) were shown in stover yield with maximum yield (7.79 t/ha) was recorded in Treatments 9 [Zinc (14 Kg/ha)+Boron (2Kg/ha)] and 8 [Zinc (12 Kg/ha) +Boron (2Kg/ha)]. This was due to enhanced translocation of photosynthates from source to sink and induced growth as well as due to optimum doses of borax and gypsum, improved vegetative growth. Similar results were reported by Raja et al. (2020) in Foxtail millet and Govinda et al.[16] in Finger millet respectively. Higher harvest index (31.76 %) was recorded in treatment 2 [Zinc (12Kg/ha)+Boron (0.5 Kg/ha)] despite being non-significant [17,18].

3.3 Economics

The data on cost of cultivation, gross returns, net returns and B:C ratio as influenced by different treatments was presented in Table 3. Maximum cost of cultivation (36330.00 INR/ha), gross returns(110632.00 INR/ha) and net returns(74302.00 INR/ha)were recorded in treatment 9 while minimum cost of cultivation (31930.00 INR/ha), gross returns (64864.00 INR/ha) and net returns (32934.00 INR/ha) in treatment 10 [control]. Maximum benefit cost ratio (2.04) was recorded in treatment 9 [Zinc (14 Kg/ha)+Boron (2Kg/ha)] while minimum benefit cost ratio (0.91) in treatment 1 [Zinc (10Kg/ha)+Boron (0.5 Kg/ha)]. High B:C ratio was recorded with soil application of boron (2 kg/ha), which might be due to higher grain and straw yield besides the lower cost of boron sources, which adds in getting higher benefit cost ratio. Similar findings have also reported by Shankar et al. [6].

4. CONCLUSION AND RECOMMENDATION

Treatment combination of Zinc (14 kg/ha) and Boron (2 kg/ha) out performed the other treatment combinations in most aspects importantly yields and benefit cost ratio. It is therefore recommended for application in finger millet production.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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