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Effect of foliar application of plant growth regulators and micronutrients on yield of acid lime (*Citrus aurantifolia* Swingle) Cv. Balaji

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Abstract
The present investigation entitled "Effect of foliar application of plant growth regulators and micronutrients on yield and quality of acid lime (*Citrus aurantifolia* Swingle) cv. Balaji" was carried out during the year 2021-2022 at farmer field, Banda Timmapur (village), konda mallepally, Nalgonda (Dist). The experiment was laid out in Randomized Block Design (RBD) with eight treatments and three replications. The results indicate that the acid lime tree sprayed with GA_3 (50 ppm) + $ZnSO_4$(0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$(0.2%) + $MnSO_4$(0.2%) + Boron(0.1%)**,** recorded maximum increase in number of flowers per shoot(18.85), fruit set (52.24%), fruit weight (45.06 g), fruit volume(52.64 ml), fruit diameter (4.11 cm), fruit length (4.24 cm), number of fruits per tree (925.00), yield per tree(41.68 kg) and minimum days required for flowering to harvesting (144.00), minimum fruit drop (38.20%).

Keywords: PGR's, micronutrients, yield, quality, acid lime

Introduction
Acid lime (*Citrus aurantifolia* Swingle) is the third-most significant fruit crop within the citrus family next to mandarin and sweet orange. It is commonly cultivated in India's tropical and subtropical regions. It belongs to the family Rutaceae and has a chromosome number (2n=18). It is a highly priced and economically remunerative fruit. Due to their distinctive flavours and medicinal properties, citrus fruits are particularly significant. It has excellent antioxidant effects and is a good source of vitamin "C". India is the world's largest producer of acid lime with an area of 3, 22, 000 Ha and a production of 35,17,000 MT (NHB 2021-22) [17]. It is largely cultivated in Andhra Pradesh, Telangana, Karnataka, Odisha, Madhya Pradesh, Maharashtra, Assam, Bihar, Chhattisgarh, Manipur, Jharkhand, Tamil Nadu, Tripura and Mizoram. The major acid lime growing districts in Telangana are Nalgonda, Suryapet, Gadwal, Mahabubnagar and Ranga Reddy. Acid lime is used to make candies, chocolate, ice cream, pastries, and 100 grams of fruit juice include 80% water, 26 IU of beta-carotene, 20 mg of vitamin A, 0.1 mg of riboflavin, 63 mg of vitamin C, 1.83 mg of iron, and 0.16 mg of copper. Because it contains oxalo-acetic acid (0.30%), malic acid, and alkaline salt (8.2%), it is important for human health. It consists of 6.3-6.6 percent citric acid. The acid lime fruits are used for making pickles and refreshing drinks as well as for manufacturing syrup and squash. It acts as an appetizer, antiscorbutic, antihelmintic and checks biliousness besides a good source of nutrients, vitamins and other antioxidant compounds (Chadha, 2002) [3]. Acid lime trees flowers three times a year in the months of January - February, June-July and September-October are known as Ambia, Mrig and Hasta bahar, respectively. The months of June–July, November–December, and April–May, respectively, see the fruits of the flowering of the Ambia, Mrig, and Hasta bahar. The flowering percentage of Ambia, Mrig and Hasta bahar arise at 47%, 36% and 17% respectively. India's citrus orchards are facing with problems pertaining to fruit size, colour, and quality, as well as an excessive amount of premature fruit drop. When used as plant growth regulators, 2,4-D is essential for preventing pre-harvest fruit drop, which eventually increases yield without affecting fruit quality. NAA promotes fruit retention, increases fruit weight, and checks pre-harvest fruit drop. It also increases fruit TSS and weight. GA_3 increases fruit weight, fruit diameter, and length, which increases yield (Shinde *et al.*, 2008) [22]. Micronutrient deficiencies (Zn, Cu, Fe, Mn, Mg, and boron) in the soil of citrus orchard also have an impact on fruit productivity, quality, and fruit drop (Ibrahim *et al.*, 2007 [11] and Ashraf *et al.*, 2012) [1].

The citrus orchards have long been noted to have severe zinc deficiencies. Zinc is crucial for fruit quality, fruit production, fruit growth, and flowering. Zinc also essential for the growth and development of fruits and enhances the chlorophyll content of leaves. As a result of iron enhancing photosynthesis and carbohydrate synthesis in the leaves, flowering, fruit set, fruit size, and fruit drop are all increased. The growth of viable seeds and pollination are both impacted by boron, which also has an impact on how fruit normally grows. Manganese is essential for photosynthesis, respiration, nitrate assimilation, the production of chlorophyll, and the activity of several enzymes. Micronutrients can significantly increase the productivity and quality of horticultural crops. Application of micronutrients through foliar spray is crucial for flowering and the production of high-quality fruit. The present study was therefore undertaken to investigate the effect of foliar application of plant growth regulators and micronutrients on yield and quality of acid lime cv.balaji., which may helps in increasing the yield and quality of the fruit.

Material and Methods

A field experiment was planned on 20 year old acid lime trees at farmer field, Banda Timmapur (village), Konda Mallepally, Nalgonda district during the year 2021-2022. The experimental site is situated at a latitude of 17^{0} .32' North, longitude of 78^{0} .40' East and altitude of 224 m above mean sea level (MSL). The experiment was laid out in Randomized Block Design (RBD) with eight treatments and three replications. There were two spray schedules *i.e.*, 1^{st} spray 2^{nd} week of march at petal fall stage and 2^{nd} spray 45 days after 1^{st} spray. Two trees were taken for each treatment. The orchard was laid out by adopting square system with a spacing of 7m x 7m. The required dose of manures, fertilizers, irrigation and plant protection measures were given to each selected tree. Treatments consisted of T_1: 2,4-D (10 ppm) + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%), T_2: 2,4-D (20 ppm) + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%), T_3: GA_3 (25 ppm) + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%), T_4: GA_3 (50 ppm) + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%), T_5: NAA (50 ppm) + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%), T_6: NAA (100 ppm) + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%), T_7: $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%), T_8: Control (Water spray). Number of fruits per plant and yield per tree were counted manually during harvesting. Randomly six flowering shoots per tree per replication were selected and number of flowers per shoot recorded and average was worked out per treatment.

Results and Discussion

1. Number of flowers per shoot

Data recorded on number of flowers per shoot as influenced by plant growth regulators and micronutrients in acid lime is presented in Table 1. The foliar spray of plant growth regulators and micronutrients had significant influence on number of flowers per shoot among the treatments. The treatment T_4 - GA_3 (50 ppm) + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%) recorded maximum number of flowers per shoot (18.85) followed by T_6, T_3 respectively. The number of flowers per shoot was recorded minimum (9.65) in T_8 -Control. Increase in number of flowers with GA_3 application might be due to fact that the plants sprayed with GA_3 may have remained physiologically more active to generate an adequate food reserve for producing flowers. Auxins are also known to promote the initiation of flower buds. Therefore, the rise in flowering may be due to increasing photosynthesis, which raised trees' capacity to produce more flower buds. The foliar application of growth regulators GA_3 and NAA application greatly reduced the flower drop and enhanced fruit retention, number of flowers per shoot was found maximum in GA_3 acid lime trees. These results are in accordance with findings of Thirugnanavel *et al*. (2007) [25] in acid lime reported that application of GA_3 showed better performance in increasing in number of flowers per shoot. Deshmukh *et al*. (2016) [7], Debbarma and Hazarika (2016) [5], Tagad *et al*. (2018) [24], in acid lime.

2. Fruit set (%)

The data with respect to fruit set percentage as influenced by various plant growth regulators and micronutrients of acid lime is presented in Table 1. Among different plant growth regulators and micronutrients significantly highest fruit set percentage (52.24%) was noticed with the treatment T_4 - GA_3 (50 ppm) + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%) followed by, T_6, T_3 respectively. Significantly the lowest fruit set per shoot (38.20%) was found with the treatment T_8 – Control. Micronutrients have a crucial role in pollination, growth-promoting elements, the electron transport system, and carbohydrates greatly improve fruit set as a result of nutrient translocation from source leaves to sink fruits with an increase in photosynthesis rate seen within kagzi lime. These results are similar to the findings of Ebeed *et al*. (2001) [9] in mango, Kachave and Bhosale (2007) [14] in kagzi Lime, Kumar *et al*. (2009) [16] in Litchi, Gurjar and Rana (2014) [10] in kinnow mandarin, Bhati *et al*. (2016) [2] in acid lime.

3. Fruit Drop (%)

The data with respect to fruit drop percentage as influenced by various plant growth regulators and micronutrients of acid lime is presented in Table 1. Among different plant growth regulators and micronutrients significantly minimum fruit drop percentage (35.28%) was noticed with the treatment T_4 - GA_3 (50 ppm) + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%) followed by T_3, T_5 respectively. Significantly the maximum fruit drop per shoot (47.23%) was found with the treatment T_8 – Control. The Treatment T_4 - GA_3 (50 ppm) + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%) It might be because GA_3 is more widely available. The synthetic auxin is known as NAA. Low auxin activity or a low auxin supply may be to cause for fruit abscission or dropping. In order to compensate for the lack of endogenous auxin that prevents the formation of the abscission layer, NAA application has been shown to increase fruit retention. NAA studied fruit decline and improved fruit retention. In addition to zinc, iron, manganese, magnesium, and boron, the combined effect of GA_3 increased yield per tree in contrast to control. It is reported to delay the development of the abscission layer by preventing the loss of pectin material in the middle lamella, hence preventing fruit drop in a variety of fruit crops. As a result, the stem has survived for a longer period. These results are in similar lines with the findings of Ebeed *et al*. (2001) [9] in mango, kachave and Bhosle (2007) [14] in Kagzi lime, Gurjar and Rana (2014) [10] who recorded maximum yield in mandarin orange by combined application of $ZnSO_4$ and $FeSO_4$, Bhati *et al*. (2016) [2] in acid lime.

4. Days required for flowering to harvesting

The data with respect to fruit set percentage as influenced by various plant growth regulators and micronutrients of acid lime is presented in Table 1. The treatment T_4 - GAɜ (50 ppm) + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%) recorded minimum days required for flowering to harvesting (144.00 days) followed by T_7 - $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%), (162.33 days) which are at par respectively. However, maximum number of days required for flowering to harvesting (164.24) was recorded in T_8 - Control. Zinc also performs a particular role in fertilization as pollen grains have a very high concentration of zinc and serve to promote perfect pollination and plays pollen germination and pollen tube growth which result in early fruit. These findings are in line with results reported by Bhati *et al*. (2016) [2] in acid lime, Debbarma and Hazarika (2016) [5] in acid lime, Deshmukh *et al.* (2016) [7], Somwanshipatil (2017) [23] in sweet orange.

5. Weight of the fruit (g)

Influence of various plant growth regulators and micronutrients on fruit weight of acid lime is presented in Table 1. The data on fruit weight reveals that effect of plant growth regulators and micronutrients on the fruit weight of acid lime was significant among the treatments. The treatment T_4 - GAɜ (50 ppm) + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%) recorded maximum fruit weight (45.06 g) followed by T_3, T_5 which are on par respectively. However, minimum fruit weight (36.85 g) was observed in the T_8 - Control. The increment in fruit weight might be due to hormone directed to transportation and accumulation of photosynthates which resulted in better fruit development and also acceleration of cell division, cell elongation, and enlargement and increase in inter cellar spaces in mesocarpic cells was reported by (Jobanjit Singh *et al*. 2018) [13]. The above results are in agreement with Jagtap *et al*. (2013) [12] in kagzi lime, Debbarma and Hazarika (2016) [5] in acid lime, Jobanjit Singh *et al*. (2018) [13] in baramasi lemon.

Table 1: Effect of foliar application of plant growth regulators and micronutrients on flowering and yield parameters of acid lime cv. Balaji

Treatments	Number of flowers per shoot	Fruit set (%)	Fruit drop (%)	Days required for flowering to harvesting	Weight of the fruit (g)
T_1	15.62	45.56	41.25	154.85	38.67
T_2	16.24	46.84	39.52	153.09	40.56
T_3	17.42	49.52	36.34	147.68	44.85
T_4	18.85	52.24	35.28	144.00	45.06
T_5	16.35	48.85	37.56	151.67	43.54
T_6	17.64	50.35	38.35	150.00	42.57
T_7	10.43	44.65	37.48	162.33	38.05
T_8	9.65	38.20	47.23	164.24	36.85
Mean	15.28	47.02	39.12	153.48	41.26
S.Em (±)	0.26	0.79	0.62	2.49	0.68
CD at 5%	0.80	2.41	1.88	7.56	2.08

6. Volume of the fruit (ml)

The influence of foliar application of growth regulators and micronutrients on fruit volume differed significantly is presented in Table 2. The treatment T_4 - GAɜ (50 ppm) + ZnSO 4 (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%) recorded maximum fruit volume (52.64 ml) followed by treatment T_3, T_6, T_1 respectively. However, the minimum fruit volume (36.45 ml) was recorded in treatment T_8 - Control. In present study foliar spray of T_4 - GAɜ (50 ppm) + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%) recorded maximum fruit volume. The application of plant growth regulators and micronutrients may have increased fruit volume because the plants develop vigorously vegetative growth and subsequent production of more photosynthates were stimulated by the optimal supply of growth regulators and micronutrients throughout the entire crop growth period (Sachs and Hackett, 1972) [20]. The involvement of GA_3 and micronutrients in hormone metabolism, enhanced cell division, cell elongation, and expansion may also contribute to the enhancement of fruit volume. The results are in accordance with the findings reported, Kachave and Bhosale (2007) [14] in Acid Lime, Shinde *et al*. (2008) [22], Debaje *et al*. (2011) [4] in Acid lime, Jagtap *et al*. (2013) [12] in kagzi lime, Debbarma and Hazarika *et al*. (2016) [5] and Kavin Prashanth *et al*. (2021) [15].

7. Fruit diameter (cm)

The data with respect to fruit diameter as influenced by various plant growth regulators and micronutrients of acid lime is presented in Table 2. The variation in diameter of the fruit was significant. The acid lime with treatment T_4 - GAɜ (50 ppm) + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%) recorded maximum diameter (4.11cm) followed by treatment T_1, T_5 which are on par respectively. However, the minimum diameter of the fruit (3.30 cm) was recorded in the treatment T_8 - Control. The application of plant growth regulators and micronutrients may have increased fruit diameter because the plants develop vigorously vegetative growth and subsequent production of more photosynthates were stimulated by the optimal supply of growth regulators and micronutrients throughout the entire crop growth period (Sachs and Hackett, 1972) [20]. The results are in accordance with the findings reported Kachave and Bhosale (2007) [14] in Acid Lime, Shinde *et al.* (2008) [22], Nawaz *et al.* (2011) [18] in kinnow mandarin, Dixit *et al.* (2013) [8] in Litchi, Jagtap *et al*. (2013) [12].

8. Fruit length (cm)

The data on effect of plant growth regulators and micronutrients on fruit length of acid lime differed significantly among the treatments is presented in Table 2.

The treatment T_4 -GA_3 (50 ppm) + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%) resulted in the maximum fruit length (4.24 cm) followed by T_3, T_1, T_5 Which are on par respectively. Whereas the minimum fruit length (3.54 cm) was observed in the T_8 - Control. Among the treatments T_4 -GA_3 (50 ppm) +$ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%) recorded maximum fruit length. Gibberellins are known for their capacity to stimulate cell enlargement, which in acid lime increases fruit length and, in turn, increases the quantity and size of living cells in the outer and inner pericarp as well as the number of cells in the core. The results are in accordance with the findings reported by Kachave and Bhosale (2007) [14] in Acid Lime, Shinde *et al*. (2008) [22], Jagtap *et al*. (2013) [12], Debbarma and Hazarika (2016) [5] and Deshlehra *et al*. (2019) [6].

9. Number of fruits per tree

The data pertaining to number of fruits per tree as influenced by various plant growth regulators and micronutrients are presented in Table 2. The foliar spray of plant growth regulators and micronutrients had significant influence on number of fruits per tree in acid lime. The treatment T_4 - GA_3 (50 ppm) + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%) recorded maximum number of fruits per tree (925.00) followed by T_3, T_6. However, the minimum number of fruits per tree (573.34) was recorded in T_8 - Control. Similar to this, micronutrients encourage the transfer of metabolites from source to sink, which helps the tree produce more fruits. The application of micronutrients may have enhanced the amount of fruits per tree by decreasing fruit loss and improving fruit retention (Saleem *et al.* 2007) [21]. Due to the effects of zinc and iron, the micronutrient treatment may have contributed to an increase in the chlorophyll content of the leaves as well as higher photosynthetic efficiency and production. These results are in accordance with the findings of Ebeed *et al.* (2001) [9] in mango, Kachave and Bhosale (2007) [14] in Kagzi lime, Nawaz *et al*. (2008) [18], Kumar *et al*. (2009) [16] in Litchi, Jagtap *et al*. (2013) [12] in acid lime.

10. Yield per tree (kg)

The data with respect to yield per tree as influenced by various plant growth regulators and micronutrients is presented in Table 2. The foliar spray of plant growth regulators and micronutrients had significant influence on the yield per tree among the treatments in acid lime. The treatment T_4 - GA_3 (50 ppm) + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%) recorded maximum yield per tree (kg) (41.68 kg) followed by T_3, T_5. The minimum yield per tree (21.12kg) was recorded in the treatment T_8 - Control. The combination of plant growth regulators and micronutrients may have improved vegetative growth and leaf chlorophyll content, which may have resulted in the production of more photosynthates and their translocation to the fruit, increasing the yield qualities of the fruits (Razzaq *et al*. 2013) [19]. The results are in agreement with the findings of, Kachave and Bhosale (2007) [14], Thirugnanavel *et al.* (2007) [25] in acid lime, Shinde *et al.* (2008) [22], Kumar *et al.* (2009) [16] in Litchi, Debaje *et al.* (2011) [4] in Acid lime, and Debbarma and Hazarika (2016) [5] in acid lime.

Table 2: Effect of foliar application of plant growth regulators and micronutrients on Yield parameters of acid lime cv. Balaji

Treatments	Volume of the fruit (ml)	Fruit diameter (cm)	Fruit length (cm)	Number of fruits per tree	Yield per tree (kg)
T_1	45.48	4.05	4.06	661.63	25.58
T_2	42.54	3.78	3.96	675.94	27.41
T_3	50.12	3.85	4.15	813.52	36.48
T_4	52.64	4.11	4.24	925.00	41.68
T_5	39.45	3.93	4.04	693.43	30.19
T_6	45.65	3.90	3.95	695.26	29.59
T_7	38.53	3.73	3.72	640.82	24.38
T_8	36.45	3.30	3.54	573.34	21.12
Mean	43.85	3.83	3.95	709.86	29.55
S.Em (±)	0.74	0.06	0.06	12.33	0.52
CD at 5%	2.26	0.19	0.20	37.42	1.59

T_1: 2,4-D (10 ppm) + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%)	**T_5:** NAA (50 ppm) + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%)
T_2: 2,4-D (10 ppm) + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%)	**T_6:** NAA (100ppm) + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) +Boron (0.1%)
T_3: GA_3 (25 ppm) + $ZnSO_4$(0.5%) + $FeSO_4$(0.2%) + $MgSO_4$(0.2%) + $MnSO_4$(0.2%) +Boron (0.1%)	**T_7:** $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron + (0.1%)
T_4: GA_3 (50 ppm) + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%)	**T_8:** Control (Water spray)

Conclusion

Based on the study, it was concluded that, the treatment GA_3 (50ppm) + $ZnSO_4$ (0.5%) + $FeSO_4$ (0.2%) + $MgSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Boron (0.1%). (T_4) Was the best for increasing the number of flowers per shoot, fruit set (%), number of fruits per tree, yield per tree, fruit weight, fruit volume, fruit diameter, fruit length, juice (%) and shelf life. Further minimum fruit drop and minimum days required for harvesting was recorded with application of GA_3 (50ppm) + $ZnSO_4$(0.5%) + $FeSO_4$(0.2%) + $MgSO_4$(0.2%) + $MnSO_4$(0.2%) +Boron (0.1%). It can be concluded that growing of acid lime with combined use of GA_3 and micronutrients was found to be effective in promoting flowering, yield, quality and shelf life of acid lime.

Future scope

Studies on the influence of combination of plant growth regulators and micronutrient on yield, economics, quality and shelf life of acid lime under high density planting can be taken up.

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Conflict of interest: None

References

1. Ashraf MY, Yaqub J, Akhtar MA, Khan M, Ali-Khan, Abert G. Improvement in yield and juice quality of kinnow (*Citrus deliciosa x Citrus nobilis*) through nutrient management. Pakistan Journal of Botany. 2012;44:259-265.
2. Bhati AS, Kanwar J, Naruka IS, Rajesh T, Gallani R, Singh O. Effect of plant growth regulators and zinc on fruiting and yield parameters of Acid Lime (*Citrus aurantifolia* Swingle). The bioscan. 2016;11(4):2665-2668.
3. Chadha KL. Handbook of Horticulture, ICAR publication, New Delhi. 2002, 209.
4. Debaje PP, Shinde ED, Ingale HV. Effect of plant growth regulators and nutrients on quality of Acid lime (*Citrus aurantifolia* Swingle). The Asian Journal of Horticulture. 2011;6(1):253-255.
5. Debbarma N, Hazarika BN. Effect of plant growth regulators and chemicals on yield and quality of acid lime (*Citrus aurantifolia* Swingle) under foothill condition of Arunachal Pradesh. International Journal of Agriculture, Environment and Biotechnology. 2016;9(2):231-236.
6. Deshlehra R, Singh KV, Lekhi R, Yadagiri J. Effect of growth regulators, micronutrients and chemicals on yield, yield attributes and economics of acid lime cv-Vikram in Ambebahar under high density planting system (*Citrus aurantifolia* Swingle). Journal of Pharmacognosy and Phytochemistry. 2019;8(6):549-551.
7. Deshmukh HK, Paithankar DH, Nimbolkar PK, Dewangan RK, Awachare C. Effect of plant growth regulators and micronutrients on reproductive attributes of acid lime (*Citrus aurantifolia* Swingle) in hasta bahar cropping season. Journal of Horticultural Sciences. 2016;11(1):63-66.
8. Dixit A, Shaw SS, Virendra Pal. Effect of micronutrient and plant, 2013.
9. Ebeed S, El-Gazzar A, Bedier R. Effect of foliar application of some micronutrients and growth regulators on fruit drop, yield, fruit quality and leaf mineral content of Mesk mango cv. Trees. Annual Agriculture Science. 2001;39(2):1279-1296.
   growth regulators on fruiting of Litchi. Hortflora Research Spectrum. 2(1):77-80.
10. Gurjar PS, Rana GS. Influence of foliar application of nutrients and growth regulators on fruit drop, yield, and fruit size and quality in kinnow mandarin. Indian Journal of Horticulture. 2014;7(1):109-111.
11. Ibrahim M, Ahmad N, Anwar SA, Majeed T. Effect of micronutrients on citrus fruit yield growing on calcareous soils. Advances in Plant and Animal Boron Nutrition. (Eds.): X.U. Fangsen, H.E. Goldbach, P.H. Brown, R.W. Bell, T. Fujiwara, C.D. Hunt, 5. Goldberg and L Shi, Springer Netherlands. 2007, 179-182.
12. Jagtap VM, Patel HC, Nehete DS. Effect of foliar application of plant growth regulators and micronutrients on growth and yield of acid lime cv. Kagzi lime (*Citrus aurantifolia* Swingle). Bioinfolet. 2013;10(2A):469-472.
13. Jobanjit Singh, Amarjeet Kaur. Influence of foliar sprays on yield and quality of baramasi lemon. Int. J Adv. Res. 2018;6(6):293-298.
14. Kachave DB, Bhosale AM. Effect of plant growth regulators and micronutrients on fruiting and yield parameters of Kagzi lime (*Citrus aurantifolia* Swingle) fruits. Asian J Hort. 2007;2(2):75-79.
15. KavinPrashanth R, Paramaguru P, Rani MA, Sujatha KB. Impact of foliar application of growth regulators and micronutrients on yield and quality of acid lime (*Citrus aurantifolia* Swingle). Journal of Pharmacognosy and Phytochemistry. 2021;10(1):2091-2093.
16. Kumar M, Kumar Singh, Rajesh RP. Effect of micronutrients and plant growth regulators on fruiting of litchi. International Journal of Agriculture Science. 2009;5(2):521-524.
17. National Horticultural board. Horticulture crops for 2021-22 (First Advance Estimates).
18. Nawaz MA, Ahmad W Ahmad S, Khan MM. Role of growth regulators on preharvest fruit drop, yield and quality in kinnow mandarin. Pakistan Journal of Botany. 2008;40(5):1971-1981.
19. Razzaq KA, Khan S, Malik AU, Shahid M, Ullah S. Foliar application of zinc influences the leaf mineral status, vegetative and reproductive growth, and yield and fruit quality of "Kinnow" mandarin. Journal of Plant Nutrtion. 2013;36:1479-1495.
20. Sachs RM, Hackett WP. Chemical inhibition of plant height. Horticulture Science, 1972.
21. Saleem BA, Malik AU, Farooq M. Effect of exogenous growth regulators application on June fruit drop and fruit quality in *Citrus sinensis* cv. Blood Red. Pakistan Journal of Agricultural Science. 2007;44(2):289-294.
22. Shinde BB, Ingle HV, Dhawale DU, Hajare AR, Dhobe SG. Effect of plant growth regulators on size, yield and quality of acid lime. J Soils and Crops. 2008;18(1):117-120.
23. Somwanshi BS, Patil MB, Nainwad RV, Shinde SE. Effect of different chemicals on pre-harvest fruit drop and fruit set of sweet orange (*Citrus sinensis* Osbeck.) var. Nucellar. International Journal of Chemical Studies. 2017;5(4):168-171.
24. Tagad SS, Patil MB, Patil SG, Deshpande DP. Effect of foliar application of plant growth regulators and micronutrients on growth and yield parameters of acid lime (*Citrus aurantifolia* L.) CV. Sai Sarbati. Journal of Pharmacognosy and Phytochemistry. 2018;7(5):741-744.
25. Thirugnanavel A, Amutha R, Beby RW, Indira K, Mareeswari P, Muthulaksmi S, *et al*. Studies on regulation of Flowering in Acid Lime (*Citrus aurantifolia* Swingle). Research Journal of Agriculture and Biological Sciences. 2007;3(4):239-241.