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# Evaluation of the Effectiveness of Modified Lignosulphonate-Chelated Zinc Fertilizer on Sweet Corn Yield

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***Abstract:** Zinc is an essential micronutrient for maize, enhancing nutrient uptake, enzyme function, and crop resilience. Zinc deficiencies in agricultural soils can significantly limit maize growth and yield. This study was, conducted from January to April 2024 at Agri Search India Pvt. Ltd. in Nashik, Maharashtra to assess the impact of various zinc formulations, ZnO, Zn-EDTA, $ZnSO_4 \cdot 7H_2O$, Modified Lignosulphonate Chelated Fertilizer (MLCF), and Borrechel-Zn applied as foliar sprays on the sweet corn variety Sweet Bite NS 8601, with a control treatment for comparison. MLCF, formulated using lignosulphonate derived from wood pulping by-products, acts as a natural chelator and slow-release carrier, enhancing zinc availability while reducing environmental impact. Key findings revealed that MLCF significantly outperformed other treatments in improving plant growth and cob yield, achieving the highest fresh cob weight (264.7 g), dry cob weight (90.5 g), cob girth (15.6 cm), grains per row (36.6), and dry weight of ten cob grains (60.5 g). As a natural and renewable product, MLCF minimizes chemical leaching and supports soil health, presenting a sustainable alternative to synthetic chelates. These results indicate that MLCF is an effective and eco-friendly option for zinc supplementation, promoting enhanced crop performance and contributing to sustainable agriculture.***

***Keywords:** Zinc, Foliar Application, Lignosulphonate, cob, grain, Sweet Corn*

## I. INTRODUCTION

Zinc (Zn) is a vital micronutrient for plants, crucial for various physiological and biochemical processes necessary for optimal growth and development. This highlights zinc's essential functions and its significance in agriculture, particularly in the cultivation of sweet corn (Zea mays L.). Maize is considered a zinc-loving crop due to its relatively high demand for zinc compared to many other crops. According to the Soil Health Card Scheme data for the year 2023–2024, approximately 52.32% of soils in Maharashtra are reported to be deficient in zinc (Department of Agriculture, Cooperation & Farmers Welfare, 2024). To address this widespread deficiency, various forms of zinc fertilizers are available for use in maize cultivation. However, identifying the most effective formulation for enhancing crop performance remains a priority. In light of this, the present study was conducted using sweet corn as the test crop, with the aim of evaluating the effectiveness of different zinc sources under field conditions.

## II. MATERIALS AND METHODS

### *A. Experimental Site*

The field experiment was carried out between January and April 2024 at the Research Farm of Agri Search India Pvt. Ltd., located in Pimpalnare, Dindori, Nashik, Maharashtra. The experimental site is geographically positioned at latitude 20°7'32.487", longitude 73°48'48.42", with an elevation of 663 ± 7 m above sea level.

### *B. Soil Analysis*

A comprehensive soil analysis of the experimental plot was conducted prior to sowing the seeds to determine its suitability for maize cultivation. Results (Table 1) revealed that the zinc content in the soil was below the desired range (1–1.5 ppm), indicating a deficiency. The soil type was identified as sandy loam with a neutral pH of 7.0.

Table 1: Experimental Plot soil analysis.

| Sr.No. | Parameter | Unit | Results | Desirable range | Reference |
|---|---|---|---|---|---|
| 1 | pH | --- | 7 | 6.5 - 7.5 | (Jackson *et al.*, 1973) |
| 2 | E.C | dS/m | 0.372 | < 1.0 | (Jackson *et al.*, 1973) |
| 3 | Organic Carbon | % | 0.80 | 1.01 - 3.0 | (Walkley and Black, 1934) |
| 4 | Nitrogen (N) | Kg/ha | 270.8 | 280 - 560 | (Subbiah and Asija, 1956) |
| 5 | Potassium | Kg/ha | 603 | 120 - 280 | (Stanford *et al.*, 1949) |
| 6 | Copper | ppm | 2.45 | 0.3 - 0.5 | (Lindsay WL et al.,1978) |
| 7 | Ferrous | ppm | 10.84 | 3.1 - 5.0 | (Lindsay WL et al.,1978) |
| 8 | Manganese | ppm | 86.35 | 0.6 - 1.0 | (Lindsay WL et al.,1978) |
| 9 | Zinc | ppm | 0.80 | 1 - 1.5 | (Lindsay WL et al.,1978) |
| 10 | Calcium | ppm | 2832.12 | 500 - 1000 | (Hesse 1971) |
| 11 | Magnesium | ppm | 589.0 | 500 - 1000 | (Hesse 1971) |

### C. *Basal Dose*

A basal dose was applied to the experimental plot, incorporating:

- Vermicompost
- Neem fruit powder
- Nitrogen, Phosphorus, and Potassium (NPK) fertilizers

### D. *Planting Material*

The maize variety used in the study was Sweet Bite NS 8601, a cultivar of sweet corn. Seeds were sown directly in the field on 5th January 2024, following a spacing pattern of 75 cm between rows and 30 cm between plants within each row, to ensure optimal plant population and uniform crop establishment.

### E. *Treatments*

The experiment included six treatments, each involving a different form of zinc to assess their effects on sweet corn growth. The zinc formulations used for foliar application included ZnO, Zn-EDTA, $ZnSO_4•7H_2O$, Modified Lignosulphonate Chelated Fertilizer, and Borrechel-Zn, with a control group receiving no zinc application. These treatments were applied as Foliar sprays at 30,40,50,60 and 80 days after sowing. The treatments were as under:

- T1: 0.25% zinc solution prepared from Zinc Oxide (ZnO), containing 39.5% zinc.
- T2: 0.2% zinc solution prepared from Zinc EDTA, containing 12% zinc.
- T3: 0.5% zinc solution prepared from Zinc Sulfate Heptahydrate ($ZnSO_4•7H_2O$), containing 21% zinc.
- T4: 0.3% zinc solution prepared from Modified Zinc Lignosulphonate, containing 6% zinc.
- T5: 0.15% zinc solution prepared from Zinc Borrechel, containing 12% zinc.
- T6 (Control): No zinc application was given to serve as a baseline for comparison.

Each treatment was carefully applied as a foliar spray at specific growth stages, allowing for a comparative assessment of zinc uptake and impact on plant development.

### *F. Planting and Data Collection*

Fertilizers were applied in accordance with standard agronomic recommendations to support healthy growth, and irrigation was provided as needed to maintain optimal soil moisture.

Throughout the growing period, the crop was closely monitored to ensure it remained free from weeds. Any insect pest infestations were promptly addressed through the targeted use of appropriate chemical treatments, ensuring the plants were protected from damage.

### *G. Data Analysis*

The data collected from the foliar application treatments on the maize crop were analyzed using Excel to evaluate the effects of different zinc formulations on various growth parameters. The following key variables were assessed:

- Fresh Cob Weight with Husk (gm)
- Dry Cob Weight without Husk (gm)
- Cob Girth (Dry Cob) (cm)
- Grains per Row
- Dry Weight of 100 Grains (gm)
- Dry Weight of 10 Cob Grains (gm)

## III. RESULTS AND DISCUSSION

Six treatments were applied, each involving a different form of zinc fertilizer at recommended dose, and their effectiveness was compared with a control group with no zinc supplementation. The data for each treatment are summarized in the Table (2).

Table 2. Effect of different forms of Zinc Foliar application on cob and grain of Sweet Corn.

| Treatments | Fresh cob Wt. with husk (gm) | Dry cob wt without husk (gm) | Cob Girth (Dry Cob) (cm) | Grains/ row | Dry wt of 100 grains (gm) | Dry wt of 10 cob grains (gm) |
|---|---|---|---|---|---|---|
| T1:(ZnO) | 250.6 | 82.5 | 15.0 | 34.5 | 11.4 | 580.5 |
| T2 :(Zn-EDTA) | 230.5 | 76.7 | 15.3 | 34.0 | 11.0 | 543.0 |
| T3:(ZnSO4.7H2O) | 230.7 | 77.0 | 15.4 | 34.8 | 11.0 | 545.5 |
| T4 :(Zinc Ligno-MLCF) | 264.7 | 90.5 | 15.6 | 36.6 | 11.5 | 605.0 |
| T5 : (Borrechel- Zn | 236.1 | 81.2 | 15.1 | 35.6 | 10.0 | 534.0 |
| T6 : Control | 236.0 | 76.9 | 15.0 | 34.2 | 9.0 | 502.0 |

The data indicates a clear variation in the measured parameters across different treatments.

- Fresh Cob Weight with Husk: Treatment T4 (Zinc Ligno-MLCF) recorded the highest fresh cob weight with husk at 264.7 gm, followed by T1 (ZnO) at 250.6 gm. The control treatment (T6) showed the lowest fresh cob weight at 236.0 gm. This suggests that zinc treatments, especially Zinc Ligno-MLCF, significantly improved the overall biomass of the cobs.
- Dry Cob Weight without Husk: Treatment T4 also led to the highest dry cob weight without husk (90.5 gm), followed by T1 (82.5 gm). The control (76.9 gm) and other treatments like T2 (Zn-EDTA) and T5 (Borrechel-Zn) showed lower values, indicating that specific zinc formulations contributed to better cob development compared to the control.
- Cob Girth: The cob girth in the dry cob was highest in T4 (15.6 cm), which was slightly greater than T3 (15.4 cm) and T2 (15.3 cm). The control and T1 treatments were similar, with a girth of 15.0 cm. This suggests that zinc treatments, particularly Zinc Ligno-MLCF, enhanced the structural development of the cob.
- Grains per Row: The number of grains per row was highest in T4 (36.6 grains), followed by T3 (34.8 grains) and T1 (34.5 grains). The control treatment had the lowest grains per row (34.2), indicating a potential positive impact of zinc supplementation on grain production.

- Dry Weight of 100 Grains: T4 (Zinc Ligno-MLCF) also showed the highest dry weight of 100 grains (11.5 gm), slightly outperforming T1 (11.4 gm) and T3 (11.0 gm). The control had the lowest dry weight (9.0 gm), supporting the hypothesis that zinc enhances grain weight.
- Dry Weight of 10 Cob Grains: The highest dry weight of 10 cob grains was observed in T4 (605.0 gm), followed by T1 (580.5 gm). The control again showed the lowest dry weight (502.0 gm), indicating the significant role of zinc in improving the quality of grains.

### *A. Effectiveness of Zinc Ligno-MLCF (T4)*

In summary, Zinc Ligno-MLCF was found to be the most effective zinc formulation in the study. It resulted in significant increase in biomass, indicated by higher fresh and dry cob weights, as well as improved grain quality, including greater grain weight and cob girth. The superior performance of Zinc Ligno-MLCF is likely due to its unique formulation, which ensures higher bioavailability of zinc, a critical micronutrient for plant physiological processes like enzyme activation, chlorophyll production, and protein synthesis. These findings align with the literature, which emphasizes zinc's role in boosting plant growth, grain development, and overall productivity (Marschner, 2012; Alloway, 2008; Broadley et al., 2007).

### *B. Positive Effects of other Zinc Treatments*

Other zinc treatments, such as ZnO (T1), $ZnSO_4·7H_2O$ (T3), and Zn-EDTA (T2), also showed notable improvements over the control (no zinc).

- ZnO (T1) and $ZnSO_4·7H_2O$ (T3) were effective in increasing dry cob weight and grain weight, validating their use as cost-effective and widely used zinc sources in agriculture (Alloway, 2008).
- Zn-EDTA (T2) demonstrated moderate effectiveness, likely due to differences in bioavailability and release rates. Chelated zinc compounds are known to improve nutrient uptake, but their efficacy can vary depending on soil and environmental conditions (Cakmak, 2008).

These results reinforce the importance of zinc application in maize cultivation and underscore the variability in performance among different zinc formulations. The most promising performance of MLCF in spite of lower Zn content indicate that this form helps to make maximum Zn available to plant as required for different metabolic functions.

### *C. Importance of Zinc for Crop Growth*

The study highlights the critical role of zinc as an essential micronutrient for Sweet Corn in:

- Biomass Production: Zinc contributes to chlorophyll synthesis and photosynthetic efficiency, resulting in improved plant growth (Marschner, 2012).
- Grain Development: Zinc is vital for protein synthesis, enzyme activation, and reproductive growth, leading to better grain weight and cob size (Alloway, 2008; Broadley et al., 2007).
- Stress Tolerance: Zinc enhances plant resilience against oxidative and environmental stresses, improving overall productivity (Cakmak, 2008).

As Zn in soil was less than desirable limit the poor performance of the control confirmed the detrimental effects of zinc deficiency, which limits maize growth and yield.

From the study for Implications for Agricultural Practices in Sweet corn /Maize production are noticed as below:

- Zinc Fertilization: Zinc Ligno-MLCF is an ideal choice for optimizing maize yield and quality, offering superior results compared to other formulations. Foliar application of zinc is validated as a practical strategy to address zinc deficiencies in crops (Alloway, 2008).
- Soil Health Management: Regular soil testing and the use of bioavailable zinc formulations can help overcome zinc deficiencies and improve nutrient management in zinc-deficient regions.
- Economic Benefits: Improved yields and grain quality through effective zinc application translate into better economic returns for farmers, particularly in regions where maize is a staple crop.

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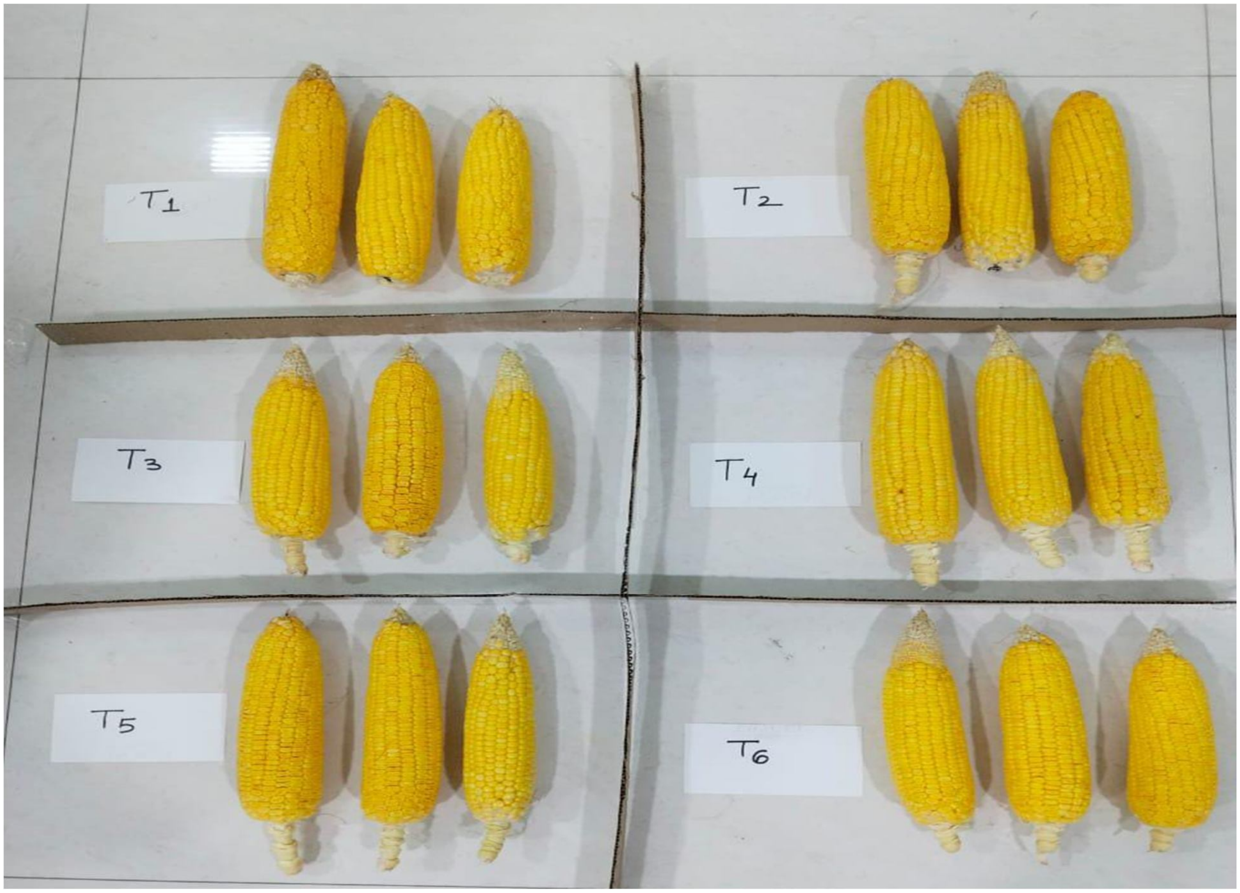


Figure 3. Cob of each Treatments (T1,T2,T3,T4,T5,T6)

## IV. CONCLUSION

The findings from this study emphasize the critical role of zinc supplementation in enhancing Sweet Corn productivity, grain quality, and overall plant health. Among the zinc formulations tested, Zinc Ligno-MLCF (T4) demonstrated the highest efficacy improving fresh and dry cob weight, grain weight, and cob girth. This superior performance can be attributed to its enhanced bioavailability, which facilitates better nutrient uptake and supports vital physiological processes such as enzyme activation, chlorophyll synthesis, and protein synthesis.

Other treatments, including ZnO (T1)**,** $ZnSO_4 \cdot 7H_2O$ (T3)**, and** Zn-EDTA (T2), also exhibited positive impacts on maize growth parameters, underscoring the importance of zinc in plant nutrition. While these forms were effective, their performance was slightly lower than that of Zinc Ligno-MLCF, highlighting the need for selecting appropriate formulations to maximize crop yield and quality. The further studies can be taken to determine doses of MLCF.

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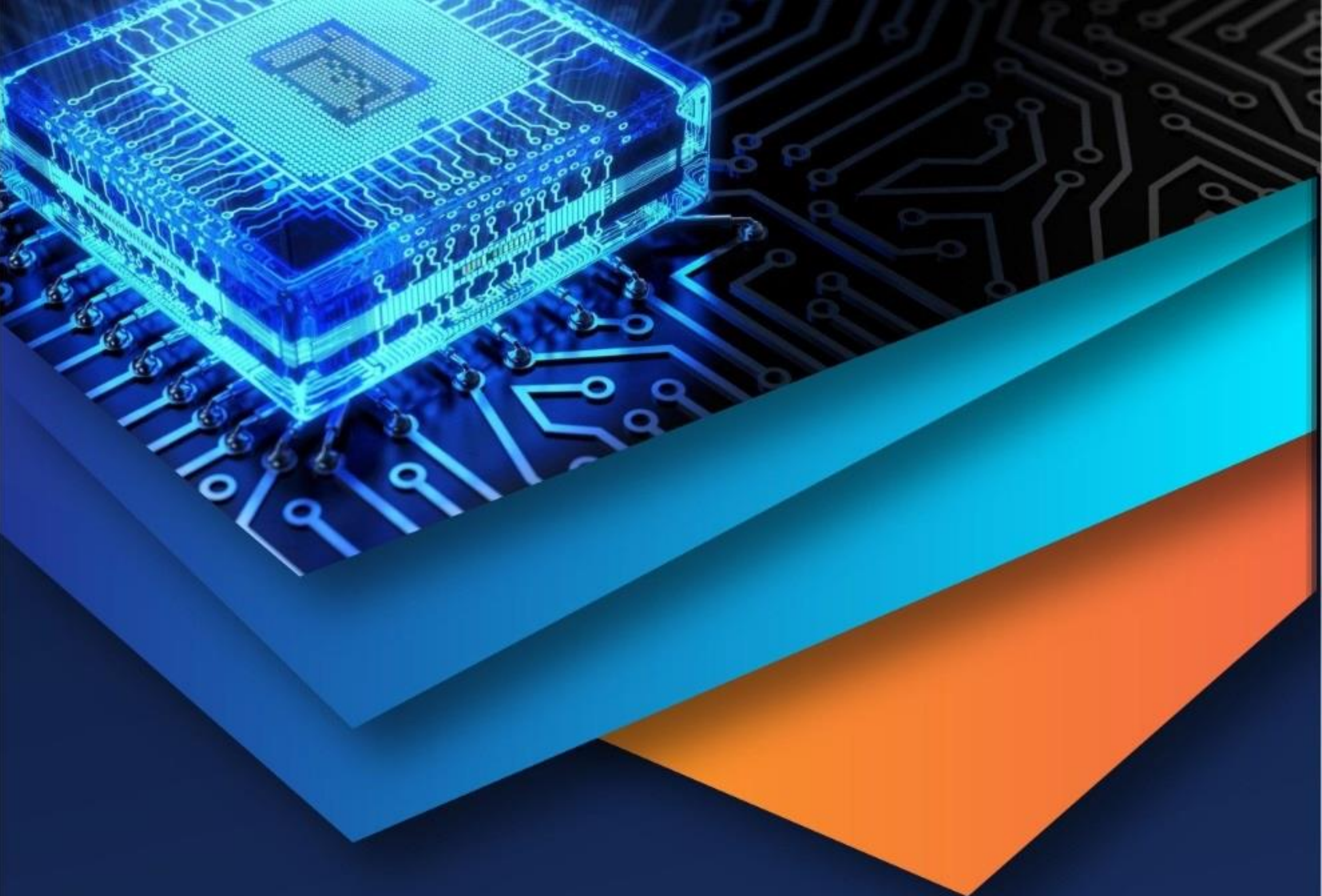


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