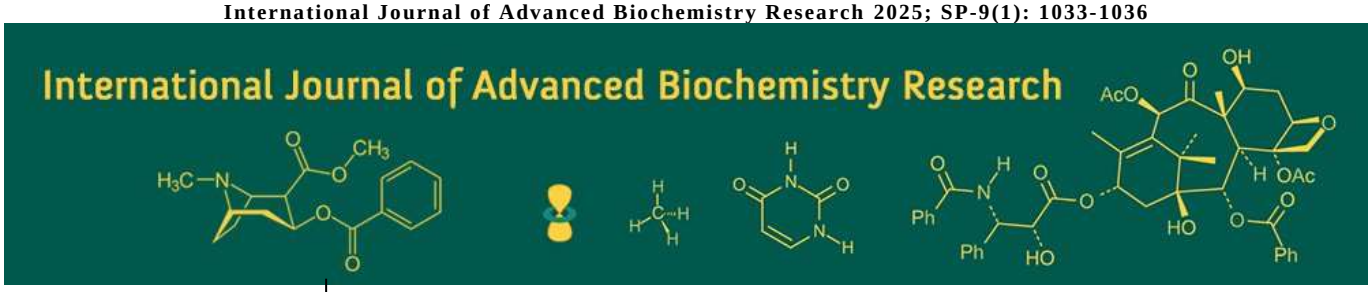

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Improving Growth and leaf nutrient content of guava (*Psidium guajava* L.) with micronutrient management

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Abstract
To improve growth and leaf nutrient content of guava under rainfed conditions an experiment was conducted with twenty four treatments comprising of different concentration of Zinc sulphate and Boric acid applied alone as well as in combination, sprayed twice during last week of October and last week of November. The results revealed that the guava trees sprayed with 0.75 percent Zinc sulphate along-with 0.50 percent Boric acid recorded maximum increase in plant height, plant spread and canopy volume. Leaf area index and leaf chlorophyll content were also recorded highest with the application of 0.75 percent Zinc sulphate along-with 0.50 percent Boric acid. Leaf nutrient analysis revealed that highest increase in leaf nitrogen and leaf potassium content were also recorded with the combined treatment of 0.75 percent Zinc sulphate + 0.50 percent Boric acid. It was concluded that the guava tree growth and leaf nutrient content improved with the foliar application of 0.75 percent Zinc sulphate + 0.50 percent Boric acid.

Keywords: Guava, micronutrient, growth, yield, leaf nutrient content

Introduction
Guava (*Psidium guajava* L.) belonging to family Myrtaceae, is a tropical fruit crop but is also very well adapted under sub-tropical conditions. In India, guava is fourth most important fruit crop in area and production after mango, banana and citrus (Pedapati et. al., 2014) [9]. It is a rich source of vitamin C, pectin, moderately good source of iron, calcium and a fair source of phosphorus, besides very rich sources of dietary fiber. In India guava occupies an area of 261 thousand hectare with annual production of 3916 thousand MT (Anonymous, 2018a) [1] which is very less as compared to other leading fruit crops in India. In J&K it is cultivated on an area of 2340 hectare with production of 7943 MT (Anonymous, 2018b) [2]. Though, guava is a hardy plant and can tolerate adversities of weather to a greater extent and fetches good price in the market, but the price gained in the market by any commodity depends particularly on quality of the fruits. Quality of a fruit is related to its physico-chemical characteristics which in turn depends upon the health of the plant and plant protection measures adopted. Application of fertilizers through soil are needed in higher quantities because of lesser nutrient use efficiency. Therefore, foliar application of nutrients particularly micronutrients is an alternative way in fruit crops. Application of nutrients through foliage can be from 10 to 20 times more effective than soil application (Zaman and Schumann, 2006) [15]. The application of both macro and micronutrients are essential to avoid the hidden nutrient hunger and to promote the optimum growth and performance of plants. If nutrients are deficient, poor is the health of the plant and poor will be quality of the fruits produced. Nutritional deficiencies in fruit crops significantly hamper the physiological processes of plants, thus reducing yield and producing inferior fruit and making the plant vulnerable to a number of biotic and abiotic stresses. It is an established fact that Indian soils, particularly North Indian soils are deficient in micronutrients particularly Zinc and Boron. Besides other nutrient elements, micro-nutrients particularly Zinc and Boron plays vital role in growth, development, retention and quality of fruits. Zinc constituent several enzyme systems, which regulate various metabolic reactions in the plant. It is essential for auxin and protein synthesis, seed production and proper maturity of fruit while boron has a key role in cell division and elongation, thus effecting increase in weight of fruit.

Therefore, Zinc increases fruit size as well as yield. The application of boron on the guava plant enhances the yield and quality of fruits. Keeping in view the agro-climatic condition of Jammu region and the role of Zinc and Boron in increasing the yield, growth and improving the quality, the present investigation was aimed to evaluate the influence of Zinc and Boron on the growth, yield and quality of guava under Jammu Subtropics with the objective to assess the effect of Zinc and Boron on growth, yield and fruit quality and leaf nutrient status of guava cultivar L-49.

Materials and Methods

Experimental trial to access the effect of zinc and boron on growth the fruit, yield and fruit quality of guava was conducted on 12 year old trees of L-49 cultivar grown in the private orchard located in rainfed area of district Samba, Jammu situated at an elevation of 332 m above mean sea level and lies at 32º39" North latitude and 74º 53" East longitude. The experiment comprised of twenty five treatments including 0.25 percent Zinc sulphate (T_1), 0.50 percent Zinc sulphate (T_2), 0.75 percent Zinc sulphate (T_3), 1.00 percent Zinc sulphate (T_4), 0.25 percent Boric acid (T_5), 0.50 percent Boric acid (T_6), 0.75 percent Boric acid (T_7), 1.00 percent Boric acid (T_8), 0.25 percent Zinc sulphate + 0.25 percent Boric acid (T_9), 0.25 percent Zinc sulphate + 0.50 percent Boric acid (T_{10}), 0.25 percent Zinc sulphate + 0.75 percent Boric acid (T_{11}), 0.25 percent $ZnSo_4$ + 1.00 percent Boric acid (T_{12}), 0.50 percent Zinc sulphate + 0.25 percent Boric acid (T_{13}), 0.50 percent Zinc sulphate + 0.50 percent Boric acid (T_{14}), 0.50 percent Zinc sulphate + 0.75 percent Boric acid (T_{15}), 0.50 percent $ZnSo_4$ + 1.00 percent Boric acid (T_{16}), 0.75 percent Zinc sulphate + 0.25 percent Boric acid (T_{17}), 0.75 percent Zinc sulphate + 0.50 percent Boric acid (T_{18}), 0.75 percent Zinc sulphate + 0.75 percent Boric acid (T_{19}), 0.75 percent Zinc sulphate + 1.00 percent Boric acid (T_{20}), 1.00 percent Zinc sulphate + 0.25 percent Bori acid (T_{21}), 1.00 percent Zinc sulphate + 0.50 percent Boric acid (T_{22}), 1.00 percent Zinc sulphate + 0.75 percent Boric acid (T_{23}), 1.00 percent Zinc sulphate + 1.00 percent Boric acid (T_{24}) and control (T_{25}) laid in Randomized Complete Block Design with three replications. Different concentration of zinc sulphate and boric acid was sprayed twice i.e. last week of October and last week of November. Observations were recorded on different parameters as per standard procedures. Plant height of individual tree was measured in meter from ground level to the top of the crown with the help of measuring staff and the height was expressed in meters. The horizontal distance from end of the canopy to the other end was recorded in two directions *i.e.* North-South and East-West with the help of measuring staff and expressed in meter. The average of value of North-South and East-West spread was calculated to work out the tree spread. The tree volume was worked by the method suggested by Westwood *et al*. (1963) [13]. For leaf area index fifty fully developed leaves were randomly collected from all directions of each experimental tree. The leaf area was measured with the help of automatic leaf area meter (221 Systronics) having a sensor and read out unit. The leaf area index was calculated by total leaf area with ground cover area. Leaf chlorophyll content (mg/100 g) content was measured by following the DMSO method of Hiscox and Israelstam (1979) [5]. Fruit yield was estimated from the average weight of the fruits by multiplying total number of fruits picking per tree and calculated in kg/tree. For estimation of leaf nutrient content, leavf samples were collected from each orchard following the procedure outlined by Chapman (1964) [4]. The leaf samples were washed, dried, ground and digested for analysis. Nitrogen, phosphorus, potassium, calcium and magnesium were estimated by standard procedures outlined by Jackson (1973) [6]. Leaf nitrogen content was estimated by Kjeldahl's method, leaf Phosphorus content was determined by colorimetric method and leaf potassium from the extract was estimated under with flame-photometer. Data collected was analysed as per method described by Panse and Sukhatme (1989) [8] to draw the statistical inferences.

Results and Discussion

Micronutrients play an important role in plant growth and fruit development and their deficiency leads to weakening of plants and disorders. They help in the uptake of major nutrients and play active role in the plant metabolism like cell wall development, photosynthesis, chlorophyll formation, enzyme activity, nitrogen fixation and oxidation-reduction reaction. Guava respond significantly to applied micronutrients like zinc and boron for improving plant growth, fruit yield and nutritional status of plants.

Tree characters

The data regarding effect of different treatments *viz*., Zinc as Zinc sulphate and Boron as Boric acid at different levels on tree characters of guava cultivar L-49 has been recorded in table 1. Plant height, plant spread, canopy volume and leaf area index of guava plant was significantly increased with different levels of Zinc sulphate and Boric acid sprayed alone as well as in combination, over control (plain water spray). Maximum increase in plant height (11.50%), plant spread (8.66% for EW and 8.40% for NS), canopy volume (31.34%) and leaf area index (3.28) of guava plant was recorded when plants were sprayed with 0.75 per cent Zinc sulphate + 0.50 per cent Boric acid (T_{18}) which was statistically superior over all the treatments and was closely followed by treatment T_{19} (0.75% Zinc sulphate + 0.75% Boric acid), T_{20}(0.75% Zinc sulphate + 1.00% Boric acid), T_{17}(0.75% Zinc sulphate + 0.25% Boric acid) T_{21}(1.00% Zinc sulphate + 0.25% Boric acid) and T_{14}(0.50% Zinc sulphate + 0.50% Boric acid). Minimum increase in values for increase in plant height (3.45%), plant spread, canopy volume and leaf area index were observed in the plants where no micronutrient application was done (control). Combined treatment of Zinc sulphate and Boric acid resulted in higher values for increase in plant height, plant spread, canopy volume and leaf area index as compared to the treatments when both were applied individually. Yadav *et al.* (2017) [14] and Kumar *et al*. (2017) [7] also confirmed increase in tree characteristics of guava with the application of zinc and boron. Increase in tree characters like plant height plant spread and canopy volume in the treated trees might be due to the active involvement of Zinc in the synthesis of tryptophan which is precursor of IAA (Skoog, 1940) [11] that might have resulted in increased growth and thus increased plant height. Zinc is also a constituent of carbonic anhydrase, which is an important enzyme involved in the photosynthesis. Foliar application of Boron significantly increased plant height which might be due to the increased photosynthetic rates of the plant, as reported by Ullah *et al.* (2012) [12]. Expansion of leaf area of plants may be due to the higher requirement of photosynthetic product accumulation in fruits which signalled for the plant to provide larger leaf area surface for the synthesis of higher food reserves.

Data presented in table 1 also reveals that application of Zinc sulphate and Boric acid singly and their combinations significantly influenced the total chlorophyll content of guava cultivar L-49 leaves. It was observed that the maximum leaf chlorophyll content (3.77 mg/g) accumulated

under treatment T_{18} (0.75% Zinc sulphate + 0.50% Boric acid) which was closely followed by 3.72mg/g chlorophyll content under the treatment T_{19} (0.75% Zinc sulphate + 0.75% Boric acid), 3.65 mg/g under T_{20} (0.75% Zinc sulphate + 1.00% Boric acid), 3.41 mg/g under T_{17} (0.75% Zinc sulphate + 0.25% Boric acid), 2.70mg/g under treatment T_{14} (0.50% Zinc sulphate + 0.50% Boric acid) and 2.68mg/g with treatment combination T_{15} (0.50% Zinc sulphate + 0.75% Boric acid),whereas, minimum total leaf chlorophyll content (1.90 mg/g) was recorded under control (T_{25}). Increase in leaf chlorophyll content may be due to the fact that Zinc helps in building the chlorophyll through its direct impact in the composition of amino acid and carbohydrates and energy compounds used in the construction of chlorophyll (Eiada *et al.* 2013). The results in the present investigation are in close conformity with those obtained by (Yadav *et al.* 2014) [14] who reported that application of Zinc sulphate (0.4%) + Boric acid (0.4%) + Ferrous sulphate (0.4%) in pomegranate cultivar Sindhuri resulted in increased chlorophyll content (0.61 mg/g). It is evident from the data presented in table 1 that the application of Zinc sulphate and Boric acid singly and their combination exerted a significant effect on the fruit yield per tree of guava cultivar L-49. Maximum fruit yield (34.60 kg/tree) was observed under the treatment 0.75% Zinc sulphate + 0.50% Boric acid (T_{18}) which was closely followed by treatment T_{19} (0.75% Zinc sulphate + 0.75% Boric acid), T_{20} (0.75% Zinc sulphate + 1.00% Boric acid), T_{17} (0.75% Zinc sulphate + 0.25% Boric acid), T_{14} (0.50% Zinc sulphate + 0.50% Boric acid) and T_{15} (0.50% Zinc sulphate + 0.75% Boric acid) with the respective fruit yield as 33.28 kg/tree, 32.31 kg/tree, 28.96 kg/tree, 28.33 kg/tree and 28.15 kg/tree respectively. While the minimum fruit yield (18.58 kg/tree) was recorded under control (T_{25}) which was significantly lower than all other treatments. The individual treatments of Zinc sulphate and Boric acid also showed significantly higher yield with the increase in concentration over control. Application of Zinc and Boron individually *i.e.* 0.75% Zinc sulphate, 0.50% Boric acid, 1.00% Zinc sulphate and 0.50% Boric acid also increased the fruit yield as 26.83 kg/tree, 25.83 kg/tree, 25.32 kg/tree and 25.23 kg/tree respectively. These results are in line with the findings of Bhoyar *et al.* (2016) [16] who reported that application of 0.5 percent Zinc Sulphate + 0.5 percent Ferrous Sulphate + 0.3 percent Borax resulted in highest fruit yield of guava cultivar L-49 as 57.1 kg per tree as compared to other treatments and minimum fruit yield as 37.1 kg per tree under control. Similar findings have been documented by Bhardwaj *et al.* (2019) [3] in guava cultivar Allahabad Safeda who reported that the foliar application of Zinc sulphate along with Boric acid increased the yield of fruits in guava.

Leaf nutrient content

Perusal of data presented in table 2 indicate that different treatments of Zinc sulphate and Boric acid influenced leaf nitrogen of guava cultivar L-49 significantly and increased leaf nitrogen content. It was observed that the highest increase in the leaf nitrogen content (12.35%) was recorded with T_{18} (0.75% Zinc sulphate + 0.50% Boric acid) which was followed by the respective increase in the nitrogen content as 11.59 percent, 11.18 percent and 10.49 percent under the treatments T_{19} (0.75% Zinc sulphate + 0.75% Boric acid), T_{20} (0.75% Zinc sulphate + 1.00% Boric acid) and T_{21} (1.00% Zinc sulphate + 0.25% Boric acid), however, lowest increase in the nitrogen content (1.85%) was obtained under the control (T_{25}). Kumar *et al.* (2017) [7] also observed increase in leaf nitrogen content with application of Zinc and Boron on guava cultivar Pant Prabhat. It is evident from the results that the leaf Phosphorus content of guava cultivar L-49 under different treatments of Zinc sulphate and Boric acid did not show any variation and did not affect the leaf phosphorus content significantly. The leaf potassium content showed maximum percent increase (9.74%) under the treatment T_{18} (0.75% Zinc sulphate + 0.50% Boric acid), however, lowest increase in the potassium content (1.28%) was obtained under the control (T_{25}). The results are in conformity with the findings of Sau *et al.* (2018) [10] who recorded increase in leaf potassium content with the application of zinc and boron in different guava cultivars.

Table 1: Effect of Zinc and Boron on tree characters of guava cultivar L-49.

Treatments	Increase in plant height (%)	Increase in plant spread (EW) (%)	Increase in plant spread (NS) (%)	Increase in canopy volume (%)	Leaf area index	Leaf chlorophyll content (mg/100 g)	Fruit yield (kg/tree)
T_1 - 0.25% $ZnSo_4$	4.19	4.46	4.33	13.55	2.43	2.08	20.55
T_2 - 0.50% $ZnSo_4$	4.78	5.22	4.98	15.75	2.54	2.18	23.40
T_3 - 0.75% $ZnSo_4$	6.48	6.29	5.93	19.90	2.74	2.47	26.83
T_4 - 1.00% $ZnSo_4$	6.28	6.11	5.25	18.71	2.65	2.43	25.32
T_5 - 0.25% H_3BO_3	3.70	3.68	3.42	11.19	2.42	1.98	22.51
T_6 - 0.50% H_3BO_3	4.15	4.35	3.49	12.50	2.46	2.10	25.83
T_7 - 0.75% H_3BO_3	4.03	4.65	3.34	12.52	2.41	2.08	25.23
T_8 - 1.00% H_3BO_3	3.82	4.07	3.16	11.47	2.39	2.04	24.16
T_9 - 0.25% $ZnSo_4$ + 0.25% H_3BO_3	5.46	4.86	4.69	15.79	2.58	2.12	23.56
T_{10} - 0.25% $ZnSo_4$ + 0.50% H_3BO_3	6.05	5.08	4.84	16.84	2.62	2.19	26.92
T_{11} - 0.25% $ZnSo_4$ + 0.75% H_3BO_3	5.83	5.02	4.42	16.07	2.59	2.17	26.52
T_{12} - 0.25% $ZnSo_4$ + 1.00% H_3BO_3	5.19	4.85	4.24	14.99	2.57	2.15	25.21
T_{13} - 0.50% $ZnSo_4$ + 0.25% H_3BO_3	7.49	6.28	6.24	21.37	2.87	2.54	25.79
T_{14} - 0.50% $ZnSo_4$ + 0.50% H_3BO_3	7.77	6.80	6.69	22.80	2.92	2.70	28.33
T_{15} - 0.50% $ZnSo_4$ + 0.75% H_3BO_3	7.08	6.68	6.31	21.45	2.89	2.68	28.15
T_{16} - 0.50% $ZnSo_4$ + 1.00% H_3BO_3	6.44	6.53	6.05	20.26	2.84	2.62	25.65
T_{17} - 0.75% $ZnSo_4$ + 0.25% H_3BO_3	8.86	8.27	7.81	27.09	3.17	3.41	28.96
T_{18} - 0.75% $ZnSo_4$ + 0.50% H_3BO_3	9.45	8.66	8.40	28.92	3.28	3.77	34.60
T_{19} - 0.75% $ZnSo_4$ + 0.75% H_3BO_3	9.34	8.60	8.37	28.68	3.21	3.72	33.28
T_{20} - 0.75% $ZnSo_4$ + 1.00% H_3BO_3	9.15	8.45	8.13	28.00	2.93	3.65	32.31
T_{21} - 1.00% $ZnSo_4$ + 0.25% H_3BO_3	7.84	7.56	7.48	24.67	2.87	2.52	26.24
T_{22} - 1.00% $ZnSo_4$ + 0.50% H_3BO_3	7.22	7.47	7.33	23.67	2.85	2.49	24.12
T_{23} - 1.00% $ZnSo_4$ + 0.75% H_3BO_3	6.77	7.23	7.03	22.53	2.82	2.46	22.45
T_{24} - 1.00% $ZnSo_4$ + 1.00% H_3BO_3	5.91	6.77	6.67	20.62	2.81	2.43	21.32
T_{25} - Control	3.66	3.52	3.16	10.70	2.30	1.90	18.58
$CD_{0.05}$	0.10	0.05	0.02	0.21	0.01	0.02	0.56

Table 2: Effect of Zinc and Boron on leaf nutrient content of guava cultivar L-49.

Treatments	Percent increase in leaf content (%)		
	Nitrogen	Phosphorus	Potassium
T_1 - 0.25% $ZnSo_4$	6.25	-	5.92
T_2 - 0.50% $ZnSo_4$	6.92	-	6.45
T_3 - 0.75% $ZnSo_4$	7.32	-	7.33
T_4 - 1.00% $ZnSo_4$	6.83	-	7.24
T_5 - 0.25% H_3BO_3	5.52	-	5.41
T_6 - 0.50% H_3BO_3	6.33	-	5.96
T_7 - 0.75% H_3BO_3	6.17	-	4.55
T_8 - 1.00% H_3BO_3	5.59	-	3.97
T_9 - 0.25% $ZnSo_4$ + 0.25% H_3BO_3	6.71	-	6.45
T_{10} - 0.25% $ZnSo_4$ + 0.50% H_3BO_3	7.41	-	6.54
T_{11} - 0.25% $ZnSo_4$ + 0.75% H_3BO_3	6.83	-	5.81
T_{12} - 0.25% $ZnSo_4$ + 1.00% H_3BO_3	6.29	-	5.23
T_{13} - 0.50% $ZnSo_4$ + 0.25% H_3BO_3	8.54	-	7.05
T_{14} - 0.50% $ZnSo_4$ + 0.50% H_3BO_3	9.88	-	7.43
T_{15} - 0.50% $ZnSo_4$ + 0.75% H_3BO_3	9.26	-	7.24
T_{16} - 0.50% $ZnSo_4$ + 1.00% H_3BO_3	8.70	-	7.05
T_{17} - 0.75% $ZnSo_4$ + 0.25% H_3BO_3	10.43	-	8.39
T_{18} - 0.75% $ZnSo_4$ + 0.50% H_3BO_3	12.35	-	9.74
T_{19} - 0.75% $ZnSo_4$ + 0.75% H_3BO_3	11.59	-	9.21
T_{20} - 0.75% $ZnSo_4$ + 1.00% H_3BO_3	11.18	-	8.78
T_{21} - 1.00% $ZnSo_4$ + 0.25% H_3BO_3	10.49	-	8.33
T_{22} - 1.00% $ZnSo_4$ + 0.50% H_3BO_3	10.06	-	7.79
T_{23} - 1.00% $ZnSo_4$ + 0.75% H_3BO_3	9.32	-	7.24
T_{24} - 1.00% $ZnSo_4$ + 1.00% H_3BO_3	9.15	-	6.58
T25 - Control	1.85	-	1.28
$CD_{0.05}$	0.38	-	0.32

Conclusion: It is concluded from the study that among fifteen treatments comprising of Zinc Sulphate and Boric acid (individual as well as in combinations) the guava plants of cultivar L-49 treated with 0.75 percent Zinc sulphate + 0.5 percent Boric acid exhibited best growth, fruit yield and resulted in highest uptake of nitrogen, phosphorus and potassium under rainfed conditions.

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