EFFECT OF FOLIAR APPLICATION OF PLANT GROWTH REGULATORS AND MICRONUTRIENTS ON GROWTH, QUALITY AND YIELD OF ACID LIME *(Citrus aurantifolia L.)* CV. SAI SARBATI.

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PARBHANI - 431 402 (M.S.), INDIA

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DISSERTATION

Submitted to the

Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani

In partial fulfillment of the requirements

For the Award of the Degree of

MASTER OF SCIENCE
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IN
FRUIT SCIENCE

DEPARTMENT OF HORTICULTURE,
COLLEGE OF AGRICULTURE, LATUR
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PARBHANI - 431 402 (M.S.), INDIA.

2018

CANDIDATE'S DECLARATION

I hereby declare that the dissertation

Or part thereof has not been

Previously submitted by me

For a degree of any

University or

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Place : **Latur** **(TAGAD SOMNATH SHIVAJI)**

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CERTIFICATE – I

This is to certify that the dissertation entitled **"EFFECT OF FOLIAR APPLICATION OF PLANT GROWTH REGULATORS AND MICRONUTRIENTS ON GROWTH, QUALITY AND YIELD OF ACID LIME (*Citrus aurantifolia* L.) Cv. SAI SARBATI"** submitted by **Mr. TAGAD SOMNATH SHIVAJI** to the Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (Horticulture)** in the subject of **FRUIT SCIENCE** is record of original and bonafide research work carried out by him under my guidance and supervision. It is of sufficiently high standard to warrant its presentation for the award of the said degree.

I also certify that the dissertation or part thereof has not been previously submitted by him for a degree of any university.

Place: **Latur**
Date: / /2018

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Research Guide
and
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Advisory Committee.

C E R T I F I C A T E - II

This is to certify that the dissertation entitled **" EFFECT OF FOLIAR APPLICATION OF PLANT GROWTH REGULATORS AND MICRONUTRIET S ON GROWTH, QUALITY AND YIELD OF ACID LIME (*Citrus aurantifolia* L.) Cv. SAI SARBATI"** submitted by **Mr. TAGAD SOMNATH SHIVAJI** to the Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE (Horticulture)** in the subject of **FRUIT SCIENCE** has been approved by the Student's Advisory Committee after oral examination in collaboration with the External Examiner.

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Place: Latur ***(TAGAD SOMNATH SHIVAJI)***

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ABBREVIATIONS

A. O. A. C.	: Association of agricultural chemists
CCC	: Cycocel
C.D.	: Critical difference
Cm	: Centimetre (s)
cv.	: Cultivar (s)
^0C	: Degree celsius (s)
et al.	: Et alli (and so on)
etc.	: Etcetera
Fig.	: Figure
$FeSO_4$	: Ferrous sulphate
G	: Gram (s)
GA_3	: Gibberellic acid
Ha	: Hectare
i.e.	: That is
Kg	: Kilogram (s)
KNO_3	: Potassium nitrate
lit.	: Litre (s)
m	: Metre (s)
mg	: Milligram (s)
ml	: Millilitre (s)
mm	: Millimetre (s)
MT	: Metric tonnes
N	: Normality
N.S.	: Non significant
No.	: Number (s)
%	: Per cent
ppm	: Parts per million
PGRs	: Plant growth regulators
S.E. ±	: Standard error
T	: Tonne (s)
TSS	: Total soluble solids
viz.	: Namely (Videlicet)
$ZnSO_4$	: Zinc sulphate

ABSTRACT

ABSTRACT

EFFECT OF FOLIAR APPLICATION OF PLANT GROWTH REGULATORS AND MICRONUTRIENTS ON GROWTH, QUALITY AND YIELD OF ACID LIME

By

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of

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in

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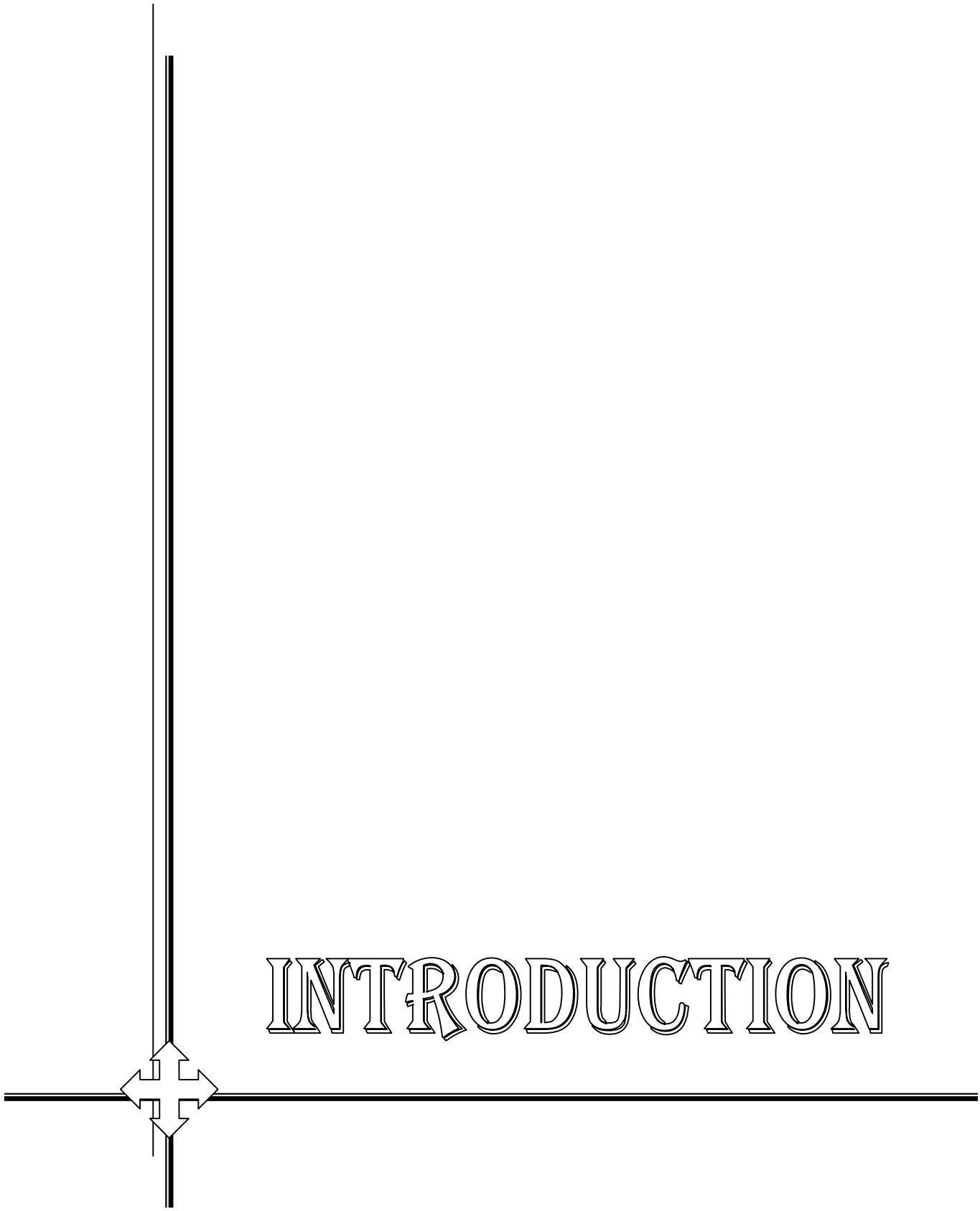
2018

Research Guide	**:**	**Dr. M. B. Patil**
Department	**:**	**Horticulture**

The present investigation entitled "Effect of plant growth regulators and micronutrients on growth, quality and yield of acid lime" was conducted at Sweet Orange Research Station, Badnapur. The objective of this experiment was to study the effect of plant growth regulators and micronutrients on growth, yield and quality of acid lime. The experiment was laid out in Randomized Block Design (RBD) with three replication and 13 treatments. Comprising spraying of Gibberellic acid (GA_3) at 50 ppm along with micronutrients combination of $ZnSO_4$ + $FeSO_4$ at 0.5% and 1% both, NAA at 100 ppm along with micronutrients combination of $ZnSO_4$ + $FeSO_4$ at 0.5 and 1 % both and control. The observations on different parameter viz., plant height, plant spread, days required for initiation of new vegetative flush, days required for flower initiation, days required for harvesting, number of flower/shoot, fruit set per cent, fruit drop per cent, number of fruits/tree, fruit weight, fruit volume, yield Kg/tree, juice per cent, peel per cent, total soluble solids, acidity, ascorbic acid, total sugars, reducing sugars and non-reducing sugars were recorded.

Among all the treatments, T_{11} GA_3 (50 ppm) + $ZnSO_4$ (1%) + $FeSO_4$ (1%) recorded maximum increase in plant height (0.25 m), plant spread East-West spread (3.74 m), North-South spread (3.54 m) and minimum days required for initiation of new vegetative flush (17.00 days), flower initiation after vegetative flush (14.00 days) and harvesting (144.00 days). While among all treatments, (T_{11}), GA3 (50 ppm) + $ZnSO_4$ (1%) + $FeSO_4$ (1%) recorded maximum number of fruits/tree (148.00 fruits/tree), fruit weight (43.33 g), fruit volume (41.30 ml), yield (6.41 kg/tree), fruit set (51.20 %), number of flower/shoot (18.57) and minimum fruit drop (35.20 %).

Treatment T_{11}, GA_3 (50 ppm) + $ZnSO_4$ (1%) + $FeSO_4$ (1%) recorded maximum TSS (8.57^0B), Ascorbic acid (30.35 mg/100 ml juice), juice per cent (50.60%), total sugars (1.825%), reducing sugars (0.90%),non-reducing sugar (0.92 %) and maximum per cent acidity (7.07%) and minimum peel per cent (25.21%).



INTRODUCTION

CHAPTER-I

INTRODUCTION

Acid lime (*Citrus aurantifolia* Swingle) is one of the most commercially grown fruit crop which is widely grown in tropical and sub-tropical region of India. It belongs to family Rutaceae. The principal cultivar grown widely is Kagzi lime. It has a papery thin rind, hence the name kagzi with abundant juice content (45 %) and acidity (7-8 %). It is a rich source of vitamin C. The acid lime fruits are used for making pickles and refreshing drinks as well as for manufacturing syrup and squash. It contains 6.3 to 6.6 % citric acid.

In India, acid lime is mainly grown in the states of Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Madhya Pradesh, Bihar, Assam, Jharkhand and Chhattisgarh. The area under acid lime in India is 255.20 thousand hectares with production of 2523.50 thousand MT and productivity 9.9 MT, while in Maharashtra, it is cultivated on 45.00 thousand hectares with production of 246.00 thousand MT with 5.5 MT productivity (Annon.,2017). In Maharashtra, the main acid lime growing districts are Ahmednagar, Solapur, Akola, Jalgaon, Pune, Nagpur, Beed, Jalna and Aurangabad.

Acid lime trees in tropical and sub-tropical conditions tends to give out continuous flushes of growth, both vegetative as well as reproductive throughout the year unless manipulated externally into a concentrated bloom in a particular season. Acid lime trees flower thrice in a year in the months of January- February, June- July and September-October known as *Ambia, Mrig* and *Hasta bahar*, respectively. The fruits of the *Ambia, Mrig* and *Hasta bahar* flowering becomes available in the month of June-July, November-December and April-May months, respectively. The flowering percentage of *Ambia, Mrig* and *Hasta bahar* occurs 47 %, 36 % and 17 %, respectively.

The fruits of *Hatsa bahar* flowering become available in the months of April-May when there is heavy demand and are sold at premium price. But *Hasta bahar* (Summer cropping) bear only 17 % flowering and fruiting is achieved in the uncontrolled condition because of the monsoon rains preceding flower initiation. Therefore, in *Hasta bahar*, to force the acid lime plants in to profuse flowering, use of plant growth regulators and micronutrients gives an effective alternative. Use of Gibberellic acid (GA_3) during stress period is known to reduce the intensity of flowering in the following flowering season nepthalic acitic acid (NAA), and gibberellic acid (GA) (Michael *et al.,* 1999). Similarly, deficiency of micronutrients (Zn, Cu, Fe, and Mn) in the soil of citrus orchards also affects the fruit yield, quality, fruit drop (Ibrahim *et al.,* 2007; Ashraf *et al.,*2012). Severe deficiency of Zn was noted long ago in the citrus orchards of Punjab and Pakisthan (Rehman *et al*., 1999). However, foliar application of Zn can improve the citrus fruit yield, quality and control the premature fruit drop (Rodriguez *et al*., 2005 and Ashraf et al., 2012). Different workers suggested that application of suitable combination of plant growth regulators and macro and micro-nutrients can control the excessive fruit drop and improve the yield and quality of citrus fruit (Doberman and Fairhurst, 2000; Rodriguez *et al.,* 2005 and Saleem *et al.,* 2005).

The water stress with hormones played an important role in regulation of flowering and there is relationship between severity of stress and flowering response (South Wick and Davenport, 1987; Barbera and Garimi, 1988). Considering the importance of *Hasta bahar* fruits, it is necessary to undertake the study on stress period with some chemicals for assured flowering of *Hasta bahar* in acid lime. Therefore, these plant growth regulators and chemicals can be effectively used for obtaining profuse flowering and fruiting for *Hasta bahar* in acid lime.

The role of plant growth regulators in the physiology of plant is one of the most interesting chapters in the science. The plant growth regulators are organic compounds other than nutrients which in small concentration influence the physiological processes of plants. They have been used for various beneficial effects such as promoting root growth and the number of flowers, increasing the fruit size, fruit set, quality and inducing early and uniform fruit ripening. The use of plant growth regulators either as plant spray or as seed treatment has brought spectacular results in both yield and quality of many fruit crops. The effects of plant growth regulators were influenced by light, temperature, moisture, nutrients and other environmental factors. The efficiency of plant growth regulators varies under different concentrations, methods of application and time of application.

Advantages of foliar application of nutrients is economical as compared to the soil application. The nutrients are made easily available if supplied at proper stage and at optimum concentration. The respective nutrient can be given when needed. Absorption through foliage is easier and effective and the phenomenon of antagonism is avoided. Micro nutrients are applied to correct the deficiency through the foliage.

Micronutrients can tremendously boost horticultural crop yield and quality . In general Zn and Fe deficiency are regular in all citrus crops. However, these can be corrected through use of organic matter and spray of zinc sulphate and ferrous sulphate during the active growth period of the Acid lime tree. Application of micronutrients either through foliar spray is important in flowering and quality fruit production and therefore present investigation was undertaken on the effect of foliar spray of micronutrients on flowering as well as, yield and fruit quality of Acid lime. However, Little information is available on concept of use of different micronutrients on growth, yield and quality of Acid lime.

To being with and to have guidelines for future work on this aspects, the present studies were planned to find out the effect of foliar application of plant growth regulators and chemicals with an objective to improve the fruit size, yield and quality of acid lime (*Citrus aurantifolia* Swingle) cv. Sai Sarbati with following objectives.

1. To study the effect of plant growth regulators and micronutrient on growth and yield of Acid lime.

2. To study the effect of plant growth regulators and micronutrient on quality of Acid lime.

REVIEW OF LITERATURE

CHAPTER-II

REVIEW OF LITERATURE

Plant growth regulating substances are systematically produce organic chemical substances, wherein extremely small quantities influence the development process. Most of their search carried out pertains to the effect plant growth regulators and micronutrients to reduce fruit drop, increase fruit production and improve fruit quality. The review of the relevant literature on the effect of plant growth regulators and micronutrients has been summarized in this chapter.

2.1 Effect of plant growth regulators and micronutrients on plant growth

Baku, (1989) reported that Zn and GA_3 treatment combinations resulted in the greatest terminal shoot length, number of leaves/terminal shoot and percent dry weight of the terminal shoot in kagzi lime. However, the total leaf area of the terminal shoot was greatest when 0.6 % Zn were applied.

El-Saida (2001) reported that Washington Navel orange trees budded on sour orange rootstock, showing Fe, Zn and Mn deficiency symptoms, while received foliar nutrition of 400 ppm of Na, Fe EDTA, Na, Zn EDTA and Mn EDTA 3 times a year (at the beginning of flowering, after fruit set, and 4 weeks later) either solely or at different combinations, improved growth parameters (shoot percentage and shoot length of different growth flushes) and leaf chlorophyll content.

Singh *et al.* (2008) reported that the maximum and significant increment in growth parameters, viz., plant height, spread, trunk girth were recorded with the combined spray of0.5 % $ZnSO_4$ + 0.4 % $CuSO_4$ + 10 ppm NAA followed by 0.5 % $ZnSO_4$ + 10 ppm NAA + 25 ppm GA_3 in aonla.

Khan *et al*. (2009) reported maximum vegetative growth (plant height, girth and spread), fruit retention, yield, size, weight and volume of

fruits were obtained in aonla with foliar application of $ZnS0_4$ (0.5 %) + thiourea (0.1 %), closely followed by borax (0.25 %) + thiourea (0.1 %).

Sarfaraz *et al.* (2010) studied the effect of chemical compounds on shoot and fruit of peach (Prunus persica L.) cv. Early coronet and resulted that the interaction between foliar spray of 5 mg.l-1 NAA x 0.2 % KNO_3 x 60 mg.l-1 Fe were the best treatment which gave highest means of shoot dry weight, total chlorophyll, fruit number, fruit length, fruit diameter and total carotene.

Ahmed *et al.* (2012) studied the effect of foliar application of Mg (137.5 ppm), Cu (97 ppm) and growth regulators (20 ppm 2, 4-D, 30 ppm GA_3, or 10 ppm BA) on growth of Washington navel orange trees and result revealed that all treatments improved most of the studied growth characters.

Eiada *et al.* (2013) investigated the influence of spraying manganese and zinc solutions on Salemy pomegranate.Zinc was applied at 0, 1.5, 3 % levels. The obtained results showed that 60 mg/l maganese with 3 % zinc recorded the highest leaf area (5.43 and 5.69 cm2), chlorophyll content (56.12and 56.26, SPAD unit).

Prasad *et al.* (2013) observed that, the application of N increases shoot growth, plant height, spread canopy volume in kinnow. The growth of acid lime fruit were significantly influenced by the application of zinc and iron fertilizers (0.25,0.50 and 0.75 %). Maximum growth observed with two sprays atone month interval of 0.5 % $ZnSO_4$ and 0.5 % $FeSO_4$.

Jagtap *et al.* (2013) reported that treatment with $ZnSO_4$ 0.5 % + $FeSO_4$ 0.5 % produced significantly maximum height of the tree (3.45, 3.73 and 3.98 m), East-west canopy spread (3.44, 3.76 and 4.04 m). North-South canopy spread(3.40, 3.70 and 3.97 m at 4, 6 and 8 month after first spray) in acid lime, respectively.

2.2 Effect of plant growth regulators and micronutrients on yield

Fruit drop is very complex problem and is known to be net result of reduction in fruit yield in citrus. Thus the combine effect of plant growth regulators mainly GA_3,NAA and micronutrients mainly $ZnSO_4$, $FeSO_4$ were found to be most effective in increasing the fruit yield in citrus.

Prasad and Bajpai (1963) revealed that, application of NAA in concentration ranging from 12.5 to 75 ppm at full bloom and again after 10 days on Phalsa var. Sarbati gave effective results in respect of yield. The highest fruit yield was obtained with 50 ppm NAA.

Rao and Subbarao (1963) tried NAA and GA_3 alone and in combination with 10 ppm 2, 4-D to minimize fruit drop in the Neelum cultivator of mango. They observed that NAA at 30 and 40 ppm was found most effective in reducing the fruit drop and ultimately increased the number of fruits and fruit yield.

Dixit *et al.* (1978) found that when kinnow orange trees were sprayed with 1 per cent $ZnSO_4$ and 0.5 per cent$FeSO_4$, they produced highest fruit yield as compared to other treatment. However, zinc sprays were superior over iron sprays in producing more yields.

Jadhav *et al.* (1979) obtained highest yield of 356 fruits/tree in mandarin cv. Nagpur Satsuma (orange) when the plants were supplied with Zn at 30 kg/ha + Fe at 15 kg/ha. The control recorded least fruit yield of 200 fruits/tree.

Raturi and Mukherjee (1981) obtained highest yield in citrus fruits when the plants were sprayed with $ZnSO_4$.

Srivastava *et al.* (1981) observed that, the sweet orange trees sprayed with Zn, Cu and Mn significantly increased the fruit yield. Zinc being the nutrient responsible for auxin synthesis would have influenced higher fruit retention and increased number of fruits per tree.

Babu *et al.* (1984) reported that application of 5-20ppm NAA at three times to 5 years old trees of lemon resulted in increased yield. The highest yield was obtained with NAA at 10ppm concentration.

Mukhtar Ahmad *et al*. (1988) found that application of NPK + planofix (NAA) recorded the highest fruit per tree (673fruits/tree) while control produced least number of fruits per tree(474 fruits) of kinnow mandarin.

Singh and Rethy (1995) conducted an experiment on the effect of zinc, copper, boron, and NAA on yield of 16 year old citrus aurantifolia tree during 1985-87 at Kanpur. They reported that the fruit yield was higher with NAA + Zn, Cu or B then with the trace element alone. The higher yield was obtained with 0.05percent Cu as copper sulphate + 200 ppm NAA.

Sinha *et al.* (1999) studied the effect of plant growth regulator (Zn, Bo GA_3) and micronutrients (zinc and boron) on fruit set, fruit drop, fruit retention and cracking of litchi and reported that higher level of micronutrients (0.8 % zinc and 0.4 %boron) along GA_3 showed marked effect on fruit retention. These treatments also help in reducing fruit drop and cracking of litchi fruits.

Ebeed *et al*. (2001) reported that spraying the trees with Fe + Zn + Mn, Fe + Mn and NAA had a beneficial effect on reducing fruit drop percentage. Spraying the trees with NAA, and Fe + Zn + Mn increased tree yield, fruit weight, pulp weight, and pulp/fruit weight in mango.

Sharma *et al.* (2005) studied the effect of plant bioregulators (PBR) and micronutrients on fruit set and quality of litchi cv. Dehradun and reported that zinc sulphate at 200 ppm produced the highest fruit set (13.33 fruits per panicle), and zinc sulphate at 100 ppm was the most effective in increasing fruit weight (18.17 g), length (3.6 cm) and diameter (3.06 cm) and L/D ratio (1.18).

Eman *et al.* (2007) reported that the spraying 0.4 % chelated zinc at mid February followed by spraying 0.4 % chelated zinc + 20 ppm GA twice at beginning of April and June seems to be the promising treatment for increasing productivity and quality of Washington navel orange.

Kachave and Bhosle (2007) studied on fifteen years old kagzi lime orchard treated with NAA (100 and 200 ppm) and GA (50 ppm) and $ZnSO_4$ mixture (0.5 % and 1 %) singly and in combination. Result revealed that NAA (200 ppm) with ZnSO4 (1%) was the best treatment for increasing fruit retention, number of fruits per tree, weight of individual fruit, yield per tree and reducing fruit drop.

Singh *et al.* (2008) reported that the maximum reduction of fruit drop were recorded with the combined spray of 0.5 % $ZnSO_4$ + 0.4 % $CuSO_4$ + 10 ppm NAA followed by 0.5 % $ZnSO_4$ + 10 ppm NAA + 25 ppm GA_3 in aonla..

Khan *et al.* (2009) recorded maximum vegetative growth (plant height, girth and spread), fruit retention, yield, size,weight and volume of fruits were obtained in aonla with foliar application of $ZnS0_4$ (0.5 %) + thiourea (0.1 %), closely followed by borax (0.25 %) + thiourea (0.1 %).

Yadlod *et al.* (2009) reported that the maximum weight of mature finger (185.60 g) of banana cv. shrimanti was found in two sprays of micronutrient mixture (1 %) followed by one spray of 1 per cent micronutrient mixture (180.82 g). Minimum reduction in per cent loss in weight (3.70 %) during ripening was found with wax (6 %) followed by two sprays of 1 %micronutrient mixture (4.32 %). IAA 80 ppm (4.36 %) and maximum was found in control (6.75 %).

Kumar *et al.* (2009) reported that the application of borax 0.4 per cent resulted in maximum fruit set (42.50 percent), fruit retention (22.60 %), size of fruit (3.72 cm x 2.90 cm),number of fruit per tree (5422), weight of individual fruit (20.91g) and fruit yield per tree (111.05 kg) in litchi. GA_3 20

ppm was also found effective treatment to increase fruit set, fruit retention and size of fruit being maximum of 42.18 per cent, 21.81 percent and 3.64 cm x 2.84 cm, respectively. GA_3 20 ppm produced maximum number of fruits/tree (5327), weight of individual fruit (20.66 gm) and fruit yield per tree (104.55 kg). Interaction between borax 0.4 per cent and GA_3 20 ppm exhibited in maximum retention of fruit (24.64 per cent) and fruit yield of123.10 kg/tree. Aril percentage was high in borax 0.2 per cent and 2, 4-D 10 ppm. Minimum fruit crack of 10.91 per cent was observed in borax 0.4 per cent.

Hassan *et al.* (2010) studied the effect of foliar sprays of Aminofert (20 % Amino acid, 12 % organic acids and 3.6 % chelated micro-elements) gibberellins and a mixture of chelated (Fe, Zn, Mn) alone or in combination (GA_3 + Aminofert or GA+ amixture of chelated Fe, Zn, Mn) on fruit set and yield and observed that the treatments increased significantly fruit set and yield as weight or number of fruits per tree in 'Hollywood' plum trees.

Ahmed *et al.* (2012) studied the effect of foliar application of Mg (137.5 ppm), Cu (97 ppm) and growth regulators (20 ppm 2, 4-D, 30 ppm GA3, or 10 ppm BA) on growth of Washington navel orange trees and result revealed that all treatments improved yield through their favorable effect on leaves chemical composition, plant pigment.

Dixit *et al.* (2013) studied the effect of micronutrients and growth regulators on fruiting in Litchi cv. Ambika Litchi-1and observed that the application of borax 0.4 % resulted in maximum fruit set (41.20 %), fruit retention (22.60 %), size of fruit (4.10 cm x 3.10 cm, number of fruit per tree (46250), weight of individual fruit (21.05 g) and fruit yield (92.85 kg/tree). GA_3 10ppm was also found effective treatment to increase fruit set, fruit retention and size of fruit. GA_3 20 ppm produce maximum number of fruit per tree and yield. Interaction between borax 0.4% and GA_3 20 ppm exhibited in maximum retention of fruits and fruit yield.

Prasad *et al.* (2013) reported that, the yield of acid lime fruit was significantly influenced by the application of zinc and iron fertilizers (0.25, 0.50 and 0.75 %). Maximum yield were observed with two sprays at one month interval of 0.5 % $ZnSO_4$ and 0.5 % $FeSO_4$. The 2, 4-D chemical could thus be used to increase fruit yield under conditions that favors fruit drop such as extreme temperature as well as water deficits.

Jagtap *et al.* (2013) carried out experiment in acid lime cv. Kagzi and revealed that treatment GA_3 50 mg/l significantly increased yield attributing characters like fruit weight (47.40 g), fruit volume (47.90 cc), fruit diameter (4.54 cm)and fruit yield per tree (46.38 kg). In case of number of fruits per tree the treatment NAA 200 mg/lit significantly increased the number of fruits per tree (1020.33).

Laila *et al.* (2014) studied the Impact of foliar application of zinc sulphate and gibberelic acid on fruit quality and quantity of "Kallamata" olives and resulted that kallamata olive trees received zinc sulphate as a source of micronutrient at0.5 % and gibberelic acid as a growth regulator at 10 ppm have complementary effect on fruit characteristic in terms of fruit weight and fruit oil percentage. Also, reduction in fruit drop and increase in individual fruit weight raised the total fruit yield per tree.

Gurjar and Rana (2014) studied the influence of foliar application of nutrients and growth regulators on fruit drop, yield and fruit size and quality in kinnow mandarin and observed that fruit drop was lowest (53.5 %) with $ZnSO_4$ 0.5 % + NAA 50 ppm and fruit weight (168.6 g), fruit yield per tree (43.7 kg) was highest with KNO_3 2 % + NAA 50ppm.

2.3 Effect of plant growth regulators and micronutrients on quality of fruits

In citrus, application of plant growth regulators and micronutrients has been found very effective in increasing the physiochemical

composition of fruits. Hence the combine effect of plant growth regulator and micronutrients ultimately improve the fruit quality of citrus.

Satyamurty *et al.* (1978) noticed that quality of acid lime fruits was not altered much by application of various growth regulators.

Gill et al. (1983) reported that, their is better response of Bordeaux mixture in combination with planofix and $ZnSO_4$ in reducing fruit drop and improving fruit quality of sweet orange.

Bal *et al.* (1984) reported that foliar application of 25 ppm of NAA increased fruit weight and pulp of the ber fruits while acid content of the fruits was decreased in all treatments of NAA .

Sharma and Dhillion (1986) reported that when panicles of litchi fruits were sprayed with 0.5 per cent, 1 per cent and 1.5 per cent $ZnSO_4$, GA_3 at 50, 75 and 100 ppm and NAA at10, 25 and 50 ppm, growth regulators treatment proved more effective in improving fruit weight and quality of litchi fruits as compared to trace elements.

Brar *et al.* (1990) reported highest juice and TSS content and lowest acidity in Kinnow mandarin with the foliar application of 400 ppm NAA.

Sharma and Awasthi (1990) noted that fruit acidity was inversely proportional to fruit size in Kinnow fruits. Foliar application of 350 ppm NAA to Kinnow fruits recorded the highest fruit weight as compared to other treatments but the acidity of fruits was lowered than control.

Kaur *et al.* (1993) observed that highest percent pulp and lowest percent peel were obtained with the GA (15 ppm), NAA(200 and 300 ppm), $ZnSO_4$, B and $FeSO_4$ + B treatments. The GAand NAA treatments also resulted in the highest percent juice content of fruits. Highest TSS contents were obtained with the B, $FeSO_4$ + B and $MnSO_4$ + B treatments. All growth

regulator and micronutrient treatments increased fruit acidity in sweet orange cv. Jaffa.

Ebeed *et al.* (2001) reported that the spraying the trees with Fe + Zn + Mn, Fe + Mn and NAA had a beneficial effect on reducing fruit drop percentage. Spraying the trees with NAA, and Fe + Zn + Mn increased tree yield, fruit weight, pulp weight, and pulp/fruit weight. Zn or Mn spray proved to be effective in increasing total soluble solids (TSS) and TSS/acid ratio of fruit juice of mango cv. Mesk.

Sharma *et al.* (2003) reported that, the application of $ZnSO_4$ (0.5 %) + 2, 4, 5-T (20 ppm) on 10 year old kagzi lime trees sprayed on the first week of January increased the fruit weight, volume and number of seeds per fruit and also increased the acidity, ascorbic acid and TSS while maximum juice was found with $ZnSo_4$ (0.5 %) + GA_3 (50 ppm).

Sharma *et al.* (2005) studied the effect of plant bio regulators (PBRs) and micronutrients on fruit set and quality of litchi cv. Dehradun and reported that TSS was highest under SADH at 1000 ppm, NAA at 5 ppm and B at 200 ppm. NAA at 2.5ppm produced the highest ascorbic acid content (39.76 mg/100ml juice).

Das *et al.* (2009) studied the effect of different commercial formulation of growth regulators and micronutrients on some physical and quality attributes of fruits of pineapple during 2006-07. Seven different treatment combination of commercial formulation of growth regulators (cytozyme and biozyme) and micronutrients (tracel-2) were evaluated against the control (distilled water). Though each formulation has beneficial role in improving the fruit physical and quality characters of fruits of pineapple, the treatment combination cytozyme at 0.10% + tracel 2 at 0.40 % was the best in this regard.

Kachave and Bhosale (2009) carried out experimentation fifteen-year old Kagzi lime orchard which he treated with two plant growth regulator,

NAA (100 ppm and 200 ppm) and GA (50ppm) single and in combination with micronutrient (0.5 and 1 %spray) at flowering and pea size fruit stage, result revealed that NAA 200 ppm + micronutrients mixture 1 % spray is the best treatment for increasing total soluble solids, acidity, ascorbic acid, reducing sugar of fruit and chlorophyll-b content of leaf.

Yadlod *et al.* (2009) reported in banana cv. Shrimanti that Maximum TSS (21.70 %) and reducing sugar (12.90 %), was recorded with IAA 80 ppm. Maximum non-reducing sugar (3.84%) was observed in two sprays of 1 % micronutrient mixture and minimum in control (3.05 %). Maximum Vit. C (0.98 mg/100 ml juice) was observed in GA_3 80 ppm which was significantly superior over all the treatments and minimum in one spray of 1% micronutrient mixture (0.69 mg/100 ml juice).

Hassan *et al.*(2010) studied the effect of foliar sprays of Aminofert (20 % Amino acid, 12 % organic acids, and 3.6 % chelated micro-elements) gibberellins and a mixture of chelated (Fe, Zn, Mn) alone or in combination (GA_3 + Aminofert or GA + amixture of chelated Fe, Zn, Mn) on fruit quality and leaf mineral content and reported that the treatments increased significantly fruit characteristics (firmness, TSS, acidity) under all treatments as compare to control in Hollywood plum trees.

Debaje *et al.* (2011) reported that two foliar spray of KNO_3 (2 %) and GA_3 100 ppm in acid lime increased fruit weight, fruit volume and improved fruit quality. Maximum juice percentage, TSS and ascorbic acid content was obtained where as acidity and peel percentage was reduced resulting in to better quality fruit.

Anees *et al.* (2011) studied the effect of foliar application of micronutrients on the quality of Mango (mangifera indica L.) cv. Dashehri fruit and observed that trees sprayed with 0.4 % $FeSO_4$ + 0.8 % H_3BO_3 + 0.8 % $ZnSO_4$ showed maximum pulp weight (169.28 g), total soluble solids (27.9 ^{0}Brix), ascorbic acid (150.3 mg/100 ml) and non reducing sugar (8.83 %) and

less stone weight (28.13 g) along with low acidity (0.178 %) in comparison to rest of the treatments and control.

Jagtap *et al.* (2013) carried out experiment in acid lime cv. Kagzi and revealed that quality attributing characters like total soluble solids (9.58 ^{0}Brix) and ascorbic acid content (30.41mg/100 g pulp) were significantly increased while number of seeds per fruit (6.13) and acidity (7.05 %) were significantly decreased under treatment GA_3 50 mg/lit.

Prasad *et al*. (2013) reported that the quality of kinnow fruits were significantly influenced by the application of zinc and iron fertilizers (0.25, 0.50 % and 0.75 %). Maximum good quality was observed with two sprays at one month interval of 0.5 % $ZnSO_4$ and 0.5 % $FeSO_4$.

Gurjar and Rana (2014) studied the influence of foliar application of nutrients and growth regulators on fruit drop, yield and fruit size and quality in kinnow mandarin and observed that TSS (10.6 ^{0}Brix) and ascorbic acid was highest with KNO_3 2 % + $ZnSO_4$ 0.5 %.

MATERIALS AND METHODS

CHAPTER-III

MATERIALS AND METHODS

The experiment on "Effect of foliar application of plant growth regulators and micronutrients on growth, yield and quality of Acid lime ***(****Citrus aurantifolia L.)* Cv. Sai sarbati". Research conducted at Sweet Orange Research Station, Badnapur. The treatment combination of different plant growth regulator and micronutrient mixture on selected and three replication is carried out on randomized block design in *Ambia bahar* and observation recorded at different stages of plant.

3.1 Experimental material.

The experiment was carried out on five years old acid lime cv. Sai Sarbati plants. For this study 39 representative uniform plants of the cultivar Sai Sarbati were selected in *Ambia bhar* of 2017. One trees were used for each treatment.

3.2 Experimental methods

3.2.1 Location

The present experiment was conducted on the Sweet Orange Research Station, Badnapur, Tq. Badnapur, Dist. Jalna (MS) during the year 2016-2017.

3.1.2 Agro-climatic conditions

Geographically, College of Agricultural Badnapur is situated at 409 m above mean sea level at 19.50^0 latitude and 47.53^0C longitudes with an altitude of 520 meters. The average rainfall of the station is about 650 mm received mostly during June to September. The minimum and maximum temperature during the last five years were 15.25 and 43.85^0 and the mean relative humidity ranges from 30 to 90 per cent and rainfall in recent year (2016-17) is 662 mm.

The meteorological data during the course of investigation for the year 2016-2017 was recorded in respect of maximum and minimum

temperature, rain fall and humidity at Agriculture Research Station, Badnapur during the period of experimentation are furnished in Appendix I.

3.1.3 Soil

The Badnapur area is dominated by black soil formed from basalt rock originated through volcanic eruption belongs to order vertisols. The soil is dominant in montmorillonite followed by moderate amount of kaolinite and traces of ellite.

On the basis of soil depth and texture, the soil have been classified in to deep black to medium black and shallow black soil. The soil is characterized by black colour dominated by montmorillonite clay with high coefficient of expansion when wet and shrinkage in summer leading to deep cracking. The soil is alkaline in reaction saturation.

3.2.2 Design and layout of experiment

1.	Name of crop	Acid lime
2.	Family	Rutaceae.
3.	Variety	Sai sarbati.
4.	Age of orchard	5 Years.
5.	Spacing	5 X 5 m.
6.	Number of treatments	13
7.	Number of replication	03
8.	Experimental design	Randomized block design.
9.	Number of plants / treatment	01
10.	Total number of plants	39
11.	Season	*Ambia bahar* 2017.

3.2.3 Treatment Details

Sr. No.	Treatment
T_1	Control
T_2	GA_3@50ppm
T_3	NAA@100ppm
T_4	$ZnSO_4$@0.5%
T_5	$FeSO_4$@0.5%
T_6	$ZnSO_4$@1.0%
T_7	$FeSO_4$@1.0%
T_8	$ZnSO_4$@0.5%+$FeSO_4$@0.5%
T_9	$ZnSO_4$@1.0%+$FeSO_4$@1.0%
T_{10}	GA_3@50ppm+$ZnSO_4$@0.5%+$FeSO_4$@0.5%
T_{11}	GA_3@50ppm+$ZnSO_4$@1.0+$FeSO_4$@1.0%
T_{12}	NAA@100ppm+$ZnSO_4$@0.5+$FeSO_4$@0.5%
T_{13}	NAA@100ppm+$ZnSO_4$@1.0%+$FeSO_4$@1.0%

3.2.4 Scheduling of spraying

The plant growth regulators and micronutrients were sprayed at two times. First spraying of plant growth regulators and micronutrients was carried at petal fall stage in the second week of March and second spraying 45 days after first spray separately in the last week of April, 2017. Spraying was done early in the morning. Each tree was sprayed heavily by taking care to wet the complete tree. It was fully ensured that all the sides of the tree were covered completely by the spray solution.

3.2.5 Manuring

A manure dose of 20 kg farmyard manure + 15 kg neem cake and fertilizer dose of 800g N: 300g P_2O_5 : 600 g K_2O per tree was applied in the form of urea, single superphosphate and muriate of potash in two split doses. First half dose of nitrogen along with full doses of P_2O_5, K_2O and FYM + 15 kg neem cake was applied at second irrigation after stress in January and second half dose of nitrogen was applied 45 days after first dose near the feeding root zone of the tree and mixed thoroughly with the soil.

3.2.3 Preparation of spray solution

Solutions of micronutrients were prepared by dissolving requisite amount of micronutrients in the water and making the final volume to 12 litres. Thus, for preparation of 0.5 % solution, 60 g of micronutrients was dissolved in distilled water and final volume made to 12 litre and for 1 % solution, 120 g of micronutrients was dissolved in distilled water and made final volume to 12 litres. The micronutrients used for making different solutions were of laboratory grade reagents.

Thousand ppm stock solution of growth regulator was prepared by dissolving 1 g of of GA_3 and 1g of NAA in small quantity of acetone and making the final volume to 1 litre each, respectively by adding demineralised water to it. From this stock solution, required quantity was taken out and diluted to make the concentration of desired quantity strength for spraying. The stock solution was prepared fresh at the time of spraying

3.3 Observations recorded

3.3.1 Growth observations

3.3.1.1 Days required for initiation of new vegetative flush

The days of required for initiation of new vegetative flush was measured after giving bahar treatment of plants.

3.3.1.2 Days required for flower initiation

The days of required for flower initiation was measured after giving bahar treatment of plants.

3.3.1.3 Number of flowers/shoot

Visual observations for position of flower intensity on shoot were observed during flowering and described as maximum on the middle of the shoot, maximum on middle to upper part of the shoot, scattered from basal to upper part of the shoot according to the nature of flower intensity on shoot observed. Randomly five flowering shoots per tree per replication were selected and number of flowers per shoot recorded and average was worked out per treatment. Labeling was done on every shoot to count the number of flowers per shoot.

3.3.1.4 Plant height (m)

The plant height was measured with the help of measuring tape in meters before spraying and after the harvest of fruits.

3.3.1.5 Plant spread (m)

The volume occupied by plant canopy was measured in E-W and N-S direction and canopy height with the help of measuring scale and plant canopy volume was calculated by taking E-W and N-S plant spread in m3.

3.3.1.6 Fruit drop (%)

The fruit drop per cent was calculated by following equation:

$$\text{Fruit drop}(\%) = \frac{\text{Total number of fruit set} - \text{Total number of fruit at Harvest time}}{\text{Total number of fruits}} \times 100$$

3.3.2 Yield parameters

3.3.2.1 Number of fruits per tree

The fruits were plucked up when they were matured and counted separately for each experimental tree. All the fruits were harvested at once and number of fruits per plant was recorded.

3.3.2.2 Fruit weight

Four randomly selected fruits from each treatment were taken and weight of individual fruit was recorded on electronic balance and average weight of all the four fruits was computed in gram.

3.3.2.3 Fruit yield

The picked fruits from each experimental tree were weighed immediately after harvesting and yield per tree was recorded in kg per tree and later as computed in tones per hectare.

3.3.2.2 Per cent of fruit set

Randomly five shoot were selected for recording fruit set. From each shoot initially number of fruits per shoot counted and at harvesting number of fruits retained per shoot counted by using following formula.

$$\text{Fruit set (\%)} = \frac{\text{No. of initial fruits / shoot}}{\text{No. of flowers / shoot}} \quad x100$$

3.3.2.3 Number of fruits per tree

Fruits of each tree in every treatment and replication were counted at each harvesting. After all harvesting it was summed up and average number of fruits per tree was computed.

3.3.2.4 Average fruit weight (g)

The weight of five observational fruit was recorded on the top pan balance. The values were summed up and average fruit weight was computed by dividing total weight of fruits by total number of fruits.

3.3.2.5 Yield per tree (kg)

At each picking, the weight of the harvested fruits from each tree under a treatment was recorded. The sum total of each picking was worked out for each tree. The average for a tree was computed and presented. Yield per tree (kg) was calculated by the following formula.

$$\text{Yield per/tree (Kg)} = \frac{\text{Total number of fruits / tree X Average fruit Weight (g)}}{1000}$$

3.3.2.6 Fruit volume (ml)

The volume of five randomly selected fruit was measured separately by the water displacement method. The mean volume of the fruit for each treatment was calculated separately and presented.

3.3.3 Quality parameters

3.3.3.1 Juice (%)

The juice from fruit was extracted by lemon squeezer. The percentage of juice content was calculated in relation to weight of fruit for each treatment

3.3.3.2 Total soluble solids (°Brix)

The total soluble solids was recorded with the help of Erma Hand refractometer (0-32 0Brix). A drop of juice was placed on the prism facing the light source and value was recorded. Care was also taken to clean the prism with distilled water and dry it before taking next reading.

3.3.3.3 Acidity (%)

The titrable acidity of the juice was determined according to the method given in A.O.A.C. (1975). For this, 10 ml of juice was titrated against 0.1 N NaOH solution using phenolphthalein as an indicator. The acidity was expressed as per cent citric acid.

Acidity (%) = 0.064 x Burette reading

3.3.3.4 Ascorbic acid (mg / 100 ml juice)

Ascorbic acid content was estimated by the procedure described by Ranganna (1979) by using 2,6 dichlorophenol dye as an oxidizing agent for titration. The ascorbic acid content of the juice was estimated on fresh weight basis and expressed as mg/100 ml juice of fruit. The ascorbic acid content less

than 100 mg /100 ml pulp was termed as fair, those between 100 to 200 mg as good and those above 200 mg as high.

3.3.3.5 Reducing sugar (%)

The reducing sugar from juice was estimated as per the method described by Ranganna (1979) and expressed in percentage. Fifty ml composite juice sample of the same kind of juice was taken and precipitated by using 2 ml neutral lead acetate (45 %). After 10 minutes, 1.8 ml of potassium oxalate (22 %) was added to delead the sample solution and then the final volume was made upto 250 ml. After filtration, the filtrate was used for estimating reducing sugar by titrating it against Fehling solution (Fehling A and B in 1 : 1 proportion) at boiling temperature with an end point as brick red by using methyl blue as an indicator.

$$\text{Reducing sugar (\%)} = \frac{50}{\text{Burette reading}} \times 100$$

3.3.3.6 Non-reducing sugar (%)

It was calculated by subtracting the value of the reducing sugar from total sugar of the juice from each sample separately.

3.3.3.7 Total sugar (%)

Total sugar was estimated by the same method as that of reducing sugar. For this, 50 ml clean filtrate was taken in 50 ml volumetric flask and 5 ml of 35 per cent hydrochloric acid (HCL) was added to it. This was hydrolysed for half an hour in hot water bath. After hydrolyzing, the excess acid was neutralized by sodium carbonate (40 %) and the volume was made to 250 ml. It was then titrated against 5 ml each of Fehling A and Fehling B solutions using methyl blue as an indicator.

$$\text{Total sugar (\%)} = \frac{250 \text{ ml}}{\text{Burette reading}} \times 100$$

3.3.3.8 Peel (%)

The peel percentage of each fruit was measured by a taking of weight of peel and presented in percentage.

3.4 Statistical analysis

The data recorded was statistically analyzed by using the technique of analysis of variance as suggested by Panse and Sukhatme (1987).

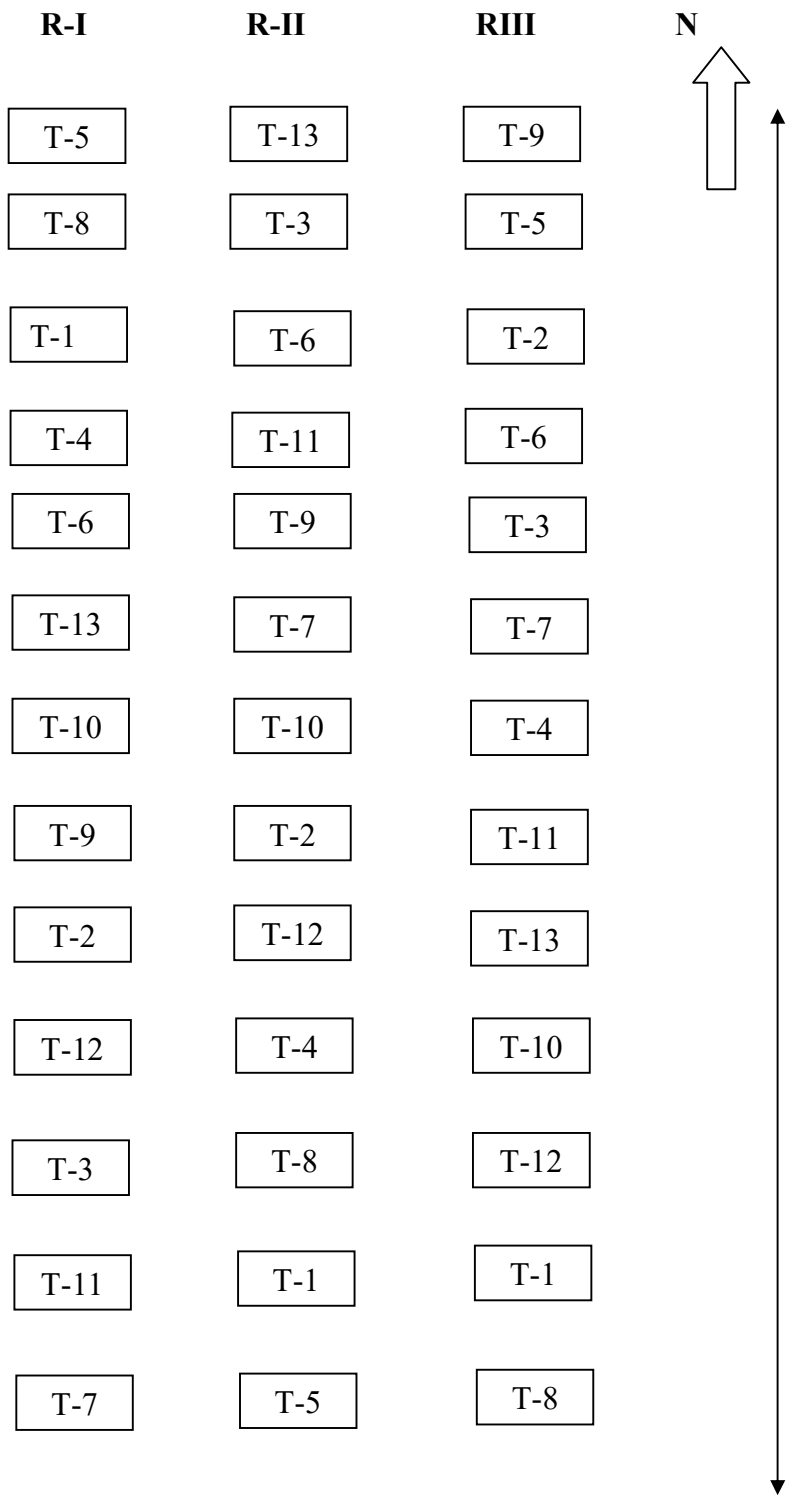


Fig.1. Plan of experimental layout

Plate No. 1 General view of experimental plot.

RESULTS

CHAPTER-IV

EXPERIMENTAL RESULTS

The experiment on "Effect of foliar application of plant growth regulators and micronutrients on growth, quality and yield of Acid lime ***(****Citrus aurantifolia L.)* Cv. Sai sarbati." Research conducted at Sweet Orange Research Station, Badnapur. The treatment combination of different plant growth regulator and micronutrient mixture on selected plants three replication is carried out on randomized block desine in *Ambia bahar* in the year 2016 . The results obtained in investigation are presented in this chapter under appropriate headings.

4.1 Growth parameters

4.1.1 Plant height (m)

The data pertaining to increase in plant height as influenced by plant growth regulators and micronutrients are presented in Table No 1. and Fig No.2. It was observed that the plant growth regulators and micronutrients influenced the increase in plant height of acid lime.

The data revealed that, though the results was nonsignificant the maximum increase in plant height (0.25 m) was recorded in T_{11}, GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%), followed by T10 (GA_3 @ 50 ppm +$ZnSO_4$ @0.5% +$FeSO_4$ @ 0.5%(0.20 m). While the minimum increase in plant height (0.04) was recorded in control (T_1).

Table 1. Effect of foliar application of plant growth regulators and micronutrients on height of acid lime.

Sr. No.	Treatment details	Plant height before spraying (m)	Plant height after spraying (m)	Increase in plant height (m)
T_1	Control	3.30	3.35	0.05
T_2	GA_3 @ 50ppm	3.55	3.63	0.08
T_3	NAA @ 100ppm	3.55	3.61	0.06
T_4	$ZnSO_4$ @ 0.5%	3.50	3.55	0.05
T_5	$FeSO_4$ @ 0.5%	3.55	3.63	0.08
T_6	$ZnSO_4$ @ 1.0%	3.30	3.45	0.15
T_7	$FeSO_4$ @ 1.0%	3.35	3.50	0.15
T_8	$ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5%	3.25	3.35	0.10
T_9	$ZnSO_4$ @ 1.0% + $FeSO_4$ @ 1.0%	3.55	3.60	0.05
T_{10}	GA_3 @ 50 ppm +$ZnSO_4$ @0.5% +$FeSO_4$ @ 0.5%	3.50	3.70	0.20
T_{11}	GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%	3.60	3.85	0.25
T_{12}	NAA @ 100ppm + $ZnSO_4$ @0.5% + $FeSO_4$ @ 0.5%	3.40	3.48	0.08
T_{13}	NAA @ 100ppm +$ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%	3.60	3.64	0.04
	S.E.m ±	**0.17**	**0.17**	
	C.D at 5%	**NS**	**NS**	

4.1.2 Plant spread

4.1.2 East-West spread (m)

The data revealed that, the maximum increase in east-west spread was presented in Table No 2. and Fig no. 3. The significantly maximum east-west spread (3.74 m) was recorded in the treatment T_{11}. Which was statistically at par with T_{12}, T_{13} and T_{10}. Whereas, minimum east-west spread (2.34 m) was observed in treatment T_1 (control).

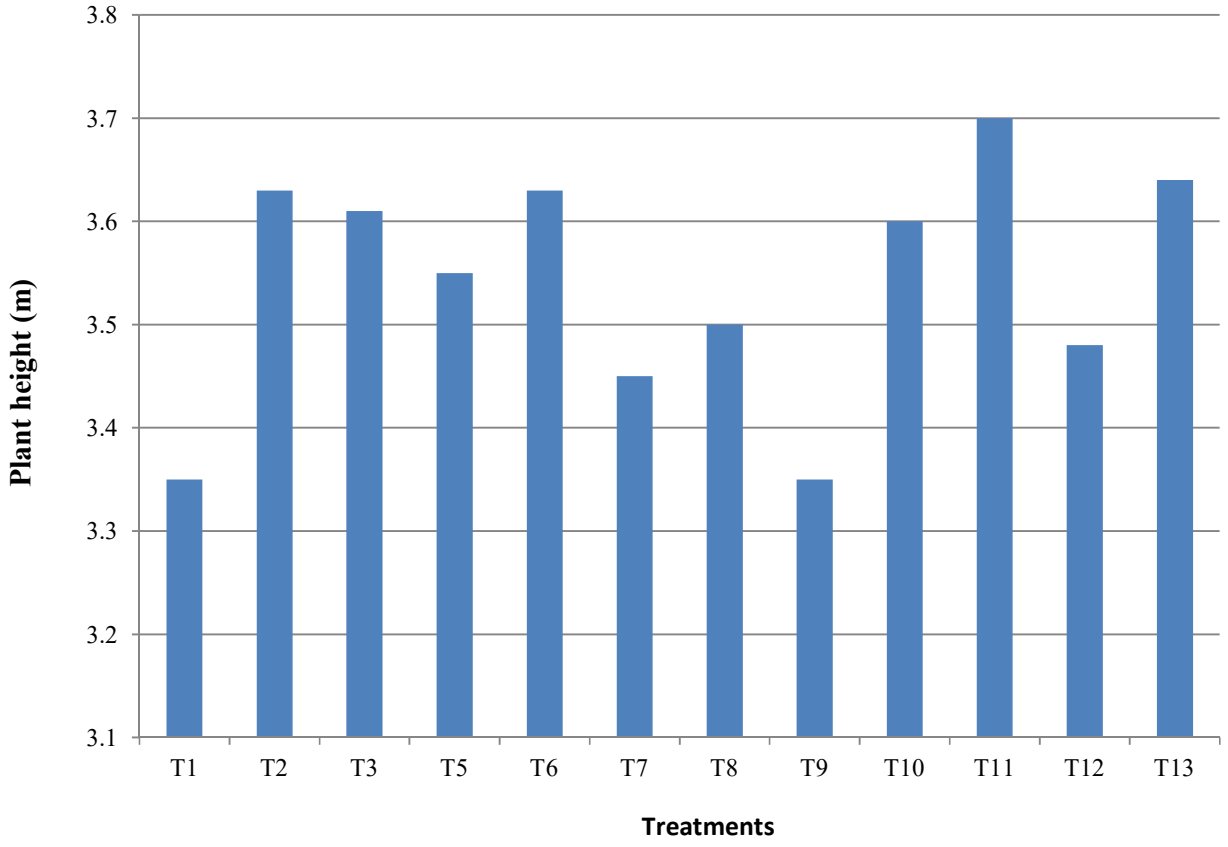


Fig. 2. Effect of foliar application of plant growth regulators and micronutrient on height of acid lime.

Table 2. Effect of foliar application of various plant growth regulators and micronutrients on plant spread of acid lime.

Sr. No.	Treatment details	East–West spread (m).	North-south spread (m).
T_1	Control	2.37	2.84
T_2	GA_3 @ 50ppm	2.84	3.06
T_3	NAA @ 100ppm	3.00	3.12
T_4	$ZnSO_4$ @ 0.5%	3.02	3.07
T_5	$FeSO_4$ @ 0.5%	3.07	3.06
T_6	$ZnSO_4$ @ 1.0%	3.08	3.11
T_7	$FeSO_4$ @ 1.0%	3.03	3.16
T_8	$ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5%	3.01	3.15
T_9	$ZnSO_4$ @ 1.0% + $FeSO_4$ @ 1.0%	3.17	3.29
T_{10}	GA_3 @ 50 ppm +$ZnSO_4$ @0.5% +$FeSO_4$ @ 0.5%	3.60	3.41
T_{11}	GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%	3.74	3.54
T_{12}	NAA @ 100ppm + $ZnSO_4$ @0.5% + $FeSO_4$ @ 0.5%	3.40	3.43
T_{13}	NAA @ 100ppm +$ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%	3.51	3.50
	S.E.m ±	**0.16**	**0.18**
	C.D at 5%	**0.47**	**0.53**

4.1.3 North-South spread (m)

The data pertaining to North- south spread is presented in Table No 2. and Fig No.3. The significantly maximum east-west spread (3.54 m) was recorded in the treatment T_{11} which was statistically at par with T_8,T_7,T_9,T_{10},T_{12} and T_{13}. Whereas, minimum east-west spread (2.84 m) was observed in treatment T_1 (control).

4.1.4. Days required for initiation of new vegetative flush

The data regarding days required for initiation of new vegetative flush after first irrigation and first spraying is presented in Table No 3. and Fig No.4. The significantly minimum days required for initiation of new vegetative flush (17.00) was recorded in the treatment $T_{11.}$Which was statistically at par with $T_{10.}$Where as, maximum days (27.33) was observed in treatment T_1

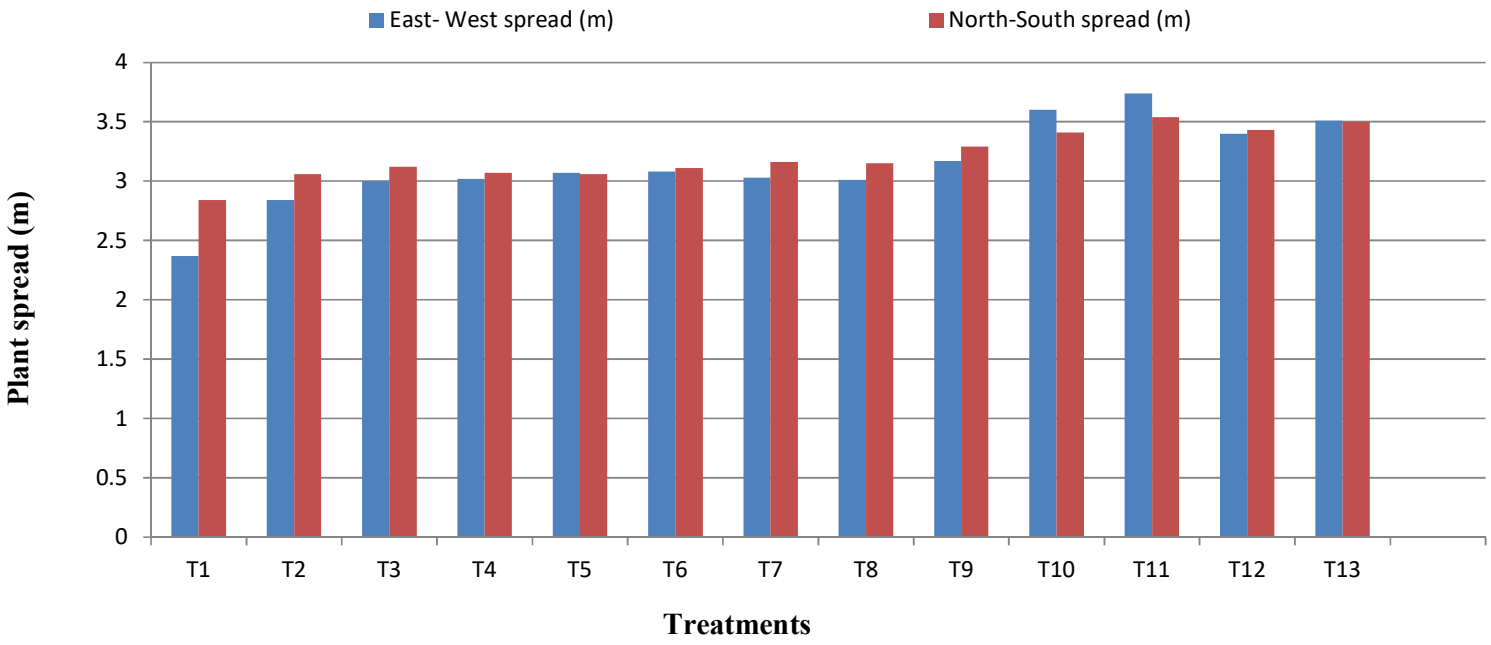


Fig. 3. Effect of foliar application of plant growth regulators and micronutrients on plant spread of acid lime.

(control).The data clearly showed that, different vegetative characters' of acid lime like days required for new vegetative flush and were significantly influenced due to different combination of plant growth regulators and micronutrients .

4.1.5. Days required for flower initiation

The data regarding days required for flowering and fruit set to maturity of sweet orange fruit influenced due to different treatments of biofertilizers and chemical fertilizers are tabulated in Table No. 3. respectively and depicted graphically in Fig. No.4. The significantly minimum days required for flower initiation (14.00) was found in T_{11} Which was statistically at par with T_{10} and $T_{13.}$ Where as minimum maximum days (24.00) was observed in T_1 (control)

Table 3. Effect of foliar application of plant growth regulators and micronutrients on days required for new vegetative flush and days required for flower initiation of acid lime

Sr. No.	Treatment details	Days required for new vegetative flush	Days required for flower initiation
T_1	Control	27.33	24.00
T_2	GA_3 @ 50ppm	27.56	22.33
T_3	NAA @ 100ppm	27.90	22.00
T_4	$ZnSO_4$ @ 0.5%	28.33	20.00
T_5	$FeSO_4$ @ 0.5%	27.33	23.50
T_6	$ZnSO_4$ @ 1.0%	29.33	21.33
T_7	$FeSO_4$ @ 1.0%	28.33	23.05
T_8	$ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5%	26.05	22.09
T_9	$ZnSO_4$ @ 1.0% + $FeSO_4$ @ 1.0%	25.03	20.33
T_{10}	GA_3 @ 50 ppm +$ZnSO_4$ @0.5% +$FeSO_4$ @ 0.5%	20.00	15.67
T_{11}	GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%	17.00	14.00
T_{12}	NAA @ 100ppm + $ZnSO_4$ @0.5% + $FeSO_4$ @ 0.5%	27.50	18.57
T_{13}	NAA @ 100ppm +$ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%	24.33	16.33
	S.E.m ±	**1.22**	**1.30**
	C.D at 5%	**3.56**	**3.80**

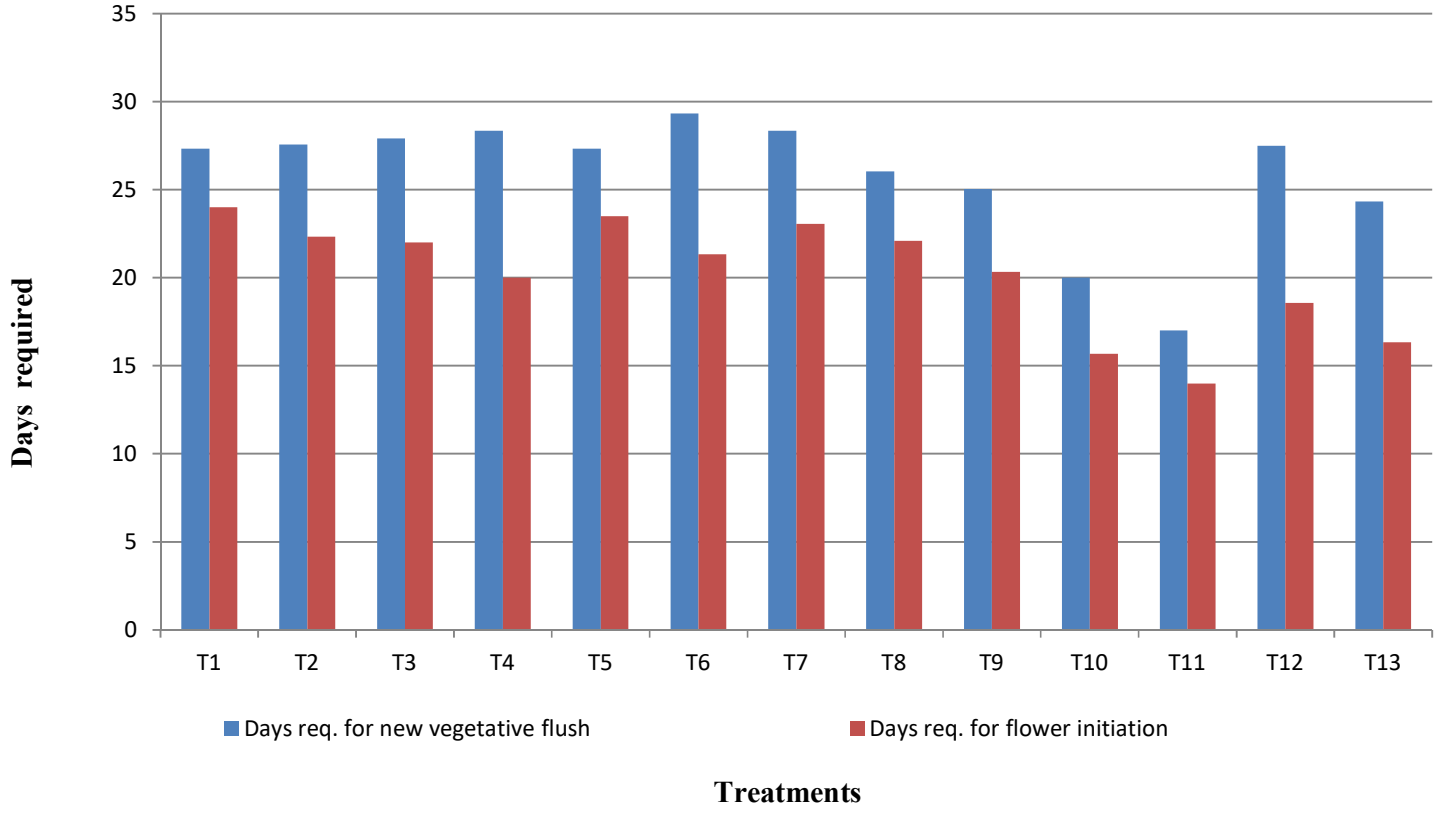


Fig. 4. Effect of foliar application of plant growth regulators and micronutrients on days required for new vegetative flush and flower initiation

Table 4. Effect of foliar application various plant growth regulators and micronutrients on number of flowers per shoot in acid lime

Sr. No.	Treatment details	Number of flower per shoot
T_1	Control	8.33
T_2	GA_3 @ 50ppm	9.45
T_3	NAA @ 100ppm	9.90
T_4	$ZnSO_4$ @ 0.5%	10.06
T_5	$FeSO_4$ @ 0.5%	13.90
T_6	$ZnSO_4$ @ 1.0%	14.10
T_7	$FeSO_4$ @ 1.0%	15
T_8	$ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5%	15.90
T_9	$ZnSO_4$ @ 1.0% + $FeSO_4$ @ 1.0%	16.30
T_{10}	GA_3 @ 50 ppm +$ZnSO_4$ @0.5% +$FeSO_4$ @ 0.5%	17.45
T_{11}	GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%	18.57
T_{12}	NAA @ 100ppm + $ZnSO_4$ @0.5% + $FeSO_4$ @ 0.5%	16.90
T_{13}	NAA @ 100ppm +$ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%	17.65
	S.E.m ±	**2.25**
	C.D at 5%	**6.65**

4.2.7 Number of flowers per shoot

The data showed that the number of flowers per shoot is presented in Table No.4 respectively and depicted in Fig No.5. The significantly maximum number of flowers (18.57/shoot) was recorded in the treatment T_{11} (GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%). It was statistically at par with T_5,T_6,T_7,T8,T_9,T_{10},T_{12} and T_{13} Whereas, minimum number of flowers (8.33/shoot) was observed in treatment T_1 (control).

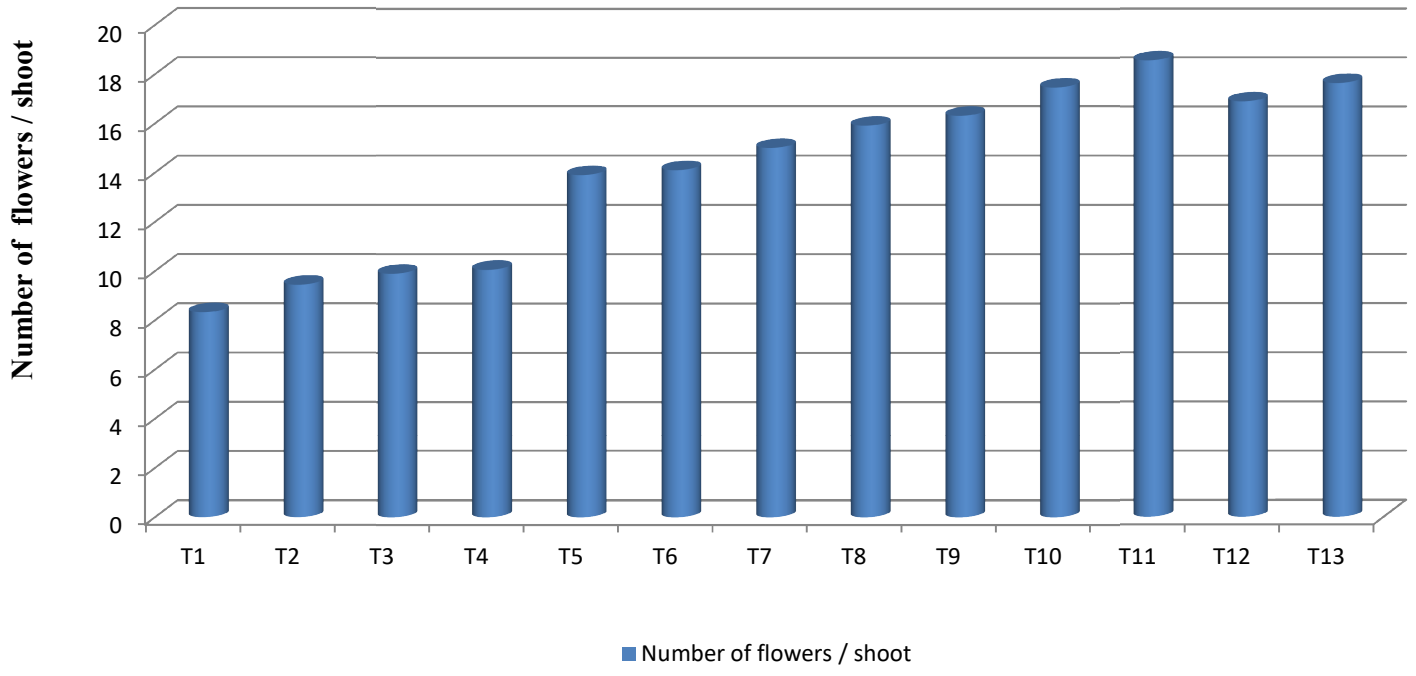


Fig. 5. Effect of foliar application of plant growth regulators and micronutrients on number of flowers / shoot in acid lime.

Table 5. Effect of foliar application of plant growth regulators and micronutrients on days required for harvesting in acid lime.

Sr. No.	Treatment details	Days required for harvesting
T_1	Control	162.33
T_2	GA_3 @ 50ppm	160.00
T_3	NAA @ 100ppm	159.00
T_4	$ZnSO_4$ @ 0.5%	158.33
T_5	$FeSO_4$ @ 0.5%	161.00
T_6	$ZnSO_4$ @ 1.0%	157.67
T_7	$FeSO_4$ @ 1.0%	156.67
T_8	$ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5%	154.85
T_9	$ZnSO_4$ @ 1.0% + $FeSO_4$ @ 1.0%	153.09
T_{10}	GA_3 @ 50 ppm +$ZnSO_4$ @0.5% +$FeSO_4$ @ 0.5%	147.67
T_{11}	GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%	144.00
T_{12}	NAA @ 100ppm + $ZnSO_4$ @0.5% + $FeSO_4$ @ 0.5%	151.68
T_{13}	NAA @ 100ppm +$ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%	150.00
	S.E.m ±	**2.75**
	C.D at 5%	**8.03**

4.1.5. Days required for harvesting

The data pertaining days required for harvesting is presented in Table No.5 and Fig No..6. The significantly minimum days required for harvesting (144.00) was recorded in the treatment T_{11} which was statistically at par with T_{10}, T_{13} and T_{12}. Whereas, maximum days (162.33) was observed in treatment T_1 (control).

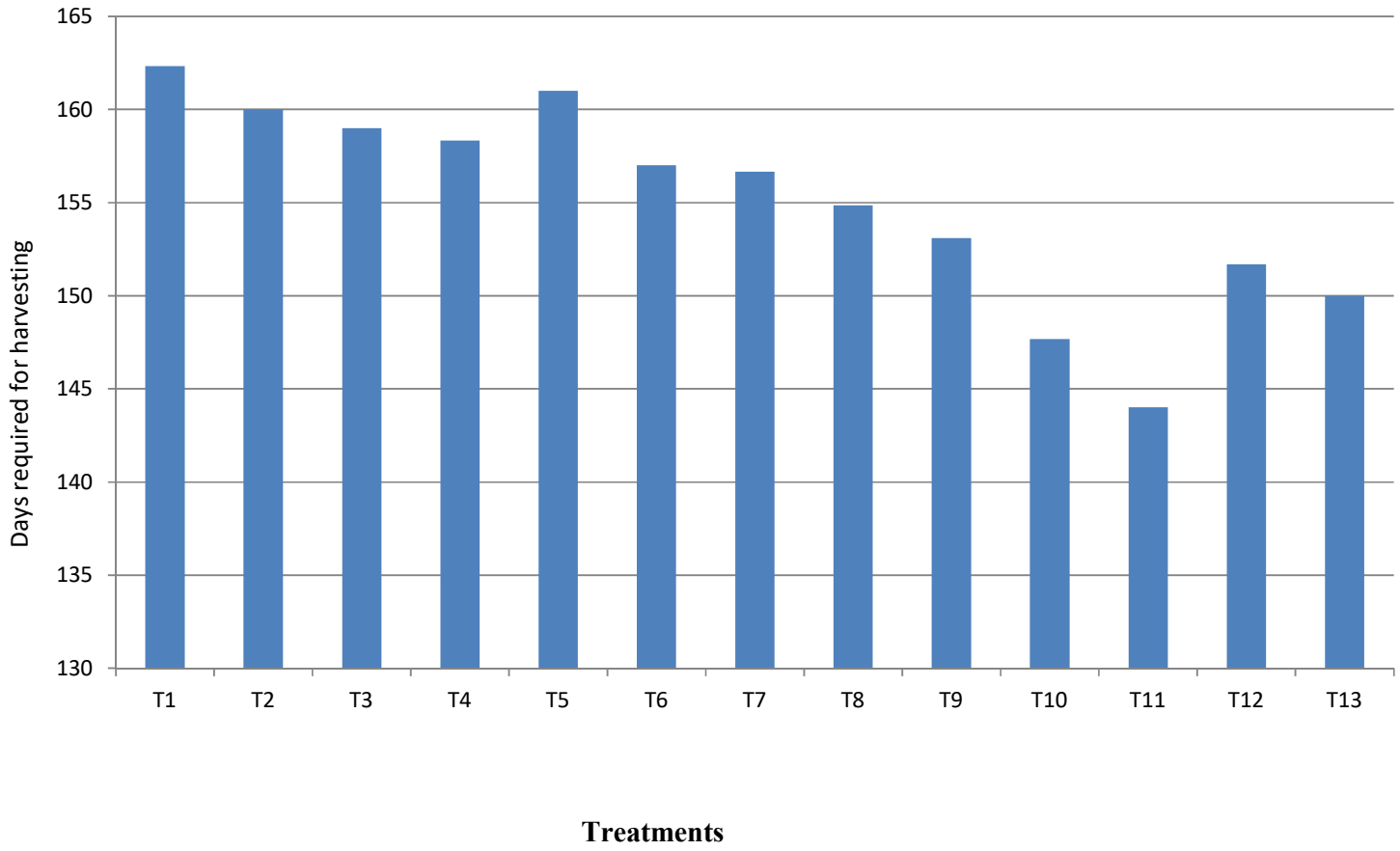


Fig .6. Effect of foliar application of plant growth regulators and micronutrients on days required for havesting of acid lime

4.2 Yield parameters

4.2.1 Weight of fruit (g)

It is cleared from data, the maximum weight of fruit is presented in Table No.6 and depicted in Fig.7. The significantly maximum weight of fruit (43.33 g) was recorded in the treatment T_{11} (GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%). Which was statistically at par with T_9, T_{10} and T_{12}, T_{13}. Whereas, minimum weight of fruit (34.50 g) was observed in treatment T_1 (control).

4.2.2 Volume of fruit (ml)

The data showed that the maximum volume of fruit (41.30 ml) was recorded in the treatment T_{11} (GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%). Which was statistically at par with T_{13} and $T_{10.}$ Where as, minimum volume of fruit (30.90 ml) was observed in treatment T_1 (control). Presented in Table No 6 and Fig.7.

Table 6. Effect of foliar application of various plant growth regulators and micronutrients on weight of fruit (g) and volume of fruit (ml) in acid lime

Sr. No.	Treatment details	Weight of fruit (g)	Volume of fruit (ml)
T_1	Control	34.50	30.90
T_2	GA_3 @ 50ppm	35.07	32.03
T_3	NAA @ 100ppm	35.99	32.50
T_4	$ZnSO_4$ @ 0.5%	35.98	32.33
T_5	$FeSO_4$ @ 0.5%	36.65	34.98
T_6	$ZnSO_4$ @ 1.0%	36.80	34.50
T_7	$FeSO_4$ @ 1.0%	36.06	35.05
T_8	$ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5%	37.10	36.10
T_9	$ZnSO_4$ @ 1.0% + $FeSO_4$ @ 1.0%	38.08	37.15
T_{10}	GA_3 @ 50 ppm +$ZnSO_4$ @0.5% +$FeSO_4$ @ 0.5%	40.20	38..05
T_{11}	GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%	43.33	41.30
T_{12}	NAA @ 100ppm + $ZnSO_4$ @0.5% + $FeSO_4$ @ 0.5%	39.06	35.04
T_{13}	NAA @ 100ppm +$ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%	40.16	37.90
	S.E.m ±	**1.85**	**1.29**
	C.D at 5%	**5.41**	**3.76**

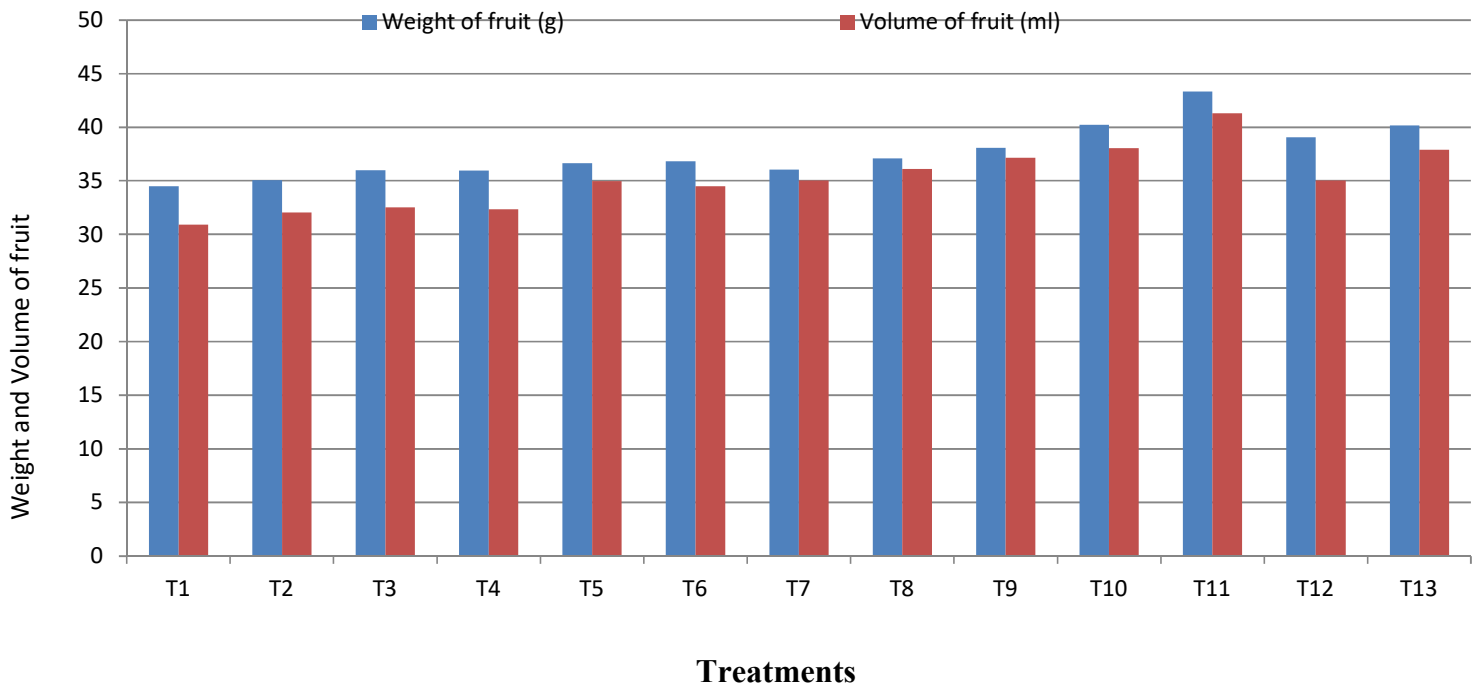


Fig . 7. Effect of foliar application of plant growth regulators and micronutrients on weight of fruit (g) and volume of fruit (ml) in acid lime

4.2.3 Number of fruit per tree

The data pertaining number of fruit per tree is presented in Table No. 7 and Fig.8 The significantly maximum number of fruit (148.00 fruit/tree) was recorded in the treatment T11 (GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%). Which was statistically at par with T_8, T_9, T_{10}, T_{12} and T_{13}. Whereas, minimum number of fruit (94.33) was observed in treatment T_1 (control).

Table 7. Effect of foliar application of various plant growth regulators and micronutrients on number of fruit / tree and yield / tree (kg) in acid lime

Sr. No.	Treatment details	Number of fruit/tree	Yield /tree (Kg)
T_1	Control	94.33	3.25
T_2	GA_3 @ 50ppm	126.67	4.44
T_3	NAA @ 100ppm	110.00	3.95
T_4	$ZnSO_4$ @ 0.5%	113.0	4.06
T_5	$FeSO_4$ @ 0.5%	117.00	4.28
T_6	$ZnSO_4$ @ 1.0%	120.33	4.41
T_7	$FeSO_4$ @ 1.0%	122.67	4.41
T_8	$ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5%	134.67	5
T_9	$ZnSO_4$ @ 1.0% + $FeSO_4$ @ 1.0%	137.00	5.28
T_{10}	GA_3 @ 50 ppm +$ZnSO_4$ @0.5% +$FeSO_4$ @ 0.5%	145.00	5.82
T_{11}	GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%	148.00	6.41
T_{12}	NAA @ 100ppm + $ZnSO_4$ @0.5% + $FeSO_4$ @ 0.5%	139.33	5.45
T_{13}	NAA @ 100ppm +$ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%	142.33	5.71
	S.E.m ±	**6.50**	**0.39**
	C.D at 5%	**18.97**	**1.25**

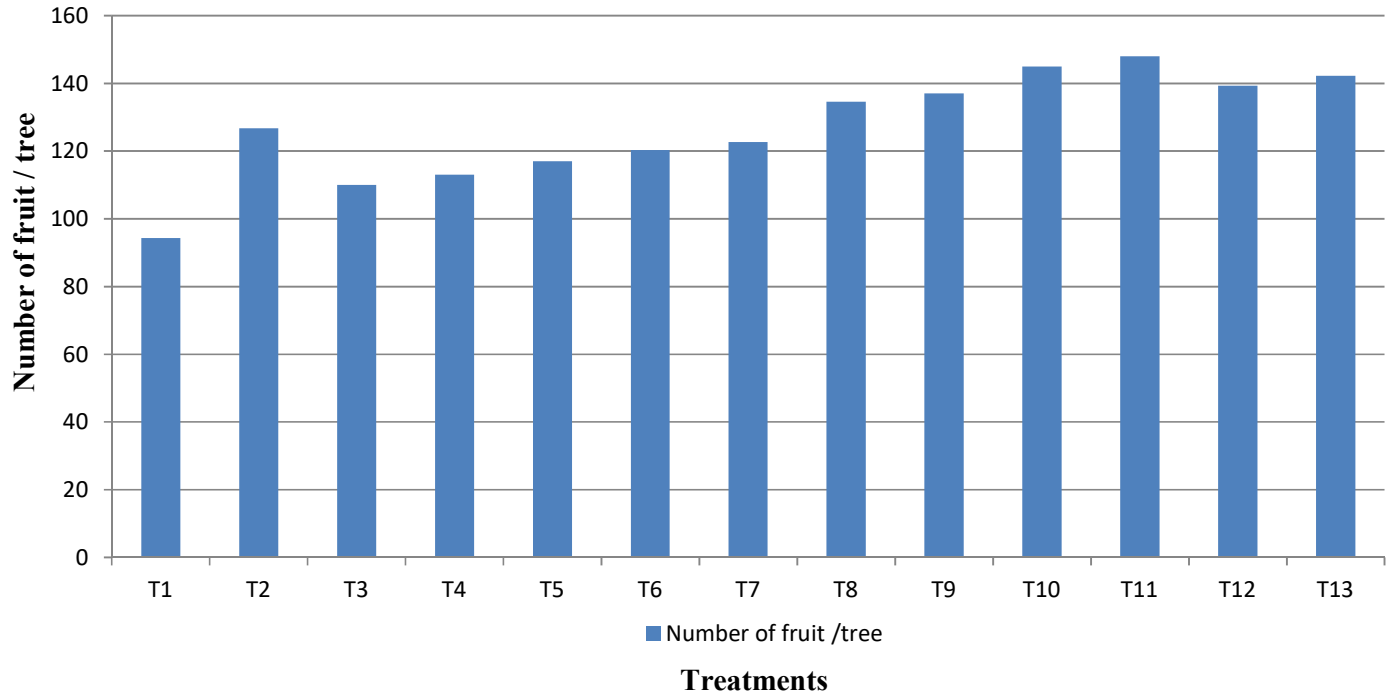


Fig. 8. Effect of foliar application of plant growth regulators and micronutrients on number of fruit/ tree in acid lime.

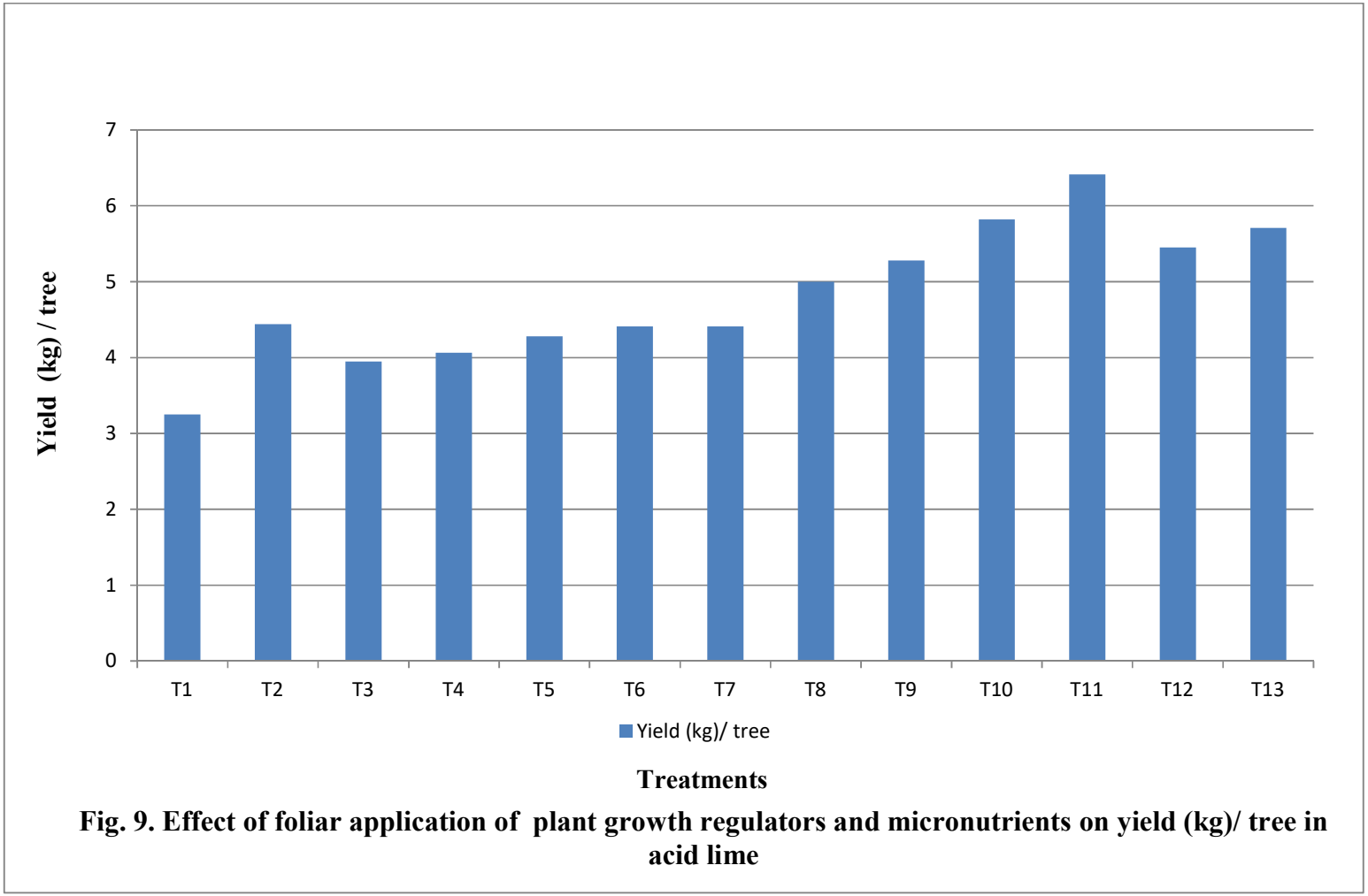


Fig. 9. Effect of foliar application of plant growth regulators and micronutrients on yield (kg)/ tree in acid lime

4.2.4 Yield per tree (Kg)

The result clearly showed that yield per tree (Kg) is presented in Table No.7 and Fig.9. Significantly maximum yield (6.41 Kg/tree) was recorded in the treatment T11 (GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%).Which was statistically at par with T_9, T_{12}, T_{13} and T_{10}. Whereas, minimum yield (3.25 Kg/tree) was observed in treatment T1 (control).

Table 8. Effect of foliar application of various plant growth regulators and micronutrients on fruit set (%) and fruit drop (%) in acid lime

Sr. No.	Treatment details	Fruit set %	Fruit drop %
T_1	Control	38.02	46.20
T_2	GA_3 @ 50ppm	41.97	39.12
T_3	NAA @ 100ppm	44.60	37.49
T_4	$ZnSO_4$ @ 0.5%	43.30	43.88
T_5	$FeSO_4$ @ 0.5%	45.60	40.84
T_6	$ZnSO_4$ @ 1.0%	44.77	42.82
T_7	$FeSO_4$ @ 1.0%	46.13	41.21
T_8	$ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5%	44.57	40.20
T_9	$ZnSO_4$ @ 1.0% + $FeSO_4$ @ 1.0%	46.50	39.50
T_{10}	GA_3 @ 50 ppm +$ZnSO_4$ @0.5% +$FeSO_4$ @ 0.5%	49.57	36.30
T_{11}	GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%	51.20	35.20
T_{12}	NAA @ 100ppm + $ZnSO_4$ @0.5% + $FeSO_4$ @ 0.5%	48.87	37.50
T_{13}	NAA @ 100ppm +$ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%	50.30	38.33
	S.E.m ±	**1.15**	**1.60**
	C.D at 5%	**3.40**	**4.56**

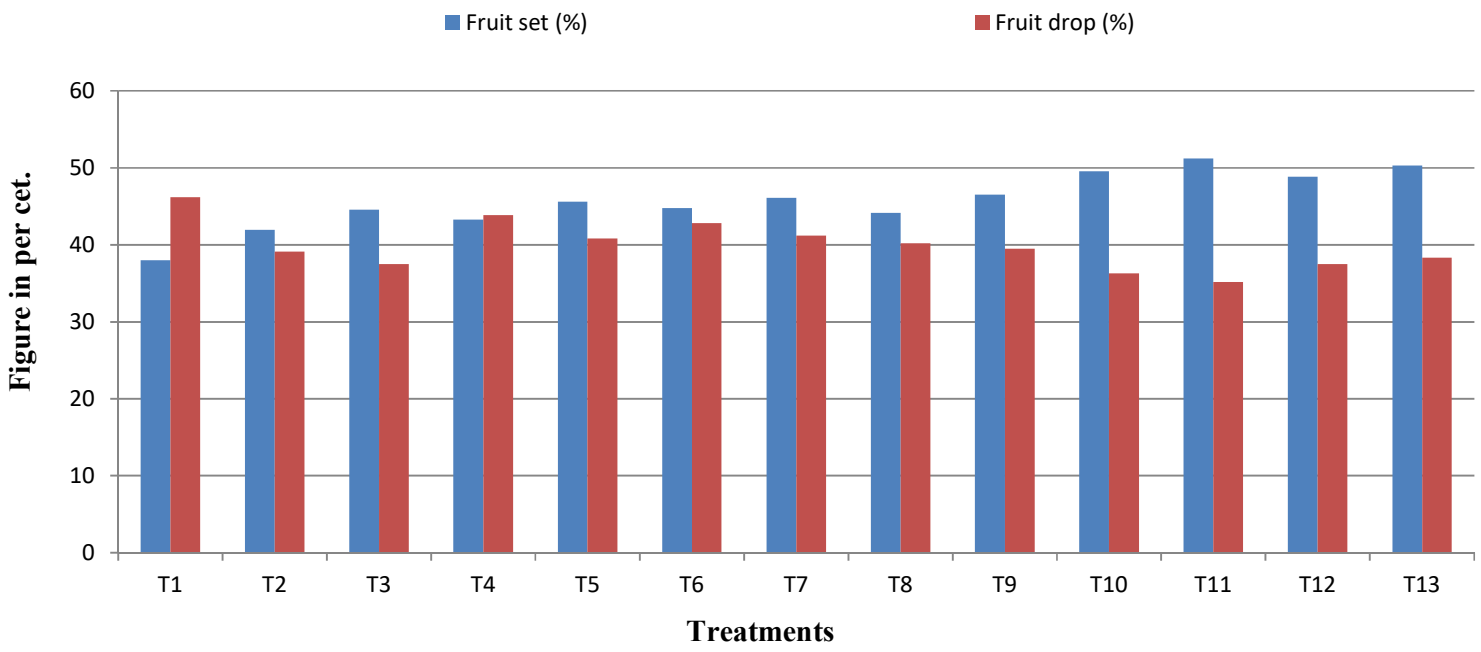


Fig . 10. Effect of foliar application of plant growth regulators and micronutrients on fruit set (%) and fruit drop (%) in acid lime.

4.2.5 Fruit set %

The result revealed that the treatments showed significantly maximum fruit set (51.20 %) was recorded in the treatment T_{11} (GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%) it was statistically at par with T_{12}, T_{10} and T_{13} Whereas, minimum fruit set (38.02 %) was observed in treatment T_1 (control) in Table No. 8 and Fig.10.

4.2.6 Fruit drop %

The data pertaining fruit drop is presented in Table No.8 and Fig.10. The significantly minimum fruit drop (35.20 %) was recorded in the treatment T_{11} (GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%) it was statistically at par with T_{10},T_{12},T_{13} and T_9. Whereas, maximum fruit drop (46.20 %) was observed in treatment T_1 (control).

4.3 Quality parameters

4.3.1 Juice %

The data pertaining juice (%) is presented in Table No.9 and depicted in Fig. No.11. The significantly maximum juice (50.60 %) was recorded in the treatment T_{11} (GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%). Which was statistically at par with T_9, T_{10}, T_{12} and $T_{13.}$ Whereas, minimum juice per cent (38.50%) was observed in treatment T_1 (control).

4.3.2 Peel %

The data clearly showed that, the minimum peel (%) is presented in Table No.9 and Fig.11. The significantly minimum peel (25.21%) was recorded in the treatment T_{11} (GA_3 @ 50ppm + $ZnSO_4$ @1.0% + $FeSO_4$@1.0%). It was statistically at par with T_{10} and $T_{13.}$ Whereas, maximum peel (45.21%) was observed in treatment T_1 (control).

Table 9. Effect of foliar application of various plant growth regulators and micronutrients on Juice(%) and Peel (%) in acid lime

Sr. No.	Treatment details	Juice (%)	Peel (%)
T_1	Control	38.50	45.21
T_2	GA_3 @ 50ppm	41.35	42.20
T_3	NAA @ 100ppm	42.15	39.45
T_4	$ZnSO_4$ @ 0.5%	45.03	40.30
T_5	$FeSO_4$ @ 0.5%	39.90	38.74
T_6	$ZnSO_4$ @ 1.0%	43.96	38.17
T_7	$FeSO_4$ @ 1.0%	46.19	37.47
T_8	$ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5%	45.88	32.04
T_9	$ZnSO_4$ @ 1.0% + $FeSO_4$ @ 1.0%	47.93	31.43
T_{10}	GA_3 @ 50 ppm +$ZnSO_4$ @0.5% +$FeSO_4$ @ 0.5%	49.03	27.11
T_{11}	GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%	50.60	25.21
T_{12}	NAA @ 100ppm + $ZnSO_4$ @0.5% + $FeSO_4$ @ 0.5%	48.87	30.59
T_{13}	NAA @ 100ppm +$ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%	48.90	28.63
	S.E.m ±	**1.06**	**1.30**
	C.D at 5%	**3.10**	**3.81**

4.3.3 TSS (^{0}Brix)

The data pertaining TSS (^{0}Brix) is presented in Table No.10 and Fig.12. The significantly maximum TSS (^{0}Brix) (8.57) was recorded in the treatment T11 (GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%). It was statistically at par with T_{10}. Whereas, minimum TSS (^{0}Brix) (6.50) was observed in treatment T_1 (control).

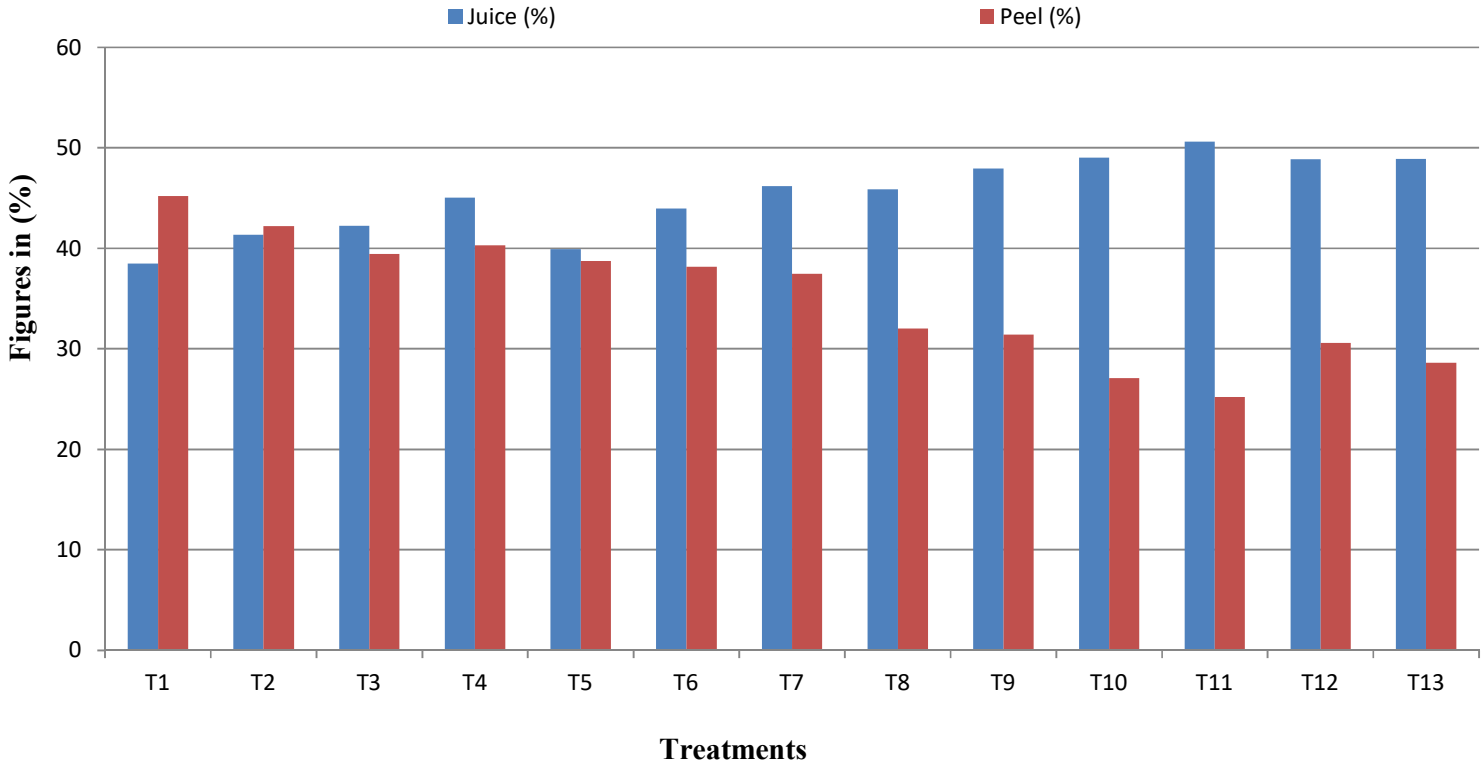


Fig. 11. Effect of foliar application of plant growth regulators and micronutrients on juice (%) and peel (%) in acid lime

4.3.4 Acidity (%)

The result clearly showed that, the acidity (%) is presented in Table No.10 and Fig.13. The significantly maximum acidity (7.89 %) was recorded in the treatment T_{11} (GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%). It was statistically at par with T_{10} and T_{13}. Whereas, minimum acidity (6.00 %) was observed in treatment T_1 (control).

Table 10. Effect of foliar application of various plant growth regulators and micronutrients on TSS and Acidity content in acid lime

Sr. No.	Treatment details	TSS (^{0}Brix)	Acidity (%)
T_1	Control	6.50	6.00
T_2	GA_3 @ 50ppm	6.58	6.26
T_3	NAA @ 100ppm	6.67	5.38
T_4	$ZnSO_4$ @ 0.5%	6.55	5.08
T_5	$FeSO_4$ @ 0.5%	6.86	5.00
T_6	$ZnSO_4$ @ 1.0%	6.86	5.93
T_7	$FeSO_4$ @ 1.0%	7.03	5.69
T_8	$ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5%	7.05	6.66
T_9	$ZnSO_4$ @ 1.0% + $FeSO_4$ @ 1.0%	7.12	6.97
T_{10}	GA_3 @ 50 ppm +$ZnSO_4$ @0.5% +$FeSO_4$ @ 0.5%	8.20	7.87
T_{11}	GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%	8.57	7.89
T_{12}	NAA @ 100ppm + $ZnSO_4$ @0.5% + $FeSO_4$ @ 0.5%	7.26	7.07
T_{13}	NAA @ 100ppm +$ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%	7.75	7.26
	S.E.m ±	**0.25**	**0.20**
	C.D at 5%	**0.74**	**0.60**

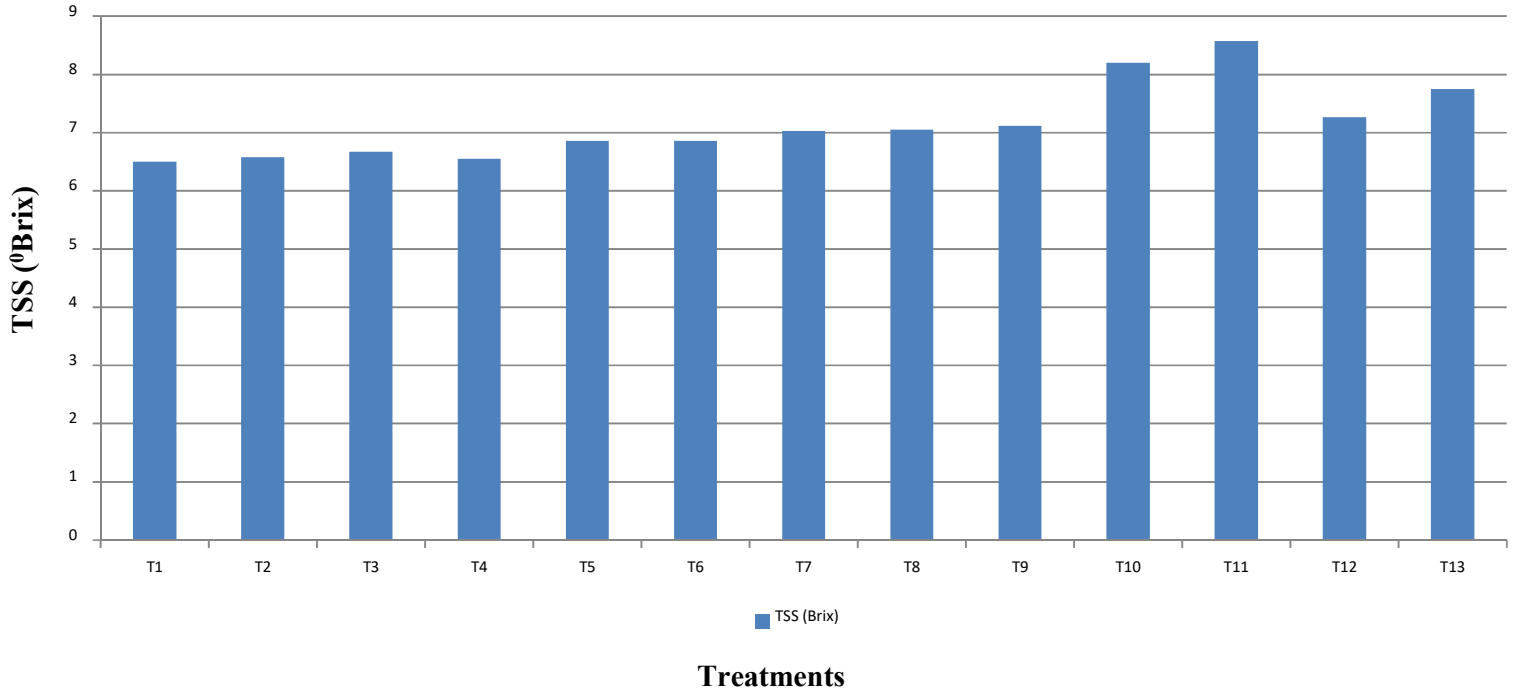


Fig. 12. Effect of foliar application of plant growth regulators and micronutrients on TSS content of acid lime

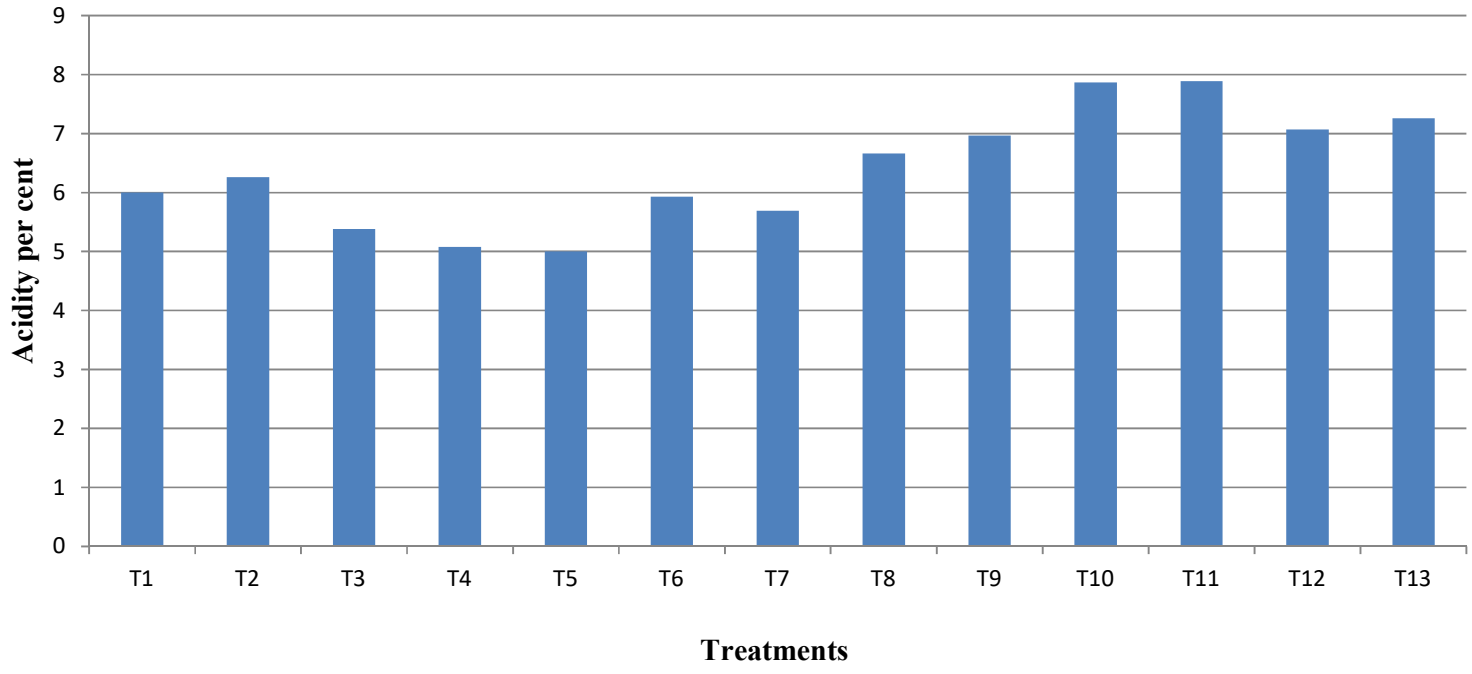


Fig.13. Effect of foliar application of plant growth regulators and micronutrients on acidity (%) of acid lime.

4.3.5 Total sugar (%)

The data pertaining total sugar per cent is presented in Table No.11 and Fig.14. The significantly maximum total sugar (1.82 %) was recorded in the treatment T_{11} (GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%). Which was statistically at par with T_9, T_{13} and T_{10}. Whereas, minimum total sugar (0.98 %) was observed in treatment T_1 (control)

Table 11. Effect of foliar application of various plant growth regulators and micronutrients on sugar content in acid lime

Sr. No.	Treatment details	Total sugar (%)	Reducing sugar (%)	Non reducing sugar (%)
T_1	Control	0.98	0.61	0.37
T_2	GA_3 @ 50ppm	1.15	0.75	0.40
T_3	NAA @ 100ppm	1.04	0.67	0.37
T_4	$ZnSO_4$ @ 0.5%	1.1	0.67	0.43
T_5	$FeSO_4$ @ 0.5%	1.19	0.69	0.50
T_6	$ZnSO_4$ @ 1.0%	1.36	0.72	0.64
T_7	$FeSO_4$ @ 1.0%	1.41	0.73	0.68
T_8	$ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5%	1.58	0.77	0.81
T_9	$ZnSO_4$ @ 1.0% + $FeSO_4$ @ 1.0%	1.66	0.80	0.86
T_{10}	GA_3 @ 50 ppm +$ZnSO_4$ @0.5% +$FeSO_4$ @ 0.5%	1.71	0.85	0.86
T_{11}	GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%	1.82	0.90	0.92
T_{12}	NAA @ 100ppm + $ZnSO_4$ @0.5% + $FeSO_4$ @ 0.5%	1.62	0.80	0.82
T_{13}	NAA @ 100ppm +$ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%	1.66	0.82	0.84
	S.E.m ±	**0.06**	**0.02**	**0.016**
	C.D at 5%	**0.18**	**0.07**	**0.047**

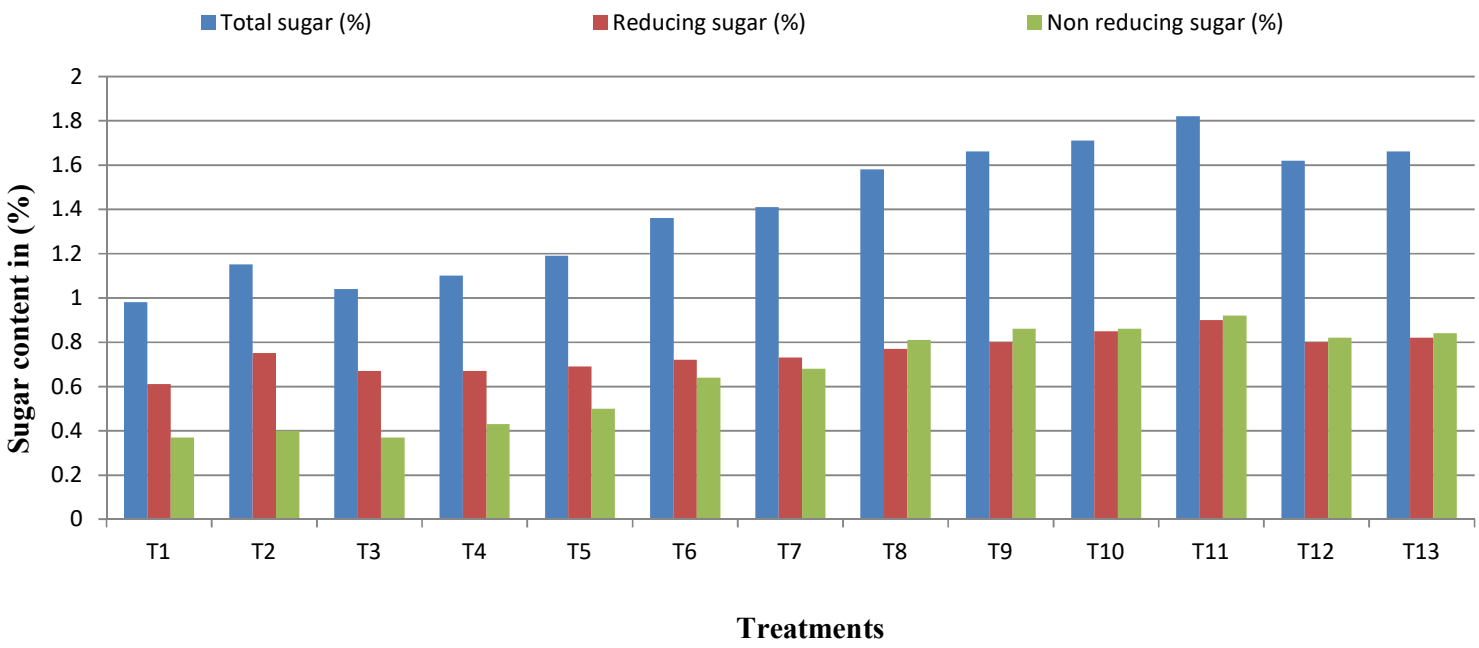


Fig .14. Effect of foliar application of plant growth regulators and micronutrients on sugar per cent of acid lime.

4.3.6 Reducing sugar (%)

The data showed that, the reducing sugar (%) is presented in Table No.11 and Fig.14. The significantly maximum reducing sugar (0.90 %) was recorded in the treatment T_{11} (GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%). It was statistically at par with T_{10}. Whereas, minimum reducing sugar (0.61 %) was observed in treatment T_1 (control).

4.3.7 Non reducing sugar (%)

The data pertaining acidity (%) is presented in Table No.11 and Fig.14. The significantly maximum non reducing sugar (0.92 %) was recorded in the treatment T_{11} (GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%).followed by treatment T_{10}, T_{13}, T_{12} and T_9, T_8. Whereas, minimum non reducing sugar (0.37 %) was observed in treatment T_1 (control).

Table 12. Effect of foliar application of various plant growth regulators and micronutrients on ascorbic acid content in acid lime

Sr. No.	Treatment details	Ascorbic acid (mg/100ml juice)
T_1	Control	24.69
T_2	GA_3 @ 50ppm	25.06
T_3	NAA @ 100ppm	25.88
T_4	$ZnSO_4$ @ 0.5%	25.11
T_5	$FeSO_4$ @ 0.5%	25.21
T_6	$ZnSO_4$ @ 1.0%	25.07
T_7	$FeSO_4$ @ 1.0%	26.93
T_8	$ZnSO_4$ @ 0.5% + $FeSO_4$ @ 0.5%	27.97
T_9	$ZnSO_4$ @ 1.0% + $FeSO_4$ @ 1.0%	28.64
T_{10}	GA_3 @ 50 ppm +$ZnSO_4$ @0.5% +$FeSO_4$ @ 0.5%	29.33
T_{11}	GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%	30.35
T_{12}	NAA @ 100ppm + $ZnSO_4$ @0.5% + $FeSO_4$ @ 0.5%	28.90
T_{13}	NAA @ 100ppm +$ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%	28.97
	S.E.m ±	**0.22**
	C.D at 5%	**0.66**

4.3.8 Ascorbic acid (mg/100ml juice)

It is the evident from data, treatment showed significantly acidity (%) is presented in Table No.12 and Fig.15. The significantly maximum ascorbic acid (30.35 mg/100ml juice) was recorded in the treatment T_{11} (GA_3 @ 50ppm + $ZnSO_4$ @1.0% +$FeSO_4$ @ 1.0%). It was statistically at par with T_{13} and T_{10}. Whereas, minimum ascorbic acid (24.69 mg/100 ml juice) was observed in treatment T_1 (control).

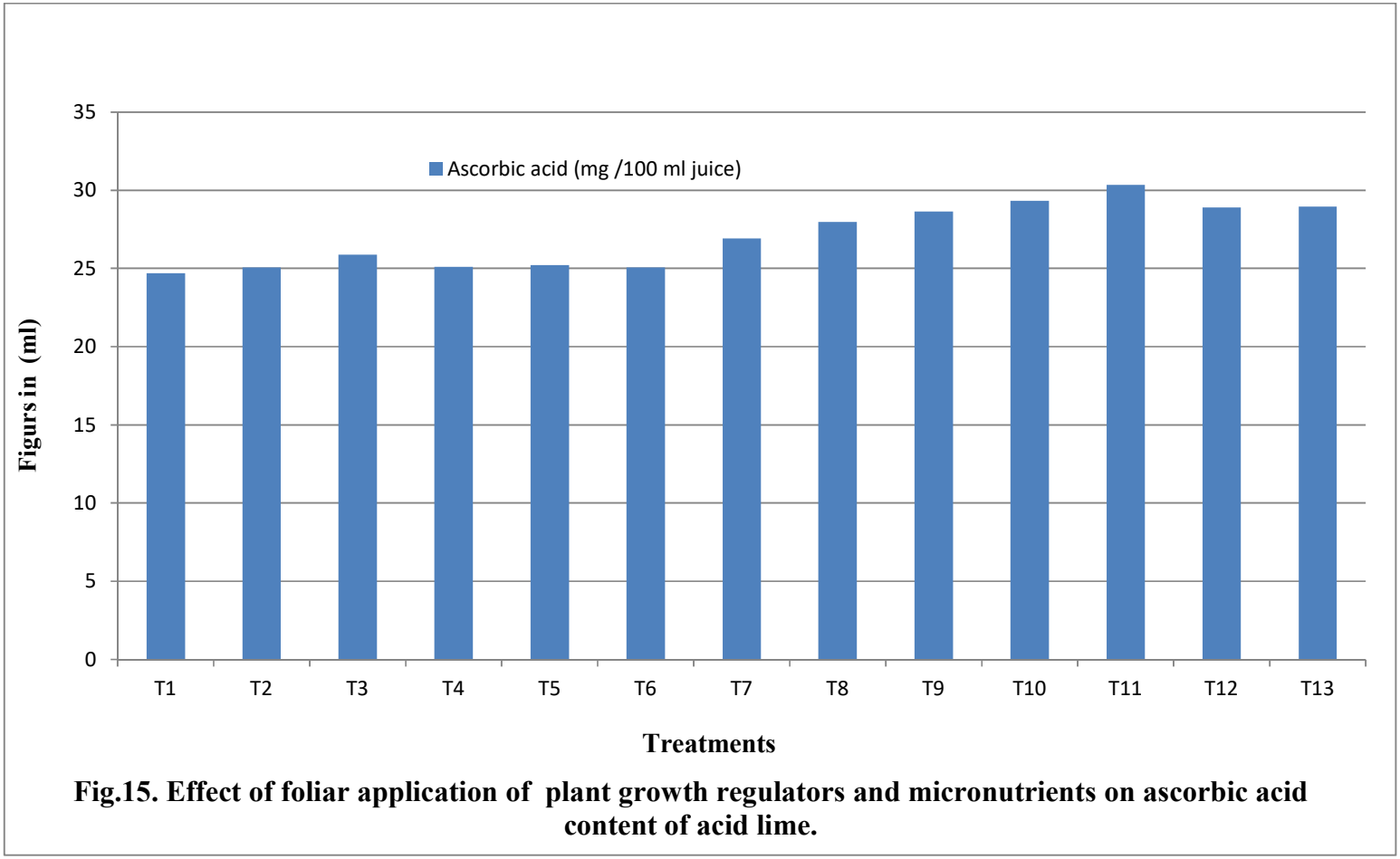


Fig.15. Effect of foliar application of plant growth regulators and micronutrients on ascorbic acid content of acid lime.

DISCUSSION

CHAPTER V.

DISCUSSION

An effort has been made in this chapter to discuss critically the important findings of the present study on the "Effect of plant growth regulators and micronutrients on growth, yield and quality of acid lime (*Citrus aurantifolia* L) cv. Sai sarbati" conducted during Ambia bahar of 2016.

5.1 Plant height (m).

It is evident from the results presented in earlier chapter (Table No.1) that the application of different plant growth regulators and micronutrients treatments at different concentrations had influenced various vegetative growth characters as compared to control. In the present investigation, it was observed that among the various plant growth regulators and micronutrients treatments attempted, application of GA_3 (50ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) resulted in higher increase in plant height as compared to other treatments. At the time of harvest, the maximum increase in plant height (0.25 m), was recorded due to application of GA_3 (50 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) (T_{11}). These results are on similar lines as that of Baku,(1989) who reported that Zn and GA_3 treatment combinations resulted in the greatest terminal shoot length, number of leaves/terminal shoot and percent dry weight of the terminal shoot in kagzi lime. However, the total leaf area of the terminal shoot was greatest when 0.6 % Zn were applied. And Prasad *et al.*(2013) reported that, the application of N increases shoot growth, plant height, spread canopy volume in kinnow. The growth of acid lime fruit were significantly influenced by the application of zinc and iron fertilizers (0.25, 0.50 and 0.75 %). Maximum growth observed with two sprays at one month interval of 0.5 % $ZnSO_4$ and 0.5 % $FeSO_4$. Jagtap *et al*.(2013) in acid lime and Eiada *et al*. (2013) in pomegranate.

5.2 Plant spread

It is evident from the results presented in earlier chapter (Table 2) that the application of different plant growth regulators and micronutrients treatments at different concentrations had influenced various vegetative growth characters as compared to control. In the present investigation, it was observed that among the various plant growth regulators and micronutrients treatments attempted, application of GA_3 (50ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) resulted in higher increase in plant spread as compared to other treatments. At the time of harvest, the maximum increase in plant spread East-west (3.74 m) and (3.54 m) North-south was recorded due to application of GA_3 (50 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) (T_{11}). These results are on similar lines as that of Jagtap *et al*.(2013), who reported that treatment with $ZnSO_4$ 0.5 % + $FeSO_4$ 0.5 % produced significantly maximum plant canopy volume East-west canopy spread (3.44, 3.76 and 4.04 m). North-South canopy spread (3.40, 3.70 and 3.97 m at 4, 6 and 8 month after first spray) in acid lime, respectively.

Prasad *et al*.(2013), in acid lime, El-Saida (2001) in Washington Navel orange, Sarfaraz *et al*.(2010) in peach and Khan *et al*.(2009), reported that foliar spray of 39 g $FeSO_4$, 98 g ZnSO4 and 39 g $MnSO_4$ per 20 litre separately or in combinations had the greatest effect on tree growth. The present results were in accordance with the finding of Singh *et al*.(2008) in aonla.

This might be due to the reason that GA_3 and micronutrients increased uptake of water and nutrients due to persuasive swelling forces leading the softening of cell wall and there by favored better development of plants resulting in greater height and number of branches per plant and ultimately the greater plant spread and canopy volume.

5.3 Days required for initiation of new vegetative flush.

It is evident from the results presented in earlier chapter that the application of different plant growth regulators and micronutrients treatments at different concentrations had influenced various vegetative growth characters

as compared to control. In the present investigation, it was observed that among the various plant growth regulators and micronutrients treatments attempted, application of GA_3 (50ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) resulted in minimum days required for initiation of new vegetative growth after first spray and irrigation (17.00) as compared to other treatments. was recorded due to application of GA_3 (50 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) (T_{11}). These results are on similar lines as that of Debbarma and Hazarika (2016) in acid lime, Babu *et al.*(1984) in acid lime, Pawar *et al.*(2016) in acid lime and Krishna *et al* (2016) in mango.

5.4 Days required for flower initiation.

It is evident from the results presented in earlier chapter that the application of different plant growth regulators and micronutrients treatments at different concentrations had influenced various vegetative growth characters as compared to control. In the present investigation, it was observed that among the various plant growth regulators and micronutrients treatments attempted, application of GA_3 (50ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) resulted in minimum days required for initiation of flowering after new vegetative growth, first spray and irrigation (14.00) as compared to other treatments. was recorded due to application of GA_3 (50 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) (T_{11}). These results are on similar lines as that of Debbarma and Hazarika (2016) in acid lime, Babu *et al.*(1984) in acid lime, Pawar *et al.*(2016) in acid lime and Krishna *et al* (2016) in mango.

5.5 Number of flower per shoot.

It is evident from the results presented in earlier chapter (Table 8). The number of flower per shoot was significantly influenced due to application of plant growth regulators and micronutrients. The maximum number of flower per shoot (18.57) found in (T_{11}) GA_3 (50 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) and minimum number of flower per shoot (8.33) found in T_1 (Control) was applied to acid lime trees produced by foliar application growth regulators GA_3 and NAA application significantly reduced the flower drop and

increased fruit retention therefore, number of number of flower per shoot was found highest in GA_3 treated acid lime trees. These results are in accordance with the findings of Venu *et al* (2014) in acid lime, Krishna *et al* (2004) in mango.

5.6 Days required for harvesting.

It is evident from the results presented in earlier chapter (Table 4) that the application of different plant growth regulators and micronutrients treatments at different concentrations had influenced various vegetative growth characters as compared to control. In the present investigation, it was observed that among the various plant growth regulators and micronutrients treatments attempted, application of GA_3 (50ppm) + $ZnSO_4$ (1 %) + FeSO4 (1 %) resulted in minimum days required for harvesting after new vegetative growth, first spray and irrigation (144.00) as compared to other treatments. was recorded due to application of GA_3 (50 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) (T_{11}). These results are on similar lines as that of Debbarma and Hazarika (2016) in acid lime, Babu *et al.*(1984) in acid lime, Pawar *et al*.(2016) in acid lime and Krishna *et al* (2016) in mango.

5.7 Weight of fruit (g).

It is evident from the results presented in earlier chapter maximum fruit weight (43.33 g) as compared to other treatment was recorded due to application of GA_3 (50 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) (T_{11}). was applied to acid lime trees .These findings are in accordance with the results obtained by Sinha *et al*. (1999) in acid lime, Singh and Rethy (1995), in Acid lime, Mukhtar Ahmad et al. (1988) in Mandrin orange, Babu *et al.* (1984) in lemon tree, The combined treatment (GA_3 + ZnSO4 + FeSO4 + MnSO4) recorded highest fruit weight due to cumulative effects of GA_3, zinc, iron and manganese in acid lime. Sharma *et al*. (2005)

5.8 Volume of fruit (ml).

It is evident from the results presented in earlier chapter Fruit volume was maximum (41.30 ml) as compared to other treatments. was recorded due to application of GA_3 (50 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) (T_{11}). was applied to acid lime trees .These findings are in accordance with the results obtained by Sinha *et al*. (1999) in acid lime, Singh and Rethy (1995), in Acid lime, Mukhtar Ahmad *et al.* (1988) in Mandrin orange, Babu *et al.* (1984) in lemon tree, Jagtap *et al.* (2013) in Kagzi lime, Laila *et al*. (2014) in "Kallamata" olives he was reported that kallamata olive trees received zinc sulphate as a source of micronutrient at 0.5 % and gibberelic acid as a growth regulator at 10 ppm have complementary effect on fruit characteristic in terms of fruit weight and fruit volume.

5.9 Number of fruit per tree.

The number of fruits per tree was significantly influenced due to application of plant growth regulators and micronutrients. It is evident from the results presented in earlier chapter (Table 6). The maximum number of fruits per tree (148.00 fruit/tree) GA_3 (50 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) (T_{11}) was produced by foliar application of The growth regulators GA3 and NAA application significantly reduced the fruit drop and increased fruit retention therefore, number of fruits per tree was found highest in GA3 treated acid lime trees. These results are in accordance with the findings of Jagtap *et al.* (2013) in acid lime, Kumar et al. (2009) in Litchi, Hassan *et al.* (2010) in Hollywood plum trees, Kachave and Bhosle (2007) in kagzi lime, Ebeed et al. (2001) in mango, Singh and Rethy (1995) in acid lime and Babu et al. (1984) in lime.

The micronutrient treatment might have helped in increasing the chlorophyll content of leaves and there might be higher photosynthetic efficiency and production of photosynthetic particularly due to action of zinc and iron. Zinc also assists the translocation of metabolites from source to sink, which leads to retention of more number of fruits on tree. Reduction in the fruit

drop and increase in the fruit retention due to application of micronutrients might have increased the number of fruits per tree in the present investigation.

5.10 Yield per tree (Kg).

Yield (kg) per tree was significantly influenced due to application of plant growth regulators and micronutrients. It is evident from the results presented in earlier chapter. The maximum number of fruits per tree (6.41 kg/tree) GA_3 (50 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) (T_{11}). was applied to acid lime. Produced by foliar application of The growth regulators GA_3 and NAA application significantly reduced the fruit drop and increased fruit retention therefore, number of fruits per tree was found highest in GA3 treated acid lime trees. These results are in accordance with the findings of Jagtap *et al.* (2013) in acid lime, Kumar et al. (2009) in Litchi, Hassan *et al.* (2010) in Hollywood plum trees, Kachave and Bhosle (2007) in kagzi lime, Ebeed et al. (2001) in mango, Singh and Rethy (1995) in acid lime and Babu et al. (1984) in lime.

The GA_3 and NAA significantly decreased the fruit drop by way of suppressing the formation of abscission layer and increased the fruit retention. Consequently, the number of fruits per tree was increased in this treatment. In addition to this, the average weight of the fruit was also increased. Due to increase in number of fruits per tree and weight of individual fruit, there was significant increase in yield per tree as compared to control.

5.11 Fruit set (%)

It is evident from the results presented in earlier chapter. The fruit set (%) per tree was significantly influenced due to application of plant growth regulators and micronutrients. The maximum fruit set found in (51.20 %) GA_3 (50 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) (T_{11}). was applied to acid lime trees produced by foliar application growth regulators GA_3 and NAA application significantly reduced the fruit drop and increased fruit retention therefore, number of fruits per tree was found highest in GA_3 treated acid lime trees. These results are in accordance with the findings of Jagtap *et al.* (2013)

in acid lime, Kumar et al. (2009) in Litchi, Hassan *et al.* (2010) in Hollywood plum trees, Kachave and Bhosle (2007) in kagzi lime, Ebeed et al. (2001) in mango, Singh and Rethy (1995) in acid lime, , Bhati *et al* (2016) in acid lime and Babu et al. (1984) in lime, Gurjar and Rana (2014) in kinnow mandarin.

The GA_3 and NAA along with $ZnSo_4$ and $FeSo_4$ significantly increase the fruit set by way of suppressing the formation of abscission layer and increased the fruit retention. Consequently, the number of fruits per tree was increased in this treatment.

5.12 Fruit drop (%)

It is evident from the results presented in earlier chapter. The fruit set (%) per tree was significantly influenced due to application of plant growth regulators and micronutrients. The maximum fruit set (51.20 %) GA_3 (50 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) (T_{11}). was applied to acid lime trees produced by foliar application growth regulators GA_3 and NAA application significantly reduced the fruit drop and increased fruit retention therefore, number of fruits per tree was found highest in GA_3 treated acid lime trees. These results are in accordance with the findings of Jagtap *et al.* (2013) in acid lime, Kumar et al. (2009) in Litchi, Hassan *et al.* (2010) in Hollywood plum trees, Kachave and Bhosle (2007) in kagzi lime, Ebeed et al. (2001) in mango, Singh and Rethy (1995) in acid lime and Babu et al. (1984) in lime, Gurjar and Rana (2014) in kinnow mandarin, Bhati *et al* (2016) in acid lime.

The cumulative effect of NAA along with zinc and iron increased the yield per tree than control. Increase in the yield due to application of micronutrients might be due to reduction in fruit drop, increase in fruit retention, number of fruits and average weight of fruits. These results are on similar lines with the findings of Gurjar and Rana (2014) who recorded maximum yield in mandrin orange by combined application of ZnSO4 and FeSO4. Kachave and Bhosle (2007) reported that foliar application of ZnSO4 (0.5 %) and FeSO4 (0.5 %) significantly increased yield per tree in acid lime as compared to control .

5.13 Juice (%)

Data presented in earlier chapter it is revealed that, juice percentage was significantly influenced by various plant growth regulators and micronutrients. The maximum juice percentage (50.60 %) was recorded in the treatment (T_{11}) GA_3 (50 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) The minimum juice percentage (38.50 %) was recorded in the treatment T1(control) Similar results were reported in acid lime Bhati *et al* (2016), Gill *et al*. (1983) in sweet orange, Brar *et al*. (1990) in Kinnow mandarin, Kaur *et al*. (1993) in sweet orange, Ebeed *et al*. (2001) in mango, Sharma *et al*. (2003) in kagzi lime, Yadlod *et al*. (2009) in banana.

The increase in juice per cent of the fruit due to application of micronutrients might be due to role of zinc in plant metabolism. Zinc regulates the semi permeability of cell wall by which more water was mobilized into the fruits, thereby increasing the percentage of juice (Sharma et al., 2003). Similarly, the iron also accelerated the fruit development, due to which, more metabolites might have diverted from the leaves to the fruits thereby increasing the juice content of fruit.

5.14 Peel (%)

Data presented in earlier chapter it is revealed that, peel percentage was significantly influenced by various plant growth regulators and micronutrients. The minimum peel percentage (25.21 %) was recorded in the treatment (T_{11}) GA_3 (50 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) The maximum peel percentage (45.21 %) was recorded in the treatment T1(control) Similar results were reported in acid lime Bhati *et al* (2016), Gill *et al*. (1983) in sweet orange, Brar *et al*. (1990) in Kinnow mandarin, Kaur *et al*. (1993) in sweet orange, Ebeed *et al*. (2001) in mango, Sharma *et al*. (2003) in kagzi lime, Debaje *et al*. (2011) in acid lime, Anees *et al*. (2011) in mango.

5.15 TSS (^{0}Brix)

Data presented in earlier chapter it is revealed that, TSS (^{o}Brix)was significantly influenced by various plant growth regulators and

micronutrients. The maximum TSS (7.26 ^{o}Brix) was recorded in the treatment (T_{11}) GA_3 (50 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) The minimum TSS (6.50 ^{o}Brix) was recorded in the treatment T1(control) Similar results were reported in acid lime Bhati *et al* (2016), Gill *et al*. (1983) in sweet orange, Brar *et al*. (1990) in Kinnow mandarin, Kaur *et al*. (1993) in sweet orange, Ebeed *et al*. (2001) in mango, Sharma *et al*. (2003) in kagzi lime, Debaje *et al*. (2011) in acid lime, Anees *et al*. (2011) in mango and Yadlod *et al*. (2009) in banana.

Increase in TSS of juice with the application of micronutrients specially zinc might be due to increased photosynthetic activity and chlorophyll content of leaves which might have resulted in production of more TSS in fruit juice. Also plant growth regulator i.e. NAA application numerically increased the TSS content of juice in sweet orange. Thus cumulative effect of plant growth regulators and micronutrients increased the TSS in fruit of acid lime.

5.16 Acidity (%)

Data presented in earlier chapter No.4 it is revealed that, TSS (^{o}Brix)was significantly influenced by various plant growth regulators and micronutrients. The maximum TSS (7.26 ^{o}Brix) was recorded in the treatment (T_{11}) GA_3 (50 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) The minimum TSS (6.50 ^{o}Brix) was recorded in the treatment T1(control) Similar results were reported in acid lime Bhati *et al* (2016), Gill *et al.* (1983) in sweet orange, Kaur *et al*. (1993) in sweet orange, Ebeed *et al*. (2001) in mango, Sharma *et al*. (2003) in kagzi lime, Debaje *et al*. (2011) in acid lime, Anees *et al*. (2011) in mango.

The diminished acidity in micronutrient treated fruits particularly due to zinc and iron might be due to their utilization in respiration and rapid metabolic transformation of organic acids into sugar. The results obtained in present investigation are also in agreement with those of Brar *et al*. (1990) in Kinnow mandarin.

5.17 Total sugar (%)

Data presented in earlier chapter No.4 it is revealed that, total sugar percentage was significantly influenced by various plant growth

regulators and micronutrients. The maximum total sugar (1.82 %) was recorded in the treatment (T_{11}) GA_3 (50 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) The minimum total sugar (0.98 %) was recorded in the treatment T1(control) Similar results were reported in acid lime Bhati *et al* (2016), Gill *et al*. (1983) in sweet orange, Brar *et al*. (1990) in Kinnow mandarin, Kaur *et al*. (1993) in sweet orange, Ebeed *et al*. (2001) in mango, Sharma *et al*. (2003) in kagzi lime, Debaje *et al*. (2011) in acid lime, Anees *et al*. (2011) in mango, Kachave and Bhosale (2009) in kagzi lime.

Increase in TSS of juice with the application of micronutrients specially zinc might be due to increased photosynthetic activity and chlorophyll content of leaves which might have resulted in production of more TSS in fruit juice. Also plant growth regulator i.e. NAA application numerically increased the TSS content of juice in acid lime. Thus cumulative effect of plant growth regulators and micronutrients increased the TSS in fruit of acid lime.

5.18 Reducing sugar (%)

Data presented in earlier chapter No.4 it is revealed that, total sugar percentage was significantly influenced by various plant growth regulators and micronutrients. The maximum reducing sugar (0.90%) was recorded in the treatment (T_{11}) GA_3 (50 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) The minimum reducing sugar (0.61 %) was recorded in the treatment T1(control) Similar results were reported in acid lime Bhati *et al* (2016), Gill *et al*. (1983) in sweet orange, Brar *et al*. (1990) in Kinnow mandarin, Kaur *et al*. (1993) in sweet orange, Ebeed *et al*. (2001) in mango, Sharma *et al*. (2003) in kagzi lime, Debaje *et al*. (2011) in acid lime, Anees *et al*. (2011) in mango, Kachave and Bhosale (2009) in kagzi lime.

Increase in reducing sugar per cent of juice with the application of micronutrients specially zinc might be due to increased photosynthetic activity and chlorophyll content of leaves which might have resulted in production of more reducing sugar per cent in fruit juice. Also plant growth regulator i.e. NAA application numerically increased the reducing sugar per

cent content of juice in acid lime. Thus cumulative effect of plant growth regulators and micronutrients increased the reducing sugar per cent in fruit of acid lime.

5.19 Non reducing sugar (%)

Data presented in earlier chapter No.4 it is revealed that, total sugar percentage was significantly influenced by various plant growth regulators and micronutrients. The maximum non reducing sugar (0.92 %) was recorded in the treatment (T_{11}) GA_3 (50 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) The minimum total sugar (0.37 %) was recorded in the treatment T1(control) Similar results were reported in acid lime Bhati *et al* (2016), Gill *et al*. (1983) in sweet orange, Brar *et al*. (1990) in Kinnow mandarin, Kaur *et al*. (1993) in sweet orange, Ebeed *et al*. (2001) in mango, Sharma *et al*. (2003) in kagzi lime, Debaje *et al*. (2011) in acid lime, Anees *et al*. (2011) in mango, Kachave and Bhosale (2009) in kagzi lime.

Increase in non reducing sugar per cent of juice with the application of micronutrients specially zinc might be due to increased photosynthetic activity and chlorophyll content of leaves which might have resulted in production of more non reducing sugar per cent in fruit juice. Also plant growth regulator i.e. NAA application numerically increased the reducing sugar per cent content of juice in acid lime. Thus cumulative effect of plant growth regulators and micronutrients increased the non reducing sugar per cent in fruit of acid lime.

5.20 Ascorbic acid (mg/100ml juice)

Data presented in earlier chapter it is revealed that, total sugar percentage was significantly influenced by various plant growth regulators and micronutrients. The maximum, Ascorbic acid (30.35 mg/100ml juice) was recorded in the treatment (T_{11}) GA_3 (50 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) The minimum Ascorbic acid (24.69 mg/100ml juice) was recorded in the treatment T_1(control) Similar results were reported in acid lime Bhati *et al* (2016), Gill *et al*. (1983) in sweet orange, Brar *et al*. (1990) in Kinnow

mandarin, Kaur *et al*. (1993) in sweet orange, Ebeed *et al*. (2001) in mango, Sharma *et al*. (2003) in kagzi lime, Anees *et al*. (2011) in mango, Kachave and Bhosale (2009) in kagzi lime, Yadlod *et al*. (2009) in banana, Jagtap *et al*. (2013) in acid lime.

In the present investigation, the ascorbic acid content in the fruit juice was significantly increased due to foliar application of zinc, iron and manganese. Higher level of sugar in micronutrients treated fruits might be the possible reason behind increase in the content of ascorbic acid in fruit juice, because it is synthesized from sugar (Debaje *et al*. 2011 in acid lime). It was also possible that the micronutrient treatments might have reduced the activities of degrading enzymes thereby increasing the ascorbic acid content of fruit juice.

SUMMARY AND CONCLUSION

CHAPTER VI

SUMMARY AND CONCLUSION

6.1 Summary

An experiment was conducted in Randomized Block Design (RBD) with three replication and 13 treatments, namely GA_3 50ppm and NAA 100 ppm along with micronutrients combination of $ZnSO_4$ + $FeSO_4$ at 0.5 and 1 % both, Gibberellic acid (GA_3) at 50 ppm along with micronutrients combination of $ZnSO_4$ + FeSO4 at 0.5 and 1 % both and NAA at 100 ppm along with micronutrients combination of $ZnSO_4$ + $FeSO_4$ at 0.5 and 1 % and control.

The important findings as regards to growth, yield and quality characters are summarized here under.

The treatment T_{11} GA_3 (50 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) recorded maximum increase in plant height, plant spread as compared to other treatments.

Application of GA_3 (50 ppm) + $ZnSO_4$ (1 %) + FeSO4 (1 %) in T_{11} was found to be more effective in increasing number of fruits per tree, average fruit weight, yield and juice per cent.

Application of GA_3 (50 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) in T_{11} was found to be more effective in minimum days required for new vegetative flush, days require for flower initiation and days required for harvesting.

However the application of GA_3 (50 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) in T_{11} was found to be more effective in increasing total soluble solids, ascorbic acid, total sugars and reducing sugars and decrease in acidity per cent then control (T_1).

The maximum non-reducing sugars was recorded in treatment T_{11} GA_3 (50 ppm) + $ZnSO_4$ (1%) + $FeSO_4$ (1 %) .

6.2 Conclusion

On the basis of present investigation it can conclude that the foliar application of GA_3 (50 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) in T_{11} was found best for increase in plant height and plant spread ,fruit weight, number of fruits per tree, yield and juice per cent and minimum days required for new vegetative flush, days require for flower initiation and days required for harvesting, TSS, total sugars, reducing sugars, ascorbic acid and increase acidity per cent in acid lime.

The result of present investigation are of only one year experimentation. Hence, require more trials for confirmation of results.

LITERATURE CITED

LITERATURE CITED

Ahmed, A.H., Khalil, M.K., Abd EL-Rahman, A.M. and Nadia,A.M. Hamed. 2012. Effect of magnesium, copper and growth regulators on growth, yield and chemical composition of Washington navel orange tree. *J.Appl. Science Research*, **8**(2):1271-1288.

Alloway, B.J. 2008. Zinc in soils and crop nutrition. International Zinc Association Brussel, Belgium.

Anonymous, 2017. Indiastat.com, Ministry of Agriculture, Gov. of India, (ON652).

A.O.A.C. (1975). Official Methods of Analysis. Assoc. of Agril. Chemists. 12th Ed. Washington, D.C.

Anees, M., Tahir, F.M., Shahzad, J., Mahmood, N. 2011.Effect of foliar application of micronutrients on the quality of mango (Mangifera indica L.) cv. *Dasheri fruit.*Mycopath. **9**(1):25-28.

Ashraf, M.Y., Yaqub, J. Akhtar, M.A., Khan, M. Ali-Khan andAbert, G. 2012. Improvement in yield and juice quality of kinnow (Citrus deliciosa x Citrus nobilis) through nutrient management. Pak. *J. Bot.,* **44**: 259-265.

Babu, G.H.V.R., Lavania, M.L. and Misra, K.K. 1984. Effect of plant growth regulator sprays on yield and physico chemical composition of Pant-Lemon-1 (Citruslimon (L.) burm.) fruit in the off flush. Prog. *Hort.***16**(3/4): 191-198.

Baku, R.S. 1989. Influence of zinc and growth regulators on vegetative growth of kagzi lime (Citrus aurantifolia Swingle*). J. Research* APAU. **17**(1):83-86.

Bal, J.S., Singh, S.N., Randhawa, J.S. and Jawanda, J.S.1984. Effect of growth regulators on fruit drop, size and quality of ber (Zizyphus marutiana Lamk).*Indian J. Hort*. **41**(3-4): 182-185.

Brar, S.S., Minhas, P.P.S. and Kaundal, G.S. 1990.Chemical thinning of Kinnow mandarin.*Punjab Hort. J*. **30**(1-4): 27-32.

Barbera, G. and Garimi, F. (1988).Sixth Intern. Citrus Congress Middle East Telavive Israel, 8 - 11 March.**88** : 2.

Das, A., Deb, P., Roy, A. and Suresh, C.P. 2009. Effect of foliar feeding of commercial formulatons of growth regulators and micronutrients on some physicochemical characters of pineapple cv. Kew. Enviorn. Ecol. **27**(1): 114-116.

Debaje, P.P., Shinde, Ekta, D. and Ingale, H.V. 2011. Effect ofplant growth regulator and nutrients on quality of acid lime.*Asian J. Hort*. **6**(1) : 253-255.

Dixit, A., Shaw, S.S., and Virendra Pal. 2013.Effect of micronutrient and plant growth regulators on fruiting of Litchi. *Hortflora Reserch Spectrum*, **2**(1):77-80.

Dixit, C.K., Yamdagni, R. and Jindal, P.C. 1978. Effect of foliar application of zinc and iron on chlorosis and yield of Kinnow – a mandarin hybrid. Prog.*Hort. J*.**10**(1):13-19.

Doberman, A. and Fairhurst, T. 2000. Rice: Nutrients disorder and nutrient management.Potash and Phosphorus Institute of Canada and International Research Institute, Los Baffios, Phillipiness.

Ebeed, S., El-Gazzar, A. and Bedier, R. 2001. 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. Ann. *Agric. Sci*. **39**(2): 1279:1296.

Eiada, A. Obaid and Mustafa Eiada A. Al-Hadethi. 2013. Effect of Foliar Application with Manganese and Zinc on Pomegranate Growth, Yield and Fruit Quality. Journal of Horticultural Science and Ornamental Plants, **5**(1):41-45.

El-Saida, S.A.G. 2001.Effect of some growth regulators and zinc sulphate treatments on yield and quality of Washington navel orange .*Annals of Agricultural Science*, **39**: 1199-1212.

Eman, A.E., El-Migged, M.A. and Omayma, M.I. 2007. GA3and zinc sprays for improving yield and fruit quality of Washington navel orange trees grown under sandy soil conditions. Res. *J. Agric. Biol. Sci***.** **3**(5):498-503.

Gurjar, P.S. and Rana, G.S. 2014. Influence of foliar application of nutrients and growth regulators on fruit drop,yield, and fruit size and quality in kinnow mandarin .*Indian J. Hort*. **7**(1): 109-111.

Gill, D.S., Chohan, G.S., Thatia, S.K. and Brar, W.S. 1983Preharvest fruit drop of sweet orange. South *Hort.* **31**(1): 232-234.

Hassan,T.,Uehara, C. and Kobashigawa, K. (2010). Effect of GA3 in preventing alternate bearing in early Satsuma, cv. Dase. Sci. Bull of College of Agril. Univ. of Okinawa, 25 : 89-95.

Ibrahim, M., Ahmed, N., Anwar, S.A. and Majeed, T. 2007.Effectof micronutrients on citrus fruit yield growing on calcareous soils. In: 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, S. Goldberg and L. Shi., Spinger Neterlands, *Hort.* **33** pp.179-182.

Jadhav, N.S., Malewar, G.U. and Varade, S.B. 1979.Effect of zinc and iron on the fruit drop, yield and quality of mandarin oranges (Citrus reticulata Blanco). *J. Maharashtra agril. Univ.* **4**(1): 106-107.

Jagtap, V.M., Patel, H.C., Nehete, D.S. and Godase, S.S. 2013.Effect of foliar application of plant growth regulators and micronutrients on yield and quality of acid limecv. Kagzi (Citrus aurantifolia Swingle).*As ian J. Hort.***8(**1): 57-53.

Jagtap, V.M., Patel, H.C. and Nehete, D.S. 2013. Effect of foliar application of plant growth regulators and micronutrients on growth and yield of acid lime cv.Kagzi (Citrus aurantifolia Swingle).*Bioinfolet***.** **10**(2A):469-472.

Kachave, D.B. and Bhosale, A.M. 2007. Effect of plant growth regulators and micronutrients on fruiting and yield parameters of Kagzi lime (Citrus aurantifolia Swingle) fruits. *Asian J. Hort*. **2**(2): 75-79.

Kachave, D.B. and Bhosale, A.M. 2009. Effect of PGR and micronutrients on certain quality attributes of Kagzi lime (Citrus aurantifolia Swingle). *International J. Agri. Sci***. 5**(1) : 50-52.

Kaur Aulakh Harminder, Kapur, P.S. and Singh, S.P. 1993.Effect of growth regulators and micronutrients on granulation and fruit quality of sweet orange cv. Jaffa. Punjab *J. Hort;* **30**(1-4):13-19.

Khan, S., Singh, H.K., Vishwanath, K. and Pratap, B. 2009.Impact of foliar application of micro-nutrients and thiourea on growth, fruit yield and quality of aonla (Emblica officinalis Gaerten) cv. Narendra Aonla-6. *Annals of Horticulture,***2**(1): 83-85.

Kumar M., Kumar Singh, Rajesh, R.P. 2009. Effect of micronutrients and plant growth regulators on fruiting of litchi. *International Journal of Agriculture science;* **5**(2): 521-524.

Laila, Hagagga, F., Abd. EI-Migeed, M.M.M., Attia Shahin, M.F.M.,Merwad, M.A., and Genaidy E.A.E. 2014.Impact of foliar application of zinc sulphate and gibbralic acid on fruit quality and quantity of

"Kallamata" olives. *Middle East Journal of Agriculture Research,* **3**(4):745-750.

Michael, F.A., Charles, W. and Jr. Coggins, C.W. 1999. The efficacy of five forms of 2, 4-D in controlling preharvest fruit drops in citrus. *Hort. Science*, **81**:266-277.

Mukhtar Ahmad, Yaqub, C.M., Tariq Mahmood, Ahmad, M.and Mahmood, T. 1988.Comparative effect of different growth regulators and fertilizers on Kinnow mandarin.*Pakistan J. Agric. Res*. **9**(3):355-358.

Panse, V.G. and Sukhatme, P.V. 1985. Statistical methods for agricultural workers. I.C.A.R., New Delhi.

Prasad, A. and Bajpai P.N. 1963. Effect of alpha NAA on fruit set, size, ripening and yield of phalasa (Grewiaasiatica L.) variety Sarbati. Kanpur Agril. College J.**22**(1): 59-61.

Prasad, H., Dasharath Prasad, Chandra Bhan, S.K. Bairwa, Subhash Babu and Suresh Pal. 2013.Effect of foliar application of urea, zinc sulphate and 2, 4-D on Kinnow mandarin. *Journal of Progressive Agriculture*,**4**:148-153.

Rao, S.N. and Subbarao, C.H. 1963. Effect of some plant growth regulators on fruit drop in Neelum mango. Punjab *Hort. J.* **3**: 205-208.

Raturi, G.P. and Mukherjee, S.K. 1981. Studies on zinc and nitrogen nutrition of citrus. Nat. Symp. Trop. and Sub Trop. Fruit Crops, Bangalore, Abstr., pp. **84**.

Ranganna, G.S. 1979. Manual of analysis of fruit and vegetable products. Tata Mc Graw Hill publishing company, Ltd. New Delhi. pp. 12-15.

Rodriguez, V.A., Mazza, S.M., Martinez G.C. and Ferrero, A.R.2005. Zn and K influence on fruit sizes of Valencia orange. Revista Brasileira de Fruticulture, **27**:132-135.

Rehman, H.U., Ali, N. and Rafique, M. 1999. Effect of foliarapplied zinc, manganese and boron on sweet orangequality. *Pak. J. Soil Sci*.,**17**:113-117.

Saleem, B.A., Ziaf, K., Farooq, M., and Ahmed, W., 2005. Fruit set and drop patterns as affected by type and dose of fertilizer application in mandarin cultivars (Citus reticulate Blanco.). *Int. J. Agri. Biol*., **7**:962-965.

Sarfaraz, F.A., Al-Bamarny, Mohommed, A., Salman Zulaykhaand Ibrahim, R. 2010.Effect of some chemical compounds on some characterstics of shoot and fruit of peach (Prunus persica L.) cv.Early coronet. Mesopotomia *J. Agric.* (ISSN 1815-316x) (**38**) No.(supplement 1).

Satyamurthy, S., Thamburaj, S. and Nagarjun, M. 1978. Effect of certain growth regulators on acid lime (Citrus aurantifolia Swingle). *Madras Agric. J.***65**(10):650-653.

Sharma, A.K., Singh, K. and Mishra, S.P. 2003. Effect of foliar spray on zinc sulphate, 2,4,5-T and GA3 on quality of Kagzi lime (Citrus aurantifolia Swingle). Orissa *J. Hort*. **31**(2): 29-32.

Sharma, R.K. and Awasthi, R.P. 1990. Effect of growth regulators on crop regulation of Kinnow (Citrus nobilis x Citrus deliciosa).*Indian J. Hort*. **47**(2):162-166.

Sharma, S.K., Singh, P. and Sharma, A.K. 2005. Effect of Plantbio-regulators (PBR) and micronutrients on fruit set and quality of litchi cv. Dehradun. *Ind. J. Hort.,***62**(1):24-26.

Sharma, S.B. and Dhillion, B.S. 1986. Effect of zinc sulphate and growth regulators on fruit and seed size of litchi (Litchi chinensis). *J. Res. Punjab Agril. Univ*.**23**(2): 233-236.

Singh, B. and Rethy, P. 1995. Effect of certain micronutrients and NAA on flowering and fruits of Kagzi lime (Citrus aurantifolia Swingle). *Indian J. Hill Fmg*. **8**(2):152-157.

Singh, J.K., Prasad, J., Singh, H.K. and Singh, A. 2008. Effect of micronutrients and plant growth regulators on plant growth and fruit drop in aonla (Emblica officinallis Gaerthn.) fruits cv.'Narendra Aonla-10'.Plant Arachive**. 8**(2): 911-913.

Sinha, A.K., Sinha, C. and Jain B.P. 1999. Effect of plant growth substances and micronutrients on fruit set, fruit drop, fruit retention, cracking of litchi cv. Purbi. *Ind. J. Hort*. **56**(4): 309-311.

Srivastava, K.C., Muthappa, D.P., Ganapathi, M.M. and Shomasundaram, K.S. 1981. Effect of micronutrients on yield and quality of sweet orange. Paperread at Nat. Symp. Trop. and Subtrop. Fruit Crops, Bangalore pp: **86**.

South Wick, S.M. and Davenport, T.L. (1987).Proc. of plant growth regulator. Soc. of Amer., **487**-488.

Yadlod, B.M., Kadam, S.S. and Rodge, B.A. 2009. Effect of plant growth regulators and micronutrients on physical and chemical characters of banana (Musa spp.) cv. Shrimanti.*J. Maharashtra Agriculture University*; **34**(3): 269-271.

***Originals are not seen.**

28	09-15 July	18.5	1.0	29.8	21.1	86	64
29	16-22 July	23.0	0.0	28.2	21.0	92	79
30	23-29 July	17.0	2.0	28.2	21.1	91	74
31	30-05 Aug	3.0	1.0	30.6	21.1	90	64
32	06-12 Aug	0.0	0.0	31.2	22.0	89	62
33	13-19 Aug	7.0	1.0	31.4	22.3	86	69
34	20-26 Aug	63.0	3.0	27.8	20.9	88	77
35	27-02 Sept	30.0	2.0	20.4	14.4	89	77
36	03-09 Sep	45.5	2.0	22.1	15.4	88	63
37	10-16 Sep	62.5	3.0	30.5	21.3	91	75
38	17-23 Sep	128.0	4.0	29.0	21.0	88	68
39	24-30 Sep	0.0	0.0	31.4	21.7	87	58
40	01-07 Oct.	7.5	1.0	34.2	19.9	70	56
41	08-14 Oct.	33.0	3.0	29.8	21.1	92	65
42	15-21 Oct.	10.5	2.0	31.7	20.0	74	35
43	22-28 Oct.	0.0	0.0	33.6	19.1	70	33
44	29-04 Nov.	0.0	0.0	33.0	16.4	59	29
45	05-11 Nov.	0.0	0.0	31.3	15.1	59	36
46	12-18 Nov.	0.0	0.0	30.4	14.2	58	33
47	19-25 Nov.	0.0	0.0	30.4	18.3	64	40
48	26-02 Dec.	0.0	0.0	30.6	12.8	58	35
49	03-09 Dec.	0.0	0.0	28.6	16.3	65	52
50	10-16 Dec.	0.0	0.0	30.1	15.0	66	59
51	17-23 Dec.	0.0	0.0	29.9	13.8	59	31
52	24-31 Dec.	0.0	0.0	25.1	10.8	48	22
	From Jan	662.0	35.0				

VITA

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A candidate for the degree
of
MASTER OF SCIENCE (HORTICULTURE)
In
FRUIT SCIENCE
2018

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