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STUDY ON SPECIFIC LEAF WEIGHT, LEAF TO PLANT WEIGHT RATIO AND HARVEST INDEX OF TUBEROSE *CV.* 'PRAJWAL' AS AFFECTED BY APPLICATION OF DIFFERENT ESSENTIAL HEAVY METALS

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ABSTRACT

An experiment was conducted with graded levels of three different essential heavy metals *viz.,* $MnSO_4$ (1000, 2000 and 3000 mg kg^{-1} soil), $CuSO_4$ (100, 200 and 300 mg kg^{-1} soil) and $ZnSO_4$ (200, 400 and 600 mg kg^{-1} soil) in addition to Control *i.e.,* without external application of any essential heavy metals mentioned above. The experiment was carried out continuously for two years in polybag culture method and conducted with a Completely Randomized Design using three replications. The data recorded at every 90 days after planting (DAP) interval on dry weight changes of tuberose *cv.* 'Prajwal' during different phases of vegetative growth were analyzed using OPSTAT software and the least significant difference was used to differentiate the treatments. Analysis of results indicated that soil application of $ZnSO_4$ @ 400 mg kg^{-1} soil recorded a significant improvement in specific leaf weight (0.37 g cm^{-2} and 0.49 g cm^{-2} respectively during 2018-19 and the pooled data analysis), leaf to plant weight ratio (0.63, 0.88 and 0.72 respectively during 2018-19, 2019-20 and the pooled data analysis) per plant.
***Keywords* :** $CuSO_4$, heavy metals, $MnSO_4$, tuberose, SLW and $ZnSO_4$.

Introduction

Contamination of soils with heavy metals is considered as one of the serious environmental concerns due to persistent nature of heavy metals as well as their bio-magnification potential in the soil. Presence of high concentrations of both essential and non-essential heavy metals are considered to affect the plant growth and development adversely and sometimes even lead to death under extreme conditions and thus heavy metal toxicity has been considered as one of the major abiotic stresses leading to hazardous effects in plants as many of them were found toxic even at a very low-level concentrations in the soil. Industrial revolution has accelerated the biosphere with heavy metals all over the world. A common response of heavy metal toxicity on plants was excessive accumulation of reactive oxygen species (ROS) which can cause peroxidation of lipids, oxidation of proteins, inactivation of enzymes, DNA damage and/or interact with other vital constituents of plant cells (Bohra *et al.*, 2015). Certain heavy metals were found nutritionally essential for healthy growth of plant in very small quantities such as iron (Fe), copper (Cu), manganese (Mn), Magnesium (Mg) and zinc (Zn). These metals were found required in specific amounts and their deficiencies or elevated concentrations will result in deleterious effects on plant growth and development and thus reduce plant productivity. Out of the several heavy metals of essential and non-essential nature, three essential heavy metals *viz.,* Mn, Cu and Zn were found required in trace amounts for better growth, development and metabolic activity of plants and thus have been selected in the present investigation to identify their level of beneficial and toxic effects on the plant's metabolic activity under heavily accumulated condition in the soil. General metabolic functions and toxicity of these essential heavy metals on plant's growth and metabolism has been briefly discussed to show the basis for selection of tuberose plants to remove these elements from soil through the process of phytoremediation in the present investigation with the main objective to find out the specific leaf weight, leaf to plant weight ratio and harvest index changes of tuberose *cv.* 'Prajwal' as influenced by graded levels of different essential heavy metals *viz.,* Mn, Cu and Zn.

Materials and Methods

The present investigation was carried out during the period from *Rabi*-2018 to *Kharif*-2020 at the College of Horticulture, Dr. Y.S.R. Horticultural University, Anantharajupeta, Kadapa district of Andhra Pradesh. The experiment was laid out in a completely randomized design (CRD) with factorial concept and replicated thrice. The experiment has consisted of 10 treatments *viz.,* T_1 = RDF+$MnSO_4$ @ 1,000 mg kg^{-1} soil, T_2 = RDF+$MnSO_4$ @ 2,000 mg kg^{-1} soil, T_3 = RDF+$MnSO_4$ @ 3,000 mg kg^{-1} soil, T_4 = RDF+$CuSO_4$ @ 100 mg kg^{-1} soil, T_5 = RDF+$CuSO_4$ @ 200 mg kg^{-1} soil, T_6 = RDF+$CuSO_4$ @ 300 mg kg^{-1} soil, T_7 = RDF+$ZnSO_4$ @ 200 mg kg^{-1} soil, T_8 = RDF+ $ZnSO_4$ @ 400 mg kg^{-1} soil, T_9 = RDF+ $ZnSO_4$ @ 600 mg kg^{-1} soil, T_{10} = Control (No RDF and no essential heavy metals application). The main objective of the investigation was to find out the specific leaf weight, leaf to plant weight ratio and harvest index changes of tuberose *cv.* 'Prajwal' as influenced by graded levels of essential heavy metals (Mn, Cu, Zn). Specific leaf weight is the ratio between leaf dry weight and leaf area. It was expressed as g cm^{-2}. Specific leaf weight was calculated by using the following formula.

$$\text{Specific leaf weight (g/cm}^2) = \frac{\text{Leaf dry weight (g)}}{\text{Leaf area (cm}^2)}$$

Leaf to plant weight ratio was the ratio of leaf dry weight to total plant dry weight. Leaf to plant weight ratio was calculated by using the following formula.

$$\text{Leaf to plant weight ratio} = \frac{\text{Leaf dry weight (g)}}{\text{Total plant dry weight (g)}}$$

Harvest index is the ratio between economic yield (dry weight of flower) and biological yield (total dry weight of plant). Harvest index was calculated by using the following formula.

$$\text{Harvest Index (\%)} = \frac{\text{Economic yield (g)}}{\text{Biological yield (g)}} \times 100$$

The data obtained was analyzed using OPSTAT software and the least significant difference was used to differentiate the treatment differences.

Results and Discussion

Significant variation was noticed in the specific leaf weight of tuberose *cv.* 'Prajwal' (Table 1). Among the graded levels of essential heavy metal concentrations, application of $ZnSO_4$ @ 400 mg kg^{-1} soil recorded significantly highest specific leaf weight (0.23 g cm^{-2}, 0.56 g cm^{-2} and 0.37 g cm^{-2} respectively during 2018-19, 2019-20 and the pooled data analysis) followed by application of $ZnSO_4$ @ 200 mg kg^{-1} soil, whereas application of $ZnSO_4$ @ 600 mg kg^{-1} soil recorded significantly lowest specific leaf weight (0.08 g cm^{-2}, 0.31 g cm^{-2} and 0.18 g cm^{-2} respectively during 2018-19, 2019-20 and the pooled data analysis) among the zinc sulphate concentrations. Among the graded levels of $MnSO_4$, application of $MnSO_4$ @ 1000 mg kg^{-1} soil recorded significantly highest specific leaf weight (0.09 g cm^{-2}), whereas significantly lowest specific leaf weight (0.06 g cm^{-2}) was recorded during 2018-19. However, application of $MnSO_4$ @ 1000 mg kg^{-1} soil recorded significantly lowest specific leaf weight (0.37 g cm^{-2} and 0.23 g cm^{-2}) during 2019-20 and the pooled data analysis respectively, whereas remaining other two higher concentrations have recorded non-significant differences between their concentrations with respect to specific leaf weight of tuberose *cv.* 'Prajwal' during 2019-20 and the pooled data analysis. Among the graded levels of $CuSO_4$, application of $CuSO_4$ @ 100 mg kg^{-1} soil recorded significantly lowest specific leaf weight (0.05 g cm^{-2}), whereas significantly highest specific leaf weight (0.08 g cm^{-2}) was recorded by application of $CuSO_4$ @ 100 mg kg^{-1} soil during 2018-19. However, application of $CuSO_4$ @ 200 mg kg^{-1} soil recorded significantly lowest specific leaf weight (0.24 g cm^{-2} and 0.13 g cm^{-2} respectively during 2019-20 and the pooled data analysis), whereas application of $CuSO_4$ @ 100 mg kg^{-1} soil recorded significantly highest specific leaf weight (0.29 g cm^{-2} and 0.15 g cm^{-2} respectively during 2019-20 and the pooled data analysis). Further, the analyzed pooled data with respect to specific leaf weight has revealed that application of $CuSO_4$ @ 100 mg kg^{-1} soil (0.15 g cm^{-2}) was found at par with the application of $CuSO_4$ @ 300 mg kg^{-1} soil (0.16 g cm^{-2}). Significantly lowest specific leaf weight was noticed in the untreated control plants (0.01 g cm^{-2}, 0.19 g cm^{-2} and 0.09 g cm^{-2} respectively during 2018-19, 2019-20 and the pooled data analysis).

Significant variation was noticed among the intervals of observation recorded with respect to the specific leaf weight of tuberose *cv.* 'Prajwal' during 2018-19, 2019-20 and the pooled data analysis. Among the intervals, significantly highest specific leaf weight (0.14 g cm^{-2}, 0.47 g cm^{-2} and 0.26 g cm^{-2} respectively during 2018-19, 2019-20 and the pooled data analysis) was recorded at 360 DAP, whereas significantly lowest specific leaf weight (0.05 g cm^{-2}, 0.25 g cm^{-2} and 0.15 g cm^{-2} respectively during 2018-19, 2019-20 and the pooled data analysis) was recorded at the initial 90

DAP interval. A gradual and significant increase in the specific leaf weight of tuberose *cv.* 'Prajwal' was noticed with the passage of time during both the years of study as well as in the pooled data analysis.

The data pertaining to interaction effect between graded levels of essential heavy metal concentrations and the intervals of observation recorded with respect to specific leaf weight was found significant during 1st year of study *i.e.,* 2018-19 and the pooled data analysis, but the data recorded during 2nd year of study *i.e.,* 2019-20 was found non-significant. Among the combination treatments, significantly highest specific leaf weight (0.37 g cm^{-2} and 0.49 g cm^{-2} respectively during 2018-19 and the pooled data analysis) was recorded by application of $ZnSO_4$ @ 400 mg kg^{-1} soil at 360 DAP followed by application of $ZnSO_4$ @ 400 mg kg^{-1} soil at 270 DAP (0.34 g cm^{-2} and 0.47 g cm^{-2} respectively during 2018-19 and the pooled data analysis), whereas significantly lowest specific leaf weight (0.01 g cm^{-2} and 0.04 g cm^{-2} respectively during 2018-19 and the pooled data analysis) was recorded in the untreated control plants at 90 DAP. Based on the analysis of results, it may be concluded that application of $ZnSO_4$ @ 400 mg kg^{-1} soil recorded highest specific leaf weight which may be correlated with the increased chlorophyll content and the rate of photosynthesis. Bowes *et al.* (1972) reported that specific leaf weight can be considered as a measure of leaf thickness and has been reported to have a strong positive correlation with photosynthesis in several crops. Arnon (1975) has revealed that specific leaf weight in plants has been considered highly correlated with the development of reproductive organs on the plant. Craufurd *et al.,* (1999) reported that thicker the leaf of plant would have more the number of mesophyll cells with high density of chlorophyll content and therefore possess a greater photosynthetic ability in the leaves in comparison with the thinner leaves.

Significant variation was noticed in the leaf to plant weight ratio of tuberose *cv.* 'Prajwal' (Table 2). Among the graded levels of essential heavy metal concentrations, application of $ZnSO_4$ @ 400 mg kg^{-1} soil recorded significantly highest leaf to plant weight ratio (0.57, 0.78 and 0.65 respectively during 2018-19, 2019-20 and the pooled data analysis), whereas application of $ZnSO_4$ @ 600 mg kg^{-1} soil recorded significantly lowest leaf to plant weight ratio (0.39) among the zinc sulphate concentrations and was found at par with the application of $ZnSO_4$ @ 200 mg kg^{-1} soil during 2018-19. Application of $ZnSO_4$ @ 600 mg kg^{-1} soil recorded significantly lowest leaf to plant weight ratio (0.39, 0.51 and 0.45 respectively during 2018-19, 2019-20 and the pooled data analysis), whereas application of $ZnSO_4$ @ 200 mg kg^{-1} soil recorded significantly moderate values between the above two concentrations of $ZnSO_4$. Application of graded levels of $MnSO_4$ recorded significant variation in the leaf to plant weight ratio and the ratio was found in the decreasing trend with increasing concentration of $MnSO_4$ during both the years of study as well as in the pooled data analysis. Application of $CuSO_4$ @ 100 mg kg^{-1} soil recorded significantly highest leaf to plant weight ratio (0.39, 0.54 and 0.45 respectively during 2018-19, 2019-20 and the pooled data) and was found at par with the application of $CuSO_4$ @ 200 mg kg^{-1} soil during both the years of study as well as in the pooled data analysis, whereas as application of $CuSO_4$ @ 300 mg kg^{-1} soil recorded significantly lowest leaf to plant weight ratio among the $CuSO_4$ concentrations. Among all the treatments, untreated control plants recorded significantly lowest leaf to plant weight ratio (0.24, 0.42 and 0.33 respectively during 2018-19, 2019-20 and the pooled data analysis).

Significant variation was noticed among the intervals of observation recorded with respect to the leaf to plant weight ratio of tuberose *cv.* 'Prajwal' by soil application of graded levels of essential heavy metal concentrations. Among the intervals, significantly highest leaf to plant weight ratio (0.44, 0.64 and 0.51 respectively during 2018-19, 2019-20 and the pooled data) was recorded at 360 DAP, whereas significantly lowest leaf to plant weight ratio (0.31, 0.49 and 0.40 respectively during 2018-19, 2019-20 and the pooled data analysis) was noticed at the initial 90 DAP interval. A gradual and significant increase in the leaf to plant weight ratio was noticed at each successive intervals of observation recorded during both the years of study as well as in the pooled data analysis.

The data pertaining to interaction effects between graded levels of essential heavy metal concentrations and the intervals of observation recording with respect to leaf to plant weight ratio of tuberose *cv.* 'Prajwal' was found significant during 2018-19, 2019-20 and the pooled data analysis. Among the combination treatments, significantly highest leaf to plant weight ratio (0.63, 0.88 and 0.72 respectively during 2018-19, 2019-20 and the pooled data analysis) was recorded by application of $ZnSO_4$ @ 400 mg kg^{-1} soil at 360 DAP followed by application of $ZnSO_4$ @ 400 mg kg^{-1} soil at 270 DAP (0.58, 0.84 and 0.71 respectively during 2018-19, 2019-20 and the pooled data analysis), whereas significantly lowest leaf to plant weight ratio (0.14, 0.38 and 0.26 respectively during 2018-19, 2019-20 and the pooled data analysis) was recorded in the untreated control at 90 DAP.

Significant variation was noticed in the harvest index of tuberose *cv.* 'Prajwal' by soil application of graded levels of essential heavy metal concentrations (Table 3). Among the graded levels of essential heavy metal concentrations, application of $ZnSO_4$ @ 400 mg kg^{-1} soil recorded significantly highest harvest index (27.33%, 36.60% and 31.07% respectively during 2018-19, 2019-20 and the pooled data analysis) followed by application of $ZnSO_4$ @ 200 mg kg^{-1} soil (24.12%, 26.50% and 32.91% respectively during 2018-19, 2019-20 and the pooled data analysis), however the data with regard to application of $ZnSO_4$ @ 200 mg kg^{-1} soil was found at par with the application of $ZnSO_4$ @ 400 mg kg^{-1} soil during 2018-19. Among the zinc sulphate concentrations, application of $ZnSO_4$ @ 600 mg kg^{-1} soil recorded significantly lowest harvest index (9.10%, 22.24% and 15.45% respectively during 2018-19, 2019-20 and the pooled data analysis). Application of $MnSO_4$ @ 1000 mg kg^{-1} soil recorded significantly lowest harvest index (3.15%), whereas application of $MnSO_4$ @ 2000 mg kg^{-1} soil recorded significantly highest harvest index (9.06%) and was found at par with the application of $MnSO_4$ @ 3000 mg kg^{-1} soil (6.81%) during 2018-19. However, soil application of graded levels of $MnSO_4$ recorded non-significant differences in the harvest index of tuberose *cv.* 'Prajwal' during 2019-20 and the pooled data analysis. Application of graded levels of $CuSO_4$ recorded non-significant differences in the harvest index of tuberose *cv.* 'Prajwal' during both the years of study as well as in the pooled data analysis. Among all the treatments, significantly lowest harvest index was recorded in the untreated control plants (0.25%, 4.02% and 1.98% respectively during 2018-19, 2019-20 and the pooled data analysis). Harvest index exhibits physiological efficiency of plants to convert the fraction of photo-assimilation to flower yield. Obviously higher the harvest index, greater will be the flower yield of crops. Based on the analysis of results obtained in the present study, it may be concluded that soil application of zinc sulphate at 200-400 mg kg^{-1} soil increased the physiological efficiency of tuberose plants of *cv.* 'Prajwal' in converting the photo-assimilates to flower yield of tuberose, hence recorded significantly highest harvest index in comparison to other essential heavy metal concentrations. Similar kind of observation was reported earlier by Singh *et al.* (2017) in maize which is in agreement with the present result.

Significant differences were noticed among the intervals of observation recorded with respect to the harvest index of tuberose *cv.* 'Prajwal' by soil application of essential heavy metal concentrations. Among the intervals, significantly highest harvest index (13.57%, 19.94% and 15.76% respectively during 2018-19, 2019-20 and the pooled data analysis) was recorded at 360 DAP, whereas significantly lowest harvest index (7.60%, 12.91% and 10.25% respectively during 2018-19, 2019-20 and the pooled data analysis) was recorded at the initial 90 DAP interval. A gradual increase observed in the harvest index of tuberose *cv.* 'Prajwal' during both the years of study as well as in the pooled data analysis has revealed that with the passage of time of the crop harvest index has increased. However, harvest index between the successive intervals at any stage of the data recording was found non-significant during both the years of study as well as in the pooled data analysis.

The data pertaining to interaction effects between graded levels of essential heavy metal concentrations and the intervals of data recording with respect to harvest index of tuberose *cv.* 'Prajwal' was found non-significant during both the years of study as well as in the pooled data analysis.

Table 1 : Influence of applied essential heavy metals (Cu, Mn, Zn) on specific leaf weight of *Polianthes tuberosa cv.* Prajwal.

Treatment (mg of element kg^{-1} soil)	Specific leaf weight (g cm^{-1})														
	2018 - 2019					2019 - 2020					Pooled (2018-20)				
	I_{90}	I_{180}	I_{270}	I_{360}	Mean	I_{90}	I_{180}	I_{270}	I_{360}	Mean	I_{90}	I_{180}	I_{270}	I_{360}	Mean
$MnSO_4$ 1000	0.07	0.08	0.10	0.13	**0.09**	0.25	0.35	0.41	0.48	**0.37**	0.16	0.18	0.25	0.27	**0.21**
$MnSO_4$ 2000	0.04	0.04	0.07	0.13	**0.07**	0.33	0.44	0.46	0.56	**0.45**	0.19	0.20	0.26	0.29	**0.23**
$MnSO_4$ 3000	0.04	0.05	0.06	0.08	**0.06**	0.36	0.43	0.48	0.55	**0.45**	0.20	0.21	0.27	0.28	**0.24**
$CuSO_4$ 100	0.04	0.05	0.07	0.07	**0.05**	0.14	0.23	0.36	0.43	**0.29**	0.09	0.11	0.21	0.22	**0.15**
$CuSO_4$ 200	0.04	0.05	0.07	0.09	**0.06**	0.15	0.18	0.26	0.36	**0.24**	0.09	0.10	0.17	0.18	**0.13**
$CuSO_4$ 300	0.06	0.07	0.08	0.11	**0.08**	0.18	0.22	0.32	0.35	**0.27**	0.12	0.13	0.20	0.21	**0.16**
$ZnSO_4$ 200	0.07	0.09	0.14	0.30	**0.15**	0.37	0.40	0.48	0.58	**0.46**	0.22	0.23	0.31	0.36	**0.28**
$ZnSO_4$ 400	0.09	0.13	0.34	0.37	**0.23**	0.45	0.48	0.61	0.68	**0.56**	0.27	0.28	0.47	0.49	**0.37**
$ZnSO_4$ 600	0.04	0.07	0.09	0.11	**0.08**	0.22	0.25	0.36	0.41	**0.31**	0.13	0.14	0.22	0.23	**0.18**
Control	0.01	0.01	0.01	0.04	**0.01**	0.08	0.15	0.24	0.30	**0.19**	0.04	0.05	0.13	0.14	**0.09**
Mean	**0.05**	**0.06**	**0.10**	**0.14**		**0.25**	**0.31**	**0.40**	**0.47**		**0.15**	**0.16**	**0.25**	**0.26**	

Factor	T	I	T × I	T	I	T × I	T	I	T × I
SEm±	0.006	0.004	0.012	0.009	0.005	0.017	0.006	0.003	0.011
CD at 5%	0.017	0.011	0.034	0.024	0.015	NS	0.016	0.010	0.031

Table 2 : Influence of applied essential heavy metals (Cu, Mn, Zn) on leaf to plant weight ratio of *Polianthes tuberosa cv.* Prajwal.

Treatment (mg of element kg^{-1} soil)	Leaf to plant weight ratio														
	2018 - 2019					2019 - 2020					Pooled (2018-20)				
	I_{90}	I_{180}	I_{270}	I_{360}	Mean	I_{90}	I_{180}	I_{270}	I_{360}	Mean	I_{90}	I_{180}	I_{270}	I_{360}	Mean
$MnSO_4$ 1000	0.32	0.37	0.44	0.47	**0.40**	0.54	0.65	0.68	0.73	**0.65**	0.43	0.46	0.56	0.57	**0.50**
$MnSO_4$ 2000	0.24	0.28	0.43	0.44	**0.35**	0.55	0.57	0.61	0.71	**0.61**	0.39	0.40	0.52	0.54	**0.46**
$MnSO_4$ 3000	0.25	0.27	0.34	0.38	**0.31**	0.40	0.44	0.51	0.64	**0.49**	0.32	0.33	0.42	0.45	**0.38**
$CuSO_4$ 100	0.35	0.37	0.40	0.45	**0.39**	0.47	0.53	0.56	0.59	**0.54**	0.41	0.42	0.49	0.49	**0.45**
$CuSO_4$ 200	0.36	0.37	0.40	0.44	**0.39**	0.49	0.55	0.57	0.54	**0.54**	0.42	0.43	0.48	0.49	**0.46**
$CuSO_4$ 300	0.24	0.26	0.36	0.39	**0.31**	0.43	0.51	0.56	0.61	**0.53**	0.34	0.35	0.46	0.47	**0.40**
$ZnSO_4$ 200	0.35	0.37	0.41	0.45	**0.39**	0.52	0.54	0.63	0.66	**0.58**	0.43	0.44	0.52	0.53	**0.49**
$ZnSO_4$ 400	0.52	0.56	0.58	0.63	**0.57**	0.66	0.74	0.84	0.88	**0.78**	0.59	0.61	0.71	0.72	**0.65**
$ZnSO_4$ 600	0.34	0.36	0.42	0.44	**0.39**	0.47	0.51	0.53	0.55	**0.51**	0.40	0.41	0.47	0.48	**0.45**
Control	0.14	0.18	0.33	0.34	**0.24**	0.38	0.40	0.43	0.48	**0.42**	0.26	0.27	0.38	0.39	**0.33**
Mean	**0.31**	**0.34**	**0.41**	**0.44**		**0.49**	**0.54**	**0.59**	**0.64**		**0.40**	**0.41**	**0.50**	**0.51**	

Factor	T	I	T × I	T	I	T × I	T	I	T × I
SEm±	0.007	0.004	0.013	0.009	0.006	0.018	0.006	0.003	0.01
CD at 5%	0.019	0.012	0.038	0.025	0.016	0.050	0.016	0.01	0.03

Table 3 : Influence of applied essential heavy metals (Cu, Mn, Zn) on harvest index of *Polianthes tuberosa cv.* Prajwal.

Treatment (mg of element kg^{-1} soil)	Harvest index (%)														
	2018 - 2019					2019 - 2020					Pooled (2018-20)				
	I_{90}	I_{180}	I_{270}	I_{360}	Mean	I_{90}	I_{180}	I_{270}	I_{360}	Mean	I_{90}	I_{180}	I_{270}	I_{360}	Mean
$MnSO_4$ 1000	1.73	1.13	4.46	5.30	**3.15**	6.56	12.23	17.43	18.33	**13.64**	4.15	5.15	10.94	11.29	**7.88**
$MnSO_4$ 2000	5.66	0.86	12.20	17.53	**9.06**	12.30	0.00	12.13	12.43	**9.21**	8.98	5.56	12.16	13.29	**9.99**
$MnSO_4$ 3000	3.26	5.66	9.00	9.33	**6.81**	11.46	12.13	10.76	17.36	**12.93**	7.36	7.97	9.88	11.26	**9.11**
$CuSO_4$ 100	4.33	5.40	9.33	15.90	**8.74**	12.83	12.30	11.60	18.76	**13.87**	8.58	8.68	10.46	13.21	**10.23**
$CuSO_4$ 200	4.00	7.93	11.76	9.00	**8.17**	12.10	6.23	5.46	18.60	**10.60**	8.05	7.66	8.61	10.68	**8.75**
$CuSO_4$ 300	0.00	8.86	7.50	9.06	**6.35**	8.46	7.50	19.96	14.26	**12.55**	4.23	5.81	13.73	12.90	**9.16**
$ZnSO_4$ 200	18.73	26.20	28.76	22.80	**24.12**	11.40	32.43	30.86	31.33	**26.50**	15.06	20.76	29.81	28.71	**23.58**
$ZnSO_4$ 400	28.60	18.16	30.63	31.96	**27.33**	37.23	34.23	37.76	37.16	**36.60**	32.91	30.22	34.19	34.34	**32.91**
$ZnSO_4$ 600	9.66	3.80	9.13	13.83	**9.10**	16.73	19.43	25.76	27.03	**22.24**	13.20	12.56	17.44	18.63	**15.45**
Control	0.00	0.00	0.00	1.00	**0.25**	0.00	4.36	7.56	4.16	**4.02**	0.00	0.87	3.78	3.30	**1.98**
Mean	**7.60**	**7.80**	**12.27**	**13.57**		**12.91**	**14.08**	**17.92**	**19.94**		**10.25**	**10.52**	**15.10**	**15.76**	

Factor	T	I	T × I	T	I	T × I	T	I	T × I
SEm±	1.97	1.24	3.94	2.54	1.61	5.09	1.66	1.05	3.33
CD at 5%	5.56	3.52	NS	7.18	4.54	NS	4.70	2.97	NS

References

Arnon, I. (1975). Mineral nutrition of maize. Berne, Switzerland: International Potash Institute.

Bowes, G.W., Orgen, L. and Hageman, R.H. (1972). Light saturated photosynthesis rate, RuBp Carboxylase activity and specific leaf weight in soybean grown under different light intensities. *Crop Science*, **12**: 77-79.

Craufurd, P.C., Wheelee, T.R., Ellis, R.H., Summerfield, R.J. and Williams, J.H. (1999). Effect of temperature and water deficit on water use efficiency, carbon isotope discrimination and specific leaf weight in peanut. *Crop Science*. **39**: 136-142.

Singh, S, Singh, V. and Mishra, P. (2017). Effect of NPK, boron and zinc on productivity and profitability of late sown kharif maize (*Zea mays* L.) in western Uttar Pradesh, India. *Annals of Agricultural Research* (New Series). **38**(3): 310-313.