Influence of foliar application of zinc on growth and yield of pearl millet (*Pennisetum glaucum* L.) varieties

- **Abstract:** A field investigation was conducted in *Kharif* (2022), at a Crop Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P). To study the " Influence of foliar application of zinc on growth and yield of pearl millet (*Pennisetum glaucum* L.) varieties." An experiment was laid out in Randomized Block Design with ten treatments each replicated thrice. The treatments consist of three different pearl millet varieties (Kaveri super boss, Nutra pearl, Nandi-75) and foliar application of Zinc on 25 DAS and 25 and 50 DAS respectively. The experimental results revealed that significantly higher values of growth parameters *viz.*, plant height (191.20 cm), dry weight accumulation (58.75 g/plant), CGR (14.07 g/m^2/day) and yield attributes *viz.*, ear head length (19.50 cm), grains/ear head (1203.60), test weight (10.02 g), grain yield (1.37 t/ha), straw yield (1.70 t/ha) were recorded maximum in treatment (Kaveri Super Boss + $ZnSO_4$ 0.5% (at 25 and 50 DAS) $T_{3.}$ These parameters were significantly influenced by increasing the foliar spray of $ZnSO_4$. However, a higher net return ₹ 30456.27 and a benefit-cost ratio of 1.31 was obtained with the application of Kaveri Super Boss + $ZnSO_4$ 0.5% (At 25 and 50 DAS).

- **Keywords:** Pearl millet, $ZnSO_4$, varieties, growth parameters and yield attributes.

1. Introduction

Popular names for pearl millet (*Pennisetum glaucum* (L.) R.Br.) include "bajra," "cattail millet," and "bulrush millet." It belongs to the family Gramineae. Following rice, wheat, and maize, pearl millet is the fourth most significant cereal food crop in India and ranks sixth globally followed by rice, wheat, corn, barley and sorghum. (Anonymous, 2010)[1]. India is the world's largest pearl millet producer, accounting for half of global production. (FAO, 2020)[2]. As a staple grain in West Africa, pearl millet is a significant crop in rain-fed regions of Africa and India. It is the millet crop that is the most grown commercially and plays a significant role in agriculture worldwide. India is the leading Pearl millet supplier, providing 10.1 million tonnes of grain annually in an area and approximately an average productivity of 1069 kg/ha. India comes in third terms of area after rice and wheat and is the world's largest producer of pearl millet, growing on around 8.75 million ha of marginal and sub-marginal lands mainly in the Indian states of Rajasthan, Gujarat, Haryana, Uttar Pradesh, and Maharashtra. Since 2010, Uttar Pradesh has seen productivity levels above 1200 kg/ha at its highest. About 15% of India's total output of pearl millet is produced in Uttar Pradesh. In India, grains are utilized for green fodder in addition to being consumed as human food. When compared to other cereals, pearl millet demonstrates tremendous physiological advantages, including the ability to withstand drought, low soil fertility, high salinity, and high-temperature tolerance. (Singh *et al.*, 2019)[3]. Pearl millet has a method for resisting drought, so it can flourish in places with protracted dry spells. Comparatively, to nutrient use in single or combination, balanced fertilization has demonstrated good impacts on several areas of plant development and biological yield of the crop.

Zinc is essential to the health and function of both humans and plants in their different physiological and metabolic processes. (Alam *et al.*, 2010)[4]. Zinc is essential for many of the enzymatic and physiological processes that occur in plants. For the growth and development of higher plants, zinc is a necessary micronutrient. (Kochian, 1993 and Marschner, 1995)[5][6] and contributes to gene expression, enzyme activation, and membrane integrity. (Kim *et al*., 2002).[7] The soil in India is the least enriched in zinc out of all the micronutrients. Zinc is an important key element for plant growth and agricultural production. (Ali *et al*., 2008)[8]. Saline and alkaline soils with low fertility predominate in the northwest Indian states. Inadequate agronomic practices and a lack of micronutrient availability, particularly zinc (Zn), further decrease the accessibility of these minerals to plants, which harms plant development and output. (Raja *et al*., 2012)[9].

Foliar feeding is a method of feeding plants that involves drenching their leaves in liquid fertilizer. Essential elements can be absorbed by plants through their leaves. Both their stomata and their epidermis are used for absorption. Foliar spray is the term used to describe the process of applying fertilizers to crop leaves as a spray solution. This technique is appropriate for applying modest amounts of fertilizers, particularly micronutrients.

The experiment was conducted with three different hybrid varieties of Pearl millet to standardize the optimum dose of zinc for better yield and quality. keeping these things in view the present investigation was taken up to study the influence of foliar application of Zinc on the growth and yield of Pearl millet (*Pennisetum glaucum* (L.) varieties.

2 Material and methods

The present investigation was done in Prayagraj, India, during the *kharif* season of (2022) at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS). (U.P.) The experimental field is situated on the left side of the Allahabad-Rewa Road, close to the Yamuna River, approximately 9 km from Prayagraj city.

The subtropical region of Uttar Pradesh, where Prayagraj is located, has hot summers and nice winters. With temperatures rarely falling below 3 °C or 4 °C, the region's average temperature varies from 46 °C to 48 °C. The relative humidity ranges from 20% to 94%. The yearly rainfall here is 1013.4 mm on average. The experiment was set up using a randomized block design for each of the 10 treatments, three replications were employed. Tables 1 and 2, respectively, contain information about the various treatment combinations. When applied simultaneously, the treatment is characterized as having a recommended dosage of phosphorus via DAP, nitrogen via urea, and potash via muriate of potash. 5g of $ZnSO_4$ are dissolved in 100ml of water using heptahydrate (21% zinc). T1 Kaveri Super Boss + Control

(No spray), T2 Kaveri Super Boss + $ZnSO_4$ 0.5% (At 25 DAS), T3 Kaveri Super Boss + $ZnSO_4$ 0.5% (At 25 and 50 DAS), T4 Nutra pearl + Control (No spray), T5 Nutra pearl + $ZnSO_4$ 0.5% (At 25 DAS), T6 Nutra pearl + $ZnSO_4$ 0.5% (At 25 and 50 DAS), T7 Nandi-75+ Control (No spray), T8 Nandi-75+ $ZnSO_4$ 0.5% (At 25 DAS), T9 Nandi-75+ $ZnSO_4$ 0.5% (At 25 and 50 DAS), T10 (80:40:40 NPK) Control.

Three different Pearl millet varieties (Kaveri super boss, Nutra pearl, Nandi-75) were sown at 45×15 cm^2 spacing on July 29th 2022. Zinc levels were maintained according to the treatment combinations and all other recommended techniques were implemented in keeping with the crop's requirement. The crop was harvested on October 16, 2022, when it reached physiological maturity. Five randomly chosen consultant plants from each plot of each replication were manually measured for plant height (cm) and dry weight accumulation (g/plant). Also, following harvest, ear heads were separated from plants and dried in the sun for three days. Later, the seeds were threshed, winnowed, and cleaned and the seed production per hectare was computed and given in kg per hectare. The Stover production from each plot was determined and reported in kg/hectare after 10 days of uninterrupted sun drying. Utilizing, the statistics were computed and examined. After the fee value of seed was substituted with stover and the overall value of crop cultivation was safeguarded, the benefit-cost ratio was revised.

Table 1 Treatment Details

Varieties	Kaveri super boss
	Nutra pearl
	Nandi -75
Zinc levels (foliar application)	Zn_1 – Control (No Spray)
	Zn_2 – $ZnSO_4$ (At 25 DAS)
	Zn_3 – $ZnSO_4$ (At 25 and 50 DAS)
	Control

Table 2 Treatment Combinations

Treatment No.	Treatment Combinations
T1	Kaveri Super Boss + Control (No spray)
T2	Kaveri Super Boss + $ZnSO_4$ 0.5% (At 25 DAS)
T3	Kaveri Super Boss + $ZnSO_4$ 0.5% (At 25 and 50 DAS)
T4	Nutra pearl + Control (No spray)
T5	Nutra pearl + $ZnSO_4$ 0.5% (At 25 DAS)
T6	Nutra pearl + $ZnSO_4$ 0.5% (At 25 and 50 DAS)

T7	Nandi 75 + Control (No spray)
T8	Nandi 75 + $ZnSO_4$ 0.5% (At 25 DAS)
T9	Nandi 75 + $ZnSO_4$ 0.5% (At 25 and 50 DAS)
T10	N:P:K (80:40:40) Control

3 Results and Discussions:

3.1 Effect on Growth Attributes

3.1.1 Plant Height

The scrutiny of data extended in [Table 3] unveiled that increasing the foliar spray of $ZnSo_4$ to the leaves of pearl millet (Kaveri super boss) variety substantially improved their growth characteristics compared to the other 2 varieties. Application of Kaveri super boss + $ZnSO_4$ 0.5% (At 25 and 50 DAS) recorded significantly the highest plant height at 30,45,60 DAS and at Harvest measuring 41.00, 98.33, 157.03, and 191.87, respectively. While Nutra pearl + $ZnSO_4$ 0.5% (At 25 and 50 DAS) at 30,45,60 DAS and at Harvest initiated statistically to be statistically at par with the highest T3 in the following [table 3]. A similar outcome was obtained by Khardia *et al.*, 2022[10] on pearl millet crop and found that in later phases of crop development, higher amounts of zinc fertilization noticeably boosted plant height in comparison to lower levels. Asodariya SR *et al*, 2021[11] also revealed that increased zinc levels led to an increase in pearl millet plant height. The superior performance of the Kaveri Super Boss variety and physiological processes led to an increase in plant height due to zinc fertilization.

3.1.2 Dry weight of the plant

Several treatments had a considerable impact on the plant's dry weight with crop maturity. Significantly, the highest amount of plant dry weight accumulated in Kaveri super boss + $ZnSO_4$ 0.5% (At 25 and 50 DAS) T3 at 30, 45, 60 DAS and at Harvest measuring 10.54, 19.32, 44.50, 58.75, respectively. While Nutra pearl + $ZnSO_4$ 0.5% (At 25 and 50 DAS) T6 at 30,45,60 DAS and harvest initiated to be statistically at par with the T3. A similar outcome was obtained from Arshewar *et al*, 2018[12] in which they revealed that with the progression of the crop growth phases, the crop's dry matter accumulation considerably increased over time. Pearl millet's tillering is known to be boosted by zinc nutrition, which may lead to a significant rise in the accumulation of dry matter. Jain *et al.*, (2001)[13] and Jakhar, S. R 2006[14] also revealed a similar result.

3.2 Yield and Yield Attributes

3.2.1 Ear head Length and Grains per Ear head

Zinc concentrations had a substantial impact on yield attributes and yield. Application of Kaveri super boss + $ZnSO_4$ 0.5% (At 25 and 50 DAS) reported significantly highest ear head length measuring 19.50 out of all treatments. While Nutra pearl + $ZnSO_4$ 0.5% (At 25 and 50 DAS) was statistically at par with the highest ear head length T3. Similarly in grains per ear head, Kaveri super boss + $ZnSO_4$ 0.5% (At 25 and 50 DAS) significantly is the highest of all treatments (1203.60) whereas, Nutra pearl + $ZnSO_4$ 0.5% (At 25 and 50 DAS) was statistically at par with the higher treatment 3 in the following [table 4]. S. K. Prasad *et al,* 2014[15] reported that zinc doses had a considerable impact on the yield parameters, such as the number and length of panicles per plant as well as the quantity, number, and weight of grains per panicle.

3.2.2 Tillers per plant and Test weight

An increased number of tillers per plant were established non significantly in Kaveri super boss + $ZnSO_4$ 0.5% (At 25 and 50 DAS) measuring 3.33 respectively, where the least number of tillers per plant was in Nandi-75+ Control (No spray) and N:P: K (80:40:40) Control. Significantly, the highest test weight of 1000 grains was found in Kaveri super boss + $ZnSO_4$ 0.5% (At 25 and 50 DAS) whereas, Nutra pearl + $ZnSO_4$ 0.5% (At 25 and 50 DAS) was statistically equivalent with the treatment 3 in the following [table 4]. R. P. Vaja *et al,* 2020[16] revealed that zinc foliar spraying more frequently led to a considerable rise in the number of total tillers per plant as well as the weight of 1000- grain. Zinc plays a role in the moisture stress and biosynthesis of indole acetic acid (IAA), which is necessary for improved growth characteristics. These findings concur with those published by Shekhawat and Kumavat *et al*, (2017)[17].

3.2.3 Grain and Stover Yield

Seed and stover yields are increased in Kaveri super boss + $ZnSO_4$ 0.5% (At 25 and 50 DAS). Application of Kaveri super boss + $ZnSO_4$ 0.5% (At 25 and 50 DAS) registering significantly higher grain yield (1.37t/ha) and stover yield (1.70t/ha). While Nutra pearl + $ZnSO_4$ 0.5% (At 25 and 50 DAS) was statistically at par with T3 in the following [table 4]. Zinc boosted the translocation of photosynthates toward the reproductive system, which improved the source sink relationship and improved yield attributes. The present findings are in close agreement with Mehta *et al*. (2008) [18], and Singh *et al*. (2017) [19].

Zinc is an essential structural component or regulatory co-factor for a large variety of enzymes in many significant metabolic pathways in plants. Lack of zinc in the plant prevents grain crops' panicles from developing and maturing Alloway, (2004)[20]. Zn plays an essential role in the synthesis of several enzymes, including some peptidases, glutamic acid dehydrogenase, lactic acid dehydrogenases, and carbonic anhydrase. It is also thought to be a precursor for the synthesis of auxin, which is involved in nitrogen metabolism, various oxidation-reduction events, the stability of RNA, and starch formation. Similar to deficiencies in soil and plants, Zn deficiency affects humans quite frequently, especially in poorer nations whose diets are high in foods derived from cereals and low in animal products. Shivam Yadav, (2022)[21] As a result, plants grow and develop more quickly when there is an adequate supply of this substance Dadhich and Gupta, (2003)[22]. Zinc's participation in the biosynthesis of indole acetic acid (IAA) and its part at the beginning of primordia for reproductive parts and the allocation of photosynthates towards them Wear and Hagler *et al.* (1968)[23], may have led to enhanced flowering and fruiting, may also be responsible for the increased yield qualities. This result is conformation with earlier reports by Singaravel *et al* (2001)[24].

4 Conclusion

The findings of the present investigation demonstrated the beneficial impacts of foliar spray, specifically increasing zinc level treatments, on several growth and yield parameters of the pearl millet plant. The foliar application of $ZnSO_4$ at a rate of 0.5% (25 and 50 DAS) combination with the variety Kaveri super boss in (T3) resulted in considerably higher grain and straw production, biometric parameters, and yield attributes of pearl millet useful for eastern Uttar Pradesh condition.

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Table -3 Influence of zinc on growth attributes of pearl millet varieties.

Treatment No	Treatments	Plant height (cm)	Dry weight (g)
1	Kaveri Super Boss + Control (No spray)	183.25	51.90
2	Kaveri Super Boss + ZnSO4 0.5% (At 25 DAS)	185.33	53.54
3	Kaveri Super Boss + ZnSO4 0.5% (At 25 and 50 DAS)	191.87	58.75
4	Nutra pearl + Control (No spray)	180.00	51.77
5	Nutra pearl + ZnSO4 0.5% (At 25 DAS)	185.53	53.44
6	Nutra pearl + ZnSO4 0.5% (At 25 and 50 DAS)	191.00	57.46

7	Nandi-75+ Control (No spray)	178.30	49.03
8	Nandi-75+ ZnSO4 0.5% (At 25 DAS)	183.88	52.56
9	Nandi-75+ ZnSO4 0.5% (At 25 and 50 DAS)	184.63	53.73
10	N:P:K (80:40:40) Control	179.17	50.17
	F test	**S**	**S**
	SEm±	1.88	0.84
	CD (p= 0.05)	5.61	2.51

Where, S – Significant

NS – Non significant

Table- 4 Influence of zinc on yield and yield attributes of pearl millet varieties.

Treatment number	Treatments	Ear head length (cm)	Tillers/plant	Grains/ear head	Test Weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest Index (%)
1.	Kaveri Super Boss + Control (No spray)	17.60	2.03	1133.53	8.90	1.21	1.62	42.75
2.	Kaveri Super Boss + ZnSO4 0.5% (At 25 DAS)	18.32	2.17	1160.00	9.29	1.28	1.65	43.68
3.	Kaveri Super Boss + ZnSO4 0.5% (At 25 and 50 DAS)	19.50	3.33	1203.60	10.02	1.37	1.70	44.62

4.	Nutra pearl + Control (No spray)	17.10	1.67	1122.70	8.88	1.19	1.61	42.50
5.	Nutra pearl + ZnSO4 0.5% (At 25 DAS)	18.40	2.07	1154.20	8.91	1.28	1.64	43.83
6.	Nutra pearl + ZnSO4 0.5% (At 25 and 50 DAS)	19.30	3.00	1197.20	9.39	1.33	1.69	44.03
7.	Nandi-75+ Control (No spray)	16.50	1.00	1122.08	8.43	1.17	1.59	42.39
8.	Nandi-75+ ZnSO4 0.5% (At 25 DAS)	18.00	1.67	1140.32	9.05	1.27	1.66	43.34
9.	Nandi-75+ ZnSO4 0.5% (At 25 and 50 DAS)	18.69	1.33	1168.65	9.12	1.28	1.65	43.68
10.	N:P:K (80:40:40) Control	16.00	1.00	1123.33	8.00	1.15	1.57	42.27
	F test	**S**	**NS**	**S**	**S**	**S**	**S**	**S**
	SEm±	0.26	0.56	17.74	0.24	0.01	0.01	0.22
	CD (p= 0.05)	0.80	-	34.45	0.72	0.05	0.03	0.66

Where, S – Significant

NS – Non significant