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Effect of soil and foliar application of micronutrients on quality and economics of guava (*Psidium guajava* L.)

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Abstract
The experiment framed was intended to study the effects of soil and foliar application of zinc, iron and boron on quality of guava and also to find out the economic dose of zinc, iron and boron. The experiment was conducted in a well-established Sardar guava orchard of fifteen years age planted at 6 x 6 m spacing during Mrig bahar 2019 with trees having uniform growth and vigor. The results of the present investigation clearly indicated that, different growth, yield and quality parameters of guava were significantly influenced due to different treatments of micronutrients. The physical and chemical quality attributes were also maximum with the said treatment. The highest gross monetary returns (Rs. 5,66,195/ha), net monetary returns (Rs.3,36,611/ha), Benefit: Cost ratio (2.47) were recorded with soil and foliar application of 100g $ZnSo_4$ + 100g $FeSo_4$ + 25g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax (T_9).

Keywords: Guava, soil and foliar, zinc, iron, boron, quality, economics, PLW.

Introduction
The guava (*Psidium guajava*, L.) is an evergreen tree native to tropics. Its family Myrtaceae under genus Psidium that contains 150 species but only *Psidium guajava* L. is exploited commercially. The common Guava is diploid (2n = 22), but natural and artificial triploid (2n = 33) and aneuploid exists. The quality of guava fruits is influenced by large number of factors. One of the important factor is inadequate supply of plant nutrient. Nutrient requirement of guava vary with varieties and agroclimatic conditions. It gives good response to manuring and fertilization out of various major nutrients phosphorus play extremely important role in guava cultivation for optimum yield and performance. Use of micronutrients also play an important role to avoid hidden nutrient hunger. Micronutrients are essentially as important as macronutrients to have better growth, yield and quality in fruit trees. The requirement of micronutrients (zinc, boron, iron, copper, chloride, molybdenum, manganese) is only in traces, which is partly met from the soil or through chemical fertilizers or through other resources. The major causes for micronutrient deficiencies are intensified agricultural practices, unbalanced fertilizer application including NPK, limited use of organic manures, depletion of nutrient and no replenishment. Horticultural crops suffer widely by zinc deficiency followed by boron, iron and Mo Deficiencies (Jeyakumar and Balamohan 2013) [6]. Furthermore, these micronutrients also help in uptake of major nutrients and play an active role in the plant metabolism process starting from cell wall development in respiration, photosynthesis, chlorophyll formation, enzyme activity, hormone synthesis, nitrogen fixation and reduction etc (Das, 2003) [4]. Nevertheless, micronutrients can tremendously boots horticultural crop yield, improve quality and post-harvest life of horticultural produce (Raja, 2009) [10]. Macronutrient are quickly taken up and utilized by the tissue of the plants by catalyzing effect of micronutrients (Phillips, 2004) [8].

Material and Methods
The experiment was carried out during June 2019 to February 2020. The Sardar guava trees grown on medium type soil planted at 6 x 6 m spacing of fifteen years age having uniform growth and vigor were subjected to bahar treatment by withholding irrigation water during April-2019. The experiment was conducted at Research Farm, college of Agriculture, Latur during 2019-20. The experiment was conducted in a Sardar guava orchard of fifteen years age during Mrig bahar 2019 on trees having uniform growth and vigor. All the cultural and horticultural practices were followed as per the recommendation.

The pruning of criss-cross branches, diseased branches was done during May 2019. The experimental trees were applied 20 kg FYM and 400:400:400 g N, $P_2O_5$and K_2O per tree along with soil application of micronutrients as per treatment before onset of monsoon, remaining half dose of N_2 was applied at fruit set stage. Three foliar application of micronutrients as per treatment were taken 1st at 15 days after onset of monsoon, 2nd at fruit set stage and 3rd at fruit development stage. The observations on different quality and economic status were recorded as per the schedule.

Results and Discussion

The different levels of zinc, ferrous and boron showed positive response on physical as well as chemical quality attributes of guava fruits. The maximum values of physical quality characters like fruit length (6.89 cm), fruit width (56.94 cm), volume of fruit (146.40 ml), weight of pulp (146.05 g), pulp: seed ratio (27.45) and minimum seed weight (5.32g) were recorded with the soil and foliar application of 100g $ZnSo_4$ + 100g $FeSo_4$ + 25g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ +0.5% Borax (T_9) and minimum values of all these parameters except seed weight were recorded in control treatment (T_{12}). The increase in length and width of guava fruit may be due to fact that zinc, ferrous and boron have indirect role in hastening the processing of cell division and cell elongation due to which size, weight and volume would have improved (Bhoyar *et al.* 2017) [3]. The increase in fruit length and width in papaya was possibly due to accumulation of more food material in the tree that lead to efficient utilization for fruits development (Preethi *et al.* 2017) [9]. The increase in fruit volume in mango with boron might be due to its involvement in hormonal metabolism which increased cell division and expansion of cell (Singh *et al*. 2017) [2, 7, 13]. Boron and Zinc appear to have indirect role in hastening the process of cell division and cell elongation which perhaps improved the size, weight and volume of guava fruits (Baranwal *et al*. 2017). The maximum values of chemical quality attributes like TSS (10.89%) was recorded with soil and foliar application of 50g $ZnSo_4$ + 50g $FeSo_4$ + 12.5g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax (T_8) and minimum was recorded in control (T_{12}). Maximum ascorbic acid (223.65 mg/100 pulp), reducing sugars, total sugars (4.69% and 7.09%) and minimum acidity (0.44%) were recorded with the soil and foliar application of 100g $ZnSo_4$ + 100g $FeSo_4$ + 25g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax (T_9) treatment. Minimum values of ascorbic acid, acidity, reducing sugars, total sugars and maximum acidity were recorded in control treatment (T_{12}). While, the minimum per cent weight loss of fruits at 2nd, 4th 6th and 8th days of storage (2.88%, 7.57%, 11.96% and 16.02% respectively) was observed in fruits produced with the soil and foliar application of 50g ZnSo4 + 50g FeSo4 + 12.5g Borax + 0.5% ZnSo4 + 0.5% FeSo4 + 0.2% Borax (T_8) and maximum per cent weight loss of fruits recorded in control (T_{12}). Increase in TSS and total sugars of guava fruits might be due to the role of zinc which helps in the enzymatic reactions like transformation of carbohydrates, activity of hexokinase and formation of cellulose and change in sugar are considered due to its action on zymohexose and boron helps in sugar transport which may be possible to improve TSS and total sugars (Bhoyar *et al.* 2017) [3]. The higher ascorbic acid content was due to the increased in total sugars content owing to the efficient translocation of available photosynthates to fruit pulp rather than to other parts. (Baranwal *et al*. 2017) [2]. It might be attributed to the fact that boron directly affects the photosynthesis activity of plant and helps in sugar transport. Besides, the boron also plays an important role in activating the synthesis of ascorbic acid. These results are in agreement with the findings of (Awasthi and Lal 2009) [1] and (Yadav *et al*. 2011) [14] in guava. The differences with respect to physiological loss in weight of guava fruits was observed among the fruits produced with the soil and foliar application of micronutrients. At 2nd, 4th 6th and 8th days of storage the minimum per cent weight loss of fruits (2.88, 7.57, 11.96 and 16.02% respectively) was observed in fruits produced with the soil and foliar application of 50g $ZnSo_4$ + 50g $FeSo_4$ + 12.5g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax (T_8). The fruits obtained with the 100g $ZnSo_4$ + 100g $FeSo_4$ + 25g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax (T_9) has shown the at par results. While, the maximum per cent weight loss (4.27, 11.39, 18.22 and 24.53% respectively) was recorded in soil application of 100g $ZnSo_4$ + 100g $FeSo_4$ + 25g Borax/tree (T_2).The minimum weight loss in the fruits produced by the application of these treatments could be attributed to slower rate of respiration and transpiration from these fruits with reduced enzymatic activities and slower the biochemical changes occurring in the fruits obtained from the trees receiving these treatments. Kumar *et al*. (2011) [5, 7, 12] reported that, reduction in weight loss of guava fruits with foliar application of borax. The minimum PLW and prolonged shelf life of was observed due to foliar application of zinc sulphate (Goswami *et al.* 2012) [5]. The economics of guava production under the influence of soil and foliar application of zinc, ferrous and boron showed variations in cost of production, gross monetary returns, net monetary returns and benefit: cost ratio. After adding 1/6 of gross returns in cost of cultivation as a rental value of land the lowest (Rs. 1, 84, 009/ha) cost of cultivation was recorded in control (T_{12}), while highest cost of cultivation (Rs. 2, 29, 584/ha) was recorded with soil and foliar application of 100g $ZnSo_4$ + 100g $FeSo_4$ + 25g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax (T_9) treatment. The highest gross monetary returns (Rs. 5, 66, 195/ha), net monetary returns (Rs. 3, 36, 611/ha) and B:C ratio (2.47) was recorded with the soil and foliar application of 100g $ZnSo_4$ + 100g $FeSo_4$ + 25g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax (T_9) and it was closely followed with the soil and foliar application of 100g $ZnSo_4$ + 100g $FeSo_4$ + 25g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax (T_9) treatment. However, minimum values of all these parameters were recorded in control (T_{12}) treatment. Foliar application of different micronutrients in guava along with recommended doses of NPK gave higher (3.50) B**:**C ratio (Sau *et al*. 2018) [11]. High net returns and higher Benefit: Cost ratio foliar application with micronutrients in guava (Srinivas *et al*. 2015). maximum Cost**:**Benefit ratio (1**:**2.72) also obtained with the combined foliar spray of zinc sulphate (0.5%) + ferrous sulphate (0.5%) + borax (0.3%) in guava Bhoyar *et al.* (2018) [3], Which strongly supports the present findings.

Table 1: Effect soil and foliar application of micronutrients on physical quality parameters of guava fruit

Tr. No.	Treatments	Fruit length (cm)	Fruit width (cm)	Volume of fruit (ml)	Weight of pulp (g)	Weight of seeds/fruit (g)	Pulp:seed ratio
T_1	50g $ZnSo_4$ + 50g $FeSo_4$ + 12.5g Borax/ tree	5.98	6.09	119.60	116.60	5.90	19.76
T_2	100g $ZnSo_4$ + 100g $FeSo_4$ + 25g Borax/ tree	6.16	6.18	122.07	119.68	5.86	20.42
T_3	125g $ZnSo_4$ + 125g $FeSo_4$ + 37.5g Borax/ tree	6.21	6.24	135.07	126.02	5.42	23.25
T_4	150g $ZnSo_4$ + 150g $FeSo_4$ + 50g Borax/ tree	5.85	5.89	117.60	112.40	5.94	18.92
T_5	0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax	6.41	6.50	131.97	134.88	5.43	25.78
T_6	1.0% $ZnSo_4$ + 1.0% $FeSo_4$ + 0.4% Borax	6.20	6.24	139.33	125.18	5.94	21.07
T_7	1.5% $ZnSo_4$ + 1.5% $FeSo_4$ + 0.6% Borax	6.13	5.99	120.93	119.60	6.11	19.57
T_8	50g $ZnSo_4$ + 50g $FeSo_4$ + 12.5g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax	6.75	6.53	142.04	140.53	5.40	26.02
T_9	100g $ZnSo_4$ + 100g $FeSo_4$ + 25g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax	6.89	6.94	146.40	146.05	5.32	27.45
T10	125g $ZnSo_4$ + 125g $FeSo_4$ + 37.5g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax	6.26	6.27	129.87	124.82	5.91	21.12
T11	150g $ZnSo_4$ + 150g $FeSo_4$ + 50g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax	6.28	6.33	120.70	119.13	6.33	18.81
T12	Control	5.86	5.93	117.00	111.56	6.51	17.13
	S.E±	0.19	0.17	3.20	5.70	0.23	-
	C.D at 5% level	0.57	0.52	9.72	17.30	0.69	-

Table 2: Effect soil and foliar application of micronutrients on chemical attributes of guava fruit

Tr. No.	Treatments	T.S.S (%)	Ascorbic acid (mg/100 pulp)	Acidity (%)	Reducing sugars (%)	Non - reducing sugars (%)	Total sugars (%)
T_1	50g $ZnSo_4$ + 50g $FeSo_4$ + 12.5g Borax/tree	9.54	215.67	0.45	4.31	2.19	6.50
T_2	100g $ZnSo_4$ + 100g $FeSo_4$ + 25g Borax/tree	9.71	217.53	0.52	4.35	2.40	6.75
T_3	125g $ZnSo_4$ + 125g $FeSo_4$ + 37.5g Borax/tree	9.91	218.78	0.49	4.38	2.33	6.70
T_4	150g $ZnSo_4$ + 150g $FeSo_4$ + 50g Borax/tree	9.49	217.80	0.49	4.24	2.41	6.65
T_5	0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax	10.54	219.39	0.45	4.54	2.39	6.93
T_6	1.0% $ZnSo_4$ + 1.0% $FeSo_4$ + 0.4% Borax	9.96	222.57	0.47	4.63	2.38	7.01
T_7	1.5% $ZnSo_4$ + 1.5% $FeSo_4$ + 0.6% Borax	9.36	216.78	0.55	4.35	2.40	6.75
T_8	50g $ZnSo_4$ + 50g $FeSo_4$ + 12.5g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax	10.89	220.12	0.47	4.61	2.30	6.91
T_9	100g $ZnSo_4$ + 100g $FeSo_4$ + 25g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax	10.56	223.65	0.44	4.69	2.39	7.09
T10	125g $ZnSo_4$ + 125g $FeSo_4$ + 37.5g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax	9.78	217.57	0.48	4.41	2.36	6.77
T11	150g $ZnSo_4$ + 150g $FeSo_4$ + 50g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax	9.60	217.08	0.50	4.29	2.56	6.85
T12	Control	9.27	214.50	0.58	4.28	2.59	6.87
	S.E±	0.26	0.57	0.04	0.07	0.04	0.08
	C.D at 5 % level	0.77	1.69	0.13	0.21	0.13	0.25

Table 3: Effect soil and foliar application of micronutrients on physiological weight loss of guava fruit

Physiological loss in weight (%)						
Tr. No.	Treatments	Initial weight (g)	After 2 days	After 4 days	After 6 days	After 8 days
T_1	50g $ZnSo_4$ + 50g $FeSo_4$ + 12.5g Borax/tree	5000	4792.47 (4.15)	4477.38 (10.45)	4165.27 (16.69)	3880.25 (22.40)
T_2	100g $ZnSo_4$ + 100g $FeSo_4$ + 25g Borax/tree	5000	4786.53 (4.27)	4430.47 (11.39)	4089.02 (18.22)	3773.27 (24.53)
T_3	125g $ZnSo_4$ + 125g $FeSo_4$ + 37.5g Borax/tree	5000	4824.62 (3.51)	4585.94 (8.28)	4398.37 (12.03)	4079.78 (18.40)
T_4	150g $ZnSo_4$ + 150g $FeSo_4$ + 50g Borax/tree	5000	4785.41 (4.29)	4466.58 (10.67)	4128.14 (17.44)	3784.79 (24.30)
T_5	0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax	5000	4831.10 (3.38)	4588.05 (8.24)	4301.59 (13.97)	4028.27 (19.43)
T_6	1.0% $ZnSo_4$ + 1.0% $FeSo_4$ + 0.4% Borax	5000	4791.00 (4.18)	4419.29 (11.61)	4104.63 (17.91)	3774.37 (24.51)
T_7	1.5% $ZnSo_4$ + 1.5% $FeSo_4$ + 0.6% Borax	5000	4794.71 (4.11)	4433.74 (11.33)	4106.23 (17.88)	3788.29 (24.23)
T_8	50g $ZnSo_4$ + 50g $FeSo_4$ + 12.5g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax	5000	4855.93 (2.88)	4621.32 (7.57)	4402.03 (11.96)	4198.77 (16.02)
T_9	100g $ZnSo_4$ + 100g $FeSo_4$ + 25g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax	5000	4854.97 (2.90)	4611.69 (7.77)	4347.72 (13.05)	4123.33 (17.53)
T10	125g $ZnSo_4$ + 125g $FeSo_4$ + 37.5g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax	5000	4792.24 (4.16)	4453.25 (10.94)	4091.35 (18.17)	3787.66 (24.25)
T11	150g $ZnSo_4$ + 150g $FeSo_4$ + 50g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax	5000	4816.42 (3.67)	4479.28 (10.41)	4180.13 (16.40)	3856.27 (22.87)
T12	Control	5000	4821.34 (3.57)	4429.81 (11.40)	4127.19 (17.46)	3791.19 (24.18)

Table 4: Effect soil and foliar application of micronutrients on economics of guava production

Tr. No.	Treatments	Cost of cultivation (Rs/ha)	Gross monetary returns (Rs/ha)	Net monetary returns (Rs/ha)	Benefit: cost ratio
T_1	50g $ZnSo_4$ + 50g $FeSo_4$ + 12.5g Borax/tree	1,88,735	3,84,134	1,95,400	2.04
T_2	100g $ZnSo_4$ + 100g $FeSo_4$ + 25g Borax/tree	1,97,375	4,29,418	2,32,044	2.18
T_3	125g $ZnSo_4$ + 125g $FeSo_4$ + 37.5g Borax/tree	2,04,432	4,62,788	2,58,356	2.26
T_4	150g $ZnSo_4$ + 150g $FeSo_4$ + 50g Borax/tree	1,94,621	4,01,225	2,06,604	2.06
T_5	0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax	2,21,813	4,84,923	2,63,110	2.19
T_6	1.0% $ZnSo_4$ + 1.0% $FeSo_4$ + 0.4% Borax	2,13,985	4,70,194	2,56,209	2.20
T_7	1.5% $ZnSo_4$ + 1.5% $FeSo_4$ + 0.6% Borax	2,07,869	4,24,671	2,16,802	2.04
T_8	50g $ZnSo_4$ + 50g $FeSo_4$ + 12.5g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax	2,26,924	5,47,975	3,21,051	2.41
T_9	100g $ZnSo_4$ + 100g $FeSo_4$ + 25g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax	2,29,584	5,66,195	3,36,611	2.47
T10	125g $ZnSo_4$ + 125g $FeSo_4$ + 37.5g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax	2,15,310	4,64,380	2,49,071	2.16
T11	150g $ZnSo_4$ + 150g $FeSo_4$ + 50g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax	2,15,785	4,61,774	2,45,990	2.14
T12	Control	1,84,009	3,65,297	1,81,288	1.99

Conclusions

The guava trees planted at 6 x 6 m spacing along with recommended dose of N, P, K (800:400:400 g/tree) should be supplied with soil and foliar application of 100g $ZnSo_4$ + 100g $FeSo_4$ + 25g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax. This dose was optimum for getting superior quality of guava fruits with maximum B:C ratio by maintaining the soil fertility. However, as the treatment of soil plus foliar application of 50g $ZnSo_4$ + 50g $FeSo_4$ + 12.5g Borax + 0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax produced at par results for most of the traits under study. Hence, it will be advisable to apply Zinc, Ferrous and Boron micronutrients @50-100g $ZnSo_4$ + 50-100g $FeSo_4$ + 12.5-25g Borax per tree through soil along with the recommended dose of N,P,K @ (800:400:400 g/tree) and foliar sprays of these nutrients should be given @0.5% $ZnSo_4$ + 0.5% $FeSo_4$ + 0.2% Borax as per the soil test report for guava trees for getting superior quality fruits with high B:C ratio by maintaining the soil fertility.

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