"STUDIES ON THE EFFECT OF FOLIAR APPLICATION OF CALCIUM, POTASSIUM AND SILICON ON YIELD, FRUIT QUALITY AND SHELF LIFE OF SWEET ORANGE (*Citrus sinensis* L.) Cv. SATHGUDI"

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By

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B.Sc. (Hons.) Horticulture

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IN PARTIAL FULFILMENT OF THE REQUIREMENTS

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January, 2021

CERTIFICATE

Ms. MANGALI MOUNIKA has satisfactorily prosecuted the course of research and that the thesis entitled **"STUDIES ON THE EFFECT OF FOLIAR APPLICATION OF CALCIUM, POTASSIUM AND SILICON ON YIELD, FRUIT QUALITY AND SHELF LIFE OF SWEET ORANGE (*Citrus sinensis* L.) Cv.SATHGUDI"** submitted, is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination.

I certify that neither the thesis nor its part thereof has been previously submitted by him for a degree of any University.

Date : **(Dr.T. SURESH KUMAR)**

Place: Rajendranagar,Hyderabad **Chairman**

CERTIFICATE

This is to certify that the thesis entitled **"STUDIES ON THE EFFECT OF FOLIAR APPLICATION OF CALCIUM, POTASSIUM AND SILICON ON YIELD, FRUIT QUALITY AND SHELF LIFE OF SWEET ORANGE (*Citrus sinensis* L.) Cv. SATHGUDI"** submitted in partial fulfilment of the requirements for the degree of Master of Science in Horticulture (Fruit Science) of Sri Konda Laxman Telangana State Horticultural University, Mulugu, Siddipet, is a record of the bonafide research work carried out by **Ms. MANGALI MOUNIKA** under our guidance and supervision.

No part of the thesis has been submitted by the student for any other degree or diploma. The published part and all assistance received during the course of the investigations have been duly acknowledged by the author of the thesis.

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I, **Ms. MANGALI MOUNIKA**, hereby declare that the thesis entitled **"STUDIES ON THE EFFECT OF FOLIAR APPLICATION OF CALCIUM, POTASSIUM AND SILICON ON YIELD, FRUIT QUALITY AND SHELF LIFE OF SWEET ORANGE (*Citrus sinensis* L.) Cv. SATHGUDI"** submitted to Sri Konda Laxman Telangana State Horticultural University**,** Mulugu, Siddipet for the degree of Master of Science in Horticulture (Fruit Science) is the result of original research work done by me. I declare that no material contained in the thesis has been published earlier in any manner.

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LIST OF SYMBOLS AND ABBREVIATIONS

%	:	Per Cent
@	:	At the rate of
±	:	Plus or minus
/	:	Per
&	:	And
ºB	:	Degree Brix
ºC	:	Degree Celsius
AOAC	:	Association of Official Analytical Chemists
ANOVA	:	Analysis of variance
CD	:	Critical Difference
Cm	:	Centimeter
cv.	:	Cultivar
DAFS	:	Days After Fruit Set
DAYS	:	Days After Storage
etc.	:	Etcetera
et al.	:	and others
Eq. wt.	:	Equivalent weight
Fe	:	Iron
Fig.	:	Figure
FYM	:	Farm Yard Manure
g	:	Gram
GA_3	:	Gibberellic acid
Ha	:	Hectare
Hcl	:	Hydrochloric acid

HRS	:	Horticulture Research Station
H_2SO_4	:	Sulphuric acid
2,4-D	:	2,4-Dichlorophenoxyacetic acid
i.e.	:	That is
IIHR	:	Indian institute of horticulturalresearch
Kg	:	Kilogram
Kg ha-1	:	Kilogram per hectare
Kg/tree	:	Kilogram per tree
M	:	Meter
m2	:	Meter square
Max	:	Maximum
MSL	:	Mean sea level
mg	:	Milligram
Mn	:	Manganese
Ml	:	Millilitre
mm	:	Millimeter
Min.	:	Minimum
MT	:	Metric tonnes
MT/ha	:	Metric tonnes per hectare
N	:	Normality
NAA	:	Naphthalene Acetic Acid
NHB	:	National Horticulture Board
NaOH	:	Sodium hydroxide
nm	:	Nano meter
No.	:	Number
NS	:	Non significant

PGR	:	Plant growth regulator
PLW	:	Physiological Loss in Weight
ppm	:	Parts per million
PH	:	Hydrogen ion concentration
q	:	Quintal
RBD	:	Randomized Block Design
RH	:	Relative humidity
SE (m) ±	:	Standard Error of Mean
Sig.	:	Significant
SKLTSHU	:	Sri Konda Laxman Telangana State Horticultural University
T	:	Tonnes
TA	:	Titrable acidity
t/ha	:	Tonnes per Hectare
TSS	:	Total Soluble Solids
viz.	:	As follows
Vol.	:	Volume
Zn	:	Zinc
KNO_3	:	Potassium Nitrate
K_2SiO_3	:	Potassium Silicate
$Ca(NO_3)_2$	:	Calcium Nitrate
$CaCl_2$	:	Calcium Chloride

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ABSTRACT

The present investigation entitled "Studies on the effect of foliar application of Calcium, Potassium and Silicon on yield, fruit quality and shelf life of sweet orange cv. Sathgudi" was conducted at Horticultural Research Station, Konda Mallepally, Nalgonda.

The objective of this experiment was to study the Effect of Calcium, Potassium and Silicon on yield, fruit quality and shelf life of sweet orange.

The experiment was laid down in Randomized Block Design (RBD) with 13 treatments and three replications. Calcium, Potassium, and Silicon at various concentrations were sprayed at before bloom stage (one month before flowering), after fruit set, and after a month of second spray.

The observations on fruit weight, fruit length, fruit volume, diameter of the fruit, peel thickness, fruit firmness, number of fruits/tree, yield per tree and quality parameters like juice content, total soluble solids, titrable acidity, total sugars, reducing sugars, non reducing sugars, ascorbic acid and shelf life parameters like physiological loss in weight, shelf life, spoilage were recorded.

The maximum fruit weight (244.93g), fruit length (6.68cm), fruit volume (145.00ml) fruit diameter (6.95cm), yield per tree (60.17kg) juice content (46.37%), TSS (12.07B^0), minimum acidity (0.53%) maximum total sugars (6.28%), reducing sugars (4.10%), non reducing sugars (2.18%) were recorded in the tree sprayed with T_4 – (4ml/L) K_2SiO_3. Maximum number of fruits per tree (250.00) was recorded in T_1 – 1 % KNO_3. while minimum was recorded in T_{13} - control.

Data on shelf life parameters of the fruits differed significantly among the treatments, Lowest physiological loss in weight, maximum shelf life (27.20days) and minimum spoilage % was recorded in treatment T_7 – 1% $Ca(NO_3)_2$ while highest physiological loss in weight, spoilage% and lowest shelf life were recorded in T_{13} control

In this study, the application of calcium, potassium and silicon nutrients T_4 - (4ml/L) K_2SiO_3 was found to be superior as revealed by the results and thus can be recommended to increase the fruit quality and yield parameters of sweet orange, and T_7 - 1% $Ca(NO_3)_2$ is recommended for extending shelf life.

CHAPTER I

INTRODUCTION

Citrus is one of the most important fruit crops which rank third in area and production after Mango and Banana in India (National Horticulture Database, 2016).

Citrus fruits contribute around 20 % of world's total fruit production. Major citrus producing countries are Brazil, USA, Mexico, China, India, South Africa, Japan, Israel, Turkey, Spain and Cuba. India ranks sixth in the production of citrus fruits in the world. Of the various types of citrus fruits grown in India, Mandarins /Santra, Sweet orange and Lime/Lemon are of commercial importance.

Citrus consist of group of fruits belonging to the family Rutaceae. It is highly priced and economically remunerative fruit.Citrus fruits have special importance due to their distinct flavours and therapeutic values.Fruits are rich in vitamin C with fair amounts of vitamins A and B. Besides this, they are rich source of minerals (Calcium, Phosphorus and Iron).

The main edible portion of a citrus fruit is juicy placental hairs which contain juice. The juice of sweet orange and mandarin contains 12% sugar, 0.5-1.5 % titrable acidity, 1% citric acid and 50 mg ascorbic acid (Vitamin C) per 100 ml of juice and about 70-90 % water along with other soluble solids. Mandarins, sweet orange and grape fruits are highly valued as table fruits. Various types of processed products like canned segments, juice concentrates, jellies, marmalade, mixed fruit jam and crystallized fruits are prepared from mandarins and sweet orange. Commercial pectin and essential oils are made from the rind of the fruits. The medicinal research reveals that eating of citrus fruits can reduce risk of heart attack and strokes.

Sweet orange is the second important citrus fruit cultivated in the country. Its origin is traced back to China, Northern India and Southern Asia. Telangana, Maharashtra, Karnataka, Punjab, Haryana and Rajasthan are main Sweet orange growing states. The major sweet orange growing districts in Telangana are Nalgonda, Suryapet, Gadwal, Mahabubnagar and Ranga Reddy.

Among the different cultivars of Sweet orange, Sathgudi is the important commercial cultivar and has wide adaptability. The fruit of this variety is medium, subglobose to spherical in shape, with smooth rind of medium thick orange colour.The flesh colour is straw or orange colour, segments are 10-12 andjuice with good flavor.

Citrus fruit contains considerable amount of vitamin C, dietary fibre (non starchy polysaccharides) that are essential for normal growth and development. The rind of citrus fruits is rich in pectin and certain essential oils. In sweet orange the chief constituent of the edible portion are sugars (glucose and sucrose), and acids (Citric acid).

Micronutrients like Calcium (Ca), Potassium (K) and Silicon (Si) play a vital role in plants.Foliar application of micro nutrients are more successful than soil application.Calcium is known to play an important role in the quality retention of fruits in maintaining the firmness, reducing respiration rate, ethylene evolution and decreasing rots (LokeshYadav and Varu, 2013). It maintains cell wall structure and delays ripening and senescence. (Carlos crisosto *et al*., 2000)

Potassium is required by most fruit crops in large quantity and practically supplied through the leaves. In addition, Potassium nutrition also effects the mineral uptake and their distribution to different plant parts like shoots, leaves, fruits etc. Market qualities, fruit size, soluble solids and yield increases upon foliar application of potassium. (Doroshenko*et al*., 2005).

Silicon is the most abundant element both on the surface of the earth and in the soil, and not yet been listed among the essential elements for higher plants. The major role of silicon in plant biology is to reduce multiple stresses including biotic and abiotic stresses. Recently the International Plant Nutrition Institute (IPNI) (2015)Georgia, USA has listed it as a “beneficial substance” The beneficial effect of silicon on mitigating various abiotic stresses is attributed to its effect on stimulating of antioxidant system in plants (Epstein E and bloom, 2003). It is also known to increase drought tolerance in plants by maintaining plant water balance, photosynthetic activity erectness of leaves and structure of xylem vessels under high transpiration rates (Melo *et al*., 2003). (Gong *et al*., 2003)observed improved water economy and dry matter yield by silicon application and it enhanced leaf water potential under water stress conditions, reduced incidence of micronutrient and metal toxicity (Matoh *et al*., 1991). It is most commonly applied as foliar spray to correct the deficiency of specific element rather than complete requirement of that element. However, foliar spraying of silicon if effective, may offer practical and viable mean of reducing plant diseases with low cost .

Therefore, foliar application of calcium potassium and silicon is necessary to produce high yield in sweet orangewith better quality along with shelf life. Considering the above facts in view, a study was conducted at Horticultural Research Station (HRS), Konda Mallepally, Nalgonda district with the following objectives.

1. To study the effect of foliar application of nutrients on yield and quality of sweet orange.
2. To study the effect of foliar application of nutrients on shelf life of sweet orange.

CHAPTER II

REVIEW OF LITERATURE

Citrus is considered to be the most remunerative fruit crop. The yield of a tree depends on its successful mineral uptake and their distribution to different plant parts like shoots, leaves, fruits. Quality of the fruit depends on maintaining the firmness reducing respiration rate, maintenance of cell wall structure.

In this context, foliar application of nutrients are perhaps the most powerful tools currently available for achieving the desired results. Foliar nutrients like calcium, potassium, silicon have been found to be the most effective means of improving productivity by directly influencing the quantitative as well as qualitative aspects of fruits and shelf life. These play an important role in controlling different growth and developmental processes of plants in conjunction with weather conditions.

In this chapter, an attempt has been made to review the available literature on effect of foliar application of nutrients on yield, quality and shelf life parameters of sweet orange and other fruit crops under the following sub headings.

2.1 Effect of foliar application of nutrients on yield and quality parameters.

2.2 Effect of foliar application of nutrients on shelf life parameters.

2.1 Effect of foliar application of nutrients on yield and quality parameters.

2.1.1 Citrus

Debaje *et al.* (2011) studied the effect of foliar spray of plant growth regulators viz., GA_3 and NAA and nutrients like urea and KNO_3 singly or in combination on qualitative parameters of hastha bahar acid lime fruits. Two foliar sprays at monthly interval were carried out and observations were recorded for fruit growth in terms of average weight and volume of fruit and qualitative parameters. Results revealed that two foliar spray of KNO_3 @ 2.0 per cent and GA_3 @ 100 ppm increased fruit weight, fruit volume and improved the fruit quality like maximum juice percentage, TSS and ascorbic acid content was obtained, where as acidity and peel percentage was reduced resulting into better quality fruit.

Mukunda lakshmi *et al*. (2014) conducted an experiment on 10 year old acid lime cv. Balaji plants to study the effectiveness of foliar spray of plant growth regulators and chemicals on fruit yield and quality and concluded that KNO_3 1% along with GA_3 @ 50 ppm, cycocel 1000 ppm was superior with number of fruits per tree (529.34), fruit weight (41.12g), yield (24.08kg/tree) juice content (34.34ml), and TSS (6.92˚ Brix.).

Aly *et al.* (2015) studied the foliar application of calcium, potassium, and zinc treatments on yield and fruit quality of washington navel orange trees and concluded that $CaCl_2$ @ 1.5% was effective in increasing the fruit weight.

Vijay *et al*. (2016) reported that foliar application of 2% KNO_3 and 4% KNO_3 was better than K_2SO_4 in increasing the juice content, quality, and yield of sweet orange cv. Jaffa.

Shraky *et al.* (2016) studied the pre and post harvest application of potassium silicate on Olinda Valencia orange and concluded that potassium silicate (K_2SiO_3) @ 4% was better in increasing the fruit yield kg/tree and enhanced physical and chemical fruit quality, weight, dimensions, fruit peel thickness and TSS/acid ratio.

Meena *et al*. (2016) investigated on preharvest spray of calcium nitrate, boric acid, and zinc sulphate on yield and quality of 8 years old Nagpur mandarin and concluded that $Ca(NO_3)_2$ @ 3.0% was best in increasing the diameter of the fruit, fruit weight, fruit volume, number of fruits per plant and yield per plant.

Vijay *et al.* (2017) studied foliar application of potassium and its spray schedule on yield and quality of orange and concluded that foliar application of

KNO_3 3% at last week of April, and August in sweet orange cv. Jaffa was superior in improving yield parameters.

Fatma *et al*. (2017) investigated effect of silica compounds on vegetative growth, yield, fruit quality and nutritional status of Olinda orange and found that potassium silicate 2.0% was effective in increasing the weight of the fruit.

Hikal *et al*. (2017) reported that spraying of Navel orange trees with $CaCl_2$ @ 2.0% along with 0.2% boric acid increased the fruit setting (%), yield (kg), fruit quality as well as average fruit weight, average fruit volume, TSS (%), and vitamin C compared to control treatment.

Emad *et al*. (2018) concluded that foliar spray of Balady orange trees with $CaCl_2$ at 2%, potassium chloride 2%, and micro silica at 1.0% were found to be most effective in increasing yield, fruit physical and chemical properties such as TSS, Vit C, and TSS/ acid ratio compared to control treatment.

Muhammad *et al*. (2018) observed that 2% KNO_3 along with GA_3 @ 25 ppm sprayed at full bloom stage, increased the fruit set and fruit yields and quality in Washington navel oranges.

Obadiya *et al*. (2018) conducted experiment on effectiveness of plant growth regulators and chemicals on vegetative and reproductive parameters of hasth bahar acid lime and concluded that GA_3 @ 50 ppm, sprayed at June, and cycocel @ 1000 ppm sprayed in September showed superior performance in regard to number of fruit per tree (382.50) initial fruit set (54.74%) and fruit retension (39.73%), yield (4.13 t/ha) and percentage increase in yield over control (52.43%).

Shinde *et al*. (2019) concluded that foliar application of potassium forms, KNO_3 @ 1%, monopotassium phosphate 1.5% and potassium sulphate 1% and micro nutrients combinations increased the quality attributes of sweet orange Cv (*Citrus sinensis* L Osbeck).

Nadia *et al*. (2018) reported that foliar application of Valencia orange trees budded on sour orange root stock with 1% potassium nitrate along with Nitrophenolate @ 630 ppm showed improving fruit rind colour.

2.1.2 Mango

Babul *et al.* (2013) reported that foliar spray of 4% KNO_3 on 9 year old mango cv. Amrapali had increased the fruit yield and highest number of fruits per plant (136.67) and biggest fruit (202.83g) maximum yield (23.14 kg/plant) as compared to control.

Ali *et al*. (2014) studied the effect of some foliar sprays on mango cultivars Hindy Be-Sinnara, Ewis, and Sedik and concluded that foliar application of calcium chloride @ 400 ppm four times in the first and mid of October and November has increased yield of cultivars.

Baiea *et al*. (2015) reported that foliar spraying of mango cv. Hindi with 2% KNO_3 along with 2% mono potassium phosphate and 2% di potassium phosphate at 4 times at full bloom stage, after fruit set, during fruit growing and before harvesting resulted effective in improving fruit retension, yield, weight (kg/tree), pulp weight, enhanced total soluble solids (TSS), total sugars, and ascorbic acid content.

Patel *et al*. (2016) conducted experiment on effects of nutrients and thiourea on yield and quality of mango cv. Kesar and concluded that foliar application of 1.0% KNO_3 in mid October followed by 0.5% thiourea in mid November induced early flowering and early maturity of fruit and increased the number of fruits per tree, yield per tree and quality parameters like TSS, ascorbic acid content and shelf life.

Fatma *et al.* (2019) concluded that foliar application of 1.0% KNO_3 in combination with boric acid 0.2% on mango cv. Summer bahisht (SB) chaunsa found more effective in improving quality and yield of mango.

Shuchi parauha *et al*. (2019) studied the influence of plant growth regulators and nutrients on fruit retension yield and quality attributes of mango cv. Amrapali and concluded that combination of GA_3 @ 30 ppm, and KNO_3 2%

showed better performance in terms of higher number of fruits at initial stage, more fruit retension percentage at harvest stage (1.94%) fruit yield (14.70 kg/tree) fruit weight (31.36 g) chemical composition of fruit via maximum TSS, ascorbic acid, reducing sugars, total sugars, and minimum acidity content (0.12%).

Manoj kumar *et al*. (2019) reported that fruit yield of mango cultivars viz. Bombay Green, Dashehari and langra was increased by spraying with KH_2PO_4 1% and 1% KNO_3.

2.1.3 Papaya

Babak Madani *et al*. (2015) reported that foliar spray of $CaCl_2$ four times at preharvest stage in papaya cv. EksotikaII at different concentrations improved fruit calcum concentration, texture and decreased weight loss and increased firmness and shelf life of fruits.

Babak *et al*. (2016) observed that preharvest calcium spray increased calcium content and post harvest quality of papaya fruits. Calcium chloride could be more suitable source of calcium for increasing calcium content in fruit.

Monika *et al*. (2018) studied the effect of foliar application of nutrients calcium, and sulphur on growth and yield of papaya (*Carica papaya* L.) and concluded that foliar spray of $Ca(No_3)_2$ along with sulphur and micronutrients resulted in highest number of fruits, fruit weight, fruit length and fruit yield.

2.1.4 Peach

Aravind preet kaur *et al*. (2012) conducted an experiment on peach cv Shan -i- Punjab to study the effect of preharvest application of potassium nitrate, calcium chloride, boric acid @ 1%, 2%, and 3% each along with growth regulators at two weeks and one week before harvesting reavealed that 2% potassium nitrate increased the TSS and TSS:acid ratio.

Aravind preet kaur *et al.* (2016) reported that pre harvest application of peach tree with 2% KNO_3 increased total soluble content and pectin. Highest fruit firmness was recorded with 2% calcium chloride.

Vikramjeet singh and kaur (2018) conducted experiment to study the effect of foliar spray of potassium nitrate, GA_3 and salicylic acid on fruit yield and quality of peach cv. Shan-i-Punjab. Results showed that KNO_3 @ 3% along with GA_3 @ 100 ppm increased the fruit weight, yield, fruit TSS, TSS:Acid ratio, reducing sugars, total sugars.

2.1.5 Guava

Jitendra kumar *et al*. (2015) studied the response of Pant bahar guava trees to foliar spray of zinc, boran, calcium and potassium at different plant growth stages and results recorded concluded that foliar spray of KNO_3 @ 0.5% at fruit set and two weeks after fruit set increased the TSS (11.50˚Brix) and total sugars (7.36%).

Manivannan *et al*. (2015) concluded that pre harvest application of calcium chloride along with potassium sulphate 1% increased the yield parameters and quality parameters in guava cv. L 49.

Kharwade *et al*. (2018) studied the effect of foliar application of chemicals on yield and economics of 9 year old guava cv. Sardar. Results revealed that two foliar spray at 30 to 60 days after flowering with $Ca(NO_3)_2$ @ 1%, and sulphate of potash 1% increased the yield, quality and profitability.

Shivpoojan *et al*. (2018) conducted experiment to investigated the foliar spray of micronutrients especially boran and calcium on quality and yield of winter guava cv. Lalit and results revealed that $CaCl_2$ 0.2% along with boran 0.1% was best with 66.5 % fruit set.

Hemanshi *et al*. (2019) studied the effect of foliar application of calcium nitrate, and gibberellic acid at the time of fruit set and 25 days, 15 days before harvest during kharif season on guava L-49 and observed that three sprays of $Ca(No_3)_2$ @ 1.5% along with gibberellic acid 100 ppm obtained better yield, quality and storage behavior of guava.

2.1.6 Pomegranate

Nazan korkma *et al*. (2016) studied the effect of foliar application of calcium nitrate and gibberellic acid in pomegranate during blossoming period and one month after blossoming and results showed that 2% $Ca(NO_3)_2$ increased the amount of total soluble solids and increased the yields and fruit weight.

Durgude *et al*. (2019) observed the effect of different chemicals on flowering, fruit set and yield in pomegranate cv Phule Bhagwa. Results recorded found that 1% KNO_3 along with soil application of D-glucose 50g/plant and microbial inoculums minimized the male flowers and maximized hermaphrodite flowers (65.31%) and increased the yield per plant (49.59 kg/tree).

2.1.7 Apple

Hassanloui *et al*. (2004) reported that foliar applications of $CaCl_2$ solutions increased fruit firmness compared with fruits receiving high rates of potassium but no calcium in apple. The maximum firmness was obtained with 8 times application of $CaCl_2$ solution. The treatment 6 with the application of potassium at 1.5 times the soil test but no foliar application of calcium chloride, resulted in the lowest firmness. The treatments did not affect fruit firmness in 90 days after storage. To increase the calcium of fruits and to improve the fruit firmness 8 biweekly foliar applications of $CaCl_2$ (beginning 3 to 4 weeks after full bloom) is recommended.

Lanauskas *et al*. (2006) reported that foliar application of calcium nitrate incombination with calcium chloride, and waxal raised the fruit calcium content in 9 years old apple tree cv. sinap orlovskij.

Walid *et al*. (2015) studied the effct of foliar application of potassium calcium, boran, and humic acid on vegetative growth, fruit set, leaf mineral composition, yield and fruit quality of Anna apple tree. Results recorded showed that $CaCl_2$ 0.2% along with potassium sulphate and 0.2% boric acid and 5% humic acid had positive effect on improving the percentage of yield, fruit set, reducing sugars, and total soluble solids.

Kuchay *et al*. (2018) studied the effect of foliar application of nitrogen and calcium on fruit quality attributes, yield and leaf nutrient content of apple cv. Red delicious and concluded that foliar spray of nitrogen 0.5% and calcium nitrate 0.5 % increased the fruit length (7.95 cm), fruit diameter (7.93 cm), fruit weight (214.42 g), acidity (0.90%), and yield (127.96 kg/tree). Calcium nitrate 0.5% significantly increased fruit firmness (8.64 kg/cm^2), and total phenol (162.02 mg GAE/100g FE).

2.1.8 Pear

Gill *et al*. (2012) studied the foliar application of Pathernakh pear with potassium nitrate at 1.0%, 1.5%, and 2%, along with k_2So_4 in three sprays, first at 15 days after full bloom, second at 3 days after full bloom, third spray at 45 days after full bloom. Results recorded & revealed that foliar application of 1.5% KNO_3 had maximum fruit size (fruit length 6.86cm and fruit breadth 6.72 cm) compared with control.

Prasad *et al*. (2015) studied the effect of pre harvest foliar application of calcium and potassium on fruit quality of pear cv. Pathernakh and concluded that KNO_3 @ 1.5% showed highest total soluble solids (11.72˚B), total sugars (7.62%), reducing sugars (6.10%), non reducing sugars (1.51%). However titrable acidity (0.46%), and ascorbic acid (6.42mg/100g) were found maximum with calcium chloride 2.0% concentration.

Changwei shen *et al*. (2016) reported that foliar spray of potassium nitrate was effective in fruit growth rate, potassium accumalation, increasing the fruit yield and quality of Kousui Japanese pear.

2.1.9 Sapota

Lalithya *et al*. (2014) studied the response of silicon and micronutrients on fruit character and nutrient content in leaf of sapota and results recorded & showed that foliar spray of potassium silicate 8 ml /Liter gave highest yield per tree (124.81 %), and (12.48 %), and fruit characters like fruit weight (99.96 g), fruit length (5.55 g), fruit diameter (5.85 g), volume of the fruit (102.38 g) and maximum shelf life (10.90 days).

Patel *et al*. (2017) reported that pre harvest foliar spray of calcium chloride 1.0% on 20 years old sapota cv . Kalipatti three weeks before harvest was effective in increasing total soluble solids, total sugars, reducing sugar, non reducing sugar, ascorbic acid with minimum acidity and moisture content.

2.1.10 Aonla

Dinesh *et al*. (2014) concluded that 9 years old aonla cv. NA-7 sprayed with combination of 0.65 % calcium nitrate + 0.4% borax +0.8 % zinc sulphate had showed increase in canopy height (0.93 m), fruit volume (44.10 ml), fruit length (4.20 cm), reducing sugar (3.56 %), non reducing sugar (2.99%), juice (78.22 %), fruit weight (45.20 g), yield per tree (42.70 kg).

Mauryai *et al.* (2016) reported that foliar application of aonla cv. NA-6 with calcium nitrate 1% in combination with zinc sulphate 0.5%, and potassium sulphate 2% resulted in maximum fruit retension (28.4%), length (4.3cm), breadth (4.40 cm), weight (44.30 g) and fruit volume (41.40 cm^3).

2.1.11 Olive

Hegazi *et al*. (2011) studied the effective concentration and application time of potassium nitrate on vegetative, nutritional status, yield and fruit quality of Picual olive tree and the results obtained showed that KNO_3 sprayed after final fruit set or pit hardening gave best values of fruit quality and flesh oil content.

Abd-EI –Rhman *et al.* (2016) concluded that foliar spray of potassium nitrate @ 30 g along with combination of salicylic acid 1000 mg at vegetative stage, beginning of flowering and after fruit setting increased the yield and fruit physical and chemical properties of olive trees under salinity stress conditions.

2.1.12 Ber

Gill and Bal *et al.* (2009) observed that spraying with KNO_3 (1.5 %) exhibited maximum fruit size, fruit weight, palatability of ber fruits than control. Maximum vitamin C (104.2 mg/100 g pulp) content was observed in NAA (30 ppm), followed by KNO_3 (1.5 %) treatment. Results indicated that NAA (30 ppm) spray was better for fruit retention. However, fruit quality in terms of size, colour and palatability rating was better with KNO_3 (1.5 %).

Sudhir kumar *et al*. (2018) studied the effect of high foliar nutrients and potassium nitrate sprayed three times at the interval of fifteen days starting from December at marble stage and observations recorded showed that potassium nitrate 1.0% was effective in enhancing the fruit growth, fruit quality and yield in ber cv. seo.

2.1.13 Banana

Hanumanthaiah *et al*. (2015) studied the effect of foliar application of silicon on fruit quality parameters of banana cv. Neypoovan and concluded that potassium silicate 2.0ml/Lit and 4.0ml /Lit sprayed at 15 and 30 days interval has increased shelf life (6.33 days), yield, total soluble solids, reducing and non reducing sugars and pulp, peel ratio of fruits compared with control.

2.1.14 Plum

Jawandha *et al*. (2017) studied the effect of foliar application of potassium nitrate at different concentrations 1.0 %, 1.5 %, 2.0 % on fruit yield, quality of plum cv. Satluj purple. Results concluded that KNO_3 @ 1.0% sprayed after two weeks of full bloom and second spray at 10 days thereafter was found to be most effective to increase the fruit yield (34.43 kg/plant), and weight (38.06 g) and size, total soluble solids, and decreased the titrable acidity (0.76%) of fruits compared with control.

2.1.15 Litchi

Divya pandey *et al*. (2018) concluded that foliar application of KNO_3 1% sprayed 10 days after fruit set in litchi cv. Dehradun increased the fruit weight (20.9 g), and quality parameters TSS, total sugars compared with control.

2.2 Effect of foliar application of nutrients on shelf life parameters.

2.2.1 Guava

Rajput *et al*. (2008) studied the effect of pre and post harvest foliar applications on shelf life and quality of guava cv. Gwalior -27 and concluded that pre harvest spray of $Ca(No_3)_2$ @ 2.0 % and post harvest dip had increased shelf life (10.17 days), higher ascorbic acid (208.77 mg/100g), and pectin content (0.97 %).

Mandal Goutam *et al.* (2010) observed the effect of pre harvest calcium spray on fruit quality attributes and post harvest life of winter guava cv. Sardar and results showed that $Ca(No_3)_2$ @ 1% is most effective in increasing the shelf life when evaluated at 20, 30, 40 days of storage during shelf life and reduced spoilage, maintained higher firmness, total soluble solids (11.9 %), and ascorbic acid.

Gowtam mandal *et al*. (2012) reported that pre harvest application of winter guava tree with KNO_3 @ 1% along with plant growth regulator NAA @ 100 ppm had increased the fruit firmness, reduced spoilage, higher TSS, and ascorbic acid and slightly desirable after 30 days of storage.

Sharad *et al* . (2014) observed the effect of pre harvest spray of calcium nitrate and gibberellic acid on growth , quality of fruit and yield of guava cv. Allahabad safeda and concluded that $Ca(No_3)_2$ @ 1.5 %, GA_3 100 ppm gave best results in terms of fruit size, firmness, specific gravity, total soluble solids, total sugars (10.20 %), reducing sugars, non reducing sugars, calcium content, ascorbic acid, decrease in physiological loss in weight, decay loss.

Kanpure *et al*. (2019) concluded that foliar pre harvest spray of GA_3 100 ppm and $Ca(NO_3)_2$ 2%, potassium sulphate 2% on two guava varities Chittidar and Dharidar had decreased the decay loss percentage on 6^{th} and 9^{th} day at storage (27.88%), and highest TSS (12.51˚B).

2.2.2 Mango

Umuhoza *et al.* (2014) concluded that pre harvest spray of calcium chloride @ 1.50 % in mango cv. Totapuri at 30 days and 15 days before harvest significantly improved the shelf life of fruit (25.89 days) physico chemical parameters like fruit length (25.89 cm), breadth (7.73 cm), thickness (6.97 cm), weight of the fruit (347.89 g), pulp weight (215.56 g), peel weight (42.11 g), stone weight(54.33 g), TSS (16.73˚Brix), total sugars (11.89 %), reducing sugar (1.95 %), non reducing sugar (9.94%), and minimum titrable acidity (0.10%) compared to control.

Umuhoza karemera *et al.* (2014) conducted experiment on role of calcium chloride spray on post harvest behavior of mango cv. Raspuri and the results obtained showed that $CaCl_2$ @ 1.50 % sprayed at 30 days and 15 days before harvest was effective in increasing the number of days for ripening (9.11days), shelf life (15.89days), and fruit physico chemical parameters, volume (225.00ml), weight of fruit (231.67g), TSS (19.13˚Brix), total sugars (13.00%) reducing sugars (2.65%), non reducing sugars (10.35%), minimum percentage of titrable acidity (0.14%), compared to all other treatments.

Umuhoza *et al*. (2014) studied the effect of pre harvest calcium chloride on post harvest behavior of mango cv. Alphonso and results recorded revealed that $CaCl_2$ @ 1.50 % sprayed 30 days before harvest significantly increased the number of days taken for ripening of fruits, shelf life of fruits (24.33 days), physico chemical parameters and organoleptic evaluation of mango fruits compared to control.

Urvish patel *et al.* (2015) conducted study on effect of pre harvest spray of chemicals on shelf life and quality of mango cv. Kesar and concluded that 2, 4,-D 200 ppm + $ZnSo_4$ 0.05% increased the shelf life and yield. and pre harvest spray of GA_3 25 ppm + $ZnSo_4$ 0.05% and GA_3 25 ppm + $CaCl_2$ @ 2 % were performed better in quality parameters like TSS, ascorbic acid, vitamin - A, colour, flavor, texture.

Sohnika rani *et al.* (2017) studied the effect of foliar nutrition on yield, quality and shelf life of mango cv. Dashehari. Results revealed that $Ca(No_3)_2$ + KNO_3 2.0 % + 1.0% $ZnSo_4$ + 0.02 % H_3BO_3 at pea stage increased the yield and nutrient status of mango. Maximum total sugars (15.07 %) reducing sugars (3.98 %), non reducing sugars (10.53 %), ascorbic acid (41.82 mg/100g) pulp were recorded. The percent physiological loss in weight was found minimum 4.83%, 8.07 %, 11.01 %, 16.61 %, 24.51 % and 29.635 % at 3, 4, 6, 8, 10 and 12 days respectively.

Mounika *et al*. (2017) observed the effect of calcium chloride, calcium nitrate, potassium nitrate and carboxyl methyl cellulose on post harvest shelf life and quality of mango cv. Amrapali and concluded that $Ca(NO_3)_2$ @ 2%

recorded significantly lower PLW %, higher fruit firmness, lower spoilage percent, higher acidity %, TSS, and sugars%. Shelf life increased upto 20.33 days compared with control (9.33 days).

2.2.3 Sapota

Sudha *et al*. (2007) observed the influence of pre and post harvest chemical treatments on physical characteristics of sapota cv. PKM-1 and concluded that 50 ppm GA_3 along with 0.2% bavistin recorded lowest physiological loss in weight, shrinkage. Pre harvest spray of 50 ppm GA_3 with post harvest dipping in 1 % $CaCl_2$ along with 0.2% bavistin recorded highest firmness.

Bhalerao *et al.* (2009) studied the preharvest spray of different sources of calcium to improve the physiological quality of sapota cv. Kalipatti and concluded that among all treatments $CaCl_2$ @ 1.0% was best with minimum physiological loss in weight (910.71 %), fruit firmness was maximum (6.62 %), shelf life was maximum (13.75 days).

Patel *et al*. (2017) reported that the pre harvest spray 3 weeks before harvest of $CaCl_2$ @ 1.5 % improved fruit weight and fruit volume (66.97 cc), increased fruit firmness (9.10 kg/cm^2), increased fruit shelf life with minimum Physiological loss in weight and spoilage of fruits (6.19, 20.00, 34.06, and 47.82 %) on 4^{th}, 6^{th}, 8^{th}, and 10^{th} day of storage.

2.2.4 Papaya

Mahmud *et al*. (2008) observed the effect of different concentrations of application of calcium on storage life of papaya and concluded that $CaCl_2$ @ 2.5 % was better in quality characters and shelf life of fruits.

Lokesh yadav and varu (2013) reported the effect of pre harvest spray of GA_3 15 ppm + carbendazim 0.05 % and post harvest dip in $CaCl_2$ @ %, individually as well as their combination were found to be more effective in reducing physiological loss in weight (7.22, 7.46, 7.89 and 8.52 % was noted 2, 4, 6 and 8 days of storage), highest ascorbic acid, TSS (8.04, 8.26, 10.44, 9.78 ˚Brix), lowest acidity, total sugars, shelf life (3.52 and 8.02 days.)

2.2.5 Ber

Sanjay *et al*. (2013) studied influence of pre and postharvest treatments on shelf life and quality of ber tree. the observations recorded showed that $CaCl_2$ @ 0.4 % along with boric acid 1.0 % sprayed at 45 days before harvesting was best with TSS (23.66 ˚Brix) compared with control. Average fruit weight was also improved (24.58 g), fruit size also increased (3.52 and 3.56 cm) while lowest reduction in Physiological loss in weight (2.8 %) in packed poly bags even after 10 days of storage.

Vimal sonkariya *et al*. (2016) concluded that pre harvest spray of KNO_3 @ 2.0 % on ber cv. Banarasi was significantly superior in reducing the weight loss (5.65 %), and decay loss (8.65 %).

2.2.6 Custard apple

Bagul *et al*. (2017) studied the effect of pre harvest application of chemicals and plant growth regulators on shelf life of custard apple (*Annona squamosa* L.) and results recorded gave best performance with GA_3 @ 50 mg/l in terms of maximum fruit weight (159.60 g), volume (96.85 cc), $CaCl_2$ @ 2% recorded minimum Physiological loss in weight (23.54 % at 6th day) and spoilage (32.22 %), maximum fruit firmness (0.25 kg/cm^2), shelf life (7.25 days), and marketable fruit percentage (67.78 %) during storage.

Jaishankar *et al*. (2018) observed in 2 years for the effect of pre harvest spray of $CaCl_2$, borax, salicylic acid and potassium silicate on custard apple cv. Balanagar and concluded that 0.60 % K_2SiO_3 and 2.0% $CaCl_2$ sprayed one month before harvesting were best in maximizing the fruit weight, volume, breadth, length, shelf life (6.33 and 6.17 days) and minimum peel weight, seed weight, Physiological loss in weight, and respiration rate compared to other treatments.

2.2.7 Strawberry

Cheour *et al*. (1990) reported that calcium chloride application increased calcium content of leaf and fruits. Calcium Chloride delayed ripening and mold development in strawberry.

Parshanth Bakshi *et al*. (2013) studied on influence of pre harvest application of calcium and micro nutrients on growth, yield, quality and shelf life of strawberry cv. Chandler and concluded that $CaCl_2$ @ 0.6 % gave highest shelf life of fruits (2.50 days), and maximum crude protein (10.79 %).

2.2.8 Litchi

Nitin *et al*. (2017) observed the effect of pre harvest foliar sprays of different chemicals on fruit quality and shelf life of litchi fruits and concluded that Physiological loss in weight was minimum (9.36 %) with salicylic acid, higher TSS (20.89˚B) minimum titrable acidity (0.29%) recorded with calcium nitrate.

Surya pratap singh *et al*. (2019) studied the effect of pre harvest foliar application of chemicals like urea 1%, Kno_3 2%, $CaCl_2$ 1% borax 1% and multiplex (0.4 %) nutrients and their combinations on litchi and observed that combination of $CaCl_2$ @ 1 % with urea 1% was best in minimising physiological loss in weight (4.68 %) and decay percentage (17.12 %).

2.2.9 Loquat

Attiq *et al*. (2010) reported that calcium chloride @ 2 %, retained maximum firmness, TSS, ascorbic acid content, reduced browning index, reduced weight loss upto 4-5 weeks in loquat cv. Surkh.

Kholy *et al*. (2018) studied on impact of potassium silicate sprays on fruiting, fruit quality and storability of loquat and results concluded that K_2SiO_3 @ 2 % sprayed at full bloom and 3 weeks later (after fruit set) recorded best results by prolonging fruit shelf life under room conditions for 6 days, improved fruit quality during cold storage at 0˚c for 8 weeks, improved fruit quality, storability and shelf life.

2.2.10 Apricot

Lal *et al*. (2011) reported that $CaCl_2$ @ 1.5 % sprayed at 80 % blooming, fruit set and 15 days before harvest was found to be most effective in minimizing weight loss in fruits during storage compared with control. Quality was good, enhanced shelf life from 3-5 days and maintained good fruit quality under ambient storage condition for upto 8 days.

Elham *et al*. (2007) studied the effect of pre harvest calcium and boric acid treatments on characteristics and storability of apricot cv. Canino and concluded that the treatment with 2 % $CaCl_2$, chelated calcium @ 25 % and boric acid @ 0.50 % and stored at 0˚ exhibited better yield and quality and shelf life after 40 days storage in comparision with other treatments.

2.2.11 Aonla

Ankit pandey *et al*. (2019) studied the effect of pre harvest treatments on storage quality of aonla cv. NA-7 and concluded that $Ca(NO_3)_2$ @ 1.5 % was best in reducing physiological loss in weight, which was only 11.30 percent physiological loss in weight. Where as control fruits exhibited maximum loss.

2.2.12 Peach

Ahmed *et al*. (2017) observed the pre harvest application of calcium chloride and chitosan on fruit quality and storability of peach cv. Swelling and reported that $CaCl_2$ @ 2 % + 1 % chitosan was most effective in minimizing weight loss (%) and decay (%) as well as maintaining maximum firmness and lengthening shelf life.

2.2.13 Persimmon

Asif wali *et al*. (2013) observed the effect of calcium chloride on post harvest shelf life of persimmon and results obtained showed that $CaCl_2$ @ 2 % was best to prevent mould growth, retard ripening and aging with in fruits, extends the shelf life by increasing the fruit firmness and retards ethylene production rates.

2.2.14 Kinnow mandarin

Hilali *et al*. (2004) found that Ca and K concentration increased when the seven-year-old mandarin cv. Fortune trees were sprayed with Ca (1.0 and 2.0 % Ca $(NO_3)_2$) and K (1.19, 2.38 and 3.57 % KNO_3). After harvest, fruits were stored at 4 and 8^0 C for 2 and 4 weeks. The highest Ca concentration (4.14 per cent) was obtained with 2 % Ca treatment compared with only 2.78 % in the control. K content in the rind of treated fruits increased slightly in all the treatments over the control.

Deepa lal *et al*. (2015) studied the effect of pre harvest application of gibberellic acid, NAA and calcium nitrate on fruit drop, maturity, and storage quality of kinnow mandarin and results showed that $Ca(NO_3)_2$ @ 2.0 %, 1.5 % and NAA 20 ppm were more effective in minimizing the loss of fruit spoilage, fruit weight, fruit juice, ascorbic acid, TSS and total sugars.

2.2.14 Pear

Satish kumar *et al*. (2017) reported that pear cv. Bartlett fruits treated with 3 % $CaCl_2$ for 30 min retained the quality and extended shelf life of pears under ambient conditions. Fruit firmness was increased with $CaCl_2$ 4 % for 30 min (5.78 kg cm^2) and physiological loss in weight was lowest (5.98 %) after 19 days of storage.

2.2.15 Plum

Kirmani *et al*. (2013) studied the effect of pre harvest application of calcium chloride, gibberellic acid and napthelene acetic acid on storage of plum cv. Santa rosa under ambient storage conditions. The results recorded indicated that $CaCl_2$ @ 0.5 % sprayed at 20 and 10 days before the expected date of harvest was most effective in retaining the fruit quality during storage, exhibited minimum loss in weight, maximum retention in firmness, and minimum spoilage on each sampling date.

CHAPTER III

MATERIAL AND METHODS

An experiment was conducted "Studies on the effect of foliar application of Calcium, Potassium and Silicon on yield, fruit quality and shelf life of sweet orange (*Citrus sinensis* L.) Cv. Sathgudi", at Horticultural Research Station (HRS), Konda Mallepally, Nalgonda district. The experiment was carried out during the year 2018-19. The materials used, techniques adopted and observations recorded during the course of investigation are furnished in this chapter.

3.1 Geographical location of the experimental site

The experimental site is situated at Horticultural Research Station, Konda Mallepally, Nalgonda district, located in Deccan plateau of Telagana State at 16^0 71' North latitude and $78^0$99' East longitude and at an altitude of 224 m above mean sea level (MSL).

3.2 Experimental site

The experiment was planned on 15 year old sweet orange trees at HRS, Konda Mallepally, Nalgonda. The orchard was laid out by adopting square system with a spacing of 7×7m. Uniform trees were selected for the experiment. Standard package of practices was followed throughout the cropping season.

3.3 Climatic condition of the experimental site

Mallepally is blessed to have the benefits of both South-West and North-East monsoons. The average rainfall of the area is 600 mm per annum. The mean maximum temperature of the experimental site is 38^0 C and the average minimum temperature is 15.7^0 C.

3.4 Experimental details

3.4.1. Design and experimental layout

The experiment "Studies on the effect of foliar application of Calcium, Potassium and Silicon on yield, fruit quality and shelf life of sweet orange (*Citrus sinensis* L.) Cv. Sathgudi" was laid out in a Randomized Block Design (RBD) with thirteen treatments and three replications.

Name of the crop	:	Sweet orange
Botanical name	:	*Citrus sinensis* L.
Location	:	Horticultural Research Station Konda Mallepally, Nalgonda.
Variety	:	Sathgudi
Age of tree	:	15 years
Spacing	:	7m × 7m
Total number of treatments	:	13
Number of replications	:	03
Number of trees per replication	:	02
Design	:	Randomized Block Design (RBD)
Time of spraying	:	1^{st} spray before bloom stage (one month before flowering). 2^{nd} spray after fruit set. 3^{rd} spray after a month of second spray.

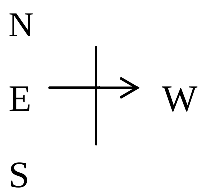
Treatment details of the Experiment

Treatment No.	Treatment details
T_1	1.0 % KNO_3
T_2	1.5 % KNO_3
T_3	2.0 % KNO_3
T_4	4 ml/L K_2SiO_3
T_5	6 ml/L K_2SiO_3
T_6	8 ml/L K_2SiO_3
T_7	1.0 % $Ca(NO_3)_2$
T_8	1.5 % $Ca(NO_3)_2$
T_9	2.0 % $Ca(NO_3)_2$
T_{10}	1.0 % $CaCl_2$
T_{11}	1.5 % $CaCl_2$
T_{12}	2.0 % $CaCl_2$
T_{13}	Control

{KNO_3 : Potassium Nitrate, K_2SiO_3 : Potassium Silicate, $Ca(NO_3)_2$: Calcium Nitrate, $CaCl_2$: Calcium Chloride.}

The layout of the experiment is given below. The treatments in each replication were allotted randomly in Fig.1.

R_1	**R_2**	**R_3**
T_4	T_8	T_{13}
T_6	T_2	T_3
T_9	T_{12}	T_8
T_{13}	T_6	T_4
T_5	T_3	T_7
T_2	T_{10}	T_{11}
T_3	T_7	T_9
T_{10}	T_4	T_5
T_{12}	T_{11}	T_{12}
T_7	T_1	T_2
T_1	T_{13}	T_{10}
T_8	T_9	T_6
T_{11}	T_5	T_1



T- Treatments **R-Replication**

Fig.1. PLAN AND LAYOUT OF THE EXPERIMENT PLOT

3.5 Preparation of potassium nitrate, potassium silicate, calcium nitrate and calcium chloride solutions for foliar spray

Based on the treatments, KNO_3, K_2SiO_3, $Ca(NO_3)_2$ and $CaCl_2$ solutions were prepared as follows.

3.5.1 Preparation of KNO_3 solution

KNO_3 at 1.0 %, 1.5 % and 2.0 % solution was prepared by weighing 1.0 g, 1.5 g and 2.0 g of KNO_3 and dissolved in little quantity of water and volume was made up to 1000 ml respectively.

3.5.2 Preparation of K_2SiO_3 solution

K_2SiO_3 at 4 ml, 6 ml, and 8 ml solution was prepared by weighing 4 g, 6 g, and 8 g of K_2SiO_3 and dissolved in little quantity of water and volume was made up to 1000 ml respectively.

3.5.3 Preparation of $Ca(NO_3)_2$ solution

$Ca(NO_3)_2$ at 1.0 %, 1.5 % and 2.0 % solution was prepared by weighing 1.0 g, 1.5 g, and 2.0 g of $Ca(NO_3)_2$ and dissolved in little quantity of water and volume was made up to 1000 ml respectively.

3.5.4 Preparation of $CaCl_2$ solution for foliar spray

$CaCl_2$ at 1.0 %, 1.5 %, and 2.0 % solution was prepared by weighing 1.0 g, 1.5 g, and 2.0 g of $CaCl_2$ and dissolved in little quantity of water and volume was made up to 1000 ml respectively.

3.6 Imposition of treatments

The different concentration of KNO_3, K_2SiO_3, $Ca(NO_3)_{2,}$ and $CaCl_2$ were prepared and all the treatments were sprayed at before bloom stage, after fruit set and after a month of second spray.

3.7 Harvesting

Fruits were harvested based on their maturity indices *viz.*, colour of fruits changes to pale green or pale yellow or orange colour.

3.8 Observations recorded

3.8.1 Yield parameters of fruit after harvest

3.8.1.1 Fruit weight (g)

The individual five fruits from each treatment were taken randomly after the harvest. The weight was measured on digital analytical balance and average weight was expressed in grams.

3.8.1.2 length of the fruit (cm)

The five fruits from each treatment were taken randomly and the distance between the stalk end and floral end of the fruit was measured with the help of digital vernier calipers, where the average value was expressed in centimeters.

3.8.1.3 Volume of the fruit (ml)

Five fruits from each treatment were brought to laboratory and volume of the fruits was recorded by water displacement method and mean was calculated.

3.8.1.4 Diameter of the fruit (cm)

The five fruits from each treatment were taken randomly and the diameter was measured with the help of digital vernier calipers at widest middle point where maximum diameter was noticed. The average value was expressed in centimeters.

3.8.1.5 Peel thickness (mm)

The peel thickness of fruits from each replication was measured with the help of vernier callipers and average values were computed. The peel was removed, and a piece was placed between the two measuring jaws and reading was taken in millimetres (mm).

Peel thickness (mm) = Main Scale Reading (M.S.R) + Vernier Scale Reading (V.S.R) X Least count (L.C)

(L.C for Vernier callipers = 1 mm)

3.8.1.6 Fruit firmness (kg/cm^2)

Fruit firmness was determined with hand Penetrometer (FT-327, USA) by taking readings on opposite sides along the fruit equatorial region using 8 mm stainless steel probe.

3.8.1.7 Number of fruits per tree

The total number of fruits per tree was physically counted when they were mature, harvested and recorded

3.8.1.8 Yield per tree (Kg)

Fruits were harvested when they were fully matured. Number of fruits and fruit weight were recorded at every harvest. The total yield was calculated by adding the values obtained in different harvesting periods and it is expressed in kilogram per tree.

3.8.2 Quality parameters of the fruit after harvest

The quality parameters such as juice content, total soluble solids, titrable acidity, total sugars, reducing sugars, non reducing sugars, ascorbic acid were recorded after harvest.

3.8.2.1 Juice (%)

Juice per cent of sweet orange fruits is generally expressed on the basis of weight except for limes and lemons (volume basis). The juice was extracted from the sample fruits with the help of juice extractor and strained through single mesh filter to remove rag, seeds and left over waste. The average weight of the fruits per replication, strained juice was weighed and percentage of juice content per fruit was worked for each replication at regular intervals.

$$\text{Juice (\%)} = \frac{\text{Weight of the juice (g)}}{\text{Weight of the fruit from which juice was taken (g)}} \times 100$$

3.8.2.2 Total Soluble Solids (^{0}Brix)

Total soluble solids (T.S.S) of ripe fruit pulp was recorded by digital pocket hand refractometer (ranging from 0-32 ^{0}Brix). Drop of extracted sweet orange pulp was put on hand refractometer and reading was recorded and expressed in terms of degree brix. Five readings were taken for each treatments and finally their average value was worked out.

3.8.2.3 Titrable acidity (%)

Method described by Ranganna (1977) was adopted for estimation of titrable acidity. To obtain acidity (per cent), 10 g of homogenized pulp was taken in a 100 ml volumetric flask and the volume was made. The suspension was filtered through Whatman No. 1 filter paper. 10 ml of the filtrate was taken by pipeting and titrated against 0.1 N NaOH. Phenolphthalein was used as an indicator. Appearance of colourless to pink colour denotes the end point. The reading of burette was noted. The per cent acidity was calculated by using following formula.

$$\text{Acidity (\%)} = \frac{\text{Titre value} \times \text{Normality of alkali} \times \text{volume made up} \times \text{Equivalent wt. of Citric acid} \times 100}{\text{Volume of sample taken for estimation} \times \text{weight of sample} \times 1000}$$

3.8.2.4 Total Sugars (%)

For estimation of total sugars, the filtrate obtained in the above estimation was used. An aliquot from the filtrate was taken and the one fifth of its volume of hydrochloric acid (1:1) was added and the inversion was carried out at room temperature for 24 hours. Subsequently, the contents were cooled and neutralized with 40 per cent sodium hydroxide using phenolphthalein as an indicator and the final volume was made up to 100ml. The solution was filtered and titration was carried out using filtrate as described for reducing sugars. The total sugars content was expressed as percentage in terms of invert sugars according to the following formula:

$$\text{Total sugars (\%)} = \frac{\text{Factor value (0.05)} \times \text{Total volume made up} \times \text{Volume madeup after inversion} \times 100}{\text{Titre value} \times \text{Weight of pulp taken} \times \text{Aliquot taken for inversion}}$$

3.8.2.5 Reducing sugar (%)

The titrimetric method of Lane and Eynon described by Ranganna (1986) was adopted for estimation of reducing sugars. The method is based on the principle that invert sugars or reducing sugars reduces copper in the Fehling's solution to red insoluble cuprous oxide. Sugars in a sample were estimated by determining the volume of unknown sugar solution required to completely reduce a measured volume of Fehling's solution. Before using, the mixture (1:1) of Fehling's solution A and B (5 ml of each) was standardized against standard glucose for obtaining glucose equivalent and to arrive at a conversion factor.

Procedure:

Twenty five gram of the pulp was taken in a volumetric flask and 2ml of 45% basic lead acetate solution was added for clarification. After 10 minutes, the solution was deleaded by adding potassium oxalate crystals in excess and the volume was made upto 250ml with distilled water and filtered through Whatman No. 1 filter paper. The filtrate was taken in a burette and titrated against boiling Fehling's mixture (5ml of Fehling's solution A + 5ml of Fehling's solution B) till the blue colour faded. Then few drops of methylene blue indicator (1%) were added and the titration was continued till the contents attained a brick red colour and titrate value was noted. The percentage of reducing sugars was calculated according to the following formula:

$$\text{Reducing sugars (\%)} = \frac{\text{Factor value (0.05)} \times \text{Total volume made up} \times 100}{\text{Titre value} \times \text{Weight of sample}}$$

3.8.2.6 Non-reducing sugar (%)

The percentage of non-reducing sugars was obtained by subtracting the percentage of reducing sugars from the total sugars and expressed in percentage.

Calculation: Non reducing sugar (%) = Total sugars – Reducing sugars

3.8.2.7 Ascorbic acid (mg /100 g)

The titrimeter vit c method described by Ranganna (1977) was adopted. Ten grams of the pulp was transferred to a 100 ml volumetric flask and volume made up with 4 % oxalic acid solution. After 30 minutes, the suspension was filtered through Whatman No. 1 filter paper.

Before actual titration the 2, 6 – Dichloropheno Indophenol dye solution was standardized by titrating against standard ascorbic acid solution and the dye factor was calculated. Five milliliters of the aliquot was taken from the filtrate against standardized dye solution through a burette. Titration was continued till the light pink colour persisted for 15 seconds. Ascorbic acid content was calculated adopting the following formula.

$$\text{Ascorbic acid (mg/100g)} = \frac{\text{Titre value} \times \text{Dye factor} \times \text{volume made up} \times 100}{\text{Aliquot of extract taken for Estimation} \times \text{Weight of sample taken for estimation}}$$

3.8.3 Shelf life parameters

3.8.3.1 Physiological loss in weight (%)

The initial weight of fruits was recorded on electronic top pan balance in each treatment. Thereafter the weight of fruits under each treatment was recorded at weekly intervals during storage. At regular intervals, the cumulative losses in weight were calculated and expressed as per cent physiological losses in weight.

Following is the formula used in calculating PLW

$$PLW = \frac{P_0 - P_1}{P_0} \times 100$$

Where,

P_0 = Initial weight

P_1= Weight after weekly interval days of storage

3.8.3.2 Shelf life (days)

Shelf life of fruits was decided based on the appearance and marketability of the fruits. When the fruits attained beyond edible ripe stage, then those fruits were considered to have reached the end of their shelf life and expressed in days (Turner, 1997).

3.8.3.3 Spoilage (%)

The number of fruits spoiled in each replication were counted and expressed in percentage. The spoilage was determined based on the following visual observations.

1. Shrivelling of the fruit and hardening of the rind.
2. Fungal infection and subsequent rotting.

$$\text{Spoilage (\%)} = \frac{\text{No. of spoiled fruits in a replication}}{\text{Total no. of fruits in a replication}} \times 100$$

3.9 Economics of cultivation

3.9.1 Cost of cultivation

The prices of all inputs prevailing at the time of their use and the labour cost were considered to work out the cost of cultivation.

3.9.2 Gross income

The gross income was worked out based on the prevailing market price of sweet orange fruits

3.9.3 Net income

The net income per hectare was calculated by using the following formula.

Net income = Gross income – Cost of cultivation

3.9.4 Benefit cost ratio

The benefit cost ratio for different treatments was worked out based on the price of inputs used for cultivation and price of marketable produce in local market by using following formula and it is expressed in ratio.

$$\text{Benefit: Cost ratio} = \frac{\text{Net income (ha}^{-1}\text{)}}{\text{Cost of cultivation (ha}^{-1}\text{)}}$$

3.10 Statistical analysis of experimental data

The data on parameters were tabulated and subjected to statistical analysis using method of analysis of variance (ANOVA) for Randomized Block Design (RBD) suggested by Fisher and Yates (1963). Whenever ‘F’ test was found significant for comparing the means of two treatments, critical difference (CD at 5 %) were worked out.

Plate No.1 General view of the experimental field

Plate No. 2 Foliar application of calcium, potassium, and silicon on sweet orange.

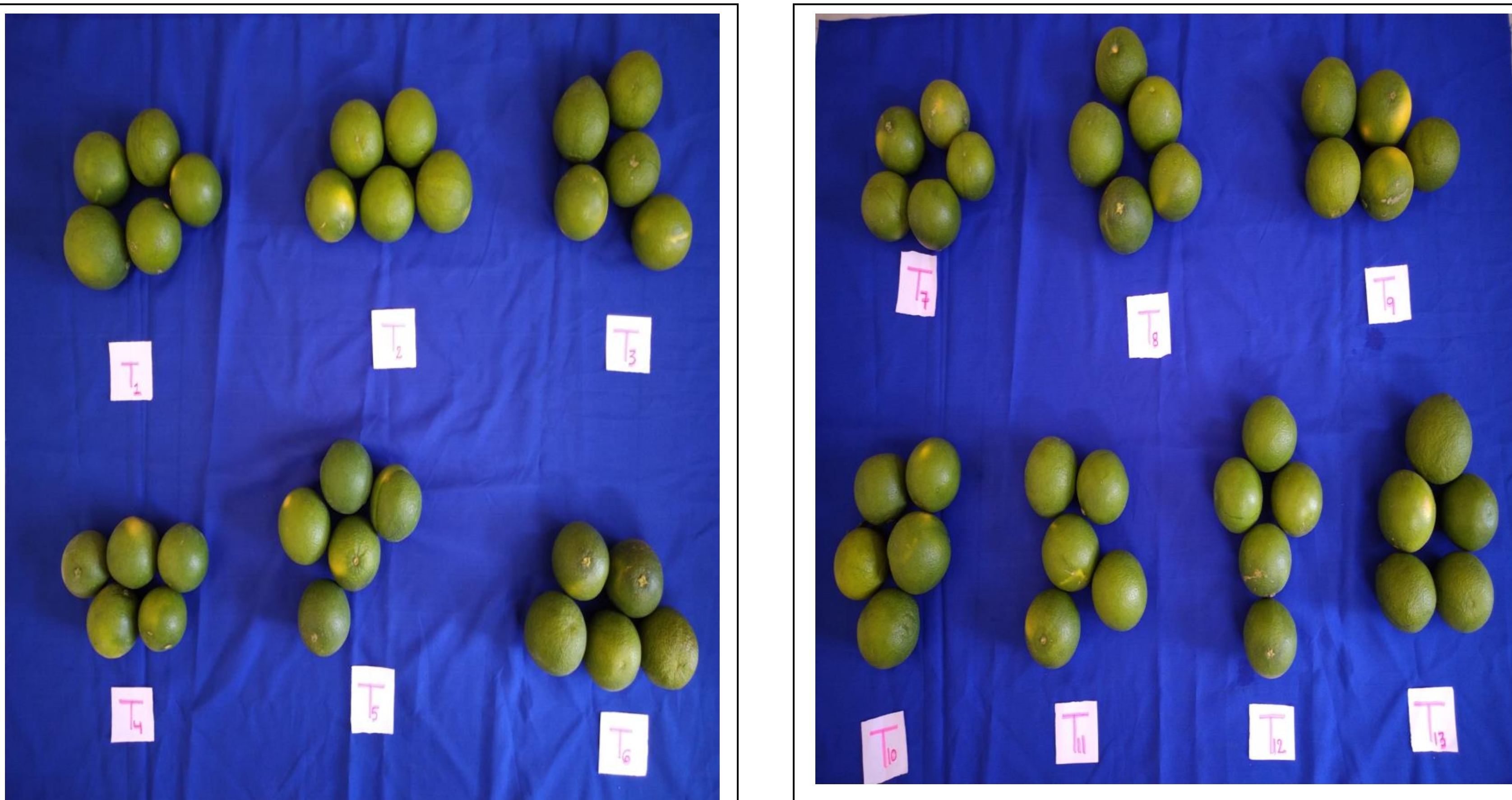


Plate No. 3 Over all view of treatments of sweet orange fruits at harvest

Sweet orange fruits with treatment T_4 - 4ml/L K_2SiO_3 Best in yield and quality.

T_{13} - control

Plate No. 4 Superior treatment of the experiment with respect to quality and yield.

T_7 – 1.0 % $Ca(NO_3)_2$ with more shelf life (days)

T_{13} - Control

Plate No. 5 Treatment of the experiment with highest shelf life (days) on storage

CHAPTER IV

RESULTS AND DISCUSSION

A field experiment on **"Studies on the effect of foliar application of calcium, potassium and silicon on yield, fruit quality and shelf life of sweet orange (*Citrus sinensis* L.) cv. Sathgudi."** was carried out at Horticultural Research Station, Konda Mallepally during the year 2018-19. The results obtained during the investigation are discussed in this chapter with the following sub headings.

4.1 Yield parameters

4.1.1 Fruit weight (g)

Influence of foliar application of calcium, potassium, and silicon on fruit weight of sweet orange is presented in Table 4.1.1 and Fig 4.1

The data on fruit weight reveals that effect of calcium, potassium, silicon on the fruit weight of sweet orange was significant among the treatments. The treatment T_4 - 4ml/L K_2SiO_3 recorded maximum fruit weight (244.93 g), followed by T_5 - 6 ml/L K_2SiO_3 with (242.70 g), T_6 - 8ml/L K_2SiO_3 with (241.07 g), T_1 - 1% KNO_3 with (237.62 g), and significantly at par among the treatments However, minimum fruit weight (206.66 g) was observed in the T_{13} – control.

The spray of 4ml/L K_2SiO_3 recorded maximum fruit weight was due to positive role of silicon in reinforcing plants for being tolerant to different environmental stress such as salinity, drought and alleviating both biotic and abiotic stress which could be reflected positively on both growth and fruiting activities (Olivia *et al*., 2016).

Application of potassium silicate resulted in increased fruit weight due to higher photosynthetic activity, more nutrients and water uptake. Silicon maintains the plant water balance, erectness of leaves and structure of xylem vessels under high transpiration (Melo *et al*., 2003).

Enhanced photosynthesis by potassium which leads to supply of more carbohydrates (Harold and George, 1966). Mobility of assimilates by potassium to the developing fruits which acted as strong metabolic sink, consequently increases the fruit weight.

The above results are in agreement with Lalithya *et al*. (2013) in sapota, Nam Sangyong *et al*. (1996) on grape, Nesreen *et al*. (2011), Khawaga and Mansour (2014) on Navel orange, Ibrahiem and AI- Wasfy (2014) on Valencia orange.

4.1.2 Fruit length (cm)

Influence of foliar application of calcium, potassium, and silicon on fruit length of sweet orange is presented in Table 4.1.2. and Fig 4.2

The data on fruit length reveals that effect of calcium, potassium silicon on the fruit length of sweet orange was significant among the treatments. The treatment T_4 - 4 ml/L K_2SiO_3 recorded maximum fruit length (6.68 cm), followed by T_5 - 6 ml/L K_2SiO_3 (6.62 cm), T_6 - 8 ml/L K_2SiO_3 (6.48 cm), T_1 - 1% KNO_3 (5.94 cm) However, minimum fruit length (5.27 cm) was observed in the T_{13} – control.

Maximum fruit length recorded when sprayed with 4ml/L K_2SiO_3 may be due to potassium silicate application increased the photosynthetic activity due to higher photosynthetic activity resulted in more translocation of metabolites and there by cell division so that length of the fruit and size of the fruit have been increased.

Ibrahim and AI-Wasfy (2014) reported silicon (or) potassium effectively enhanced growth characters, nutritional status of the tree. Silicon plays an important role in increasing and enhancing fruit crops to biotic and abiotic stresses, nutrient and water uptake, photosynthesis, plant pigments synthesis and cell division (Epstein 1999 and Ma 2004).

The results are in accordance with the findings reported by Thippeshppa *et al*. (2014) in sapota, Lalithya *et al*. (2013) in sapota, Nam Sangyong *et al*. (1996) on grape, Nesreen *et al*. (2011), Khawaga and Mansour (2014) on Navel orange, Ibrahiem *et al*. (2014) on Valencia orange.

4.1.3 Volume of the fruit (ml)

Influence of foliar application of calcium, potassium, and silicon on fruit length of sweet orange is presented in Table 4.1.3 and Fig 4.3

The data on fruit volume reveals that effect of calcium, potassium and silicon on the fruit volume of sweet orange was significant among the treatments.

The treatment T_4 – 4 ml/L K_2SiO_3 recorded maximum fruit volume (145.00 ml), followed by T_5 – 6 ml/L K_2SiO_3 with (143.00 ml), T_6 - 8 ml/L K_2SiO_3 with (142.33 ml), T_1 - 1% KNO_3 with (139.00 ml), However, minimum fruit volume (104.66 ml) was observed in the T_{13} – control.

Among the treatments T_4 - 4 ml/L K_2SiO_3 recorded maximum fruit volume. The increase in fruit volume by the application of potassium silicate might be due to optimum supply of silicon and potassium in right time. Silicon application increases plant growth significantly (Alvaraz and Dantoff, 2001). The other possible reason for enhancement of fruit volume might be due to cell division, and expansion. The results are in accordance with the findings reported by Lalithya *et al.* (2013) in sapota, Nam Sangyoung *et al*. (1996) on grape, Nasreen *et al*. (2011) in beans, Gorecki and Danielski bush (2009), Stamatakis *et al*. (2003).

4.1.4 Fruit diameter (cm)

Influence of foliar application of calcium, potassium, and silicon on fruit diameter of sweet orange is presented in Table 4.1.4. and Fig 4.4

The data on fruit diameter reveals that effect of calcium, potassium and silicon on the fruit diameter of sweet orange was significant among the treatments. The treatment T_4 – 4 ml/L K_2SiO_3 recorded maximum fruit diameter (6.95 cm), followed by T_5 – 6 ml/L K_2SiO_3 with (6.50 cm), T_6 – 8 ml/L K_2SiO_3 with (6.40 cm), However, minimum fruit diameter (4.89 cm) was observed in the T_{13} – control.

Among the treatments T_4 – 4 ml/L K_2SiO_3 recorded maximum fruit diameter. Potassium silicate application increased the photosynthetic activity resulted in more translocation of metabolites and there by cell division so that diameter of the fruit and size of the fruit have been increased.

Silicon plays an important role in increasing and enhancing fruit crops to biotic and abiotic stresses, nutrient and water uptake, photosynthesis, plant pigment synthesis and cell division (Epstein 1999 and Ma 2004). Yadav *et al.* (2014) there was significant effect in increasing fruit diameter with potassium application. The results are in accordance with the findings reported by Thippeshppa *et al.* (2014) in sapota, Lalithya *et al*. (2013) in sapota, Nam

Sangyong *et al*. (1996) on grape, Nesreen *et al*. (2011), EI-Khawaga and Mansour (2014) on Navel orange, Ibrahiem *et al*. (2014) on Valencia orange.

4.1.5 Peel thickness (mm)

The data with respect to peel thickness as influenced by foliar application of calcium, potassium, and silicon on sweet orange is presented in Table 4.1.5. and Fig 4.5.

There was no significant differences between the effect of treatments on peel thickness of sweet orange. However maximum peel thickness recorded in T_{13}-Control. While minimum peel thickness was recorded in T_4 – 4 ml/L K_2SiO_3 (2.81 mm)

4.1.6 Fruit firmness (kg/cm^2)

The data with respect to fruit firmness as influenced by foliar application of calcium, potassium, and silicon on sweet orange is presented in Table 4.1.6. and Fig 4.6

There was no significant difference between the effect of treatments on fruit firmness of sweet orange. However more fruit firmness was recorded in T_{10} - 1% $CaCl_2$ (10.33) while less firmness was in T_{13} - control (12.70).

4.1.7 Number of fruits /tree

The data with respect to number of fruits per tree as influenced by foliar application of calcium, potassium, and silicon on sweet orange is presented in Table 4.1.7. and Fig 4.7

The data on number of fruits per tree reveals that effect of calcium, potassium and silicon on number of fruits per tree of sweet orange was significant among the treatments. The treatment T_1 - 1% KNO_3 recorded maximum number of fruits per tree with (250.00), followed by T_4 - 4 ml/L K_2SiO_3 with (245.66), T_5 – 6 ml/L K_2SiO_3 with (242.00), T_2 - 1.5% KNO_3 with (241.66), T_6 – 8 ml/L K_2SiO_3 with (239.00), T_7 - 1 % $Ca(NO_3)_2$ with (238.33), T_{10} - 1% $CaCl_2$ with (236.00), T_3 - 2% KNO_3 with (234.66) and all are at par among the treatments and minimum number of fruits were recorded in T_{13} - control with (207.33)

Among the treatments T_1- 1% KNO_3 recorded maximum number of fruits per tree. Potassium and nitrogen nutrients might have helped in the translocation of the photosynthates from source to sink ultimately fruit yield was increased.

The increase in yield might be due to increase in fruit resevers which serves the fruits till harvest and retains more fruits. Spraying of potassium nitrate with girdling had a positive effect on fruit yield (Mostafa and saleh 2006). Potassium is known for development of fruit, movement of sugars and indirectly photosynthesis. Application of potassium increased mineral content and crop yield (Safty *et al*. 1998).

The results are in accordance with the findings reported by Debaje *et al*. (2011) in acid lime, Vijay *et al.* (2016), Fatma *et al.* (2019) in mango, Durgude *et al.* (2019) in pomegranate, Jawandha *et al.* (2017) in plum, Mukunda laxmi *et al*. (2014) in acid lime.

4.1.8 Yield per tree (kg)

The data with respect to number of fruits per tree as influenced by foliar application of calcium, potassium, and silicon on sweet orange is presented in Table 4.1.8. and Fig 4.8

The data on Yield per tree reveals that effect of calcium, potassium and silicon on yield per tree of sweet orange was significant among the treatments. The treatment T_4 – 4 ml/L K_2SiO_3 recorded maximum yield per tree with (60.17 kg), followed by T_1 - 1% KNO_3 with (59.40 kg), T_5 – 6 ml/L K_2SiO_3 with (58.73 kg), T_6 – 8 ml/L K_2SiO_3 with (57.62 kg), T_2 – 1.5% KNO_3 with (56.91 kg), T_7 - 1% $Ca(NO_3)_2$ with (55.29 kg), all are significantly at par among the treatments and minimum yield per tree was recorded in T_{13}- control with (42.84 kg).

Among the treatments T_4 - 4 ml/L K_2SiO_3 recorded maximum number of fruits per tree. Spraying of potassium silicate had positive effect on growth and yield, increased yield might have attributed due to increased photosynthetic activity of plant, water metabolism, chlorophyll content, more formation of carbohydrates, membrane lipid peroxidation, protective enzymes under drought condition and more uptake of essential nutrients (Yasuto and Eiichi 1983).

Silicon enhanced the leaf water potential under water stress conditions, reduced the incidence of micronutrients and metal toxicity (Matoh *et al*. 1991). Silicon application increased the plant growth and yield significantly (Alvarez and Datnoff, 2001) enhanced tolerance against various abiotic and biotic stress, heavy metal toxicity and water stress (Majeed Zargar *et al*. 2010). Silicon sources like potassium silicate significantly increased the fruit yields (Thippeshppa *et al*. 2014)

The results are supported by findings of Ganeshamurthy *et al*. (2011) in banana and grapes, Lalithya *et al*. (2013) in sapota, Nam Sangyong *et al*. (1996) on grape, Nesreen *et al*. (2011), Khawaga and Mansour *et al*. (2014) on Navel orange, Ibrahiem *et al*. (2014) on Valencia orange and Yasuto (1983) in cucumber.

4.2 Quality parameters

4.2.1 Juice content (%)

The data with respect to juice content as influenced by effect of foliar application of calcium, potassium, and silicon on sweet orange is presented in Table 4.2.1 and Fig 4.9

The data on juice content reveals that effect of calcium, potassium and silicon on juice content of sweet orange was significant among the treatments. The treatment T_4 – 4 ml/L K_2SiO_3 recorded maximum juice content with (46.37 %), followed by T_1 - 1% KNO_3 with (46.13 %), T_5 – 6 ml/L K_2SiO_3 with (44.31 %), T_2 - 1.5% KNO_3 with (43.00 %), and minimum juice content was recorded in T_{13}- control with(37.66 %) respectively.

Among the treatments T_4 - 4 ml/L K_2SiO_3 recorded maximum juice content. Increase in juice content may be due to regulatory role of potassium in many physiological and bio chemical processes of plant including enzymes activation, protein synthesis, stomatal function, stabilization of internal pH, photosynthesis, turgor related processes and transport of metabolites and extensibility (Alva *et al*. 2006). Potassium is used as an osmosis agent in opening and closing stomata, an important mechanism of water uptake and usage. More nutrient water uptake resulted in increase of juice content.

The results are supported by findings of Fatma *et al.* (2017) in Valencia orange, Vijay *et al.* (2016) in sweet orange, shraky *et al.* (2016) in olinda valencia orange.

4.2.2 Total soluble solids

The data with total soluble solids as influenced by foliar application of calcium, potassium, and silicon on sweet orange is presented in Table 4.2.2. and Fig 4.10

The data on TSS reveals that effect of calcium, potassium and silicon on TSS of sweet orange was significant among the treatments. The treatment T_4 -4 ml/L K_2SiO_3 recorded maximum TSS with (12.07 B^0), followed by T_5 – 6 ml/L K_2SiO_3 with (11.45 B^0), T_{11}- 1.5% $CaCl_2$ with (11.37 B^0), T_6 – 8 ml/L K_2SiO_3 with (11.30 B^0), T_8 – 1.5 % $Ca(NO_3)_2$ with (11.09 B^0) and minimum TSS was recorded in T_{13} - control with (9.04 B^0) respectively.

Among the treatments T_4 - K_2SiO_3 4ml/L recorded maximum total soluble soilds. Potassium silicate helped in synthesis of more sugar content in fruits and thus resulted in increasing maximum total soluble solids (Stamatakis *et al*. 2003).

Silicon and potassium helped in synthesis of more sugars in the fruit and thus helped in increasing TSS (Bhavya *et al*. 2010). Increase in Total soluble solids content with application of potassium is related with role of potassium in translocation of sugars from leaves to fruits (Havlin *et al*. 2007).

Increase in Total soluble solids content might be because potassium has prominent role in translocation of photo-assimilates, sugars and other soluble solids which are responsible for increased TSS (Kumar *et al* 2015)

The results are in accordance with the findings reported by Bhavya *et al*. (2010) on grapes, Stamatali *et al.* (2003) in tomato, Kumar *et al*. (2015) on guava and Vijay *et al* (2016) in sweet orange.

4.2.3 Titrable acidity (%)

The data with titrable acidity as influenced by calcium, potassium, and silicon on sweet orange is presented in Table 4.2.3. and Fig 4.11

The data on acidity reveals that effect of foliar application of calcium, potassium and silicon on acidity of sweet orange was significant among the treatments. The treatment T_4 – 4 ml/L K_2SiO_3 recorded minimum acidity with (0.53 %), followed by T_7 - 1% $Ca(NO_3)_2$ with (0.65), T_1 -1% KNO_3 (0.68 %) is on par with T_3 - 2% KNO_3 with (0.68 %) and maximum acidity was found in T_{13}- control with (1.10 %).

Among the treatments T_4 - 4ml/L K_2SiO_3 recorded minimum acidity. The decrease in acidity with potassium silicate might be due to increase in total soluble solids and fast conversion of metabolites into sugar and their derivatives. Potassium neutralizes organic acids and plays a role in controlling acidity and pH of the fruit juice. Increase in total soluble solids leads to decrease in acidity content (Bhavya *et al*. 2010).

Lower acidity in fruits results due to higher accumulation of sugars, better translocation of sugars into fruit tissues and conversion of organic acids into sugars (Beniwal *et al* 1992). The depletion in organic acids could be due to fast conversion of acids into sugars and their derivatives or their utilization in respiration or both (Gupta and Brahmachari 2004). Increased sugar which minimize the acidity in fruit or other hands the reduction of acidity might be due to increase in TSS in fruits (Vijay *et al*. 2016)

The results are in accordance with the findings reported by Bhavya *et al*. (2010) in grapes, Beniwal *et al.* (1992) in grapes, Gupta *et al*. (2004) in mango, Vijay *et al*. (2016) in sweet orange, Dalal *et al*. (2017) in sweet orange, Yadav *et al*. (2014) in ber, Baiea *et al*. (2015) in mango.

4.2.4 Total Sugars (%)

The data with total sugars as influenced by foliar application of calcium, potassium, and silicon on sweet orange is presented in Table 4.2.4. and Fig 4.12

The data on total sugars reveals that effect of foliar application of calcium, potassium and silicon on total sugars of sweet orange was significant among the treatments. The treatment T_4 – 4 ml/L K_2SiO_3 recorded maximum total sugars with (6.28 %), followed by T_5 – 6 ml/L K_2SiO_3 with (6.00 %), T_6 – 8 ml/L K_2SiO_3 with (5.65 %), T_2 - 1% KNO_3 with (5.25 %) is on par with T_{12} - $CaCl_2$ 2% with (5.25 %), However lowest was recorded in T_{13} - control with (5.21).

4.2.5 Reducing Sugars (%)

The significant differences were noticed in reducing sugars with foliar application of calcium, potassium, and silicon on sweet orange is presented in Table 4.2.5. and Fig 4.13. The treatment T_4 – 4 ml/L K_2SiO_3 recorded maximum reducing sugars with (4.10 %), followed by T_5 – 6 ml/L K_2SiO_3 with (3.83 %), T_6 -8 ml/L K_2SiO_3 with (3.53 %), treatment T_9 – 2% $Ca(NO_3)_2$ with (3.13 %) is on par with T_{10} – 1.0 % $CaCl_2$ with (3.13 %) and lowest reducing sugar (3.11 %) was recorded in T_{13}- control.

4.2.6 Non Reducing Sugars (%)

The non reducing sugar content of fruits varied significantly among the treatments is presented in Table 4.2.6. and Fig 4.14. The treatment T_4 - 4ml/L K_2SiO_3 recorded maximum non reducing sugars with (2.18 %), followed by T_5 - 6ml/L K_2SiO_3 with (2.17 %), T_1 - 1% KNO_3 with (2.13 %) is on par with T_2 - 1.5% KNO_3 with (2.13 %), and lowest was recorded in T_{13} - control with (2.10 %).

Potassium is known for helping in sugar translocation in plants, thus its application increases reducing sugar and total sugar (Chaudhary *et al.* 2016). Potassium enables higher accumulation of sugars and organic acids in fruits by promoting translocation of assimilates from source to sink (Liwerant, 1960 and Lalatta, 1975).

These results are supported by findings of Fatma *et al*. (2017) in olinda orange, Hanumanthaiah *et al*. (2015) in banana, Vikramjeet singh *et al*. (2018) in peach, Prasad *et al*. (2015), Sharad *et al*. (2014) in guava.

4.2.7 Ascorbic acid (mg/100g)

The data with ascorbic acid as influenced by foliar application of calcium, potassium, and silicon on sweet orange is presented in Table 4.2.7. and Fig 4.15.

There was no significant difference between the effect of treatments on ascorbic acid content of sweet orange. However maximum was observed in T_4 - 4ml/L K_2SiO_3 (45.66) followed by T_2 - 1.5 % KNO_3 (44.66) and minimum was observed in T_{13}- Control (40.00).

4.3 Shelf life parameters

4.3.1 physiological loss in weight (%)

The data with Physiological loss in weight as influenced by foliar application of calcium, potassium, and silicon on sweet orange is presented in Table 4.3.1. and Fig 4.16

The data on PLW reveals that effect of foliar application of calcium, potassium and silicon on PLW of sweet orange was significant among the treatments. At 7^{Th} day, the treatment T_7 - 1 % $Ca(NO_3)_2$ recorded minimum physiological loss in weight with (5.61 %), followed by T_8 - 1.5% $Ca(NO_3)_2$ with (5.71 %), and T_{12} - 2 % $CaCl_2$ with (5.71 %) which are on par. T_9- 2 % $Ca(NO_3)_2$ with (5.75 %), highest PLW was recorded in T_{13}- control with (5.72 %).

On 14^{th} day, the treatment T_7 - 1 % $Ca(NO_3)_2$ recorded minimum physiological loss in weight with (7.74 %), followed by T_8 -1.5% $Ca(NO_3)_2$ with (7.87 %), and T_{12} – 2 % $CaCl_2$ with (7.89 %) which are on par. T_9 - 2 % $Ca(NO_3)_2$ with (7.91 %), highest PLW was recorded in T_{13}- control with (10.21 %).

On 21st day the treatment T_7 – 1 % $Ca(NO_3)_2$ recorded minimum physiological loss in weight with (11.14 %), followed by T_8 – 1.5% $Ca(NO_3)_2$ with (11.29 %), T_9 - 2 % $Ca(NO_3)_2$ with (11.60 %), and highest PLW was recorded in T_{13}- control with (13.34 %).

Among the treatments T_7 -1% $Ca(NO_3)_2$ recorded minimum physiological loss in weight. The physiological loss in weight of fruits is essentially due to transpiration and respiration (Shanta Krishnamurthy and Subramanyam, 1970) Lowest physiological loss in weight with calcium nitrate application might be the net result of decrease in moisture loss and loss of storage reserves as respiratory substrate. (Kumar *et al.* 2005).

Calcium nitrate had the ability to protect cell membrane from disorganization and other anti senescence properties (Garg, 2007). Calcium play an important role in maintaining the structure of cell wall and cell membrane and there by helps in reducing moisture loss associated with senescence.

Calcium reduces endogenous substrate metabolisn during respiration by limiting diffusion of substrate from vacuoles to the cytoplasm and favour the uptake of sorbital thus disallowing its involvement in reactions related with internal breakdown (Bangerth, 1972).

Calcium controls the disintegration of mitochondria, endoplasmic reticulium and cytoplasmic membrane and thus help in retarding the respiration rate (Jones *et al* 1970)

These results are supported by findings of Ankit pandey *et al*. (2019) in aonla, Kumar *et al*. (2005) in aonla, Sohnika rani (2017) in mango, T.Mounika *et al.* (2017) in mango, Hadi *et al*. (2018) in ber, Mandal Goutam *et al*. (210) in guava.

4.3.2 Shelf life (days)

The data with shelf life as influenced by foliar application of calcium, potassium, and silicon on sweet orange is presented in Table 4.3.2 and Fig 4.17.

The data on shelf life reveals that effect of foliar application of calcium, potassium and silicon on shelf life of sweet orange was significant among the treatments. The treatment T_7 – 1 % $Ca(NO_3)_2$ recorded maximum shelf life with (27.70 %) days, followed by T_8 –1.5% $Ca(NO_3)_2$ with (26.29 %), and T_{12} – 2 % $CaCl_2$ with (25.52 %) , is on par with T_9 -2 % $Ca(NO_3)_2$ with (25.48 %), and lowest shelf life was recorded in T_{13}- control with (17.66 %).

Among the treatments T_7 – 1 % $Ca(NO_3)_2$ recorded maximum shelf life days. Calcium compounds extends the shelf life of fruits by maintaining firmness (Medina and Santigo, 1960), calcium minimise the rate of respiration, protein breakdown and disease incident (Scott and Wilis, 1975; Bangerth *et al*. 1972).

Calcium contributes in blocking physiological disorders, respiration rate decrease, decaying fruit tissues (Magee *et al.* (2002) which extends the shelf life.

The role of calcium on maintaining the membrane integrity and influence on cellulose organization there by controlling respiratory breakdown. The binding action of calcium in the cell wall may suppress ethylene production and retard ripening (Lakshmana and Reddy, 1999, Aradhya *et al*. 2006, Bhanja and Lenka, 1994 in sapota).

These results are supported by findings of Rajput *et al.* (2008) in guava, Sharad *et al.* (2014) in guava, Kapure *et al*. (2019) in guava, Mounika *et al*. (2017) in mango, Hadi *et al.* (2018) in ber, Ankit pandey *et al*. (2019) in aonla, Deepa *et al*. (2015) in kinnow mandarin.

4.3.3 Spoilage (%)

The data with spoilage as influenced by foliar application of calcium, potassium, and silicon on sweet orange is presented in Table 4.3.3. and Fig 4.18.

The data on spoilage reveals that effect of foliar application of calcium, potassium and silicon on spoilage of sweet orange was significant among the treatments. Up to 10 days there was no spoilage observed .

At 15Th day, the treatment T_7 – 1 % $Ca(NO_3)_2$ recorded minimum spoilage with (1.12 %), followed by T_8 – 1.5% $Ca(NO_3)_2$ with (1.13 %), and T_{12} – 2 % $CaCl_2$ with (1.14 %), T_{10} -1% $CaCl_2$ with (1.15 %), is on par with T_{11} – $CaCl_2$ with (1.15 %) and highest spoilage was recorded in T_{13}- control with (2.70 %).

At 20Th day, the treatment T_7 - 1 % $Ca(NO_3)_2$ recorded minimum spoilage with (1.83 %), followed by T_8 – 1.5% $Ca(NO_3)_2$ with (2.14 %), T_9 –2 % $Ca(NO_3)_2$ with (2.49 %), T_{12} – 2 % $CaCl_2$ with (2.54 %) , T_{11} - $CaCl_2$ 1.5% with (2.60 %), and highest spoilage was recorded in T_{13}- control with (4.62 %).

At 25Th day, the treatment T_7 – 1 % $Ca(NO_3)_2$ recorded minimum spoilage with (2.90 %), followed by T_8 – 1.5% $Ca(NO_3)_2$ with (2.90 %), T_9 – 2 % $Ca(NO_3)_2$ with (2.96 %), T_{12} – 2 % $CaCl_2$ with (3.50 %) , T_{11} - $CaCl_2$ 1.5% with (3.67 %), and highest spoilage was recorded in T_{13}- control with (6.35 %).

Among the treatments T_7 – 1 % $Ca(NO_3)_2$ recorded lowest spoilage. Calcium nitrate increased their storage life by increasing the calcium content of the fruit, reducing physiological weight loss, reducing decay percentage, maintain the fruit firmness and retard the rate of respiration (Conway *et al.* 1987)

Calcium level reduces respiration rate which ultimately reduce fruit decay percentage (Singh *et al*. 1993).

These results are supported by findings of Rajput *et al.* (2008) in guava, Sharad *et al.* (2014) in guava, Kapure *et al*. (2019) in guava, Mounika *et al*.

(2017) in mango, Hadi *et al*. (2018) in ber, Ankit pandey *et al*. (2019) in aonla, Deepa *et al*. (2015) in kinnow mandarin.

4.4.1 Benefit : cost ratio

The benefit cost ratio differed significantly among treatments of sweet orange (*citrus sinensis* L.) cv. Sathgudi fruits as presented in table 4.4.1.

The maximum benefit : cost ratio (3.08) was found in trees sprayed with T_1 - 1 % KNO_3 followed by T_4 – 4ml/L K_2SiO_3 with (3.01). minimum benefit : cost ratio was obtained in T_{13} – control (1.95). due to low cost of potassium nitrate and with good fruits fetched higher price. Hence, Maximum Benefit : Cost ratio was realised in the trees sprayed with 1% KNO_3.

Table 4.1.1 Effect of foliar application of calcium, potassium and silicon nutrients on fruit weight (g) in sweet orange Cv. Sathgudi.

S.No	Treatment details	Fruit weight (g)
T_1	1.0 % KNO_3	237.62
T_2	1.5 % KNO_3	235.51
T_3	2.0 % KNO_3	233.33
T_4	4ml/L K_2SiO_3	244.93
T_5	6ml/L K_2SiO_3	242.70
T_6	8ml/L K_2SiO_3	241.07
T_7	1.0 % $Ca(NO_3)_2$	231.99
T_8	1.5 % $Ca(NO_3)_2$	229.00
T_9	2.0 % $Ca(NO_3)_2$	227.00
T_{10}	1.0 % $CaCl_2$	225.33
T_{11}	1.5 % $CaCl_2$	222.66
T_{12}	2.0 % $CaCl_2$	216.70
T_{13}	Control	206.66
	S.Em ±	2.48
	CD	7.29

Table 4.1.2 Effect of foliar application of calcium, potassium and silicon nutrients on length of the fruit (cm) in sweet orange Cv. Sathgudi.

S.No	Treatment details	Fruit length (cm)
T_1	1.0 % KNO_3	5.94
T_2	1.5 % KNO_3	6.33
T_3	2.0 % KNO_3	5.46
T_4	4ml/L K_2SiO_3	6.68
T_5	6ml/L K_2SiO_3	6.62
T_6	8ml/L K_2SiO_3	6.48
T_7	1.0 % $Ca(NO_3)_2$	5.46
T_8	1.5 % $Ca(NO_3)_2$	5.53
T_9	2.0 % $Ca(NO_3)_2$	5.28
T_{10}	1.0 % $CaCl_2$	5.38
T_{11}	1.5 % $CaCl_2$	5.27
T_{12}	2.0 % $CaCl_2$	5.34
T_{13}	Control	5.27
	S.Em ±	0.37
	CD	1.10

Table 4.1.3 Effect of foliar application of calcium, potassium and silicon nutrients on volume of the fruit (ml) in sweet orange Cv. Sathgudi.

S.No	Treatment details	Fruit volume (ml)
T_1	1.0 % KNO_3	139.00
T_2	1.5 % KNO_3	137.00
T_3	2.0 % KNO_3	135.66
T_4	4ml/L K_2SiO_3	145.00
T_5	6ml/L K_2SiO_3	143.00
T_6	8ml/L K_2SiO_3	142.33
T_7	1.0 % $Ca(NO_3)_2$	134.00
T_8	1.5 % $Ca(NO_3)_2$	129.00
T_9	2.0 % $Ca(NO_3)_2$	130.66
T_{10}	1.0 % $CaCl_2$	131.00
T_{11}	1.5 % $CaCl_2$	130.00
T_{12}	2.0 % $CaCl_2$	126.00
T_{13}	Control	104.66
	S.Em ±	2.98
	CD	8.76

Table 4.1.4 Effect of foliar application of calcium, potassium and silicon nutrients on diameter of fruit (cm) in sweet orange Cv. Sathgudi.

S.No	Treatment details	Fruit diameter (cm)
T_1	1.0 % KNO_3	5.34
T_2	1.5 % KNO_3	5.46
T_3	2.0 % KNO_3	5.48
T_4	4ml/L K_2SiO_3	6.95
T_5	6ml/L K_2SiO_3	6.50
T_6	8ml/L K_2SiO_3	6.40
T_7	1.0 % $Ca(NO_3)_2$	5.51
T_8	1.5 % $Ca(NO_3)_2$	5.41
T_9	2.0 % $Ca(NO_3)_2$	5.37
T_{10}	1.0 % $CaCl_2$	5.34
T_{11}	1.5 % $CaCl_2$	5.87
T_{12}	2.0 % $CaCl_2$	6.35
T_{13}	Control	4.89
	S.Em ±	0.40
	CD	1.17

Table 4.1.5 Effect of foliar application of calcium, potassium and silicon nutrients on peel thickness (mm) in sweet orange Cv. Sathgudi.

S.No	Treatment details	Peel thickness (mm)
T_1	1.0 % KNO_3	3.31
T_2	1.5 % KNO_3	3.36
T_3	2.0 % KNO_3	3.29
T_4	4ml/L K_2SiO_3	2.81
T_5	6ml/L K_2SiO_3	3.22
T_6	8ml/L K_2SiO_3	3.29
T_7	1.0 % $Ca(NO_3)_2$	3.66
T_8	1.5 % $Ca(NO_3)_2$	3.74
T_9	2.0 % $Ca(NO_3)_2$	3.53
T_{10}	1.0 % $CaCl_2$	3.84
T_{11}	1.5 % $CaCl_2$	3.12
T_{12}	2.0 % $CaCl_2$	2.97
T_{13}	Control	3.93
	S.Em ±	0.25
	CD	N/A

Table 4.1.6 Effect of foliar application of calcium, potassium and silicon nutrients on fruit firmness (kg/cm^2) in sweet orange Cv.Sathgudi.

S.No	Treatment details	Fruit firmness (kg/cm^2)
T_1	1.0 % KNO_3	11.00
T_2	1.5 % KNO_3	10.66
T_3	2.0 % KNO_3	11.33
T_4	4ml/L K_2SiO_3	11.66
T_5	6ml/L K_2SiO_3	11.33
T_6	8ml/L K_2SiO_3	11.66
T_7	1.0 % $Ca(NO_3)_2$	11.33
T_8	1.5 % $Ca(NO_3)_2$	10.66
T_9	2.0 % $Ca(NO_3)_2$	11.33
T_{10}	1.0 % $CaCl_2$	10.33
T_{11}	1.5 % $CaCl_2$	12.33
T_{12}	2.0 % $CaCl_2$	10.66
T_{13}	Control	12.70
	S.Em ±	0.79
	CD	N/A

Table 4.1.7 Effect of foliar application of calcium, potassium and silicon nutrients on number of fruits/tree in sweet orange Cv. Sathgudi.

S.No	Treatment details	Number of fruits/tree
T_1	1.0 % KNO_3	250.00
T_2	1.5 % KNO_3	241.66
T_3	2.0 % KNO_3	234.66
T_4	4ml/L K_2SiO_3	245.66
T_5	6ml/L K_2SiO_3	242.00
T_6	8ml/L K_2SiO_3	239.00
T_7	1.0 % $Ca(NO_3)_2$	238.33
T_8	1.5 % $Ca(NO_3)_2$	233.66
T_9	2.0 % $Ca(NO_3)_2$	226.33
T_{10}	1.0 % $CaCl_2$	236.00
T_{11}	1.5 % $CaCl_2$	229.66
T_{12}	2.0 % $CaCl_2$	227.33
T_{13}	Control	207.33
	S.Em ±	2.88
	CD	8.47

Table 4.1.8 Effect of foliar application of calcium, potassium and silicon nutrients on yield per tree (kg) in sweet orange Cv. Sathgudi.

S.No	Treatment details	Yield per tree (kg)
T_1	1.0 % KNO_3	59.40
T_2	1.5 % KNO_3	56.91
T_3	2.0 % KNO_3	54.75
T_4	4ml/L K_2SiO_3	60.17
T_5	6ml/L K_2SiO_3	58.73
T_6	8ml/L K_2SiO_3	57.62
T_7	1.0 % $Ca(NO_3)_2$	55.29
T_8	1.5 % $Ca(NO_3)_2$	53.51
T_9	2.0 % $Ca(NO_3)_2$	51.36
T_{10}	1.0 % $CaCl_2$	53.18
T_{11}	1.5 % $CaCl_2$	51.17
T_{12}	2.0 % $CaCl_2$	49.16
T_{13}	Control	42.84
	S.Em ±	1.01
	CD	2.97

Table 4.2.1 Effect of foliar application of calcium, potassium and silicon nutrients on juice content (%) in sweet orange Cv. Sathgudi.

S.No	Treatment details	Juice (%)
T_1	1.0 % KNO_3	46.13
T_2	1.5 % KNO_3	43.00
T_3	2.0 % KNO_3	38.04
T_4	4ml/L K_2SiO_3	46.37
T_5	6ml/L K_2SiO_3	44.31
T_6	8ml/L K_2SiO_3	41.66
T_7	1.0 % $Ca(NO_3)_2$	40.66
T_8	1.5 % $Ca(NO_3)_2$	38.72
T_9	2.0 % $Ca(NO_3)_2$	41.66
T_{10}	1.0 % $CaCl_2$	40.66
T_{11}	1.5 % $CaCl_2$	38.33
T_{12}	2.0 % $CaCl_2$	39.00
T_{13}	Control	37.66
	S.Em ±	1.01
	CD	2.97

Table 4.2.2 Effect of foliar application of calcium, potassium and silicon nutrients on Total soluble solids (°Brix) in sweet orange Cv. Sathgudi.

S.No	Treatment details	TSS (˚Brix)
T_1	1.0 % KNO_3	9.17
T_2	1.5 % KNO_3	9.04
T_3	2.0 % KNO_3	9.09
T_4	4ml/L K_2SiO_3	12.07
T_5	6ml/L K_2SiO_3	11.45
T_6	8ml/L K_2SiO_3	11.30
T_7	1.0 % $Ca(NO_3)_2$	11.03
T_8	1.5 % $Ca(NO_3)_2$	11.09
T_9	2.0 % $Ca(NO_3)_2$	10.03
T_{10}	1.0 % $CaCl_2$	11.00
T_{11}	1.5 % $CaCl_2$	11.37
T_{12}	2.0 % $CaCl_2$	9.07
T_{13}	Control	9.04
	S.Em ±	0.21
	CD	0.62

Table 4.2.3 Effect of foliar application of calcium, potassium and silicon nutrients on Titrable acidity (%) in sweet orange Cv. Sathgudi.

S.No	Treatment details	Titrable acidity (%)
T_1	1.0 % KNO_3	0.68
T_2	1.5 % KNO_3	0.71
T_3	2.0 % KNO_3	0.68
T_4	4ml/L K_2SiO_3	0.53
T_5	6ml/L K_2SiO_3	0.68
T_6	8ml/L K_2SiO_3	0.69
T_7	1.0 % $Ca(NO_3)_2$	0.65
T_8	1.5 % $Ca(NO_3)_2$	0.82
T_9	2.0 % $Ca(NO_3)_2$	0.70
T_{10}	1.0 % $CaCl_2$	0.67
T_{11}	1.5 % $CaCl_2$	0.71
T_{12}	2.0 % $CaCl_2$	0.9
T_{13}	Control	1.10
	S.Em ±	0.04
	CD	0.11

Table 4.2.4 Effect of foliar application of calcium, potassium and silicon nutrients on Total sugars (%) in sweet orange Cv. Sathgudi.

S.No	Treatment details	Total sugars (%)
T_1	1.0 % KNO_3	5.24
T_2	1.5 % KNO_3	5.25
T_3	2.0 % KNO_3	5.23
T_4	4ml/L K_2SiO_3	6.28
T_5	6ml/L K_2SiO_3	6.00
T_6	8ml/L K_2SiO_3	5.65
T_7	1.0 % $Ca(NO_3)_2$	5.28
T_8	1.5 % $Ca(NO_3)_2$	5.27
T_9	2.0 % $Ca(NO_3)_2$	5.24
T_{10}	1.0 % $CaCl_2$	5.24
T_{11}	1.5 % $CaCl_2$	5.22
T_{12}	2.0 % $CaCl_2$	5.25
T_{13}	Control	5.21
	S.Em ±	0.15
	CD	0.46

Table 4.2.5 Effect of foliar application of calcium, potassium and silicon nutrients on Reducing sugars (%) in sweet orange Cv. Sathgudi.

S.No	Treatment details	Reducing sugars (%)
T_1	1.0 % KNO_3	3.11
T_2	1.5 % KNO_3	3.12
T_3	2.0 % KNO_3	3.11
T_4	4ml/L K_2SiO_3	4.10
T_5	6ml/L K_2SiO_3	3.83
T_6	8ml/L K_2SiO_3	3.53
T_7	1.0 % $Ca(NO_3)_2$	3.16
T_8	1.5 % $Ca(NO_3)_2$	3.16
T_9	2.0 % $Ca(NO_3)_2$	3.13
T_{10}	1.0 % $CaCl_2$	3.13
T_{11}	1.5 % $CaCl_2$	3.11
T_{12}	2.0 % $CaCl_2$	3.13
T_{13}	Control	3.11
	S.Em ±	0.07
	CD	0.23

Table 4.2.6 Effect of foliar application of calcium, potassium and silicon nutrients on Non reducing sugars (%) in sweet orange Cv. Sathgudi.

S.No	Treatment details	Non reducing sugars (%)
T_1	1.0 % KNO_3	2.13
T_2	1.5 % KNO_3	2.13
T_3	2.0 % KNO_3	2.12
T_4	4ml/L K_2SiO_3	2.18
T_5	6ml/L K_2SiO_3	2.17
T_6	8ml/L K_2SiO_3	2.12
T_7	1.0 % $Ca(NO_3)_2$	2.12
T_8	1.5 % $Ca(NO_3)_2$	2.11
T_9	2.0 % $Ca(NO_3)_2$	2.11
T_{10}	1.0 % $CaCl_2$	2.11
T_{11}	1.5 % $CaCl_2$	2.11
T_{12}	2.0 % $CaCl_2$	2.12
T_{13}	Control	2.10
	S.Em ±	0.01
	CD	0.02

Table 4.2.7 Effect of foliar application of calcium, potassium and silicon nutrients on Ascorbic acid (mg/100g) in sweet orange Cv. Sathgudi.

S.No	Treatment details	Ascorbic acid (mg/100g)
T_1	1.0 % KNO_3	42.66
T_2	1.5 % KNO_3	44.66
T_3	2.0 % KNO_3	40.66
T_4	4ml/L K_2SiO_3	45.66
T_5	6ml/L K_2SiO_3	44.33
T_6	8ml/L K_2SiO_3	41.66
T_7	1.0 % $Ca(NO_3)_2$	42.66
T_8	1.5 % $Ca(NO_3)_2$	43.33
T_9	2.0 % $Ca(NO_3)_2$	41.00
T_{10}	1.0 % $CaCl_2$	42.66
T_{11}	1.5 % $CaCl_2$	42.00
T_{12}	2.0 % $CaCl_2$	43.33
T_{13}	Control	40.00
	S.Em ±	1.39
	CD	N/A

Table 4.3.1 Effect of foliar application of calcium, potassium and silicon nutrients on Physioogical loss in weight (PLW%) in sweet orange Cv. Sathgudi.

S.No	Treatment details	PLW at 7^{Th} day	PLW at 14^{th} day	PLW at 21^{st} day
T_1	1.0 % KNO_3	6.20	8.51	12.77
T_2	1.5 % KNO_3	6.40	8.61	12.80
T_3	2.0 % KNO_3	6.60	8.66	12.82
T_4	4ml/L K_2SiO_3	5.89	8.11	12.33
T_5	6ml/L K_2SiO_3	6.08	8.22	12.46
T_6	8ml/L K_2SiO_3	6.29	8.35	12.67
T_7	1.0 % $Ca(NO_3)_2$	5.61	7.74	11.14
T_8	1.5 % $Ca(NO_3)_2$	5.71	7.87	11.29
T_9	2.0 % $Ca(NO_3)_2$	5.75	7.91	11.60
T_{10}	1.0 % $CaCl_2$	5.80	7.96	12.19
T_{11}	1.5 % $CaCl_2$	5.76	8.03	12.08
T_{12}	2.0 % $CaCl_2$	5.71	7.89	11.77
T_{13}	Control	5.72	10.21	13.34
	S.Em ±	0.008	0.035	0.37
	CD	0.02	0.10	1.11

Table 4.3.2 Effect of foliar application of calcium, potassium and silicon nutrients on Shelf life (days) in sweet orange Cv. Sathgudi.

S.No	Treatment details	Shelf life (days)
T_1	1.0 % KNO_3	19.44
T_2	1.5 % KNO_3	19.87
T_3	2.0 % KNO_3	20.21
T_4	4ml/L K_2SiO_3	21.07
T_5	6ml/L K_2SiO_3	21.00
T_6	8ml/L K_2SiO_3	19.81
T_7	1.0 % $Ca(NO_3)_2$	27.70
T_8	1.5 % $Ca(NO_3)_2$	26.29
T_9	2.0 % $Ca(NO_3)_2$	25.48
T_{10}	1.0 % $CaCl_2$	22.76
T_{11}	1.5 % $CaCl_2$	24.04
T_{12}	2.0 % $CaCl_2$	25.52
T_{13}	Control	17.66
	S.Em ±	0.60
	CD	1.77

Table 4.3.3 Effect of foliar application of calcium, potassium and silicon nutrients on spoilage (%) in sweet orange Cv. Sathgudi.

S.No	Treatment details	At 15th day	At 20th day	At 25th day
T_1	1.0 % KNO_3	2.60	3.73	4.20
T_2	1.5 % KNO_3	2.23	3.75	4.22
T_3	2.0 % KNO_3	2.36	3.80	4.45
T_4	4ml/L K_2SiO_3	2.16	3.81	3.75
T_5	6ml/L K_2SiO_3	2.26	3.79	3.83
T_6	8ml/L K_2SiO_3	1.44	3.90	3.97
T_7	1.0 % $Ca(NO_3)_2$	1.12	1.83	2.90
T_8	1.5 % $Ca(NO_3)_2$	1.13	2.14	2.90
T_9	2.0 % $Ca(NO_3)_2$	1.16	2.49	2.96
T_{10}	1.0 % $CaCl_2$	1.15	2.66	3.70
T_{11}	1.5 % $CaCl_2$	1.15	2.60	3.67
T_{12}	2.0 % $CaCl_2$	1.14	2.54	3.50
T_{13}	Control	2.70	4.62	6.35
	S.Em ±	0.11	0.16	0.20
	CD	0.33	0.48	0.59

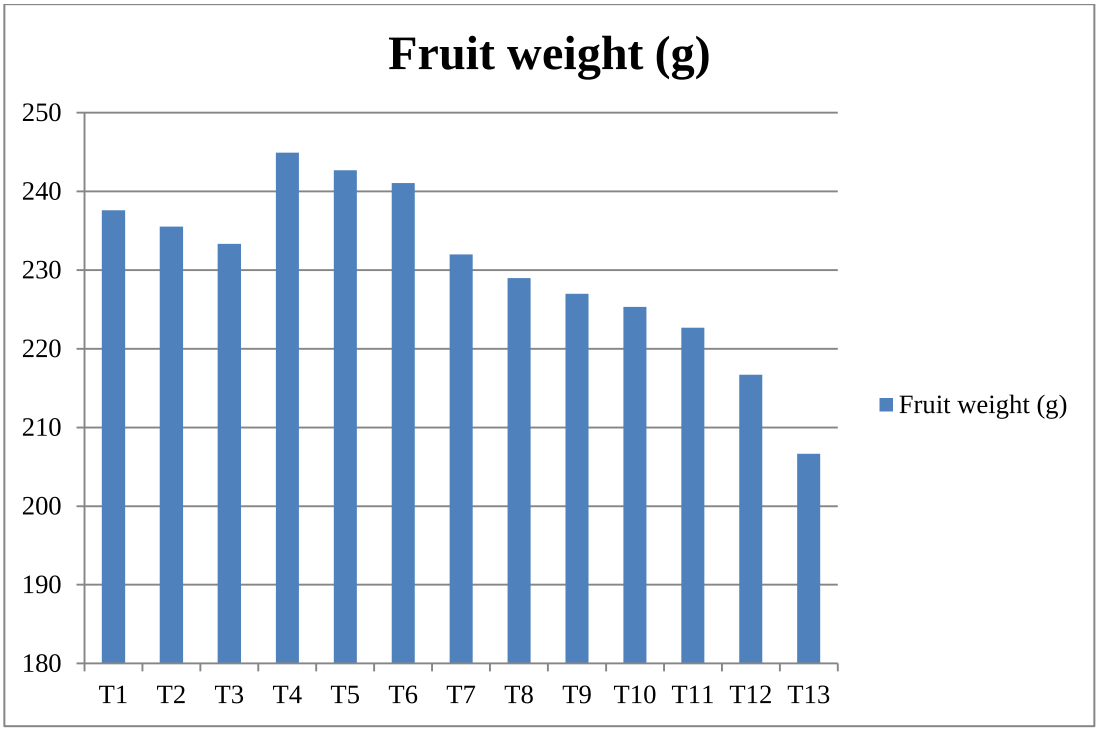


Fig.No : 4.1

Effect of foliar application of nutrients on fruit weight (g) in sweet orange Cv. Sathgudi.

T_1 – 1.0 % KNO_3

T_2 – 1.5 % KNO_3

T_3 – 2.0 % KNO_3

T_4 – 4 ml/L K_2SiO_3

T_5 – 6 ml/L K_2SiO_3

T_6 – 8 ml/L K_2SiO_3

T_7 – 1.0 % $Ca(NO_3)_2$

T_8 – 1.5 % $Ca(NO_3)_2$

T_9 – 2.0 % $Ca(NO_3)_2$

T_{10} – 1.0 % $CaCl_2$

T_{11} – 1.5 % $CaCl_2$

T_{12} – 2.0 % $CaCl_2$

T_{13} - Control

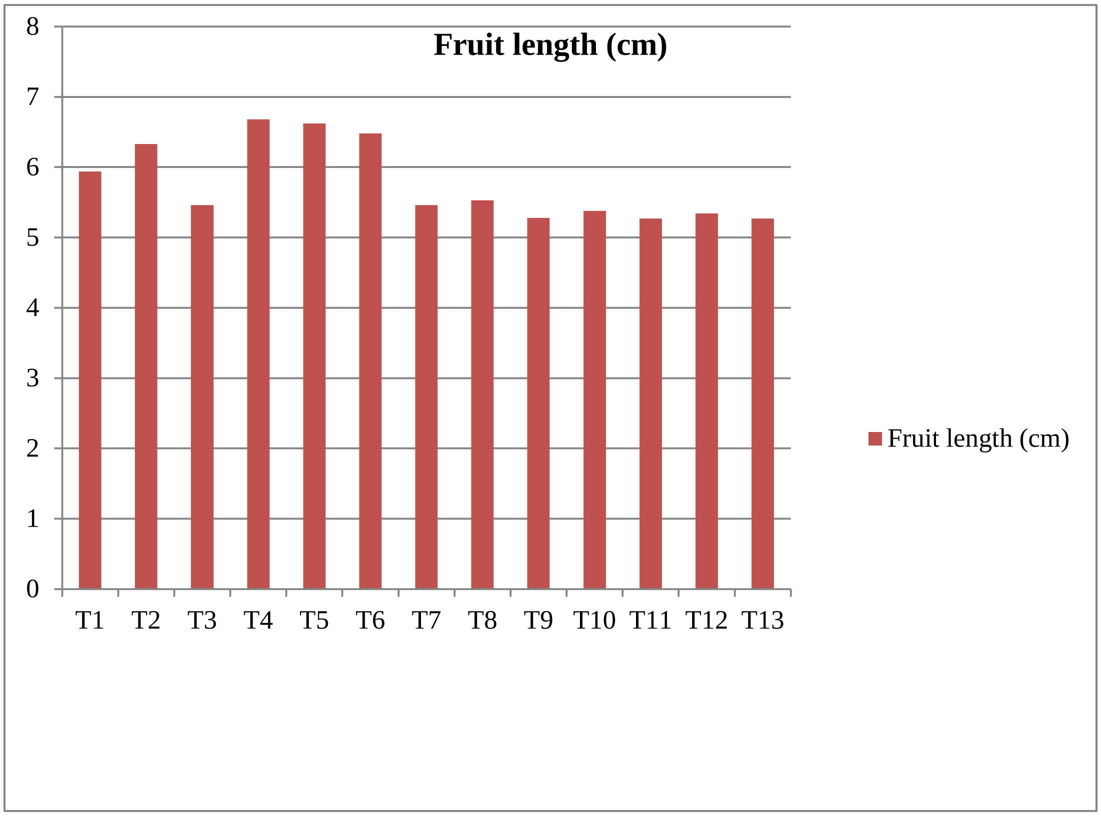


Fig .No : 4.2

Effect of foliar application of nutrients on length of the fruit (cm) in sweet orange Cv. Sathgudi.

T_1 – 1.0 % KNO_3	T_8 – 1.5 % $Ca(NO_3)_2$
T_2 – 1.5 % KNO_3	T_9 – 2.0 % $Ca(NO_3)_2$
T_3 – 2.0 % KNO_3	T_{10} – 1.0 % $CaCl_2$
T_4 – 4 ml/L K_2SiO_3	T_{11} – 1.5 % $CaCl_2$
T_5 – 6 ml/L K_2SiO_3	T_{12} – 2.0 % $CaCl_2$
T_6 – 8 ml/L K_2SiO_3	T_{13} - Control
T_7 – 1.0 % $Ca(NO_3)_2$	

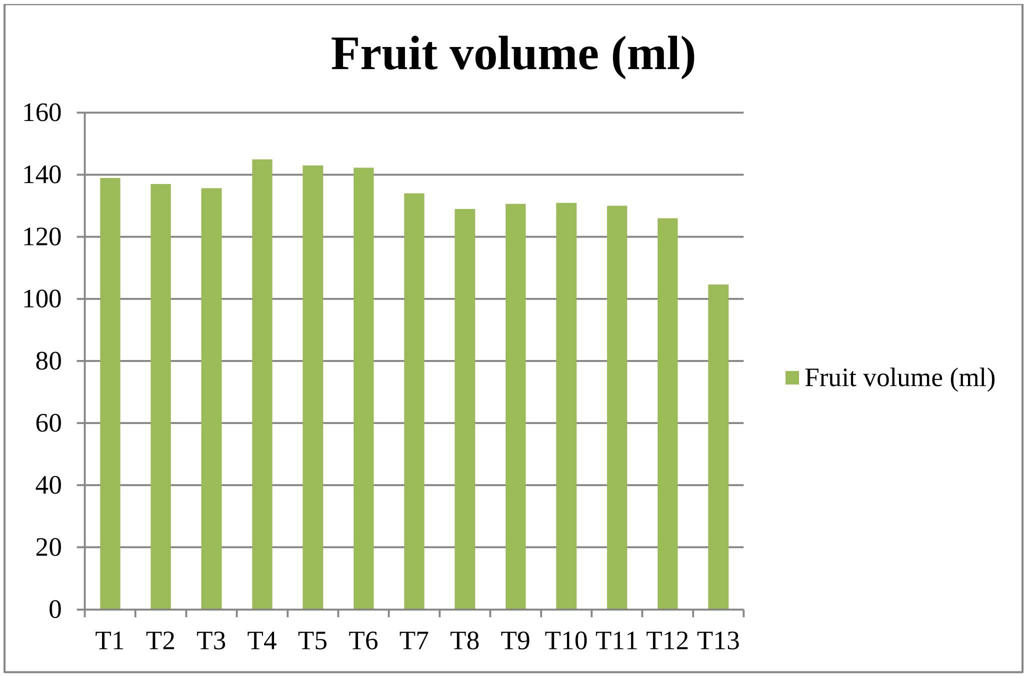


Fig .No : 4.3

Effect of foliar application of nutrients on volume of the fruit (ml) in sweet orange Cv. Sathgudi

T_1 – 1.0 % KNO_3

T_2 – 1.5 % KNO_3

T_3 – 2.0 % KNO_3

T_4 – 4 ml/L K_2SiO_3

T_5 – 6 ml/L K_2SiO_3

T_6 – 8 ml/L K_2SiO_3

T_7 – 1.0 % $Ca(NO_3)_2$

T_8 – 1.5 % $Ca(NO_3)_2$

T_9 – 2.0 % $Ca(NO_3)_2$

T_{10} – 1.0 % $CaCl_2$

T_{11} – 1.5 % $CaCl_2$

T_{12} – 2.0 % $CaCl_2$

T_{13} - Control

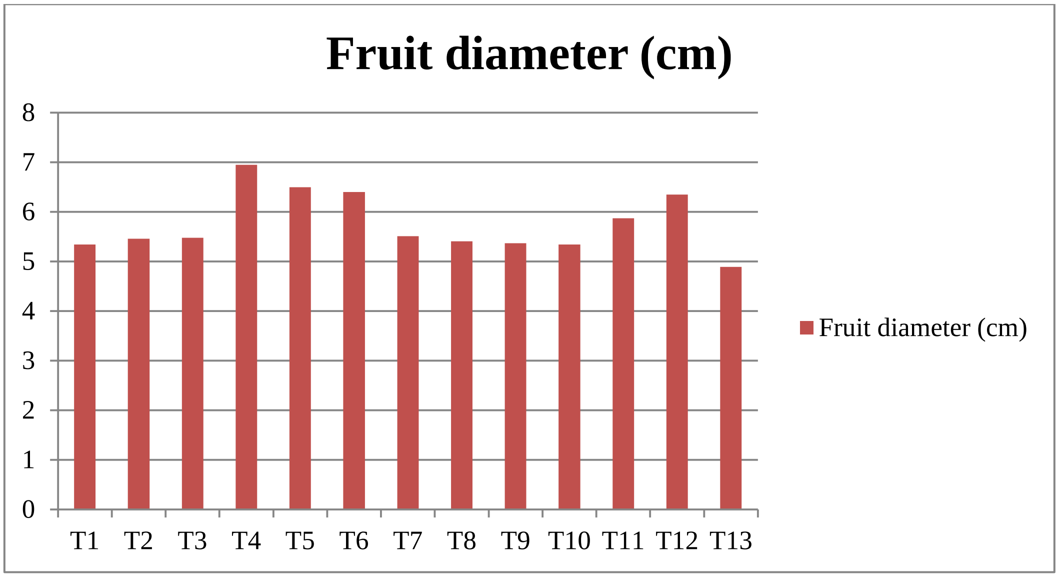


Fig .No : 4.4

Effect of foliar application of nutrients on diameter (cm) of the fruit in sweet orange Cv. Sathgudi.

T_1 – 1.0 % KNO_3

T_2 – 1.5 % KNO_3

T_3 – 2.0 % KNO_3

T_4 – 4 ml/L K_2SiO_3

T_5 – 6 ml/L K_2SiO_3

T_6 – 8 ml/L K_2SiO_3

T_7 – 1.0 % $Ca(NO_3)_2$

T_8 – 1.5 % $Ca(NO_3)_2$

T_9 – 2.0 % $Ca(NO_3)_2$

T_{10} – 1.0 % $CaCl_2$

T_{11} – 1.5 % $CaCl_2$

T_{12} – 2.0 % $CaCl_2$

T_{13} - Control

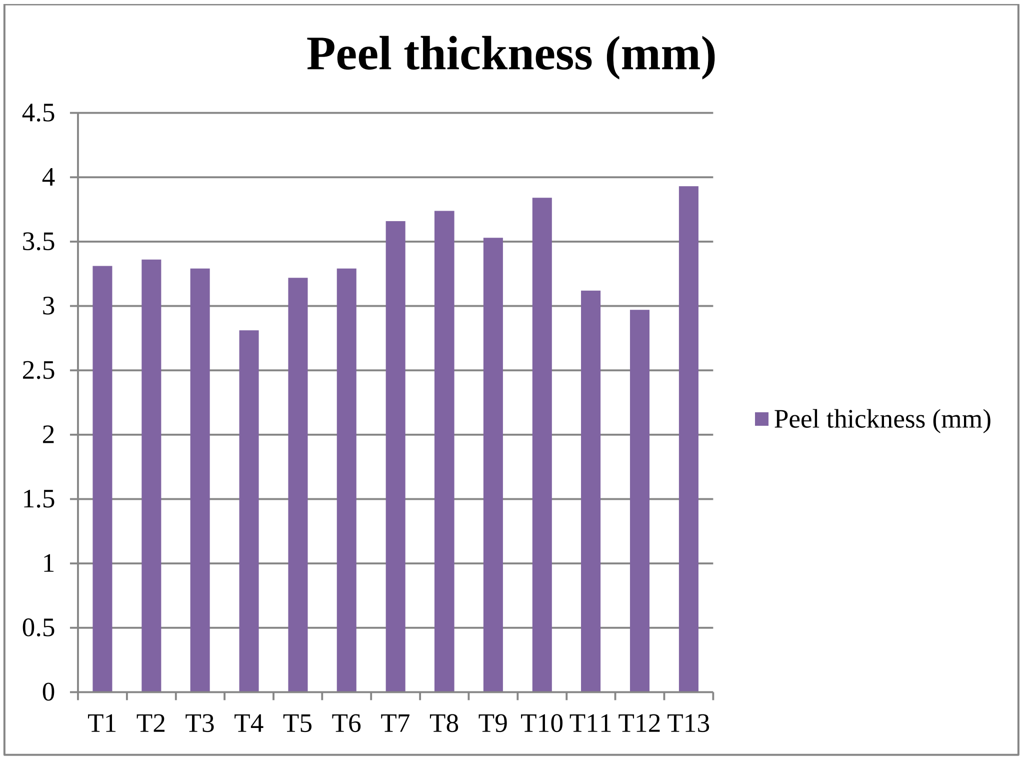


Fig .No : 4.5

Effect of foliar application of nutrients on peel thickness (mm) of the fruit in sweet orange Cv. Sathgudi.

T_1 – 1.0 % KNO_3

T_2 – 1.5 % KNO_3

T_3 – 2.0 % KNO_3

T_4 – 4 ml/L K_2SiO_3

T_5 – 6 ml/L K_2SiO_3

T_6 – 8 ml/L K_2SiO_3

T_7 – 1.0 % $Ca(NO_3)_2$

T_8 – 1.5 % $Ca(NO_3)_2$

T_9 – 2.0 % $Ca(NO_3)_2$

T_{10} – 1.0 % $CaCl_2$

T_{11} – 1.5 % $CaCl_2$

T_{12} – 2.0 % $CaCl_2$

T_{13} - Control

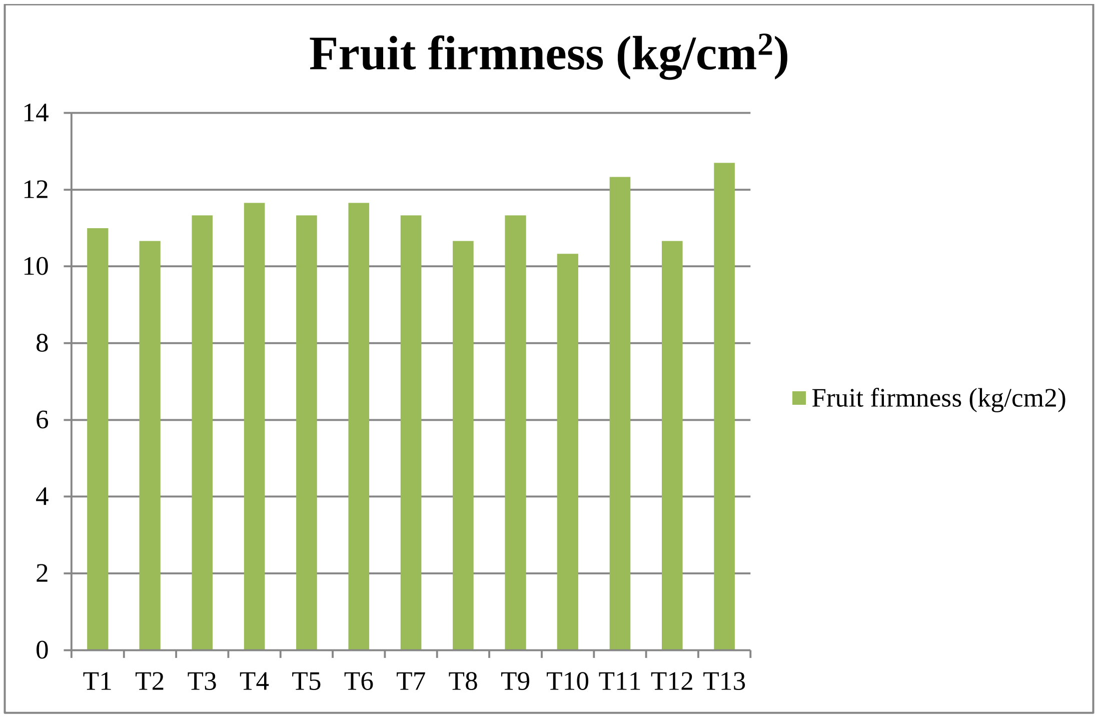


Fig .No : 4.6

Effect of foliar application of nutrients on fruit firmness (kg/cm^2) of the fruit in sweet orange Cv. Sathgudi.

T_1 – 1.0 % KNO_3

T_2 – 1.5 % KNO_3

T_3 – 2.0 % KNO_3

T_4 – 4 ml/L K_2SiO_3

T_5 – 6 ml/L K_2SiO_3

T_6 – 8 ml/L K_2SiO_3

T_7 – 1.0 % $Ca(NO_3)_2$

T_8 – 1.5 % $Ca(NO_3)_2$

T_9 – 2.0 % $Ca(NO_3)_2$

T_{10} – 1.0 % $CaCl_2$

T_{11} – 1.5 % $CaCl_2$

T_{12} – 2.0 % $CaCl_2$

T_{13} - Control

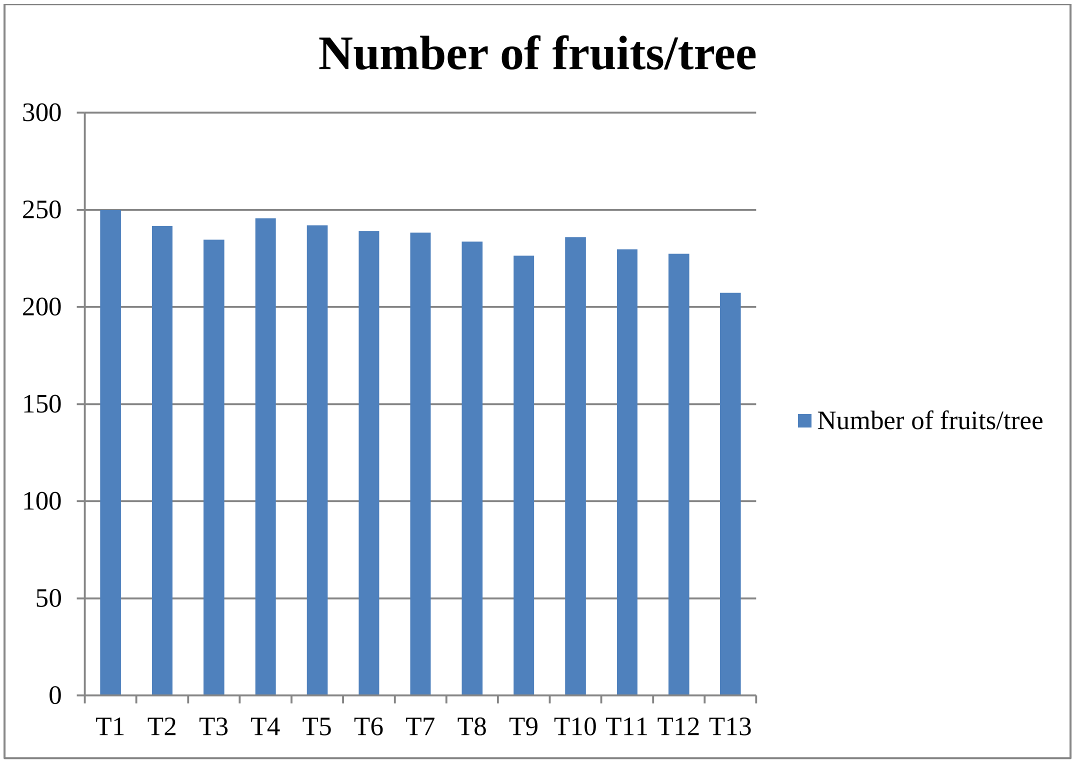


Fig .No : 4.7

Effect of foliar application of nutrients on number of fruits /tree in sweet orange Cv. Sathgudi.

T_1 – 1.0 % KNO_3

T_2 – 1.5 % KNO_3

T_3 – 2.0 % KNO_3

T_4 – 4 ml/L K_2SiO_3

T_5 – 6 ml/L K_2SiO_3

T_6 – 8 ml/L K_2SiO_3

T_7 – 1.0 % $Ca(NO_3)_2$

T_8 – 1.5 % $Ca(NO_3)_2$

T_9 – 2.0 % $Ca(NO_3)_2$

T_{10} – 1.0 % $CaCl_2$

T_{11} – 1.5 % $CaCl_2$

T_{12} – 2.0 % $CaCl_2$

T_{13} - Control

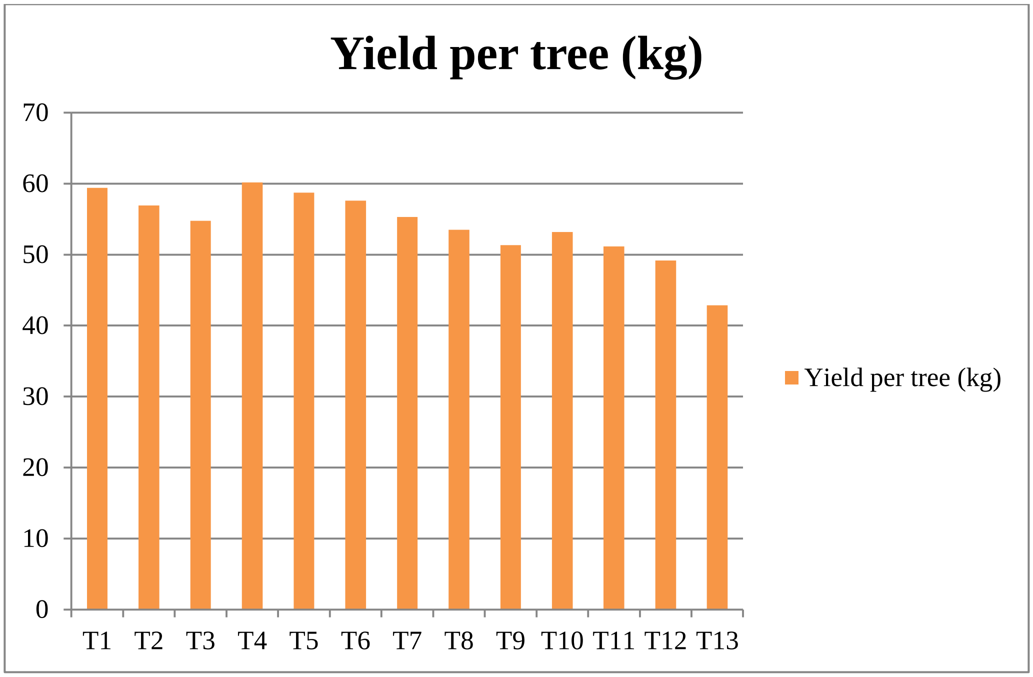


Fig .No : 4.8

Effect of foliar application of nutrients on yield per tree (kg) in sweet orange Cv. Sathgudi.

T_1 – 1.0 % KNO_3

T_2 – 1.5 % KNO_3

T_3 – 2.0 % KNO_3

T_4 – 4 ml/L K_2SiO_3

T_5 – 6 ml/L K_2SiO_3

T_6 – 8 ml/L K_2SiO_3

T_7 – 1.0 % $Ca(NO_3)_2$

T_8 – 1.5 % $Ca(NO_3)_2$

T_9 – 2.0 % $Ca(NO_3)_2$

T_{10} – 1.0 % $CaCl_2$

T_{11} – 1.5 % $CaCl_2$

T_{12} – 2.0 % $CaCl_2$

T_{13} - Control

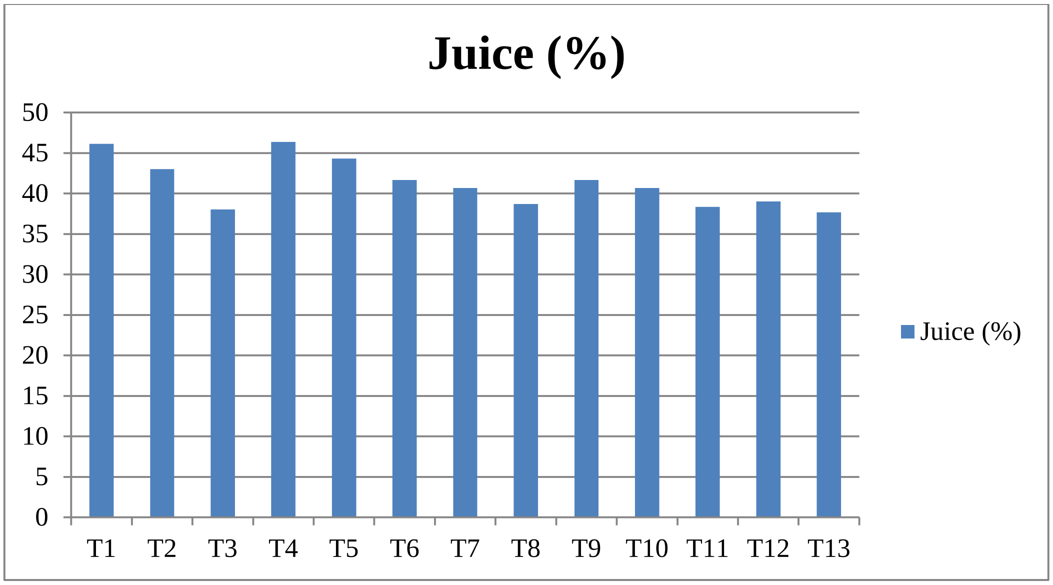


Fig . No : 4.9

Effect of foliar application of nutrients on juice content (%) in sweet orange Cv. Sathgudi.

T_1 – 1.0 % KNO_3

T_2 – 1.5 % KNO_3

T_3 – 2.0 % KNO_3

T_4 – 4 ml/L K_2SiO_3

T_5 – 6 ml/L K_2SiO_3

T_6 – 8 ml/L K_2SiO_3

T_7 – 1.0 % $Ca(NO_3)_2$

T_8 – 1.5 % $Ca(NO_3)_2$

T_9 – 2.0 % $Ca(NO_3)_2$

T_{10} – 1.0 % $CaCl_2$

T_{11} – 1.5 % $CaCl_2$

T_{12} – 2.0 % $CaCl_2$

T_{13} - Control

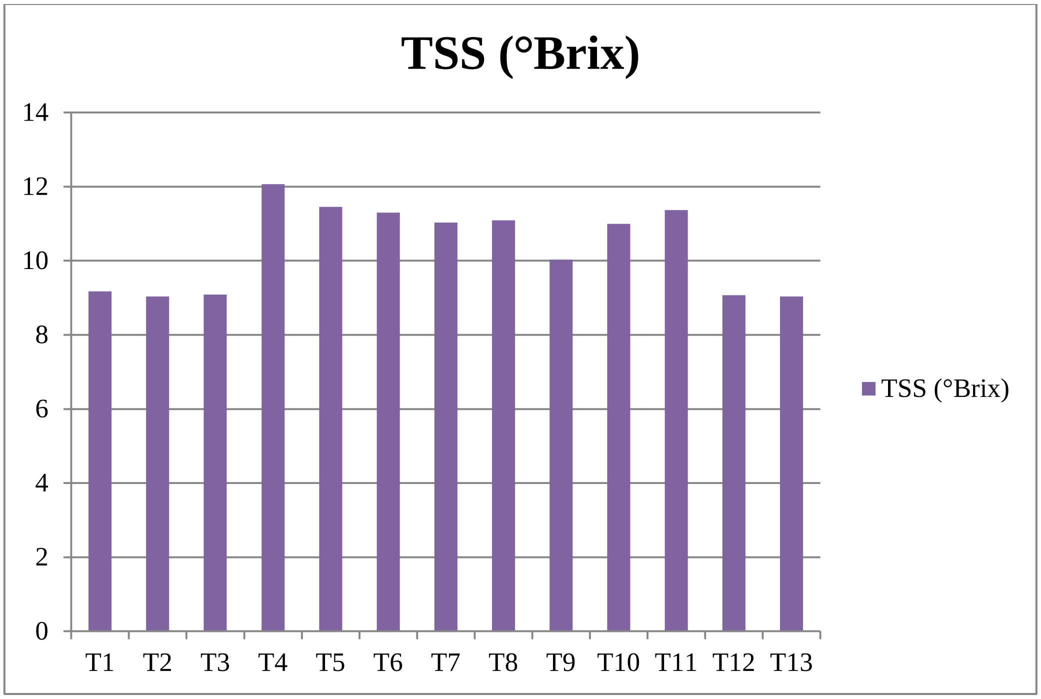


Fig . No : 4.10

Effect of foliar application of nutrients on total soluble solids (^{0}Brix) in sweet orange Cv. Sathgudi.

T_1 – 1.0 % KNO_3

T_2 – 1.5 % KNO_3

T_3 – 2.0 % KNO_3

T_4 – 4 ml/L K_2SiO_3

T_5 – 6 ml/L K_2SiO_3

T_6 – 8 ml/L K_2SiO_3

T_7 – 1.0 % $Ca(NO_3)_2$

T_8 – 1.5 % $Ca(NO_3)_2$

T_9 – 2.0 % $Ca(NO_3)_2$

T_{10} – 1.0 % $CaCl_2$

T_{11} – 1.5 % $CaCl_2$

T_{12} – 2.0 % $CaCl_2$

T_{13} - Control

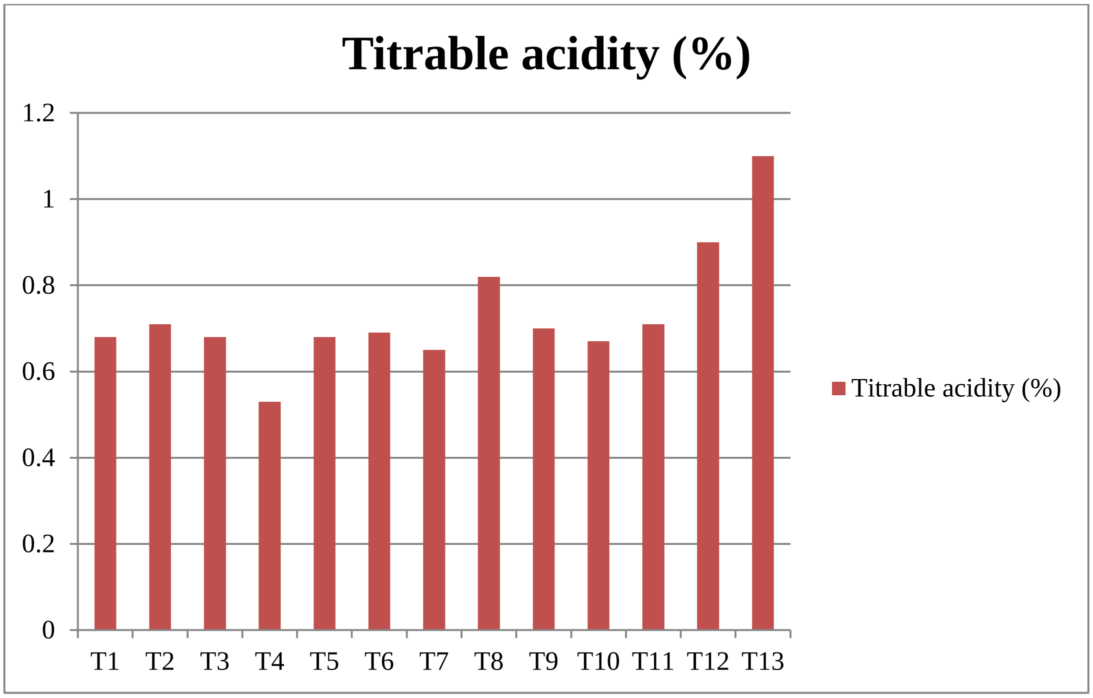


Fig . No : 4.11

Effect of foliar application of nutrients on titrable acidity (%) in sweet orange Cv. Sathgudi.

T_1 – 1.0 % KNO_3

T_2 – 1.5 % KNO_3

T_3 – 2.0 % KNO_3

T_4 – 4 ml/L K_2SiO_3

T_5 – 6 ml/L K_2SiO_3

T_6 – 8 ml/L K_2SiO_3

T_7 – 1.0 % $Ca(NO_3)_2$

T_8 – 1.5 % $Ca(NO_3)_2$

T_9 – 2.0 % $Ca(NO_3)_2$

T_{10} – 1.0 % $CaCl_2$

T_{11} – 1.5 % $CaCl_2$

T_{12} – 2.0 % $CaCl_2$

T_{13} - Control

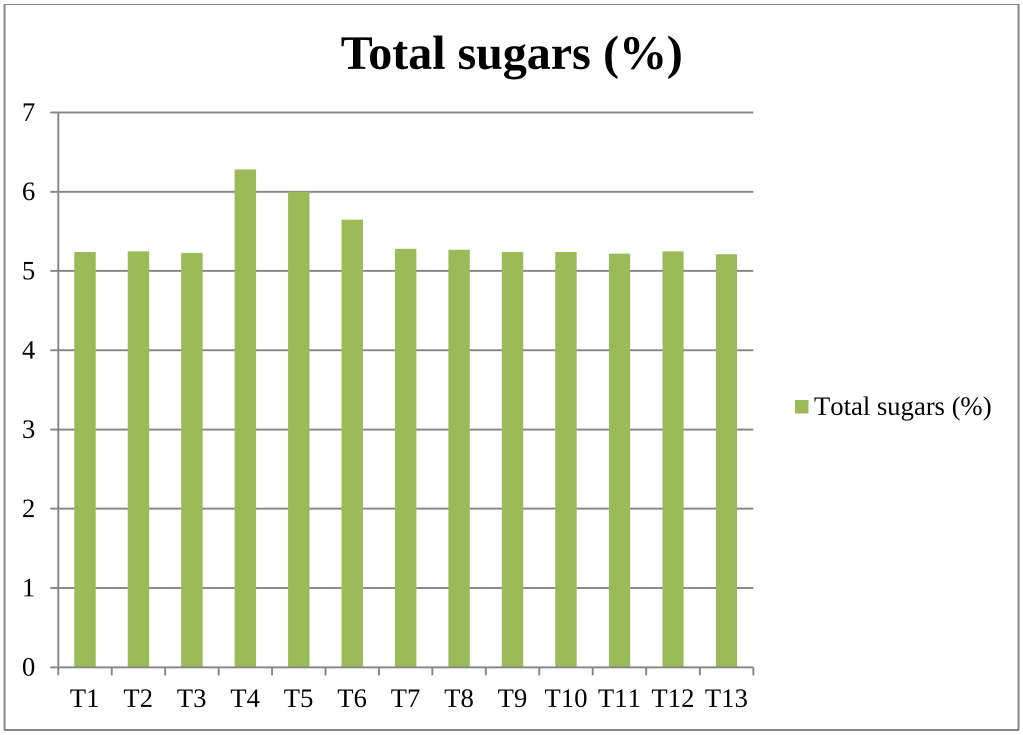


Fig . No : 4.12

Effect of foliar application of nutrients on total sugars (%) in sweet orange Cv. Sathgudi.

T_1 – 1.0 % KNO_3

T_2 – 1.5 % KNO_3

T_3 – 2.0 % KNO_3

T_4 – 4 ml/L K_2SiO_3

T_5 – 6 ml/L K_2SiO_3

T_6 – 8 ml/L K_2SiO_3

T_7 – 1.0 % $Ca(NO_3)_2$

T_8 – 1.5 % $Ca(NO_3)_2$

T_9 – 2.0 % $Ca(NO_3)_2$

T_{10} – 1.0 % $CaCl_2$

T_{11} – 1.5 % $CaCl_2$

T_{12} – 2.0 % $CaCl_2$

T_{13} - Control

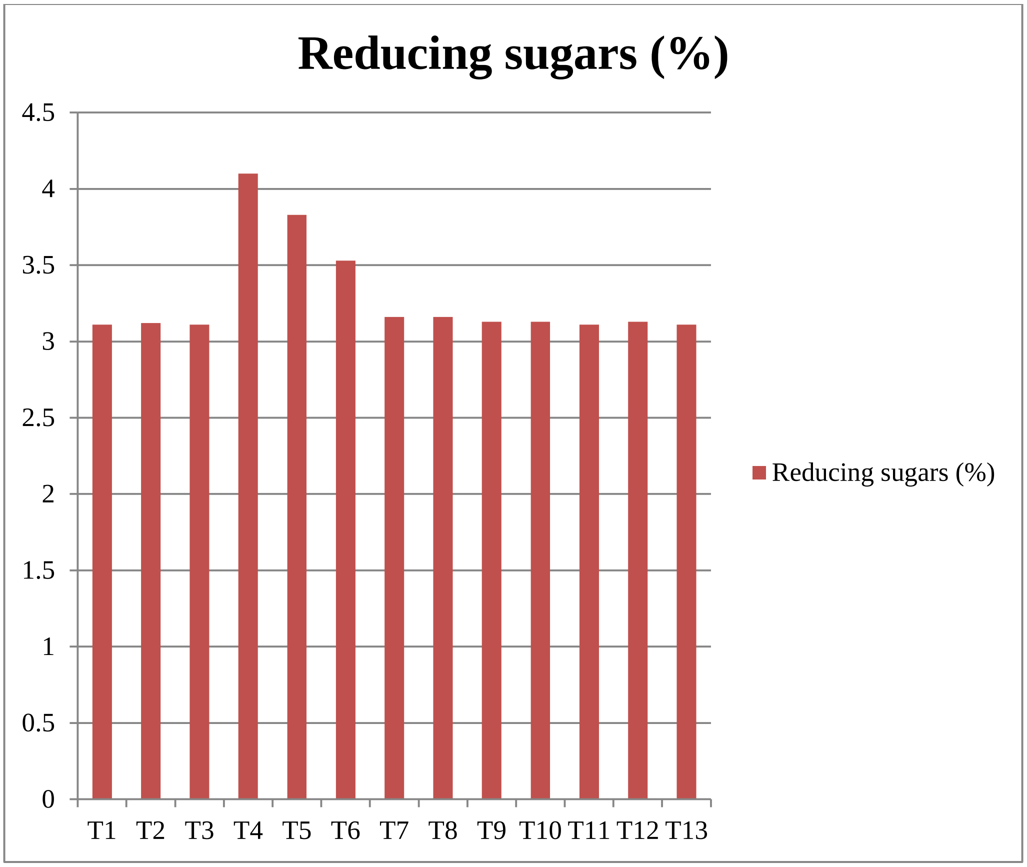


Fig .No : 4.13.

Effect of foliar application of nutrients on reducing sugars (%) in sweet orange Cv. Sathgudi.

T_1 – 1.0 % KNO_3	T_8 – 1.5 % $Ca(NO_3)_2$
T_2 – 1.5 % KNO_3	T_9 – 2.0 % $Ca(NO_3)_2$
T_3 – 2.0 % KNO_3	T_{10} – 1.0 % $CaCl_2$
T_4 – 4 ml/L K_2SiO_3	T_{11} – 1.5 % $CaCl_2$
T_5 – 6 ml/L K_2SiO_3	T_{12} – 2.0 % $CaCl_2$
T_6 – 8 ml/L K_2SiO_3	T_{13} - Control
T_7 – 1.0 % $Ca(NO_3)_2$	

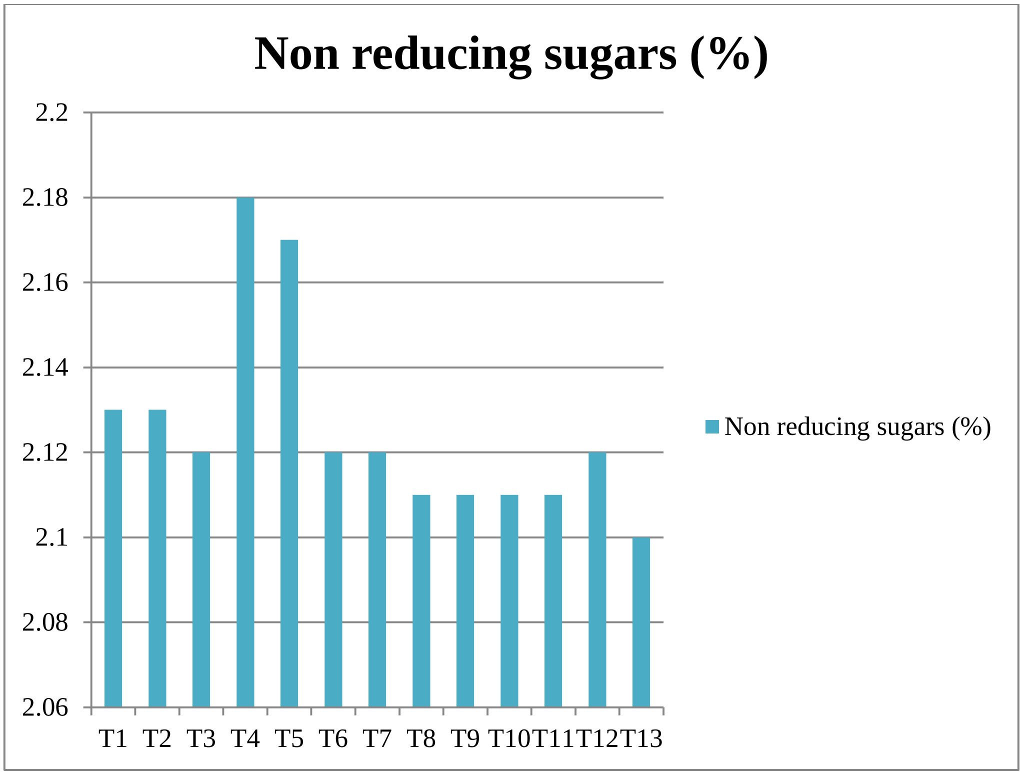


Fig . No : 4.14

Effect of foliar application of nutrients on non reducing sugars (%) in sweet orange Cv. Sathgudi.

T_1 – 1.0 % KNO_3

T_2 – 1.5 % KNO_3

T_3 – 2.0 % KNO_3

T_4 – 4 ml/L K_2SiO_3

T_5 – 6 ml/L K_2SiO_3

T_6 – 8 ml/L K_2SiO_3

T_7 – 1.0 % $Ca(NO_3)_2$

T_8 – 1.5 % $Ca(NO_3)_2$

T_9 – 2.0 % $Ca(NO_3)_2$

T_{10} – 1.0 % $CaCl_2$

T_{11} – 1.5 % $CaCl_2$

T_{12} – 2.0 % $CaCl_2$

T_{13} - Control

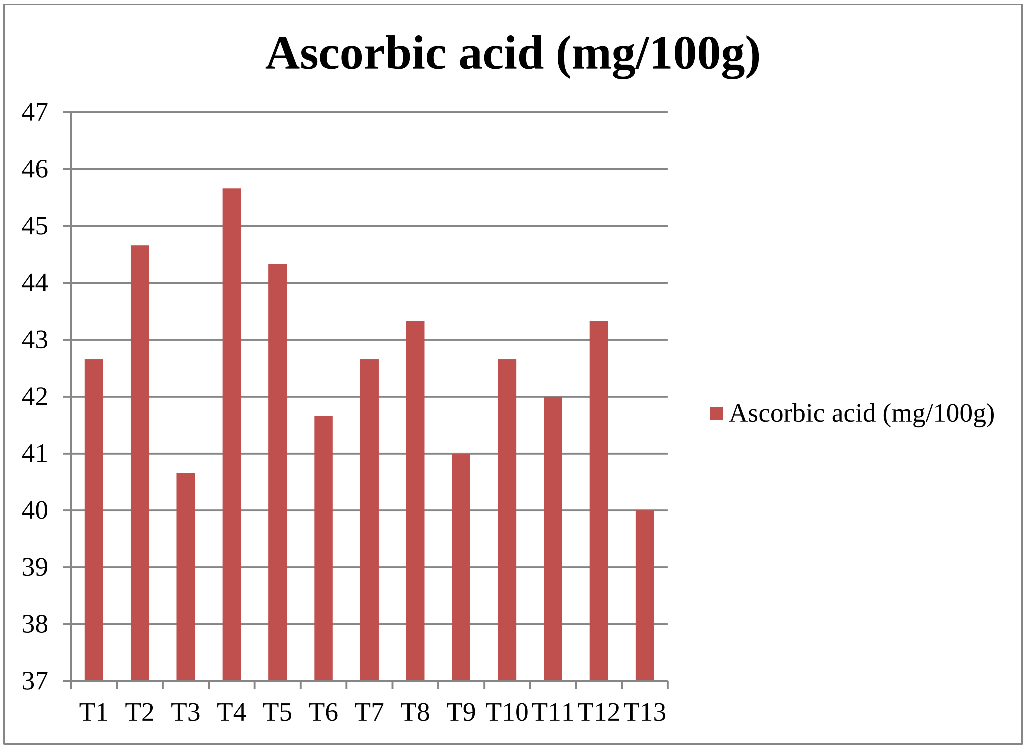


Fig .No : 4.15

Effect of foliar application of nutrients on ascorbic acid (mg/100g) in sweet orange Cv. Sathgudi.

T_1 – 1.0 % KNO_3

T_2 – 1.5 % KNO_3

T_3 – 2.0 % KNO_3

T_4 – 4 ml/L K_2SiO_3

T_5 – 6 ml/L K_2SiO_3

T_6 – 8 ml/L K_2SiO_3

T_7 – 1.0 % $Ca(NO_3)_2$

T_8 – 1.5 % $Ca(NO_3)_2$

T_9 – 2.0 % $Ca(NO_3)_2$

T_{10} – 1.0 % $CaCl_2$

T_{11} – 1.5 % $CaCl_2$

T_{12} – 2.0 % $CaCl_2$

T_{13} - Control

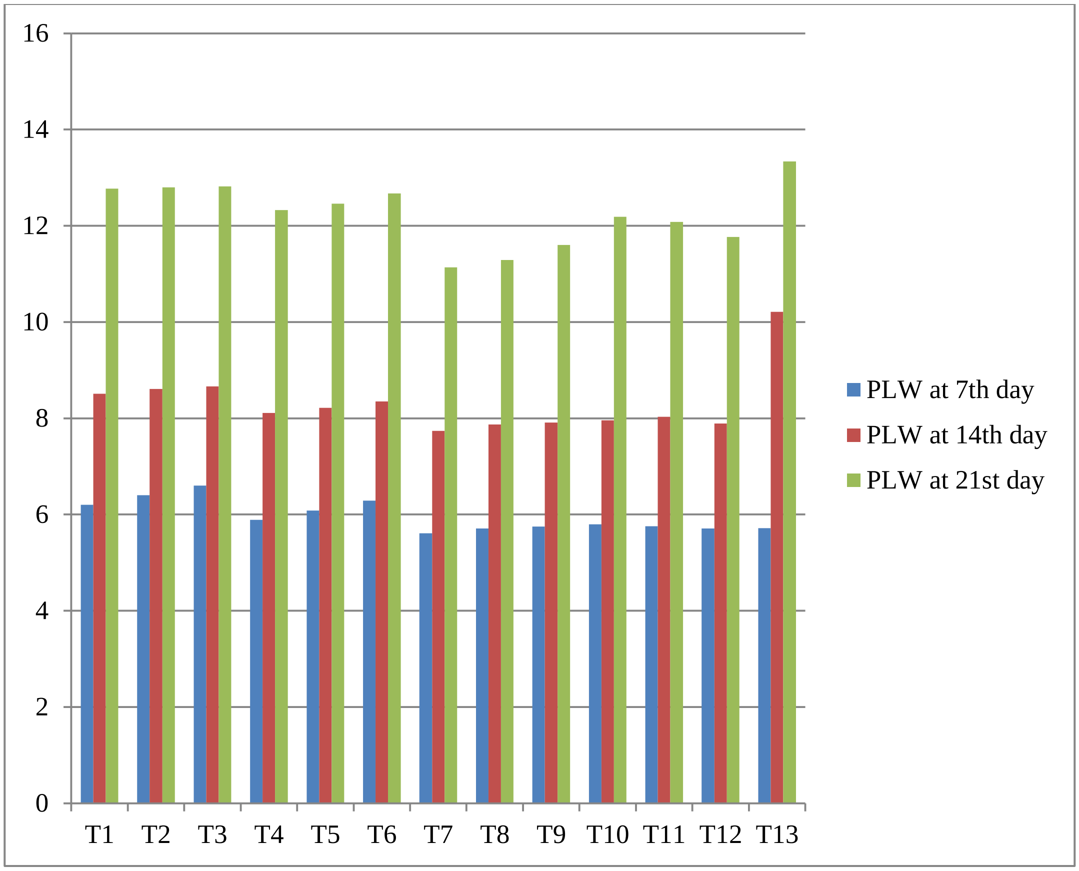


Fig .No : 4.16

Effect of foliar application of nutrients on physiological loss in weight (PLW %) of the fruit in sweet orange Cv. Sathgudi.

T_1 – 1.0 % KNO_3

T_2 – 1.5 % KNO_3

T_3 – 2.0 % KNO_3

T_4 – 4 ml/L K_2SiO_3

T_5 – 6 ml/L K_2SiO_3

T_6 – 8 ml/L K_2SiO_3

T_7 – 1.0 % $Ca(NO_3)_2$

T_8 – 1.5 % $Ca(NO_3)_2$

T_9 – 2.0 % $Ca(NO_3)_2$

T_{10} – 1.0 % $CaCl_2$

T_{11} – 1.5 % $CaCl_2$

T_{12} – 2.0 % $CaCl_2$

T_{13} - Control

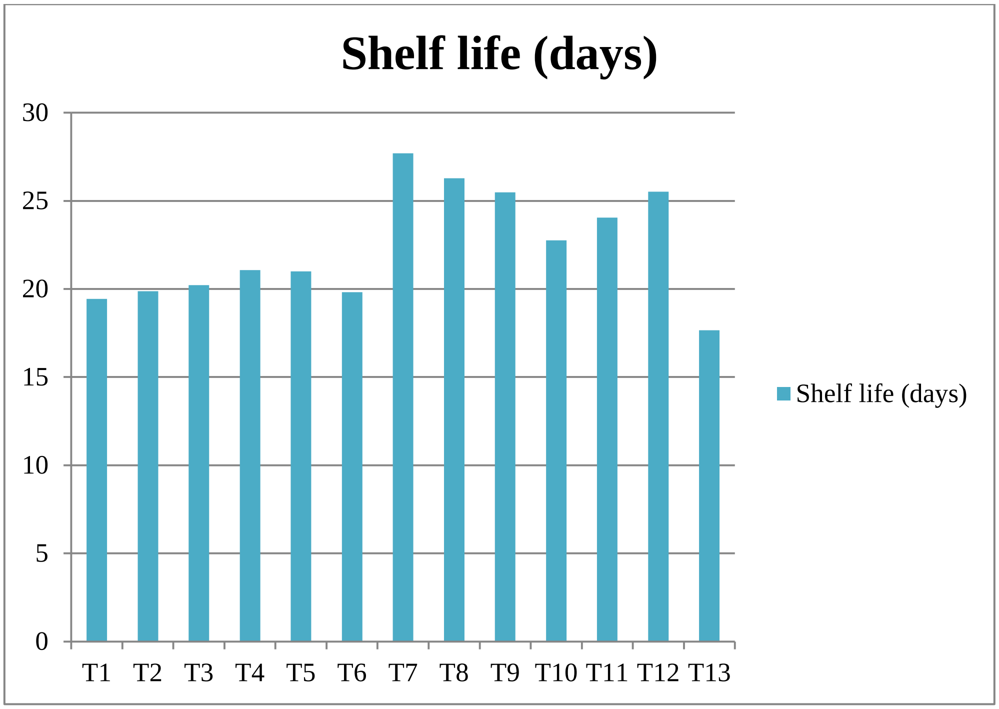


Fig .No : 4.17

Effect of foliar application of nutrients on shelf life (days) of the fruit in sweet orange Cv. Sathgudi.

T_1 – 1.0 % KNO_3

T_2 – 1.5 % KNO_3

T_3 – 2.0 % KNO_3

T_4 – 4 ml/L K_2SiO_3

T_5 – 6 ml/L K_2SiO_3

T_6 – 8 ml/L K_2SiO_3

T_7 – 1.0 % $Ca(NO_3)_2$

T_8 – 1.5 % $Ca(NO_3)_2$

T_9 – 2.0 % $Ca(NO_3)_2$

T_{10} – 1.0 % $CaCl_2$

T_{11} – 1.5 % $CaCl_2$

T_{12} – 2.0 % $CaCl_2$

T_{13} - Control

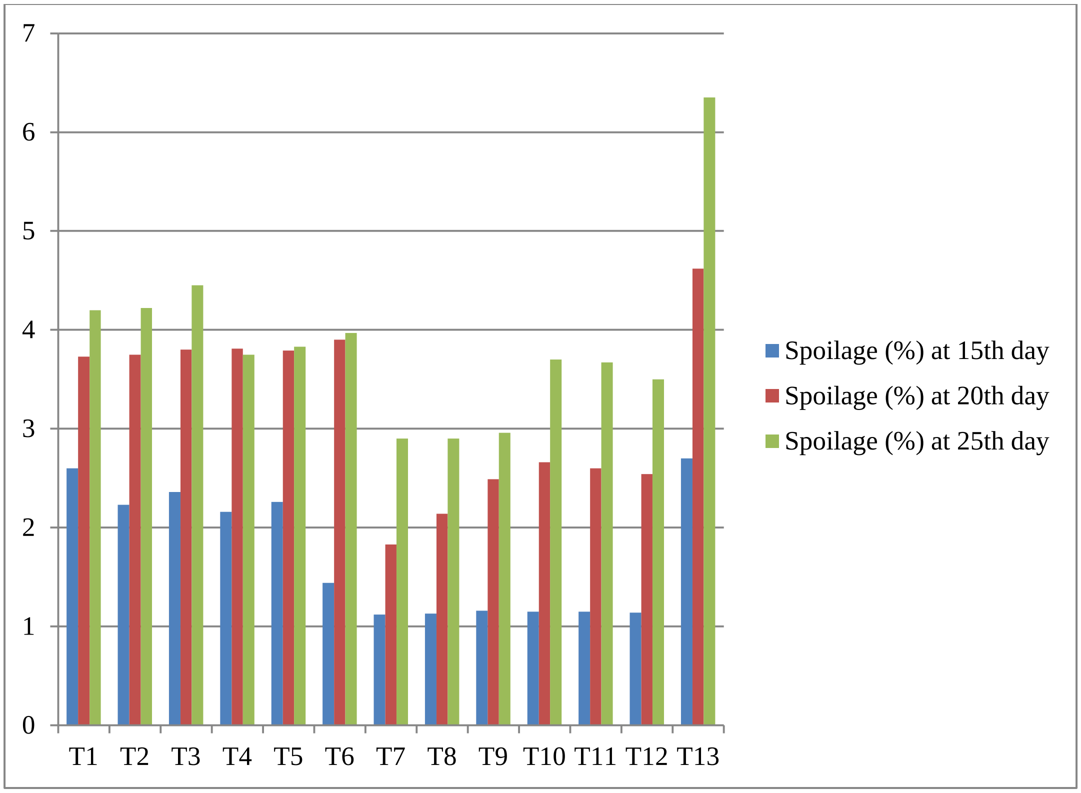


Fig .No : 4.18

Effect of foliar application of nutrients on spoilage (%) in sweet orange Cv. Sathgudi.

T_1 – 1.0 % KNO_3

T_2 – 1.5 % KNO_3

T_3 – 2.0 % KNO_3

T_4 – 4 ml/L K_2SiO_3

T_5 – 6 ml/L K_2SiO_3

T_6 – 8 ml/L K_2SiO_3

T_7 – 1.0 % $Ca(NO_3)_2$

T_8 – 1.5 % $Ca(NO_3)_2$

T_9 – 2.0 % $Ca(NO_3)_2$

T_{10} – 1.0 % $CaCl_2$

T_{11} – 1.5 % $CaCl_2$

T_{12} – 2.0 % $CaCl_2$

T_{13} - Control

CHAPTER V

SUMMARY AND CONCLUSIONS

The present work entitled **"**Studies on the effect of foliar application of Calcium, Potassium, and Silicon on yield, fruit quality and shelf life of sweet orange (*Citrus sinensis*L.) cv. Sathgudi.**"** was carried out at Horticultural Research Station (HRS), Konda Mallepally, Nalgonda during the year 2018-19. The main objective of the investigation was to find out the effect of calcium, potassium, and silicon on yield, fruit quality and shelf life of sweet orange. The experiment was laid out in RBD with thirteen treatments and three replications.

The salient features of the experimental findings are summarized here under.

Among the different treatments, T_4 – 4ml/L K_2SiO_3 recorded maximum fruit weight (244.93 g), followed by T_5 - 6 ml/L K_2SiO_3 (242.70 g), T_6 -8ml/L K_2SiO_3 (241.07 g) which are at par. and followed by T_1 - 1% KNO_3 (237.62 g), However, minimum fruit weight (206.66 g) was observed in the T_{13} – control.

T_4 - 4ml/L K_2SiO_3 recorded maximum fruit length (6.68 cm), fruit volume (145.00 ml), fruit diameter (6.95 cm) followed by T_5 - 6 ml/L K_2SiO_3, minimum observed in the T_{13} – control.

The treatment T_1- 1% KNO_3 recorded maximum number of fruits per tree (250.00), followed by T_4 - 4ml/L K_2SiO_3 (245.66), T_5 -6 ml/L K_2SiO_3 (242.00), T_2 - 1.5% KNO_3 (241.66), T_6 - 8 ml/L K_2SiO_3 (239.00), T_7 - 1 % $Ca(NO_3)_2$ (238.33), T_{10} - 1% $CaCl_2$ (236.00), and minimum number of fruits were recorded in T_{13} - control with (207.33)

The treatment T_4 - 4ml/L K_2SiO_3 recorded maximum yield per tree (60.17 kg), followed by T_1 - 1% KNO_3 (59.40 kg), T_5 -6 ml/L K_2SiO_3 (58.73 kg), T_6 - 8ml/L K_2SiO_3 (57.62 kg), T_2 -1.5% KNO_3 (59.91 kg), T_7 - 1% $Ca(NO_3)_2$ (55.29 kg), and minimum yield per tree was recorded in control with (42.84 kg).

The treatment T_4 - 4ml/L K_2SiO_3 recorded maximum juice content (46.37 %), followed by T_1 - 1% KNO_3 (46.13 %), T_5 - 6ml/L K_2SiO_3 (44.31%), T_2 -1.5% KNO_3 (43.00 %), and minimum juice content was recorded in control with (37.66 %) respectively.

The treatment T_4 - 4ml/L K_2SiO_3 recorded maximum TSS (12.07 B^0), followed by T_5 - 6ml /L K_2SiO_3 (11.45 B^0), T_{11} -1.5% $CaCl_2$ (11.37 B^0), T_6 - 8ml/L K_2SiO_3 (11.30 B^0), T_8 – 1.5% $Ca(NO_3)_2$ (11.09 B^0) and minimum TSS was recorded in T_{13} - control with (9.04 B^0) respectively.

The treatment T_4 - 4ml/L K_2SiO_3 recorded minimum acidity (0.53 %), followed by T_7 - 1% $Ca(NO_3)_2$ (0.65 %), T_1 - 1% KNO_3 (0.68 %) is on par with T_3- 2% KNO_3 (0.68) and maximum acidity was found in control (1.10 %).

Maximum total sugars (6.28 %), reducing sugars (4.10 %), and non reducing sugars (2.18 %) were recorded in T_4 – 4 ml/L K_2SiO_3. However lowest was recorded in T_{13} control.

With respect to Physiological loss in weight, At 7^{Th} day, the treatment T_7 – 1 % $Ca(NO_3)_2$ recorded minimum physiological loss in weight (6.28 %), followed by T_8 – 1.5% $Ca(NO_3)_2$ (5.71 %), and T_{12} – 2 % $CaCl_2$ (5.71 %) which are on par. T_9 -2 % $Ca(NO_3)_2$ (5.75 %), highest PLW was recorded in T_{13}- control (5.72 %).

On 14^{th} day the treatment T_7 –1 % $Ca(NO_3)_2$ recorded minimum physiological loss in weight (7.74 %), followed by T_8 – 1.5% $Ca(NO_3)_2$ (7.87 %), and T_{12} – 2 % $CaCl_2$ (7.89 %) which are on par. T_9 -2 % $Ca(NO_3)_2$ (7.91 %), highest PLW was recorded in T_{13}- control (10.21 %).

On 21st day the treatment T_7 – 1 % $Ca(NO_3)_2$ recorded minimum physiological loss in weight (11.14 %), followed by T_8 –1.5% $Ca(NO_3)_2$ (11.29 %), T_9 - 2 % $Ca(NO_3)_2$ (11.60 %),and highest PLW was recorded in T_{13}- control with (13.34 %).

the treatment T_7 – 1 % $Ca(NO_3)_2$ recorded maximum shelf life (27.20 days), followed by T_8 – 1.5% $Ca(NO_3)_2$ (26.29 days), and T_{12} –2 % $CaCl_2$ (25.52 days), is on par with T_9 - 2 % $Ca(NO_3)_2$ (5.75 days), and lowest shelf life was recorded in T_{13}- control with (17.66 days).

At 15^{Th} day, the treatment T_7 – 1 % $Ca(NO_3)_2$ recorded minimum spoilage (1.12 %), followed by T_8 –1.5% $Ca(NO_3)_2$ (1.13 %), and T_{12} –2 %

$CaCl_2$ (1.14 %), T_{10}- 1% $CaCl_2$ (1.15 %), is on par with T_{11} – 1.5% $CaCl_2$ (1.15 %) and highest spoilage was recorded in T_{13}- control (2.70 %).

At 20Th day, the treatment T_7 – 1 % $Ca(NO_3)_2$ recorded minimum spoilage (1.83 %), followed by T_8 – 1.5% $Ca(NO_3)_2$ (2.14 %), T_9 – 2 % $Ca(NO_3)_2$ (2.49 %), T_{12} – 2 % $CaCl_2$ (2.54 %) , T_{11} - 1.5% $CaCl_2$ (2.60 %), and highest spoilage was recorded in T_{13}- control with (4.62 %).

At 25Th day, the treatment T_7 – 1 % $Ca(NO_3)_2$ recorded minimum spoilage (2.90 %), followed by T_8 –1.5% $Ca(NO_3)_2$ (2.90 %), T_9 – 2 % $Ca(NO_3)_2$ (2.96), T_{12} – 2 % $CaCl_2$ (3.50), T_{11} - 1.5% $CaCl_2$ (3.67 %), and highest spoilage was recorded in T_{13}- control with (6.35 %).

CONCLUSIONS

Based on the results of the study the following conclusions could be drawn.

Application of foliar spray of T_4 – 4ml /L K_2SiO_3 can be recommended for obtaining higher yields with good quality fruits and T_7 -1% $Ca(NO_3)_2$ can be used for obtaining better shelf life of sweet orange.

With respect to peel thickness, and fruit firmness, ascorbic acid, effect of calcium, potassium and silicon nutrients was found to be non significant.

It can be concluded that growing of sweet orange with the combined use of potassium and silicon in the form of potassium silicate was found to be effective in increasing the quality and yield of sweet orange.

FUTURE LINE OF WORK

In continuation of the present investigation, the following further work has been proposed for producing higher yield of sweet orange.

Studies on the effect of combination of silicon nutrients and growth regulators on yield, quality and shelf life of sweet orange under high density planting can be taken up.

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Table 4.4.1 Effect of Calcium, potassium, and silicon on Benefit : Cost ratio of sweet orange cv. Sathgudi.

S.No	Treatment Details	Total cost of cultivation (Rs/ha)	Fruit yield (t/ha)	Gross income (Rs/ha)	Net income (Rs/ha)	B : C Ratio
1	1.0 % KNO_3	65200	12.12	266640	201440	3.08
2	1.5% KNO_3	65300	11.61	255420	190120	2.91
3	2.0% KNO_3	65400	11.16	245520	180120	2.75
4	4ml/L K_2SiO_3	67203	12.27	269940	202736	3.01
5	6ml/L K_2SiO_3	68304	11.98	263560	195255	2.85
6	8ml/L K_2SiO_3	69406	11.75	258500	189093	2.72
7	1.0 % $Ca(NO_3)_2$	65091	11.27	247940	182848	2.80
8	1.5 % $Ca(NO_3)_2$	65137	10.91	240020	174882	2.68
9	2.0 % $Ca(NO_3)_2$	65183	10.48	230560	165376	2.53
10	1.0 % $CaCl_2$	65155	10.84	238480	173324	2.66
11	1.5 % $CaCl_2$	65232	10.43	229460	164227	2.51
12	2.0 % $CaCl_2$	65310	10.04	220880	155569	2.38
13	Control (water spray)	65000	8.74	192280	127280	1.95

APENDIX-I

Common cost of cultivation of sweet orange

S.NO	Material/works	Hectare (204 plants)
I	**Inputs**	
1	Fertilizers 800 g of urea,300 g of SSP and 600 g of MOP per plant and 5 kg of FYM/plant	**(20,000)**
	a. Urea (5.4 Rs/Kg)	4320
	b. SSP (9 Rs/Kg)	2700
	c. MOP (12.8 Rs/Kg)	9600
	d. FYM	3380
II	**Labour charges**	**(45000)**
1	Spraying of calcium, potassium, and silicon nutrients-20 Labour (500 Rs/day)	10000
2	Weeding – 20Labours (400 Rs/day)	8000
3	Irrigation – 20 Labours (500 Rs/day)	10000
4	Plant protection – 15Labours (300 Rs/day)	4500
5	Harvesting – 20Labours (300 Rs/day)	6000
6	Transportation and marketing charges	5000
7	Miscellaneous	1500

Price of sweet orange - @ Rs. 22/kg, Price of KNO_3- @ Rs. 1.96/2g, Price of K_2SiO_3 - @ Rs. 5.4/2g, Price of $Ca(NO_3)_2$ - @ Rs. 0.9/g, $CaCl_2$ - @Rs 1.52/2g

APENDIX II

Treatment wise cost of cultivation of sweet orange per hectare

S. No.	Particulars	Treatments												
		T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	T_{13}
1	Land preparation	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
2	**Cost of calcium, potassium and silicon nutrients**													
i.	KNO_3 cost per ha	199.9	299.8	399.8	-	-	-	-	-	-	-	-	-	-
ii.	K_2SiO_3 cost per ha	-	-	-	2203	3304	4406	-	-	-	-	-	-	-
iii.	$Ca(NO_3)_2$ cost per ha	-	-	-	-	-	-	91.8	137	183	-	-	-	-
iv.	$CaCl_2$ cost per ha	-	-	-	-	-	-	-	-	-	155	232	310	-
3	**Cost of cultural operations**													
i.	Chemicals spraying	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
ii.	Weeding	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
iii.	Plant protection chemical	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500	4500
iv.	Spraying	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
v.	Irrigation	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
4	Harvesting	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
5	Transportation and marketing charges	7000	7000	7000	7000	7000	7000	7000	7000	7000	7000	7000	7000	7000
6	Miscellaneous	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
7	Total cost of cultivation	65200	65300	65400	67203	68304	69406	65091	65137	65183	65155	65232	65310	65000