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Effect of Micronutrients on Yield of Acid Lime (*Citrus aurantifolia* Swingle) cv. Kagzi Lime

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was carried out during *Ambe bahar* 2019 at Horticultural Instructional Farm, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, District: Banaskantha, Gujarat. The present experiment consist fifteen treatments with three replications which was laid out in a Randomized Block Design. The findings of the present studies indicated that the treatment $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + Borax 0.2% (T_8) was significantly superior with respect to yield over rest of the other treatments. Further, results revealed that the maximum fruit diameter (4.58 cm), average fruit weight (44.06 g), fruit volume (43.83 cc), number of fruit per tree (946), fruit yield (41.68 kg per tree) and total fruit yield (115.46 quintal per hectare) were recorded with treatment $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + Borax 0.2% (T_8) as compared to other treatments.

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1. 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. Commercially sweet orange, mandarin and acid lime are grown in different agro climatic regions. Citrus species fruits like oranges, limes, lemons, *etc.* have been under cultivation in India since time immemorial. Most of the citrus species are believed to have originated on slopes of Northern Himalayas and adjoining Myanmar and disseminated to other parts of world in due course. The South Eastern Asia has been considered as 'natural home' of lemon. It is also called as Kagzi Lime in the Northern India. The word Kagzi being derived from the word kagaj meaning paper, as the rind of the fruit is very thin.

It is a rich source of vitamin C and has good antioxidant properties. Fruit 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 [1].

It is cultivated in almost all the states in India, mainly in Andhra Pradesh, Gujarat, Maharashtra, Karnataka, Bihar, Madhya Pradesh, Assam and Chhattisgarh. In the world citrus is dominated by sweet orange with a 71% contribution followed by mandarins with 13% contribution, limes and lemons 10% and the rest of the 7% is contributed by grape fruit and others. The area under acid lime in India is 327 thousand hectares with production of 3,548 thousand MT [2]. In Gujarat, citrus is cultivated in 48,503 hectares with production of 6,25,833 MT [3].

The improvement in plant growth and development could be due to the involvement of micronutrients in the synthesis of many compounds which are essential for plant growth and development and also act as an activator for many enzymes [4]. It is essential for the formation of chlorophyll and function of normal photosynthesis [5].

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 [6]. Iron plays an important role in the activation of chlorophyll and in the synthesis of many proteins such as different cytochrome, which participate in different functions in the plant metabolism 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 [7].

Boron is important element for flowering, fruiting, growth and quality of fruit. 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 [8].

Effective use of micronutrients like zinc, iron and boron 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.

2. MATERIALS AND METHODS

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 6 m × 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 a 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: $ZnSO_4$ 1.0%; T_4: $FeSO_4$ 0.5%; T_5: $FeSO_4$ 1.0%; 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% + $FeSO_4$ 1.0% + Borax 0.2%; T_{10}: $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + Borax 0.4%; T_{11}: $ZnSO_4$ 0.5% + $FeSO_4$ 1.0% + Borax 0.4%; T_{12}: $ZnSO_4$ 1.0% + $FeSO_4$ 0.5% + Borax 0.2%; T_{13}: $ZnSO_4$ 1.0% + $FeSO_4$ 1.0% + Borax 0.2%; T_{14}: $ZnSO_4$ 1.0% + $FeSO_4$ 0.5% + Borax 0.4%; T_{15}: $ZnSO_4$ 1.0% + $FeSO_4$ 1.0% + Borax 0.4%.

3. RESULTS AND DISCUSSION

3.1 Fruit Diameter (cm)

The data related to effect of micronutrients on fruit diameter are presented in Table 1. The maximum fruit diameter 4.58 cm 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} and T_{11}. While, minimum fruit diameter 3.50 cm was recorded with control plot (T_1).

The fruit diameter might be Increased due to the favorable effect was attributed to the fact that zinc is essential in the nitrogen metabolism [9] and it also increase the synthesis of auxin which promote the cell size [10]. The cumulative effect of combination of Zn + Fe + B on faster cell division, cell expansion and increase volume of intercellular spaces in mesocarpic cells. It could also be due to higher mobilization of food and minerals from other parts of plants towards the developing fruit that are extremely active metabolic sink. Similar results were also found by Venu et al*.* [11], Sawale et al*.* [12], Deshlehra et al*.* [13] and Rajamanickam et al*.* [14] in acid lime, Meena et al*.* [15] in Nagpur mandarin, Trivedi et al*.* [16] in guava, Razzaq et al*.* [17] in mango, Yadav et al*.* [18] in pomegranate, Meena et al*.* [15] and Ambaliya and Masu [19] in aonla.

3.2 Average Fruit Weight (g)

The data showed that the effect of micronutrients on average fruit weight is presented in Table 1. The maximum average fruit weight (44.06 g) 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}. The minimum average fruit weight (34.40 g) was recorded in treatment T_1 (control). It might be due to the zinc micronutrients application which plays a vital role to promote starch formation, iron required to suitable cell enlargement and cell division and boron actively involved in transportation of carbohydrates in plants. Thus, the cumulative effect of combined treatment of Zn + Fe + B might have resulted higher fruit weight. The possible reason for increase in fruit weight by the micronutrients might be due to faster loading and mobilization of photo assimilates to fruit and involvement in cell division and cell expansion which ultimately reflected into more weight of fruit in treated plants [20]. These findings are supported by the results obtained by Venu et al*.* [11], Sawale et al*.* [12] and Rajamanickam et al*.* [14] in acid lime, Tariq et al*.* [21] in sweet orange, Meena et al*.* [22] in Nagpur mandarin, Nehete et al*.* [23] and Razzaq et al*.* [17] in mango, Modi et al*.* [24] in papaya, Ningavva et al*.* [25] in banana, Bhoyar and Ramdevputra [26] in guava and Ambaliya and Masu [19] in aonla.

3.3 Fruit Volume (cc)

The data regarding effect of micronutrients on fruit volume are presented in Table 1. Data showed that the effect of micronutrients on fruit volume was found significant. The maximum fruit volume (43.83 cc) 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} and T_{12}. However, the minimum fruit volume (32.96 cc) was recorded in treatment T_1 (control).

These might be due to the Zn plays vital role to promote starch formation, iron required to suitable cell enlargement and cell division and B actively involved in transportation of carbon in plants. Thus, the cumulative effect of combination of Zn + Fe + B on faster cell division and cell expansion reflected on higher fruit volume. Similar results were also noted by Venu et al*.* [11], Sawale et al*.* [12], Deshlehra et al*.* [13] and Rajamanickam et al*.* [14] in acid lime, Tariq et al*.* [21] in sweet orange, Meena et al*.* [22] in Nagpur mandarin, Goswami et al*.* [27], Jat and Kacha [28] and Bhoyar and Ramdevputra [26] in guava, Yadav et al*.* [29] in pomegranate and Ambaliya and Masu [19] in aonla.

3.4 Number of Fruit Per Tree

A perusal of data presented that effect of micronutrients on number of fruit per tree was found significant. The maximum number of fruit

Table 1. Effect of micronutrients on yield parameters (cm)

Code	Treatment	Fruit diameter (cm)	Average fruit weight (g)	Fruit volume (cc)	Number of fruit per tree	Fruit yield (kg per tree)	Total fruit yield (q ha^{-1})
T_1	Control	3.50	34.40	32.96	698.83	24.04	66.59
T_2	$ZnSO_4$ 0.5%	3.87	38.93	38.46	809.17	31.50	87.25
T_3	$ZnSO_4$ 1.0%	3.72	36.89	36.42	774.67	28.58	79.16
T_4	$FeSO_4$ 0.5%	3.80	38.04	37.96	797.17	30.33	84.01
T_5	$FeSO_4$ 1.0%	3.68	36.21	35.87	758.83	27.48	76.11
T_6	Borax 0.2%	3.74	37.41	37.20	786.00	29.41	81.46
T_7	Borax 0.4%	3.61	35.90	35.28	752.83	27.03	74.86
T_8	$ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + Borax 0.2%	4.58	44.06	43.83	946.00	41.68	115.46
T_9	$ZnSO_4$ 0.5% + $FeSO_4$ 1.0% + Borax 0.2%	4.38	43.15	42.58	901.00	38.88	107.68
T_{10}	$ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + Borax 0.4%	4.32	42.79	41.96	881.67	37.72	104.49
T_{11}	$ZnSO_4$ 0.5% + $FeSO_4$ 1.0% + Borax 0.4%	4.28	42.03	41.06	868.67	36.51	101.13
T_{12}	$ZnSO_4$ 1.0% + $FeSO_4$ 0.5% + Borax 0.2%	4.18	41.45	40.87	851.67	35.30	97.79
T_{13}	$ZnSO_4$ 1.0% + $FeSO_4$ 1.0% + Borax 0.2%	4.13	41.15	40.29	847.17	34.92	96.72
T_{14}	$ZnSO_4$ 1.0% + $FeSO_4$ 0.5% + Borax 0.4%	4.08	40.43	39.25	834.00	33.72	93.40
T_{15}	$ZnSO_4$ 1.0% + $FeSO_4$ 1.0% + Borax 0.4%	3.96	39.04	38.82	821.83	32.08	88.87
	S.Em. ±	0.13	1.58	1.21	33.40	1.89	5.22
	C.D. (P = 0.05)	0.38	4.57	3.50	96.74	5.46	15.13
	C.V.%	5.69	6.93	5.38	7.04	10.01	10.01

per tree (946) 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} and T_{12}. While, minimum number of fruit per tree (698) was recorded in treatment T_1 (control).

All the micronutrients when sprayed alone or in combination involved directly in various physiological processes and enzymatic activity. This might have resulted into better photosynthesis, greater accumulation of starch in fruit and involvement of Zn in auxin synthesis and B in translocation of starch to fruit. The balance of auxin in plant regulates the fruit drop or retention in plants, which altered the control of fruit drop and increased the total number of fruit per tree. Similar findings have been observed by Venu et al. [30], Yadav et al. [18] and Deshlehra et al. [13] in acid lime, Gurjar and Rana [31] and Reetika et al. [32] in kinnow mandarin, Bhowmick et al. [33] and Gurjar et al. [34] in mango, Suman et al. [35] in guava, Dhurve et al. [36] in pomegranate and Ambaliya and Masu [19] in aonla.

3.5 Fruit Yield (Kg Per Tree)

The data pertaining to effect of micronutrients on fruit yield are presented in Table 1. The maximum fruit yield (41.68 kg per tree) 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} and T_{11}. Whereas, the minimum fruit yield (24.04 kg per tree) was recorded with the treatment T_1 (control).

An increased in fruit yield per tree might be due to cumulative effect of number of fruit, reduction in fruit drop and higher fruit weight by effect of foliar spray of micronutrients. Promotion of starch formation followed by rapid transportation of carbohydrates in plants is activated by Zn and B is well established. Iron (Fe) is highly associated with chlorophyll synthesis which later on boosted up the photosynthesis. Foliar spray of micronutrients might have affected the physiological processes resulting into higher yield. This finding is in the accordance with the result of Deshmuk et al. [37], Venu et al. [30], Yadav et al. [18] and Deshlehra et al. [13] in acid lime, Sajid et al. [38] in sweet orange, Ilyas et al. [39] in kinnow mandarin, Bhalerao and Patel [40] in papaya, Gurjar et al. [34] in mango, Suman et al. [35] in guava, Abhijith et al. [41], Ambaliya and Masu [19] and Jangid et al. [42] in aonla and Dhurve et al. [36] in pomegranate.

3.6 Total Fruit Yield (q ha^{-1})

Data regarding to total fruit yield are presented in Table 1. Data showed that effect of micronutrients on total fruit yield was found significant. The maximum total fruit yield (115.46 q ha^{-1}) 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} and T_{11}. However, the minimum total fruit yield (66.59 quintal per hectare) was recorded in treatment T_1 (control).

The increase in total fruit yield by application of micronutrient treatments may be due to the direct or indirect involvement of nutrients which provide better mobilization of nutrients and metabolites for the growth and development of fruit by increase in metabolic activities and better cellular pathways. These activities improve their size, weight and volume, number of fruit and thereby synergistically increased the total fruit yield. These results are in confirmation with those of Deshmuk et al. [37], Venu et al. [30], Yadav et al. [18], Deshlehra et al. [13] and Rajamanickam et al. [14] in acid lime, Sajid et al. [38] in sweet orange, Ilyas et al. [39] in kinnow mandarin, Gurjar et al. [34] in mango, Suman et al. [35] in guava and Abhijith et al. [41] in aonla.

4. CONCLUSION

On the basis of experimental results, it may be concluded that the combined application of $ZnSO_4$ 0.5% + $FeSO_4$ 0.5% + Borax 0.2% was found effective and promising for increasing fruit diameter, fruit volume, fruit weight, number of fruit per tree, fruit yield per tree and total fruit yield per hectare of Acid Lime (*Citrus aurantifolia* Swingle) cv. Kagzi Lime.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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