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Effect of micronutrients on growth, yield and leaf nutrient status in guava (*Psidium guajava* L.) cultivar Allahabad Safeda

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Abstract
The study was carried out on three years old guava plants during the year 2017-18 at RHR&TS, Dhaulakuan, Sirmour (H.P.), India. The experiment was laid out in a Randomized Block Design (RBD) with three replications comprising of sixteen treatment combinations Among different treatments, significantly maximum increase in annual shoot growth, plant height, spread, stem girth, flowering, fruit set, yield and reduction in fruit drop were recorded in T_{15} (zinc sulphate @ 0.5% + borax @ 0.2% + manganese sulphate @ 0.5% + iron sulphate @ 0.4%). Leaf nutrient contents were also significantly affected by foliar application of combined micronutrients. Therefore, it is concluded that combined foliar application of zinc sulphate @ 0.5% + borax @ 0.2% + manganese sulphate @ 0.5% + iron sulphate @ 0.4% proved to be the most effective treatment.

Keywords: Guava, micronutrients, flowering, growth, yield

Introduction
Guava (*Psidium guajava* L.) is one of the most popular fruit grown in tropical and sub-tropical regions of India, which belongs to the family Myrtaceae. It is the fifth most important fruit in respect of area after mango, banana, citrus and apple and in production after banana, mango, citrus and papaya. It is cultivated in India since early 17th century. Due to its wider adaptability in diverse soils and agro-climatic regions, low cost of cultivation, prolific bearing and being highly remunerative with nutritive values, it has gained more popularity among the fruit growers (Das *et al*., 1995) [7]. This fruit is a native of tropical America and extensively grown in South Asian countries. The leading guava growing states are Uttar Pradesh, Bihar, Madhya Pradesh and Maharashtra.

In India the total area under guava cultivation is about 268 thousand hectare with a production of 3997 thousand MT (Anonymous, 2018) [3]. It is grown in Himachal Pradesh on an area of about 2,292 ha with a total production of 2,660 MT (Anonymous, 2017) [2].

Low productivity of guava in Himachal Pradesh as compared to national productivity may be due to poor adoption of improved crop management technology in respect of planting system, nutrition, plant protection and irrigation etc. Among several factors, probably nutrition is a key factor affecting the productivity of fruit trees. As guava tree removes large amount of nutrients from soil, balanced fertilization seems to be an important factor governing the productivity of guava trees.

Nutrients to the plant can be made available by the basal as well as by the foliar application. The foliar feeding of fruit tree has gained much importance in recent years, as nutrients applied through soil are needed in higher quantity because some amount leaches down and some become unavailable to the plant due to complex soil reactions.

Foliar application is based on the principle that the nutrients are quickly absorbed by leaves and transported to different parts of the plant to fulfill the functional requirement of nutrition. This method is highly helpful for the correction of element deficiencies to restore disrupted nutrient supply, overcome stress factors limiting their availability and it plays important role in improving fruit set, productivity and quality of fruits and recovery of nutritional and physiological disorders in fruit trees.

Thus, keeping in view the importance of micronutrients the present study was undertaken with the objective to study the effect of micronutrients on growth, yield and leaf nutrients status in guava.

Materials and Methods

The present investigation entitled "Effect of micronutrients on growth, yield and leaf nutrient status in guava (*Psidium guajava* L.) cultivar Allahabad Safeda" was carried out on three years old guava plants in the experimental block of Regional Horticultural Research and Training Station, Dhaulakuan, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, during 2017-2018. The experiment was laid out in a Randomized Block Design (RBD) with three replications comprising of sixteen treatment combinations (Table 1).

Tree growth characters: The growth parameters were recorded at the end of the growing season. The annual shoot growth (cm), increase in plant height (%), increase in plant spread (%) and increase in stem girth (%) were measured following standard procedure. Leaf area was measured with the help of an Automatic Leaf Area Meter (Licor Model 3100) and the values were expressed in square centimetre (cm^2). Total chlorophyll content was estimated as per the method suggested by Hiscox and Israelstam (1979) [11].

Fruit set and yield: Observations pertaining to different phases of fruit set were recorded visually. The number of fruits per plant was recorded at each harvest and total was calculated at last harvesting by summation of values of all pickings. Fruit set per cent was calculated by counting total number of tagged flowers on the selected shoots of individual plant and the number of flowers converted into fruit. Fruit drop was calculated by subtracting the total number of fruits retained from total number of fruit set. The yield of fruits under different treatments was recorded at the time of harvest by weighing the total fruits on top pan balance. The yield was expressed in kilograms per tree (kg/plant). The yield efficiency of each selected tree was calculated as per the method given by Westwood (1993) [24] and expressed in kg/cm^2.

Leaf nutrients status: Leaf samples were collected from the middle of the current season's growth around the periphery of the tree. Samples were cleaned, dried, ground and stored according to the procedure laid down by Chapman (1964). The digestion of the leaf samples for various nutrient elements was done in diacid mixture (Nitric acid: Perchloric acid 4:1). For nitrogen estimation, a separate digestion was carried out using concentrated H_2SO_4 and digestion mixture as suggested by Jackson (1967) [18]. Total nitrogen was estimated by micro-kjeldahl's method (Jackson, 1973) [13]. Phosphorus was determined by Vanado-molybido phosphoric yellow colour method (Jackson, 1973) [13] estimated under spectrophotometer; potassium was estimated under flam photometer and zinc, iron, manganese was determined on Atomic Absorption Spectrophotometer AAS4141. Macro and micro nutrients were expressed on dry weight basis as per cent and ppm, respectively.

Results and Discussion

Tree growth characters: The growth parameters *viz*. annual shoot growth, per cent increase in tree height, tree spread and stem girth show consistent influence with the application of different micronutrients alone or in combination (Table 2). However, highest value for growth was recorded in treatment T_{15} (zinc sulphate @ 0.5% + borax @ 0.2% + manganese sulphate @ 0.5% + iron sulphate @ 0.4%), and the minimum in T_{16} (control). Among different treatments; maximum leaf area, total chlorophyll content were observed in T_{15} (zinc sulphate @ 0.5% + borax @ 0.2% + manganese sulphate @ 0.5% + iron sulphate @ 0.4%). However, lowest leaf area and total chlorophyll content were found in T_{16} (control) during present course of investigation (Table 3).

These findings are in line with earlier reports of Lal and Sen (2000) [19], El-Sissy and Waaz (2011) [11] and Kumawat *et al.* (2012) [17], who have shown that application of micronutrients alone or in combinations had significant effect on plant height, plant spread, canopy volume, shoot length, leaf area, number of leaves per shoot and total chlorophyll content in guava plant. This maximum increase in growth attributes might be due to the favourable influence of application of micronutrients zinc sulphate @ 0.5% + borax @ 0.2% + manganese sulphate @ 0.5% + iron sulphate @ 0.4% on growth characteristics because of their catalytic or stimulatory effect on most of the physiological and metabolic processes of plant. Zinc and boron are essential components of enzymes responsible for nitrogen and carbohydrates metabolism respectively, thereby resulting into increase in uptake of nitrogen by the plant. Further, involvement of Zn in the synthesis of tryptophan, which is a precursor of indole acetic acid synthesis, consequently it increased the tissue growth and development. It has important role in starch metabolism, and acts as co-factor for many enzymes, affects photosynthesis reaction, nucleic acid metabolism and protein biosynthesis (Alloway, 2008) [1]. Iron is also necessary for vital plant metabolic functions such as chlorophyll synthesis, various enzymatic reactions, respiration and photosynthesis (Ram and Bose, 2000) [22]. In addition, manganese, being an essential factor in respiration and nitrogen metabolism, activates a number of enzymes. Manganese also plays an important role in synthesis of chlorophyll molecules which increases the photosynthesis and consequently plant growth (Devlin, 1972) [8].

Fruit set and yield: Fruit set was not significantly affected by application of different micronutrients. However, the maximum fruit set (62.30%) was recorded in T_{12} (zinc sulphate @ 0.5% + borax @ 0.2% + iron sulphate @ 0.4%) and minimum (60.03%) in T_1 (zinc sulphate @ 0.5%). Different treatments exerted significant effect on fruit drop (Table 4). Minimum fruit drop (40.50%) was recorded in T_{15} (zinc sulphate @ 0.5% + borax @ 0.2% + manganese sulphate @ 0.5% + iron sulphate @ 0.4%). Application of different micronutrients alone or in combination significantly influenced yield parameters (Table 5). Among different treatments; maximum number of fruits per plant and yield per plant were observed in T_{15} (zinc sulphate @ 0.5% + borax @ 0.2% + manganese sulphate @ 0.5% + iron sulphate @ 0.4%) while, minimum number of fruits per plant and yield per plant were found in T_{16} (control) during present course of investigation. The highest yield efficiency was recorded in T_{11} (zinc sulphate @ 0.5% + borax @ 0.2% + manganese sulphate @ 0.5%) and the lowest yield efficiency was recorded in T_{10} (manganese sulphate @ 0.5% + iron sulphate @ 0.4%).

As is evidenced from the data in Table 4, the micronutrients alone or in combinations had no significant effect on fruit set. The possible reason for non-significant effect on fruit set in the present study might be because of the foliar application of micronutrients started after the fruit set. Foliar application of different micronutrients alone or in combination resulted in significant effect on fruit drop. The results are in conformity with those of Hada *et al.* (2014) [10]; Bagali *et al.* (1993) [4];

Balakrishnan (2000) [5] who found reduction in fruit drop in guava with foliar application of micronutrients. The reduction in fruit drop might be due to the fact that the foliar application of micronutrients affected metabolic activities of the tree, improved the source sink relationship and favourably influenced the metabolic status resulting in better control of drop and enhancing the fruits retention (Katiyar *et al*., 2008) [15]. The highest fruit yield which was obtained by foliar spray of micronutrients may be attributed to better uptake and mobilization of nutrients to the sink which caused better fruit development. These findings are also supported by earlier reports of Bagali *et al.* (1993) [4], Rajkumar *et al.* (2014) [20], Jat and Kacha (2014) [14] who also found that foliar application of micronutrients increases the yield of guava.

Leaf nutrients status: The leaf nutrient contents N, P and K were found markedly higher in the plants treated with foliar application of micronutrients (Table 6). The maximum leaf nitrogen content was recorded in T_{15} (zinc sulphate @ 0.5% + borax @ 0.2% + manganese sulphate @ 0.5% + iron sulphate @ 0.4%); the maximum leaf phosphorus content was recorded under T_{13} (zinc sulphate @ 0.5% + manganese sulphate @ 0.5% + iron sulphate @ 0.4%); and the maximum leaf potassium content was recorded with T_3 (manganese sulphate @ 0.5%). Whereas, the lowest leaf N, P and K content were observed in T_{16} (control). The leaf micronutrients (Zn, Fe and Mn) content were found maximum under their individual respective application. The maximum leaf zinc content was recorded with the spray of zinc sulphate @ 0.5% (T_1). The maximum leaf Fe content was recorded with the spray of iron sulphate @ 0.4% (T_4). The maximum leaf Mn content was recorded with the spray of manganese sulphate @ 0.5% (T_3). The above findings are in conformity with those of El-Sissy and Waaz (2011) [11] who reported that the foliar application of iron, manganese and zinc significantly increased the concentration of macronutrients (N, P and K) in guava leaves. Rajkumar *et al.* (2017) [21] also reported that the leaf N, P and K contents were increased with increasing levels of zinc and boron in guava. According to Sau *et al.* (2017) [23] foliar application of Zn, B and Cu increased the macronutrients (N, P and K) content in leaves of guava. Sau *et al.* (2017) [23] also reported that the foliar feeding of micronutrients significantly improved micronutrient contents (B, Zn and Cu) in guava leaves over control. The results are also in conformity with those of Rajkumar *et al.* (2017) [21] who reported that leaf zinc content was increased significantly after the foliar application of various concentrations of zinc sulphate. El-Sissy and Waaz (2011) [11] reported that the foliar application of Fe, Mn and Zn significantly increases the concentration of these micronutrients as compared to control. Lal *et al.* (2000) [19] reported that the foliar spray of $ZnSO_4$ at 4 g per plant per year significantly increased the Zn content of leaves in guava cultivar Allahabad Safeda. Khan *et al.* (2012) [16] also reported that combined application of boric acid (0.3%) and zinc sulphate (0.5%) at fruit set stage effectively improved the B and Zn level in the leaves of Feutrell's early madarin.

Table 1: Treatment details

Treatments	Concentration	Time of application
T_1: Zinc Sulphate	0.5%	1^{st} spray at Fruit Set and 2^{nd} Spray 15 days after Fruit Set
T_2: Borax	0.2%	
T_3: Manganese Sulphate	0.5%	
T_4: Iron Sulphate	0.4%	
T_5: Zinc Sulphate + Borax	0.5% + 0.2%	
T_6: Zinc Sulphate + Manganese Sulphate	0.5% + 0.5%	
T_7: Zinc Sulphate + Iron Sulphate	0.5% + 0.4%	
T_8: Borax + Manganese Sulphate	0.2% + 0.5%	
T_9: Borax + Iron Sulphate	0.2% + 0.4%	
T_{10}: Manganese Sulphate + Iron Sulphate	0.5% + 0.4%	
T_{11}: Zinc Sulphate + Borax + Manganese Sulphate	0.5% + 0.2% + 0.5%	
T_{12}: Zinc Sulphate + Borax + Iron Sulphate	0.5% + 0.2% + 0.4%	
T_{13}: Zinc Sulphate + Manganese Sulphate + Iron Sulphate	0.5% + 0.5% + 0.4%	
T_{14}: Borax + Manganese Sulphate + Iron Sulphate	0.2% + 0.5% + 0.4%	
T_{15}: Zinc Sulphate + Borax + Manganese Sulphate + Iron Sulphate	0.5% + 0.2% + 0.5% + 0.4%	
T_{16}: Control (Water Spray)	-	

Table 2: Effect of micronutrients on plant growth parameters of guava

Treatments	Annual shoot growth (cm)	Increase in plant height (%)	Increase in plant spread (%)	Increase in stem girth (%)
T_1	47.40	18.22	29.12	13.58
T_2	43.47	15.53	25.03	11.59
T_3	44.37	16.84	26.16	12.33
T_4	44.07	16.34	25.40	11.99
T_5	48.23	18.93	29.95	13.74
T_6	51.80	19.69	31.68	14.65
T_7	50.60	19.42	30.96	14.25
T_8	45.40	17.31	28.61	12.74
T_9	45.20	16.92	27.17	12.63
T_{10}	46.20	17.76	28.44	13.15
T_{11}	55.30	21.61	33.70	15.84
T_{12}	53.60	20.95	33.50	15.06
T_{13}	56.10	21.89	34.44	16.20
T_{14}	53.40	20.19	32.23	14.82
T_{15}	58.43	23.53	36.75	17.59
T_{16}	39.23	12.30	20.57	9.11
$CD_{0.05}$	3.88	3.16	4.34	2.31

Table 3: Effect of micronutrients on leaf area and total chlorophyll content of guava

Treatments	Leaf area (cm^2)	Total chlorophyll content (mg/g)
T_1	69.88	1.41
T_2	66.54	1.36
T_3	67.15	1.40
T_4	71.58	1.44
T_5	69.51	1.40
T_6	69.58	1.41
T_7	83.86	1.63
T_8	69.01	1.35
T_9	73.06	1.59
T_{10}	79.94	1.60
T_{11}	70.79	1.43
T_{12}	83.99	1.74
T_{13}	85.67	1.79
T_{14}	82.95	1.62
T_{15}	88.23	1.93
T_{16}	62.79	1.03
$CD_{0.05}$	3.50	0.31

Table 4: Effect of micronutrients on per cent fruit set and fruit drop in guava

Treatments	Fruit set (%)	Fruit drop (%)
T_1	60.03	45.66
T_2	61.33	47.14
T_3	60.08	48.84
T_4	60.89	49.16
T_5	61.83	42.88
T_6	61.01	43.62
T_7	60.66	44.29
T_8	60.08	46.22
T_9	60.78	47.76
T_{10}	60.33	48.52
T_{11}	62.27	41.24
T_{12}	62.30	41.36
T_{13}	61.32	42.08
T_{14}	60.12	43.94
T_{15}	61.21	40.50
T_{16}	61.34	58.60
$CD_{0.05}$	NS	1.91

Table 5: Effect of micronutrients on number of fruits per plant, yield and yield efficiency of guava

Treatments	Number of fruits/plant	Yield (kg/tree)	Yield efficiency (kg/cm^2 TCSA)
T_1	42.67	5.82	0.23
T_2	41.67	5.51	0.26
T_3	41.00	5.06	0.24
T_4	40.67	4.91	0.20
T_5	44.67	6.42	0.32
T_6	44.33	6.87	0.27
T_7	43.33	6.07	0.24
T_8	42.33	5.68	0.23
T_9	41.67	5.38	0.28
T_{10}	41.33	5.19	0.16
T_{11}	47.33	8.00	0.40
T_{12}	46.00	7.35	0.34
T_{13}	45.33	7.50	0.35
T_{14}	45.67	6.77	0.34
T_{15}	48.00	8.57	0.35
T_{16}	37.00	4.33	0.25
$CD_{0.05}$	1.91	0.31	0.02

Table 6: Effect of micronutrients on leaf nutrient status of guava

Treatments	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Zinc (ppm)	Iron (ppm)	Manganese (ppm)	Copper (ppm)
T_1	2.62	0.21	1.78	65.4	148.5	50.4	11.2
T_2	2.46	0.19	1.75	46.7	165.0	55.7	12.6
T_3	2.52	0.24	2.06	43.5	151.8	74.0	11.4
T_4	2.74	0.22	2.05	41.2	196.1	50.4	10.1
T_5	2.59	0.23	1.86	58.3	161.7	51.5	10.4
T_6	2.60	0.21	1.81	55.5	135.5	62.1	10.2
T_7	2.79	0.20	1.79	54.6	178.4	43.0	9.1
T_8	2.53	0.21	1.82	44.4	168.4	71.8	11.7
T_9	2.76	0.20	1.67	43.0	185.7	51.5	11.4
T_{10}	2.79	0.21	1.63	38.9	182.0	58.9	9.8
T_{11}	2.74	0.21	1.79	56.0	135.5	66.4	10.4
T_{12}	2.81	0.24	1.63	54.1	175.1	50.4	10.8
T_{13}	2.84	0.25	1.97	49.5	171.7	57.9	11.5
T_{14}	2.79	0.21	1.74	36.1	171.7	67.5	12.3
T_{15}	2.90	0.21	1.78	51.8	168.4	57.9	9.5
T_{16}	2.35	0.18	1.54	48.5	145.3	55.7	9.3
$CD_{0.05}$	0.11	0.02	0.07	4.78	7.40	4.08	NS

Conclusion

On the basis of results obtained in the present investigation, it is concluded that combined foliar application of zinc sulphate @ 0.5% + borax @ 0.2% + manganese sulphate @ 0.5% + iron sulphate @ 0.4% proved to be the most effective treatment as the combined application of micronutrients resulted in significant improvement in growth in terms of annual shoot growth, increase in plant height, spread, stem girth, flowering, yield and reduction in fruit drop. Leaf

nutrient contents were also increased significantly with the application of micronutrients.

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