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EFFECT OF SECONDARY AND MICRONUTRIENTS ON YIELD AND YIELD FORMING CHARACTERS OF MAIZE (*Zea mays* L.)

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ABSTRACT

A field experiment was conducted at Agricultural College Farm, Mahanandi on sandy loam soils to know the response of maize to secondary and micronutrients with pioneer hybrid P3369. The experiment comprised of 9 treatments consisting of recommended dose of fertilizer of NPK through soil application and foliar application of secondary and micronutrients at 25 DAS. Results showed that Foliar application of micronutrient mixture along with RDF recorded significantly highest grain yield (4702 kg ha^{-1}) and Stover yield (7318 kg ha^{-1}) as compared to RDF (3773 and 6430 kg ha^{-1} of grain and Stover yield, respectively). Yield attributes *viz*., number of rows cob^{-1}(16.97), number of grains row^{-1}(36.99), cob length (19.86 cm) were highest with the application of RDF + foliar application of $ZnSO_4$ @ 0.2 per cent (T_7) and highest hundred grain weight (31.26 g) was recorded with RDF + foliar application of one per cent each of $CaNO_3$, $MgNO_3$ and sulphur + foliar application of $ZnSO_4$ @ 0.2 per cent . However, number of cobs $plant^{-1}$ and cob girth was not influenced by secondary and micronutrients. The treatment with RDF + foliar application of micronutrient mixture @ 0.2 per cent (T_9) recorded the highest gross returns, net returns and B: C ratio.

KEYWORDS: Maize, Secondary nutrients, Micronutrients, Yield attributes and Yield.

INTRODUCTION

Maize (*Zea mays* L.) is the most important food grain crop next only to rice and wheat in World and India. It is one of the most important cereal crops in the world's agricultural economy, both as a food and feed crop and its value added products have a good export potential. Due to its versatile characteristics of suitability and adaptability to various Agro-climates, maize is gaining popularity among the Indian farmers. It is known as the **"Queen of Cereals"** due to its high yielding potential. Globally maize is cultivated in an area of 170.39 million hectares with a production of 883.46 million tonnes and productivity of 5.18 tonnes ha^{-1} (www.indiastat.com). In India, it is grown in an area of 8.55 million hectares with a production of 21.73 million tonnes and an average productivity of 2540 kg ha^{-1}. In Andhra Pradesh, it is cultivated in an area of 9.72 lakh hectares with a production of 48.55 lakh tonnes and productivity of 4994 kg ha^{-1}. To achieve higher yields in maize, the crop require large quantities of soil nutrients for its growth and development but most of the farmers use only fertilizers that supply major nutrients of N, P and K and less attention is paid to secondary and micro nutrients which led to rapid depletion of secondary and micronutrients necessitating periodic or yearly supply of these nutrients. Although the requirement of secondary and micronutrients is less as compared to the primary nutrients, nevertheless their deficiency can limit the crop growth and production. Furthermore, the adequate supplies of these nutrients help to increase the efficiency of applied fertilizers. Therefore, a field study was undertaken to optimize the nutrient management strategy for higher productivity of maize and evaluating the effects of secondary (Ca, Mg and S) and micronutrients of zinc and their mixture (Fe, Mn, Zn, Cu, B and Mo) with recommended dose of nitrogen, phosphorus and potassium.

MATERIAL AND METHODS

A field experiment was conducted on maize hybrid P3369, under irrigated conditions during *kharif,* 2015 on sandy loam soils of Agricultural College Farm, Mahanandi, Andhra Pradesh. The soil of the experimental site was neutral pH (7.58), medium in organic carbon (0.46%), N (287 kg ha^{-1}), P_2O_5 (149 kg ha^{-1}) and high in K_2O (742 kg ha^{-1}). Exchangeable calcium, magnesium (10.41 and 7.22 C mol. (P^+) kg^{-1}) and available sulphur (13.32 kg ha^{-1}) were sufficient in availability whereas, micronutrients availability (Fe, Mn, Zn, Cu, B and Mo) was more than their critical limits.

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The experiment was laid out in a randomized block design having ten treatments and replicated thrice. The treatments consisting of T_1 : Control, T_2 : RDF: 250-60-60 kg N-P_2O_5-K_2O ha^{-1}, T_3 : RDF + foliar application of one per cent $CaNO_3$, T_4 : RDF+ foliar application of one per cent $MgNO_3$, T_5 : RDF + foliar application of one per cent sulphur, T_6 : RDF + foliar application of one per cent each of $CaNO_3$, $MgNO_3$ and sulphur, T_7 : RDF + foliar application of $ZnSO_4$ @ 0.2 per cent, T_8 : RDF + foliar application of one per cent each of $CaNO_3$, $MgNO_3$ and sulphur + foliar application of $ZnSO_4$ @ 0.2 per cent and T_9 : RDF + micronutrient mixture @ 0.2 per cent. The crop was sown on ridges with a spacing of 75cm x 15cm on second fortnight of July 2015 and harvested on 23.11.2015. The recommended dose of nitrogen was applied in three splits i.e., at sowing, at 30-35 DAS and remaining at 50-55 DAS in the form of urea, where as entire dose of phosphorus and potassium was applied as basal dose at the time of sowing in the form of diammonium phosphate and muriate of potash respectively. The secondary and micronutrients were supplied as foliar spray at 25 DAS in the form of $CaNO_3$, $MgNO_3$, wettable sulphur, $ZnSO_4$ and micronutrient mixture [Boron (B) 1.5%, Copper (Cu) 0.5%, Iron (Fe) 3.4%, Manganese (Mn) 3.2%, Molybdenum (Mo) 0.05% and Zinc (Zn) 4.2%]. Carbofuran 3G granules @ 5 kg ha^{-1} were applied to control the stem borers. All the cultural practices were taken up as per the recommendations made by ANGRAU.

RESULTS AND DISCUSSION

Effect of secondary and micronutrients on yield attributes of maize

The results indicated that different combinations of secondary and micronutrients had significant effect on yield attributes of maize (Table 1).The maximum values of yield attributes like number of rows cob^{-1}(16.97), number of grains per row (36.99), cob length (19.86 cm) were recorded with the treatment T_7 (RDF + foliar application of $ZnSO_4$ @ 0.1 per cent) which was comparable with T_9 (RDF + Foliar application of 0.1 per cent micronutrient mixture). However, highest hundred grain weight was recorded with T_8 (RDF + foliar application of one per cent each of $CaNO_3$, $MgNO_3$ and sulphur + $ZnSO_4$ @ 0.2 per cent) which was on par with T_9 (RDF + Foliar application of 0.2 per cent micronutrient mixture). Data on number of cobs per plant and cob girth was not influenced by secondary and micronutrients.

A marked increase of these yield attributes were nearly found with $ZnSO_4$. Zinc is an essential micronutrient required for the promotion of the meristematic and physiological activities such as leaf spread, root development, plant dry matter production, greater availability of metabolites and nutrients leading to efficient absorption and translocation of water and nutrients and interception of solar radiation.

Nitrogen in the presence of sufficient zinc shows its optimal performance and promotes higher photosynthetic activities leading to the production of enough assimilates for subsequent translocation to various sinks and there by leading to production of higher sink components like number of cobs $plant^{-1}$, cob length, cob girth, number of rows cob^{-1}, number of grains row^{-1} and 100-grain weight. The results are in conformity with the findings of Aruna *et al.* (2006), Parasuraman *et al.* (2008), Bishnu hari *et al.*(2010) and Khan *et al*. (2014).

Among the secondary nutrients, T_4 (RDF + foliar application of one per cent $MgNO_3$) had shown profound effect with respect to yield attributes and remaining treatments are comparable with other. This increment on yield attributes might be due to the presence of magnesium, as grain number are direct index of pollen viability and where magnesium is proved to increase the fruit set and pollen viability, and significantly affect the pollen formation (Mahgoub *et al.*2010 and Siam *et al.*2008). This element will also participate in the transportation of carbohydrates to the sink organs (Barlog and Frckowiak-Pawalak 2008).

Effect of secondary and micronutrient on grain and stover yield

Data regarding the grain yield and stover yield (Table 1) showed that the treatment with T_9 (foliar application of 0.2 per cent micronutrient mixture with RDF) recorded highest grain (4702 kg ha^{-1}) and stover yields (7318 kg ha^{-1}) which was on par with T_7 (RDF + foliar application of 0.2 per cent $ZnSO_4$), while the lowest grain and stover yields were recorded with T_1 (Control). This increase may be due to the additional availability of micronutrients as foliar application which had beneficial effect on physiological processes, plant metabolism, growth etc. which will directly put forth for higher grain yield. Synergetic role of micronutrients in improving plant growth and other biochemical and physiological activities was given by (Kassab *et. al,* 2004 and Zeiden *et. al,* 2010).

Table 1. Effect of secondary and micronutrients on yield attributes and yield of maize

Treatments	Number of cobs plant^{-1}	Number of rows cob^{-1}	Number of grains row^{-1}	Cob length (cm)	Cob girth (cm)	100-Grain weight (g)	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_1	1.00	12.98	19.99	11.99	11.66	21.76	2666	4728
T_2	1.00	14.11	32.14	17.13	14.25	26.30	3773	6430
T_3	1.00	15.12	33.85	18.14	14.81	27.45	4237	6858
T_4	1.00	15.66	34.95	17.46	13.89	28.67	4293	7095
T_5	1.06	15.53	33.17	19.04	14.24	28.46	4188	6603
T_6	1.00	15.87	35.11	19.09	14.69	29.47	4417	7065
T_7	1.06	16.97	36.99	19.86	14.72	29.70	4546	7185
T_8	1.00	16.40	34.03	19.14	14.61	31.26	4206	6956
T_9	1.00	15.99	36.09	18.27	14.21	30.53	4702	7318
SEm±	0.03	0.13	0.30	0.19	1.43	0.23	47	71
CD(P=0.05)	N.S	0.39	0.92	0.59	N.S.	0.71	141	215

Table 2. Cost of cultivation, gross returns, net returns (₹ ha^{-1}) and B: C ratio of maize as influenced by secondary and micro nutrients

Treatments	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net return (₹ ha^{-1})	B: C ratio
T_1	16270	34667	18397	1.13
T_2	21771	49059	27288	1.25
T_3	22421	55081	32695	1.45
T_4	22371	55809	33436	1.49
T_5	21871	54454	32583	1.49
T_6	24121	54696	30575	1.38
T_7	22171	59098	36927	1.59
T_8	24521	54678	30157	1.22
T_9	22771	61109	38338	1.68
S.Em±	-	611	607	0.02
CD (P=0.05)	-	1833	1821	0.06

The nutrients also enhance the carbohydrate supply to kernels by diverting the assimilates from sources, increasing yield components like cob length, cob girth, number of rows cob^{-1}, number of grains row^{-1} and test weight, which have direct influence on grain yield. Similar results were reported by Aruna *et al.* (2006), Ghaffari *et al* (2011) and Salem *et al*. (2012).

ECONOMICS

The successful adoption of nutrient management practice is finally determined by the net financial gain (Table 2). The best nutrient management practice was foliar application of 0.2 per cent micronutrient mixture with RDF (T_9) attaining highest (₹ 38,338 ha^{-1}) net field benefits with B:C ratio of 1.68 which was comparable with foliar application of 0.2 per cent $ZnSO_4$ + RDF (T_7) (₹ 36,927 ha^{-1}) and superior over remaining treatments.

CONCLUSION

Based on the findings of study, it can be recommended that foliar application of 0.2 % micronutrient mixture along with recommended dose of NPK is feasible for enhancing yield and profitability of maize.

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