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Nutraceutical Verification of Zinc and Iron Nutrition in Corn (*Zea Mays* L.) Through Agronomic Approach

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ABSTRACT

A field experiment was conducted for two consecutive late *kharif* seasons of 2003 and 2004 to study the response of hybrid maize to micronutrient management practices. Foliar application of Zn and Fe (T_7) registered the highest protein, tryptophan and crude protein content, which was comparable with soil application of Zn and Fe (T_4) and foliar application of Zn (T_5) during both the years of study. The highest Zn uptake by grain was recorded with foliar application of Zn and Fe (T_7), which was in parity with soil application of Zn and Fe (T_4) and foliar application of Zn (T_5). With respect to Fe uptake foliar application of Zn and Fe (T_7), however, was comparable with foliar application of Fe ($T\text{-}_6$) only. The lowest grain yield, with poor quality grain and lesser Zn and Fe uptake were observed with control (T_1) during both the years.

Key words : Iron, Maize, Quality, Yield, Zinc.

Maize (*Zea mays* L.) is one of the most important cereal crops in the world's agricultural economy, both as a food for human consumption and as a feed for livestock. It is known as a "queen of cereals" because of its maximum yield potential (22 t ha^{-1}) among the cereals. It has higher level of industrial utilization than any other cereal grains because of it's diversified by products, higher production potential and wider adaptability. The cultivation must attract attention to eradicate twin problems of hunger and malnutrition in our country. Maize as good source of carbohydrates and rich in dietary fibers (2.7g $100g^{-1}$), is now being an essential part of balanced nutritional diet, prevents constipation, colon cancer, obesity, diabetes, hypertension and certain types of heart ailments. It is rich in iron (3 mg $100g^{-1}$) ; zinc (3 mg $100g^{-1}$), fats (3.6g $100g^{-1}$), vitamins, minerals (1.5gm 100 g^{-1}) and protein content (11g $100g^{-1}$) compared to other cereals. It has 7% albumin, 5% globulin, 52% prolamin, 2.5% glutein), 6% non proteinaceous nitrogen and 5% residual nitrogen. The order of nutritional quality of the four soluble fractions of cereal proteins are albumin> globulin> glutein>prolamin. In recent years, new maize genotype known as Quality Protein Maize (QPM) hybrids *Viz.* Shakthi -1, Shaktiman-1, Shaktiman-2 have 80% biological value and 92% true protein besides 2 to 3 fold increase in essential amino acids like lysine and tryptophan respectively. Exploitive agriculture involving modern production technology with the introduction of high yielding hybrids, coupled with use of high analysis fertilizers lead to deficiency of micronutrients, particularly zinc and iron. In future, it may emerge as an alarming situation in the intensively cultivated areas.

Khurana *et al.,* (2002) observed spectacular response of maize to Zn and Fe application. Since maize is gaining accelerated popularity and the micronutrients, particularly zinc and iron have attained a great significance in the present version of intensive and exploitive agriculture, aiming at increased productivity and nutritional security. Undoubtedly, the use of high analysis fertilizers must be suprlumented with zinc and iron applied at the right time through an appropriate method (soil or foliar) to, sustain and improve productivity besides quality of corn (Singh *et al.,* 2000).Employing a suitable method of application of optimum doses of Zn and Fe enhances the use efficiency and its recovery in the economic produce.

MATERIAL AND METHODS

The field experiment was carried out during wet season at S.V. Agricultural College Farm, Tirupati. The soil was sandy loam, neutral in reaction (pH 7.0 and 6.93), with low organic carbon

(0.25 and 0.27%) and available N (181 and 196 kg ha^{-1}), medium in available P (29.3 and 29.1 kg ha^{-1}) and K (176 and 173 kg ha^{-1}) in the respective growing seasons. The experiment was laid out in randomized block design with three replications. T_1-Control, T_2-Soil application of $ZnSO_4$ @ 25 kg ha^{-1}, T_3-Soil application of $FeSO_4$ @ 25 kg ha^{-1}, T_4-Soil application of $ZnSO_4$ + $FeSO_4$ @ 25 kg ha^{-1} each, T_5-Foliar application of $ZnSO_4$ at tasseling and silking, T_6-Foliar application of $FeSO_4$ at tasseling and silking, T_7-Foliar application of $ZnSO_4$ + $FeSO_4$ at tasseling and silking . Maize, DHM-103 was used in the study. Uniform dose of 60 kg ha^{-1} each of P_2O_5 and K_2O were applied as basal for all the treatments. The protein content was estimated with Lowry's method (Lowry *et al.,* 1951), Tryptophan content by Colorimetric method (Sadasivam and Manickam 1992) and stover crude protein by(A.O.A.C 1984) and available Zinc and Iron ((Lindsay and Norvel, 1978) in the laboratory.

RESULTS AND DISCUSSION

Effect of Zinc and Iron on the yield of Maize

The results of investigation have clearly brought out a noticeable trend of response to micronutrient management practices (Table -1), during both the years of study. The highest seed yield of maize was recorded with foliar application of Zn and Fe (T_7), which was however, comparable with soil application of Zn and Fe (T_4) and foliar application of Zn alone (T_5).These three treatments increased the grain yield to the tune of 32.4, 30.0 and 29.8 per cent, respectively over the control. Increase in yield due to Zn and Fe application is attributed to early bloom, increased number of bold seeds, grain weight per cob and 100 seed weight. The results corroborates with the concept of Basavaraju *et al.,* (1995). The next best treatment was T_2, which was however, comparable with foliar application of Fe (T_6) and soil application of Fe (T_3). Application of Fe through foliage (T_6) and soil (T_3) recorded 15.0 and 14.1 per cent higher yield, respectively over control. Iron is a structural component of cytochrome and feridon and it plays an important role in the synthesis and maintenance of chlorophyll, oxidation-reduction reactions and nucleic acid metabolism. Application of Zn alone or along with Fe either through soil or foliage (T_7, T_4, T_5 and T_2) increased the stover yield over rest of the treatments, which might be due to higher stature of growth parameters (plant height and dry matter).

Effect of zinc and Iron on quality parameters of Maize

Grain Protein content:

Different micronutrient management practices exerted considerable influence on the protein content of maize grain, during both the years of study. Foliar application of Zn and Fe (T_7) registered the highest protein content, which was in parity with soil application of Zn and Fe (T_4) and foliar application of Zn (T_5), during both the years of investigation. This may be ascribed due to the vital role played by the zinc in IAA synthesis and protein metabolism. The results are in accordance with those of Narwal and Mahendra Singh (1993). Control plot (T_1) recorded the lowest protein content, which was however, comparable with soil application of Fe (T_3) and foliar application of Fe (T_6), during both the years under study.

Grain Tryptophan content:

Micronutrient management practices exerted noticeable effect on tryptophan content of maize grain, during both the years of study. The highest tryptophan content was recorded with foliar application of Zn and Fe (T_7), which was in parity with soil application of Zn and Fe (T_4), foliar application of Zn (T_5) and soil application of Zn (T_2), during both the years of study. Increase in tryptophan may be ascribed due to function of Zn as an activator of tryptophan. Control plot (T_1) recorded the lowest tryptophan content, which was however, comparable with soil application of Fe (T_3) and foliar application of Fe (T_6), during both the years of study.

Crude protein content in maize stover:

During both the years of investigation, the highest content of crude protein in the maize stover was registered with foliar application of Zn and Fe (T_7), which was in parity with soil application of Zn and Fe (T_4), foliar application of Zn (T_5) and soil application of Zn (T_2). The control plot (T_1) recorded the lowest crude protein of the stover, which was however, comparable with soil application of Fe (T_3) and foliar application of Fe (T_6), during both the years of investigation.

Table 1. Seed yield (kg ha^{-1}), Protein and tryptophan content (%) of maize grain as influenced by Zinc and Iron nutrition during 2003 and 2004.

Treatments	2003			2004		
	Seed yield	Protein	Tryptophan	Seed yield	Protein	Tryptophan
T_1	2650	8.46	0.021	2600	8.49	0.024
T_2	3100	9.11	0.048	3108	9.19	0.044
T_3	3025	8.48	0.023	3005	8.53	0.029
T_4	3447	9.62	0.053	3410	9.62	0.058
T_5	3441	9.55	0.051	3390	9.52	0.053
T_6	3050	8.53	0.024	3020	8.61	0.030
T_7	3510	9.73	0.058	3450	9.71	0.060
SEm±	107.5	0.136	0.0051	90.2	0.097	0.0048
CD (P=0.05)	331	0.42	0.016	228	0.30	0.015

Table 2. Zinc and Iron uptake (kg ha^{-1}) of maize grain and the crude protein (%) of stover as influenced by Zinc and Iron nutrition during 2003 and 2004.

Treatments	2003			2004		
	Zinc	Iron	Crude protein	Zinc	Iron	Crude protein
T_1	0.136	Grain	7.30	0.135	Grain	7.31
T_2	0.158	0.525	8.38	0.159	0.512	8.36
T_3	0.137	0.780	7.34	0.138	0.746	7.39
T_4	0.181	0.732	8.66	0.180	0.718	8.70
T_5	0.176	0.820	8.51	0.175	0.816	8.61
T_6	0.140	0.800	7.40	0.138	0.810	7.59
T_7	0.181	0.990	8.96	0.181	0.981	8.96
SEm±	0.0051	1.086	0.230	0.0045	1.089	0.221
CD (P=0.05)	0.016	0.048	0.71	0.014	0.045	0.68

Effect of zinc and iron on nutrient uptake

Zinc uptake by grain: During both the years of study, the highest Zn uptake by grain was recorded with foliar application of Zn and Fe (T_7), which was however, comparable with soil application of Zn and Fe (T_4) and foliar application of Zn (T_5). This might be due to higher concentration of Zn accumulated in the grain from the active leaves closer to the cob, which received foliar feeding at tasselling and silking stages. Control plot (T_1) recorded the lowest Zn uptake by grain, which was however, on par with foliar application of Fe (T_6) and soil application of Fe (T_3), during both the years of investigation.

Iron uptake by grain: The highest Fe uptake by maize grain was recorded with foliar application of Zn and Fe (T_7), which was however, comparable with foliar application of Fe (T_6). Control plot (T_1) recorded the lowest grain Fe uptake, during both the years of study. Foliar application of Fe alone or along with Zn resulted in direct absorption of Fe by the actively growing foliage. Contrary to this, the lower Fe uptake with soil application might be due to reversion to unavailable forms, shortly after it is applied to iron deficit soils, indicating the fact that the soil application of iron is agronomically less efficient (Khurana *et al.,* 2002).From the fore going discussion, we can infer that the grain yield and zinc uptake by grain were the highest with foliar application of Zn and Fe (T_7), which were however, comparable with soil application of Zn and Fe (T_4) and foliar application of Zn alone (T_5). All the cereals without exception are deficit in three essential minerals viz., iron, zinc and calcium, over 2 billion people suffer worldwide from nutritional anemia. So there is every need to maintain quality besides productivity. In view of the recently emerging nutraceutical concept, adequate nutrition of crops with Zn and Fe is important.

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