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EFFECT OF FORMS OF ZINC AND LEVELS OF IRON ON GROWTH AND YIELD OF SUMMER MAIZE (*Zea mays* L.)

SUMANT KUMAR DIWAKAR*, SHIKHA SINGH AND B. SHEKHAR MAHANTA
Department of Agronomy, Naini Agricultural Institute,
SHUATS, Prayagraj -211 008
e-mail: sumantarya.198@gmail.com

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***Corresponding author**

ABSTRACT

A field study was conducted at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during Zaid season of 2019, to evaluate the effect of forms of Zinc and levels of Iron on growth and yield of summer Maize (*Zea mays* L.). The experiment consisted of 12 treatment combinations involving ($ZnSO_4$ and chelated zinc along with $FeSO_4$). All treatments received NPK @ 120-50-40 kg/ha respectively. Results showed that plant height (178.79 cm) and number of leaves per plant (9.87) did not differ significantly. However, The treatment combination [(application of 5 kg chelated Zinc + 20 kg/ha $FeSO_4$ (T5) recorded the higher values in growth parameters *viz*., leaf area index (3.63) and dry weight (244.38 g/plant) and higher grain yield (4.86 t/ha), Stover yield (7.31 t/ha), yield parameters *viz*., number of grains per row (37.27) rows per cob (18.40), seed index (34.29 g). This experiment shown treatment receiving 5 kg chelated Zinc + 20 kg/ha $FeSO_4$ was more productive.

INTRODUCTION

Maize (*Zea mays* L.) is the most important food crop of the world. It is cultivated in both tropical and temperate regions of the world. Maize is the third most important food grain in India after wheat (*Triticum aestivum* L.) and rice (*Oryza sativa* L.). Maize is called as "queen of cereals" and "miracle crop" because of its higher productive yield potential (22 t/ha) compared to any other cereal crops in India, out of total production of maize, 45 % is consumed as a staple food in various forms. It is grown worldwide over an area of 185 million hectares with a production of 1018 million tonnes and productivity of 5.49 tonnes/ha. In India, maize is grown in an area of 9.43 million hectare, with production of 24.53 million tonnes and productivity of 2583.00 kg/ha (Agricultural statistics at a glance, 2014) and in Uttar Pradesh, the production of maize 1.15 million tonnes with the productivity of 1462.2 kg/ha (ministry of agriculture, GOI). In India, about 28 % of maize produced is used for human food purpose, about 11% as livestock feed, 48% as poultry feed, 12% in wet milling industry and 1% as seed (Anonymous, 2007). On an average maize grain is composed of 60 % carbohydrate, 10 % protein, 4.5 % oil, 3.5 % fibre and 2 % minerals. It also contains 348 mg P, 286 mg K, 114 mg S, 10 mg Ca, 2.3 mg Fe and 90 mg of carotene per 100 g grain.

All India Coordinated Research Project on Micronutrients delineated the soils of India regarding the deficiency of micronutrients. At present about 48.1 % of Indian soils are deficient in diethylene - tri amine pent acetate (DTPA) extractable zinc and 11.2 % in iron. Zinc (Zn) and iron (Fe) deficiencies are well-documented public health issue and an important soil fertility constraint to crop production. Maize is highly susceptible to Zn deficiency and Zn fertilizers are used routinely in many parts of the world where the crop is grown. According to soil test analysis, zinc and iron deficiency were found in Prayagraj. In India, average response of 0.47 t maize grain/ha (mean values of 280 experiments) to Zn fertilizer application has been reported by Singh and Behera, 2011. Zinc is essential for plants, animals and man. A critical small concentration of Zinc is required to perform several key pathways in plant. Balanced nutrition is considered as one of the basic needs "to achieve the potential yield" (Yadav *et al*., 2017). Hence, soil application of Zn fertilizers is recommended for ameliorating Zn deficiency in soil and for obtaining higher crop yield and better crop quality. Many Zn containing material such as inorganic compounds, chelates and multi-micronutrient mixtures are available in the market for ameliorating Zn deficiency in soil. Zinc fertilizers could potentially be improved by using chelates that facilitate metal absorption by plant roots (Marschner, 1995). In the chelated form, metal ions are less likely to react and immobilize by the soil components and are more likely to be delivered to the plant root (Mortvedt *et al*., 1999).

In humans and animals, iron plays a central role in metabolic processes. Being a component of haemoglobin, iron helps in the oxygen transport and storage in red blood cells. It is also necessary for oxidative metabolism and cellular growth of organisms and serves as co-factor of important enzyme systems. Iron nutrient is critical for chlorophyll formation, photosynthesis, plant enzyme systems and respiration and plays role in biological redox system, enzyme activation and oxygen carrier in nitrogen fixation. Generally, there is a close geographical overlap between soil deficiency and human deficiency of Zn and Fe indicating a high requirement for increasing concentrations of micronutrients. A rapid and complementary approach is therefore required for biofortification of food crops with Zn and Fe in the short term. The present study was there for carried out to assess the effect of forms of Zn (chelated zinc and $ZnSO_4$) and levels of Iron sulphate on growth, yield and yield attributes of maize grown on SHUATS, Prayagraj.

MATERIALS AND METHODS

The proposed research was conducted at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (UP), which is located at 25°24' 42" N latitude, 81° 50' 56" E longitude and 98 m altitude above the mean sea level, during summer (zaid) season of 2019 on sandy loam soil. The climate of the region is semi-arid subtropical. The experiment was conducted using randomized block design (RBD) having three replications. The experiment was comprised of treatments combination of T_1 - 25 kg/ha $ZnSO_4$ + 15 kg/ha $FeSO_4$, T_2 - 25 kg/ha $ZnSO_4$ + 20 kg/ha FeSO4, T_3 - 25 kg/ha $ZnSO_4$ + 25 kg/ha $FeSO_4$, T4 - 5 kg chelated Zinc + 15 kg/ha $FeSO_4$, T_5 - 5 kg chelated Zinc + 20 kg/ha $FeSO_4$, T_6 - 5 kg chelated Zinc + 25 kg/ha $FeSO_4$, T_7 - 10 kg chelated Zinc + 15 kg/ha $FeSO_4$, T_8 - 10 kg chelated Zinc + 20 kg/ha $FeSO_4$, T_9 - 10 kg chelated Zinc + 25 kg/ha $FeSO_4$, T_{10} - 15 kg chelated Zinc + 15 kg/ha $FeSO_4$, T_{11} - 15 kg chelated Zinc + 20 kg/ha $FeSO_4$ and T_{12} - 15 kg chelated Zinc + 25 kg/ha $FeSO_4$. Maize composite variety SHIATS MAKKA -2 @25kg/ ha was sown using fertilizer @ 120-50-40 NPK (kg/ha). Full dose of P, K and half dose of N was applied by broadcast at sowing while remaining nitrogen was equally side dressed at knee high (days after sowing) and tesseling stages for all treatments. Seeds were sown in line that is 45 cm apart with plant to plant distance of 30 cm, placing two seeds per hill. Thinning was done after 15 days of emergence. Zinc and iron fertilizers were also applied at the time sowing of using recommended dose according to the treatment combinations. Zinc and Iron are firstly mixed with small amount of soil after that it applied in the furrow.

Chemical analysis of soil

Composite soil samples were collected before layout of the experiment to determine the intial soil properties. Soil samples were taken before sowing of crop at a depth of 15 cm for physico-chemical analysis (Table 1) and were dried under shade, were powdered with wooden pestle and mortar, passed through 2 mm sieve and were used for analysis. Collected soil samples were analyzed for organic carbon by rapid titration method (Sparks, 1996), Available nitrogen was estimated by alkaline permanganate method by Subbiah and Asija (1956), available phosphorus by Olsen's method as outlined by Jackson (1967), available potassium was determined by extracting with natural normal ammonium acetate solution and estimating by using flame photometer (ELICO Model) as outlined by Jackson (1973), available $ZnSO_4$ was estimated by Atomic Absorption Spectrophotometer method as outlined by Lindsay and Norvell (1978) and available iron was estimated by DTPA soil testing method.

Statistical analysis

Data collected in one season experimentation and subjected to statistically analysis by using Fishers method of Analysis of variance (ANOVA), the procedures given by Gomez and Gomez (1984). Critical Difference (CD) values were calculated the 'F' test was found significant at 5% level.

RESULTS AND DISCUSSION

Growth indices of maize

Application of chelated zinc and iron did not significantly improve the plant height and number of leaves per plant. Comparative study of mean values (Table 2) Maximum plant height (185.79 cm) and leaves per plant (9.87) were recorded in 5 kg chelated Zinc + 20 kg/ha $FeSO_4$ while least plant height (160.5 cm) and leaves per plant (8.53) were observed in 25 kg/ha $ZnSO_4$ + 20 kg/ha $FeSO_4$ and 25 kg/ha $ZnSO_4$ + 25 kg/ha $FeSO_4$ respectively, Although not significant. This was probably attributable to the genetic factor which control plant height and number of leaves per plant. This was in accordance with the findings of S. Sreethu and Shikha Singh (2020).

Significant effect of Zn chelates and iron on leaf area was observed by using leaf area meter (Tahir *et al*., 2009). Comparison of mean values revealed significant differences among the treatment means ranging from minimum LAI (1.08) in 25 kg/ha $ZnSO_4$ + 15 kg/ha $FeSO_4$ to maximum (2.60) in 5 kg chelated Zinc + 20 kg/ha $FeSO_4$ followed by 15 kg chelated Zinc + 20 kg/ha $FeSO_4$ (2.44), which were statistically at par. The chelated zinc exhibited higher values of leaf count, which may be due to the efficient and quick absorption of zinc by maize (Obrador *et al*., 2003).

Comparison of mean values revealed significant differences among the treatment means ranging from minimum dry matter production (188.27 g/plant) in 25 kg/ha $ZnSO_4$ + 15 kg/ha $FeSO_4$ to maximum dry weight (244.38 g/plant) in 5 kg chelated Zinc + 20 kg/ha $FeSO_4$ followed by 5 kg chelated Zinc + 25 kg/ha $FeSO_4$ (228.27 g/plant) and 15 kg chelated Zinc + 25 kg/ha $FeSO_4$ (238.02 g/plant) at harvesting stages, which were statistically at par. Similar findings were observed (Kumar and Salakinkop, 2018). This phenomenon might be due to slow, continuous release and proper nourishment of crop with zinc and iron application could be attributed to increased total dry matter production as results of better uptake of Zn and Fe and their translocation to reproductive parts. Chelation releases the nutrients slowly in the soil system in such a way that the nutrients are protected from fixation and made available to

Table 1: Physico-chemical Characteristic

Parameter	Value (pre sowing)	Value (post sowing)
Texture	Sandy loam	Sandy loam
pH	7.6	7.5
EC	0.305dS/m	0.65dS/m
Organic carbon	0.32	0.35
Available nitogen	83.50 kg/ha	78.75 kg/ha
Available phosphorus	9.4 kg/ha	18.0 kg/ha
Available potassium	187.5 kg/ha	257.6 kg/ha
Zinc	0.72 ppm	0.80 ppm
Iron	4.97 ppm	7.74 ppm

Table 2: Effect of forms of zinc and levels of iron on growth of maize (at harvest)

Treatments combination	Plant height (cm)	Leaves/plant (No.)	Leaf area index (at75 DAS)	Dry weight (g/plant)
25 kg/ha $ZnSO_4$ + 15 kg/ha $FeSO_4$	174.31	9.13	1.86	188.27
25 kg/ha $ZnSO_4$ + 20 kg/ha $FeSO_4$	160.56	9.8	3.02	196.05
25 kg/ha $ZnSO_4$ + 25 kg/ha $FeSO_4$	169.59	8.53	3.3	222.77
5 kg chelated Zinc + 15 kg/ha $FeSO_4$	166.9	8.73	2.92	214.72
5 kg chelated Zinc + 20 kg/ha $FeSO_4$	185.79	9.87	3.63	244.38
5 kg chelated Zinc + 25 kg/ha $FeSO_4$	177.32	9.67	3.03	228.07
10 kg chelated Zinc + 15 kg/ha $FeSO_4$	166.31	9.07	3.05	213.43
10 kg chelated Zinc + 20 kg/ha $FeSO_4$	175.74	9.13	3.35	221.72
10 kg chelated Zinc + 25 kg/ha $FeSO_4$	167.6	9.2	3.18	198.07
15 kg chelated Zinc + 15 kg/ha $FeSO_4$	179.65	9.73	3.22	193.4
15 kg chelated Zinc + 20 kg/ha $FeSO_4$	177.32	9.6	3.17	221.25
15 kg chelated Zinc + 25 kg/ha $FeSO_4$	184.15	9.33	3.12	238.02
SEm±	7.21	0.47	0.13	7.26
CD (P=0.05)	NS	NS	0.36	21.3

Table 3: Effect of forms of zinc and levels of iron on yield of maize

Treatments combination	Grains/row (No.)	Rows/cob (No.)	Seed index (g)	Gains yield (t/ha)	Stover yield (t/ha)
25 kg/ha $ZnSO_4$ + 15 kg/ha $FeSO_4$	26.4	13.2	25.18	3.02	6.24
25 kg/ha $ZnSO_4$ + 20 kg/ha $FeSO_4$	31.07	14	26.43	3.03	6.43
25 kg/ha $ZnSO_4$ + 25 kg/ha $FeSO_4$	30.55	15.2	27.4	3.46	6.61
5 kg chelated Zinc + 15 kg/ha $FeSO_4$	34.67	15.6	28.6	3.51	7.09
5 kg chelated Zinc + 20 kg/ha $FeSO_4$	37.27	18.4	34.29	4	7.31
5 kg chelated Zinc + 25 kg/ha $FeSO_4$	35.2	16.8	29.5	3.5	7.06
10 kg chelated Zinc + 15 kg/ha $FeSO_4$	32.6	17.87	29.8	3.77	7.19
10 kg chelated Zinc + 20 kg/ha $FeSO_4$	34.47	15.47	28.55	3.45	6.95
10 kg chelated Zinc + 25 kg/ha $FeSO_4$	36.13	16	28.49	3.41	6.89
15 kg chelated Zinc + 15 kg/ha $FeSO_4$	34.27	15.6	29.89	3.51	7.07
15 kg chelated Zinc + 20 kg/ha $FeSO_4$	35	15.73	29.94	3.52	7.13
15 kg chelated Zinc + 25 kg/ha $FeSO_4$	35.73	16	29.95	3.52	7.32
SEm±	2.48	0.98	1.44	0.16	0.29
CD (P=0.05)	5.15	2.05	2.98	0.47	0.6

the plant root system throughout the crop growth (Meena *et al.*, 2000). Enhanced dry matter production with adequate supply of NPK and Zn, as evidenced in this investigation corroborates the findings of Meena *et al.*, 2013. Application of micronutrients might enhance dry matter transformation from store part to sink parts (Singaraval *et al.*, 1996).

Yield indices of maize

The results are quite conclusive in predicting the significant impact of chelated zinc and iron treatment combination on yield indices of maize. Number of grains/row, rows/cob, 100-grains weight (g), grain yield (t/ha) and stover yield (t/ha) were affected significantly.

A study of comparison of mean (Table 4) for 100-grain weight showed significant differences among the treatment ranging from (25.18 g) in 25 kg/ha $ZnSO_4$ + 15 kg/ha $FeSO_4$ to (34.29 g) in 5 kg chelated Zinc + 20 kg/ha $FeSO_4$. These results were found similar with the findings of Hariss *et al.* (2007) who reported significant results regarding concerned parameter.

On the other hand comparison of mean values for number of grains per row and rows per cob showed significant differences among the treatment means that varied from 26.40 to 37.27 and 13.20 to 18.40 respectively. Maximum number of grains per row (37.27) and rows per cob (18.40) were reported in 5 kg chelated Zinc + 20 kg/ha $FeSO_4$ which is superior over application of 25 kg/ha $ZnSO_4$ + 15 kg/ha $FeSO_4$, 25 kg/ha $ZnSO_4$ + 20 kg/ha $FeSO_4$ and application of 25 kg/ha $ZnSO_4$ + 25 kg/ha $FeSO_4$, others treatment were found at par. While the least number of grains per cob (26.40) were recorded in 25 kg/ha $ZnSO_4$ + 15 kg/ha $FeSO_4$. And rows per cob (18.40) were reported in 5 kg chelated Zinc + 20 kg/ha $FeSO_4$ followed by application of 5 kg chelated Zinc + 25 kg/ha $FeSO_4$ and application of 10 kg chelated Zinc + 15 kg/ha $FeSO_4$ which is at par. While the least number of grains per cob (26.40) and rows per cob (13.20) were recorded in 25 kg/ha $ZnSO_4$ + 15 kg/ha $FeSO_4$ where Zn chelates were not applied. These results were found similar with the findings of Hariss *et al.* (2007) who reported that there was significant increase in the grains number per cob and rows per cob with the application of Zinc.

The increase in grain yield (4.00 t/ha) of maize due to the soil application of 5 kg chelated Zinc + 20 kg/ha $FeSO_4$ followed by 10 kg chelated Zinc + 15 kg/ha $FeSO_4$ (3.77 t/ha) which were statistically at par and stover yield (7.32 t/ha) due to application of 15 kg chelated Zinc + 25 kg/ha $FeSO_4$ followed by 5 kg chelated Zinc + 20 kg/ha $FeSO_4$ which were statistically at par. Similar observations were recorded by (Kumar and Salakinkop, 2018). This could be due to the improved in yield attributes like increased number of grains per row (37.27), no. rows per cob (18.40) and test weight (34.29 g) compared to other treatment. Variation in yield and yield attributes could be traced back to the improved growth parameters like leaf area index and dry matter production. The increase in the yield attributes could be due to continuous supply of chelated zinc along with iron combination to the crop. Zn and Fe are part of the photosynthesis, assimilation and translocation of photosynthates from source (leaves) to sink (Singh *et al.*, 1995). The increase in yield due to zinc and iron application may be attributed to their role in various physiological processes and improvement in growth components better partitioning of carbohydrates from leaf to reproductive parts resulting in increased yield. It could also be ascribed to its improvement in metallo enzymes system regulatory function and growth promoting auxin production especially during the enrichment process to last for a longer time and release the nutrients slowly in the soil system in such a way that the nutrients are protected from fixation and made available to the plant root system throughout the crop growth (Veeranagappa *et al.*, 2010) resulting increase grain yield , stover yield of maize crop. The results are in conformity with the findings of Meena *et al.*, 2015, Mugenzi *et al.*, 2018, Nikhil *et al.*, 2018 and singh *et al.*, 2015.

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