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# Effect of Foliar Spray of Nutrients and Plant Growth Regulator on Quality and Yield of Acid Lime (*Citrus aurantifolia* Swingle)

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## ABSTRACT

The present study was conducted to see the effect of foliar spray of nutrients and plant growth regulator on quality and yield of Acid lime (*Citrus aurantifolia* Swingle). Result revealed that maximum total soluble solids (8.39 $^0$Brix), acidity (7.27 %), TSS / acid ratio (1.15), ascorbic acid (30.11 mg / 100 ml juice), total sugars (1.45%), reducing sugar (0.77%), non-reducing sugar (0.67%) were recorded in alone treatment $T_6$ ($GA_3$ @ 75 ppm) , while maximum number of fruits plant1 (1037.60), fruit weight (40.40 g), fruit yield plant$^{-1}$ (41.92 kg) and fruits yield ha$^{-1}$ (11.61 tonnes) was obtained in alone treatment $T_9$ ($ZnSO_4$ @ 0.6%). In combined treatments $T_{15}$ ($KNO_3$ @ 2% + $GA_3$ @ 75 ppm + $ZnSO_4$ @ 0.6%) was recorded the maximum total soluble solids (8.89 $^0$Brix), acidity (7.42 %), TSS / acid ratio (1.20), ascorbic acid (32.45 mg / 100 ml juice), total sugars (1.67%), reducing sugar (0.88%), non-reducing sugar (0.79%), maximum number of fruits plant$^{-1}$ (1098.04), fruit weight (48.67 g), fruit yield plant$^{-1}$ (53.44 kg) and fruits yield (14.80 tonnes) ha$^{-1}$.

**Keywords** Acid lime, Nutrients, Yield, Quality, Vitamin C.

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## INTRODUCTION

Acid lime (*Citrus aurantifolia* Swingle) is mainly cultivated for its multi-fold nutritional and medicinal values which made acid lime more important among the fruits. It is good appetizer, anti-helmentic and it checks biliousness and stomach ache. 100 grams of fruit juice contains 80 % of water, carotene 26 *IU*, Vitamin A, Vitamin $B_1$ 20 mg, Riboflavin 0.1 mg, Vitamin C 63 mg, Iron (Fe) 1.83 mg, Copper (Cu) 0.16 mg, Oxalo-acetic acid 0.30%, Malic acid and alkaline salt 8.2% therefore, it is very essential for human health (Ranganna *et al.*2017).

It has also rich source of bioflavonoid, acid and volatile oils. Special interest in limes has been flavonoids called flavonol glycosides, including many kaempferol- related molecules. While, these flavonoids have been shown to stop cell division in many cancer cell lines, they are perhaps most interesting for their antibiotic effects and also contains of coumarins such as bergapten which sensitive the skin to sunlight. Bergapten is sometimes added to tanning preparation

since it promotes pigmentation in the skin, though it can cause dermatitis or allergic responses in some people (Venu *et al.* 2014).

In India, acid lime is grown in a variety of agro-climates comprising from the northern plains and central highlands having hot semi arid eco-region with black and red soils. Acid limes are grown commercially in Andhra Pradesh, Tamil Nadu, Karnataka, Gujarat, Bihar and West Bengal. In Madhya Pradesh it is cultivated in Badawani, Khargone, Khandwa, Ujjain, Ratlam, Mandsaur, Neemuch, Shajapur, Gwalior, Burhanpur, Hoshangabad, Morena, Guna, Jabalpur and Bhopal districts. The total area, production and productivity of acid lime/lemons in India are about 286000 hectares, 3148000 MT and 11 MT ha $^{-1}$, respectively. (NBH data base 2017-18) Acid lime is considered to be continuous bloomer due to its peculiar cyclic flushing behavior but the main blooming period starts from February to March with lean period from July to August. The flowering percentage of ambe, mrig and hasta bahar occurs 47%, 36% and 17 % respectively. The fruits of hasta bahar are ready to harvest in the months of April – May when there is heavy demand and are sold at premium prices (Rai *et al.* 2018).

A very little work has been made to words the effect of zinc and $GA_3$ on yield with better quality of kagzi lime (Singh *et al.* 2011). Severe deficiency of Zn element was seen long ago in the citrus orchards of Madhya Pradesh. Zinc is an important element for flowering, fruiting, growth and quality of fruits.

Effective use of micro-nutrients in kagzi lime is one such research gap. Micro-nutrients can tremendously boost kagzi lime flowering and fruiting quality. The problem of micro-nutrients deficiency in kagzi lime causes great concern to the fruit growers and also flower drop as well as fruit drop is a major problem. Use of micro-nutrients will boost up the yield and quality of kagzi lime than ultimately farmers will get economical benefits (Venu *et al*. 2014).

## MATERIALS AND METHODS

The present investigation entitled effect of foliar spray of nutrients and plant growth regulator on quality and yield of Acid lime (*Citrus aurantifolia* Swingle) was conducted during 2018-2019 at the Instructional cum Research Fruit Orchard, Department of Fruit Science College of Horticulture Mandsaur (MP). Experimental site is situated at $23.45^0$ to 24.130 N latitude and $74.44^0$ to $75.18^0$ E longitudes at an altitude of 435 m mean sea level (MSL). The experiment was laid out in Randomized Block Design (RBD) with three replications consisted sixteen treatments i.e. $T_1$- $KNO_3$ @ 1%, $T_2$- $KNO_3$ @ 1.5%, $T_3$- $KNO_3$ @ 2%, $T_4$- $GA_3$ @ 25 ppm, $T_5$- $GA_3$ @ 50 ppm, $T_6$ -$GA_3$ @ 75 ppm, $T_7$- $ZnSO_4$ @ 0.2%, $T_8$- $ZnSO_4$ @ 0.4%, $T_9$- $ZnSO_4$ @ 0.6%, $T_{10}$- $KNO_3$ @ 1% + $GA_3$ @ 25 ppm, $T_{11}$- $KNO_3$ @ 1% + $GA_3$ @ 25 ppm + $ZnSO_4$ @ 0.2%, $T_{12}$- $KNO_3$ @ 1.5% + $GA_3$ @ 50 ppm, $T_{13}$- $KNO_3$ @ 1.5% + $GA_3$ @ 50 ppm + $ZnSO_4$ @ 0.4%, $T_{14}$- $KNO_3$ @ 2% + $GA_3$ @ 75 ppm, $T_{15}$- $KNO_3$ @ 2% + $GA_3$ @ 75 ppm + $ZnSO_4$ @ 0.6%, $T_{16}$- Control (Water Spray) keeping one tree per treatment. For determination of fruit quality, five healthy fruits were selected randomly from each tree at full maturity stage. The fruits were washed thoroughly before analysis for the following contents the quality parameters of fruits viz., TSS in ($^0$Brix) by hand refractometer. Acidity was estimated by simple acid–alkali titration method as described in AOAC (1970), Assay method of ascorbic acid was followed given by Ranganna (1997), sugars in fruit juice were estimated by the method as suggested by Nelson (1944). Yield and yield contributing characters of guava were recorded after the picking of mature fruits of each tree.

## RESULTS AND DISCUSSION

The results of an experiment have been discussed in the light of acceptable principles and available literature as under.

### Quality parameters

Result showed that the maximum total soluble solids (8.39 $^0$Brix), acidity (7.27 %), TSS / acid ratio (1.15), ascorbic acid (30.11 mg / 100 ml juice), total sugars (1.45%), reducing sugar (0.77%), non-reducing sugar (0.67%) were recorded in alone treatment $T_6$ ($GA_3$ @ 75 ppm). Maximum total soluble solids (8.89 $^0$Brix), acidity (7.42 %), TSS / acid ratio (1.20), ascorbic acid (32.45 mg / 100 ml juice), total sugars (1.67%),

reducing sugar (0.88%), non-reducing sugar (0.79%) were reported in combined foliar spray of $KNO_3$ @ 2% + $GA_3$ @ 75 ppm + $ZnSO_4$ @ 0.6% ($T_{15}$) followed by $T_{14}$ while, minimum value for quality characters were recorded in control.

Potassium nitrate sprays increased the TSS due to increase in the mobilization of carbohydrates from source to sink. Highest TSS, TSS: acid ratio, total sugars, reducing sugar and non-reducing sugar was recorded with applications of $KNO_3$. The increased acidity by K application may be due to synthesis of more organic acids. Increased ascorbic acid with foliar application of potassium might be related with improved sugar metabolism (Mengal 1997). Increasing in vegetative growth, net photosynthetic rate, NPK content and chlorophyll content were associated with increasing of K levels. Potassium affects respiration, photosynthesis, leaf NPK content, chlorophyll development, water content of leaves, carbon dioxide ($CO_2$) assimilation and carbon movement (Sangakkara *et al.*2000). Sugars increased significantly in most of the treatments as compared to control. It was due to the fact that potassium enables higher accumulation of sugars and organic acids in fruits by promoting the translocation of assimilates from source to sink (Liwerant 1960).

Increase in TSS content with zinc may be attributed to the quick metabolic transformation of starch and pectin into soluble compounds and rapid translocation of sugars from leaves to developing fruits (Brahmachari and Rani 2001). Increased SSC (soluble solids concentrations) and TA (titrateable acidity) due to Zn sprays may be attributed to their effects on different enzymes which are involved in the formation of proteins, acids and sugars (Srivastava and Gupta 1996). The increased ascorbic acid content of fruit juice was due to increase in the synthesis of catalytic activity by enzyme and coenzyme, which are represented in ascorbic acid synthesis. The Chlorophyll production, pollen function and fertilization require zinc (Kaya *et al*. 2005). Increase in the level of total sugars in treatments containing Zn may be attributed to its effects on the activities of aldolase enzyme which is involved in the formation of sugars in fruits (Alloway 2008). The results are in conformity with the observations recorded by Jagtap *et al*. (2013) in acid lime cv Kagzi lime, Razzaq *et al.* (2013) in Kinnow mandarin, Lukshmi *et al.* (2014) in acid lime cv Balaji, Kazemi (2014) in tomato, Neware *et al.* (2015) sweet orange cv Mosambi, Gurung *et al.* (2016) in Darjeeling Mandarin, Singh and Kaur (2016) in litchi cv Dehradun, Dalal *et al.* (2017) in sweet orange cv Jaffa, Neware *et al.* (2017) sweet orange cv Mosambi, Singh *et al.* (2018) in Kinnow mandarin and Singh and Kaur (2018) in Baramasi lemon.

**Yield parameters**

It is clear from Table 1 that alone treatment $T_9$ ($ZnSO_4$ @ 0.6%) was recorded maximum number of fruits (1037.60) plant$^{-1}$, fruit weight (40.40 g), fruit yield plant$^{-1}$ (41.92 kg) and fruits yield (11.61 tonnes) ha$^{-1}$. In combined foliar spray of $KNO_3$ @ 2% + $GA_3$ @ 75 ppm + $ZnSO_4$ @ 0.6%) ($T_{15}$) was recorded maximum number of fruits (1098.04) plant$^{-1}$, fruit weight (48.67 g), fruit yield (53.44 kg) plant$^{-1}$ and fruits yield (14.80 tonnes) ha$^{-1}$ followed by 48.29 g fruit weight in $T_{14}$ and yield in $T_{13}$ (51.86 kg per plant and 14.37 tonnes ha$^{-1}$ yield), respectively. The minimum value for yield characters under control may be due to lack of supply of nutrients.

$GA_3$ may have affected the auxin metabolism, which may have indirectly aided in fruit enlargement and thus the production of fruits in higher number, ultimately increases yield per plant and yield per hectare (Kappel and MacDonald 2007 and Singh and Singh 2006).

The beneficial effects of potassium on growth, yield and fruit quality may be attributed to their vital role in stimulating cell division and elongation as well as the bio-synthesis and trans-located of organic foods in favor of enhancing growth and fruiting of trees (Nijjar 1985).

The improvement occurred in fruit quality and quantity due to supplying trees with zinc could be attributed to its effect on enhancing formation and translocation of carbohydrates and carbohydrate enzymes (Ram and Bose 2000). Zinc assists the translocation of metabolites from source to sink, which reduce fruit drop and leads to retention of

**Table 1.** Effect of foliar spray of nutrients and plant growth regulator on quality and yield characters of acid lime cv Kagzi lime.

| Treatment | TSS (°Brix) | Acidity (%) | TSS / acid ratio | Ascorbic acid (mg / 100 ml juice) | Total sugars (%) | Reducing sugars (%) | Non reducing sugars (%) | Number of fruits per plant | Fruit weight (g) | Fruit yield per plant (kg) | Fruit yield per hectare (tonnes) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | 7.97 | 7.14 | 1.12 | 28.94 | 1.45 | 0.78 | 0.67 | 937.15 | 40.89 | 38.32 | 10.62 |
| $T_2$ | 8.06 | 7.17 | 1.12 | 29.19 | 1.46 | 0.78 | 0.68 | 944.47 | 41.42 | 39.12 | 10.84 |
| $T_3$ | 8.14 | 7.19 | 1.13 | 29.47 | 1.49 | 0.79 | 0.70 | 958.77 | 41.98 | 40.25 | 11.15 |
| $T_4$ | 8.22 | 7.22 | 1.14 | 29.65 | 1.39 | 0.74 | 0.65 | 971.68 | 42.62 | 41.42 | 11.47 |
| $T_5$ | 8.29 | 7.25 | 1.14 | 29.86 | 1.42 | 0.76 | 0.66 | 982.50 | 43.31 | 42.56 | 11.79 |
| $T_6$ | 8.39 | 7.27 | 1.15 | 30.11 | 1.45 | 0.77 | 0.67 | 989.47 | 44.19 | 43.73 | 12.11 |
| $T_7$ | 7.64 | 7.04 | 1.08 | 28.29 | 1.29 | 0.69 | 0.60 | 1008.79 | 39.08 | 39.42 | 10.92 |
| $T_8$ | 7.72 | 7.07 | 1.09 | 28.55 | 1.32 | 0.71 | 0.61 | 1021.58 | 39.76 | 40.62 | 11.25 |
| $T_9$ | 7.81 | 7.09 | 1.10 | 28.84 | 1.35 | 0.72 | 0.63 | 1037.60 | 40.40 | 41.92 | 11.61 |
| $T_{10}$ | 8.47 | 7.29 | 1.16 | 30.43 | 1.50 | 0.80 | 0.70 | 1049.52 | 45.78 | 48.05 | 13.31 |
| $T_{11}$ | 8.55 | 7.32 | 1.17 | 30.77 | 1.54 | 0.81 | 0.73 | 1075.03 | 46.28 | 49.75 | 13.78 |
| $T_{12}$ | 8.67 | 7.34 | 1.18 | 31.09 | 1.57 | 0.83 | 0.74 | 1058.53 | 46.91 | 49.65 | 13.75 |
| $T_{13}$ | 8.74 | 7.37 | 1.19 | 31.35 | 1.60 | 0.85 | 0.75 | 1086.65 | 47.73 | 51.86 | 14.37 |
| $T_{14}$ | 8.80 | 7.39 | 1.19 | 31.76 | 1.63 | 0.86 | 0.77 | 1067.63 | 48.29 | 51.55 | 14.28 |
| $T_{15}$ | 8.89 | 7.42 | 1.20 | 32.45 | 1.67 | 0.88 | 0.79 | 1098.04 | 48.67 | 53.44 | 14.80 |
| $T_{16}$ | 7.06 | 6.87 | 1.03 | 25.72 | 1.23 | 0.68 | 0.55 | 869.28 | 38.10 | 33.12 | 9.17 |
| SEm. ± | 0.015 | 0.06 | 0.01 | 0.29 | 0.03 | 0.015 | 0.02 | 3.04 | 0.43 | 0.47 | 0.10 |
| CD at 5% | 0.044 | 0.16 | 0.03 | 0.84 | 0.08 | 0.045 | 0.07 | 8.78 | 1.25 | 1.36 | 0.30 |

more number of fruits on tree. Application of $ZnSO_4$ fruit weight, number of fruits per plant and fruit yield per tree is increases which ultimately increase fruits yield in terms of tonnes per hectare. The results are in accordance with the findings of Neware *et al.* (2017) sweet orange cv Mosambi, Maurya *et al.* (2018) in guava cv Allahabad Safeda, Rai *et al*. (2018) in acid lime, Singh *et al.* (2018) in Kinnow mandarin, Singh and Kaur (2018) in peach cv. Shan-e-Punjab and Devi *et al.* (2019) in ber cv Banarasi karaka.

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