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Influence of micronutrients on quality of acid lime (*Citrus aurantifolia* Swingle) cv. Kagzi Lime

DM Dabhi, MV Patel and TD Gurjar

Abstract
The present research work entitled "Influence of micronutrients on quality of acid lime (*citrus aurantifolia* Swingle) cv. Kagzi lime" was carried out during *ambe bahar* 2019 at the Horticultural Instructional Farm, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, District: Banaskantha, Gujarat. Experiment was laid out in Randomized Block Design with three replications. Total fifteen treatments were evaluated with respect to quality parameters of acid lime. Among various treatments, treatment $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + Borax 0.2% (T_8) was significantly superior over rest of treatments with respect to quality. Results revealed that maximum juice (55.14%), total soluble solids (9.69 ^{0}Brix), reducing sugar (0.82%), total sugar (1.34%), ascorbic acid (31.03 mg/100 ml juice) and minimum acidity (6.29%) were observed under treatment $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + Borax 0.2% (T_8) compared to other treatments and control.

Keywords: Micronutrients, juice, total soluble solids, reducing sugar, total sugar, ascorbic acid, acidity, acid lime

Introduction
Acid Lime *(Citrus aurantifolia* Swingle), belongs to the family Rutaceae. Citrus is the third largest fruit crop grown in India next to mango and banana. It is generally grown under both tropical and subtropical climatic conditions. The main acid lime growing districts in Gujarat are Ahmedabad, Kheda, Mehsana, Bhavnager, Gandhinagar and Junagadh. It is a rich source of vitamin C and has good antioxidant properties. Fruits being acidic in nature, they are largely used for garnishing and flavoring several vegetarian and non-vegetarian dishes. Besides its value-added products like pickle, juice, squash *etc.*, lime peel oil, peel powder etc. are also in great demand in soap and cosmetic industry (Debaje *et al*. 2011) [7].

Foliar feeding of micronutrients has become a commercial practice in citrus in many countries. Rapid fixation of nutrient elements in the soil is major problem; therefore, use of foliar spray of micronutrients is practically use for nutrient availability. Due to slow response of micronutrient application in soil, their addition as a spray on the foliage offers a practical device for avoiding their deficiency and resultant crop losses before the deficiency symptom actually set in or give a clue of their emergence.

Zinc is required to obtain good fruit set and size. Its role in flowering is due to synthesis of tryptophan which is a precursor of auxin and promotes flowering. It also helps in the process of translocation of metabolites to the bud itself or to the site of bud development. Its deficiency produces small and narrow leaves, shorter shoot internodes and terminal dieback (Ryugo, 1988) [21]. Iron is required for the synthesis of enzymes responsible for chlorophyll synthesis. Iron deficiency is expressed as yellow leaves due to low levels of chlorophyll (chlorosis), which first appears on the younger upper leaves in interveinal tissues. Severe iron deficiency may cause leaves to turn completely yellow or almost white and then brown as leaves die (Pandey and Sinha, 2006) [17].

Boron is important element for flowering, fruiting, growth and quality of fruits. Boron also increase the chlorophyll content of leaves and play an important role in enzymatic activities. Foliar application of boron (B) improves tree growth, productivity and fruit quality in citrus. Deficiency of boron in citrus has serious consequences for tree health and crop production and also leads to low sugar content, granulation and excessive fruit abortion as well as rind thickness, symptoms that are seen regularly in fruit grown. So it has to be need of foliar application of boron for its role in the yield and fruit quality of citrus (Prasad *et al*. 2013) [19].

Effective use of micronutrients in acid lime is one such research gap. Micronutrients can tremendously boost up acid lime flowering and fruiting quality.

The problem of micronutrients deficiency in acid lime causes great concern to fruit growers and also flower drop as well as fruit drop major problem.

Material and Method

Experiment was carried out during *Ambe bahar* of the year 2019 under field condition at the Horticultural Instructional Farm, C. P. College of Agriculture, Department of Horticulture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Dist. Banaskantha, Gujarat. The investigation was conducted on 15 years old plants of acid lime cultivar "Kagzi Lime". All the plants selected were uniform in growth and size which planted at the distance of 6m × 6 m and were subjected to uniform application of cultural practices like weeding, irrigation, manures, fertilizers and plant protection measures etc.

Experiment was laid out in randomized block design with three replications. Total fifteen treatments were evaluated in the present study *viz*., T_1: Control; T_2: $ZnSO_4$ 0.5%; T_3: $ZnSO_4$ 1%; T_4: $FeSO_4$ 0.5%; T_5: $FeSO_4$ 1%; T_6: Borax 0.2%; T_7: Borax 0.4%; T_8: $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + Borax 0.2%; T_9: $ZnSO_4$ 0.5% + $FeSO_4$ 1% + Borax 0.2%; T_{10}: $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + Borax 0.4%; T_{11}: $ZnSO_4$ 0.5% + $FeSO_4$ 1% + Borax 0.4%; T_{12}: $ZnSO_4$ 1% + $FeSO_4$ 0.5% + Borax 0.2%; T_{13}: $ZnSO_4$ 1% + $FeSO_4$ 1% + Borax 0.2%; T_{14}: $ZnSO_4$ 1% + $FeSO_4$ 0.5% + Borax 0.4%; T_{15}: $ZnSO_4$ 1% + $FeSO_4$ 1% + Borax 0.4%.

Result and Discussion

Juice (%)

A perusal of data presented in Table 1 and graphically illustrated in Fig. 1. The maximum juice (55.14%), was observed with treatment T_8 ($ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + Borax 0.2%) which was statistically at par with treatment T_9. Whereas, the minimum juice (39.10%), was recorded with the treatment T_1 (control). The increased in juice content might be due to the micronutrients enhanced the mobilization and accumulation of foods and minerals from other parts of the plants towards the developing fruits which increased source to sink ratio resulted in the increased juice content of the fruits. The above results were confirmed by the findings of Tariq *et al.* (2007) [26] and Sajid *et al.* (2012) [23] in sweet orange, Khan *et al.* (2012) [12] in feutrell's early, Meena *et al.* (2016) [13] in Nagpur mandarin and Al-Obeed *et al.* (2017) [2] in kinnow mandarin.

Total soluble solids (^{0}Brix)

The data related to effect of micronutrients on total soluble solids are presented in Table 1 was found significant. The maximum total soluble solids (9.69 ^{0}Brix), was observed with treatment T_8 ($ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + Borax 0.2%) which was statistically at par with treatment T_9 and T_{10}. Whereas, the minimum total soluble solids (7.64 ^{0}Brix), was recorded with the treatment T_1 (control).

The increase in TSS of fruit by the influence of zinc might be due to the hydrolysis of complex polysaccharides in to simple sugar, synthesis of metabolites and rapid translocation of photosynthesis product and minerals from other parts of plants to developing fruits. Similarly, increase in TSS of fruit by the influence of boron may probably due to the increased mobilization of sugars. Ferrous is a catalyst to chlorophyll formation and acts as an oxygen carrier helps from certain respiratory systems. This observation is in agreement with the observations recorded by Venu *et al.* (2016) [28] in acid lime, Ilyas *et al.* (2015) [8] and Al-Obeed *et al.* (2017) [2] in kinnow mandarin, Rawat *et al.* (2010) [20], Arshad and Ali (2016) [4] and Bhoyar and Ramdevputra (2017) [6] in guava, Anees *et al.* (2011) [3] in mango and Jangid *et al.* (2018) [9] in aonla.

Reducing sugar (%)

The results on reducing sugar influenced by different micronutrients are presented in Table 1. The maximum reducing sugar (0.81%) was observed with treatment T_8 ($ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + Borax 0.2%) which was statistically at par with treatment T_9, T_{10}, T_{11}, T_{12} and T_{13}. Whereas, the minimum reducing sugar (0.68%) was recorded with the treatment T_1 (control).

The increase in reducing sugar fraction by the foliar feeding of zinc, boron and iron might be due to their involvement in photosynthesis of metabolites and rapid translocation of sugars from other part of the plants to developing fruits (Singh *et al*., 2012) [24]. This result corroborate the findings of Venu *et al.* (2016) [28] in acid lime, Tariq *et al.* (2007) [26] in sweet orange, Meena *et al.* (2016) [13] in Nagpur mandarin, Bhowmick *et al.* (2011) [5] in mango, Ningavva *et al.* (2014) [16] in banana and Abhijith *et al.* (2018) [1] and Jangid *et al.* (2018) [9] in aonla.

Total sugar (%)

The data pertaining to effect of micronutrients on total sugar are presented in Table 1 was found significant. The maximum total sugar (1.34%) was observed with treatment T_8 ($ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + Borax 0.2%) which was statistically at par with treatment T_9, T_{10}, T_{11}, T_{12} and T_{13}. Whereas, the minimum total sugar (1.11%) was recorded with the treatment T_1 (control). These might be due to an association of zinc with synthesis of auxins in plants played a vital role along with the increase in enzymatic activities. It also acts as a catalyst in oxidation-reduction processes in plants. Fe is associated with the development flavo-proteins. Besides, Zn 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. The present study is supported by the findings of Venu *et al.* (2016) [28] in acid lime, Khan *et al.* (2012) [12] in feutrell's early, Sajid *et al.* (2012) [23] in sweet orange, Nehete *et al.* (2011) [15] in mango, Jat and Kacha (2014) [10] and Bhoyar and Ramdevputra (2017) [6] in guava and Abhijith *et al.* (2018) [1] in aonla.

Ascorbic acid (mg/100 ml juice)

Appraisal of data presented in Table 1 and graphically presented in Fig. 2 that was found significantly the maximum ascorbic acid (31.03 mg/100 ml juice) was observed with treatment T_8 ($ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + Borax 0.2%) which was statistically at par with treatment T_9, T_{10}, T_{11}, T_{12}, T_{13} and T_{14}. Whereas, the minimum ascorbic acid (24.41 mg/100 ml juice) was recorded with the treatment T_1 (control).

The higher ascorbic acid content was due to the increased in total sugar content owing to the efficient translocation of available photosynthates to fruit pulp rather than to other parts (Singh and Rajput, 1976) [25]. Similar trend was also observed by Venu *et al.* (2016) [28] in acid lime, Al-Obeed *et al.* (2017) [2] in kinnow mandarin, Patel *et al.* (2010) [18] in banana, Modi *et al.* (2012) [14] in papaya, Arshad and Ali (2016) [4] in guava and Jangid *et al.* (2018) [9] in aonla.

Acidity (%)

The data regarding to effect of micronutrients on acidity are presented in Table 1 was found significant. The minimum acidity (6.29%) was observed with treatment T_8 ($ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + Borax 0.2%) which was statistically at par with treatment T_9, T_{10}, T_{11}, T_{12} and T_{13}. Whereas, the maximum acidity (7.78%) was recorded with the treatment T_1 (control).

These might be due to either speedily converted into sugars and their derivatives by reactions involving reverse glycolytic pathways or might have been used in respiration or both. These results are in close conformity with the findings of Venu *et al.* (2016) [28] in acid lime, Jeyabaskaran and Pandey (2008) [11] in banana, Trivedi *et al.* (2012) [27] and Bhoyar and Ramdevputra (2017) [6] in guava, Ilyas *et al.* (2015) [8], Al-Obeed *et al.* (2017) [2] in kinnow mandarin and Jangid *et al.* (2018) [9] in aonla.

Table 1: Influence of micronutrients on quality parameters (cm)

Code	Treatment	Juice (%)	Total soluble solids (⁰Brix)	Reducing sugar (%)	Total sugar (%)	Ascorbic acid (mg/100 ml juice)	Acidity (%)
T_1	Control	39.10	7.64	0.68	1.11	24.41	7.78
T_2	$ZnSO_4$ 0.5%	45.19	8.32	0.73	1.20	26.85	7.19
T_3	$ZnSO_4$ 1%	42.87	8.03	0.71	1.16	26.23	7.46
T_4	$FeSO_4$ 0.5%	43.81	8.30	0.73	1.19	26.78	7.22
T_5	$FeSO_4$ 1%	42.13	7.96	0.70	1.15	25.67	7.49
T_6	Borax 0.2%	43.53	8.24	0.71	1.18	26.52	7.31
T_7	Borax 0.4%	40.79	7.74	0.69	1.14	25.46	7.65
T_8	$ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + Borax 0.2%	55.14	9.69	0.81	1.34	31.03	6.29
T_9	$ZnSO_4$ 0.5% + $FeSO_4$ 1% + Borax 0.2%	53.28	9.43	0.79	1.32	30.95	6.42
T_{10}	$ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + Borax 0.4%	51.98	9.22	0.78	1.31	30.26	6.56
T_{11}	$ZnSO_4$ 0.5% + $FeSO_4$ 1% + Borax 0.4%	50.38	9.02	0.78	1.28	30.12	6.62
T_{12}	$ZnSO_4$ 1% + $FeSO_4$ 0.5% + Borax 0.2%	49.76	8.87	0.77	1.27	29.76	6.84
T_{13}	$ZnSO_4$ 1% + $FeSO_4$ 1% + Borax 0.2%	48.97	8.77	0.76	1.26	29.49	6.96
T_{14}	$ZnSO_4$ 1% + $FeSO_4$ 0.5% + Borax 0.4%	47.49	8.58	0.75	1.24	28.97	7.03
T_{15}	$ZnSO_4$ 1% + $FeSO_4$ 1% + Borax 0.4%	46.63	8.46	0.74	1.20	27.84	7.14
	S.Em. ±	0.89	0.17	0.02	0.03	0.74	0.19
	C.D. (P = 0.05)	2.58	0.48	0.05	0.08	2.15	0.56
	C.V.%	3.30	3.35	4.09	4.05	4.59	4.73

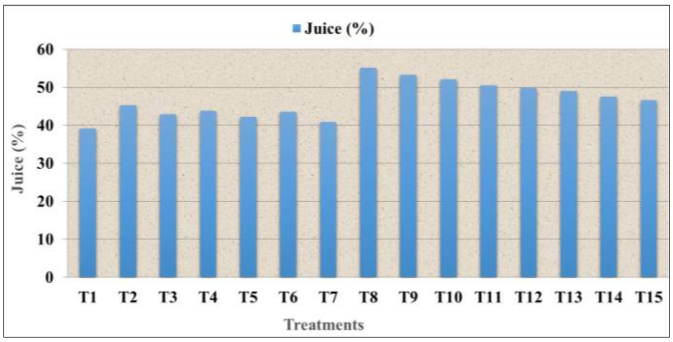

Fig 1: Influence of micronutrients on juice (%)

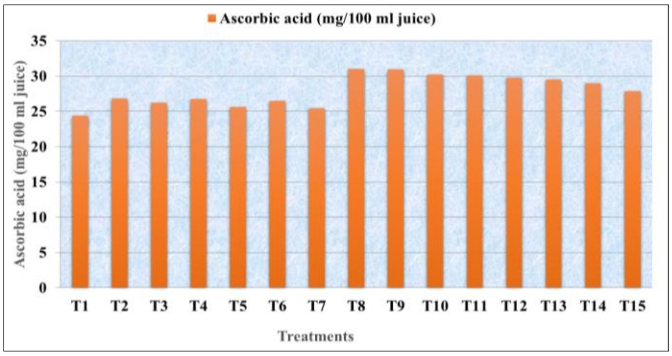

Fig 2: Influence of micronutrients on ascorbic acid (mg/100 ml juice)

Conclusion

On the basis of experimental results, the combined application of $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + Borax 0.2% was found effective and promising in increasing of juice (%), total soluble solids (⁰Brix), reducing sugar (%), total sugar (%), ascorbic acid (mg/100 ml juice) and acidity (%) in Acid Lime (*Citrus aurantifolia* Swingle) cv. Kagzi Lime.

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