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Influence of foliar nutrition of $ZnSO_4$ and GA_3 on yield and yield attributes of maize (*Zea mays* L.)

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Abstract
A field experiment was carried out at Agriculture College Farm, Raichur during *kharif* 2018 an enttitled Influence of foliar nutrition of $ZnSO_4$ and GA_3 on physiological, biochemical and yield parameters of maize (*Zea mays L.*). The experiment was laid out in Factorial randomized complete block design (RCBD) with eighteen treatments.. The treatments were foliar nutrition of $ZnSO_4$ @ 0.25 per cent, $ZnSO_4$ @0.5 per cent and $ZnSO_4$ @ 1.0 per cent and GA_3 at 25 ppm, GA_3 @ 50 ppm sprayed at different stages (V5, V6, and V5 & V6). Among the different treatments, foliar application of $ZnSO_4$ (1.0%) at V5 stage revealed a significant effect on yield parameters such as cob length, cob weight, cob girth and number of rows per cob. Cob length was significantly higher in treatment ZnSO4 1% at V5 stage compared to other treatments. Number of kernels per row was more in ZnSO4 1% at V5 stage it ultimately leading to increasing in the yield. The test was highest in treatment ZnSO4 1% at V5 stage and T_{11} (1% ZnSO4 at V6 stage) & T_{12} (1% ZnSO4 at V5&V6) stage are a par with each other. Yield parameters were increased when foliar nutrition was given at early stages (V5 & V6 stage). It was concluded from the results that foliar nutrition during 25 to 30 days after sowing could increase maize productivity significantly by increasing morpo physiological and yield parameters of maize significantly.

Keywords: Foliar application, yield and yield attributes

Introduction
Maize (*Zea mays* L.) is an important cereal in the agricultural economy after rice and wheat, in the world as well as in India. It is a versatile crop grown in diverse environmental conditions, has multiple uses and yield potential far higher than any other cereal and hence it is referred as the 'queen of cereals'

Among all the cereals, maize in general and hybrids in particular are responsive to nutrients of maize. In India, maize occupies an area of 9.2 m ha, production of 23.6 million tonnes with the productivity of 2564 kg/ha. In Karnataka, it is cultivated in an area of 1.34 million ha with a production of 3.91 million tonnes and the productivity of 2921 kg/ha (Anon., 2017). It is cultivated throughout the year in all states of the country for various purposes. The predominant maize growing states are Andhra Pradesh, Karnataka, Tamil Nadu, Rajasthan, Maharashtra, Bihar, Uttar Pradesh, Madhya Pradesh and Gujarat.

It is an exhaustive crop which consumes large quantity of nutrients at different growth stages for growth and development. Under the present trend of exploitive agriculture in India, inherent soil fertility can no longer be maintained on the sustainable basis. It is said that nutrient supplying capacity of soil declines steadily under continuous and intensive cropping system. Foliar application of the major nutrients appeared to increase yield and quality of different crops. Nutrient uptake occurs both via leaf cuticle (Brasher *et al*., 1953) [5], stomata (Eichert and Burkhardt, 1999) [8] and through hydrophilic pores within the leaf cuticle (Tyree *et al.*, 1990) [15]. Several nutrient elements are readily absorbed by leaves when they are dissolved in water and sprayed on them. Foliar application technique is a particular way to supply macro and micro-nutrients in rapid absorption (Ahmed *et al*., 1994) [1]. If applied properly, foliar spraying can be considered practical to supply nutritional plant requirements.

Zinc application stimulates protein synthesis and enhances the remobilization from stored carbohydrates in vegetative organs to grain. Zinc micronutrient mainly controls the reproductive growth of plant. Zinc plays an important role in the phloem translocation and also helps in the starch sugar synthesis. Higher yield and profits can be obtained by supplying the nutrients to the plant at critical stages of development.

The yield of maize is based on the number of kernels per ear and kernel weight. Timing of nutrient demand and acquisition by maize is nutrient specific and associated with key vegetative or reproductive growth stages. Thus, dynamics of nutrient accumulation to sink organs and the fate of foliar-applied nutrients at specific growth stages would provide useful information to deliver nutrients more efficiently to meet requirement, thus improving nutrient management and sustainable intensification and obtaining greater yield. With the above background an experiment was planned to evaluate the Influence of foliar nutrition of $ZnSO_4$ and GA_3 on physiological biochemical and yield parameters of maize (Z*ea mays* L.).

Materials & method

The experiment was conducted at Agricultural College Farm, University of Agricultural Sciences, Raichur situated in North Eastern Dry Zone of Karnataka at latitude of 16º15′ North, longitude of 77º21′ East with an altitude of 389 meters above mean sea level. Maize hybrid RCRMH 2 was used for the experimental purpose. The experiment was laid out in Factorial randomized complete block design with five replications consisting of eighteen treatments. The details of the treatments were T_1-No foliar spray at V5 stage, T_2-No foliar spray at V6 stage, T_3-No foliar spray at V5 & V6 stage, T_4-$ZnSO_4$ (0.25%) at V5 stage, T_5-$ZnSO_4$ (0.25%) at V6 stage, T_6ZnSO_4 (0.25%) at V5 & V6 stages, T_7ZnSO_4 (0.5%) at V5 stage-, T_8-$ZnSO_4$ (0.5%) at V6 stage, T_9-$ZnSO_4$ (0.5%) at V5 & V6 stages, T_{10}-$ZnSO_4$ (1.0%) at V5 stage, T_{11}-$ZnSO_4$ (1.0%) at V6 stage, T_{12}-$ZnSO_4$ (1.0%) at V5 & V6 stages, T_{13}-GA_3 (25 ppm) at V5 stage, T_{14}-GA_3 (25 ppm) at V6 stage, T_{15}-GA_3 (25 ppm) at V5 & V6 stages T_{16}-GA_3 (50 ppm) at V5 stage T_{17}-GA_3 (50 ppm) at V6 stage, T_{18}-GA_3 (50 ppm) at V5 & V6 stages. Three tagged plants used for recording morphological observations were harvested at physiological maturity and were also used for recording the following yield and yield components. The length of the cob was measured from butt end to the tip of the cob from three randomly selected cobs and the mean was expressed in centimeter (cm). The cobs from three randomly selected plants were removed thoroughly, air dried, cleaned and weighed. The average cob weight was taken as weight of cob in gram (g). The circumference was measured at the center of the cob using thread. This was taken as girth of the cob and expressed in centimeter (cm). The randomly selected cobs were cleaned and number of rows in each cob was counted manually. Then average number of rows of selected cobs was taken as number of rows per cob. The number of grains per row of three cobs was measured manually and the average was worked out to get the number of grains per row.

Hundred grains were randomly collected from net plot yield with eight per cent moisture content and the grains were weighed and expressed in grams (g).

Results & Discussion

Nutrient management at the critical growth stage is an important factor which largely decides the yield of the crop. The economic yield is the manifestation of various biological events involving morphological, growth, biochemical and physiological changes which take place during development in accordance with the supply of light, water, temperature and nutrients (Donald, 1962) [6]. The grain yield depends on the synthesis and accumulation of photosynthates and their distribution among various plant parts. The production and translocation of synthesized photosynthates depend upon mineral nutrition supplied either through soil or foliar application and plant growth and development during early stages of crop growth. Foliar nutrition increases the utilization of plant nutrients more efficiently.

The major factors attributing to variation in grain yield of maize are yield components *viz.*, cob characteristics, number rows of per cob, number of kernels per row, & test weight.

Cob characteristics include cob length, cob girth and cob weight. These parameters are indicator of yield performance. The improvement in the cob characteristics of maize bolsters the prospects of foliar nutrition at different vegetative stages as compared to control.

Among the different foliar nutrition and different vegetative stages, foliar spray of $ZnSO_4$ at early stages (V5 & V6) improved the cob characteristics compared to other treatments. This significant effect of foliar nutrition on cob length, cob girth and cob weight might be due to the improved leaf dry matter production, higher photosynthetic rate, chlorophyll content with the application of foliar nutrition at early stages. This may result in improvement of the grain size of the plants. This finding is in line with Anjum *et al.* (2017) [3] who reported that increment in carbohydrates partitioning to grains might exert positive influence on cob length and girth. These results are in accordance with Mohsin *et al.* (2014) [11], Manasa and Devaranavadagi (2015) [10], Prajwal *et al.* (2018) [13].

Number of kernel rows per cob and number of kernels per row are the major yield attributing parameters of maize.

The foliar application of different nutrients improved the number of kernel rows per cob and number of kernels per row compared to the control. Among the different treatments, foliar spray of $ZnSO_4$ at early vegetative stages (V5 & V6) showed the better performance. This might be due to the fact that number of rows per cob and number of kernels per row are predetermined factor at early vegetative stage between V5 to V6. The foliar nutrition at these critical stages helped in the increased nutrient supply for cob development. This present work is in line with Tahir *et al.* (2012) [14], Mohsin *et al.* (2014) [11] and Ehsanullah *et al.* (2015) [7]. Although Manasa and Devaranavadagi (2015) [10] and Anjum *et al.* (2017) [3] reported increase in number of kernels per cob at grand growth stage.

The yield potential of any variety is always determined by the test weight and this trait is the most important yield-contributing factor for deciding the potential of maize hybrids.

From the present investigation it was found that foliar application of different nutrients depicted the influence on test weight. However, the $ZnSO_4$ foliar spray at early stages (V5 & V6) showed the increased test weight compared to control where only recommended dose of fertilizer was applied. This might be due to the improved dry matter production, higher photosynthesis and sugar accumulation at early vegetative stages of foliar spray.

Similar results were recorded by Bakry *et al.* (2009) [4] who reported that the beneficial and salubrious enhancement of all physiological and yield parameters of maize was due to micronutrients applications which stimulated cell division and expansion or elongation, consequently increasing number and weight of grains. Anjum *et al.* (2017) [3] also reported that yield-contributing components of maize were significantly increased by the combined application of foliar zinc.

Grain yield is an ultimate end product of many yield-contributing components, physiological and morphological processes taking place in plants during growth and development. Grain yield depends on the synthesis and accumulation of photosynthates and their distribution among various plant parts. The synthesis, accumulation and translocation of photosynthates depend upon efficient photosynthetic structure as well as the extent of translocation into sink (grains) and also on plant growth and development during early stages of crop growth. This may be attributed to fulfillment of the demand of the crop by higher assimilation and translocation of photosynthates from source (leaves) to sink (grains) through supply of required nutrients by foliar spray.

In the present investigation, it is clear that foliar application of nutrients increased the grain yield compared to control where only recommended dose of fertilizers was applied. Among the different treatments, foliar spray of $ZnSO_4$ at early vegetative stages (V5 & V6) increased the grain yield by 5.87 and 5.27 per cent respectively as compared to control.

Foliar nutrition at the early vegetative stage improved the cob development and grain yield pertaining to the significant variation in early silking, increased chlorophyll contents, photosynthesis rate which in turn increased the sugar contents and dry matter production. In addition, the foliar nutrients improved translocation and assimilation of nutrients by maize plants leading to significant increase in grain yield. Similar results were obtained by El-Azab (2015) [9], who reported that foliar application of $ZnSO_4$ at 5th leaf stage significantly increased the grain yield of maize hybrid. These results are also in consonance with a study which exhibited that foliar application of $ZnSO_4$ is better to increase the grain yield of maize hybrids (Tariq *et al*., 2014). Similar findings were reported by Mohsin *et al.* (2014) [11], Manasa and Devaranavadagi (2015) [10], Munirah *et al.* (2015) [12], Anees *et al.* (2016) [2] and Wasaya *et al.* (2017) [16].

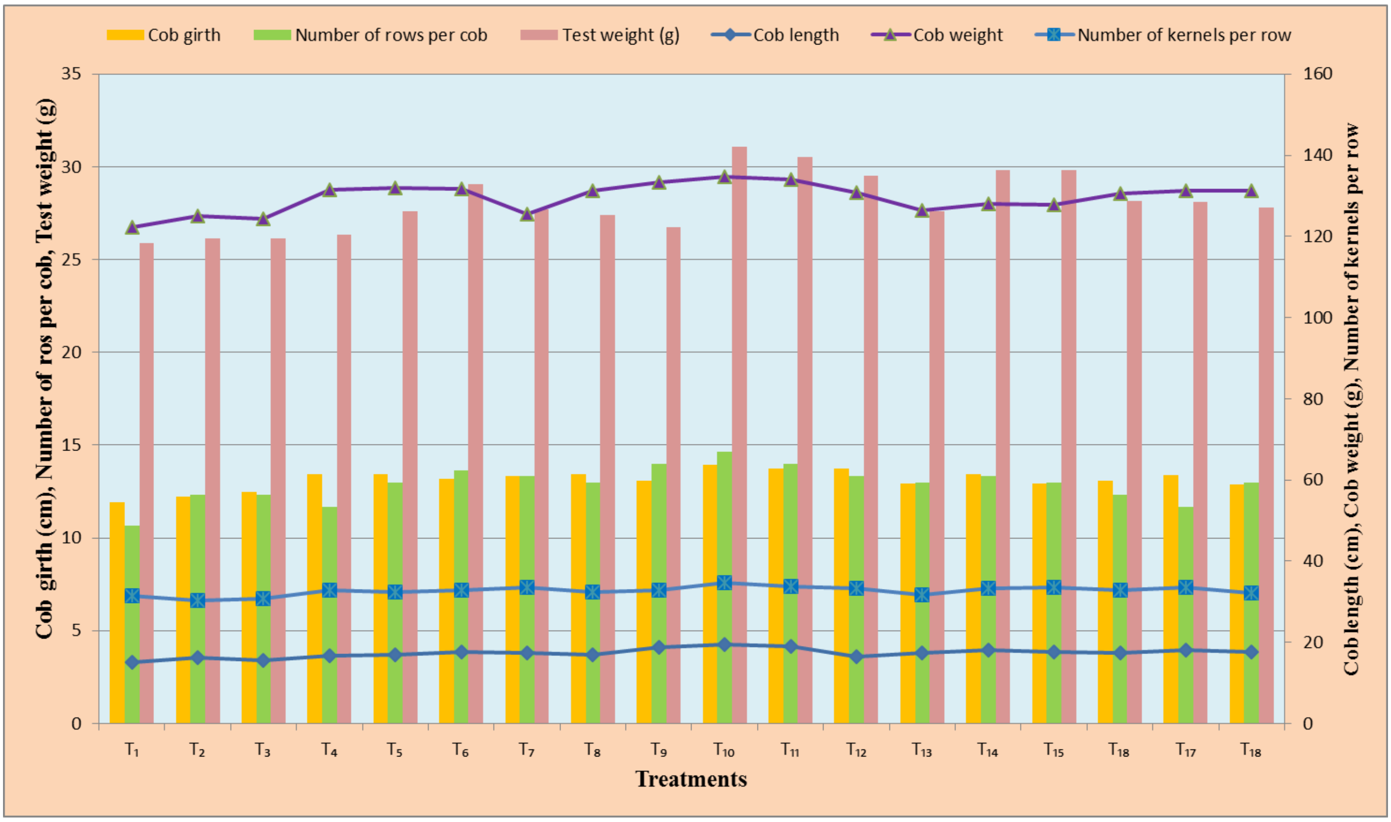

Fig 1: Influence of foliar nutrition of $ZnSO_4$ and GA_3 on yield and yield components in maize hybrid

Table 1: Influence of foliar nutrition of $ZnSO_4$ and GA_3 yield & Yield components of maize hybrid

Treatments	Cob length (cm)	Cob girth (cm)	Cob weight (g)	Number of rows per cob	Number of kernels per row	Test weight (g)	Yield Kg/ha
T_1- No foliar spray at V5 stage (F_0S_1)	15.00	11.94	122.25	10.66	31.55	25.88	7740.02
T_2- No foliar spray at V6 stage (F_0S_2)	16.25	12.22	125.09	12.33	30.21	26.16	7751.78
T_3- No foliar spray at V5 & V6 stages (F_0S_3)	15.60	12.46	124.43	12.33	30.77	26.15	7702.42
T_4- $ZnSO_4$ (0.25%) at V5 stage (F_1S_1)	16.66	13.45	131.57	11.66	32.77	26.35	7921.35
T_5- $ZnSO_4$ (0.25%) at V6 stage (F_1S_2)	16.98	13.43	131.92	13.00	32.42	27.58	7902.85
T_6- $ZnSO_4$ (0.25%) at V5 & V6 stages (F_1S_3)	17.73	13.16	131.72	13.66	32.90	29.08	7881.55
T_7- $ZnSO_4$ (0.5%) at V5 stage (F_2S_1)	17.42	13.32	125.54	13.33	33.60	27.72	7857.95
T_8- $ZnSO_4$ (0.5%) at V6 stage (F_2S_2)	16.93	13.46	131.25	13.00	32.43	27.40	8037.99
T_9- $ZnSO_4$ (0.5%) at V5 & V6 stages (F_2S_3)	18.74	13.08	133.33	14.00	32.76	26.74	7870.95
T_{10}- $ZnSO_4$ (1.0%) at V5 stage (F_3S_1)	19.56	13.92	134.69	14.66	34.66	31.09	8194.53
T_{11}- $ZnSO_4$ (1.0%) at V6 stage (F_3S_2)	18.92	13.76	133.94	14.00	33.66	30.52	8159.36
T_{12}- $ZnSO_4$ (1.0%) at V5 & V6 stages (F_3S_3)	16.44	13.73	130.71	13.33	33.41	29.54	8056.19

T_{13}- GA_3 (25 ppm) at V5 stage (F_4S_1)		17.49	12.91	126.53	13.00	31.73	27.59	8026.97
T_{14}- GA_3 (25 ppm) atV6 stage (F_4S_2)		17.98	13.44	128.03	13.33	33.28	29.83	8023.03
T_{15} –GA_3 (25 ppm) at V5 & V6 stages (F_4S_3)		17.68	12.92	127.79	13.00	33.48	29.81	8021.95
T_{16}- GA_3 (50 ppm) at V5 stage (F_5S_1)		17.31	13.10	130.62	12.33	32.82	28.16	8016.29
T_{17}- GA_3 (50 ppm) at V6 stage (F_5S_2)		18.13	13.38	131.28	11.66	33.42	28.10	7957.22
T_{18}- GA_3 (50 ppm) at V5 & V6 stages (F_5S_3)		17.65	12.86	131.29	13.00	32.13	27.82	7915.99
Mean		17.36	13.14	129.55	12.90	32.63	28.08	7946.58
S.Em (±)	A	0.45	0.23	0.82	0.36	0.49	0.48	38.15
	B	0.63	0.32	1.17	0.51	0.69	0.68	53.95
	AXB	1.10	0.56	2.02	0.88	1.21	1..18	93.45
C.D at 5%	A	1.29	0.66	2.37	1.03	1.42	1.38	109.64
	B	1.83	0.93	3.36	1.46	2.01	1.96	155.06
	AXB	NS	NS	NS	NS	NS	NS	NS

Conclusion

Foliar application of $ZnSO_4$ @ 1.0 per cent at (V5 & V6) stages showed significantly higher performance in all the yield and yield components of the maize crop. Availability of nutrients to plants through foliar application at early vegetative stages improves cob development leading to better grain yield.

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