Impact of foliar application of Fe, Zn and B in combination with Mg on growth, yield and quality of Acid lime (*Citrus aurantifolia* Swingle) under *Alfisols* of Andhra Pradesh

ABSTRACT

A Field experiment was conducted on well established four years old orchard of acid lime at Citrus Research Station, Petlur, Dr. YSR Horticultural University, Andhra Pradesh during 2012-2018 to investigate the effect of micronutrient fertilization on the growth, yield and quality of acid lime *cv*. CRS-1. The experiment was laid out in a randomized block design with seven different combinations of three micronutrients (Fe 0.5%, Zn 0.5% and B 0.1%) in combination with Mg 0.2% and a control imposed each treatment on five plants. Foliar application was done during before flowering, late bloom stage and berry sized fruit stage. The result displayed that combined application of iron @ 0.5%, zinc @ 0.5%, boron @ 0.1% and Mg @ 0.2% recorded highest fruits per tree (618.33) and fruit yield (22.60 kg per tree), and improved fruit physical and chemical parameters like fruit weight, fruit diameter, juice %, total soluble solids, ascorbic acid, acidity % *etc*. The leaf nutrient content in acid lime leaf was significantly altered plants treated with combined application of Fe, Zn, B and Mg, *i.e*. T8. From these results, it concluded that combined foliar application of Mg, Fe, Zn and B is not only most effective for getting higher production and also better quality fruits of Acid lime under *Alfisols* of Andhra Pradesh.

Keywords: Acid lime; micronutrients; plant growth; fruit yield and quality.

1. INTRODUCTION

Acid lime is considered as one of the most important citrus group fruit crop grown mainly in tropical and sub-tropical regions of India. The total area under acid lime in India is 0.31 million ha with the production of 3.77 million tons, whereas Andhra Pradesh is the leading producer of acid lime in India, producing almost 0.9 million tons of raw fruit from 45.2 thousand hectares area with productivity of 20 t ha^{-1} [1].

Acid lime fruits are consumed and relished worldwide for its fresh flavor and juiciness. Fruits of citrus genus are endowed with various health-benefiting properties owing to the presence of an array of bioactive components in them. They are well known for their vitamin C, folic acid, and carotenoid content. Citrus flavonoids and limonoids have been

associated with many disease-preventive properties such as anticancer, lipid-lowering, and cardiovascular-protective activities [2]. Despite higher production potentialities of acid lime, fruits often possess poor quality due to insipidness and infestation of number of pests and diseases. So, there is an ample scope to perk up the quality aspects of acid lime through best management practices. Nutritional deficiencies in fruit crops significantly hampered the physiological process of plants thus reducing yield and produced inferior fruit, and also makes the plant vulnerable to numbers of biotic and abiotic stresses [3 and 4].

Now-a-days micronutrients have received a greater attention for crop production, because of its wide-spread deficiency due to intensive cropping system and insufficient use of organic manure compared to high analysis chemical fertilizers for fruit crop production [5]. Micronutrients like Fe, Zn and B are not only essential but also equally important like other macro nutrients, in spite of their low requirements. These micronutrients help in uptake of major nutrients and play an active role in the plant metabolism like cell wall development, photosynthesis, chlorophyll formation, enzyme activity, nitrogen fixation and reduction [6]. Acid lime responds significantly to applied micronutrients, especially iron, zinc and boron for improving growth, yield and quality [7]. Horticultural crops respond well to the foliar feeding 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 times of maximum requirements by the plants [9].

Acid lime is a nutrient loving plant, but growers of this region are seldom using secondary and micronutrient fertilizers, which causes serious nutritional disorders in acid lime. Moreover, soils of this region are mostly calcareous in nature and alkaline in reaction and these conditions are not favorable to micronutrients availability. Similarly, secondary and micronutrients applied to alkaline soils are usually adsorbed or precipitated on the surface and does not move readily to the root zone. However, soil application of secondary and micronutrients is therefore not very effective to recover these deficiencies in calcareous and alkaline soils. Further, acid lime is deep rooted crop, so secondary and micronutrients application to soil may be of little value. For production maximization, we often compromised with the quality aspects of fruits. But, to compete in domestic as well as foreign markets, quality-fruit production is becoming a major challenge of the fruit industry. The alternative way is to supply the deficient secondary and micronutrient fertilizers through foliar spray. Thus, foliar fertilization of secondary and micronutrient could be the new exploitable technology that may produce acid lime of superior quality. Keeping in view of the unfavorable physico-chemical conditions of our soils, it becomes necessary to supply

secondary and micronutrients in balanced amount through foliar spray to raise the acid lime production and improve the fruit quality. Therefore, the present experiment designed to study the effect of micronutrients in combination with Mg on the yield, quality and leaf composition of acid lime growing under *Alfisols* of Andhra Pradesh.

2. MATERIALS AND METHODS

2.1 Study Site

The experiment was carried out during 2012-2018 at the Citrus Research Station, Petlur, Dr. YSR Horticultural University, Andhra Pradesh, India (13°954' N, 79°617' E, 60 m above mean sea level). The research conducted on four years old, well managed, uniform statured acid lime trees cv. CRS-1 spaced at 6 x 6 m in both the way. The treatments were imposed on four years old, five trees of similar age, size, height and vigour for each treatment were selected and each tree was tagged according to the treatment. The climate of the region is sub-tropical with hot-humid summers and mild winters. The mean annual rainfall is 1,050 mm, out of which 60% is normally received from the south-west monsoons and 40% received from north-east monsoons. The soil was sandy clay loam in texture (64.8 % sand, 24.8 % clay and 10.4 % silt), mildly alkaline to moderately alkaline in reaction (pH 7.89), non-saline, moderately calcareous, low in organic carbon (0.47%) and available N (168.80 kg ha^{-1}); high in available P (26.05 kg ha^{-1}) and available K (287.50 kg ha^{-1}). The soil characters of the study area mentioned in the table-1.

Table1: Soil characteristics of the study site

Soil Property	Parameter value	Rating
pH	7.89	Mildly alkaline
EC (dSm^{-1})	0.27	Non-saline
$CaCO_3$ (%)	5.14	Moderately calcareous
Organic carbon (%)	0.47	Low
Available N (kg ha^{-1})	168.80	Low
Available P_2O_5 (kg ha^{-1})	26.05	High
Available K_2O (kg ha^{-1})	287.50	High
Cu (mg kg^{-1})	0.36	Medium
Mn (mg kg^{-1})	2.15	Medium
Fe (mg kg^{-1})	3.82	Low
Zn (mg kg^{-1})	0.96	Low
B (mg kg^{-1})	0.24	Low

2.2 Experimental Details and Fertilizer Application

The experiment was laid out in a randomized block design with eight treatments; the treatment details are as follows:

T_1 : Recommended dose of fertilizer (RDF)

T_2 : RDF + Fe @ 0.5%
T_3 : RDF + Zn @ 0.5%
T_4 : RDF + B @ 0.1%
T_5 : RDF + Fe + Zn
T_6 : RDF + Fe + B
T_7 : RDF + Zn + B
T_8 : RDF + Fe + Zn + B

} + Mg @ 0.2%

Time of foliar spray: 1st at the time of before flowering, 2nd at the time of late bloom stage, and 3rd at the time of berry sized fruit.

All the plants selected were subjected to uniform application of cultural practices like weeding, irrigation, manures, fertilizers and phytosanitary measures for pest and disease control. The treatments are replicated thrice and all the treatments received recommended doses of NPK fertilizer *i.e*. 250:375:250 gram per plant.

2.2.1 Source of the Mg and micronutrients:

The source of magnesium (Mg) is magnesium sulphate ($MgSO_4$) having 20% Mg and micronutrients source for Boron (B) as boric acid (H_3BO_3) containing 17% B, Zinc (Zn) as zinc sulphate ($ZnSO_4.7H_2O$) containing 21% Zn and Iron (Fe) as ferrous sulphate ($FeSO_4.7H_2O$) containing 19% Fe applied three times (during before flowering, late bloom stage and berry sized fruit) according to the treatment combinations to the respective acid plants in all the experimental years.

2.3 Observations and Data Collection

Observations on growth, fruit yield and quality indicators of acid lime such as plant height, stem girth, tree volume and fruit yield, fruit weight, diameter, juice percentage, ascorbic acid content, TSS and acidity were recorded. To determine fruit morphological characteristics like fruit size (length and diameter), fruit weight and fruit volume, twenty fruits were selected randomly from each tree replication. Leaf N, P, K and Mg content was estimated by the methods as described by [11]. Leaf B content was determined by Azomethine-H colorimetric method [12], whereas estimation of leaf Fe and Zn were done through tri-acid mixture (HNO_3:H_2SO_4:$HClO_4$ @ 9:1:4) digestion [13].

The total Soluble Solid Concentrate (TSS) was estimated using digital refractometer and was expressed as ^oBrix. The total titratable acidity (TA) was determined by volumetric

procedure [13]. Ascorbic acid content of the acid lime fruit was estimated by using 2, 6-dichlorophenolindophenol dye titration method [13].

2.4 Statistical Analysis

Statistical analysis was performed by the analysis of variance (ANOVA) for randomized 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 [14].

3. RESULTS AND DISCUSSION

3.1 Growth and yield attributes acid lime

The maximum number of total fruits per tree (618.33) was obtained from trees treated with Fe, Zn, B and Mg (T8) with an increment of 22.10% over control. Present findings showed that irrespective of micronutrient fertilization, fruit yield was significantly improved compared to control (Table 2). The highest fruit yield (22.60 kg per tree) was obtained with foliar application of Fe, Zn, B and Mg (T8) which was 33.27% higher than control (T1). Saurav *et al*. [15] found similar results with the foliar application of micronutrients like B, Zn and Cu in different forms for improvement of fruit retention and yield in acid lime. The increased fruit set, retention and yield in acid lime trees as the result of foliar spray of boron may be explained by the beneficial role of boron in pollen grain germination, pollen tube development and fruit set [16] while zinc has been reported to play an important role in flower bud formation and fruit drop reduction by synthesis of tryptophan and regulate the translocation of metabolites to the site of bud development [17].

Table 2. Effect of micronutrients on growth and yield of acid lime

Treatments		Plant height (m)	Stem girth (cm)	Tree volume (m^3)	No. of Fruits per plant	Yield (Kg per plant)
T1	Recommended dose of fertilizer (RDF)	3.80	40.00	35.19	481.67	15.67
T2	RDF + Fe @ 0.5%+ Mg @ 0.2%	4.10	42.53	41.87	527.33	18.57
T3	RDF + Zn @ 0.5%+ Mg @ 0.2%	3.90	46.67	39.59	521.67	18.00

T4	RDF + B @ 0.1%+ Mg @ 0.2%	4.07	45.00	35.72	519.00	16.22
T5	RDF + Fe + Zn + Mg @ 0.2%	4.03	41.67	41.67	545.00	21.33
T6	RDF + Fe + B + Mg @ 0.2%	4.07	48.33	37.39	602.33	18.94
T7	RDF + Zn + B + Mg @ 0.2%	3.97	46.33	41.67	570.00	20.33
T8	RDF + Fe + Zn + B+ Mg @ 0.2%	4.17	49.00	51.03	618.33	22.60
S.Em.±		0.15	0.59	0.57	2.01	0.35
C.D. at 5 %		NS	1.82	1.75	6.16	1.08
C.V. %		6.24	2.29	2.45	0.63	3.24

3.2 Leaf nutrient content

The macronutrient (N, P and K) content in acid lime leaf was significantly altered with different foliar micronutrient fertilization (Table 3). The highest N, P, K and Mg contents were found in plants treated with combined application of Fe, Zn, B and Mg, *i.e*. T8 than other treatments. The percent change of N, P, K and Mg over the control was 27.27%, 50.00%, 44.23% and 47.50%, respectively. The highest iron, zinc and boron concentration (77.56, 28.50 and 27.50 mg kg^{-1}, respectively) in acid lime leaf was recorded from the trees fertilized with Fe, Zn, B and Mg, which was 24.43%, 56.45% and 51.23%, Fe, Zn and B respectively higher than control. Higher uptake of leaf nutrients in acid lime as influenced by micronutrient fertilization has also been reported by [18 and 19]. Application of micronutrients might have altered the physiological processes of the leaves which led to rapid absorption and utilization of nutrients for primary metabolic processes [20]. The possible causes of higher N concentration in acid lime leaf with foliar application of boron might be the significant role of the micronutrient in synthesis of amino acids and proteins [21]. Increased K concentration in leaf tissue treated with B may be due to synergistic relationship between K and B at sugar and carbohydrate transport.

Table 3. Leaf nutrient composition in the different treatments of the experiment

Treatments		N (%)		P (%)		K (%)		Mg (%)		Fe mg kg^{-1}		Zn mg kg^{-1}		B mg kg^{-1}	
		Before foliar spray	After foliar spray	Before foliar spray	After foliar spray	Before foliar spray	After foliar spray	Before foliar spray	After foliar spray	Before foliar spray	After foliar spray	Before foliar spray	After foliar spray	Before foliar spray	After foliar spray
T1	Recommended dose of fertilizer (RDF)	0.91	1.33	0.10	0.09	2.04	2.11	0.10	0.21	23.75	58.61	6.70	12.41	8.51	13.41
T2	RDF + Fe @ 0.5%+ Mg @ 0.2%	1.08	1.35	0.11	0.10	2.33	2.26	0.12	0.23	31.55	69.66	8.06	14.49	9.12	14.49
T3	RDF + Zn @ 0.5%+ Mg @ 0.2%	1.07	1.62	0.08	0.11	1.95	2.01	0.15	0.25	35.43	72.31	9.12	23.66	9.66	15.66
T4	RDF + B @ 0.1%+ Mg @ 0.2%	1.09	1.29	0.12	0.14	1.68	1.72	0.17	0.24	33.98	63.69	10.86	21.01	10.01	22.01
T5	RDF + Fe + Zn + Mg @ 0.2%	1.12	1.77	0.10	0.09	1.47	1.54	0.19	0.28	29.11	71.51	11.26	29.63	11.13	19.63
T6	RDF + Fe + B + Mg @ 0.2%	1.04	1.54	0.09	0.11	1.61	1.45	0.25	0.31	35.85	76.34	12.04	20.83	10.23	25.83
T7	RDF + Zn + B + Mg @ 0.2%	1.15	1.49	0.10	0.06	1.55	2.12	0.22	0.29	72.31	60.45	10.35	22.75	11.00	22.75
T8	RDF + Fe + Zn + B+ Mg @ 0.2%	1.20	1.84	0.10	0.12	2.45	2.60	0.27	0.40	29.34	77.56	11.48	28.50	11.15	27.50
S.Em.±		0.056	0.014	0.01	0.006	0.017	0.031	0.025	0.012	1.713	0.64	0.900	0.433	0.73	0.96
C.D. at 5 %		NS	0.042	NS	0.018	0.050	0.094	NS	0.036	5.196	1.969	NS	1.313	NS	1.52
C.V. %		8.91	1.55	16.7	10.1	1.53	2.71	8.18	2.71	3.81	0.99	8.05	2.51		

3.3 Fruit physical and biochemical properties

The results presented in Table 4 indicate that fruit weight of acid lime was significantly improved with the application of foliar micronutrients and Mg, and highest fruit weight (62.55 g) was obtained from the plants that received Fe, Zn, B and Mg, *i.e.* T8. As fruit diameter significantly altered by foliar micronutrient fertilization combined with Mg (T8) recorded highest fruit diameter (53.7 mm) which was significantly higher over the all treatments. An increase in the fruit weight and volume on account of various micronutrient sprays was also recorded by [23 and 24] in acid lime crop. Zinc has reported to act as the principal component in biosynthesis of tryptophan which promote the synthesis of auxin responsible for overall plant growth [25] and directly associated with improvement of fresh weight of fruits [26] in citrus. Boron also plays an important role in regulating cell division, sugar metabolism and accumulation of carbohydrates [27].

Micronutrient fertilization exerted positive impact on most of the fruit biochemical quality parameters by increasing juice percentage, vitamin-C and TSS content of fruit (Table 4). Fruit harvested from the trees receiving Fe, Zn, B and Mg, *i.e*. T8 recorded maximum juice percent, vitamin-C and TSS *i.e*., 48.61%, 34.92 mg and 7.86%, respectively over other treatments. However, the acidity was recorded in decreasing trend. Increase in TSS 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 [31& 32]. The same foliar micronutrient treatment significantly lowered titratable acidity (6.71%) as compared to control. Ruffner *et al*. [33] 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. In harmony to the present findings, [34 and 35] reported such beneficial effect of micronutrient in increasing the ascorbic acid content in acid lime. It is in agreement with the findings [36] in acid lime where they found the highest amount of ascorbic acid content from the fruits treated with B and Zn treatment in combination.

Table 4. Fruit quality parameters in the different treatments of the experiment

Treatments		Fruit weight (gm)	Fruit diameter (mm)	Juice (%)	Vit-C (mg $100\ ml^{-1}$)	TSS (%)	Acidity (%)
T1	Recommended dose of	48.57	41.4	37.17	30.18	6.69	7.45

	fertilizer (RDF)						
T2	RDF + Fe @ 0.5%+ Mg @ 0.2%	50.23	43.6	38.95	30.37	7.04	7.16
T3	RDF + Zn @ 0.5%+ Mg @ 0.2%	50.78	44.1	38.82	30.44	7.65	7.08
T4	RDF + B @ 0.1%+ Mg @ 0.2%	49.47	43.8	39.37	30.21	6.93	7.38
T5	RDF + Fe + Zn + Mg @ 0.2%	52.82	44.6	40.74	31.22	7.82	7.02
T6	RDF + Fe + B + Mg @ 0.2%	50.64	43.8	39.07	33.18	7.84	6.83
T7	RDF + Zn + B + Mg @ 0.2%	57.59	47.4	43.85	32.54	7.79	7.06
T8	RDF + Fe + Zn + B+ Mg @ 0.2%	62.55	53.7	48.61	34.92	7.86	6.71
S.Em.±		0.322	0.51	0.86	0.46	0.07	0.06
C.D. at 5 %		0.978	1.56	2.63	1.41	0.21	0.18
C.V. %		1.14	1.95	3.64	2.52	1.57	1.44

4. CONCLUSION

In the present study, combined application of RDF, Mg, Fe, Zn and B performed good for all parameters, however, the best outcome in respect of fruit yield and related attributes and quality of acid lime plant was obtained through applying combination of RDF + Fe (0.5%) + Zn (0.5%) + B (0.1%) + Mg @ 0.2%. So, from this study, it is worth concluding that the combined application of Mg, Fe, Zn and B at right dose and time is a profitable option for acid lime cultivation under *Alfisols* of Andhra Pradesh.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

REFERENCES

1.NHB. Online statistical database of National Horticultural Board, Ministry of Agriculture, Govt. of India. http://www.Indiastat.com. 2022.

2.Qi Y. Liu H, Agar OT, Imran A, de Souza TSP, Barrow C, Suleria HA. Phytochemicals in finger lime and their potential health benefits: A review. Food Reviews International. 2024;40(8):2167-2187.

3. Kumar R, Tiwari R, Kumawat BR. Quantitative and qualitative enhancement in guava *(Psidium guajava* L.) cv. Chittidar through foliar feeding. International Journal of Agricultural Sciences,2013; 9 (1): 177-181.

4. Sharma G, Sharma OC, Thakur BS. Systematics of fruit crops, New India Publishing Agency, New Delhi. 2009, pp. 123-256.

5. Zia MH, Ahmad R, Khalig I, Irshad M. Micronutrients status and management in orchards: Applied aspects. Soil and Environment, 2006; 25: 6-16.

6. Das DK. Micronutrients: Their behaviours in soils and plants. Kalyani Publisher, Ludhiana, 2003; pp. 1-2.

7. Singh PN, Chhonkar VS. Effect of zinc, boron and molybdenum as foliar spray on chemical composition of citrus fruit. Punjab Horticulture Journal, 1983; 23 (1-2): 34-37.

8. Fernandez V, Sotiropoulos T, Brown PH. Foliar Fertilization. In: Scientific Principles and Field Practices. International Fertilizer Industry Association, 2013.

9. Stiles WC. Nutrient sprays for tree fruits. Fruit Notes, 1982; 47: 6-10.

10. Nornal R. Formula for determination of chlorophyllous Pigments extracted with N -Dimethyleformamide. Plant Physiology, 1982; 69; 1371-1381.

11. Jackson ML. Soil chemical analysis. Prentice Hall of India Pvt. Ltd, New Delhi, India, 1973.

12. Gaines TP, Mitchell GA. Boron determination in plant tissue by the azomethine H method. Communications in Soil Science and Plant Analysis, 1979; 10: 1099-1108.

13. AOAC: Official methods of Analysis. 17th ed. Association of Official Analytical Chemist, Arlington, VA, 2000.

14. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. John Wiley & Sons. Inc., New York. 1984.

15. Saurav B, Saurav N, Dipika S, Arjun Kumar S. Effect of foliar application of micronutrients on growth, fruit retention and yield parameters of acid lime (*Citrus aurantifolia* Swingle), Cogent Food & Agriculture, 2022; 8:1, 2-15.

16. Ganie MA, Akhter F, Bhat MA, Malik AR, Junaid JM, Shah MA. Boron - a critical nutrient element for plant growth and productivity with reference to temperate fruits. Current Science, 2013; 104: 76-85.

17. Day K. Correcting zinc deficiency in stone fruit orchard. California Grower, 1994; 18:14-15.

18. Lal G, Sen NL. Flowering and fruiting of guava *(Psidium guajava* L.) cv. Allahabad safeda as influenced by application of nitrogen, zinc and manganese. Journal of Eco-Physiology, 2002; 5(3-4): 87-91.

19. Prakash, Singh NP, Sankaran M. Influence of nitrogen, Zn and B on leaf nutrient composition and yield of guava cv. L49 *(Psidium guajava* L.). Environment Ecology, 2006; 24 (4): 1158-1160.

20. Ghumare VS, Padhiar BV, Dilip K, Babita K. Study of micronutrient sprays on physiological parameters and leaf nutrient status of sapota cv. Kalipatti. Asian Journal of Horticulture, 2013; 8: 612-615.

21. El-Dissoky RA, Abdel Kadar AES. Effect of boron as a foliar application on some potatoes cultivars under Egyptian alluvial soil conditions. Research Journal of Agriculture and Biological Sciences, 2013; 9:232-240.

22. Shitole SM, Dhumal KN. Influence of foliar applications of micronutrients on photosynthetic pigments and organic constituents of medicinal plant *Cassia angustifolia* Vahl. Annals of Biological Research, 2012; 3: 520-526.

23. Manivannan MI, Irulandi S, Thingalmaniyan KS. Studies on the effect of preharvest application of plant growth regulators and chemicals on yield and quality of guava *(Psidium guajava* L.) cv. L.49. International Journal of Agricultural Sciences, 2015; 11 (1):138-140.

24. Rajkumar, Tiwari JP, Lal S. Influence of zinc sulphate and boric acid spray on vegetative growth and yield of winter season guava *(Psidium guajava* L.) cv. Pant Prabhat. Pantnagar Journal of Research, 2010; 8 (1): 135-138.

25. Kumar J, Kumar R, Rai R, Mishra DS, Singh SK, Nimbolkar PK. Influence of foliar application of Mineral Nutrients at different Growth Stages of Guava. Journal of Plant Nutrition, 2016; 40: 656-661.

26. Sourour MM. Effect of foliar application of some micronutrient forms on growth, yield, fruit quality and leaf mineral composition of Valencia orange trees grown in North Sinai, Alexandria. Journal of Agricultural Research, 2000; 45 (1): 269-285.

27. Shivanandam VN, Pradeep SL, Rajanna KM, Shivappa. Effect of zinc sulphate on growth and yield of mango varieties and hybrids. J. Soils and Crops, 2007; 17: 225-259.

28. Bhatia SK, Yadav S, Ahlawat VP, Dahiya SS. Effect of foliar application of nutrients on the yield and fruit quality of winter season guava cv. L49. Haryana Journal of Horticulture Science, 2001; 30: 6-7.

29. Kumar J, Kumar R, Rai R, Mishra DS. Response of 'pant prabhat' guava trees to foliar sprays of zinc, boron, calcium and potassium at different plant growth stages. The Bioscan, 2015; 10 (2): 495-498.

30. Srinivas M, Prasad VM, Baradwaj K, Ajmeera V, Ravulapenta S, Veerendra AC. Effect of different sources of organic and inorganic plant nutrients on fruit growth, yield and quality of guava *(Psidium guajava* L.) cv. Allahabad Safeda. Environment and Ecology, 2015; 33(1): 126-130.

31. Goswami AK, Shukla HS, Mishra DS. Influence of preharvest nutrients application on the physicochemical quality and storage behaviour of guava *(Psidium guajava* L.) fruit cv. L49. Progressive Horticulture, 2014; 46 (1): 54-57.

32. Kundu S, Mitra SK. Response of guava to foliar spray of copper, boron and zinc. IndianAgriculturist, 1999; 43(1-2): 49-54.

33. Ruffner HP, Hoblet W, Rast D. Gluconeogenesis in the ripening berries of *Vitis vinifera.*Phytochemistry, 1975; 13: 314-328.

34. Dutta P, Banik AK. Effect of foliar feeding of nutrients and plant growth regulators on physico-chemical quality of Sardar guava grown in West Bengal. Acta Horticulturae, 2007; 335: 407-411.

35. Dilip, M. W. S. (2024). Effect of micronutrients on growth, yield and fruit quality of acid lime (*Citrus aurantifolia* Swingle) CV. Sai Sharbati (Doctoral Dissertation, MAHATMA PHULE KRISHI VIDYAPEETH.

36. Bastakoti S, Nepal S, Sharma D, Shrestha AK. Effect of foliar application of micronutrients on growth, fruit retention and yield parameters of acid lime

(*Citrus aurantifolia* Swingle). Cogent Food nad Agriculture. 2022;8(1): 211-242.