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

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Abstract
In Kharif (2022), a field study was carried out at the Crop Research Farm, SHUATS, Prayagraj (U.P). to investigate the "impact of zinc foliar application on pearl millet variety growth and yield." Ten treatments, each of which was replicated three times, were used in the Randomized Block Design experiment. The treatments include foliar zinc spray on 25 DAS and 25 and 50 DAS, respectively, and three distinct pearl millet types (Kaveri super boss, Nutra pearl, and Nandi-75). The results of the experiment showed that the treatment (Kaveri Super Boss + ZnSO4 0.5% (At 25 & 50 DAS) T3) had the highest values of the following growth parameters: plant height (191.20 cm), dry weight accumulation (58.75 g/plant), CGR (10.55 g/m2/day), and yield attributes: 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). Increasing ZnSO4 foliar spray has a substantial impact on these parameters. However, using Kaveri Super Boss + ZnSO4 0.5% (at 25 and 50 DAS) resulted in higher gross returns (53610.00), net return ₹ (29699.78), and benefit cost ratio 1.24.

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

Introduction
Pearl millet (*Pennisetum glaucum* L.), also known as "bajra," "cattail millet," and "bulrush millet." The Gramineae family includes it. Pearl millet ranks sixth globally, behind rice, wheat, corn, barley, and sorghum, and fourth in India in terms of cereal food crops, after maize, rice, and wheat. (Anonymous, 2010) [4]. India produces half of the world's pearl millet, making it the greatest producer in the world. (FAO, 2020) [7]. Pearl millet is an important crop in rain-fed areas of Africa and India and is a staple grain in West Africa. Pearl millet is a C4 plant with a high capacity for dry matter production and photosynthetic efficiency.

India ranks third in terms of land area after rice and wheat, and it is the world's largest producer of pearl millet. Approximately two-thirds of India's millet production is grown on 8.75 million hectares of marginal and sub-marginal lands, primarily in Rajasthan, Gujarat, Haryana, Uttar Pradesh, and Maharashtra. Given that there is little room to expand the net cultivated area (142 million ha), higher productivity per unit area may lead to a general rise in the output of food grains. Pearl millet is a staple crop grown mostly by small and marginal farmers in Asia and Africa. Because pearl millet is resistant to abiotic stress, it may be grown in areas where other cereal crops, such as maize and wheat, would not flourish. (Sammauria *et al.* (2010) [15]. Pearl millet has significant physiological benefits over other grains, such as resistance to drought, low soil fertility, high salinity, and high temperature tolerance. (Singh *et al.* 2019) [18]. Pearl millet may thrive in areas with prolonged dry spells because of a mechanism that makes it resistant to drought. Balanced fertilization has shown positive effects on several aspects of plant growth and crop biological production as compared to single or combination nutrient application.

One of the most significant micronutrients is zinc, which is presently ranked fourth in terms of yield-limiting factors, behind potassium, phosphorus, and nitrogen. Numerous physiological functions in plants, including photosynthesis, the synthesis of proteins and sugars, seed formation and fertility, growth control, and the immune system against disease, depend on it

(Khinchi *et al*., 2017) [9]. Both human and plant health and function depend on zinc for a variety of physiological and metabolic processes. (Alam *et al*., 2010) [1]. Zinc is an essential element for higher plants' growth and development. (Kochian, 1993 and Marschner, 1995) [11, 12] and contributes in gene expression, enzyme activation, and membrane integrity. (Kim *et al*., 2002) [10]. For agricultural output and plant growth, zinc is a crucial component. (Ali *et al*., 2008) [2].

Plants are fed by foliar feeding, which entails soaking their leaves in liquid fertilizer. Plants can absorb essential elements through their leaves. Their epidermis and stomata are both utilized for absorption. The method of administering nutrients to crop leaves as a spray solution is known as foliar spray. Applying small amounts of fertilizers, especially micronutrients, is suitable for this method.

Materials and Methods

The experiment was conducted at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, U.P, during the Kharif season of 2022. To assess the "Influence of foliar application of zinc on growth and yield of Pearl millet varieties" Ten treatment combinations and three replications make up the RBD used to lay out the trial. The treatment is described as having a recommended dosage of nitrogen via urea, potash via MOP, and phosphorus via DAP when administered concurrently. 100 millilitres of water are used to dissolve 5 grams of ZnSO4 in heptahydrate (21% zinc). The specifics of the treatments are T1. Kaveri Super Boss + Control (No spray), T2. Kaveri Super Boss + ZnSO4 0.5% (At 25 DAS), T3. Kaveri Super Boss + ZnSO4 0.5% (At 25 and 50 DAS), T4. Nutra pearl + Control (No spray), T5. Nutra pearl + ZnSO4 0.5% (At 25 DAS), T6. Nutra pearl + ZnSO4 0.5% (At 25 and 50 DAS), T7. Nandi-75+ Control (No spray), T8. Nandi-75+ ZnSO4 0.5% (At 25 DAS), T9. Nandi-75+ ZnSO4 0.5% (At 25 and 50 DAS) and T10. N:P: K (80:40:40) Control. A number of growth variables, such as plant height, plant dry weight, and yield parameters, such as Ear head length (cm), Number of tillers/plants, Number of grains/ear head, test weight, grain yield, stover yield, and harvest index, were recorded.

Results and Discussion

Post-Harvest observations

Ear head length (cm) and Grains/ear head

Among all the treatments, the Kaveri Super Boss + $ZnSO_4$ 0.5% (at 25 and 50 DAS) treatment 3 produced the most notable ear head length (19.50 cm). The 0.5% Nutra pearl + ZnSO4 treatment 6 (at 25 and 50 DAS, or 19.30 cm) was determined to be statistically equivalent to treatment 3.

Likewise, in terms of grain/ear head the treatment 3 with Kaveri Super Boss + ZnSO4 0.5% (at 25 and 50 DAS) had a significantly higher grain/ear head (1203.60) than the other treatments. However, it was discovered that treatment 6 with Nutra pearl + ZnSO4 0.5% (at 25 and 50 DAS) (1197.20) was statistically equivalent to treatment 3.

Zinc dosages significantly affected the yield characteristics, including the quantity, number, and weight of grains per panicle as well as the length and number of panicles per plant. Similar results were previously reported by S.K. Prasad *et al*., (2014) [13].

Tillers/plant

In the treatment 3 with Kaveri Super Boss + 0.5% ZnSO4 (at 25 and 50 DAS), the maximum number of tillers/plant (3.33) was observed. On the other hand, Nandi-75+ Control (No spray), treatments 7 and N:P: K (80:40:40) Control, treatments 10 achieved the lowest tillers per plant (1.00).

Zinc foliar spraying more frequently resulted in a significant increase in the weight of 1000-grain and the number of total tillers per plant, according to R. P. Vaja *et al* (2020) [19]. Zinc contributes to the biosynthesis of indole acetic acid (IAA), which is required for better growth characteristics, and moisture stress. These results are consistent with those that presented by Shekhawat and Kumavat *et al* [16].

Test weight (g)

Among all the treatments, Kaveri Super Boss + ZnSO4 0.5% (at 25 and 50 DAS) which is treatment 3 had the noticeably highest test weight (10.02 g). However, treatments 6 with Nutra pearl + ZnSO4 0.5% (at 25 and 50 DAS) 9.39 g, were shown to be statistically equivalent to treatment 3.

Auxin and tryptophan are synthesized when zinc is applied to pearl millet crops, which enhances total ear head development. Increased ear head length, gains/ear head, and seed test weight have all been linked to the positive effects of zinc application on crops' nutrient metabolism, biological activity, and growth parameters. Zinc applications typically result in longer and higher enzyme activity. Similar results were previously reported by Asodariya *et al*., (2021) [5].

Grain and yield (t/ha)

Out of all the treatments, treatment 3 which is Kaveri Super Boss + $ZnSO_4$ 0.5% (at 25 and 50 DAS) observed higher seeds and stover yield. The application of Kaveri Super Boss + $ZnSO_4$ 0.5% (at 25 and 50 DAS) resulted in noticeably higher grain yield (1.37t/ha) and stover yield (1.70t/ha). However, it was discovered that treatment 6 which is Nutra pearl+ ZnSO4 0.5% (at 25 and 50 DAS) (1.33 t/ha) was statistically equivalent to treatment 3.

Zinc enhanced photosynthate translocation toward the reproductive system, improving yield qualities and the source-sink relationship. The current results closely match those of Singh *et al*., (2017) [17].

The grain yield performance of pearl millet varieties was very optimistic and exhibited a comparable trend to that of yield attributes. The higher seed yield and straw yield of the pearl millet variety Kaveri Super Boss over other varieties could be attributed to improved production efficiency as reflected by improvements in various yield attributing characters. Similar findings were reported by Meena *et al*., (2018) [14].

Since zinc is involved in many physiological processes of plants, including chlorophyll synthesis, stomatal control, and starch utilization, which enhance seed yield, zinc is necessary to increase seed yield. In crops, zinc also causes ammonia to turn into nitrate, increasing yield. These results are in confirmatory with the work of Anandhan (2021) [3].

Harvest index (%)

Out of all the treatments, Kaveri Super Boss + ZnSO4 0.5% (at 25 and 50 DAS) which is treatment 3, had the noticeably highest harvest index (%) (44.62). However, it was discovered that treatment 6, Nutra pearl + ZnSO4 0.5% (At 25 and 50) 44.03 was statistically equivalent to treatment 3.

Table 1: Influence of Zinc on Yield and yield parameters of Pearl millet Varieties.

Treatments	Ear head length (cm)	Grains/ear head	Tillers/ plant	Test Weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)
Kaveri Super Boss + Control (No spray)	17.60	1133.53	2.03	8.90	1.21	1.62	42.75
Kaveri Super Boss + ZnSO4 0.5% (At 25 DAS)	18.32	1160.00	2.17	9.29	1.28	1.65	43.68
Kaveri Super Boss + ZnSO4 0.5% (At 25 and 50 DAS)	19.50	1203.60	3.33	10.02	1.37	1.70	44.62
Nutra pearl + Control (No spray)	17.10	1122.70	1.67	8.88	1.19	1.61	42.50
Nutra pearl + ZnSO4 0.5% (At 25 DAS)	18.40	1154.20	2.07	8.91	1.28	1.64	43.83
Nutra pearl + ZnSO4 0.5% (At 25 and 50 DAS)	19.30	1197.20	3.00	9.39	1.33	1.69	44.03
Nandi-75+ Control (No spray)	16.50	1122.08	1.00	8.43	1.17	1.59	42.39
Nandi-75+ ZnSO4 0.5% (At 25 DAS)	18.00	1140.32	1.67	9.05	1.27	1.66	43.34
Nandi-75+ ZnSO4 0.5% (At 25 and 50 DAS)	18.69	1168.65	1.33	9.12	1.28	1.65	43.68
N:P: K (80:40:40) Control	16.00	1123.33	1.00	8.00	1.15	1.57	42.27
F test	S	S	NS	S	S	S	S
S.Em±	0.26	17.74	0.56	0.24	0.01	0.01	0.22
CD (p= 0.05)	0.80	34.45	-	0.72	0.05	0.03	0.66

Table 2: Influence of zinc on Economics of Pearl millet.

Treatments	Cost of cultivation	Gross returns	Net returns	B:C Ratio
Kaveri Super Boss + Control (No spray)	23760.22	48890.00	25129.78	1.06
Kaveri Super Boss + ZnSO4 0.5% (At 25 DAS)	23880.22	50890.00	27009.78	1.13
Kaveri Super Boss + ZnSO4 0.5% (At 25 and 50 DAS)	23910.22	53610.00	29699.78	1.24
Nutra pearl + Control (No spray)	23770.22	48300.00	24529.78	1.03
Nutra pearl + ZnSO4 0.5% (At 25 DAS)	23890.22	50760.00	26869.78	1.12
Nutra pearl + ZnSO4 0.5% (At 25 and 50 DAS)	23920.22	52560.00	28639.78	1.20
Nandi-75+ Control (No spray)	23780.22	47580.00	23799.78	1.00
Nandi-75+ ZnSO4 0.5% (At 25 DAS)	23900.22	50790.00	26889.78	1.12
Nandi-75+ ZnSO4 0.5% (At 25 and 50 DAS)	23930.22	50890.00	26959.78	1.13
N:P: K (80:40:40) Control	23780.22	46860.00	23079.78	0.97

Economics

Cost of cultivation

Treatment 9's Nandi 75 + ZnSO4 0.5% (at 25 and 50 DAS) had the highest production cost, Rs. 23930.22/ha, whereas treatment 1's Kaveri Super Boss + No spray had the lowest, Rs. 23760.22/ha.

Gross return

Treatment 3 (Kaveri Super Boss + ZnSO4 0.5% (At 25 and 50 DAS)) produced higher gross returns than the other treatments (Rs. 53610.00/ha), followed by treatment 6 (Nutra pearl + ZnSO4 0.5% (At 25 and 50 DAS)) (Rs. 52560.00/ha). Treatment 10 (N:P: K (80:40:40) Control) produced the lowest gross returns (Rs. 46860.00/ha).

Net return

The Higher Net returns have been noted with the treatment 3 which is Kaveri Super Boss + $ZnSO_4$ 0.5% (At 25 and 50 DAS) (Rs. 29699.78/ha) over rest of the treatments followed by treatment 6, Nutra pearl + $ZnSO_4$ 0.5% (At 25 and 50 DAS) (Rs 28639.78/ha) whereas minimum Net returns were recorded with treatment 10, N:P: K (80:40:40) Control (Rs. 23079.78/ha).

B:C Ratio

The Kaveri Super Boss + ZnSO4 0.5% (At 25 and 50 DAS) treatment 3 had a higher benefit-cost ratio (1.24) than the other treatments, followed by the Nutra Pearl + ZnSO4 0.5% (At 25 and 50 DAS) treatment 6 (1.20). However, treatment 10 which was N:P:K (80:40:40) Control, had a lower benefit cost ratio (0.97).

Conclusion

The conclusion is that the treatment 3, which was Kaveri Super Boss + ZnSO4 0.5% (at 25 and 50 DAS) resulted in the highest grain yield (1.37 t/ha) and cost-benefit ratio (1.24) for the pearl millet crop.

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