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Comparative analysis of zinc sources and levels on growth and phenology of wheat (*Triticum aestivum* L.)

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Abstract
The present investigation was conducted during 2024-25 at Agronomy Research Farm, School of Agricultural Sciences, Jaipur National University, Jaipur, Rajasthan to evaluate the "Effect of Different Sources and Levels of Zinc on Growth Attributes and phenology of Wheat (*Triticum aestivum* L.). The experiment was laid out in Randomized Block Design with three replications. The experiment consists of ten treatments *viz.*, T_1: Control (No zinc or fertilizer), T_2: RDF of 120:60 N:P_2O_5 kg ha^{-1}, T_3: RDF + soil application of $ZnSO_4$ at 15 kg ha^{-1}, T_4: RDF + soil application of $ZnSO_4$ at 30 kg ha^{-1}, T_5: RDF + soil application of Zn-EDTA at 1.5 kg ha^{-1}, T_6: RDF + soil application of Zn-EDTA at 3.0 kg ha^{-1}, T_7: RDF + foliar $ZnSO_4$ at 0.5% at CRI, tillering and milking stage, T_8: RDF + foliar $ZnSO_4$ at 1.0% at CRI, tillering and milking stage, T_9: RDF + foliar Zn-EDTA at 0.25% at CRI, tillering and milking stage and T_{10}: RDF + foliar Zn-EDTA at 0.5% at CRI, tillering and milking stage. The present study revealed that significantly higher plant height, number of tillers per plant and dry matter accumulation with the soil application of $ZnSO_4$ at 30 kg ha^{-1} but it was at par with RDF + Soil application of Zn EDTA @ 3.0 kg ha^{-1} and RDF + Soil application of $ZnSO_4$ @ 15 kg ha^{-1} compared to control and RDF alone. Whereas, Zinc Sources and different levels did not exhibit a significant influence on plant stand, days required to 50% flowering and maturity.

Keywords: Growth, phenology, zinc, fertility and wheat

Introduction
Wheat (*Triticum aestivum* L.) is one of the most vital cereal crops worldwide, grown across all continents and serving as a staple food in over 90 countries. In India, wheat is a key component of national food security and an important export commodity, with major markets including Bangladesh, Nepal, Taiwan, and the UAE (Comtrade, 2023; DGCI & S, 2023) [8, 9]. Nutritionally, wheat grains offer 8-15% protein, 60-68% starch, 1.5-2% fat, 2-2.5% dietary fiber, and essential minerals, making them a valuable part of the human diet (Kumar *et al*., 2022) [13]. Globally, wheat is grown on about 220 million hectares, with an estimated production of 783 million tonnes in 2023-24, making it a vital contributor to global food and nutritional security (FAO, 2023) [11]. It is cultivated on 31.6 million hectares of area with 112.74 million tonnes of production and 3560 kg/ha productivity in India during 2023-24 (Anonymous, 2023) [a] [3], whereas in Rajasthan, crop grown on 5.5 million hectares area and produce 15.6 million tonnes with average productivity of 2840 kg/ha (Anonymous, 2023) [4].
Despite Rajasthan being a major wheat producer, its productivity is lower than the national average. among This difference can be attributed to factors like varying soil fertility, irrigation availability and crop management practices between regions. Among them, fertilizer and zinc management are crucial for the growth, yield, and quality of wheat. Zinc deficiency is particularly widespread in Indian soils, especially in arid and semi-arid regions, where it leads to poor vegetative growth, reduced biomass accumulation, and lower wheat yields (Shukla *et al*., 2017) [18]. Zinc is vital for various plant processes, including enzyme activation, protein synthesis and auxin production, all of which directly impact wheat development (Rengel and Graham, 1995) [17]. Addressing zinc deficiency through proper nutrient management can help improve wheat productivity, enhance resistance to diseases, and optimize grain quality, thus

contributing to better food security and economic stability. Efficient zinc management through soil application of zinc sulphate ($ZnSO_4$) or chelated zinc (Zn-EDTA) as well as foliar sprays at critical growth stages, has been shown to improve crop performance and nutrient use efficiency (Cakmak, 2008; Ramesh *et al.*, 2018) [6, 15]. Considering the importance of zinc nutrition for wheat growth, the present investigation was carried out to evaluate the effect of different sources and levels of zinc on growth attributes of wheat (*Triticum aestivum* L.). under the semi-arid conditions of Rajasthan, India.

Materials and Methods

Experimental Site

The experiment was conducted at the Research Farm, School of Agricultural Sciences, Jaipur National University, Jaipur, Rajasthan, located at 26°85' N latitude and 75°87' E longitude, with an altitude of 390 m above sea level. The site falls under the NARP agro-climatic zone IIIa (Semi-Arid Eastern Plain Zone) of Rajasthan.

Weather

The region has a hot semi-arid climate with extreme temperatures and low to moderate rainfall. Summers can reach up to 45°C, while winters are cooler, dropping to 5°C. The monsoon season brings limited rainfall (527 mm annually) and varying humidity, from 20-30% in summer to 60-80% in the monsoon. Winds range from 5-15 km/h, with gusts up to 40 km/h during dust storms. The area enjoys 8-10 hours of sunshine in summer, 6-8 hours in winter, and 4-6 hours during the monsoon. During the 2024-25 rabi season, temperatures fluctuated from 33.8 °C to 8.6 °C, with occasional rainfall.

Sampling and analyses

The soil in the experimental area is sandy loam of Gangetic alluvial origin, with 78% sand, 12% silt, and 10% clay. It has an alkaline pH of 7.74, low organic carbon (0.41%), and moderate levels of nitrogen (133.26 kg/ha), phosphorus (19.89 kg/ha), and high potassium (231.19 kg/ha). Physical analysis showed a bulk density of 1.52 Mg/m^3, particle density of 2.53 Mg/m^3, and porosity of 39.92%. The soil was analyzed using methods like the International Pipette Method and techniques for pH, conductivity, and nutrient analysis, as per established research standards.

Experimental setup

The experiment was laid out in Randomized Block Design with three replications. The experiment consists of ten treatments *viz.*, T_1: Control (No zinc or fertilizer), T_2: RDF of 120:60 N:P_2O_5 kg ha^{-1}, T_3: RDF + soil application of $ZnSO_4$ at 15 kg ha^{-1}, T_4: RDF + soil application of $ZnSO_4$ at 30 kg ha^{-1}, T_5: RDF + soil application of Zn-EDTA at 1.5 kg ha^{-1}, T_6: RDF + soil application of Zn-EDTA at 3.0 kg ha^{-1}, T_7: RDF + foliar $ZnSO_4$ at 0.5% at CRI, tillering and milking stage, T_8: RDF + foliar $ZnSO_4$ at 1.0% at CRI, tillering and milking stage, T_9: RDF + foliar Zn-EDTA at 0.25% at CRI, tillering and milking stage and T_{10}: RDF + foliar Zn-EDTA at 0.5% at CRI, tillering and milking stage. All required agronomic practices were implemented to ensure optimal crop growth and development. Observations were taken from five randomly selected plants in each plot to evaluate various growth attributes and dry matter from the gross plot. The number of days from sowing to 50% flowering and physiological maturity was also recorded. Statistical analysis of the data for each character was performed following the experimental design, and the simple correlation coefficient ('r') for each character was calculated (Gomez and Gomez1984) [12].

Results and Discussion

The influence of various sources and levels of zinc on wheat growth parameters, including plant population, plant height, number of tillers, and dry matter accumulation, is presented in Tables 1 to 3. Data presented in Table 1 and 2 indicate the different sources and levels of zinc significantly enhanced the growth parameters *viz.* plant height (cm), Number of tillers $plant^{-1}$and DMA (g $plant^{-1}$) at 30, 60, 90 DAS and at harvest.

Effect of different sources and levels of zinc

Plant stand

Plant population is a critical indicator of crop establishment and survival under different nutrient management practices. Whereas, Zinc Sources and different levels of zinc did not exhibit a significant influence on plant stand. Although plant population at 20 DAS and at maturity was statistically unaffected, slight numerical improvements under foliar Zn EDTA suggest enhanced early seedling vigor, consistent with reports by Cakmak (2008) [6] and Alloway (2009) [2].

Plant height (cm)

Plant height, a key parameter reflecting vegetative growth, showed significant improvement with zinc application at all stages of growth. The presented in Table 1 showed that significantly tallest plants were observed in T_4 (RDF + soil $ZnSO_4$ @ 30 kg ha^{-1}) with 27.50 cm, followed by T_6 (27.07 cm) and T_3 (26.62 cm), whereas the control plants recorded the lowest height of 19.41 cm. This trend persisted at 60 DAS, with T_4, T_6 and T_3 recording 76.80, 75.61, and 74.34 cm, respectively, while control plants remained significantly shorter at 60.48 cm. At 90 DAS and at maturity, T_4 consistently maintained the tallest stature (80.90 cm and 85.30 cm, respectively), followed by T_6 and T_3, with the control treatment recording the lowest values (63.71 cm and 67.17 cm, respectively). These observations suggest that soil-applied $ZnSO_4$, particularly at higher levels, enhanced vegetative growth throughout the crop cycle, likely due to improved nutrient uptake and utilization. This effect is attributed to zinc's role in auxin synthesis, cell elongation, and nutrient utilization (Marschner, 2012; Rashid *et al.*, 2011) [14, 16]. Foliar applications provided transient benefits but were less effective than soil treatments.

Number of Tillers per Plant

The number of tillers per plant, an important determinant of yield potential, was positively influenced by zinc application, although differences were statistically non-significant (Table 2). Maximum tillering was observed in T_4, which produced 7.53 tillers per plant, followed by T_6 (7.41) and T_3 (7.29). In contrast, the control plants produced the lowest number of tillers (6.45), whereas RDF-alone and other zinc treatments recorded intermediate values. Foliar-applied zinc treatments resulted in slightly lower tiller numbers (6.55-6.79), indicating that soil applications were more effective in promoting tillering compared to foliar sprays. These results demonstrate that zinc, particularly when applied to the soil, contributes to the enhancement of productive tillers per plant. Tillering showed a positive trend under soil-applied zinc, indicating better meristem activity and tiller survival, whereas foliar sprays had a limited effect, aligning with findings of Cakmak *et al.* (2010) [5] and Rengel (2015) [17].

Dry Matter Accumulation

Dry matter accumulation, an indicator of overall biomass production and crop vigor, exhibited significant differences among treatments at all stages of growth (Table 2). At 30 DAS, T_4 recorded the highest accumulation of 0.920 g plant^{-1}, followed by T_6 (0.906 g plant^{-1}) and T_3 (0.891 g plant^{-1}), while the control showed the lowest accumulation (0.725 g plant^{-1}). This trend continued at 60 DAS, with maximum biomass recorded in T_4 (4.50 g plant^{-1}), followed by T_6 (4.43 g plant^{-1}) and T_3 (4.36 g plant^{-1}), and the control at 2.94 g plant^{-1}. At 90 DAS, T_4 (11.90 g plant^{-1}) and T_6 (11.71 g plant^{-1}) again demonstrated superior biomass accumulation, whereas the control remained the lowest (8.37 g plant^{-1}). At maturity, the highest dry matter was observed in T_4 (13.65 g plant^{-1}), followed by T_6 (13.44 g plant^{-1}) and T_3 (13.21 g plant^{-1}), while the control treatment accumulated the least (9.75 g plant^{-1}). The enhanced dry matter accumulation under soil-applied $ZnSO_4$, particularly at 30 kg ha^{-1}, indicates improved photosynthetic efficiency and nutrient assimilation, resulting in higher biomass production throughout the growth period. The crop cycle, reflecting improved photosynthesis, enzyme activity, and nutrient assimilation (Abbas *et al*., 2009, Cakmak, 2000; Fageria *et al*., 2011) [1, 7, 10]. Foliar applications, though beneficial, supported comparatively lower biomass due to limited nutrient availability.

Phenological parameters

The data presented in Table 2 revealed that zinc fertilization had a measurable impact on the time required to attain 50% flowering and days required to maturity in wheat. Although the differences among treatments were statistically non-significant, zinc-treated plots consistently reached 50% flowering and maturity earlier than the control (T_1) and RDF alone (T_2). This indicates that soil-applied zinc, particularly at higher levels, may facilitate early flowering by improving zinc availability in the rhizosphere, leading to better enzymatic functioning and enhanced metabolic activity.

Table 1: Effect of different sources and levels of zinc on plant stand and Plant height (cm) of wheat

Treatments		Plant stand (000 ha^{-1})		Plant height (cm)			
		20 DAS	At Maturity	30 DAS	60 DAS	90 DAS	At Maturity
T_1	Control	890000	887632	19.41	60.48	63.71	67.17
T_2	Recommended dose of fertilizer (RDF) 120:60 N P_2O_5 kg ha^{-1}	890125	887757	23.60	65.91	69.43	73.20
T_3	RDF + Soil application of $ZnSO_4$ @ 15 kg ha^{-1}	890145	887777	26.62	74.34	78.31	82.57
T_4	RDF +Soil application of $ZnSO_4$ @ 30 kg ha^{-1}	890156	887788	27.50	76.80	80.90	85.30
T_5	RDF + Soil application of Zn EDTA @ 1.5 kg ha^{-1}	890126	887758	26.39	73.71	77.64	81.87
T_6	RDF + Soil application of Zn EDTA @ 3.0 kg ha^{-1}	890156	887788	27.07	75.61	79.64	83.97
T_7	RDF+ Foliar application of $ZnSO_4$ @ 0.5% at CRI, tillering and milking stage	890126	887758	24.56	68.58	72.24	76.17
T_8	RDF + Foliar application of $ZnSO_4$ @ 1.0% at CRI, tillering and milking stage	890135	887767	24.78	69.21	72.91	76.87
T_9	RDF + Foliar application of Zn EDTA @ 0.25% at CRI, tillering and milking stage	890256	887888	24.03	67.10	70.69	74.53
T_{10}	RDF + Foliar application of Zn EDTA @ 0.5% at CRI, tillering and milking stage	890250	887882	23.90	66.75	70.32	74.14
S.Em±		16484	16459	0.40	1.13	1.19	1.25
CD (p=0.05)		NS	NS	1.20	3.35	3.53	3.72

Table 2: Effect of different sources and levels of zinc on Number of tillers plant^{-1} at maturity and Dry matter accumulation (g plant^{-1}) of wheat

Treatments		Number of tillers plant^{-1} at maturity	Dry matter accumulation (g plant^{-1})				Phenological parameters	
			30 DAS	60 DAS	90 DAS	At Maturity	Days to 50% flowering	Days to Maturity
T_1	Control	6.45	0.725	2.94	8.37	9.75	75.68	134.56
T_2	Recommended dose of fertilizer (RDF) 120:60 N P_2O_5 kg ha^{-1}	7.23	0.790	3.86	10.21	11.71	74.09	136.00
T_3	RDF + Soil application of $ZnSO_4$ @ 15 kg ha^{-1}	7.29	0.891	4.36	11.52	13.21	71.82	138.50
T_4	RDF +Soil application of $ZnSO_4$ @ 30 kg ha^{-1}	7.53	0.920	4.50	11.90	13.65	70.32	140.00
T_5	RDF + Soil application of Zn EDTA @ 1.5 kg ha^{-1}	7.23	0.883	4.32	11.42	13.10	72.31	138.00
T_6	RDF + Soil application of Zn EDTA @ 3.0 kg ha^{-1}	7.41	0.906	4.43	11.71	13.44	71.25	139.00
T_7	RDF+ Foliar application of $ZnSO_4$ @ 0.5% at CRI, tillering and milking stage	6.72	0.822	4.02	10.63	12.19	72.97	136.80
T_8	RDF + Foliar application of $ZnSO_4$ @ 1.0% at CRI, tillering and milking stage	6.79	0.829	4.06	10.72	12.30	72.60	137.10
T_9	RDF + Foliar application of Zn EDTA @ 0.25% at CRI, tillering and milking stage	6.58	0.804	3.93	10.40	11.93	73.20	136.50
T_{10}	RDF + Foliar application of Zn EDTA @ 0.5% at CRI, tillering and milking stage	6.55	0.800	3.91	10.34	11.86	73.52	136.20
SEm±		1.25	0.014	0.07	0.17	0.20	1.84	2.06
CD (p=0.05)		NS	0.040	0.20	0.52	0.60	NS	NS

Conclusion

The appropriate zinc nutrition, especially through soil-applied $ZnSO_4$, significantly enhances wheat growth and biomass accumulation, leading to improved crop performance. Integrating zinc management into wheat cultivation optimizes nutrient use efficiency and boosts productivity, particularly in semi-arid regions. The application of $ZnSO_4$ at 30 kg ha^{-1} resulted in superior dry matter accumulation and biomass production across all growth stages. This emphasizes its critical role in enhancing photosynthesis, nutrient assimilation, and overall crop vigor.

Future Prospects

The results of this study highlight the critical role of zinc in enhancing wheat growth and biomass production. Future research may focus on optimizing integrated zinc management strategies, combining soil and foliar applications to maximize nutrient use efficiency. Evaluation of diverse wheat genotypes under varying agro-climatic conditions can refine zinc fertilization recommendations. Additionally, investigating the interactions of zinc with other macro- and micronutrients and its impact on grain quality, nutrient content, and stress resilience will contribute to sustainable and high-yielding wheat production systems.

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References

1. Abbas G, Aslam M, Malik MA, Ahmad I, Hussain M. Impact of soil-applied zinc and iron on wheat grain yield and yield components. Pak J Agric Sci. 2009;46(3):181-188.
2. Alloway BJ. Soil factors associated with zinc deficiency in crops and humans. Environ Geochem Health. 2009;31:537-548.
3. Anonymousa. Agricultural Statistics 2023-24: National Crop Production Report. New Delhi: Government of India, Ministry of Agriculture and Farmers’ Welfare; 2023. p. 45-46.
4. Anonymousb. Agricultural Statistics 2023-24: Rajasthan Crop Production Report. Jaipur: Government of Rajasthan, Department of Agriculture; 2023. p. 23-24.
5. Cakmak I, Kalayci A, Kaya M, Torun H. Zinc deficiency as a critical issue in wheat production. J Plant Nutr. 2010;33:1445-1466.
6. Cakmak I. Enrichment of cereal grains with zinc: Agronomic or genetic biofortification? Plant Soil. 2008;302:1-17.
7. Cakmak I. Role of zinc in protecting plant cells from reactive oxygen species. New Phytol. 2000;146:185-205.
8. Comtrade. World Trade Statistics 2023. New York: United Nations; 2023.
9. DGCI & S. Annual Export and Import Data 2023. Kolkata: Directorate General of Commercial Intelligence and Statistics, Government of India; 2023.
10. Fageria NK, Baligar VC, Clark RB. Micronutrients in crop production. Adv Agron. 2011;110:49-122.
11. FAO. World Food and Agriculture Statistics 2023. Rome: FAO Statistics Division; 2023.
12. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. 2nd ed. New York: John Wiley & Sons; 1984.
13. Kumar S, Sharma R. Nutritional composition of wheat and its role in human health. Int J Food Sci Nutr. 2020;5(2):101-110.
14. Marschner H. Marschner’s Mineral Nutrition of Higher Plants. 3rd ed. London: Academic Press; 2012.
15. Ramesh P, Sharma S, Meena V. Foliar and soil application of zinc improves wheat growth and grain yield. Indian J Agron. 2018;63(3):345-352.
16. Rashid A, Rengel B, Cakmak I. Zinc nutrition and its role in plant growth and development. Plant Soil. 2011;339:7-15.
17. Rengel Z, Graham RD. Importance of zinc in crop production and human health. Plant Soil. 1995;174:129-140.
18. Shukla AK, Singh S, Tiwari PK. Zinc nutrition in wheat: Growth, yield, and quality responses. J Plant Nutr. 2017;40(12):1795-1807.