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Effect of Zinc Levels and Plant Geometry on Growth and Yield of Kharif 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* season (2021) at Crop Research Farm, Department of Agronomy, SHUATS, Allahabad (U.P.) to assess the response of finger millet on spacing and zinc levels on growth and yield. Soil of experimental plot was sandy loam in texture. Treatments consisted of T_1- Zn @ 2kg/ha + 30 cm x 10 cm, T_2- Zn @ 2kg/ha + 20 cm x 10 cm, T_3- Zn @ 2kg/ha + 40 cm x 10 cm, T_4- Zn @ 4kg/ha + 30 cm x 10 cm, T_5- Zn @ 4kg/ha + 20 cm x 10 cm, T_6- Zn @ 4kg/ha + 40 cm x 10 cm, T_7- Zn @ 6kg/ha + 30 cm x 10 cm, T_8- Zn @ 6kg/ha + 20 cm x 10 cm, T_9- Zn @ 6kg/ha + 40 cm x 10 cm. An experiment was laid out in Randomized Block Design, with 9 treatments replicated thrice. Results revealed that maximum plant height (95.49 cm), numbers of tillers per plant (9.86), plant dry weight (21.98 g/plant), effective tillers per m^2(466.66), test weight (4.5 g) and number of fingers per plant (7.1), grain yield (3.23 t/ha) and straw yield (4.30 t/ha) was significantly influenced with application zinc 6 kg/ha and crop sown at spacing 30x10 cm. It can be concluded that zinc 6 kg/ha + spacing 30x10 cm was found to be more productive.

Keywords: Finger millet; zinc; plant geometry; yield attributes; kharif.

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1. INTRODUCTION

Finger millet (*Eleusine coracana* L.) is a cereal grass grown mostly for its grain. Finger millet is a robust, tufted, tillering annual grass, up to 170 cm high. The inflorescence is a panicle with 4-19 finger like spikes that resembles a first when mature, hence the name of finger millet. The spikes bear up to 70 alternate spikelets, carrying 4 to 7 small seeds. In many African and South Asian countries, finger millet is a staple food. The grain is easily digested, nutrient-dense, and versatile, and it can be cooked like rice, ground into porridge or flour, or used to make cakes. Infants and the elderly should consume sprouted grains. Finger millet is also used to manufacture liquor and beer, which results in by-products that can be fed to livestock. It contains protein (7.3g), fiber (3.6g), minerals (2.7g), iron(3.9mg) and calcium(344mg) (Indian Institute of Millets Research 2021). "Major ragi growing states are Karnataka, Maharashtra, Uttarakhand, Tamil Nādu, Andhra Pradesh, Jharkhand, Odisha, Chhattisgarh and Gujarat. It occupied an area of 1.19 million hectares accounting for a production of 1.98 million tonnes" [1].

"Zinc is a divalent cation exhibiting important role in mankind health and functioning the various physiological and metabolic functions of plant" [2]. **"**Zinc is essential element for crop production and growth development of plant" [3]. "Finger millet requires considerable amount of zinc as well as iron for its growth and grain development. It is found that most of the farmers are not applying micro nutrients for this crop." [4]. "Deficiency of micronutrients leads to reduction in number of effective tillers and improper grain filling. In order to sustain the yield and reduce the dependency on inorganic fertilizer use, conjunctive use of organic manures, bio fertilizers and fertilizers is very much essential" [5].

"Crop geometry is an important factor to achieve higher production by better utilization of moisture and nutrients from the soil (root spread) and above ground (plant canopy) by harvesting maximum possible solar radiation and in turn better photosynthates formation" [6]. In order to achieve the best plant stand in the field and thus a higher yield, the optimal crop geometry must be used. In terms of grain and straw yield, wider spacing outperformed narrow spacing. Furthermore, the appropriate crop geometry can lower seed rates, maintain a healthy stand in the main field, and increase yield. Therefore, it is important to optimize micronutrient management and selection of best spacing for obtaining better yield. Because, of the need to know the proper spacing and micronutrient requirement this study was conducted to evaluate the effect of zinc levels and plant geometry on growth and yield of finger millet.

2. MATERIALS AND METHODS

The experiment was carried out during the *Kharif* season of 2021, at the CRF (Crop Research Farm) SHIATS, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh. The Crop Research Farm is situated at 25.75^0 N latitude, 87.19^0 E longitude and at an altitude of 98m above mean sea level. Prayagraj has a subtropical and semi-arid climatic condition, with both extremes of temperature, *i.e*., winter and summer. The soil of the experiment field contains soil pH of about 6.9, available nitrogen of 278.93 Kg/ha, available phosphorus of 10.8 Kg/ha and available potassium of 206.4 Kg/ha. The experiment was laid out in Randomized Block Design (RBD) with three replications and nine treatments: T_1-Zn@2kg/ha+30 x10cm, T_2-Zn@2kg/ha+20 x10cm, T_3- Zn@2kg/ha+40 x10cm, T_4- Zn@4kg/ha+30 x10cm, T_5-Zn@4kg/ha+20 x10cm, T_6- Zn@4kg/ha+40 x10cm, T_7- Zn@6kg/ha+30 x10cm, T_8-Zn@6kg/ha+20 x10cm, T_9- Zn@6kg/ha+40 x10cm.The recommended RDF(Recommended Dose of Fertilizer) for the crop is 60:30:30 N:P:K Kg/ha. Finger millet GPU- 28 variety was used with a spacing of 30×10 cm with an area of 3 × 3 m for each plot. For line sowing the seed rate used was 8-10 kg/ha. The seeds were sown in rows and the extra plants were thinned out with recommended spacing after 15 DAS. For each plot five plants were selected for collecting of data in 20 days interval up to harvesting. For the purpose of determining the results, one quadrate was harvested from each plot, and the data was statistically analyzed individually using the analysis of variance technique (ANOVA). The least significant difference test was used to assess the differences between treatment means at 5% probability levels.

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

Growth parameters of finger millet were measured in terms of plant height (cm), the number of tillers per plant and plant dry weight(g/plant) at harvesting time. (Table1).

3.1.1 Plant height (cm)

Maximum plant height (95.49 cm) was recorded with application of zinc 6 kg/ha and crop sown at 30 x 10 cm spacing which was significantly superior over all other treatments and statistically at par with treatment of zinc 6 kg/ha + 20 x 10 cm spacing (94.71 cm) and zinc 4 kg/ha + 20 x 10 cm spacing (93.27 cm).

In all the stages of plant growth, plant height was found to be increased with increase in plant density. The spacing of 30 cm a part rows resulted in taller plant height as compared to other rows spacing this may be due to the competition between plants for the light within a dense plant population. Also, high plant density could reduce light intensity within the plant canopy and encourage IAA synthesis and increase stem elongation. Similar findings were reported by [7].

3.1.2 Number of tillers

The highest number of tillers was recorded with the treatment of the application of zinc 6 kg/ha and crop sown at spacing 30 x 10 cm (9.86) which were significantly superior over all other treatments and the treatment with application of zinc 6 kg/ha and crop sown at spacing 20 x 10 cm (9.66), zinc 2 kg/ha and crop sown at spacing 30 x 10 cm (9.22) which were statistically at par with treatment of application of zinc 6 kg/ha and crop sown at spacing 30 x 10 cm. Wider crop geometry had given tillers/plant all the growth stages compared to others.

The two wider spatial arrangements of 30 x 10 cm and 40 x 10 cm appeared to encourage tiller formation. Similar findings were reported by [8].

3.1.3 Dry weight (g/plant)

The highest dry weight was recorded with the treatment of application of zinc 6 kg/ha and crop sown at spacing 30 x 10 cm (21.98) which were significantly superior over all other treatments and treatment with the application of zinc 6 kg/ha and crop sown at spacing 20 x 10 cm (21.64), which were statistically at par with treatment of application of zinc 6 kg/ha spacing 30 x 10 cm.

“Increased plant population due to closer placing and double seedling/hill increased the number of tillers and eventually plant dry matter accumulation. Improvement of leaves might have increased the photosynthetic efficiency of finger millet and have induced to produce plant dry matter production.” This was in accordance with the earlier findings of [9,10].

3.2 Yield Attributes

Yield attributes of finger millet were measured in terms of the number of effective tillers per m^2, number of ear-head per plant and test weight(g) at harvesting time. (Table 2).

3.2.1 EFFECTIVE TILLERS PER m^2

Treatment with application of zinc 6 kg/ha and crop sown at 30 x 10 cm spacing was recorded maximum number of effective tillers per m^2 (466.66) which was significantly superior over all other treatments and treatment with of application of zinc 6 kg/ha and crop sown at 20 x 10 cm spacing (450) which was statistically at par with the treatment with zinc 4 kg/ha and crop sown at 20 x 10 cm spacing.

Table 1. Effect of zinc and plant geometry on growth attributes of kharif Finger millet

Treatment details (Zinc application + spacing)	Plant height (cm)	No. of tillers	Plant dry weight (g/plant)
zinc@2kg/ha+30×10 cm	90.58	9.22	19.70
zinc@2kg/ha+20×10 cm	85.98	8.88	18.98
zinc@2kg/ha+40×10 cm	86.92	8.55	18.27
zinc@4kg/ha+30×10 cm	92.74	8.87	20.53
zinc@4kg/ha+20×10 cm	93.27	9.21	20.76
zinc@4kg/ha+40×10 cm	89.92	8.96	19.35
zinc@6kg/ha+30×10 cm	95.49	9.86	21.98
zinc@6kg/ha+20×10 cm	94.71	9.66	21.64
zinc@6kg/ha+40×10 cm	92.23	8.99	20.31
F- test	S	S	S
SEm (±)	0.89	0.21	0.21
CD (5%)	2.68	0.64	0.65

Wider crop geometry had given a greater number of tillers per plant, but presence of more plants in unit area increased number of tillers per m^2, [11,10].

3.2.2 Number of ear-head per plant

Treatment with application of zinc 6 kg/ha and crop sown at 30 x 10 cm spacing was recorded maximum number of ear-head per plant (7.10) which was significantly superior over all other treatments and treatment with of application of zinc 6 kg/ha and crop sown at 20 x 10 cm spacing (6.70) which was statistically at par with the treatment with zinc 6 kg/ha and crop sown at 30 x 10 cm spacing.

Plant spacing 30 x 10 cm provides a favourable microclimate to crop for effective utilization of available moisture, nutrient and its early adoption leads to better partitioning of photosynthates to reproductive parts thereby recording better growth and yield attributes. Closer row spacing 30 cm produced the highest number of ear head. Similar findings were reported by [11].

3.2.3 Test weight(g)

Treatment with application of zinc 6 kg/ha + 30 x 10 cm was recorded maximum test weight (4.50 g) which was significantly superior over all other treatments.

The increased grain weight may be due to the application of spacing 30 x 10 cm recorded maximum grain weight (4.5 g). Similar findings were found by [12].

Table 2. Effect of zinc and plant geometry on yield attributes of kharif Finger millet

Treatment details (Zinc application + spacing)	Effective tillers per m^2	No of ear-head per plant	Test weight (g)
zinc@2kg/ha+30×10 cm	240	4.5	3.77
zinc@2kg/ha+20×10 cm	350	4.2	3.67
zinc@2kg/ha+40×10 cm	160	3.5	3.57
zinc@4kg/ha+30×10 cm	333.33	5.6	4.03
zinc@4kg/ha+20×10 cm	280	6.2	4.10
zinc@4kg/ha+40×10 cm	220	4.6	3.70
zinc@6kg/ha+30×10 cm	466.66	7.1	4.50
zinc@6kg/ha+20×10 cm	450	6.7	4.13
zinc@6kg/ha+40×10 cm	213.33	4.6	3.97
F- test	S	S	S
SEm (±)	16.28	0.26	0.06
CD (5%)	48.81	0.79	0.19

Table 3. Effect of zinc and plant geometry on yield of kharif Finger millet

Treatment details (Zinc application + spacing)	Grain yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
zinc@2kg/ha+30×10 cm	2.53	3.99	38.82
zinc@2kg/ha+20×10 cm	2.29	3.95	36.72
zinc@2kg/ha+40×10 cm	2.24	3.91	36.48
zinc@4kg/ha+30×10 cm	2.87	4.12	41.06
zinc@4kg/ha+20×10 cm	2.96	4.17	41.55
zinc@4kg/ha+40×10 cm	2.39	3.97	37.23
zinc@6kg/ha+30×10 cm	3.23	4.30	42.72
zinc@6kg/ha+20×10 cm	3.13	4.29	42.58
zinc@6kg/ha+40×10 cm	2.67	4.07	39.58
F- test	S	S	S
SEm (±)	0.04	0.01	0.33
CD (5%)	0.12	0.03	1.00

3.3 Yield

The yield of finger millet was measured in terms of grain yield, stover yield and harvest index.

Treatment with application of zinc 6 kg/ha + 30 x 10 cm was recorded maximum Grain yield (3.23 t/ha) which was significantly superior over all other treatments and the treatment with application of zinc 6 kg/ha + 20 x 10 cm (3.13 t/ha) which was statistically at par with the treatment with zinc 6 kg/ha + 30 x 10 cm. An optimum planting pattern is the prerequisite for proper utilization of growth resources and ultimately to exploit the potential productivity of any crop. The higher grain yield was recorded from the interaction effect of 30 cm spacing (2214.4 kg/ha). Similar findings were reported by [13].

Treatment with the application of zinc 6 kg/ha + 30 x 10 cm was recorded maximum stover yield (4.30 t/ha) which was significantly superior overall treatments and treatments with the application of 6 kg/ha + 20 x 10 cm (4.29) is statistically at par with the treatment of zinc 6 kg/ha + 30 x 10 cm. More plant population owing to closer spacing at 30 x 10 cm might have contributed to maximum plant dry matter production and number of leaves which ultimately enhanced the straw yield. Similar findings have also been reported earlier by [11,10].

Treatment with the application of zinc 6 kg/ha and sown at 30 x 10 cm spacing which was recorded maximum Harvest index (42.72%) which was significantly superior over all other treatments and treatment with the application of zinc 6 kg/ha and sown at 20 x 10 cm spacing (42.58%), which were statistically at par with treatment with zinc 6 kg/ha and sown at 30 x 10 cm spacing. This was mainly due to an increase in grain yield with an optimum straw yield which in turn resulted in a higher harvest index. These results were in conformity with the findings of [14].

4. CONCLUSION

Based on the outcomes of the above investigation, it was concluded that zinc 6 kg/ha and crop sown at spacing 30x10 cm was found more productive in terms of growth, yield attributes and yield.

5. FUTURE SCOPE

As there was less research happened in the field, further research should be done to obtain proper results and help farmers to choose better performing treatment. Since the findings are based on the research done in one season, further trails are needed to confirm the results of this experiment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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