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Impact of chelated micronutrient in the growth parameters at different growth stages of rice

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Abstract

Micronutrient deficiencies in soil significantly limit the productivity and nutritional quality of rice (*Oryza sativa* L.). This study evaluates the impact of chelated micronutrient (Zinc (Zn) and Iron (Fe) in amino acid forms) on key growth parameters at critical developmental stages: active tillering, panicle initiation and at harvest stage. In the kallikudi block of Madurai district, Tamil Nadu, a lack of available Iron (Fe) and Zinc (Zn) in the soil was identified as a primary constraint to rice productivity. To address this, a field study was carried out with fourteen replications on a farmer's land from November 2018 to January 2019 using a randomized block design with five replications to assess how different levels of chelated micronutrients impact rice yield and its components. The experimental results demonstrated that the T₁₃ treatment [RDF + chelated micronutrient (Zn lysinate and Fe methionate at 12.5 kg ha⁻¹)] significantly improved the growth parameters viz., plant height and number of tillers per hill. This performance highlights the effectiveness of using amino acid-chelated micronutrients in combination with the recommended dose of fertilizer (RDF), has a significant positive effect on both crop growth and soil fertility of rice in the Madurai region.

Keywords: Rice (*Oryza sativa*), Chelated Micronutrients, Zn - lysinate, Fe - methionate, Growth parameters

1. Introduction

Rice is a strategic and leading staple food crop for more than 50% of the world's population. It serves as a primary nutritional pillar, contributing roughly 21% of total dietary energy and 15% of protein intake per person. These figures are especially significant in major rice-producing regions, which account for 90% of the world's total rice production and consumption (Depar *et al.*, 2011) [3]. While polished rice is a fundamental source of calories and some protein, the refining process strips away the embryo and the nutrient-dense aleurone layer. Consequently, the remaining grain is a deficient source of vital micronutrients, particularly Zinc (Zn) and Iron (Fe), which are necessary for maintaining human health (Yang *et al.*, 2013) [13].

Polished rice contains significantly lower nutritional concentrations of Zinc (Zn) and Iron (Fe) compared to other cereal crops, failing to meet global nutritional targets. Typical Zn levels in polished rice range from approximately 10.38 to 11 mg kg⁻¹ (Ravindra Babu 2013) [11], while Fe concentrations average just 2 to 2.5 mg kg⁻¹ (Martinez *et al.*, 2010) [9]. These values fall substantially below the essential biofortification goals set by the Harvest Plus program target for Zn is 28 mg kg⁻¹ (Bouis and Welch 2010) [2] and also global biofortification target for Fe is 14 mg kg⁻¹ (He *et al.*, 2013) [5].

Various effective agricultural management techniques are commonly employed to boost the amount of available Zinc (Zn) and Iron (Fe) in the soil, thereby increasing the quantity of these minerals that plants can absorb. These strategies support optimal crop development and contribute significantly to efforts in bio-fortifying the grain. The foundation of these agronomic interventions involves a calculated approach utilizing different sources, application rates, and methods for delivering Zn and Fe fertilizers to the crop (Ghasemi *et al.*, 2014) [4]. When compared to other types of micronutrient fertilizers (like inorganic salts or synthetic chelates), amino acid chelates demonstrate a significantly greater positive impact on growth parameters, yield components and on nutritional quality (Yuan *et al.*, 2013) [14]. Jie *et al.* (2008) [7] indicated

that Fe and Zn amino acid fertilizers compared to Zn and Fe Sulfate, and Zn and Fe- EDTA enhanced all rice growth parameters by about 2 times.

Given the concerns regarding the potential health and environmental risks associated with EDTA, transitioning to amino acid-chelated minerals offers a safer and more effective alternative for managing nutrient deficiencies. In the Indian agricultural landscape, particularly within high-yielding lowland rice systems, the lack of available Zinc (Zn) and Iron (Fe) remains a critical hurdle. Consequently, investigating how chelated Fe and Zn formulations influence rice growth parameters is essential for optimizing productivity and grain quality

2. Materials and Methods

This chapter details the methodology and analytical techniques employed in the field experiment, which investigated the growth of rice in soils with varying Zinc and Iron treatments. During the period from November 2018 to January 2019, a field study was carried out in Lalapuram village, located within the Kallikudi block of the Madurai district. The research focused on the TKM 13 rice variety, a semi-dwarf cultivar with a 135-day growth cycle as the primary test crop. The study utilized an experimental design consisting of 14 distinct treatment and replicated 5 times. The size of the experimental plot was 5 x 4 m and 0.5 cm wide of irrigation channels were placed between the replications to ensure uninterrupted flow of irrigation water and 21 days old rice seedlings were transplanted per hill at a spacing of 25 x 25 cm.

Physico-chemical properties of the soil were measured by the standard methods of soil chemical analysis. The analysis of experimentation revealed that the soil is neutral in reaction, Non-Saline, low organic carbon (0.45), low available nitrogen (193.2 kg/ha), medium available phosphorus (20 kg/ha), medium available potassium (156 kg/ha), low DTPA Fe and Zn with 2.88 ppm and 1.28 ppm respectively. The treatment details were Control with no RDF (T₁), RDF @ 150:50:50 kg ha⁻¹ (T₂), RDF + ZnSO₄ @ 25 kg ha⁻¹ (T₃), RDF + FeSO₄ @ 50 kg ha⁻¹ (T₄), RDF + Chelated Zn @ 2.5 kg ha⁻¹ (T₅), RDF + Chelated Zn @ 3.75 kg ha⁻¹ (T₆), RDF + Chelated Zn @ 5 kg ha⁻¹ (T₇), RDF + Chelated Fe @ 5 kg ha⁻¹ (T₈), RDF + Chelated Fe @ 7.5 kg ha⁻¹ (T₉), RDF + Chelated Fe @ 10 kg ha⁻¹ (T₁₀), Chelated micronutrient mixture @ 7.5 kg ha⁻¹ (T₁₁), Chelated micronutrient mixture @ 10 kg ha⁻¹ (T₁₂), Chelated micronutrient mixture @ 12.5 kg ha⁻¹ (T₁₃), TNAU micronutrient mixture @ 12.5 kg ha⁻¹ (T₁₄).

In accordance with the experimental protocol, a fertilizer regimen of 150 kg N, 50 kg P₂O₅, and 50 kg K₂O per hectare was implemented using urea, single superphosphate, and muriate of potash. While the full dose of phosphorus was provided as a basal application, the nitrogen and potassium were distributed in four equal increments (25% each) at the following growth stages: planting (basal), active tillering, panicle initiation, and heading. Zinc sulphate @ 25 kg ha⁻¹ (T₃) and Ferrous sulphate @ FeSO₄ @ 50 kg ha⁻¹ (T₄) were mixed with sand for uniform distribution, were applied in each plots. The Zn lysinate @ 2.5, 3.75 & 5 kg ha⁻¹, Fe methionate @ 5, 7.5 & 10 kg ha⁻¹, chelated micronutrient mixture (Zn lysinate + Fe methionate) @ 7.5, 10

& 12.5 kg ha⁻¹ and TNAU micronutrient mixture @ 12.5 kg ha⁻¹ were mixed with sand (25 kg), then the mixture was broadcasted uniformly as per the schedule (T₅ to T₁₄). Observations on growth parameters like plant height and number of tillers per hill were recorded. All replicated data were analyzed statistically using AGRES software.

3. Results and Discussion

3.1 Growth parameters of rice at different growth stages of rice

3.1.1 Plant height (Table 1): The data presented in the table is the influence of different levels and sources of Fe and Zn application. Application of chelated micronutrient mixture along with RDF was found to be superior over other treatments.

In the field of Lalapuram village, the plant height ranged from 39.2 to 51.8, 70 to 94 and 73.5 to 96.9 cm at tillering, at panicle initiation and harvest stages respectively. Among the treatments, application of 12.5 kg ha⁻¹ of chelated micronutrient mixture (T₁₃) was significantly superior in improving the plant height by recording the 51.8, 94.0 and 96.9 cm followed by T₁₂ (chelated micronutrient mixture @ 10 kg ha⁻¹). The lowest plant height of 39.2, 70.0 and 73.5 cm at active tillering, panicle initiation and at harvest stages respectively were registered in absolute control. Typically, rice roots absorb iron and zinc in their ionic forms (Fe²⁺ and Zn²⁺). However, when these micronutrients are provided as chelates, their bioavailability is significantly enhanced a crucial factor in the deficient soils of this study. This increased availability of iron, in particular, promotes optimal plant height by facilitating chlorophyll synthesis and essential energy transfer processes within both root and plant cells, as documented by (Rawashdeh and Sala 2014) [12].

According to research by Naik and Das (2008) [10], the notable growth in plant height can be linked to a sufficient supply of zinc. This micronutrient is essential for stimulating enzymatic processes and regulating auxin metabolism, both of which are critical for cell elongation and structural development in rice.

3.1.2 Tillers (No. hill⁻¹) (Table 2)

The treatment (T₁₃) chelated micronutrient mixture @ 12.5 kg ha⁻¹ showed a significant result on number of tillers hill⁻¹ in the soil of Lalapuram village at all the stages of a crop. The number of tillers hill⁻¹ varied with chelated micronutrient application, comparing the three different levels of mixture, application of chelated micronutrient mixture @ 12.5 kg ha⁻¹ recorded the maximum tillers (26.3 and 38.5) at active tillering and at panicle initiation stage respectively. The lowest number of tillers was noticed in the treatment T₁ receiving absolute control.

Abbas *et al.*, (2009) [11] investigations with wheat showed that in the absence of iron, the number of tillers hill⁻¹ was reduced than the treatment supplied with Fe + RDF. This might be the reason behind the improved tiller numbers in the treatment which have received chelated micronutrient mixture in the soils of both the experiments. Also, Zn involved in protein production, photosynthesis and in provoking enzymes and nitrogen metabolism that promotes the increased number of tillers. This result corroborated with that Maftoun (1989) [8] and Hossain (2008) [6], who reported higher number of tillers in rice due to zinc chelate application.

Table 1: Effect of chelated Fe and Zn on Plant height (cm) at different growth stages of rice (Mean of five replications)

Treatments	Lalapuram village- Plant height (cm)		
	Active Tillering (50-55 DAS)	Panicle Initiation (70-75 DAS)	At harvest
T ₁	39.2	70.0	73.5
T ₂	46.0	82.0	85.3
T ₃	46.3	83.6	86.8
T ₄	46.6	84.3	87.5
T ₅	47.1	85.7	88.2
T ₆	47.5	86.8	89.1
T ₇	48.5	88.5	90.6
T ₈	48.0	87.2	89.5
T ₉	48.5	89.0	91.5
T ₁₀	49.0	90.6	93.0
T ₁₁	49.1	90.8	93.7
T ₁₂	50.5	92.5	95.0
T ₁₃	51.8	94.0	96.9
T ₁₄	50.3	92.2	95.4
SEd	0.56	0.36	0.69
CD(P=0.05)	1.15	1.36	1.43

Table 2: Effect of chelated Fe and Zn on Number of tillers hill⁻¹ at different growth stages of rice (Mean of five replications)

Treatments	Lalapuram village - Number of tillers hill ⁻¹	
	Active Tillering (50-55 DAS)	Panicle Initiation (70-75 DAS)
T ₁	16.0	25.0
T ₂	23.0	32.9
T ₃	23.2	33.5
T ₄	23.5	33.7
T ₅	23.7	34.3
T ₆	24.0	34.8
T ₇	24.5	35.2
T ₈	24.2	35.0
T ₉	24.7	35.5
T ₁₀	25.0	36.0
T ₁₁	25.1	36.1
T ₁₂	25.6	37.0
T ₁₃	26.3	38.5
T ₁₄	25.5	36.9
SEd	0.28	0.39
CD(P=0.05)	0.58	0.8

4. Conclusion

The results of the field study showed that soil application of chelated micronutrient mixture (Iron methionate + Zinc lysinate) @ 2.5 kg ha⁻¹ with RDF (150:50:50 kg NPK ha⁻¹) significantly increased the plant height (51.8, 94 & 96.9 cm in Lalapuram village) at active tillering, panicle initiation and at harvest stages respectively and number of tillers hill⁻¹ (26.3 & 38.5 numbers in Lalapuram village) at active tillering and at panicle initiation stages respectively. This research is a preliminary attempt to increase the growth parameters of aerobic rice using Fe and Zn chelated micronutrient mixture. It could be concluded from the present study, that the application of chelated nutrients enhances plant height and number of tillers per hill than applying non-chelated micronutrient source.

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