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Influence of foliar nutrition at different growth stages on physiological and biochemical parameters of maize (*Zea mays* L.)

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Abstract
A field experiment was carried out at Agriculture College Farm, Raichur during kharif -2017 to study the influence of foliar nutrition at different growth stages on physiological & biochemical parameters and yield of maize. The experiment was laid out in randomized complete block design (RCBD) with thirteen treatments including the control. The treatments were foliar nutrition of NPK (19:19:19) at 1 per cent, H_3BO_3 at 0.1 per cent and $ZnSO_4$ at 0.5 per cent along with recommended dose of fertilizer sprayed at different growth stages (V5, V6, V11 and V12). Among the different treatments, foliar application of $ZnSO_4$ (0.5 %) at V6 stage revealed a significant effect on physiological parameters such as photosynthesis rate and normalized difference vegetative index (NDVI) and biochemical parameters viz., chlorophyll a, chlorophyll b, total chlorophyll, reducing and non- reducing sugar content in leaves ultimately leading to increasing in yield. Physiological and biochemical parameters except transpiration rate were increased when foliar nutrition was given at early stages (V5 and V6 stage) than late stage (V11 and V12 stage) of leaf growth. It was concluded from the results that foliar nutrition during 25 to 30 days after sowing could increase maize productivity significantly by increasing physiological and biochemical activity.

Keywords: Foliar application, photosynthesis rate, transpiration rate, NDVI, chlorophyll content, sugar content 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, as the productivity is mainly dependent on it. Maize being a C_4 plant has more photosynthetic efficiency than other cereals. 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) [6], stomata (Eichert and Burkhardt, 1999) [8] and through hydrophilic pores within the leaf cuticle (Tyree *et al.*, 1990) [23]. Several nutrient elements are readily absorbed by leaves when they are dissolved in water and sprayed on them. As macro and micro-nutrients are added to the soil, their availability will be affected by soil environmental factors. Foliar application technique is a particular way to supply macro and micro-nutrients which could avoid these factors and results in rapid absorption (Ahmed *et al*., 1994). If applied properly, foliar spraying can be considered practical to supply nutritional plant requirements. Nitrogen application stimulates protein synthesis and enhances the remobilization from stored carbohydrates in vegetative organs to grain. Phosphorus mainly controls the reproductive growth of plant. It is needed for the growth, utilization of sugar and starch, photosynthesis, cell division, nucleus formation, fat and albumen formation. Potassium plays an important role in the phloem translocation and also helps in the starch sugar synthesis. A primary function of boron (B) is related to cell wall formation. Hence boron deficient plants may be stunted. Sugar transport in plants, flower retention and pollen formation and germination also are affected by boron. Zinc exerts a great influence on basic plant life processes, such as nitrogen metabolism – uptake on nitrogen and protein quality, photosynthesis – chlorophyll synthesis, carbon anhydrase activity, development and function of floral tissues and resistance to abiotic and biotic stresses – protection against oxidative

damage. 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. These factors are predetermined at the particular leaf stage and are influenced by the availability of nutrients and environmental conditions. At present, the nutrients are applied only at the time of sowing and in addition nitrogen is top dressed at 45 days after sowing. This may not be as much helpful for grain formation and development since the grain numbers in cob will be determined at 5th to 6th leaf stage and grain development takes place at 12th leaf stage. Timing of nutrient demand and acquisition by maize is nutrient specific and associated with key vegetative or reproductive growth stages. Thus, the knowledge of 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.

Materials and methods

A field experiment was conducted to evaluate the studies on the influence of foliar nutrition on physiological and biochemical changes in maize (*Zea mays* L.) during *kharif* season of 2017. 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 randomized complete block design with five replications consisting of thirteen treatments including control. The details of the treatments were T_1 - NPK (19:19:19) (1%) at V5 stage, T_2 - NPK (19:19:19) (1%) at V6 stage, T_3 - NPK (19:19:19) (1%) at V11 stage, T_4 - NPK (19:19:19) (1%) at V12 stage, T_5 - H_3BO_3 (0.1%) at V5 stage, T_6 - H_3BO_3 (0.1%) at V6 stage, T_7 - H_3BO_3 (0.1%) at V11 stage, T_8 - H_3BO_3 (0.1%) at V12 stage, T_9 - $ZnSO_4$ (0.5%) at V5 stage, T_{10} - $ZnSO_4$ (0.5%) at V6 stage, T_{11} - $ZnSO_4$ (0.5%) at V11 stage, T_{12} - $ZnSO_4$ (0.5%) at V12 stage and T_{13} - Control (RDF). To find out the effect of treatments application, three plants were selected plants from each plot to obtain the data according to observations on physiological parameters and biochemical parameters at the time interval of 15, 25 and 35 days after treatment during the cropping periods for research purposes.

The physiological parameters *viz.*, photosynthetic rate and transpiration rate was measured using infra-red gas analyzer (IRGA) (TPS-2 portable photosynthesis system version 2.01). The measurements were made on the portion of leaves exposed directly to sunlight and it is expressed in µ mol CO_2 m^{-2} s^{-1} and m mol H_2O m^{-2} s^{-1}. Normalized Difference Vegetation Index (NDVI) was measured using the hand held Green seeker. The biochemical parameters *viz.*, chlorophyll contents (a, b and total) of the leaves was determined by following dimethyl sulphoxide (DMSO) method as devised by Hiscox and Israelstam (1979) [10] and were calculated by the following formula given by Arnon (1949) [5] and expressed in mg per g of fresh weight.

$$\text{Total chlorophyll (mg g}^{-1}\text{ fresh weight)} = \frac{[(20.2 \times A_{645}) + (8.02 \times A_{663})] \times V}{1000 \times W \times a}$$

$$\text{Chlorophyll a (mg g}^{-1}\text{ fresh weight)} = \frac{[(12.7 \times A_{663}) - (2.69 \times A_{645})] \times V}{1000 \times W \times a}$$

$$\text{Chlorophyll b (mg g}^{-1}\text{ fresh weight)} = \frac{[(22.9 \times A_{645}) - (4.68 \times A_{663})] \times V}{1000 \times W \times a}$$

where, A - Absorbance at specific wave length (645 & 663 nm), V - Final volume of the chlorophyll extract (ml), W - Fresh weight of the sample (g) and a - Path length of light (1 cm). Reducing and non- reducing sugars content in leaves was estimated following the standard procedure given by Nelson and Somogyi (1952) [17]. The collected research data was subjected to the analysis of variance by following the method of Sukhatme and Panse (1967) [21] with the level of significance used as P = 0.05.

Results and discussion

Physiological parameters

The photosynthetic rate under a given environmental condition is a function of the various biophysical and biochemical processes which involves diffusion of CO_2 from atmosphere to chloroplast and subsequent enzymatic reaction. The findings of present study (Table 1 and Figure 1) indicated that foliar application of nutrients increased the photosynthesis at all stages compared to control (only RDF). Foliar application of $ZnSO_4$ @ 0.5 percent at all the vegetative stages (V5, V6, V11 and V12) increased the photosynthetic rate than other treatments. However, among the different foliar nutrients and different vegetative stages, foliar nutrition of $ZnSO_4$ @ 0.5 per cent at early vegetative stages (V5 and V6) increased photosynthetic rate enormously at 15, 25 and 35 days after treatment in maize which may be due to its involvement in activation of many enzymes of photosynthesis, cell elongation and cell division (Cakmak, 2008) [7]. Photosynthetic rate was found to be higher when foliar nutrition was given at early vegetative stages (V5 and V6) compared to late vegetative stage (V11 and V12 stage) which may be due to the enhanced photosynthetic enzyme synthesis such as carbonic anhydrase and improved photosystem II performance by the foliar spray of zinc at early stages and declined photosynthetic rate at the later stages due to the onset of senescence. Ahmed *et al.* (2009) observed severe reduction in crop photosynthetic activities due to zinc deficiency in cotton. However, foliar application of zinc increased gas exchange parameters and maintained membrane integrity (Khan *et al.*, 2004). This increase in photosynthetic rate may be due to increasing the performance of photo-system II by the foliar spray of zinc. Qiao *et al.* (2014) [18] observed that foliar application of zinc at tillering stage enhanced carbonic anhydrase activity in rice leaves and hence increased photosynthesis. Carbonic anhydrase is considered as zinc containing enzyme involved in photosynthesis. Similar results were reported by Munirah *et al.* (2015) [13] in maize. Anees *et al.* (2016) [3] also reported that integrated foliar spray of potassium and zinc enhanced photosynthetic rate in maize.

The transpiration rate differed significantly among the foliar nutrition and different growth stages. Foliar application of nutrients increased the transpiration rate to a lesser extent compared to control. Foliar application of $ZnSO_4$ @ 0.5 percent at all the vegetative stages (V5, V6, V11 and V12) increased the transpiration rate than other treatments. However, the transpiration rate was less when foliar nutrition was given at early vegetative stage (V5 and V6) compared to late vegetative stage (V11 and V12 stage). These findings are in agreement with those of Wang and Jin (2005) [24], who reported that micronutrients affect gas exchange characteristics like photosynthetic rate, transpiration rate and stomatal conductance which were significantly enhanced by their application. Similar findings were reported by Liu *et al.* (2016) [11] in maize (Table 2).

Normalized difference vegetative index

The NDVI, which is a combination of red and NIR reflectance measurements, is one of the most widely used vegetation indices and has been extensively used to analyse the greenness of plant which is related to the amount of chlorophyll present in plant leaf. In the present investigation, foliar application of nutrients at early vegetative stages (V5 and V6) showed significant difference on NDVI (Table 3). However, there was no significant difference due to foliar application of nutrients at 15, 25 and 35 DAT on NDVI at V11 stage. Higher NDVI might be due to higher greenness which is attributed to higher nitrogen content. The higher nitrogen absorption may be due to stimulatory effect of zinc on nitrogen uptake and translocation into plant parts, which might have increased the nitrogen content of plants. These findings are similar to the results of El-Azab (2015) [9] in corn plant and Wiatrak (2013) [26] noticed that wheat seeds coated with micronutrients (Cu, Mn and Zn) increased the nitrogen uptake and zinc uptake in plants along with increase in NDVI which had positive correlation with grain yield.

Chlorophyll content

Chlorophyll has been rightly designated as “Pigments of life” because of their central role in living systems responsible for harvesting sunlight and transforming its chemical energy into biochemical energy essential for life on earth. In the present study chlorophyll a, chlorophyll b and total chlorophyll were significantly improved by the foliar nutrition (Figure 2, 3 & 4). Foliar treated plants showed different chlorophyll accumulation in leaves under different observation times. In addition, chlorophyll content was significantly higher in leaves of zinc treated plants than that of leaves of control plants at all observation times (Table 4, 5 and 6). These results suggest that zinc application might have increased chlorophyll accumulation in leaves of corn plants. Zinc is important for the formation and activity of chlorophyll and in the functioning of several enzymes and the growth hormone (auxin). Similar increase in chlorophyll a, b and total was observed by Mosanna and Behrozya (2015) [12] by the foliar application of zinc. Similar increase in chlorophyll a, b, total and carotenoids was observed by Nahed *et al.*, (2007) [16] in *Salvia farinacea* by the foliar application of zinc. Results are also in line with Massoud *et al.*, (2005) [14] in pea plants and Wenrong *et al.*, (2008) [25] in *Cupressus sempervirens* who observed that zinc deficiency resulted decline in leaf chlorophyll content. The physiological analysis of photosynthetic pigments like chlorophyll a, b and total chlorophyll were significantly increased by application of micronutrients due to enhancement in secondary metabolites (Shitole and Dhumal, 2012) [19]. These findings are also in corroboration with Singh and Bhatt (2013) [22] in lentil, Munirah *et al.* (2015) [13] in maize, and Suhasini and Doddamani (2016) [20] in greengram.

Reducing and non-reducing sugars

The production and consequent compound function of carbon is determined by phenological stage, edapho climatic condition and plant nutritional status. The present investigation showed that plants treated with $ZnSO_4$, H_3BO_3 and NPK (19:19:19) recorded significant increase in the level of reducing and non-reducing sugar in leaves at all the stages at different times of observation as compared to control. The higher level of reducing and non-reducing sugar content in maize leaves might be probably due to foliar application of macro and micronutrients which have stimulated the rate of photosynthesis leading to higher rate of production of photosynthates in the leaves (Table 7 & 8). Among the three foliar nutrients, zinc proved more beneficial expression. These changes in the concentration of total and non-reducing sugars in the treated plants are attributed to the role of zinc, starch and nucleic acid metabolism and activities of various enzymes involved in these biochemical reactions (Alloway, 2008) [2]. These results showed resemblance with the consequence of Nalini *et al.* (2013) [15] in blackgram and Ali *et al.* (2017) [4] in mustard.

Table 1: Influence of foliar nutrition on photosynthetic rate (μ mol CO_2 m^{-2} s^{-1}) at different growth stages in maize

Treatment	V5 stage			V6 stage			V11 stage			V12 stage		
	Days after treatment											
	15	25	35	15	25	35	15	25	35	15	25	35
NPK (19:19:19) (1%)	13.04	16.76	18.24	15.54	17.52	18.96	18.24	19.50	16.08	19.04	17.54	15.42
H_3BO_3 (0.1%)	13.76	17.46	18.76	15.72	17.68	19.10	17.94	18.56	15.36	18.26	16.68	15.08
$ZnSO_4$ (0.5%)	14.88	18.20	19.70	16.50	18.20	20.62	19.82	20.30	17.26	20.04	18.04	16.66
Control (RDF only)	12.20	15.00	16.32	14.52	16.28	17.88	16.14	17.24	14.80	17.22	15.58	13.96
Mean	13.47	16.86	18.26	15.57	17.42	19.14	18.04	18.90	15.88	18.64	16.96	15.28
S.Em (±)	0.49	0.41	0.68	0.39	0.38	0.33	0.49	0.68	0.37	0.57	0.56	0.24
C.D at 5%	1.52	1.26	2.10	1.19	1.16	1.03	1.50	2.09	1.14	1.78	1.72	0.73

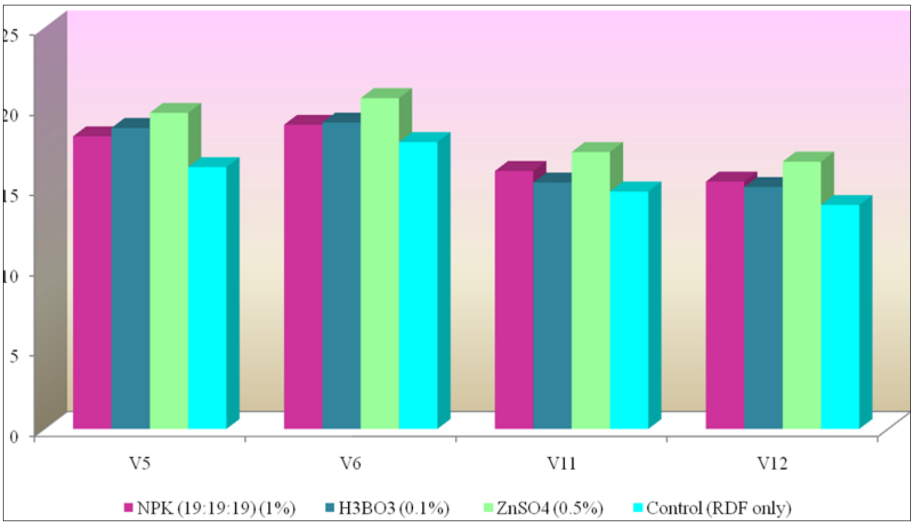

Fig 1: Influence of foliar nutrition on photosynthetic rate (μ mol CO_2 m^{-2} s^{-1}) at 35 DAT at different growth stages in maize

Table 2: Influence of foliar nutrition on transpiration rate (m mol H_2O m^{-2} s^{-1}) at different growth stages in maize

Treatment	V5 stage			V6 stage			V11 stage			V12 stage		
	Days after treatment											
	15	25	35	15	25	35	15	25	35	15	25	35
NPK (19:19:19) (1%)	8.61	8.79	9.49	8.69	9.43	9.65	9.62	9.75	9.89	9.71	10.75	10.89
H_3BO_3 (0.1%)	8.67	8.84	9.56	8.73	9.49	9.69	9.55	9.70	9.84	9.63	10.68	10.80
$ZnSO_4$ (0.5%)	8.73	8.95	9.70	8.98	9.61	9.76	9.72	9.83	10.01	9.80	10.83	10.98
Control (RDF only)	8.49	8.65	9.36	8.60	9.38	9.52	9.44	9.63	9.75	9.54	10.62	10.73
Mean	8.63	8.81	9.53	8.75	9.48	9.65	9.58	9.73	9.87	9.67	10.72	10.85
S.Em (±)	0.03	0.03	0.04	0.02	0.03	0.03	0.04	0.03	0.03	0.03	0.03	0.03
C.D at 5%	0.09	0.08	0.12	0.06	0.09	0.10	0.12	0.09	0.09	1.78	1.72	0.73

Table 3: Influence of foliar nutrition on normalized difference vegetative index (NDVI) at different growth stages in maize

Treatment	V5 stage			V6 stage			V11 stage			V12 stage		
	Days after treatment											
	15	25	35	15	25	35	15	25	35	15	25	35
NPK (19:19:19) (1%)	0.64	0.67	0.70	0.66	0.70	0.72	0.72	0.73	0.72	0.73	0.72	0.61
H_3BO_3 (0.1%)	0.65	0.68	0.72	0.68	0.72	0.74	0.70	0.72	0.71	0.72	0.71	0.59
$ZnSO_4$ (0.5%)	0.68	0.71	0.73	0.70	0.75	0.76	0.73	0.75	0.74	0.74	0.74	0.63
Control (RDF only)	0.62	0.65	0.69	0.64	0.67	0.68	0.68	0.70	0.68	0.71	0.69	0.56
Mean	0.65	0.68	0.71	0.67	0.71	0.73	0.71	0.73	0.71	0.72	0.71	0.60
S.Em (±)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.01	0.01
C.D at 5%	0.03	0.03	0.03	0.03	0.03	0.05	NS	NS	NS	NS	0.03	0.03

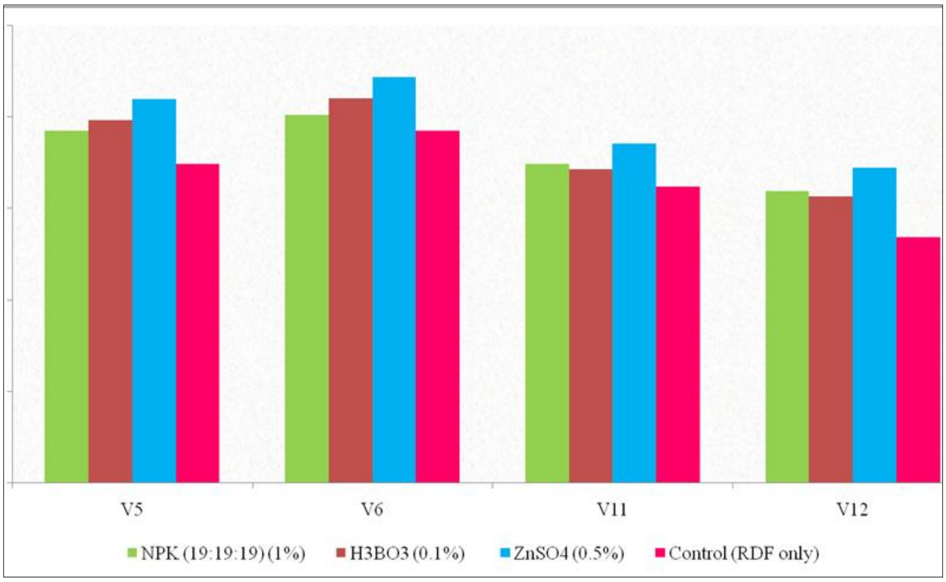

Fig 2: Influence of foliar nutrition on Chlorophyll a conetent (mg g^{-1}) at 35 DAT at different growth stages in maize

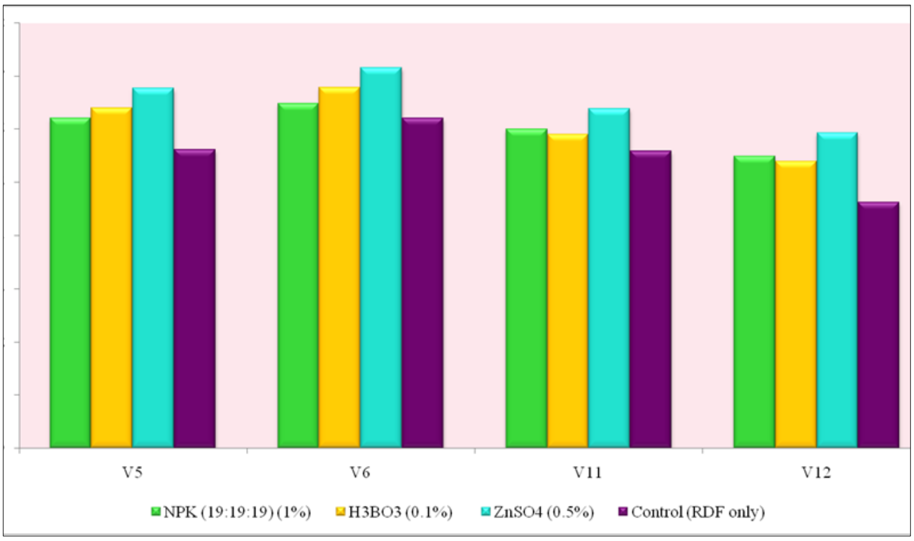

Fig 3: Influence of foliar nutrition on Chlorophyll b content (mg g-1) at 35 DAT at different growth stages in maize

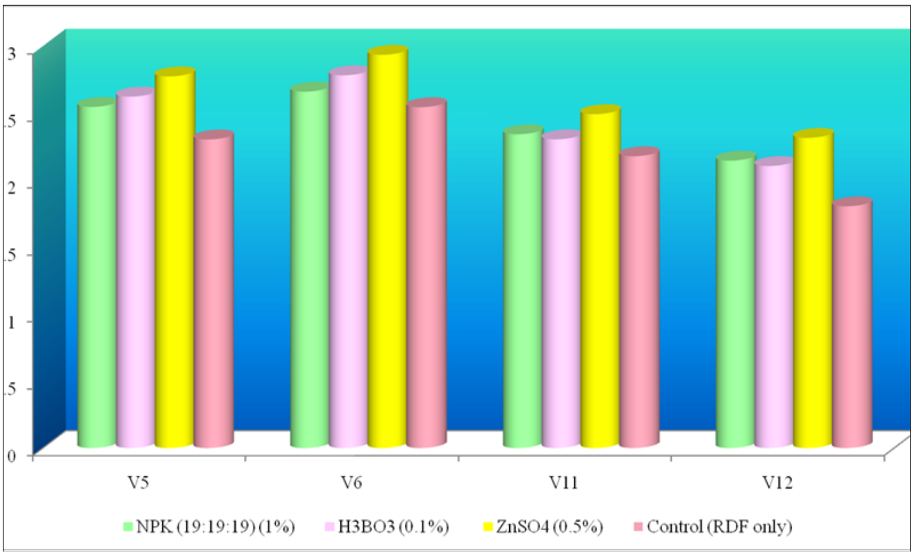

Fig 4: Influence of foliar nutrition on total chlorophyll (mg g-1) at 35 DAT at different growth stages in maize

Table 4: Influence of foliar nutrition on chlorophyll a content (mg g-1 fresh weight) at different growth stages in maize

Treatment	V5 stage			V6 stage			V11 stage			V12 stage		
	Days after treatment											
	15	25	35	15	25	35	15	25	35	15	25	35
NPK (19:19:19) (1%)	1.682	1.752	1.926	1.744	1.910	2.012	2.006	2.104	1.742	2.108	1.794	1.596
H_3BO_3 (0.1%)	1.778	1.878	1.984	1.868	1.970	2.104	1.966	2.044	1.714	2.076	1.734	1.566
$ZnSO_4$ (0.5%)	1.902	2.008	2.098	2.000	2.098	2.220	2.088	2.190	1.854	2.214	1.908	1.722
Control (RDF only)	1.570	1.692	1.742	1.686	1.732	1.924	1.742	1.914	1.620	1.924	1.656	1.342
Mean	1.733	1.833	1.938	1.825	1.928	2.065	1.951	2.063	1.733	2.081	1.773	1.557
S.Em (±)	0.006	0.008	0.008	0.006	0.007	0.009	0.005	0.027	0.024	0.023	0.017	0.008
C.D at 5%	0.019	0.024	0.024	0.019	0.022	0.028	0.016	0.083	0.073	0.071	0.053	0.024

Table 5: Influence of foliar nutrition on chlorophyll b content (mg g-1 fresh weight) at different growth stages in maize

Treatment	V5 stage			V6 stage			V11 stage			V12 stage		
	Days after treatment											
	15	25	35	15	25	35	15	25	35	15	25	35
NPK (19:19:19) (1%)	0.561	0.584	0.621	0.563	0.616	0.649	0.647	0.679	0.601	0.669	0.619	0.550
H_3BO_3 (0.1%)	0.593	0.606	0.640	0.603	0.635	0.679	0.634	0.659	0.591	0.659	0.598	0.540
$ZnSO_4$ (0.5%)	0.634	0.648	0.677	0.645	0.677	0.716	0.674	0.706	0.639	0.703	0.658	0.594
Control (RDF only)	0.523	0.546	0.562	0.544	0.559	0.621	0.562	0.617	0559	0.611	0.571	0.463
Mean	0.578	0.596	0.625	0.589	0.622	0.666	0.629	0.665	0.597	0.660	0.611	0.537
S.Em (±)	0.002	0.003	0.002	0.002	0.002	0.003	0.002	0.009	0.008	0.007	0.006	0.003
C.D at 5%	0.006	0.008	0.008	0.006	0.007	0.009	0.005	0.027	0.025	0.022	0.018	0.008

Table 6: Influence of foliar nutrition on total chlorophyll content (mg g^{-1} fresh weight) at different growth stages in maize

Treatment	V5 stage			V6 stage			V11 stage			V12 stage		
	Days after treatment											
	15	25	35	15	25	35	15	25	35	15	25	35
NPK (19:19:19) (1%)	2.243	2.336	2.547	2.307	2.526	2.661	2.653	2.783	2.343	2.777	2.413	2.146
H_3BO_3 (0.1%)	2.371	2.484	2.624	2.471	2.605	2.783	2.600	2.703	2.305	2.735	2.332	2.106
$ZnSO_4$ (0.5%)	2.536	2.656	2.775	2.645	2.775	2.936	2.762	2.896	2.493	2.917	2.566	2.316
Control (RDF only)	2.093	2.238	2.304	2.230	2.291	2.545	2.304	2.531	2.179	2.535	2.227	1.805
Mean	2.311	2.438	2.563	2.413	2.549	2.731	2.580	2.728	2.330	2.741	2.384	2.093
S.Em (±)	0.008	0.010	0.010	0.009	0.010	0.012	0.007	0.036	0.032	0.030	0.023	0.011
C.D at 5%	0.025	0.032	0.031	0.026	0.030	0.037	0.021	0.110	0.098	0.094	0.071	0.033

Table 7: Influence of foliar nutrition on reducing sugar in leaves (mg g^{-1}) at different growth stages in maize

Treatment	V5 stage			V6 stage			V11 stage			V12 stage		
	Days after treatment											
	15	25	35	15	25	35	15	25	35	15	25	35
NPK (19:19:19) (1%)	2.23	2.39	2.81	2.33	2.90	3.89	3.02	4.04	3.92	3.90	3.80	3.54
H_3BO_3 (0.1%)	2.42	2.59	3.10	2.51	3.14	4.14	2.79	3.75	3.44	3.62	3.39	3.06
$ZnSO_4$ (0.5%)	2.60	3.09	3.59	2.93	3.65	4.47	3.48	4.27	4.12	4.17	3.95	3.64
Control (RDF only)	1.94	2.12	2.63	2.06	2.61	3.39	2.63	3.39	3.08	3.37	3.12	2.88
Mean	2.30	2.55	3.04	2.46	3.08	3.97	2.98	3.86	3.64	3.77	3.57	3.28
S.Em (±)	0.03	0.03	0.04	0.04	0.06	0.05	0.04	0.04	0.06	0.05	0.04	0.06
C.D at 5%	0.09	0.09	0.13	0.12	0.19	0.14	0.12	0.12	0.18	0.15	0.13	0.17

Table 8: Influence of foliar nutrition on non-reducing sugar in leaves (mg g^{-1}) at different growth stages in maize

Treatment	V5 stage			V6 stage			V11 stage			V12 stage		
	Days after treatment											
	15	25	35	15	25	35	15	25	35	15	25	35
NPK (19:19:19) (1%)	15.65	15.82	16.97	15.81	16.41	17.68	18.59	18.38	18.15	18.45	18.14	16.12
H_3BO_3 (0.1%)	16.29	17.46	18.19	17.88	18.86	20.01	17.39	17.31	16.97	17.47	17.27	15.10
$ZnSO_4$ (0.5%)	18.84	19.17	20.10	19.83	20.24	21.00	20.46	20.28	19.80	19.51	19.29	17.78
Control (RDF only)	13.68	14.76	15.91	14.66	15.27	16.40	16.41	15.97	15.16	15.80	15.16	13.23
Mean	16.16	16.80	17.79	17.04	17.69	18.77	18.21	17.99	17.52	17.81	17.46	15.56
S.Em (±)	0.47	0.54	0.45	0.40	0.38	0.39	0.43	0.44	0.48	0.28	0.26	0.28
C.D at 5%	1.46	1.67	1.37	1.24	1.16	1.19	1.34	1.35	1.48	0.88	0.82	0.86

Conclusion

Foliar application of $ZnSO_4$ @ 0.5 per cent along with recommended dose of fertilizers at early growth stages (V5 and V6) showed significantly higher performance in all the physiological and biochemical parameters changes in maize which would increase the yield and yield components of the crop plants.

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