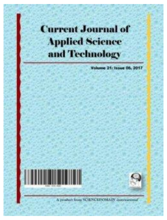

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Effect of Foliar Application of B, Zn and Cu on Yield, Quality and Economics of Rainy Season Guava Cultivation

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Authors' contributions

This work was carried out in collaboration between all authors. Authors S. Sau and S. Sarkar designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors KR and DG managed the analyses of the data. Authors PD and BG managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The study was aimed to investigate the effects of micronutrients fertilization on the growth, yield and quality as well as economics of guava fruits (cv. Allahabad Safeda) in new alluvial zone of West Bengal, India.

Methodology: A field experiment was conducted at Horticulture Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, West Bengal during rainy seasons of 2013-14 and 2014-15.

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The experiment was laid out in a randomized block design with seven different combinations of three micronutrients (B, Zn and Cu) and a control (without micronutrient).

Results: Experimental findings showed that combined application of Boron (B) and Zinc (Zn) recorded the highest fruits number/tree (133) and fruit yield (12.63 kg/tree) amongst different micronutrient combinations. The same treatment also significantly increased fruit physical and chemical parameters like fruit weight, fruit volume, fruit pulp thickness, total soluble solids, ascorbic acid, and sugar content. Higher uptake of plant-nutrients and increased chlorophyll content in guava leaf were also recorded from the plants with combined application B and Zn.

Conclusion: The results of this study indicate that combined foliar application of B and Zn is not only most effective for getting higher production but also for better quality fruits in alluvial Gangetic plains of West Bengal.

Keywords: Psidium guajava; micronutrient; leaf nutrient; fruit weight; total soluble solids.

1. INTRODUCTION

Guava (*Psidium guajava* L.) is one of the most important fruit from family Myrtaceae with high nutritive value, having several health benefits [1]. It is cultivated in the large areas of India [2] for its wide adaptability in variable soil and climatic conditions. The total area under guava in India is about 0.27 million ha with the production of 3.66 million t, whereas West Bengal is one of the leading producers of guava in India, producing almost 186.00 thousand tonnes of raw fruit from 14.40 thousand hectares area with productivity of 13 t/ha [3]. In subtropical climate, there are three distinct periods for growth and fruiting of guava. Despite higher production potentialities of guava in rainy season fruits often possess poor quality due to insipidness and infestation by a number of pests and diseases than in winter season [4]. So, there is an ample scope to perk up the quality aspects of rainy season guava through adoption of the best management practices. Nutritional deficiencies in fruit crops significantly hamper the physiological process of plants thus reducing yield and producing inferior fruit, and making the plant vulnerable to a number of biotic and abiotic stresses. Micronutrients have received a greater attention for crop production nowadays, because of its widespread deficiency in soil due to intensive cropping production and insufficient use of organic manure compared to high mineral fertilization for fruit crop production [5]. In spite of low requirements, Micronutrients like Fe, Zn, Mn, Cu and B are not only essential but also equally important like other macronutrients. These micronutrients help the plant uptake of major nutrients and play active roles in the plant metabolism like cell wall development, photosynthesis, chlorophyll formation, enzyme activity, nitrogen fixation and oxidation-reduction reaction [6]. Guava responds significantly to applied micronutrients, especially zinc (Zn), boron (B), copper (Cu) and molybdenum (Mo) for improving growth, yield and quality [7]. Horticultural crops generally respond better to the foliar application of micronutrients than soil application [8]. Moreover, micronutrients are required by plants in comparatively lesser amount and thus, can be applied more safely through foliar spraying which offers the possibility of quick absorption in plant cells at time of maximum requirements by the plants [9].

To compete in domestic as well as foreign markets, quality-fruit yield is becoming a major challenge of the fruit industry. Thus, foliar fertilization of micronutrients could be the new exploitable technology that may not only produce guava of superior quality in rainy season but also reduced the loss of soil applied micronutrients. To the best of our knowledge, no detailed studies have been conducted to investigate the effect of micronutrients (B, Zn and Cu) in rainy season on guava in alluvial zone of West Bengal. Therefore, the objective of the present study was to determine the most optimal and economical combination of micronutrients fertilization for improving guava fruit quality in rainy season in West Bengal, India.

2. MATERIALS AND METHODS

2.1 Study Area

Experiment was carried out during rainy seasons of 2013-14 and 2014-15 at the Horticulture Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India (22º56' N, 88º31' E, 9.75 m above mean sea level) in five years old, well managed, uniform statured guava trees cv. Allahabad Safeda spaced at 4 m × 4 m in both way. The climate of the region is humid sub-tropical with hot-humid summers and cool winters. The mean annual rainfall is 1,750 mm, out of which 80-90% is normally received from June to September. The soil was sandy clay loam in texture (64.8% sand, 10.4% silt and 24.8% clay), neutral in reaction (pH 6.9), medium in organic carbon (0.55%); high in available K (287.50 kg/ha) and available P (26.05 kg/ha) and low available N (168.80 kg/ha). Available B, Zn and Cu contents of the experimental soil was 0.059 mg kg^{-1} (very low), 0.67 mg kg^{-1} (low) and 0.31 mg kg^{-1} (high), respectively.

2.2 Experimental Treatments and Measurements

The experiment was laid out in a randomized block design with eight treatments [$B_0Zn_0Cu_0$ = Control (without micronutrient), B_1 = (H_3BO_3 @ 0.2%), Zn_1 = ($ZnSO_4$ @ 0.5 %), Cu_1 = ($CuSO_4$ @ 0.5%), B_1Zn_1 = (H_3BO_3 @ 0.2% + $ZnSO_4$ @ 0.5 %), B_1Cu_1 = (H_3BO_3 @ 0.2% + $CuSO_4$ @ 0.5%), Zn_1Cu_1 = ($ZnSO_4$ @ 0.5 %+ $CuSO_4$ @ 0.5%), $B_1Zn_1Cu_1$ = (H_3BO_3 @ 0.2% + $ZnSO_4$ @ 0.5 %+ $CuSO_4$ @ 0.5%)] replicated three times. All guava plants received recommended doses of NPK fertilizer i.e. 250:375:250 g :: $N:P_2O_5:K_2O$/plant. Micronutrients (B as boric acid containing 17% B, Zn as zinc sulphate containing 21% Zn, and Cu as copper sulphate containing 24% Cu) were applied twice (1st spray during flowering and 2nd spray after one month of 1st spray) according to the treatments combination to the respective guava plants in both of the experimental years. The plants were kept under standard cultural practices and same phytosanitory treatments for insect pest control.

2.3 Observations on Growth and Yield Attributes

Observations on yield indicators of guava such as % fruit set, %fruit drop, %fruit retention and % unmarketable fruit were calculated out using the formula suggested by [10,11]. Total fruits from trees were harvested (in 2-3 intervals) as per treatment combination, and fruit yield per tree was calculated accordingly.

2.4 Measurement of Leaf Chlorophyll and Nutrient Content

Chlorophyll content (Chlorophyll a, b and total chlorophyll) from fresh leaves was determined by using the formula developed by [12]. Leaf nitrogen (N), phosphorus (P) and potassium (K) contents were estimated by methods described by [13]. Leaf B content was determined by Azomethine-H colorimetric method [14], whereas estimation of leaf Zn and Cu were done through tri–acid mixture ($HNO_3:H_2SO_4:HClO_4$::9:1:4) digestion [13].

2.5 Measurement of Fruit Physical and Biochemical Properties

To determine fruit morphological characteristics like fruit size (length and diameter), fruit weight and fruit volume, twenty fruits were selected randomly from replicates. The specific gravity was calculated by dividing weight of fruit by its volume. Fruit firmness of guava was determined by a screw type Penetrometer and the reading was expressed in kg/cm^2. To determine seed content, fruits were allowed to ferment by dipping into water and thereafter seeds were separated from fermented pulp and counted accordingly.

The Soluble Solid Concentrate (SSC) was estimated using digital refractometer and was expressed as ^oBrix. The total titratable acidity (TA) was determined by volumetric procedure [15]. Ascorbic acid content of the guava fruit was estimated by using 2, 6-dichlorophenolindophenol dye titration method [16]. Total sugar, reducing sugar and non-reducing sugar of fruits were determined according to the method explained by [16].

2.6 Statistical Analysis

Statistical analysis was performed by the analysis of variance (ANOVA) for randomised block design (RBD) using SAS software version 9.2 applying analysis of variance (PROC GLM) with subsequent multiple comparisons of means for both of the experimental years [17]. The ANOVA of the growth, yield and quality parameters of guava cultivation across the year's revealed a non-significant ($p>0.05$) variance within the years as well as for the interaction year × cultivar. The homogeneity of error of variance was tested using Bartlett's x^2 test. As error of variance was homogeneous, thus pooled analysis was performed and presented accordingly.

3. RESULTS AND DISCUSSION

3.1 Guava Growth and Yield Attributes

Application of micronutrients significantly increased fruit set of guava over control

($B_0Zn_0Cu_0$) as evident in Table 1. Nevertheless, application of B_1Zn_1 recorded the maximum fruit set which was 28.97% higher than the control. Micronutrient fertilization was also effective to reduce fruit drop of guava (Table 1). In harmony to fruit set percentage, spraying of B_1Zn_1 was resulted in the lowest fruit drop (44.17%) accounting 41.11% lower values than the plants receiving no micronutrient fertilization. The same treatment recorded the maximum fruit retention (52.89%) with an increase of 23.53% over $B_0Zn_0Cu_0$ (Table 1). The maximum number of total fruits/tree (133) was also obtained from trees treated with B_1Zn_1 with an increment of 24.39% over control. Present findings showed that fruit yield was significantly improved by micronutrient fertilization as compared to control treatment (Table 1). The highest fruit yield (12.63 kg/tree) was obtained with foliar application of B_1Zn_1 which was 37.39% higher than control ($B_0Zn_0Cu_0$). The least amount of unmarketable fruits was obtained in plants receiving foliar micronutrient fertilization of Zn_1Cu_1 (18.15%) which were statistically at par with rest other foliar micronutrient treatments (Table 1). Hada et al. [18] found similar results with the foliar application of micronutrients like B and Zn in different levels for improvement of fruit retention and yield by guava plants. The increased fruit set, retention and yield in guava trees as the result of foliar spray of B may be explained by the beneficial role of B in pollen grain germination, pollen tube development and fruit set by [19] in temperate fruit crops, while Zn has been reported to play an important role in fruit bud formation and fruit drop reduction in stone fruits by synthesis of tryptophan and regulate the translocation of metabolites to the site of bud development [20].

3.2 Leaf Nutrient and Chlorophyll Content

The macronutrients (N, P and K) contents in guava leaf were significantly altered with the application of different foliar micronutrient fertilization (Table 2). The highest N content was found in plants treated with combined application of $B_1Zn_1Cu_1$ (66.67% higher than the control), which was statistically at par with B_1Zn_1 (Table 2). The maximum K content (1.62%) of guava leaf was observed in the plant fertilized with B_1Zn_1. Micronutrient fertilization (applied either alone or in combination) failed to bring any significant changes in leaf P content. The highest B concentration (19.01 ppm) in guava leaf was recorded from the trees fertilized with B_1Zn_1, which were 32.20 higher than the control. Similarly, the highest Zn concentration was found in the leaves treated with Zn_1Cu_1 (39.36 ppm) which was statistically at par with the results obtained from application of $B_1Zn_1Cu_1$ and Zn_1. Unlike Zn concentration, the highest Cu concentration in guava leaves was found in trees that received foliar fertilization of Cu_1, which was 65.70% higher than the trees receiving no micronutrient fertilizers (Table 2). Higher concentration of leaf nutrients in guava as influenced by micronutrients fertilization has also been reported by [21 and 22]. Cu has a smaller contribution among the tested micronutrients to increase leaf N, P, K contents possibly due to a high available Cu concentration in experimental soil.

Leaf pigment (cholorophyll a, cholorophyll b and total cholorophyll) content of guava was significantly improved with foliar fertilization of micronutrients. As evident from Fig. 1, spraying of guava trees with $B_1Zn_1Cu_1$ recorded the maximum amount of total leaf chlorophyll, which was statistically at par with other micronutrients application. This increment may be explained by the role of micronutrients in the regulation of cytoplasmic concentration of nutrients and enhancement in secondary metabolites concentration [23].

3.3 Fruit Physical and Biochemical Properties

The results presented in Table 3 indicate that foliar application of B_1Zn_1 produced fruits with larger size in respect to length (6.05 cm) than the fruits obtained from the trees received no micronutrient (control) ($B_0Zn_0Cu_0$), and diameter (5.84 cm), although not significantly different from other treatments. Still, fruit weight of guava was significantly improved by the application of foliar micronutrients, and the highest fruit weight was obtained in plants that received B_1Zn_1. But foliar micronutrient fertilization resulted in a non-significant impact on fruit shape index of guava. Fruit volume was also significantly improved with application of B_1Zn_1 (28.29% higher than the control) (Table 3). The increased fruit weight and volume by various micronutrient sprays was also recorded by [24,25] in guava. Zinc has been reported as a principal component of tryptophan biosynthesis pathway which promotes the synthesis of auxin [26] and is directly associated with improvement of fresh weight of guava fruits [27]. Boron also plays an important role in regulating of cell division, sugar

Table 1. Effect of micronutrients on yield and yield attributes of rainy season guava (Pooled data of 2013-14 and 2014-15)

Treatments	Fruit set percentage (%)	Fruit drop percentage (%)	Fruit retention percentage (%)	Total number of fruits/ tree	Fruit yield (kg/tree)	Unmarketable fruit percentage (%)
$B_0Zn_0Cu_0$	54.82 b	62.33 a	42.32 b	107.06 b	9.20 c	24.94 a
B_1	63.37 ab	48.04 b	50.27 ab	115.01ab	10.92 abc	22.39 ab
Zn_1	68.02 ab	47.14 b	50.99 ab	121.11 ab	11.44 ab	20.40 ab
Cu_1	60.91 ab	50.93 ab	47.64 ab	114.11 ab	10.39 bc	18.92 ab
B_1Zn_1	70.71 a	44.17 b	52.89 a	133.18 a	12.63 a	19.63 ab
B_1Cu_1	61.33 ab	50.74 ab	47.63 ab	129.91 ab	11.27 abc	19.01 ab
Zn_1Cu_1	63.05 ab	52.17 ab	48.79 ab	126.04 ab	11.10 abc	18.15 b
$B_1Zn_1Cu_1$	68.30 ab	45.88 b	52.28 a	130.06 ab	12.31 ab	19.07 ab

Means followed by a different letter are significantly different (otherwise statistically at par) at p≤0.05 by Tukey's HSD (honest significant difference) test

Table 2. Effect of micronutrients on leaf nutrient contents of rainy season guava (Pooled data of 2013-14 and 2014-15)

Treatments	Total nitrogen (%)	Total phosphorus (%)	Total potassium (%)	Total boron (ppm)	Total zinc (ppm)	Total copper (ppm)
$B_0Zn_0Cu_0$	1.11 d	0.22 a	1.12 b	14.38 c	27.92 c	44.76 d
B_1	1.66 abc	0.18 a	1.58 a	18.68 a	28.71 c	51.10 c
Zn_1	1.53 bc	0.17 a	1.47 a	14.83 bc	38.53 ab	54.93 c
Cu_1	1.46 c	0.19 a	1.19 b	14.90 bc	29.26 c	74.17 a
B_1Zn_1	1.77 ab	0.18 a	1.62 a	19.01 a	37.77 b	55.23 c
B_1Cu_1	1.48 c	0.15 a	1.51 a	18.83 a	28.13 c	65.76 b
Zn_1Cu_1	1.53 bc	0.18 a	1.45 a	15.32 b	39.36 a	62.32 b
$B_1Zn_1Cu_1$	1.85 a	0.15 a	1.56 a	18.32 a	38.62 ab	68.45 ab

Means followed by a different letter are significantly different (otherwise statistically at par) at p≤0.05 by Tukey's HSD (honest significant difference) test.

metabolism and accumulation of carbohydrates [28]. Specific gravity of guava was more or less constant and recorded no significant changes with micronutrient application (Table 3).

The maximum fruit pulp thickness (1.40 cm) was obtained from guava trees receiving B_1Zn_1 (37.25% more than $B_0Zn_0Cu_0$) which was statistically at par with the fruits obtained from the trees receiving Zn_1, B_1Cu_1, Zn_1Cu_1 and B_1Zn_1Cu1, (Table 3). Micronutrient fertilization exerted positive but non-significant impact on the fruit firmness; however, fruit treated with B_1Zn_1 recorded the highest fruit hardness (9.97 kg cm^{-2}) (Table 3). Bhatia et al. [29] expressed similar opinion for increasing fruit hardness of guava due to different micronutrient application over the control. A considerable reduction in number of seeds per fruit was recorded with micronutrient application, but foliar feeding of micronutrient (sole or in combination) failed to record any significant changes to seeds number per fruit over control. However, least number of seeds per fruit (193.33 seeds) was obtained with the application of $B_1Zn_1Cu_1$ and it may be due to their dominating role to the accumulation of flesh in the fruits as reported earlier by [30] in guava. Seeds weight of guava significantly changed with foliar fertilization and the highest seed weight (0.75 g) was recorded by $B_1Zn_1Cu_1$, which was statistically at par with Zn_1, Cu_1, B_1Cu_1 and Zn_1Cu_1.

Micronutrient fertilization also exerted a positive impact on fruit biochemical quality by increasing SSC, ascorbic acid and sugar content (reducing and total) of fruits (Table 4). Fruit harvested from the trees receiving B_1Zn_1 recorded the maximum SSC content (11.07 °Brix). Pearson correlation showed that SSC content of guava fruit was positively correlated with leaf N (r = 0.556**), K (r = 0.691**) and B (r = 0.543**) content (Table 5).

Table 3. Effect of micronutrients on fruit physical parameters of rainy season guava (Pooled data of 2013-14 and 2014-15)

Treatments	Fruit length (cm)	Fruit diameter (cm)	Fruit shape index	Fruit weight (g)	Fruit volume (cm^3)	Specific gravity	Fruit pulp thickness (cm)	Fruit firmness (kg/cm^2)	Number of seeds/ fruit	Weight of 100 seeds (g)
$B_0Zn_0Cu_0$	5.23 b	5.27 a	0.99 a	77.24 c	74.83 b	1.07 a	1.02 c	7.40 a	235.33 a	0.55 c
B_1	5.97 ab	5.75 a	1.04 a	83.36 bc	78.80 ab	1.05 a	1.08 bc	7.50 a	212.00 a	0.59 bc
Zn_1	5.92 ab	5.60 a	1.06 a	94.68 ab	84.44 ab	1.09 a	1.27 abc	8.13 a	218.67 a	0.65 abc
Cu_1	5.52 ab	5.43 a	1.02 a	80.86 bc	76.17 ab	1.07 a	1.07 bc	7.47 a	202.00 a	0.70 ab
$B_1 Zn_1$	6.05 a	5.84 a	1.04 a	104.33 a	96.00 a	1.10 a	1.40 a	9.97 a	227.67 a	0.58 bc
B_1Cu_1	5.90 ab	5.73 a	1.03 a	84.6 bc	76.33 ab	1.09 a	1.25 abc	8.20 a	215.00 a	0.71 ab
Zn_1Cu_1	5.97 ab	5.67 a	1.05 a	83.66 bc	76.67 ab	1.07 a	1.23 abc	9.20 a	210.67 a	0.62 abc
$B_1 Zn_1Cu_1$	6.02 ab	5.62 a	1.07 a	91.79 abc	80.52 ab	1.15 a	1.33 ab	9.77 a	193.33 a	0.75 a

Means followed by a different letter are significantly different (otherwise statistically at par) at $p \leq 0.05$ by Tukey's HSD (honest significant difference) test.

Table 4. Effect of micronutrients on fruit bio-chemical parameters of rainy season guava (Pooled data of 2013-14 and 2014-15)

Treatments	SSC (^{o}Brix)	Titratable acidity (%)	SSC: Acid ratio	Ascorbic acid (mg/ 100 g)	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)
$B_0Zn_0Cu_0$	8.20 b	0.65 a	12.64 c	75.67 b	6.15 b	2.93 b	3.22 a
B_1	10.40 ab	0.50 ab	20.81 abc	95.00 ab	8.35 ab	3.66 a	4.69 a
Zn_1	9.83 ab	0.48 ab	21.21 abc	91.67 ab	8.71 ab	3.90 a	4.81 a
Cu_1	9.00 ab	0.58 ab	15.57 bc	88.33 ab	8.18 ab	3.64 a	4.54 a
B_1Zn_1	11.07 a	0.42 b	26.79 a	120.67a	9.32 a	4.03 a	5.29 a
B_1Cu_1	10.33 ab	0.51 ab	20.76 abc	90.00 ab	7.83 ab	3.67 a	4.16 a
Zn_1Cu_1	10.43 ab	0.49 ab	21.39 abc	106.00 ab	8.49 ab	3.74 a	4.75 a
$B_1Zn_1Cu_1$	10.27 ab	0.44 ab	23.61 ab	115.00 a	8.74 ab	3.72 a	5.02 a

SSC, Soluble solid concentrate; Means followed by a different letter are significantly different (otherwise statistically at par) at $p \leq 0.05$ by Tukey's HSD (honest significant difference) test.

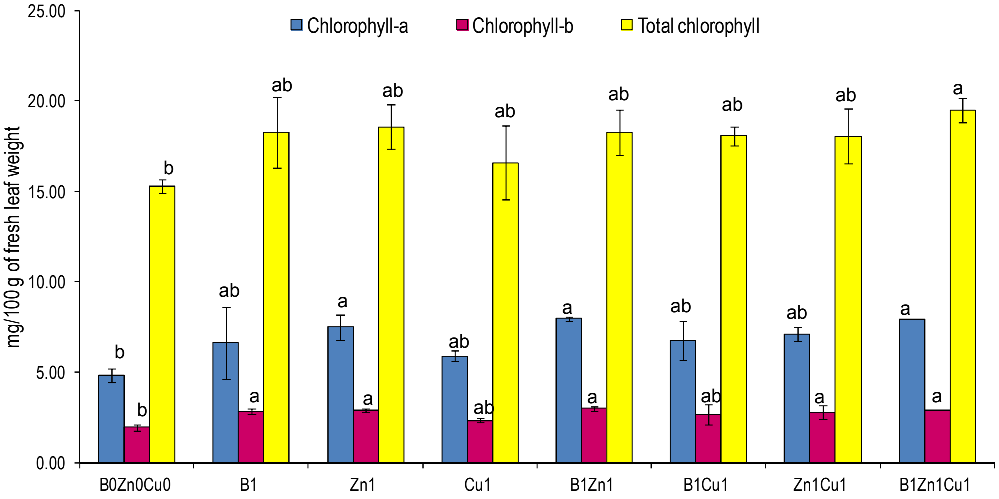

Fig. 1. Effect of micronutrients on chlorophyll content (Chlorophyll a, b and total chlorophyll) of guava leaf (based on mean data of two year)

Vertical bar followed by different letters are significantly different (otherwise statistically at par) at p≤0.05 by Tukey's HSD (honest significant difference) test. Error bar are Standard Deviation (±) of the mean.

Table 5. Pearson correlation analysis of relationship between leaf nutrient with SSC (°Brix), ascorbic acid and total sugar contents of guava fruit after foliar application of micronutrients (n = 24)

	N	P	K	B	Zn	Cu
SSC	0.556**	− 0.316	0.691**	0.543**	0.39	0.13
Ascorbic acid	0.671**	− 0.348	0.645**	0.459*	0.607**	0.207
Total sugar	0.668**	− 0.432*	0.617**	0.299	0.502*	0.229

N = Total Nitrogen (%) concentration of leaf; P = Total Phosphorus (%) concentration of leaf; K = Total Potassium (%) concentration of leaf; B = Total Boron (ppm) concentration of leaf; Zn = Total Zinc (ppm) concentration of leaf, Cu = Total copper (ppm) concentration of leaf.

SSC = Soluble solid concentrate (°Brix); Indicate significant correlations at p ≤ 0.05.;**Indicate significant correlations at p ≤ 0.01; Values are mean data of 2 years.*

Table 6. Effect of micronutrients on economic returns of rainy season guava (Pooled data of 2013-14 and 2014-15)

Treatments	Common cost for cultivation* (US$ /ha)†	Treatment cost# (US$ /ha)	Total cost of cultivation (US$ /ha)	Gross return♣ (US$ /ha)	Net return (US$/ ha)	Benefit : Cost ratio
$B_0Zn_0Cu_0$	532.91	0.00	532.91	1915.77 c	1382.86 c	2.59 b
B_1	532.91	25.00	557.91	2274.28 abc	1716.37 abc	3.07 ab
Zn_1	532.91	26.00	558.91	2383.24 ab	1824.39 ab	3.26 ab
Cu_1	532.91	36.00	568.91	2164.30 bc	1595.40 bc	2.81 ab
B_1Zn_1	532.91	51.00	583.91	2631.22 a	2047.31 a	3.50 a
B_1Cu_1	532.91	61.00	593.91	2334.92 abc	1754.34 abc	2.95 ab
Zn_1Cu_1	532.91	62.00	594.91	2312.47 abc	1717.56 abc	2.89 ab
$B_1Zn_1Cu_1$	532.91	87.00	619.91	2563.86 ab	1943.95 ab	3.13 ab

**Common cost of cultivation was estimated considering all the inputs in guava cultivation, except cost; #Treatment cost varies only due to difference in micronutrient fertilization levels; ♣Gross return is calculated by multiplying fruit yield with selling price i.e. US$ 0.33 kg^{-1}, †1 US$ = ₹ 60.00. Means followed by a different letter are significantly different (otherwise statistically at par) at p≤0.05 by Tukey's HSD (honest significant difference) test*

Kumar et al. [31] and Srinivas et al. [32] also found the positive impacts of micronutrients on SSC. Increase in SSC content with these micronutrients may be attributed to the quick metabolic transformations of polysaccharides and pectin into soluble compounds and rapid translocation from leaves to the developing fruits due to improved source-sink relationship [33].

The same foliar micronutrient treatment (B_1Zn_1) significantly lowered titratable acidity (0.42%) and thus maximized SSC:TA ratio (26.79) as compared to $B_0Zn_0Cu_0$. Ruffner et al. [34] suggested that, titratable acid under the influence of chemicals might have either been rapidly converted into sugars and their derivatives by the reactions involving reversal of glycolytic pathway or might be used in respiration, or both. The highest ascorbic acid content (59.46% higher than control) of fruits was also recorded from the plants treated with B_1Zn_1 (Table 4). Correlation study also revealed positive relationships between ascorbic acid content of fruits with leaf nutrients like N ($r = 0.671^{**}$), K ($r = 0.645^{**}$), B ($r = 0.459^{*}$) and Zn ($r = 0.607^{**}$) content (Table 5). In harmony to the present findings, [32 and 29] reported such beneficial impacts of micronutrients in increasing the ascorbic acid content of guava. Reducing sugar content of guava was increased significantly with micronutrient fertilization over control, but the effects of different treatments were statistically at par among themselves. Fruits treated with B_1Zn_1 recorded the highest total sugar content (9.32%) which was statistically at par with other micronutrient treatments. Total sugar content was also positively correlated with leaf nutrients like N ($r = 0.668^{**}$), K ($r = 0.617^{**}$) and Zn ($r = 0.502^{*}$) and correlated negatively with leaf P content ($r = -0.432^{*}$) (Table 5). It is in the agreement with the findings [35] in guava who found that the highest sugar content in fruits with the application of B and Zn in combination.

3.4 Economics of Guava Cultivation

The foliar application of different micronutrients along with recommended doses of NPK gave higher fruit yield as well as higher net returns (Table 6). The treatment based on B_1Zn_1 has been found to be the most effective dose providing the highest net return (US$ 2047.31/ ha) and benefit:cost ratio (3.50) mainly due to production of larger and uniform sized fruits which mostly attract by the consumers and received a good market price. Srinivas et al. [32] also found higher economic net returns and higher benefit: cost ratio by foliar application with micronutrients (0.3% B and 0.3% Zn).

4. CONCLUSION

Foliar applied B, Zn and Cu has significant impact on growth, yield and quality parameters of guava. However, the best outcome in respect to fruit yield and related attributes, quality and economics of guava plant was obtained through applying B and Zn in combination. So, from this study, it is worth to conclude that the combined foliar application of B and Zn at right dose and time is a profitable option for rainy season guava cultivation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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