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Effect of Micronutrients Mixture on Economic Feasibility of Maize (*Zeamays*)

Suhal Sardar¹, Mohd. Nayeem Ali², Riya Jakhwal³, Suraj Singh⁴, Rajkumar^{5,6} and Ashok Kumar⁷

^{1,2,3,4,5,6} Assistant Professor, Shri Ram College, Muzaffarnagar

⁷ Director, Shri Ram College, Muzaffarnagar

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ABSTRACT

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Corresponding Author
***Suhal Sardar**

A field experiment was conducted during *Kharif* 2023 at Crop Research center Shri Ram College, Muzaffarnagar, Uttar Pradesh to study the Effect of micronutrients mixture on economic feasibility of maize (*Zea mays*). Two grades of micronutrients mixture, one for soil application (SMM) and another for foliar spray (FMM) were tested with 7 treatment combinations and replicated thrice in a randomized completely block design with maize as test crop. The treatment with Recommended Dose of Fertilizers (150:75:40 kg ha⁻¹ N: P₂O₅: K₂O) + FYM @ 10 t ha⁻¹ was considered as control. Soil grade SMM was applied as basal @ 30 kg ha⁻¹ whereas foliar grade FMM was tested in two concentrations *i.e.*, 0.40% and 0.80% sprayed at 30 and 45 Days After Sowing. Significantly higher kernel and stover yield of maize (82.00 and 83.67 q ha⁻¹) were recorded with soil application of SMM + foliar application of FMM@ 0.8% along with RDF+FYM over control and found on par with same treatment combination except FMM was sprayed @ 0.4%. The percent increase in kernel and stover yield were 42.28 and 42.61 over control.

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INTRODUCTION

Application of two or more essential nutrients (Nitrogen, phosphorus with or without Potassium) is not adequate to achieve potential yield of crops. Deficiency of one or more plant essential elements will results in yield and quality reduction in crops (Nazim Hussain *et al.*, 2005) ^[16]. Among 17 essential elements quantity of microelements required are much less than macro and secondary elements. Generally, soil supplies are adequate but added benefits from fertilizer additions may be common depending on the area and soil conditions.

Micronutrient deficiencies are difficult to diagnose and consequently the problem may be termed 'hidden hunger' in analogy to the term used in human nutrition. On an average 43.0%, 12.1%, 5.4%, 5.5% and 18.3% of

Indian soils are deficient in Zn, Fe, Cu, Mn and B, respectively (Majumdar and Prakash, 2018) ^[11]. Micronutrients play an active role in the plant metabolic process, they directly or indirectly affect in photosynthesis, vital processes in plant such as respiration, protein synthesis and reproduction phase (Marschner, 1995) ^[14]. Micronutrient requirements of the maize crop are relatively small and ranges between their deficiencies and toxicities in plants and soils are rather narrow. So, supplying adequate quantity of micronutrient through external application to soil or foliar spray is important. Moreover, foliar spraying of micronutrient is very helpful when the roots cannot provide necessary nutrients (Kinaci and Gulmezoglu, 2007) ^[10]. Many workers have attempted to correct the deficiencies of micronutrients singly. But, intensive

cultivation of crops has led to multi micronutrient deficiencies. As such, importance of multi – micronutrient mixtures are very much needed, as multi-micronutrients mixture facilitate the application of the wide range of plant nutrients in the proportion and to suit the specific requirements of a crop at different stages of growth and are more relevant under site specific nutrient management practices (Hegde *et al.*, 2007) [9]. Therefore, there is a need to promote balanced fertilization for which use of appropriate multi-micronutrient mixture grades would play a big role to improve nutrients use efficiency and enhance crop productivity for food and nutritional security. But, so far there is limited research carried out on multi-micronutrient mixtures which are crop specific and location specific. Keeping in view all these aspects, present study on effect of soil and foliar application of micronutrients mixture on growth and yield of maize in *Alfisols* of Southern Dry Zone of Karnataka in India was initiated.

MATERIALS AND METHODS

A field experiment was conducted during *Kharif-2023* at Crop Research center Shri Ram College, Muzaffarnagar, Uttar Pradesh. The soil belongs to sandy loam in texture. The soil was neutral in reaction and low in soluble salts. The soil was low in organic carbon and available major nutrients but high in available Sulphur. The exchangeable calcium and magnesium content of soil were 3.9 and 2.2 meq 100 g⁻¹, respectively. The DTPA extractable micronutrients content *viz.*, zinc,

iron, copper, manganese and boron were 0.41, 6.4, 0.55, 8.40 and 0.42 mg kg⁻¹, respectively. Zinc and B content were below the critical limit. The initial physical and chemical properties of soil at the experimental site are given in table 1.

Two grades of micronutrients mixture, one as soil application (SMM) and another as foliar spray (FMM) were tested with seven treatment combinations and replicated thrice in a randomized completely block design with maize (Variety NAH-1137) as test crop. The treatment details are furnished in table 2. The treatment with Recommended Dose of Fertilizers (150:75:40 kg ha⁻¹ N: P₂O₅: K₂O) + FYM @ 10 t ha⁻¹ was considered as control. One-third of recommended N and entire amount of P and K were applied as basal dose and remaining two-third of N was applied in two equal splits at 30 DAS and 45 DAS as top dressing. The nutrients were applied in the form of urea, single super phosphate and murate of potash. Two grades of micronutrients mixture were prepared by mixing respective sulphate salts of Zn, Mn, Fe and Cu and for boron boric acid was used. Soil grade (SMM) was applied as basal @ 30 kg ha⁻¹ whereas foliar grade (FMM) was tested in two concentrations *i.e.*, 0.40% and 0.80% sprayed at 30 and 45 Days after Sowing (DAS) as per treatments. The pH of spray solution was brought to neutral using KOH and citric acid. The nutrient composition of soil and foliar grade micronutrients mixture prepared are given in table 3.

Table 1: Initial physical and chemical properties of soil at the experimental site

S.No.	Parameter	Value
Physical Properties		
1	Sand (%)	75.10
2	Silt (%)	18.25
3	Clay (%)	6.65
4	Soil texture	Sandy loam
Chemical Properties		
1	pH 1:2.5	7.25
2	EC 1:2.5(dS m ⁻¹)	0.16
3	CEC(cmol (p+) kg ⁻¹)	7.60
3	Organic carbon(gkg ⁻¹)	4.95
4	Available N(kg ha ⁻¹)	250.88

5	Available P ₂ O ₅ (kgha ⁻¹)	9.56
6	Available K ₂ O (kgha ⁻¹)	107.2
7	Available Ca (cmolk ⁻¹)	3.90
8	Available Mg (cmol kg ⁻¹)	2.20
9	Available S (mgkg ⁻¹)	16.38
10	DTPA Fe(mg kg ⁻¹)	6.40
11	DTPA Zn(mgkg ⁻¹)	0.41
12	DTPA Mn(mg kg ⁻¹)	8.41
13	DTPA Cu(mg kg ⁻¹)	0.55
14	Hot water soluble Boron(mg kg ⁻¹)	0.42

Table 2: Treatment details

T1	Absolute control
T2	RDF+ FYM @ 10 t ha ⁻¹ (control)
T3	T2+FMM @ 0.40%at 30 & 45DAS
T4	T2+FMM @ 0.80%at 30 & 45DAS
T5	T2+SMM @ 30kg ha ⁻¹ as basal
T6	T2+SMM @ 30kg ha ⁻¹ +FMM @ 0.40%at 30 & 45 DAS
T7	T2+SMM @ 30kg ha ⁻¹ +FMM @ 0.80%at 30 & 45 DAS

(SMM-Soil Micronutrients Mixture; FMM- Foliar Micronutrients mixture; DAS- Days after sowing; RDF: Recommended Dose of Fertilizer)

Table3: Nutrient composition (percent/w) of soil and foliar micronutrients mixture grades

Nutrients	Soil Grade	Foliar Grade
	SMM	FMM
Zinc(%)	7.57	5.35
Manganese(%)	4.55	5.36
Iron (%)	5.35	3.54
Copper (%)	3.39	5.98
Boron (%)	1.16	2.00

(SMM- Soil Micronutrients Mixture; FMM-Foliar Micronutrients Mixture)

The observations on growth parameters *viz.*, plant height, number of leaves, leaf area and yield parameters *viz.*, number of rows per cob, number of kernels per row, test weight, kernel yield and Stover yield were recorded at harvest by selecting five plants randomly from each plot. The data were subjected to statistical analysis as described by Gomez and Gomez (1984).

The level of significance used in “F” was P=0.05. Critical Difference (CD) values were calculated for the P = 0.05 whenever “F” test was found significant.

RESULTS AND DISCUSSION

Response of micronutrients mixture on growth characters of maize

Soil and foliar application of multi micronutrients mixture and their combinations significantly influenced the growth parameters *viz.*, plant height, number of leaves per plant and leaf area of maize at harvest (Table 4). Significantly higher growth parameters were recorded with soil application of SMM @ 30 kg ha⁻¹ as basal combined with foliar application of FMM@ 0.80% (T₇) over control and found on par with treatments T₆ (SMM@ 30 kg ha⁻¹ + FMM@ 0.40%) and T₄ (FMM @ 0.80% at 30&45DAS). The percent increase in plant height, number of leaves and leaf area over control by treatment T₇ was 15.88, 38.55 and 23.49, respectively and by treatment T₆ was 12.40, 26.6 and 23.39, respectively. Combined application of micronutrients increased all morphological, physiological and productivity characters compared to control (Farhan and Al-Dulaemi, 2011)^[6].

Improvement in growth characters as a result of application of micronutrients might be due to the enhanced photosynthetic and other metabolic activity

which leads to an increase in various plant metabolites responsible for cell division and elongation as opined by Hatwar *et al.*, (2003)^[7]. Mallik and Muthukrishnan (1980)^[12] explained that the presence of zinc activates the synthesis of tryptophan, the precursor of IAA and it is responsible to stimulate plant growth. Fe plays an important role in promoting growth characters, being a component of ferredoxins, an electron transport protein and is associated with chloroplast. It helps in photosynthesis intern responsible for better vegetative growth (Hazra and Mandal., 1988)^[8].

KERNEL AND STOVER YIELD OF MAIZE

The highest kernel and stover yield of maize (82.00 and 83.67 q ha⁻¹, respectively) were recorded with soil application of SMM as basal combined with foliar application of FMM@ 0.8% (T₇) which was significantly higher than that of control (Table 5). The percent increase in kernel and stover yield by this treatment were 48.20 and 42.61, respectively over control. Treatment T₇ is found on par with T₆ and T₄ treatments.

Table 4: Effect of soil and foliar application of micro nutrients mixture on plant height, number of leaves and leaf area of maize

Treatments	Plant height (cm)	No.of leavesplant ⁻¹	Leaf area(cm ² plant ⁻¹)
T 1 Absolute control	147.20 ^d	10.20 ^e	2855.33 ^c
T 2 RDF+ FYM @ 10 t ha ⁻¹ (control)	175.87 ^c	12.63 ^d	4618.33 ^b
T 3 T2+ FMM@ 0.40%at 30& 45DAS	185.20 ^{bc}	13.23 ^{cd}	5238.33 ^a
T 4 T2+ FMM@ 0.80%at30&45DAS	188.00 ^{abc}	13.53 ^c	5447.67 ^a
T 5 T2+ SMM@30kg ha ⁻¹	179.00 ^c	13.08 ^{cd}	4802.33 ^b
T 6 T2+ SMM@30kg ha ⁻¹ +FMM@ 0.40%	197.67 ^{ab}	16.00 ^b	5698.33 ^a
T 7 T2+ SMM@30kg ha ⁻¹ +FMM@ 0.80%	203.80 ^a	17.50 ^a	5703.33 ^a

S.Em+	5.66	0.26	183.94
CD @ 5%	17.43	0.81	566.77

Table 5: Effect of soil and foliar application of micronutrients mixture on yield and yield parameters of maize

Treatments	No. of seed rows cob ⁻¹	No. of seeds row ⁻¹	Test Weight(g)	Kernel yield (qha ⁻¹)	Stover yield(qha ⁻¹)
T1	11.24	25.40	23.33	43.83 (87.08)	47.33 (76.78)
T2	12.63	31.30	25.53	55.33 (48.20)	58.67 (42.61)
T3	13.64	33.24	31.81	73.67 (11.30)	80.17 (4.36)
T4	14.07	33.83	32.03	76.33 (7.42)	81.33 (2.87)
T5	13.37	32.70	31.97	72.83 (12.59)	77.22 (8.35)
T6	14.85	34.57	32.37	79.33 (3.36)	82.60 (1.29)
T7	15.10	35.98	33.77	82.00	83.67
S.Em+	0.44	2.07	0.71	2.35	1.93
CD @ 5%	1.36	6.39	2.18	7.27	5.95

Multi micronutrients application through foliar showed better kernel and stover yield compared to soil application. Though foliar spray is not substitute to soil application but it is considered as a supplement to soil application. Among the method of nutrient application foliar application is recognized as important method of fertilization. Since, foliar spray usually penetrates the leaf cuticle or stomata and enters the cells facilitating the easy and rapid utilization of nutrients (Choudhary *et al.*, 2015) ^[3]. Further, the foliar application helps in eliminating losses through leaching and fixation and helps in regulating the uptake of nutrients by plants (Manomani and Srimath, 2009) ^[13]. However, in the present

study combined application of SMM as basal and foliar application of FMM (T₇) produced significantly highest kernel and stover yield of maize over alone application of micronutrients mixture as soil (T₅) or as foliar at lower concentration (T₃) but found on par with high concentration (T₄). This suggests that supplementation of multi micronutrients through foliar along with soil application is essential for better crop growth and yield. Similarly, the beneficial effect of combined soil and foliar application of multi micronutrients mixture on growth and yield have been reported in wheat (Ali *et al.*, 2009) ^[1] and in sorghum (Choudhary *et al.*, 2015) ^[3].

Table 6: Economics of maize as influenced by soil and foliar application of micronutrients mixture

Treatments		Cost of Cultivation(Rs.ha ⁻¹)	Gross returns (Rs.ha ⁻¹)	Net returns (Rs.ha ⁻¹)	B:C ratio
T1	Absolute control	19700	49637	29937	2.52
T2	RDF+ FYM@ 10 t ha ⁻¹ (control)	33662	76960	43298	2.29
T3	T2+ FMM@ 0.40%at 30& 45DAS	34457	83438	48981	2.42
T4	T2+ FMM@ 0.80%at30&45DAS	34633	86407	51774	2.49
T5	T2+ SMM@30kg ha ⁻¹	35422	82433	47011	2.33
T6	T2+ SMM@30kg ha ⁻¹ +FMM@ 0.40%	36797	89745	52948	2.44
T7	T2+ SMM@30kg ha ⁻¹ +FMM@ 0.80%	36983	92710	55727	2.51

The data on economics of maize as influenced by soil and foliar application of micronutrients mixture are represented in the Table 6. The treatment T₇ with RDF + FYM + SMM@30 kg ha⁻¹ + FMM@ 0.80% has registered highest cost of cultivation (Rs. 36983 ha⁻¹) followed by T₆ with RDF + FYM + SMM@ 30 kg ha⁻¹ + FMM@ 0.40% treatment (Rs. 36,797 ha⁻¹). Among all the treatment plots significantly lower cost of cultivation was found in control (Rs. 33662 ha⁻¹). Gross returns were ultimately the result of kernel and stover yield of different treatments. T₇ with RDF + FYM + SMM@ [30kg ha⁻¹ + FMM@ 0.80%](#) has highest (Rs. 92,710 ha⁻¹) gross returns followed by T₆ with RDF + FYM + SMM@ 30 kg ha⁻¹ + FMM@ 0.40% treatment (Rs. 89,745 ha⁻¹). Among all the treatment plots significantly lower gross returns was found in control (Rs. 76,960 ha⁻¹). Treatment T₇ with application of FYM + SMM@ 30 kg ha⁻¹ + FMM@ 0.80% had given higher (Rs. 55,727 ha⁻¹) net returns over control (Rs. 43,298 ha⁻¹) with B:C ratio of 2.51 and 2.29, respectively.

CONCLUSIONS

Maize crop being exhaustive crop and due to intensive cultivation resulted in the

occurrence of widespread of micronutrient deficiencies in maize growing areas. Application of multi micronutrients is inevitable. Combined application of soil micronutrient mixture grade SMM @30kg ha⁻¹ as basal along with foliar application of FMM @ 0.8% at 30 & 45 DAS gave significantly higher kernel and stover yield over control and found to be more profitable compared to other treatments.

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