Original Research Article

Effect of Zinc and Boron on growth, yield and economics of Finger millet (*Eleusine coracana* L.)

ABSTRACT

A field experiment was conducted during *Kharif* 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P) on the topic "Effect of zinc and boron on growth, yield and economics of finger millet (*Eleusine coracana* L.)", to study treatments consisting of three levels of zinc (10, 12 and 14 kg/ha) with combination of boron (0.5, 1 and 2 kg/ha). 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 results revealed that significant and 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) was recorded in treatment 9 [Zinc (14 Kg/ha) + Boron (2 Kg/ha)].

Keywords: *Zinc, Boron, Growth, Yield, Economics.*

Introduction

Finger millet is an important small millet 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 **(Vijayakumar *et al.,* 2020)**. They are also recognized for their health beneficial effects, such as anti-diabetic, anti-tumerogenic, atherosclerogenic effects, antioxidant and antimicrobial properties **(Mrudula *et al.,* 2021)**. 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.

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.

The deficiency of Zn and B are 49%, 33% respectively in Indian soils. Among the seven micronutrient elements essential for plant growth, Zn has assumed extensively important place in Indian agriculture **(Rathnakar *et al*., 2021).** 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.

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 zig zag appearance and plant height is reduced. Plants 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 **(Shukla and Behera, 2012)**. 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 **(Shankar *et al.*, 2017)**. 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.

MATERIALS AND METHODS

A field experiment was conducted during *Kharif* 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P) on the topic "Effect of zinc and boron on growth,yield and economics of finger millet (*Eleusine coracana* L.)", to study treatments consisting of three levels of zinc (10, 12 and 14 kg/ha)with combination of boron (0.5, 1 and 2 kg/ha). 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 are Treatment 1 [Zinc (10 Kg/ha) + Boron (0.5 Kg/ha)], Treatment 2 [Zinc (12 Kg/ha) + Boron (0.5 Kg/ha)], Treatment 3 [Zinc (14 Kg/ha) + Boron (0.5 Kg/ha)],Treatment 4 [Zinc (10 Kg/ha) + Boron (1 Kg/ha)], Treatment 5 [Zinc (12 Kg/ha) + Boron (1 Kg/ha)], Treatment 6 [Zinc (14 Kg/ha) + Boron (1 Kg/ha)], Treatment 7 [Zinc (10 Kg/ha) + Boron (2

Kg/ha)], Treatment 8 [Zinc (12 Kg/ha) + Boron (2 Kg/ha)], Treatment 9 [Zinc (14 Kg/ha) + Boron (2 Kg/ha)], Treatment 10 [Control (RDF) 60:30:30 NPK Kg/ha]. The Data recorded on different aspects of crop, such as, growth parameters, yield attributes were subjected to statistically analysis by analysis of variance method **(Gomez and Gomez, 1976)**.

RESULT AND DISCUSSION

Growth parameters of Finger millet

Plant height (cm)

Significant and higher plant height (64.78 cm) was recorded in treatment 9 [Zinc (14 Kg/ha) + Boron (2 Kg/ha)]. Significant and higher plant height was with application of zinc might be due to high photosynthetic activity and chlorophyll synthesis which resulted into better vegetative growth namely plant height. Similar results was reported by **Mrudhula *et al.* (2021).** Further, significant higher plant height was with application of boron might be due to boron have 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).**

Number of tillers/hill

significant and maximum number of tillers/hill (7.79) was recorded in treatment 9 [Zinc (14 Kg/ha) + Boron (2 Kg/ha)]. Significant and higher number of tillers/ hill was observed with application of zinc might be due to more 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.* (2021)** in rice. Further, significantly higher number of tillers/ hill was observed with application of boron (2 kg/ha) may be due to improved quantity of interception of photosynthetically live radiation and more photosynthesis via way of means of the crop and builds the cellulose and improved quantity of tillers/ hill. Similar result was reported by **Srinu *et al.* (2022)** in foxtail millet**.**

Plant Dry weight (g)

significant and higher plant dry weight (20.25 g) was recorded in treatment 9 [Zinc (14 Kg/ha) + Boron (2 Kg/ha)]. However, treatment 8 [Zinc (12 Kg/ha) + Boron (2 Kg/ha)] was statistically at par with the treatment 9 [Zinc (14 Kg/ha) + Boron (2 Kg/ha)]. Significant and higher plant dry weight was with application of zinc might be due to 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. Similar result was reported by **kakarla *et al.* (2021)** in pearl millet**.** Further, significantly higher plant dry weight was with application of boron may be 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 was reported by **Saleem *et al.* (2020)** in wheat.

Crop growth rate (g/m^2/day)

significant and higher crop growth rate (13.3 g/m^2/day) was recorded in treatment 3 [Zinc (14 Kg/ha) + Boron (0.5 Kg/ha)]. However, treatment 10 [Control] and treatment 5 [Zinc (12 Kg/ha) + Boron (1 Kg/ha)] were statistically at par with the treatment 3 [Zinc (14 Kg/ha) + Boron (0.5 Kg/ha)]. Significant and higher crop growth rate was observed with application of zinc might 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, which leads to higher photosynthetic efficiency. Similar result was reported by **Bhanuprakash *et al.* (2022)** in Sorghum. Further, significantly higher crop growth rate was observed with application of boron may be due to boron helped the plants to better utilize the available nutrients with increased leaf area, high photosynthesis and dry matter accumulation which enhanced crop growth rate. Similar result was reported by **Muhammad *et al.* (2011)** in wheat.

Relative growth rate (g/g/day)

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

Yield and yield attributes of Finger millet

Number of Seeds/finger:

Significant and higher number of seeds/finger (296.52) was recorded in Treatment 9 [Zinc (14 Kg/ha) + Boron (2 Kg/ha)]. However, treatment 8 [Zinc (12 Kg/ha) + Boron (2 Kg/ha)] was statistically at par with the treatment 9 [Zinc (14 Kg/ha) + Boron (2 Kg/ha)].

Significant and maximum number of seeds/finger was observed with application of zinc might be due to zinc acts as an activator of enzymes in plants and is directly involved in the biosynthesis of auxin, which produces more cells and dry matter that in turn will be stored in seeds as sink. Similar results were reported by **Mahmoud *et al.* (2022)** in sorghum. Further, significantly maximum number of seeds/finger was observed with application of boron may be due to boron foliar spray at booting stage as boron played a key role in grain formation and reduces sterility which may have produced more grains in each finger, hence increases number of seeds/finger. Similar result was reported by **Muhammad *et al.* (2020)** in wheat.

Number of fingers/plant:

Significant and maximum number of fingers/plant (5.25) was recorded in Treatment 9 [Zinc (14 Kg/ha) + Boron (2 Kg/ha)]. However, treatment 8 [Zinc (12 Kg/ha) + Boron (2 Kg/ha)] and treatment 7 [Zinc (10 Kg/ha) + Boron (2 Kg/ha)were statistically at par with treatment 9 [Zinc (14 Kg/ha) + Boron (2 Kg/ha)].

Significant and maximum number of fingers/plant was observed with application of zinc might be due to adequate supply of zinc increased the availability and uptake of other essential nutrients and resulted in the improvement of number of fingers/plant. Similar results was reported by **Khan *et al.* (2007)** in rice. Further, significantly maximum number of fingers/plant was observed with application of boron may be due to role of boron in plant physiological functions especially during plant reproductive phase so its growth parameters such as number of fingers/plant and weight of fingers improved. Similar result was reported by **Saleem *et al.* (2011)** in rice.

Test weight (g):

Highest test weight (3.14 g) was recorded in treatment 9 [Zinc (14 Kg/ha) + Boron (2 Kg/ha)] and there was no significant difference among the treatments.

Seed yield (t/ha):

Significant and higher seed yield (2.90 t/ha) was recorded in Treatment 9 [Zinc (14 Kg/ha) + Boron (2 Kg/ha)]. However, treatment 8 [Zinc (12 Kg/ha) + Boron (2 Kg/ha)] and treatment 7 [Zinc (10 Kg/ha) + Boron (2 Kg/ha)] were statistically at par with treatment 9 [Zinc (14 Kg/ha) + Boron (2 Kg/ha)].

Significant and higher seed yield was observed with application of zinc (14 kg/ha) might be due to catalytic or stimulatory effect on most of the physiological and metabolic process of plants participation of Zn in biosynthesis of indole acetic acid (IAA) and its role in initiation of primordial reproductive parts and partitioning of photosynthates towards them are responsible for increased yield. Similar result was reported by **Mandal *et al.* (2009)** in rice. Further significantly higher seed yield was observed with application of boron (2 kg/ha) may be due to enhanced pollen tube germination, pollination and improvement of seed setting, key role in plant metabolism and root growth through its influence on utilization of nitrogen and synthesis of carbohydrates, proteins besides efficient use of water. Similar result was reported by **Shankar *et al.* (2017)** in finger millet.

4.6.5 Stover yield (t/ha):

Significant and higher stover yield (7.79 t/ha) was recorded in Treatment 9 [Zinc (14 Kg/ha) + Boron (2 Kg/ha)]. However, treatment 8 [Zinc (12 Kg/ha) + Boron (2 Kg/ha)] was statistically at par with the treatment 9 [Zinc (14 Kg/ha) + Boron (2 Kg/ha)].

Significant and higher stover yield was observed with application of zinc might be due to better translocation of photosynthates from source to sink and higher growth attributing characters like higher number of leaves and dry matter production and its accumulation into different parts of plant and yield attributing characters. Similar result was reported by **Raja *et al.* (2020)** in Foxtail millet. Further, significantly higher stover yield was observed with application of boron may be due to optimum doses of borax and gypsum, improved vegetative growth and increased number of tillers and ear heads number which resulted increased in straw yield. Similar result was reported by **Govinda *et al.* (2020)** in Finger millet.

4.6.6 Harvest index (%):

Higher harvest index (31.76 %) was recorded in treatment 2 [Zinc (12 Kg/ha) + Boron (0.5 Kg/ha)] and there was no significant difference among the treatments.

Economics:

The data on cost of cultivation, gross returns, net returns and B:C ratio as influenced bydifferent treatments was presented in Table 3.

Cost of cultivation (INR/ha)

Maximum cost of cultivation (INR 36330.00) was recorded in treatment 9 [Zinc (14 Kg/ha) + Boron (2 Kg/ha)] and Minimum cost of cultivation (INR 31930.00) was recorded in treatment 10 [control] as compared to other treatments.

Gross Returns (INR/ha)

Maximum gross returns (INR 110632.00) was recorded in treatment 9 [Zinc (14 Kg/ha) + Boron (2 Kg/ha)] and minimum gross returns (INR 64864.00) was recorded in treatment 10 [control] as compared to other treatments.

Net Returns (INR/ha)

Maximum net returns (INR 74302.00) was recorded in treatment 9 [Zinc (14 Kg/ha) + Boron (2 Kg/ha)] and minimum net returns (INR 32934.00) was recorded in treatment 10 [control] as compared to other treatments.

Benefit Cost Ratio (B:C)

Maximum benefit cost ratio (2.04) was recorded in treatment 9 [Zinc (14 Kg/ha) + Boron (2 Kg/ha)] and minimum benefit cost ratio (0.91) was recorded in treatment 1 [Zinc (10 Kg/ha) + Boron (0.5 Kg/ha)].

Higher 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.* (2017).**

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

		At 80 DAS				
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 (RDF) 60:30:30 NPK Kg/ha	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 (RDF) 60:30:30 NPK Kg/ha	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

CONCLUSION

It is concluded that in finger millet with treatment combination of Zinc (14 kg/ha) and Boron (2 kg/ha) observed higher yield and benefit cost ratio.

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