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Zinc Nutrition in Banana (cv. Grand Naine) at Early Growth Stage

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Banana is one of the most important and globally popular table purpose fruit. This plant requires good nutrition management with respect to macro and all micronutrients combining both the organic and inorganic sources. Out of different micronutrients, zinc plays a vital role in normal growth of banana plants starting from young stage. With the view, the present experiment was carried out to study the effect of zinc nutrition on early growth of banana plants (cv. Grand Naine).
Study Design: The experiment was laid out in Completely Randomized Design (CRD) with seven treatments and three replications.
Place and Duration of Study: Present study has been carried out at Horticultural Farm, Department of Horticulture and Postharvest Technology, Institute of Agricuture, Visva-Bharati, Sriniketan, West Bengal in the year 2022.
Methodology: In the present experiment, treatments comprised of different levels of zinc nutrition using zinc sulphate $ZnSO_4$ (@ 0.25% and 0.5%) which were applied on different days (15, 30, and 45 DAP). The experiment was laid out in Completely Randomized Design (CRD) with three replications and seven treatments ($ZnSO_4$ @ 0.25% applied at 15 and 30 DAP, $ZnSO_4$ @ 0.5% applied at 15 and 30 DAP, $ZnSO_4$ @ 0.25% applied at 30 and 45 DAP, $ZnSO_4$ @ 0.5% applied at 30 and 45 DAP, $ZnSO_4$ @ 0.25% applied at 15 and 45 DAP, $ZnSO_4$ @ 0.5% applied at 15 and 45

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DAP and control or no zinc sulphate application). The neutralization of zinc sulphate solution was done by adding required amount of lime.
Results: It was observed that the foliar application of zinc significantly influenced plant growth. Foliar application of $ZnSO_4$ @ 0.25% at 15 and 45 DAP recorded maximum in plant height (54.23 cm), pseudostem girth (26.82 mm), number of leaves (9.86), leaf length (36.73 cm), lamina length (29.85 cm), petiole length (5.18 cm) and leaf breadth (15.77). On the other hand, foliar application of $ZnSO_4$ @ 0.5% at 15 and 30 DAP increased the root length (42.33 cm), shoot fresh weight (177.64 g), shoot dry weight (56.39 g), and fresh root weight (26.15 g) and dry root weight (2.85 g). The maximum number of roots (25.46) was recorded on the foliar application of $ZnSO_4$ @ 0.5% applied at 30 and 45 DAP.
Conclusion: Application of zinc on banana plants shows better growth than the control and the application of $ZnSO_4$ @ 0.5%applied at 15 and 30 DAP was observed with both moderate shoot and root growth.

Keywords: Banana; zinc sulphate; growth; early stage.

1. INTRODUCTION

Banana is the 4th largest food crop in the world and the world's largest monoecious, monocarpic, monocotyledonous perennial herb, and has an annual production of 29.78 million tonnes from an area of 0.83 million ha and accounts for 19.2 % of the world's production. Bananabelongs to the Musaceae family and under the order Scitamineae. It is botanically named *Musa paradisiaca.*

Banana is regarded as one of the most important sources of energy. It's high in vitamins A, B, C, and minerals like Ca, Mg, K, and P, as well as a rich source of energy. It can have up to 20% sugar content [1,2]. A 100g dessert banana contains 368 kilojoules of energy, while a 100g plantain contains 368 kilojoules energy while plantain contains 556 kilojoules of energy [3]. Grand Nain bananas are a variety of the well-known Cavendish banana. This accounts for the majority of Cavendish bananas sold on the global market. Grand Naine ripens more slowly, has a richer flavour, and the banana peel can be allowed to get yellowish-green speckled while still having firm flesh inside [4].

Banana plants are a heavy feeder of nutrients due to their size, development rate, rooting pattern, and bud differentiation phenomena, all of which have an impact on production [5,6]. Micronutrients play a crucial function in plant growth and development. Despite their minimal requirements, they are just as vital to plant nutrition as primary (N, P, and K) and secondary macronutrients (Ca, Mg, and S) [7]. These micronutrients also aid in the absorption of major nutrients and play an important role in the plant metabolism process, which includes cell wall construction, photosynthesis, chlorophyll creation, enzyme activity, hormone synthesis, nitrogen fixation, and reduction. Micronutrients are essential for plant nutrition. Micronutrients such as Cu, Zn, Mo, B, and Mn are required for banana growth [8].

P. Maze demonstrated the need for zinc for plant growth in corn in 1914. Carbonic anhydrase, dehydrogenases, proteinases, and peptidases are all zinc-dependent enzymes in plant metabolism. With Zn deficiency, the amount of RNA and ribosomes in the cell decreases. Zinc is an essential constituent of alcohol dehydrogenase, glutamic dehydrogenase, lactic dehydrogenase, carbonic anhydrase (which regulates carbon dioxide metabolism), alkaline phosphatase, carboxypeptidase, and other protein-metabolizing enzymes like dehydro peptidase and glycylglycine dipeptidase [9,10]. It also modulates water relations, improves cell membrane integrity, and stabilizes sulfhydryl groups in ion transport membrane proteins. In the presence of low Zinc availability, the mass of a bunch will treble in response to an increase in the Zinc rate. Zinc has a limited mobility rate in the phloem from the leaves to the fruits at high concentrations. Zinc is usually absorbed by the roots and transferred to the aerial section of plants. Zinc is transported passively by transpiration flow [11].

2. MATERIALS AND METHODS

The experiment was conducted at Horticultural Farm, Department of Horticulture and Post-Harvest Technology, Palli-Siksha Bhavana, (Institute of Agriculture) Visva-Bharati, Sriniketan, West Bengal located at 23°40'26.9" North latitude and 87°39'40.3" East longitude with an average altitude of 40 m above from mean sea level. The minimum weekly temperature ranged from 16°C in January to 25°C in March and the maximum weekly temperature varied from 24.24°C in January to 36.12°C and the weekly maximum relative humidity ranged from 92.14 % in January to 79.33 % in March and the minimum from 78.29 % in January to 48.67 % in March. And the mean total rainfall during the experimental period was 1.44 mm and the mean sunshine hours received was 6.44 hours day^{-1} during the experimental period. Following doses of fertilizers have been applied in the present experiment:

Chart 1. Application of fertilizers

Application	Fertilizers	Dose
1st application	Urea as a foliar spray	5 g/l of water
2nd application	Urea	10 granules/ plant
3rd application	10:26:26 (N,P,K)	10 granules/plant
4th application	10:26:26 (N,P,K)	10 granules/plant

The experiment was conducted in completely randomized design (CRD) with 3 replications and 7 treatments. The poly bags were cleaned and put holes for drainage before filling the media. Soil, well rotten farmyard manure, and sand in the ratio of 2:1:1/2 are mixed thoroughly and filled in poly bags of size 30 × 50 cm. The plants are carefully planted in the middle of the poly bags filled with media. After transplanting, the plantlets were given light irrigation. All the plants in the experimental field were fertilized with Urea and 10:26:26 twice each at 7 days intervals.

2.1 Preparation of $ZnSO_4$ Solution

For 0.25% $ZnSO_4$, 0.5 g of $ZnSO_4$ is dissolved in 20 ml of water and 0.25 g of lime is added and the volume was made up to 200 ml. For 0.5% $ZnSO_4$, 1 g of $ZnSO_4$ is dissolved in 20 ml of water and 0.5 g of lime is added and the volume was made up to 200 ml.

2.2 Treatment Detail

Chart 2. List of treatments

Notations	Treatments	Time of application	
		1st	2nd
T_1	$ZnSO_4$ @ 0.25%	15 DAP	30 DAP
T_2	$ZnSO_4$ @ 0.5%	15 DAP	30 DAP
T_3	$ZnSO_4$ @ 0.25%	30 DAP	45 DAP
T_4	$ZnSO_4$ @ 0.5%	30 DAP	45 DAP
T_5	$ZnSO_4$ @ 0.25%	15 DAP	45 DAP
T_6	$ZnSO_4$ @ 0.5%	15 DAP	45 DAP
T_7	Control (no $ZnSO_4$)		

2.3 Observations Recorded

Throughout the investigation, a number of observations were made. Shoot growth development characteristics were recorded in 15, 30, 45, 60, and 75 DAP, and the fresh and dry weight of shoots was recorded after 75 DAP. The root characteristics were recorded once after 75 DAP. The observation was recorded on different aspects of banana cv. Grand Naine viz. plant height (cm), number of leaves, pseudostem girth (mm), leaf length (cm), leaf lamina length (cm), leaf lamina breadth (mm), petiole length (cm), root length (cm), Root dimeter (mm), number of roots, fresh and dry weight of root and shoot (gm).

2.4 Statistical Analysis of Data

Data recorded on various aspects were analyzed statistically as per the procedures given by Arya and Singh [12] for Completely Randomized Design with seven treatments and three replications.

3. RESULTS AND DISCUSSION

3.1 Effect of Zinc Sulphate on Shoot Growth

Treatment T_5 ($ZnSO_4$ @ 0.25% applied at 15 and 45 DAP) gives a positive response to vegetative growth parameters and at 75 DAP, it was recorded with maximum plant height (54.23 cm), pseudostem girth (26.82 cm), number of leaves per plant (9.86), leaf length (36.73 cm), lamina length (36.73 cm), leaf breadth (15.77 cm), and petiole length (5.18 cm). Treatment T_2 ($ZnSO_4$ @ 0.5% applied at 15 and 30 DAP) was found statistically at par with Treatment T_5 in all the vegetative growth parameters with plant height (50.13 cm), pseudostem girth (25.28 cm), number of leaves per plant (9.53), leaf length (32.68 cm), lamina length (28.04 cm), leaf breadth (14.84 cm), and petiole length (4.63 cm) sown in Table 1.

The results of this study indicate that using zinc sulphate increases plant height. The activation of particular enzymes involved in cell division and elongation by zinc may account for the rise in plant height [13]. Auxin production is enhanced by zinc, which increases cell size and quantity, resulting in increased plant height [14]. Plant height was also reported to increase with zinc application by Wang et al. [15] and Arya and

Singh [12]. Helial and Atawia [16] in pawpaw and Shrivastava [17] in pineapple reported similar results.

Zinc aids in the metabolism of auxin, starch, and protein synthesis, which could explain the increase in pseudostem girth. Zinc is a necessary component for plant growth and production [18]. Zinc is a crucial component of ribosomes and is required for their formation, according to the findings. The addition of zinc to plants can increase the accumulation of amino acids in plant tissues as well as enhance protein production, resulting in increased plant growth [19], Helial and Atawia [16] in pawpaw, Shrivastava [17] in pineapple, Bahadur et al. [13] in mango and Razzaq et al. [20] in kinnow mandarin also showed similar results.

The increase in leaf number with zinc application could be due to an increase in photosynthetic compounds and leaf chlorophyll, which are involved in leaf bud formation, cell division, cell enlargement, and cell wall development of plant and leaf tissues, resulting in an increase in leaf number, delayed leaf senescence, and provided strength for their persistence [21] Ballabh et al. [22] found similar results in mango and Srivastava [8] in banana. The positive response to zinc sulphate application observed in this experiment could be due to Zinc's close relationship with nitrogen metabolism and protein synthesis which favours leaf growth and development [23,24,25]. Jeyabaskaran and Pandey [26] in banana, Khan et al. [27] in onion, and Hossain et al. [28] in cauliflower found similar results.

The increase in petiole length with the application of $ZnSO_4$ might be due to zinc being the component of carbonic anhydrase as well as several dehydrogenases and auxin production which enhance plant growth. Singh et al. [29] in papaya, Bhatti et al. [30] in strawberry cv. Selva and Lolaei et al. [31] in strawberry cv. Camarosa also found similar results.

3.2 Effect of Zinc Sulphate on Root Growth

In the plant root system, the effect of zinc was significant in T_4 ($ZnSO_4$ @ 0.5% applied at 30 and 45 DAP) in the number of roots (25.46), whereas on the other quality parameters like root length, fresh and dry weight of roots T_2 ($ZnSO_4$ @ 0.5% applied at 15 and 30 DAP) was found to be better i.e., 42.33 cm, 26.15 g, and 2.85 g respectively are presented in Table 2. However, in the root diameter, there was no significant difference among the treatments.

There is a positive response from the plant for better development of roots growth with zinc application with the maximum number of roots. The roots of plants that are treated with zinc show better growth than the controlled and this might be associated with the active participation of zinc with increasing nitrogen metabolism and protein synthesis [23, 24, 25]. These results are in conformity with Srinvastava [8] in banana, Chattopadhyay et al. [3] in soybean, Malik et al. [32] in rice and Ballah et al. [22] in onion.

3.3 Effect of Zinc Sulphate on Fresh Weight and Dry Weight of Plant

The fresh and dry weight of shoots was significantly influenced by different zinc treatments. The highest fresh weight (177.64 g) and dry weight (56.39 g) of shoots were recorded in zinc treatment T_2 ($ZnSO_4$ @ 0.5% applied at 15 and 30 DAP) are presented in Table 2 and minimum weight was found in controlled plants. zinc is essential for water uptake in the plant, which helps plants absorb water and nutrients, favouring more fresh weight and resulting in increased dry matter accumulation. These findings are in conformity with Dashadi et al. [33] in strawberries, Epstein and Bloom [11] in broccoli and Saini et al. [34] in chrysanthemum.

The maximum root weight of both fresh and dry was recorded in T_2 ($ZnSO_4$ @ 0.5 per cent applied at 15 and 30 DAP)was found to be better i.e., 26.15 g, and 2.85 g respectivelyand the minimum in untreated plants. Agrawal et al. [7] recorded maximum uptake of NPK, copper and iron with zinc application in tomatoes. This was linked due to improved leaf and vegetative growth, increased photosynthesis in soil-applied zinc, increased delivery of photosynthates to the root, and improved tomato nutrient utilization ability. These findings are in conformity with Bakry et al. [14] in citrus and Ballah et al. [22] in onion.

Table 1. Effect of zinc sulphate on shoot growth

Treatments	Plant height	Pseudostem girth	Number of leaves	Leaf length	Lamina length	Leaf breadth	Petiole length
T_1	42.41	22.93	9.06	31.23	24.75	13.67	4.44
T_2	50.13	25.28	9.53	32.68	28.04	14.84	4.63
T_3	45.33	24.73	8.86	31.84	26.53	13.16	4.31
T_4	47.85	22.45	9.13	31.8	25.22	13.55	4.57
T_5	54.23	26.82	9.86	36.73	29.85	15.77	5.18
T_6	44.46	22.88	9.13	29.70	24.70	13.06	4.11
T_7	38.13	20.57	7.73	26.72	23.21	11.08	3.32
C.D. (0.05)	6.73	3.03	0.66	5.16	3.63	2.10	0.90
S.Em(±)	2.24	1.01	0.22	1.72	1.21	0.70	0.30

Table 2. Effect of zinc sulphate on root growth and (fresh and dry) weight of plant

Treatments	Number of roots	Root length (cm)	Root diameter (mm)	Fresh weight of shoot (g)	Dry weight of shoot (g)	Fresh weight of root (g)	Dry weight of root (g)
T_1	21.31	36.66	4.27	164.54	50.65	23.22	2.11
T_2	24.43	42.33	4.82	177.64	56.39	26.15	2.85
T_3	20.66	36.33	4.82	158.68	48.73	23.49	2.14
T_4	25.46	25.33	4.79	156.55	51.52	23.03	2.21
T_5	22.13	35.33	4.54	163.72	49.46	21.56	1.92
T_6	20.05	30.66	4.76	163.37	50.91	20.64	1.87
T_7	20.47	28.66	4.21	145.83	41.62	18.86	1.76
C.D. (0.05)	3.36	5.31	NS	16.05	6.18	4.53	0.57
S.Em(±)	1.12	1.77	NS	5.31	2.06	1.51	0.19

4. CONCLUSION

The best concentration for shoot growth was recorded in 0.25% $ZnSO_4$ applied at 15 and 45 DAP and root growth was observed in 0.5% $ZnSO_4$ applied at 15 and 30 DAP. The concentration of $ZnSO_4$ 0.5% applied at 15 and 30 DAP was recorded with both moderate shoot and root growth. It was also found that all zinc treatments gave better results than control.

COMPETING INTERESTS

Authors declare that there is no financial and personal relationships with other people or organizations that could inappropriately influence the present work and no potential conflicts of interest with respect to employment, consultancies, honoraria, paid expert testimony, patent applications/registrations, and grants or other funding. Authors declare that no competing interests exist with the present article.

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