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Interaction of Zinc with Cationic Micronutrients under Graded Levels of Chelated Zn in Typic Haplustalf

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ABSTRACT

The field experiment was conducted at 'B' block of Agricultural College and Research Institute, TNAU, Madurai in 2017-18 during *rabi* season to evaluate the interaction of Zn with cationic micronutrients on Typic Haplustalf with rice (TKM 13) as a test crop. The DTPA extractable Zn concentration in soil was greater with chelated Zn compared with $ZnSO_4$ application. The maximum Zn concentration in active tillering, panicle initiation, heading and post harvest stages was found to be 10.62, 11.23, 10.02 and 8.82 mg kg^{-1}, respectively, noticed in the treatment received 15 kg Zn ha^{-1} as Zn lysinate + RDF. The DTPA extractable iron, copper and manganese were found to be maximum in the treatment received RDF alone at all growth stages of rice. The maximum DTPA extractable Fe, Cu and Mn at post harvest stage soil were recorded as 11.9, 2.0 and 3.07 mg kg^{-1} respectively in RDF alone.

Key words: *Oryza sativa*, Zinc, Iron, Copper, Manganese, Zn lysinate, $ZnSO_4$

In India, rice (*Oryza sativa*) is considered as the principal cereal crop. Zinc is one of the essential micronutrients for plants, especially for rice growing under submerged conditions. Zinc is extremely indispensable nutrient for the growth and reproduction of rice and needed comparatively in trivial concentrations (5-100 mg kg^{-1}) failing which leads to Khaira disease will occur. The inadequate provision of Zn from the soil harmfully affects yield and the quality of crop.

Under submerged conditions, the conversion and supply zinc becomes low which leads to its deficiency (Hazra *et al*. 1987). Rice exhibits several deficiency symptoms viz. brown colour blotches in older leaves, stunted growth, longer duration for maturity, less in yield and ultimately plant may die at times (Neue and Lantin 1994). The easily dissolving $ZnSO_4$ is normally suggested for the correction of zinc deficiency. The Ethylene Diamine Tetra-Acetic acid (EDTA) is considered as important sources due to its chelated action but it has carcinogenic effect in the food chain. The chelated compounds are very slow in their nutrient releasing pattern leading to continuous supply with high stability than any other non-chelated compounds (Welch and Norvell 1993). The use of Zn – amino acid chelate may be an effective source than $ZnSO_4$ and Zn – EDTA. The antagonistic effect between Zn with cationic micronutrients generally reduces the availability and uptake of other micronutrients due to its competition. The application of chelated Zn increases the zinc availability by its slow release, non- conversion in the form of carbonates and conversion of less soluble fractions to more plant-available fractions. In case of higher doses of chelated Zn application might have replaced the other micronutrients from the adsorption sites and there by lowered the uptake and availability of Fe, Mn and Cu. Hence this study has been made to evaluate the interaction of Zn with cationic micronutrients by applying graded levels of chelated Zn and $ZnSO_4$.

MATERIALS AND METHODS

The field experiment was conducted at 'B' block of Agricultural College and Research Institute, TNAU, Madurai in 2017-18 during *rabi* season to evaluate the interaction of Zn with cationic micronutrients on Typic Haplustalf with rice (TKM 13) as a test crop. The field lies with GPS co-ordinates of 09°58'02.2" N latitude, 78°12'25.8" E longitude at an elevation of 147 m above MSL. The variety TKM 13 is semi dwarf, with 135 days maturity. The experiment was laid out in a randomized block design with eight treatments and replicated thrice. The eight treatments are RDF + $ZnSO_4$ @ 25 kg ha^{-1} (T_1), RDF + Zn lysinate @ 15 kg ha^{-1} (T_2), RDF + Zn lysinate @ 12.5 kg ha^{-1} (T_3), RDF + Zn lysinate @ 10 kg ha^{-1} (T_4), RDF + Zn lysinate @ 7.5 kg ha^{-1} (T_5), RDF + Zn lysinate @ 5.0 kg ha^{-1} (T_6), RDF + Zn lysinate @ 2.5 kg ha^{-1} (T_7) and RDF (150:50:50 kg NPK ha^{-1}) alone (T_8) were imposed to assess the interaction between chelated Zn and cationic micronutrients. As per the treatment schedule, nitrogen, phosphorus and potassium fertilizers were applied at the rates of 150, 50 and 50 kg ha^{-1} in the form of urea, super phosphate and muriate of potash, respectively. The entire dose of P was applied basally and N and K were applied in four equal splits viz. 1/4 as basal, 1/4 at active tillering stage and 1/4 at panicle initiation stage and 1/4 at heading stage of the crop.

Zinc sulphate @ 25 kg ha^{-1} mixed with sand for uniform distribution, was applied basally in the treatment, T_1. The Zn lysinate 2.5, 5.0, 7.5, 10.0, 12.5 and 15 kg ha^{-1} was mixed with sand (25 kg) and the mixture was broadcasted uniformly as per the schedule (T_7 to T_2). The T_8 was applied only with RDF. The size of each plot was 5 × 4 m. After execution of all treatment materials in the respective plots, 21-day-old rice seedlings were transplanted per hill at a spacing of 25 × 25 cm. Irrigation channels measuring 0.5 m wide were placed between the replications to ensure easy and uninterrupted flow of irrigation water where an individual plot was independently irrigated from the irrigation channels.

Chemical properties of experimental soil were pH 8.2, EC (0.32) dSm^{-1}, organic C 6.4 g kg^{-1}, CEC 25.2 cmol (p^+) kg^{-1}, DTPA- Zn 0.92 mg kg^{-1}, DTPA- Fe 18.4mg kg^{-1}, DTPA- Cu 3.09 mg kg^{-1}, DTPA - Mn 5.22 mg kg-1, available N 196 kg ha^{-1}, available P 24.5 kg $ha^{-1}$and available K 321 kg ha^{-1}. The DTPA extractable Zn, Fe, Cu and Mn were recorded at different growth stages of rice. The micronutrients are analysed using Atomic Absorption Spectrophotometer ICE 3000 series (3300 Model) from M/s Thermofisher India Private Ltd. All replicated data were analyzed statistically using AGRES software.

RESULTS AND DISCUSSION

DTPA extractable Zn in soil

The amount of DTPA extractable Zn in soil as affected by different sources and levels of Zn is presented in (Fig 1). Higher levels of available Zn resulted from soil application of Zn lysinate @ 15 $kgha^{-1}$ (8.82 mg kg^{-1}) and lesser available Zn was found in RDF alone (0.55 mg kg^{-1}) in post harvest stage soil. The availability of zinc decreased with advancement of crop growth and could be attributed to uptake and other losses during the crop growth. Based on results, available Zn gradually increased in initial growth stages thereafter decreased with growth of the crop. The similar study was concluded by Kirk and Bajita (1995). In water logged soil, the availability of native as well as applied Zn as $ZnSO_4$ decreases due to precipitation as $ZnCO_3$ or ZnS. The relatively higher maintenance of DTPA-Zn in soil is mainly due to application of chelated Zn. This might due to less reaction of chelated Zn with various components of soil, results higher concentrations in soil solution. The similar findings were reported by Ortiz and Garcia (1998). The fixation of Zn was more in $ZnSO_4$ treated soil compared to chelate application. Because of rapid dissociation of Zn^{2+} causes subsequent precipitations in soil. These results are in accordance to the findings of Giordano *et al*. (1974).

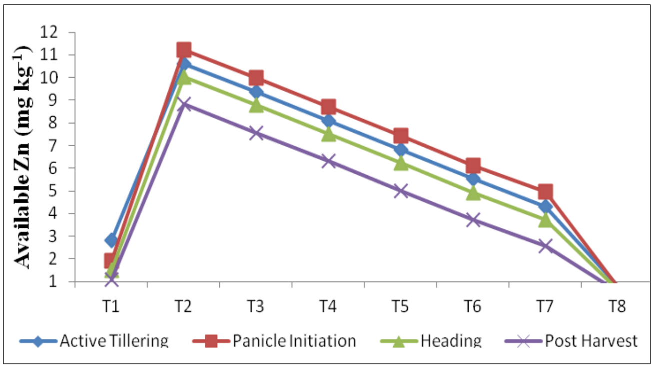

Fig 1 Effect of chelated Zn on soil available Zn (mg kg^{-1}) at different growth stages of rice

Interaction with other micronutrients

DTPA extractable Iron

The results showed that application of chelated Zn at graded levels had a significant influence on availability of Fe by the rice crop at different growth stages. Among the treatments, the treatment which had received RDF alone registered higher available Fe than chelated Zn and $ZnSO_4$ treatment. Lowest availability was recorded in the treatment received chelated Zn 15 kg ha^{-1} + RDF. At active tillering stage, the availability (Table 1) varied from 9.8 to 16.3 mg kg^{-1}. At panicle initiation and heading stages, availability ranged from 6.6 to 13.5 mg kg^{-1} and 5.2 to 12.4 mg kg^{-1}, respectively. The soil application of RDF alone (T_8) recorded highest iron availability at all the growth stages (16.3 mg kg^{-1} at active tillering, 13.5 mg kg^{-1} at panicle initiation and 12.4 mg kg^{-1} at heading stages). The lesser available iron is registered in treatment (T_2) with soil application of chelated Zn 15 kg ha^{-1} + RDF at all the growth stages (9.8 mg kg^{-1} at active tillering, 6.6 mg kg^{-1} at panicle initiation and 5.2 mg kg^{-1} at heading stages).

Table 1 Effect of chelated Zn on DTPA - iron (mg kg^{-1}) at different growth stages of rice

Treatments	DTPA - iron (mg kg^{-1})			
	Active tillering	Panicle initiation	Heading	Post harvest
T_1	16.1	12.9	11.6	11.1
T_2	9.8	6.6	5.2	4.5
T_3	10.1	6.9	5.5	4.8
T_4	11.3	8.1	6.7	6.0
T_5	12.9	9.7	8.3	7.6
T_6	14.0	10.8	9.4	8.7
T_7	15.7	12.5	11.1	10.4
T_8	16.3	13.5	12.4	11.9
S.Ed.	0.17	0.15	0.20	0.11
CD (P=0.05)	0.37	0.33	0.43	0.24

The availability of iron in post harvest soil (11.9 mg kg^{-1}) was found to be maximum in the treatment T_8 (RDF alone). Among chelated Zn applied treatments, the availability of iron will be decreased with increasing levels of chelate Zn application. This is due addition of higher doses of chelated Zn might have replaced the iron from the adsorption sites resulted in the lower available Fe. The maximum amount of Fe was found because of its less utilization from soil. These results are in line with the earlier findings of Sakal *et al.* (1993).

Table 2 Effect of chelated Zn on DTPA - copper (mg kg^{-1}) at different growth stages of rice

Treatments	DTPA - copper (mg kg^{-1})			
	Active tillering	Panicle initiation	Heading	Post harvest
T_1	2.63	2.18	1.97	1.87
T_2	1.53	1.07	0.87	0.79
T_3	1.71	1.25	1.05	0.97
T_4	1.91	1.45	1.25	1.17
T_5	2.17	1.71	1.51	1.43
T_6	2.35	1.89	1.69	1.61
T_7	2.58	2.15	1.92	1.78
T_8	2.74	2.28	2.08	2.0
S.Ed.	0.04	0.03	0.03	0.04
CD (P=0.05)	0.09	0.07	0.06	0.08

DTPA extractable - Copper

The application of chelated Zn significantly influences the availability of Cu at different growth stages. The available Cu (Table 2) ranged from 1.53 to 2.74 mg kg^{-1} at active tillering stage. The soil application of RDF alone (T_8) recorded maximum available Cu of 2.74 mg kg^{-1} at active tillering stage. At panicle and heading stages, available Cu ranges from 1.07 to 2.28 mg kg^{-1} and 0.87 to 2.08 mg kg^{-1} respectively. The maximum availability was registered by RDF alone as 2.28 panicle initiation stage and 2.08 mg kg^{-1} at heading stage. The treatment received (T_2) chelated Zn 15 kg ha^{-1} + RDF registered lower available Cu in both the stages viz. panicle initiation (1.07 mg kg^{-1}) and heading stage (0.87 mg kg^{-1}). The soil application of RDF alone was recorded as maximum available Cu in post harvest soil as 2 mg kg^{-1}. The results are in agreement with the findings of Banerjee *et al.* (2006) who reported that availability of Copper decreased with increasing level of chelated Zn application at all the stages of the crop which could be due to release of these nutrients into soil solution by mineralization and through improved soil environment which would have favoured more absorption. This might due to antagonistic effect between Zinc and Copper.

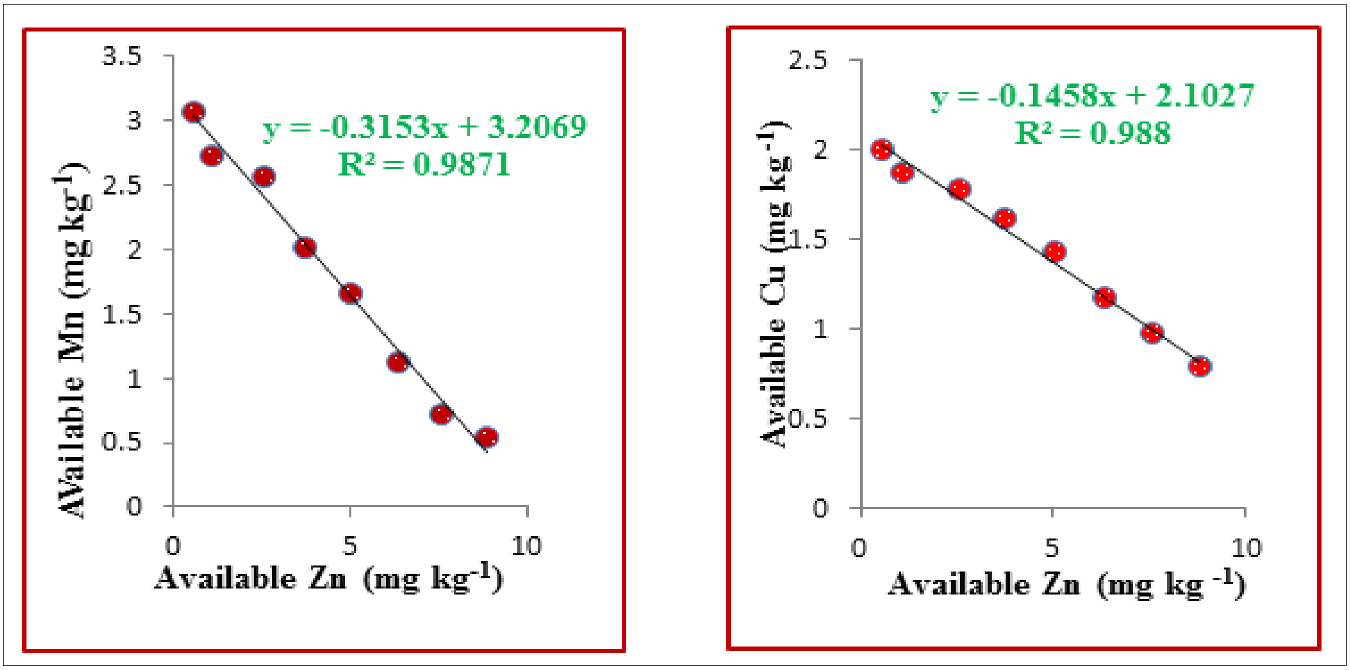

Fig 2 Correlation between available Zn and available Mn and Cu (mg kg^{-1}) at postharvest stage

DTPA extractable- Manganese

Manganese availability decreased with growth stages of rice (Table 3). At the active tillering stage, available manganese ranged from 2.29 to 4.52 mg kg^{-1}. The soil application of RDF alone (T_8) recorded maximum availability of 4.52 mg kg^{-1}. The maximum available Mn was observed by the same treatment at panicle initiation (3.59 mg kg^{-1}) and heading stages (3.23 mg kg^{-1}). The lesser available manganese were recorded in treatment received chelated Zn 15 kg ha^{-1} + RDF alone (T_2) in tillering, panicle initiation and heading stages (2.29, 1.23 and 0.77mg kg^{-1} respectively). The application of RDF alone (T_8) recorded the maximum available manganese in post harvest stage (3.07mg kg^{-1}) than all other treatments followed by the application of (T_1) chelated $ZnSO_4$ @ 25 kg ha^{-1} + RDF. Wu *et al.* (2005) also documented decreased micro nutrient availability by treatmental combination of chelated Zn with recommended dose of NPK. Cakmak (2010), Stalin *et al.* (2011) also reported that chelated Zn application to Zn deficient soil increased uptake of Mn. The application of chelated Zn in higher doses decreased the availability of Mn due to antagonistic effect between Zn and other micronutrients. Competition for adsorption sites between Zn and other micronutrients might be maximum at higher doses of chelated Zn application. The similar findings also reported by Takkar *et al.* (1989). The available Zn and other micronutrients are negatively correlated due to its antagonistic effect between the nutrients. The correlation between the available Zn and other nutrients are depicted in (Fig 2, 3).

Table 3 Effect of chelated Zn on DTPA - manganese (mg kg^{-1}) at different growth stages of rice

Treatments	DTPA - manganese (mg kg^{-1})			
	Active tillering	Panicle initiation	Heading	Post harvest
T_1	4.48	3.42	2.96	2.73
T_2	2.29	1.23	0.77	0.54
T_3	2.47	1.41	0.95	0.72
T_4	2.87	1.81	1.35	1.12
T_5	3.40	2.34	1.88	1.65
T_6	3.76	2.70	2.24	2.01
T_7	4.32	3.26	2.80	2.57
T_8	4.52	3.59	3.23	3.07
S.Ed.	0.08	0.04	0.03	0.02
CD (P=0.05)	0.19	0.09	0.07	0.05

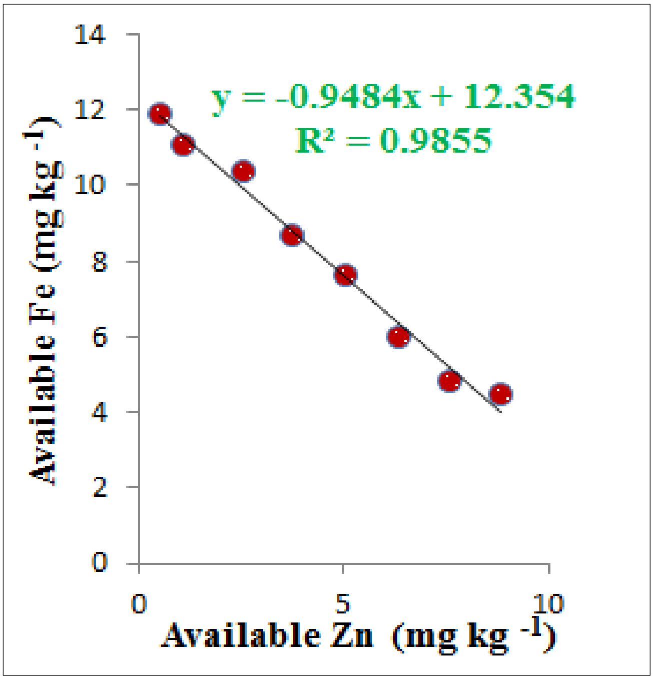

Fig 3 Correlation between available Zn and available Fe (mg kg^{-1}) at post harvest stage

LITERATURE CITED

Banerjee H, Pal S and Maiti S. 2006. Integrated effect of organic and inorganic fertilizer on the productivity and profitability of rice grown under rice–rice crop sequences in the Gangetic West Bengal. *Journal of Crop and Weed* **2**(1): 40-44.

Cakmak I. 2010. Biofortification of cereals with zinc and iron through fertilization strategy. *In*: *19th World Congress of Soil Science, Soil Solutions for a Changing World* **5**: 1-6.

Giordano P M, Noggle J C and Mortvedt J J. 1974. Zinc uptake by rice, as affected by metabolic inhibitors and competing cations. *Plant and Soil* **41**(3): 637-646.

Hazra G C, Mandal B and Mandal L N. 1987. Distribution of zinc fractions and their transformation in submerged rice soils. *Plant and Soil* **104**(2): 175-181.

Kirk G J D and Bajita J B. 1995. Root-induced iron oxidation, pH changes and zinc solubilization in the rhizosphere of lowland rice. *New Phytologist* **131**(1): 129-137.

Neue H U and Lantin R S. 1994. Micronutrient toxicities and deficiencies in rice. *In*: *Soil Mineral Stresses*. Springer. pp 175-200.

Ortiz E M E and Garcia O A. 1998. Process of sorption of zinc in three soils of Colombia cultivated with rice (*Oryza sativa*) of the dry land variety Llano-5. *In*: *Proceedings of the VIII Congress of Soil Sciences, Santa Marta, Colombia. Suelos-Ecuatoriales* **28**: 112-117.

Sakal R, Sinha R B, Singh A P and Bhogal N S. 1993. Evaluation of methods and time of zinc application to rice. *Journal of the Indian Society of Soil Science* **41**(1): 195-196.

Stalin P, Das T, Muthumanickam D, Chitdeshwari T and Velu V. 2011. Foliar nutrition of rice to enhance micronutrient concentration in grains. *International Rice Research Notes*. pp 117-4185.

Takkar P N, Chhibba I M and Mehta S K. 1989. Twenty years of coordinated research on micronutrients in soils and plants. Indian Institute of Soil Science, Bhopal. pp 1967-87.

Welch R M and Norvell W A. 1993. Growth and nutrient uptake by barley (*Hordeum vulgare* L. cv Herta): Studies using an N-(2-Hydroxyethyl) ethylenedinitrilotriacetic acid-buffered nutrient solution technique (II. Role of zinc in the uptake and root leakage of mineral nutrients). *Plant Physiology* **101**(2): 627-631.

Wu S C, Cao Z H, Li Z G, Cheung K C and Wong M H. 2005. Effects of biofertilizer containing N-fixer, P and K solubilizers and AM fungi on maize growth: a greenhouse trial. *Geoderma* **125**(1/2): 155-166.