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Effect of soil and foliar application of micronutrients mixture on economics of maize (*Zea mays*) in Alfisols

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Abstract

A field experiment was conducted during *kharif* 2015 at College of Agriculture VC Farm, Mandya to study the response of maize to soil and foliar application of micronutrients mixture. 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: P_2O_5: K_2O) + 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 42.61over control.

Keywords: Micronutrients mixture, soil and foliar application, maize productivity

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 micro elements 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 is 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*-2015 at College of Agriculture, V.C. Farm, Mandya that comes under Agro climatic Zone-6, Southern Dry Zone of Karnataka. The soil belongs to *Alfisols* which was 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 m eq 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: P_2O_5: K_2O) + 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 muriate 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

Sl. 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 (c mol(p+) kg^{-1})	7.60
3	Organic carbon (g kg^{-1})	4.95
4	Available N (kg ha^{-1})	250.88
5	Available P_2O_5 (kg ha^{-1})	9.56
6	Available K_2O (kg ha^{-1})	107.2
7	Available Ca (c mol kg^{-1})	3.90
8	Available Mg (c mol kg^{-1})	2.20
9	Available S (mg kg^{-1})	16.38
10	DTPA Fe (mg kg^{-1})	6.40
11	DTPA Zn (mg kg^{-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

T_1	Absolute control
T_2	RDF + FYM @ 10 t ha^{-1} (control)
T_3	T_2 + FMM @ 0.40% at 30 & 45 DAS
T_4	T_2 + FMM @ 0.80% at 30 & 45 DAS
T_5	T_2 + SMM @ 30 kg ha^{-1} as basal
T_6	T_2 + SMM @ 30 kg ha^{-1} + FMM @ 0.40% at 30 & 45 DAS
T_7	T_2 + SMM @ 30 kg 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)

Table 3: Nutrient composition (per cent, w/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% (T_7) over control and found on par with treatments T_6 (SMM@ 30 kg ha^{-1}+ FMM@ 0.40%) and T_4 (FMM @ 0.80% at 30 & 45 DAS). The percent increase in plant height, number of leaves and leaf area over control by treatment T_7 was15.88, 38.55 and 23.49, respectively and by treatment T_6 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 ferrodoxin, an electron transport protein and is associated with chloroplast. It helps in photosynthesis in tern responsible for better vegetative growth (Hazraand Mandal., 1988) [8].

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

Treatments		Plant height (cm)	No. of leaves plant^{-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	T_2 + FMM @ 0.40% at 30 & 45 DAS	185.20^{bc}	13.23^{cd}	5238.33^a
T_4	T_2 + FMM @ 0.80%at 30 & 45 DAS	188.00^{abc}	13.53^c	5447.67^a
T_5	T_2 + SMM@ 30 kg ha^{-1}	179.00^c	13.08^{cd}	4802.33^b
T_6	T_2 + SMM@ 30 kg ha^{-1}+ FMM@ 0.40%	197.67^{ab}	16.00^b	5698.33^a
T_7	T_2 + SMM@ 30 kg ha^{-1}+ FMM@ 0.80%	203.80^a	17.50^a	5703.33^a
	S.Em$\pm$	5.66	0.26	183.94
	CD @ 5%	17.43	0.81	566.77

Yield components of maize

The data pertaining to yield parameters such as number of rows cob^{-1}, number of seeds row^{-1} and test weight are depicted in table 5. The yield parameters of maize were significantly influenced due to soil and foliar application of multi micronutrients mixture and their combinations. The highest yield parameters (15.10, 35.98 and 33.77 g, respectively) were recorded with soil application of SMM as basal combined with foliar application of FMM @ 0.8% (T_7) which was significantly higher than that of control. This treatment was found on par with treatments T_6 (SMM@ 30 kg ha^{-1}+ FMM@ 0.40%) and T_4 (FMM @ 0.80% at 30 & 45 DAS). The percent increase in number of seed rows cob^{-1}, number of seeds row^{-1} and test weight over control by treatment T_7 were 19.55, 14.95 and 32.27, respectively and by treatment T_6 were 17.5, 10.45 and 26.79, respectively. Similarly, Choudhary *et al*., (2015) [3] reported that combined soil and foliar application of micronutrients along with RDF provided greater availability of nutrients for the development of reproductive structures and increase in the grain and stover yield of sorghum.

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% (T_7) which was significantly higher than that of control (Table 5 and Fig. 1). The percent increase in kernel and stover yield by this treatment were 48.20 and 42.61, respectively over control. Treatment T_7 is found on par with T_6 and T_4 treatments.

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 (q ha^{-1})	Stover yield (q ha^{-1})
T_1	11.24	25.40	23.33	43.83 (87.08)	47.33 (76.78)
T_2	12.63	31.30	25.53	55.33 (48.20)	58.67 (42.61)
T_3	13.64	33.24	31.81	73.67 (11.30)	80.17 (4.36)
T_4	14.07	33.83	32.03	76.33 (7.42)	81.33 (2.87)
T_5	13.37	32.70	31.97	72.83 (12.59)	77.22 (8.35)
T_6	14.85	34.57	32.37	79.33 (3.36)	82.60 (1.29)
T_7	15.10	35.98	33.77	82.00	83.67
S.Em$\pm$	0.44	2.07	0.71	2.35	1.93
CD @ 5%	1.36	6.39	2.18	7.27	5.95

Figures in parenthesis indicates per cent increase over control.

The beneficial effect of micronutrients on growth and yield have been reported in different crops *viz*., okra (Mendhi and Kakati, 1994) [15], tomato (Bose and Tripathi, 1996) [2], wheat (Nazim and Javed, 2005; El-Magid, 2000) [17, 4], maize (El-Nagar, 2002) [5] and soybean (Thiyageshwari and Ramanathan, 2001) [20]. The increase in growth and yield of maize due to application of multi micronutrients along with NPK and FYM can be ascribed to the balanced and favourable nutritional environment in root rhizosphere and higher absorption of nutrient by plant leading to the increased photolytic efficiency and production of assimilates (Singh, 2006; Sareen and Sharma, 2010) [19, 18].

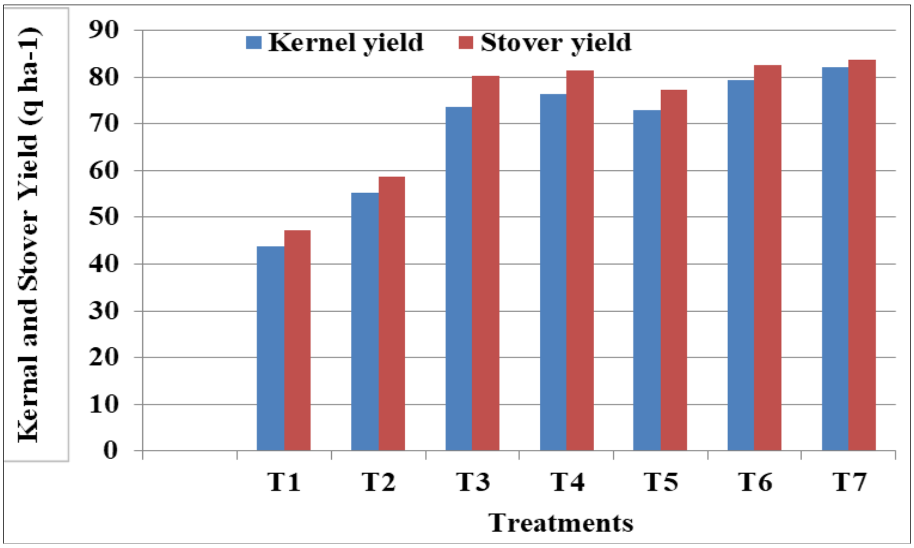

Fig 1: Effect of soil and foliar application of micronutrient mixture on kernel and stover yield of maize

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 (T_7) produced significantly highest kernel and stover yield of maize over alone application of micronutrients mixture as soil (T_5) or as foliar at lower concentration (T_3) but found on par with high concentration (T_4). 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
T_1	Absolute control	19700	49637	29937	2.52
T_2	RDF + FYM @ 10 t ha^{-1} (control)	33662	76960	43298	2.29
T_3	T_2 + FMM @ 0.40% at 30 & 45 DAS	34457	83438	48981	2.42
T_4	T_2 + FMM @ 0.80%at 30 & 45 DAS	34633	86407	51774	2.49
T_5	T_2 + SMM@ 30 kg ha^{-1}	35422	82433	47011	2.33
T_6	T_2 + SMM@ 30 kg ha^{-1}+ FMM@ 0.40%	36797	89745	52948	2.44
T_7	T_2 + SMM@ 30 kg 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 T_7 with RDF + FYM + SMM@ 30 kg ha^{-1}+ FMM@ 0.80% has registered highest cost of cultivation (Rs. 36983 ha^{-1}) followed by T_6 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. T_7 with RDF + FYM + SMM@ 30 kg ha^{-1}+ FMM@ 0.80% has highest (Rs. 92,710 ha^{-1}) gross returns followed by T_6 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 T_7 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 wide spread of micronutrient deficiencies in maize growing areas. Application of multi micronutrients is inevitable. Combined application of soil micronutrient mixture grade SMM @ 30 kg 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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