Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2021; 10(1): 370-372
Received: 01-11-2020
Accepted: 03-12-2020

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Effect of chelated zinc fertilizer on growth parameters of maize crop

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DOI: https://doi.org/10.22271/phyto.2021.v10.i1f.13332

Abstract
Maize is a high nutrient demanding and zinc responsive crop. A Field study was conducted at farmer's field, Pavali village of Viruthunagar district during 2019-2020 to evaluate the effect of chelated zinc fertilizer on growth parameters of maize (*Zea mays* L.). The experiment was laid out as randomized block design with five replication. The results showed that plant height (192.5 cm), leaf length (80.4 cm), leaf breadth (9.82 cm), no. of leaves (13.2) and leaf area index (5.28) responded positively towards soil and foliar application of chelated Zn Formulation @ 7.5 kg ha^{-1} with 0.5% as foliar spray at 30 & 45 DAS (T_8) than absolute control.

Keywords: Chelated zinc, plant height, leaf area index, maize

Introduction
Maize (*Zea mays)* is called as "Queen of cereals" and one of the world's paramount cereal crops after Rice and Wheat and a high nutrient demanding crop which is used for human consumption and feed for animals. In India, maize is cultivated in 9.02 million ha (2017-18) area with an annual production of 28.1 million tonnes (2019-20) and productivity in 3070 kg ha^{-1} (India stat 2017-2018). In Tamil Nadu, Maize is cultivated on 0.39 million ha with the production of 2.83 million tonnes and the productivity is 7258 kg ha^{-1} (India stat, 2017-18).
The micronutrients even being required in smaller amounts are of equally vital for plant growth and development as of macronutrients because micronutrients not only enhance the grain yields but also contribute to the improvement of the quality of grain nutrients. It was further elucidated that micronutrients can increase grain yield up to 50% and increase macronutrients' use efficiency (Tariq *et al*. 2014). Among the micronutrients, Zn is considered to be the most important nutrient and it also ranks next to the macronutrients *viz*., N, P, and K throughout the world (Pandey *et al.*, 2013) [10]. Zn availability is critical for several key physiological functions in plants including growth regulation, photosynthesis, sugar formation, seed production, and defense mechanisms against various diseases (Khattak *et al.* 2015). It is estimated that almost half of the soils in the world are deficient in Zn (Alloway, 2008) [1]. Plants generally uptake Zinc as a free divalent cation (Zn^{2+}), but monovalent cation ($ZnOH^{+}$) prevails at high pH. On calcareous soils, adsorption and fixation reactions can substantially reduce the efficacy of micronutrients (Tahir *et al.*, 2009) [13]. The efficiency of micronutrients can be increased up to 60 – 80% when it is chelated. Apart from expensive, synthetic fertilizers such as EDTA and DTPA poses a serious threat to the environment because of poor biodegradability and leaching. Further compared with synthetic chelates, amino chelates represent a safer and more efficient form of fertilizer, resulting in better plant performance and fewer environmental risks. Aminochelates represent effective fertilizers for both soil and particularly for foliar applications (Souri 2016) [12]. In this regard a study was conducted in order to assess the effect of chelated micronutrient on growth of maize.

Materials and Methods
Site description: The field experiment was conducted in farmer's field during *Rabi* season (November - February) of 2019-2020 at Pavali village, Virudhunagar district, Tamil Nadu with GPS co-ordinates of 9 º6' N latitude and 77 º56' E longitude at an elevation of 215 m above MSL. The soil of experimental field was sandy clay loam, calcareous with pH of 8.2 (moderately alkaline) and EC of 0.26 dsm^{-1} (non saline). The nutrient status of field include low in available N (135 kg ha^{-1}), medium in available P (7.6 kg ha^{-1}), low in available K (41.3 kg ha^{-1}) and low amount of DTPA extractable zinc (1.12 mg kg^{-1}).

Experimental design: The study was carried out to assess the effect of aminoacid chelated fertilizer in enhancing the potential of maize. The experiment was laid out in Randomized Block Design with nine treatments replicated five times. Plot size of 5 x 4 m (20 m^2) was adopted with buffer channel around each plot in the experimental field with maize variety COH (M) 8 as a test crop. The treatment details were absolute control (T_1), STCR (soil test crop response) (T_2), T_2 + Blanket recommendation ($ZnSO_4$ @ 37.5 kg ha^{-1}) (T_3), T_2 + $ZnSO_4$ Enriched FYM @ 37.5 kg ha^{-1} (T_4), T_2 + Chelated Zn Formulation @ 5.0 kg ha^{-1}(T_5), T_2 + Chelated Zn Formulation @ 7.5 kg ha^{-1} (T_6), T_2 + Chelated Zn Formulation @ 5.0 kg ha^{-1} + 0.5% spray at 30 & 45 DAS (T_7), T_2 + Chelated Zn Formulation @ 7.5 kg ha^{-1} + 0.5% spray at 30 & 45 DAS (T_8), T_2 + Commercially available Chelated Zn @ 5.0 kg ha^{-1} (T_9). The full dose of P and K was applied as basal. As per the treatment schedule, N was applied in three equal splits, $1/4^{th}$ at time of sowing, remaining half the dose of N was applied on 30 DAS and the remaining quarter quantity of N was applied on 45 DAS as top dressing for all the treatments (T_2 to T_9) except control based on soil test crop response (STCR). N, P and K were supplied through Urea, Single Super Phosphate and Muriate of Potash, respectively. Zinc sulphate @ 37.5 kg ha^{-1}(T_3), FYM enriched $ZnSO_4$ (1:10 ratio) (T_4) was applied as a basal treatment. The Zn lysinate chelate @ 5.0, 7.5 kg ha^{-1} was mixed with sand (25 kg) and the mixture was broadcast uniformly as per treatment schedule (T_5 to T_8)**.** 0.5% of foliar application of zinc lysinate was given for the treatments T_7 and T_8 at 30 and 45 DAS.

Observation: Five plants from each plot were selected randomly and labeled for recording growth parameters at different growth stages *viz.*, 30, 60 days after sowing and at harvest of the crop. Height of the five labeled plants was measured from the base of the plant to fully opened leaf and the average was computed to get plant height. Length of all the fully opened leaf was measured from the base to top of the leaf and breadth was taken at the widest point of the leaf laminate. The product of leaf length and the breadth was multiplied by the factor 0.75. Leaf area index is defined as leaf area per unit land area. It was calculated by dividing the leaf area per plant by the land area occupied by each plant. The data recorded on various growth parameters were analyzed following statistical analysis of SAS software.

Research findings and discussion

Effect of treatments on growth attributes of maize

The growth parameters of maize *viz*., plant height, leaf length, leaf width, no of leaves and leaf area index were positively influenced due to chelated zinc application.

Plant height (Table 1): The maximum plant height was recorded with the treatment receiving chelated Zn Formulation @ 7.5 kg ha^{-1} with 0.5% as foliar spray at 30 & 45 DAS (T_8) (103.6, 187.9 and 192.5 cm) and the least plant height of 65.6, 122.1 and 127.9 cm was observed with the absolute control (T_1) at vegetative, tasseling and harvest stages respectively (table 1). The conclusive effect of Zn fertilization on plant height is similar to the findings of Naik and Das (2007) [9] who reported that due to the adequate supply of zinc which contributed to accelerate the enzymatic activity and auxin metabolism in plants. Further the results obtained were in close conformity with Khalid *et al.*, 2013 [6] who revealed that application of Zn in chelated form increases the plant height significantly compared to Zn applied in the form of $ZnSO_4$. The favorable effect of micronutrients Zn in improving plant height is due to its role in enhancement of photosynthetic and chlorophyll structure formation, augmenting cell elongation and division which lead to an increase in plant metabolism resulting in the increased plant growth parameters over the control. (Rukmani *et al.*, 2018) [11]

Leaf length, leaf breadth and no. of leaves per plant (Table 2): Maximum leaf length and breadth of 80.4 and 9.82 cm was recorded from the treatment received Chelated Zn Formulation @ 7.5 kg ha^{-1} with 0.5% as foliar spray at 30 & 45 DAS (soil + foliar application) which significantly differ from other treatments and minimum leaf length and breadth (66.9 and 7.11 cm) was recorded with absolute control (table 2). Leaf length, leaf breadth and no. of leaves per plant were important yield contributing parameters in maize. A significant variation in no. of leaves per plant due to the effect of application of chelated Zn was observed as compared other treatments. The number of leaves per plant ranged between 8.8 to 13.2 cm at harvest stages respectively. With respect to other treatments the maximum no. of leaves per plant was documented with chelated Zn Formulation @ 7.5 $kgha^{-1}$ $^{+}$ 0.5% as foliar spray at 30 & 45 DAS (T_8) with13.2 which was statistically equivalent with T_7 (13.0) and lowest no. of leaves per plant (8.8) was recorded with the absolute control at harvest stages. An increase in the above growth parameters due to application of zinc may be attributed to improvement in plant growth and enhancement in the photosynthetic and other metabolic activities which led to increase in various plant metabolites responsible for cell division and cell elongation due to optimum supply of nutrients and also increased growth of internodal portion with higher synthesis of growth hormones like indole acetic acid (IAA) and metabolizing gibberlic acid (Asha *et al.*, 2012; Dhanalakshmi *et al.*, 2019; Krishnaraj *et al.*, 2020) [4, 5, 8].

Leaf area index (Table 2): Higher values of leaf area index (5.28) is prevailed with application of chelated Zn Formulation @ 7.5 kg ha^{-1} with 0.5% as foliar spray at 30 & 45 DAS compared to the absolute control (1.91). The increase in LAI with Zn application probably may be due to increase in tryptophan amino acid and indole acetic acid hormone which are two main factors in leaf area expansion (Amanullah *et al.*, 2016) [2]. Leaf area index enhanced with increasing growth period, after reaching the maximum, it stopped to the final harvest of the crop. It was observed that foliar application of zinc had positive effect on biological activity, metabolism and stimulating the photosynthetic pigments and enzyme activity encouraged the vegetative growth of the plants, consequently increased the leaf area index (Anees *et al*., 2016) [3].

Conclusion

Soil application of chelated Zn Formulation @ 7.5 kg ha^{-1} with 0.5% as foliar spray at 30 and 45 DAS enhanced the growth parameters and leaf area index due to easy and timely availability of zinc compared to other sources of zinc application.

Table 1: Effect of chelated zinc fertilizer on plant height at different growth stages of Maize (Mean of five replications)

Treatments	Plant height (cm)		
	Vegetative Stage	Tasseling Stage	At harvest
T_1 - Absolute Control	65.6	122.1	127.9
T_2 - STCR	90.2	160.6	168
T_3 - T_2 + Blanket recommendation ($ZnSO_4$ @ 37.5 $kgha^{-1}$)	92.3	164.0	171.8
T_4 - T_2 + $ZnSO_4$ Enriched FYM @ 37.5 $kgha^{-1}$	94.7	167.5	175.6
T_5 - T_2 + Chelated Zn Formulation @ 5.0 $kgha^{-1}$	96.2	170.9	177.9
T_6 - T_2 + Chelated Zn Formulation @ 7.5 $kgha^{-1}$	99.7	178.5	184.7
T_7 - T_2 + Chelated Zn Formulation @ 5.0 $kgha^{-1}$ + 0.5% spray at 30 & 45 DAS	101.5	183.3	188.6
T_8 - T_2 + Chelated Zn Formulation @ 7.5 $kgha^{-1}$ + 0.5% spray at 30 & 45 DAS	103.6	187.9	192.5
T_9 - T_2 + Commercially available Chelated Zn @ 5.0 $kgha^{-1}$	98.2	175.2	181.6
SEd	0.94	1.68	1.72
CD(P=0.05)	1.91	3.41	3.50

*DAS – Days after sowing

Table 2: Effect of chelated zinc fertilizer on leaf length, leaf breadth, no. of leaves and leaf area index at harvest stage of Maize

Treatments	Leaf length (cm)	Leaf breadth (cm)	No. of leaves	Leaf area index
T_1	60.9	7.11	8.8	1.91
T_2	69.2	8.84	11.8	3.61
T_3	71.8	9.04	12.0	3.89
T_4	74.1	9.22	12.2	4.17
T_5	74.4	9.26	12.3	4.24
T_6	77.1	9.45	12.5	4.55
T_7	79.3	9.64	12.6	4.82
T_8	81.4	9.82	13.2	5.28
T_9	76.7	9.43	12.9	4.67
SEd	1.02	0.08	0.09	0.05
CD(P=0.05)	2.08	0.16	0.18	0.11

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