International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(5): 831-833

Received: 19-07-2019
Accepted: 21-08-2019

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Effect of combination of nitrogen and foliar applied zinc on growth and yield of hybrid maize

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Abstract
Field experiment was conducted at the experimental farm, Department of Agronomy, Faculty of Agriculture, Annamalai University during the Kharif season 2016 to study the effect of combined application of nitrogen and foliar application of zinc on growth and yield of hybrid maize. The experiment was conducted with ten treatments which includes absolute control and increased level of nitrogen with two different sources of zinc viz., $ZnSo_4$ and Zn EDTA. The growth and yield components of maize were favourably influenced by increased level of nitrogen along with zinc in this study. Among the treatments, application of 150% RDN + 0.5% $ZnSO_4$ as foliar spray (T_7) showed markable variation and recorded increased growth components like plant height, LAI, dry matter production and crop growth rate. This was statistically on par with the treatment 150% RDN + 0.5% Zn EDTA as foliar spray (T_{10}) at all stages of crop growth. The yield components and yield like cob length, cob diameter and number of grains cob^{-1}, grain yield and straw yield also recorded higher with the application of 150% RDN + 0.5% $ZnSO_4$ as foliar spray (T_7) and this was statistically on par with the treatment 150% RDN + 0.5% Zn EDTA as foliar spray (T_{10}). Hence increased level of nitrogen along with foliar application of micronutrient increase the yield and economically benefit.

Keywords: Maize, nitrogen, $ZnSO_4$, growth yield, foliar application

Introduction

Maize is one of the third most important cereals. Maize has been an important cereal crop because of its high production potential compared to any other cereal crop. In cereals, maize is grown throughout the year mainly due to photo-thermal insensitive character, hence called "Queen of Cereals". Maize grain has greater nutritional values and it is grown extensively in temperate, sub tropical and tropical regions in the world. Maize is also drought resistant and can be grown almost every corner around the world. In India, maize occupies an area of 8.67 million hectares with a production of 21.73 million tones and the productivity of 2.54 t ha^{-1}. In Tamil Nadu, it is cultivated in an area of 0.36 million hectares with production of 2.38 million tones and a productivity of 6.5 t ha^{-1} and also it occupies fourth position in Indian maize production (AICRP, 2016) [1]. Maize is being a C_4 plant, has higher yield potential depends on nutrient supplying capacity of the soil. Among the essential nutrients, nitrogen is the most important limiting factor for plant growth and its application increases the nitrogen and crude protein content in grains. It plays a vital role in nutritional and physiological status of plants, promote changes in mineral composition of plants (Karasu, 2012) [8]. Nitrogen is a component of protein and nucleic acids and when N is sub-optimal, growth is reduced (Haque *et al*., 2001) [7].

Among the micronutrients, zinc is an essential nutrient for the standard and healthy growth and development of plants. It also plays a very important role in better plant growth and metabolic functions and also increases protein content in grain because it helps in protein synthesis in grain and hence, it is called as essential trace element or a micronutrient. Amongst the different methods of application, the foliar spray of micronutrients is an efficient one for enhancement of crop productivity. Foliar application is an effective method due to its direct absorption and application on leaves (Hosseini *et al*., 2007) [6]. Zinc sulphate ($ZnSO_4$) is used more than any other kind of zinc fertilizer, because of its high solvency. By using $ZnSO_4$, higher yield can be achieved which is limiting among all the micronutrients in cereal crops because of its low availability at pH above 7.0 (Alloway, 2008) [2]. Zinc EDTA (Zn EDTA) is easily translocated within the plants, hence it can be used for foliar application. It is quickly available to the plant system and versatile in nature.

Chelated EDTA hold on to the trace elements and stop them from binding to other elements. It also enhances photosynthesis, catalyze carbon dioxide into carbohydrates thus improve the strength of photosynthesis, increase the sugar content and also increase the grain protein content.

Materials and Methods

Experimental details

The field experiment was conducted during 2016 at the experimental farm of Department of Agronomy, Annamalai University. The treatment comprised of control (T_1), 100% Recommended Dose Fertilizer (RDF) (T_2), 125% Recommended Dose of Nitrogen (RDN)(T_3), 150% RDN (T4), 100% RDN + 0.5% $ZnSo_4$ (T_5), 125% RDN + 0.5% $ZnSo_4$ (T_6), 150% RDN + 0.5% $ZnSo_4$ (T_7), 100% RDN + 0.5% Zn EDTA (T_8), 125% RDN + 0.5% Zn EDTA (T_9), 150% RDN + 0.5% Zn EDTA(T_{10}).

The experimental field was laid out with randomized block design with three replications with each plot of 5m width and 4m breadth. Each plots are fertilized with full doses of phosphorous and potassium and half dose of nitrogen except in control plots. The fertilizer schedule followed was 135:62.5:50 kg NPK ha^{-1}. The nitrogen application was supplied through urea, phosphorous was supplied as diammonium phosphate and potassium through muriate of potash. The hybrid seed choosen for this study was SSR 4572. The soil of the field was with pH of 7.1 and the nutrient status of the soil was low in nitrogen and medium in phosphorous and high in potassium. Water for irrigation was utilized from Uppanar channel, a drainage outlet of Cauvery river. The application of nitrogen is splitted into two splits, one as basal and the other as foliar application on 30 DAS.$ZnSo_4$ and Zn EDTA was applied as foliar application with the concentration of 0.5% on 30 DAS.

Results and Discussion

Growth Components

Among the different treatments, application of 150% RDN + 0.5% $ZnSO_4$ (T_7) showed highest plant height on at 30 DAS (93.2 cm), 60 DAS (195.5 cm) and at harvest (205.5 cm). The plant height observed on 30 DAS was statistically on par with the application of 150% RDN + 0.5% Zn EDTA (T_{10}) and 150% RDN (T_4) and the plant height observed on 60 DAS and at harvest was on par with the treatment 150% RDN + 0.5% Zn EDTA (T_{10}). This treatment exhibited the higher values for plant height at 30, 60 DAS and at harvest may be due to increasing level of nitrogen as it increases cell division, cell enlargement and cell elongation and nucleus formation. Similar findings were reported by Dawadi and Sah (2012) [4]. The lowest plant height 145.1 cm and 155.2 cm at 60 DAS and at harvest was obtained in the treatment control (T_1). The synergistic and cumulative effect of nitrogen with $ZnSO_4$ could be the reason for better performance of maize in terms of plant height, at all the stages of crop growth due to increase in metabolic process of plant which in turn promotes meristamatic activities causing apical growth.

The highest dry matter production of 5150 kg ha^{-1} was observed in the treatment with 150% RDN + 0.5% $ZnSo_4$ (T_7) which was taken on 30 DAS and the highest dry matter production of 11310 kg ha^{-1} and 15700 kg ha^{-1} on 60 DAS and at harvest was observed in the treatment 150% RDN + 0.5% $ZnSo_4$ (T_7) and the minimum of 7950 kg ha^{-1} and 9977 kg ha^{-1} at 60 DAS and at harvest, respectively was recorded in the control (T_1). Vegetative growth and consequently biological yield are highly dependent on consumption of micro and macro elements by the maize plant, so application of fertilizers that contain these elements leads to increase in biological yield of maize. These findings are in accordance with the results of Ehsanullah *et al*. (2015) [5].

The maximum leaf area index (LAI) was observed in the treatment 150% RDN + 0.5% $ZnSo_4$ (T_7) with the value of 3.98 at 30 DAS and 7.55 at 60 DAS which was statistically on par with the treatment 150% RDN + 0.5% Zn EDTA (T_{10}). The minimum LAI of 3.16 at 30 DAS and 5.60 at 60 DAS were obtained in the treatment control (T_1).The increased leaf area index which also increased photosynthetic assimilation in plant which finally paved way for increased dry matter accumulation. In the present study, the non supply of nutrients through any sources resulted in poor performance of maize could be noticed by registering lower values of all the growth and physiological parameters in the treatment control. Similar findings were reported by Sarwar *et al*. (2012) and Mona E. El-Azab (2015) [10].

Yield Components

The maximum cob length (20.98cm) and cob diameter (6.78) was obtained from the treatment 150% RDN + 0.5% $ZnSo_4$ (T_7) which was on par with the treatment 150% RDN + 0.5% Zn EDTA (T_{10}). The least value of cob length (12.1cm) and cob diameter (5.78cm) was obtained from the treatment under control (T_1). The maximum numbers of grain cob^{-1} (446) was received 150% RDN + 0.5% $ZnSo_4$ (T_7) and the minimum numbers of grain cob^{-1} (270) in control (T_1). This improvement in yield parameters was also observed by Mohsin *et al*. (2014) [9], who stated the increase in cob length and cob diameter with application of zinc as foliar spray. This result might be due to direct absorption of zinc by foliar spray.

Yield

Grain yield of maize was significantly influenced by the nutrient management practices. Application of 150% RDN+ 0.5% $ZnSO_4$ (T_7) registered the higher grain yield of 6023 kg ha^{-1}. It was statistically on par with the application of 150% RDN + 0.5% Zn EDTA (T_{10}) which recorded the grain yield of 5925 kg ha^{-1}. The treatment control (T_1) recorded lower grain yield value of 2500 kg ha^{-1}. The increase in grain yield of maize was due to increase in cob length, cob diameter and higher number of grains cob^{-1}. This was attributed due to zinc fertilization which enhanced the synthesis of carbohydrates and their transport to the site of production. Nitrogen through urea readily supplied the nutrient to the crop at critical stages with a good cob size, vigour and also the quality of grains, provided by $ZnSO_4$ helped the plant in attaining higher plant growth and yield parameters. These results are in accordance with Mohsin *et al*. (2014) [9].

The higher stover yield of 9665 kg ha-1 was recorded with the application of 150% RDN+ 0.5% ZnSO4 (T_7). This was statistically on par with the application of 150% RDN + 0.5% Zn EDTA (T_{10}) and the minimum stover yield (5000 kg ha-1) was obtained from the treatment control (T_1). This might have been due to the increased plant height, LAI and better nutrient uptake. Results showed that productivity in maize can be enhanced by increasing the harvest index without a major increase in the biological yield. The harvest index failed to produce significant difference among the treatments but it ranged from 33.33 to 38.39. Although dry matter accumulation provides the base for expression of harvest index, the higher partitioning efficiency towards sink also accounts for higher harvest index. Similar findings were reported by Amin and Saeed (2015) [3] and Shivay *et al*. (2015) [12].

Nutrient Uptake

Application of 150% RDN + 0.5% $ZnSO_4$ (T_7) recorded maximum nutrient uptake with the values 72.6 kg N ha^{-1}, 7.60 kg P_2O_5 ha^{-1} and 77.3 kg K_2O ha^{-1} at 30 DAS and 164 kg N ha^{-1}, 32.86 kg P_2O_5 ha^{-1}, 192.3 kg K_2O ha^{-1} at 60 DAS and at harvest 235.5 kg N ha^{-1}, 64.47 kg P_2O_5 ha^{-1} and 266.9 kg K_2O ha^{-1}. This was on par with the treatment 150% RDN + 0.5% Zn EDTA (T_{10}) and 150% RDN (T_4). The lowest uptake of nutrients was observed in the treatment control (T_1). The increase in values might be due to proper and adequate supply of NPK with zinc increased the uptake of nitrogen during crop growth stage and ultimately improved the dry matter production. Similar result was supported by Mustafa *et al*. (2011) who reported that balanced supply of NPK with zinc might have increased the uptake and availability of other essential nutrients, which resulted in improvement of plant metabolic process and finally increased the crop growth. These results are in conformity with Paramasivan *et al*. (2010) and Mona E. El-Azab (2015) [10].

Conclusion

By observing the growth and yield performance of maize, it can be concluded that the application of 150% RDN along with 0.5% $ZnSO_4$ was found to be efficient and most suitable for producing high yield.

Table 1: Effect of combined application of nitrogen and foliar application of zinc on growth of maize

Treatments	Plant height (cm)			Dry matter production (kg/ha)			Leaf area index	
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS
T_1	66.1	145.1	152.2	3898	7950	9977	3.16	5.60
T_2	81.8	177.6	184.8	4630	9670	12540	3.49	6.01
T_3	86.9	181.7	189.3	4830	10100	13550	3.68	6.38
T_4	91.9	187.7	196.8	5060	10770	14590	3.93	6.98
T_5	83.2	183.6	191.7	4710	10200	13700	3.55	6.59
T_6	88.1	189.3	198.8	4920	10850	14750	3.72	7.12
T_7	93.2	195.5	205.5	5150	11310	15700	3.98	7.55
T_8	82.9	182.4	190.6	4690	10150	13640	3.52	6.50
T_9	87.2	188.5	197.2	4870	10780	14660	3.70	7.07
T_{10}	92.5	193.9	203.9	5130	11280	15500	3.95	7.50

Table 2: Effect of combined application of nitrogen and foliar application of zinc on the yield components

Treatments	Cob length (cm)	Cob diameter (cm)	Number of grains cob^{-1}
T_1	12.01	5.78	270
T_2	13.95	6.16	380
T_3	15.94	6.32	405
T_4	18.36	6.58	426
T_5	16.15	6.36	412
T_6	18.56	6.61	430
T_7	20.98	6.78	446
T_8	16.02	6.33	408
T_9	18.45	6.59	428
T_{10}	20.87	6.76	440

Table 3: Effect of combined application of nitrogen and foliar application of zinc on yield

Treatments	Grain yield	Stover yield	Harvest index
T_1	2500	5000	33.33
T_2	4930	8500	36.71
T_3	5104	8735	36.88
T_4	5556	9224	37.59
T_5	5197	8880	36.92
T_6	5710	9355	37.90
T_7	6023	9665	38.39
T_8	5145	8800	36.89
T_9	5635	9315	37.69
T_{10}	5925	9620	38.12

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