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Influence of foliar nutrition of $znso_4$ and ga_3 on Morpho-physiological and yield parameters 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 entitled 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 $ZnSO_4$ at 0.25 per cent, $ZnSO_4$ at 0.5 per cent and $ZnSO_4$ at 1.0 per cent and GA_3 at 25 ppm, GA_3 at 50 ppm sprayed at different stages (V5, V6, V5 & V6). Among the different treatments, foliar application of $ZnSO_4$ (1.0%) at V5 stage revealed a significant effect on Morpho physiological parameters such as plant height, total dry matter production and ultimately leading to increasing in the yield. Morpho Physiological 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 Morpho physiological and yield parameters of maize significantly.

Keywords: Foliar application, plant height leaf area index, total dry matter production, days to 50% silking and yield

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) [4], stomata (Eichert and Burkhardt, 1999) [7] and through hydrophilic pores within the leaf cuticle (Tyree *et al.*, 1990) [24]. 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 Morpho physiological and yield parameters of maize (*Zea mays* L.).

Material and Methods

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 RCRMH2 was used for the experimental purpose. The experiment was laid out in Factorial randomized complete block design with five replications consisting of eighteen treatments including control. 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_7 $ZnSO_4$ (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. The plant height was measured from the base of the plant to the fully opened top leaf up to the stage of tassel. After tasseling, plant height was measured from the base of the plant to collar of the flag leaf from three tagged plants and the mean plant height was worked out and expressed in centimeters. Leaf area index (LAI) is defined as leaf area per unit land area. It was worked out by dividing the leaf area per plant by land area occupied by the plant as per Watson (1952) [27]. Plant samples for dry matter studies were collected at 30, 60 and 90 DAS. At each sampling, three plants were uprooted at random in border rows in each treatment and partitioned into leaf, stem and reproductive parts. These samples were oven dried at 70ºC in hot air oven for 48 hours to get constant weight. The dry weights of different plant parts were recorded. The total dry matter production per plant was obtained with the summation of dry weight of all plant parts and was expressed on per plant basis (g plant^{-1}). The number of days from sowing to 50 per cent flowering were noted when 50 per cent of plants in each plot flowered and was expressed in days. On the basis of net plot grain yield, the grain yield per ha was computed and expressed as in kilograms yield per hectare.

Results and Discussion

Foliar application of $ZnSO_4$ @ 1.0 per cent at early vegetative stages (V5 & V6) increased the plant height as compared to other treatments and the lower plant height was recorded with control where recommended dose of fertilizer was applied. Significant variation in the plant height might be due to in time availability of the needed nutrients to the plant at the important growth stages and foliar application of zinc has led to production of IAA resulting in increased plant height (Cakmak *et al.* 1989) [5].

Ghazvineh and Yousefi (2012) [10] concluded that integrated foliar application of potassium and zinc on maize increased the plant height when applied at 4-5 leaf stage. El-Azab (2015) [8] also recorded significantly higher plant height of maize with the combined foliar fertilization of zinc @ 2 per cent and NPK at 45 and 90 days after planting. Manasa and Devaranavadagi (2015) [13] recorded significantly higher plant height (205.20 cm) to the foliar spray of $ZnSO_4$ @ 1.0 per cent along with the recommended dose of N, P_2O_5, K_2O during grand growth stage. Verma *et al.* (2004) [25], Singh and Bhatt (2013) [23] and Amanullah *et al.* (2016) [2] also reported that foliar application of zinc increased the plant height.

The results were inconformity with Naveenaa (2018) [18] reported that, plant height increased at all the growth stages. Maximum plant height was recorded in foliar application of $ZnSO_4$ @ 1 per cent at V5 stage and the minimum height was recorded in control over all the other treatments.

Leaf area index is one of the most important and commonly used indices to analyze the growth of crop plant. It depends on the per cent of expansion of crop canopy to utilize the sunlight for photosynthesis.

In the present investigation, at all the stages of growth (60, 90 DAS and at harvest) and among all the treatment studied, the maximum leaf area index was recorded with foliar application of $ZnSO_4$ @ 1.0 per cent at early vegetative stages (V5 & V6).

Early application of foliar nutrition improved the vegetative growth and increased leaf area index. Increased in leaf area index by zinc application might be due to increase in auxin and indole acetic acid hormone which are two main factors in leaf area expansion (Nadergholi *et al.*, 2011) [16]. Similar results were reported by Safyan *et al.* (2012) [21] and Mohsin *et al.* (2014) [14] in maize crop.

Increase in dry matter production per unit area is a first step in achieving higher yield. Dry matter production during various growth stages of any crop is an important pre requisite for higher yields as it signifies overall utilization efficiency of resources and better interception of light. Dry matter production and its accumulation in various plant parts depend upon photosynthetic capacity of the plants which in-turn depends on dry matter accumulation in leaves as influenced by leaf area and leaf area index.

Dry matter partitioning into different plants parts differed significantly due to application of nutrients & PGRs. Dry matter content increased from 30 to 90 DAS. It was found that maximum dry matter accumulation in leaves, stem and cob were recorded in the treatment foliar spray of $ZnSO_4$ @ 1.0 per cent during early vegetative stages (V5 &V6) at 60, 90 DAS and at harvest as compared to control. The higher dry matter accumulation in leaves, stem and cob were recorded with foliar spray @ 1.0 per cent at different growth stages. Similarly, total dry matter was recorded in an increasing manner from 30 DAS to harvest.

Significant response of maize to foliar zinc might be due to activation of various enzymes such as carbonic anhydrase, alcohol dehydrogenase, superoxide dismutase and RNA polymerase. It also favors increased synthesis of enzymes and hormones along with the metabolism of major nutrients, which in turn promoted the growth components. The foliar nutrition at early vegetative stage increased due to increase in the leaf area index and accumulation of photosynthates which contributed the increase in dry matter production.

The results are in agreement with the findings of Grezebisz *et al.* (2008) [11], Parasuraman (2008) [19] and Kumar *et al.* (2016) [12]. Nalini *et al.* (2013) [17] reported similar findings in green gram where foliar application of zinc at pre flowering stage improved total dry matter and its partitioning. Roul *et al.* (2017) [20] reported that foliar application of all the

micronutrients and their combination significantly increased leaf dry matter, stem dry matter, pod dry matter and total dry matter of the plant at 45, 60 and 90 DAS over control where RDF alone was applied in sesame. Deswal and Pandurangam (2018) [6] also reported highest increment in dry matter of about 91.67 per cent and 87.38 per cent during 40 and 50 DAS when foliar spray of zinc @ 1.0 percent was applied at two growth stages 30 and 40 DAS in maize.

Different environmental factors such as light and temperature show predictable and repeatable pattern of variation during the year and have a major effect on flowering season in wild plants. There are also other factors such as nutrient content in the substrate that can influence the onset of flowering in different plant species. It seems that zinc, as a mineral nutrient, may play here a special role.

Results revealed that foliar spray of $ZnSO_4$ @ 1.0 per cent at early vegetative stages (V5 & V6) taken less days to silking compared to control. Similar finding were recorded by Ewa and Pawel (2012) [9] indicating that zinc ions present in the growth medium promote early flowering in *A.arenosa* and this effect may depend on zinc concentration used. Zinc-induced early flowering in *A. arenosa* seemed to be a universal plant response present within the species and is not an effect of stress or physiological adaptation to high Zn content in the environment. Anees *et al*. (2016) [3] also noticed minimum number of days to 50 per cent silking in maize on combined foliar spray of potassium (1.0%) and zinc (0.1%) at 20 and 50 days after sowing compared to control. Sangolli *et al.* (2018) [22] also reported that soil application of $ZnSO_4$ @ 10 kg per ha and foliar application of $ZnSO_4$ @ 0.5 per cent recorded minimum days to flowering in chick pea.

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) [8], 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) [14], Manasa and Devaranavadagi (2015) [13], Munirah *et al.* (2015) [15], Anees *et al.* (2016) [3] and Wasaya *et al.* (2017) [26].

Table 1: Influence of foliar nutrition of $ZnSO_4$ and GA_3 on Morpho -Physiological, & yield of maize hybrid

Treatments		60 Days After Sowing						
		Plant HT	LAI	Leaf DM	Stem DM	Total DM	Days to 50% silking	Yield Kg/ha
T_1- No foliar spray at V5 stage (F_0S_1)		178.46	2.69	25.14	45.72	70.86	66	7740.02
T_2- No foliar spray at V6 stage (F_0S_2)		177.53	2.60	26.23	47.54	73.77	68	7751.78
T_3- No foliar spray at V5 & V6 stages (F_0S_3)		177.90	2.69	23.75	48.61	72.36	66	7702.42
T_4- $ZnSO_4$ (0.25%) at V5 stage (F_1S_1)		182.25	3.51	31.95	51.76	85.73	65	7921.35
T_5- $ZnSO_4$ (0.25%) at V6 stage (F_1S_2)		182.23	3.41	31.58	52.40	83.99	66	7902.85
T_6- $ZnSO_4$ (0.25%) at V5 & V6 stages (F_1S_3)		186.40	3.38	32.21	53.20	85.41	65	7881.55
T_7- $ZnSO_4$ (0.5%) at V5 stage (F_2S_1)		181.66	3.36	32.90	50.89	83.79	65	7857.95
T_8- $ZnSO_4$ (0.5%) at V6 stage (F_2S_2)		183.90	3.56	31.77	51.07	82.84	65	8037.99
T_9- $ZnSO_4$ (0.5%) at V5 & V6 stages (F_2S_3)		185.93	3.53	32.20	52.79	86.44	66	7870.95
T_{10}- $ZnSO_4$ (1.0%) at V5 stage (F_3S_1)		190.03	3.66	35.65	54.00	87.02	62	8194.53
T_{11}- $ZnSO_4$ (1.0%) at V6 stage (F_3S_2)		189.16	3.59	34.60	53.78	86.45	64	8159.36
T_{12}- $ZnSO_4$ (1.0%) at V5 & V6 stages (F_3S_3)		183.33	3.43	32.00	52.32	84.32	66	8056.19
T_{13}- GA_3 (25 ppm) at V5 stage (F_4S_1)		177.40	3.42	32.67	50.10	82.77	66	8026.97
T_{14}- GA_3 (25 ppm) atV6 stage (F_4S_2)		187.26	3.45	31.51	52.41	86.21	64	8023.03
T_{15} –GA3 (25 ppm) at V5 & V6 stages (F_4S_3)		181.33	3.50	29.93	53.26	83.19	64	8021.95
T_{16}- GA_3 (50 ppm) at V5 stage (F_5S_1)		184.40	3.50	33.27	51.89	85.17	66	8016.29
T_{17}- GA_3 (50 ppm) at V6 stage (F_5S_2)		183.36	3.45	33.63	52.82	86.21	67	7957.22
T_{18}- GA_3 (50 ppm) at V5 & V6 stages (F_5S_3)		183.63	3.48	32.53	52.95	85.49	66	7915.99
Mean		183.12	3.34	31.30	51.53	82.84	66	7946.58
S.Em (±)	Stages of crop (A)	1.19	0.012	0.93	0.68	1.25	0.52	38.15
	Concentration of treatments (B)	1.68	0.017	1.31	0.97	1.77	0.74	53.95
	Interaction of (AXB)	2.92	0.030	2.28	1.68	3.06	1.28	93.45
C.D at 5%	Stages of crop (A)	3.42	0.035	2.68	1.97	3.59	1.52	109.64
	Concentration of treatments (B)	4.84	0.050	3.79	2.79	5.08	2.12	155.06
	Interaction of (AXB)	NS	0.086	NS	NS	NS	NS	NS

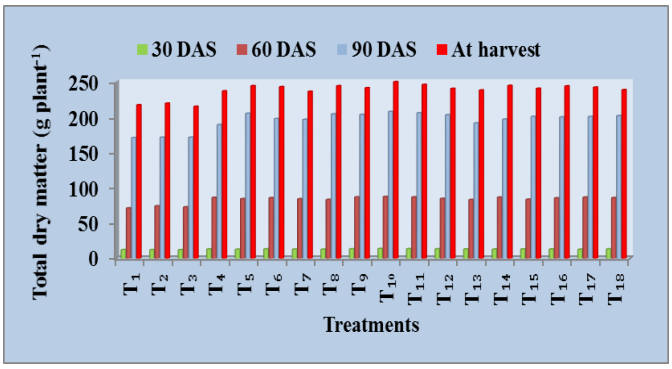

Fig 1: Influence of foliar nutrition of $ZnSO_4$ and GA_3 on total dry matter (g/plant) at different growth stages in maize hybrid

Conclusion

Foliar application of $ZnSO_4$ @ 1.0 per cent at (V5 & V6) stages showed significantly higher performance in all the Morpho physiological changes in maize which increased the yield and yield components of the maize crop.

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