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Effect of zinc and magnesium on growth and yield of maize (*Zea mays* L.)

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Abstract
A field experiment was conducted during Zaid (summer) season of 2023 at Crop Research Farm Department of Agronomy. The experiment was laid out in a Randomized Block Design with 10 treatments and replicated thrice. The treatments consisted of soil application of zinc at 20 kg/ha, foliar application at 0.5% and their combination at 0.5% and 10 kg/ha and 3 levels of (Magnesium at 5, 15, 25 kg/ha) along with recommended doses of nitrogen, phosphorus and potash and a control (120-60-40 kg N-P-K/ha). Foliar application of 0.5% Zinc with the combination of soil application of 10 kg/ha Zinc and 25kg/ha Magnesium (treatment 9) recorded higher plant dry weight (95.16 g), yield attributes more No. of cobs per plant (1.93), Grains per cob (249.33), Test Weight (268.1 g), Grain yield (6.58 t/ha) and benefit cost ratio of (2.68).

Keywords: Maize, zinc, magnesium, growth and yield

Introduction
Maize (*Zea mays* L.) is a domesticated grass of tropical Mexican origin belongs to large and important family of Poaceae and being a C4 plant has the highest potential of per day carbohydrate productivity. Maize has ten chromosomal pairs, based on the endosperm of the kernels, it is split into eight classes. It is grown all over the world and is one of the most significant cereal crop. Maize is a flexible crop that may be produced in a variety of agro-climatic zones and a growing cycle spanning from 3 to 13 months (CIMMYT, 2000). Maize provides staple food for human beings, quality feed for animals and serves as a basic raw material to thousands of industrial products. Maize grain contains about 72% starch, 10% protein, 4.8% oil, 5.8% fiber, 3.0% sugar and 1.7% ash (Narwal, 1993) [6]. In India, the total area under cultivation is 9.89 million hectares, production 31.65 million tonnes, productivity 31.99 q/ha. Among Indian states Madhya Pradesh and Karnataka has highest area under maize and Andhra Pradesh and Telangana having the highest productivity.

Zinc was one of the first micronutrients, essentiality of which for plant growth has been confirmed. Zinc also plays a role in nucleic acid and protein synthesis and helps in the utilization of phosphorus and nitrogen, as well as in seed formation. Zinc being essential nutrient plays a significant role in stomatal regulation, various enzymatic and physiological activities and performs many catalytic functions in plant system besides transformation of carbohydrates, chlorophyll and protein synthesis (Singh, 2009) [10]. Maize is the plant species particularly vulnerable to zinc deficiency. Zn is a micronutrient that increases maize grain productivity. Zinc can be supplied directly to soil or by foliar spray or treated to the seed. Zinc, a critical nutrient, plays an important part in stomata regulation and lowering the stresses of less water by creating ionic balance in the plant system, as well as being involved in physiological processes such as protein and glucose synthesis.. Magnesium is key component of several biological processes (CO2 fixation in photosynthesis, photophosphorylation, protein and chlorophyll synthesis, phloem loading, and translocation of assimilates) in leaves (Cakmak and Yazici, 2010) [2]. The photosynthetic assimilates from leaves are transported to the sink organs (such as roots, shoot tips, and seeds), and stored as starch or converted to hexoses to increase crop yield under sufficient Mg status. Sucrose transport from source to sink tissues occurs through phloem by invertase and sucrose synthase enzymes.

Hence, appropriate Mg concentration in leaves is essential to ensure activities of enzymes involved in source-to-sink transport of Mg and sugars, which can be achieved by planting proper species as well as managing Mg fertilizer rates (White and Broadley, 2009) [14]. Mg2+ and closely related sugar production in leaves are of utmost importance for biomass accumulation and grain development. Mg2+ also promotes assimilate partitioning and translocation to source tissues.

Materials and Methods

This experiment was laid out during the *Zaid* season of 2022 at Crop Research Farm, Department of Agronomy. A field experiment was conducted during Zaid season of 2023 at Crop Research Farm of the Department of Agronomy. The soil of experimental plot was sandy loam, having a nearly neutral soil reaction (pH 7.1), electrical conductivity 0.29 ds/m, medium in available nitrogen (225 kg/ha) and potassium (240.7 kg/ha), and low in available phosphorous (38.2 kg/ha). Maize seeds (Hybrid Maize G-0786) were sown on April 20, 2023 with a spacing of 45 × 10 cm. Fertilizers were applied as band placement, for which 4-5 cm deep furrows were made along the seed rows with a hand hoe. The recommended dose of 120-60-60 kg NPK/ha was applied. Half of nitrogen, whole phosphorus and potash was applied as basal at the time of sowing. Manual weeding was done at 30 and 45 days after sowing. Zinc and Magnesium were applied as per the treatments. Data recorded on different aspects was statistically analyzed. (Gomez and Gomez, 1984**)** [3] and economic data analysis mathematical method.

Results and Discussion

Growth parameters Plant dry weight

At 80 DAS, highest plant dry weight (134.15) was recorded in treatment 9. However, treatments 1, 2, 3, 4, 5, 6, 7 and 8 (125.05 g, 127.45 g, 128.13 g, 129.91 g, 130.24 g, 131.22 g, 132.30 g, 133.25 g) were found to be statistically at par with the maximum.

kumar *et al*. (2019) [5] study indicated that, the growth contributing characters, namely plant height (206.07 cm), dry matter per plant (89.76 g) and yield contributing characters. Zn is an element of vital importance and has numerous essential functions in plants. Zn is important for plant growth as it induces photosynthesis and enzymatic activity of carbonic anhydrase. Dry matter yield of maize seedling to interaction of magnesium and nitrogen rate with 120 kg/ha increased the seedling biomass at the 5th leaf stage in accordance with increasing rate of Mg up to 22 kg/ha. Szulc and Waligora (2010) [12]**.**

Number of cobs per plant

Significant and maximum number of cob/plants Treatment9 (1.93). However, treatment 6, 7 and 8 (1.63 and 1.75) were found to be statistically at par with maximum.

An experimental data showed that, the yield contributing characters namely cob/plant (1.34), number of rows/cob (14.19), number of seeds/cob (405), cob weight (97.88), cob length (14.82 cm) was significantly higher by seed treatment of Zn at 4 g/kg with sulphur 20 kg/ha (Rengel 1995) [15]. Ali *et al*, (2013) [1] found that application of sulphur at 25 and 35 kg/ha and zinc at 4 g/kg gave significant increase in no. of days of tasseling and silking.

Number of grains per cob

Significant effect was observed by the statistical analysis of number of grains/cobs. Treatment9 and treatment8(238.00) found to be statistically at par with maximum.

Dissoky *et al.* (2017) [8] research concluded that increase of significantly grain and stalk, 100 grain weight, grain contain of oil protein by the application of Mg rate of 50 kg 0.5% of Mg foliar spray in clay loam soil and for the rate 75 kg in sandy soil. The result of this experiment showed that combined application of zinc sulphate at 37.5 kg/ha with 0.5% foliar spray at 20 and 40 DAS recorded significantly higher in growth and yield parameters like plant height (211.6 cm), dry matter production (12758 kg/ha), cob initiation (48.73 days), green cob yield (18637 kg/ha) and green fodder yield (31592 kg/ha) compared to other treatments

Seed index (g)

Significant and maximum (26.81 g) was recorded with treatment (8). However, treatment 9 was statistically at par with the maximum.

Hanuman *et al*. (2021) [4] reported that soil application of Zinc (5.0 kg/ha) and Iron (10 kg/ha) along with 2.5 t/ha vermicompost gave maximum increase in yield attributing characteristics *viz.* cob length (19.25cm & 19.80 cm), cob girth (13.60cm & 13.95 cm), number of grain row/cob (17cm & 17cm), number of grains/row (33 & 35), test weight (24.10 gm & 24. 30 gm) in comparison to all the treatments during 2019 and 2020.

Grain yield (t/ha)

The grain yield showed increasing trend with the application of Magnesium and zinc in maize. The highest grain yield was obtained with the treatment 9 (6.58). Treatment 5,6,7 and 8 were found to be statistically at par with maximum.

Shamsun *et al* (2015) [9] studied that the response of maize to magnesium was quadratic in nature and the optimum dose of magnesium appear to be 19 kg/ha which resulted in the maximum yield of 10,507 kg/ha. The application of 10 kg zinc/ha recorded significantly higher dry matter accumulation of (103.69 g/plant) and green fodder yield (33.07t/ha) over non zinc application (30.78 t/ha), respectively. Tahira *et al*. (2018) [13].

Table 1: Influence of Zinc and magnesium on yield attributes and yield of maize.

S. No.	Treatment combinations	Dry weight (g)	No. of cobs/pl ant	No. of grains/cob	Seed index (g)	Grain yield (t/ha)	B:C ratio
1.	0.5% Zinc Foliar application+5 kg/ha Magnesium	125.05	1.22	214.67	21.44	3.79	1.41
2.	0.5% Zinc Foliar application+5 kg/ha Magnesium	127.45	1.32	216.00	22.9	4.54	1.77
3.	0.5% Zinc Foliar Application + 25 kg/ha Magnesium	128.13	1.44	217.67	23.17	4.87	1.91
4.	20 kg/ha Zinc soil Application+ 5 kg/ha Magnesium	129.91	1.52	219.00	23.82	4.96	1.97
5.	20 kg/ha Zinc soil Application+ 15 kg/ha Magnesium	130.24	1.59	225.00	24.49	5.34	2.12
6.	20 kg/ha Zinc Application + 25 kg/ha Magnesium	131.22	1.63	227.67	25.19	6.09	2.45
7.	0.5% Zinc foliar Application + 10 kg/ha zinc soil application + 5 kg/ha Magnesium	132.30	1.75	238.00	25.75	6.23	2.62
8.	0.5% Zinc Foliar Application + 10 kg/ha zinc soil application+ 15 kg/ha Magnesium	133.25	1.81	245.00	26.81	6.35	2.62
9.	0.5% Zinc Foliar Application + 10 kg/ha zinc soil application + 25 kg/ha Magnesium	134.15	1.93	249.33	26.56	6.58	2.68
	S.Em(±)	3.42	0.10	3.89	1.34	0.44	-
	CD (p = 0.05)	10.17	0.31	11.56	3.98	1.32	-

Conclusion

It is concluded that foliar application of 0.5% and soil application of 10 kg/ha zinc in combination with 25 kg/ha of magnesium (treatment 9) recorded highest grain yield and benefit cost ratio.

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