“STUDIES ON MICRONUTRIENTS APPLICATION ON YIELD AND QUALITY OF GUAVA UNDER HIGH DENSITY PLANTING Cv.SARDAR.”

By

Miss. Lambe Yogita Trimbak

(Reg. No. 12/314)

A thesis submitted to the
MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI - 413 722, DIST.AHMEDNAGAR,
MAHARSHTRA, INDIA

In the partial fulfilment of the requirements of degree

Of

MASTER OF SCIENCE IN (HORTICULTURE)

IN

FRUIT SCIENCE

DEPARTMENT OF HORTICULTURE

MAHATMA PHULE KRISHI VIDYAPEETH,
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CANDIDATE'S DECLARATION

I, hereby declare that this thesis or part there of has not been submitted by me or other person to any other University or Institute for a Degree or Diploma

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CERTIFICATE

This is to certify that the thesis entitled, **“STUDIES ON MICRONUTRIENTS APPLICATION ON YIELD AND QUALITY OF GUAVA UNDER HIGH DENSITY PLANTING Cv. SARDAR”**, submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **FRUIT SCIENCE**, embodies the results of piece of bona *fide* research work carried out by **MISS. YOGITA TRIMBAK LAMBE,** under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

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C E R T I F I C A T E

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Place : MPKV., Rahuri

Date : / 05 /2014 (Lambe Y.T.)

CONTENTS

CANDIDATE'S DECLARATION	Iii
CERTIFICATES	
1. Research Guide	iv
2. Associate Dean (PGI)	v
ACKNOWLEDGEMENTS	Vi
LIST OF TABLES	Xii
LIST OF FIGURES	Xiii
LIST OF ABBREVIATIONS	xi
ABSTRACT	Xvi
1. INTRODUCTION	**1**
2. REVIEW OF LITERATURE	**4**
2.1 Chemical application	4
2.2.1. Calcium nitrate	5
2.2.2. Zinc	11
2.2.3. Boron	15
2.2.4. Magnesium	17
2.2.5. Water spray	17

3.	**MATERIAL AND METHODS**	**19**
3.1	Experimental details	19
3.2	Materials	22
3.2.1	Trees	22
3.2.2	Micronutrients	23
3.3	Methods	23
3.3.1	Physical characters	23
3.3.2	Quality characters	24
3.3.3	Storage characters	27
3.4	Statistical analysis	28
4.	**EXPERIMENTAL RESULTS**	**29**
4.1	Yield and yield contributing parameters	29
4.1.1	Average number of fruits per tree	30
4.1.2	Average weight of fruit (g)	30
4.2.3	Yield per tree (kg)	30
4.2.4	Yield per hectare (tonnes)	31
4.2.5	Equatorial diameter (cm)	31
4.2.6	Polar diameter (cm)	31

4.3 Quality parameters 32

4.3.1 Total soluble solids (^{0}Brix) 32

4.3.2 Total sugars (%) 35

4.3.3 Reducing sugars (%) 35

4.3.4 Non-reducing sugars (%) 35

4.3.5 Calcium (mg/100g) 36

4.3.6. Ascorbic acid (mg/100g) 36

4.3.7. Pectin (%) 37

4.3.8. Acidity (%) 37

4.4 Storage parameters 38

4.4.1 Physiological loss in weight (%) 38

4.4.2 General appearance 40

5. DISCUSSION 42

5.1 Yield and yield contributing parameters 42

5.2 Quality parameters 44

5.3 Storage parameters 46

6. SUMMARY AND CONCLUSION **49**

6.1 Summary 49

6.1.1 Yield and yield contributing parameters 49

6.1.2 Quality parameters 50

6.1.3 Storage parameters 51

6.2 Conclusion 51

7. LITERATURE CITED **52**

8. APPENDIX **61**

9. VITA **63**

LIST OF TABLES

No.	Title	Page
1.	Effect of different micronutrients on yield and yield contributing characters of guava Cv. Sardar	29
2.	Effect of different micronutrients on quality characters of guava Cv. Sardar	33
3.	Effect of different micronutrients on physiological loss in weight (%) of guava Cv. Sardar	38
4.	Effect of different micronutrients on general appearance of guava Cv. Sardar	41

LIST OF FIGURES

No.	Title	Between Pages
1.	Plan of experiment layout	22-23
2.	Effect of different micronutrients on physiological loss in weight (%) of guava Cv. Sardar	38-39
3.	Treatment wise effect on physiological loss in weight (%) of guava Cv. Sardar	38-39
4.	Treatment wise effect on physiological loss in weight (%) of guava Cv. Sardar	38-39

LIST OF ABBREVIATIONS

%	:	Per cent
µg	:	Microgram (s)
µl	:	Microlitre
/	:	Per
@	:	At the rate of
^{0}C	:	Degree celcius (S)
B	:	Boron
C.D.	:	Critical difference
Ca	:	Calcium
cm	:	Centimeter (s)
Conc.	:	Concentration
Cv.	:	Cultivar
et al.	:	And others (et alli)
etc.	:	Etcetera
Fig.	:	Figure
g	:	Gramme (s)
ha	:	Hectare (s)
hr	:	Hours (s)
i.e.	:	That is (*id est*)
K	:	Potassium
km	:	Kilometer (s)
lit.	:	Litre (s)

ml	:	Mililitre (s)
mm	:	Milimeter (s)
Mg	:	Magnesium
MT	:	Metric tonnes
N	:	Normality
NAA	:	Naphthalene Acetic Acid
N.S.	:	Non significant
No.	:	Number (s)
ppm	:	Parts per million
S.Em.	:	Standard error of means
t	:	Tonne (s)
TSS	:	Total soluble solids
viz.	:	Namely
Zn	:	Zinc

ABSTRACT

STUDIES ON MICRONUTRIENTS APPLICATION ON YIELD AND QUALITY OF GUAVA UNDER HIGH DENSITY PLANTING Cv. SARDAR

By

Miss. Lambe Yogita Trimbak

A candidate for the degree

of

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in

FRUIT SCIENCE

Mahatma Phule Krishi Vidyapeeth.,

Rahuri – 413 722

2014

Research Guide	:	Dr. S.S. Kulkarni
Department	:	Horticulture
Major field	:	Fruit Science

The present investigation entitled,“Studies on micronutrients application on yield and quality of guava under high density planting Cv. Sardar” was conducted at Instructional-Cum Research Orchard, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri, during 2013-14. The experiment was conducted on 4 year old healthy, vigorous ultra high density plantation (2 x 2 m.).

Abstract contd.... **Y.T. Lambe**

The experiment was laid out in Randomized Block Design with ten treatments and three replications. Sprays of micronutrients *viz.* calcium nitrate, zinc, boron, magnesium and water spray were carried out at 50 % flowering and one month after first spray.

The yield contributing parameters *viz.,* average number of fruits, average weight of fruit, yield per tree and per ha. were significantly influenced with application of micronutrient. The data revealed statistically non - significant differences in equatorial and polar diameter of fruit.

The maximum average number of fruit per tree (101.67), average weight of fruit (218.87 g), yield per tree (22.25 kg) and per ha. (55.63 tonnes) was recorded in T_1 [Ca $(NO_3)_2$ (1%)]. The maximum equatorial diameter of fruit (7.88 cm) was recorded in T_2 [Ca $(NO_3)_2$ (2%)]. The maximum polar diameter (9.33 cm) was recorded in T_1 [Ca $(NO_3)_2$ (1%)]. Quality parameters like TSS, total sugars, reducing sugars, non-reducing sugars, calcium, ascorbic acid pectin content and acidity were significantly influenced due to various treatments.

The maximum TSS (11.72 ^{0}Brix), total sugars (7.81 %), reducing sugars (6.09 %), non-reducing sugars (3.96 %), ascorbic acid (212.98), pectin (0.64) and the minimum acidity (0.48 %) was recorded in T_8 [Mg (0.2%)]. The maximum calcium (3.85 mg/100g) was recorded in T_1 [Ca $(NO_3)_2$ (1%)].

Abstract contd.... **Y.T. Lambe**

The data relating to physiological loss in weight and general appearance were recorded at 2 days interval of storage. The data revealed statistically significant differences in PLW. Guava fruits under the treatments T_1 and T_2 could be stored up to 10 days. The shelf life of the fruit in T_9 (water spray) and in T_{10} (Control) was upto six days.

The minimum PLW (16.41 %) throughout the complete storage period was recorded in T_2 [Ca $(NO_3)_2$ (2%)]. The PLW was minimum (10.85 %) in T_2 [Ca $(NO_3)_2$ (2%)] and the maximum (19.08 %) was in T_{10} (Control) on 6th day of storage. On the 8th day of storage, the minimum PLW (15.05 %) was recorded in T_2 [Ca $(NO_3)_2$ (2%)] and the maximum PLW (21.61 %) was recorded in T_4 [Zn (0.2%)]. On 10th day of storage the minimum PLW (16.41) was recorded in T2 [Ca $(NO_3)_2$ (2%)] and the maximum PLW (22.26 %) was recorded in T_8 [Mg (0.1%)].

The general appearance and acceptance (attractive, greenish yellow and optimum firmness) of fruits was observed in T_1, T_2 and T_8 than other treatments.

From the present investigation, it could be concluded that, foliar application of [Ca $(NO_3)_2$ (1%)] at 50 % flowering was beneficial in improving yield and yield contributing parameters. The fruits under the treatment [Ca $(NO_3)_2$ (2%)] showed minimum PLW on 8th day however, it was at par with [Ca $(NO_3)_2$ (1%)].

Abstract contd.... **Y.T. Lambe**

under the treatment [Ca $(NO_3)_2$ (2%)] showed minimum PLW on 8th day however, it was at par with [Ca $(NO_3)_2$ (1%)].

Thus, it could be concluded that, foliar application of [Ca $(NO_3)_2$ (1%)] was beneficial in improving yield, quality and shelf life of guava Cv. Sardar.

Pages 1 to 63

1. INTRODUCTION

The guava (*Psidium guajava* L.*)* the apple of tropics is one of the important fruit crops of India. Though it is native to tropical America its cultivation has expanded to all tropical countries and become especially important in India (Samson, 1980). It belongs to the natural order Myrtal and the botanical family Myrtaceae.

Guava is hardy, prolific bearer and highly remunerative fruit. Guava fruit considered to be a poor man's apple because of it's high nutritive value and comparatively low price.

Guava is rich source of vitamin C, vitamin A, vitamin B_2 (Riboflavin) and minerals like calcium, phosphate and iron. The Vitamin C content of guava fruit is 212 mg/100 g and pectin content (1.15 %). Guava fruit is also utilized to make products like jelly, jam, cheese, ice-cream and toffee. Two types of wines- guava juice wine and guava pulp wine are also prepared from guava fruit.

Guava is cultivated commercially in south Asian countries, the Hawaiian Islands, Cuba and India (Mitra and Sanyal, 2004). In India guava is mainly grown in Bihar, Uttar Pradesh, Karnataka, Madhya Pradesh, Gujarat, Andhra Pradesh and Maharashtra. The area under the fruit in India is 6383 thousand ha. of which guava comprises 219.9 thousand ha. with production of 2510.4 thousand MT and productivity of 11.4 MT/ha. The area under guava in Maharashtra is 37000 ha. with total production of 322000 MT having productivity 8.7 MT (Annon., 2012).

For higher production timely nutrient application is mandatory. Role of major as well as miner nutrients is well understood. Generally, major nutrients are applied with a care but, the micronutrients are not much given importance.

In high density planting as the plant population is more in a unit area. The requirement of nutrients is also supposed to be more. It has been observed that, standardization of nutrient application in high density planting is not yet been done. However, application of major nutrients as per requirement is carried on an adhoc basis.

Micronutrient play an important role in production and it's deficiency leads in lowering the productivity. Guava plant also shows micronutrient deficiency and could be responsible for lesser yield and quality.

Thus, it is important to correct the deficiency by exogenous application of micronutrients through soil or foliar application. However, foliar micronutrient application is easiest way to correct the deficiency. Foliar feeding of nutrients to fruit plants has gained much importance in recent years which is quite economical and an ideal way of evading the problems of micronutrients availability. (Ravat *et al.*, 2010)

Micronutrients especially Ca, B and Zn are responsible for metabolic activities in plant as well as fruit physiology. Application of micronutrient at flowering and at in first growth phase was found to be beneficial.

Calcium is important constituent of the middle lamella in cell wall. It is essential in strengthening of the cell wall of plants tissue and also in the formation of cell membrane, cell division. Zinc is involved in the biosynthesis of the growth hormones auxin and also in protein synthesis. It participates in chlorophyll formation or prevents chlorophyll destructions. Boron is playing vital role in the synthesis of nucleic acid. It is constituent of cell membrane and essential for cell division. It acts as a regulator of potassium-calcium ratio in the plant and also helps in nitrogen absorption and translocation of sugar in plant. Boron increases nitrogen availability to the plant. (Trivedi *et al.*, 2012).

Thus, micronutrients especially calcium, boron and zinc perform a specific role in the growth and development of plant as well as fruit, quality of produce and uptake of major nutrients. Keeping in view the importance of application of micronutrients for improving fruit quality, present study was undertaken with following objectives.

i. To study the effect of micronutrients application on yield of guava.

ii. To study the effect of micronutrients application on quality of guava.

2. REVIEW OF LITERATURE

2.1 Micronutrients application

Foliar micronutrient application is easiest way to correct deficiency. It is quite economical and an ideal way of evading the problems of micronutrients availability.

For improving fruit quality and yield foliar application of micronutrients *viz.,* calcium nitrate [Ca $(NO3)_2$], zinc (Zn), boron (B) and magnesium (Mg) were found to be effective.

Foliar application of nutrients can supply essential elements directly to the foliage at times when rapid response are desired. Calcium plays an important role in physicochemical and biochemical processes in fruits. Calcium can delay ripening and senescence, increase firmness, reduce respiration and extend the storage life (Sharma *et al.,* 1996).

Boron has been found to be effective in photosynthesis in plants (Lal and Patil, 1948) and also influences the cell division, meristematic activity of tissues and expansion of cell wall (Berger, 1949). Shek (1958) observed that, boron improved translocation of sugar and synthesis of cell wall material.

The literature pertaining to the application of micronutrients *viz.,* calcium nitrate, zinc, boron and magnesium on the fruit yield and quality of fruits is obscure and as such the literature pertaining to the effect of micronutrients application on the other fruit crops have been reviewed, here under.

2.1.1 Calcium nitrate

The effect of pre-harvest sprays of calcium nitrate on yield, quality and shelf life of fruits has been reported earlier in various fruit crops and is narrated as below.

2.1.1.1 Tropical fruits

Singh and Chauhan (1981) reported that, in guava Cv. Sardar with pre harvest application of calcium nitrate (1 and 2 %), fruit softening processes were slowed down by reduced activity of cellulose enzyme and retained higher pectin content under cold storage conditions. They further reported that, reduced activity of cellulose obtained with calcium treatment might be due to influence on respiration rate.

Singh *et al.* (1987) studied the effect of pre-harvest spray of calcium nitrate on storage life of mango Cv. Amrapali and concluded that, calcium nitrate (1.5 %) significantly reduced the loss in weight and rotting and also prolonged the storage life by delaying onset of senescence. The reduced loss in weight was mainly due to reduced rate of transpiration and respiration. Calcium nitrate was most effective than calcium chloride in prolonging the storage life of fruits.

Singh (1988) studied the effect of calcium nitrate (1 and 2 %) on storage of Allahabad Safeda guava and recorded reduction in respiration rate, weight loss and incidence of fruit rot. It was effective in maintaining the edible quality and marketability of fruits more than 6 days by delaying the onset of senescence.

Bhanja and Lenka (1994) studied the effect of pre and post harvest treatments of calcium nitrate (1 and 2 %) on storage life of sapota fruits Cv. Oval and reported that, application of calcium nitrate (1 and 2 %) extended the storage life for 13.5 to 16 days. However, the percentage of rotting after ripening was maximum (10.0 %) under ambient storage.

Singh *et al.* (1998), reported in mango Cv. Amrapali, that the pre-harvest foliar feeding of $CaCl_2$ (1.5 %) and Ca $(NO_3)_2$ (1.5 %) showed better results in reducing physiological loss in weight of fruits over the control. The increased weight loss of untreated fruits was due to the increased storage break down associated with higher respiratory rate.

Fruits treated with Ca $(NO_3)_2$ (1.5 %) showed minimum physiological loss in weight. Fruits treated with $CaCl_2$ (1.5 %) showed highest TSS, total sugars, ascorbic acid content and minimum acidity. Higher level of sugar in treated fruits might be the possible reason for increase in ascorbic acid because it is synthesized from sugar. The maximum β-carotene was found in $CaCl_2$ (1.5 %). 'Ca' salts increased the activity of chlorophyllase enzyme which is responsible for breakdown of chlorophyll and enhanced β-carotene content in fruits.

The 'Ca' treatments helped in retaining fruit firmness, decrease in storage breakdown, rotting and browning. It was also reported that 'Ca' protected membranes from disorganization and maintains protein synthesizing cells.

Ruby Rani and Brahmachari (2004) studied the effect of growth substances and calcium compounds on fruit retention, growth and yield of Amrapali mango and reported that, calcium nitrate (1 and 2 %) was most effective treatment than calcium chloride (1 and 2 %) with regards to fruit retention, fruit weight, pulp weight, specific gravity and yield of fruits.

Jayachandran *et al.* (2005) in guava Cv. Lucknow reported that the pre-harvest spray of calcium nitrate (1 %) showed higher retention of fruit firmness, TSS and pectin percentage and lower acidity and physiological loss in weight. Calcium nitrate (1 %) delayed softening and enhanced the shelf life of fruits up to 11 days under ambient temperature. They further reported that, 1 % calcium nitrate showed highest firmness retention which was due to presence of calcium ions, which limit polygalacturonase activity in the cell wall of fruit skin. Calcium nitrate was most effective treatment than calcium chloride and calcium sulphate.

Wali and Kumar (2006) studied the effect of pre-harvest sprays of calcium nitrate, zinc sulphate and silver nitrate on physico-chemical characteristics of guava Cv. Sardar during storage at room temperature and reported that, calcium nitrate (2.0 %) was more effective than control with regards to increasing fruit weight, firmness, specific gravity, TSS, acidity, total sugars and ascorbic acid and reduced decay and physiological loss in weight of fruits. They further reported that, reduction in fruit decay with calcium nitrate was due to its beneficial effect on firmness of tissues.

2.1.1.2 Subtropical fruits

Gupta *et al.* (1980) studied the effect of pre harvest application of calcium nitrate on the storage behaviour of grape Cv. Perlette and concluded that, all concentrations (0.25, 0.50, 0.75 and 1.00 %) significantly reduced the weight loss and decay over control during 3 days of storage. Among the concentrations 1 per cent calcium nitrate was found to be the best.

Singh *et al.* (1987) studied the effect of pre harvest application of calcium nitrate (1.5 %) on storage life of sweet orange Cv. Malta Blood Red and reported that, it improved the shelf life of fruits and produced 50 per cent marketable fruits as compared to control (5 %). Calcium nitrate also recorded highest TSS, better organoleptic properties and decreased physiological loss in weight and fruit rot.

Gupta and Mehta (1988) reported in ber Cv. Gola that the pre-harvest sprays of Ca $(NO_3)_2$ (1 %)10 days before harvest showed better results in increasing shelf life by reducing the weight and decay losses. $Ca(NO_3)_2$ (1 %) helped in reducing respiration and ethylene production as well as retaining the firmness of the fruit by delaying senescence and thus checked the entry of the fruit decaying organisms.

Siddikqui and Gupta (1989) studied the effect of pre-harvest spray of calcium on shelf life of ber and concluded that, calcium nitrate (10.3 g/lit.) decreased the weight loss and decay loss and enhanced the shelf life of fruits.

Kumar *et al.* (1990) studied the effect of pre-harvest application of different chemicals on quality of grapes Cv. Delight and reported that, calcium as calcium nitrate (1 %) maintained the freshness of the grapes by lowering down changes during storage and increased organoleptic rating which coincided with good appearance and better quality of fruits. They also reported that, TSS and acidity contents increased up to 4^{th} and 18^{th} days at room temperature and low temperature, respectively.

Kumar and Chauhan (1990) reported that, in Kinnow mandarin, calcium nitrate (1.0 %) alone or in combination with Bavistin (0.1 %) was effective in reducing physiological loss in weight and decay loss and maintained the various quality parameters like TSS, acidity and ascorbic acid contents. Fruits were of acceptable quality up to 90 days of storage (4 $\pm$ 1^{0}C) with better organoleptic rating

Subburamu *et al.* (1990) studied the effect of pre-harvest sprays of calcium in grapes Cv. Muscat and reported that, calcium nitrate was not so effective as calcium chloride in improving the shelf life and reducing spoilage of fruits.

Roychauhdari *et al.* (1992) reported that, in litchi Cv. Bombai quality parameters like TSS, total and reducing sugar content and ascorbic content were higher and acidity and physiological loss in weight were lower with calcium nitrate (1.0 %) as pre-harvest spray. They further reported that, calcium is an essential nutrient which is involved in a number of physiological processes in fruit which maintained the cell wall integrity and effective to inhibit the senescence of fruits.

Brahmachari *et al.* (1999) reported that in litchi Cv. Purbi the pre-harvest sprays of 2 per cent calcium nitrate was found most effective in extending storage life of fruits and maintained the firmness of fruit by retarding the rate of respiration and preventing cellular disintegration of enzymes. Biochemical constituents and organoleptic rating of fruits after 9th day of storage were at higher level in this treatment. Reduced physiological losses in weight and decay losses were also recorded.

Lakshmana and Reddy (1999) studied the effect of pre-harvest spray of calcium as calcium chloride or calcium nitrate (0.25, 0.50 and 1.0 %) along with 0.01 per cent Teepol on sapota Cv. Kalipatti and reported that calcium nitrate at all concentrations enhanced the storage life of sapota fruits by 2 to 3 days and significantly reduced the post-harvest fruit rotting.

Heshi (1999) concluded that, in pomegranate Cv. G-137 and P-26, pre-harvest spraying of calcium nitrate (2 %) at 90 days after full anthesis was found beneficial for improving the quality of freshly harvested fruits and 120 days after full anthesis improved the storage quality of fruits by reduced the physiological loss in weights and rotting. Increase in TSS and decrease in acidity was also recorded.

2.1.1.3 Temperate fruits

Gautam *et al.* (1981) studied the effect of calcium nitrate (0.10, 0.20, 0.40, 0.60, 0.80 and 1.00 %) on the physico-chemical characteristics and storage of peach Cv. Kanto-5 and reported that, storage life was extended with 0.80 and 1.0 per cent concentration up to 9 days by increased firmness of flesh. They also reported that, calcium nitrate at 1.0 per cent significantly reduced the spoilage of fruits in storage.

Gupta *et al.* (1984) studied the effect of calcium compounds as pre-harvest spray on the shelf life of peach Cv. Sharbati and reported that, calcium nitrate @ 1.5 per cent showed minimum per cent loss in weight, increase in TSS and decreased acidity up to 6th day of storage at room temperature.

Bhullar *et al.* (1985) studied the role of pre-harvest calcium application as calcium nitrate in extending the post harvest life of subtropical peach and reported that, calcium nitrate (2 %) recorded highest TSS and organoleptic rating, maximum mean firmness and minimum physiological losses in weight and rotting of fruits under cold storage ($0^0 \pm 3.3^0C$) up to 42 days.

Resnizky and Sive (1991) studied the effect of calcium nitrate sprays for reducing storage disorders in apple and reported that, 1 per cent pre harvest sprays of calcium nitrate treatment delayed the appearance of storage disorders which improved the quality of fruits.

Asrey *et al.* (2004) observed that, in strawberry Cv. Chandler, calcium nitrate (1 %) extended the shelf life and helped in developing quality of ripe fruits in terms of retaining high reducing sugars, and higher vitamin C retention and minimum cumulative physiological loss in weight. They further reported that, reduction in cumulative physiological loss in weight during storage may be due to strengthening of middle lamella and consequently cell wall, which later may have inhibited the free passes of solutes.

2.1.2 Zinc

2.1.2.1 Tropical fruits

Singh and Rajput (1976) reported in mango Cv. Chausa that the foliar spraying of *Zn* (0.8 %) significantly improved the vegetative growth of mango obtained in terms of length of shoot, number of leaves and leaf area per shoot, increased the number of hermaphrodite flowers and fruit set and decreased male flowers.

Physico-chemical composition of fruits were significantly influenced by different concentrations of *Zn*. It was observed that *Zn* (0.8 %) concentration on mango was beneficial to obtain promising results in terms of increasing fresh fruit weight, TSS, reducing sugars, non reducing sugars and ascorbic acid content.

Singh and Chhonkar (1983) reported in guava, Cv. Allahabad Safeda that the pre-harvest foliar sprays of *Zn* (0.2 %) recorded maximum TSS, reducing sugars, pectin content and acidity than boric acid (0.4 %). While, boric acid application (0.4 %) recorded maximum non-reducing sugars and ascorbic acid.

Ghosh (1986) conducted experiment at Regional Research Station, Thargram (W.B.) in guava Cv. L-49. The results showed that, the use of 0.3 per-cent solution of *Zn* and 0.3 percent borax produced highest number of fruits per tree. Boron in combination with Zn increased average fruit weight about 9 percent higher than control.

2.1.2.2 Sub tropical fruits

Awasthi *et al.* (1973) reported in litchi, that the foliar spraying of Zn (0.5 %) increased its content in leaves and decreased fruit drop and registered a significant increase in fruit weight. The decrease in fruit drop as well as increment in fruit weight might be anticipated to increase biosynthesis of IAA in Zn treated plants, which could have raised the endogenous production of the auxin, thereby decreased fruit drop, Zn (0.5 %) sprays were effective in reducing fruit drop, increasing TSS and decreasing total acidity.

Nijjar and Brar (1973) reported in Kinnow mandarin that the foliar application of *Zn* (0.4 %) showed higher Zn content in leaves as compared to soil application and helped in increasing weight and diameter of fruit as well as acidity, TSS and vitamin C as compared to soil application (1 kg/ha.).

Sri Hari *et al.* (1982) reported in lime that the foliar application of *Zn* (0.3 % and 0.6 %) showed increased physical traits and chemical composition of juice. The treatment *Zn* (0.6 %) recorded the maximum fresh fruit weight, diameter of fruit, percentage of juice, TSS, acidity and ascorbic acid content. The plant receiving Zn, produced fruit having 6 percent more juice than control.

Number of seeds increased by zinc treatments. This increased in number of seeds might be responsible for the increase in diameter and weight of the fruits.

Sharma and Dhillon (1983) reported in litchi Cv. Dehradun, that the pre-harvest foliar spray of *Zn* (1.5 %) recorded the lowest number of cracked fruits than other concentrations of *Zn* (0.5 % and 1.0 %) and control. This maintained the quality of fruits by reducing cracking in litchi fruits. It was due to active auxin in the plant, as Zn helped in synthesis of auxin hormone which reduced cracking of fruits.

Langthasa and Bhattacharya (1991) reported that application of 0.4 % *Zn* sprays to Assam lemon recorded highest fruit juice, maximum TSS, total sugar, reducing and non reducing sugar and ascorbic acid content of fruit as compared to control.

Gowardhan (1995) found that, application of Zn + boric acid enhanced the sugar content of sweet orange fruits. Increase in sugar content might be due to increased metabolic and enzymatic processes resulting in the synthesis and accumulation of sugars.

Tayde and Ingle (1999) revealed no significant influence of micronutrient sprays on quality in Nagpur mandarin.

However, consistently bigger sized fruits were obtained with the foliar application with 0.25% Zn. Higher juice and ascorbic acid contain in fruit juice were found to be associated with foliar application of 0.2% Boron. The maximum TSS in fruit juice was found with foliar application of 0.25% Zn.

Ruby Rani and Brahmachari (2001) reported in litchi, that the foliar application of *Zn* (0.5 % and 1 %), borax (0.4 % and 0.8 %) and Ca $(NO3)_2$ (1 % and 2 %) showed great influence on cracking, fruit drop and also on physico-chemical parameters of fruit. Fruit cracking was minimum with borax (0.4 %). This might be due to direct application of boron to the fruit to meet the requirement. Fruit size, fruit weight and pulp weight was greatly increased with *Zn* (1 %), this might be due to Zn involved in hormonal metabolism, increased cell division and expansion of cell. Fruit quality in terms of increasing TSS, total sugars, reducing sugars was maximum with borax (0.4 %), this might be due to rapid mobilization of sugars and other soluble solids to developing fruits.

Zn is involved in the biosynthesis of IAA auxin. Existence of high level of endogenous auxin might have prevented fruit cracking and maintained fruit quality.

Sharma *et al.* (2003) reported in Kagzi lime that, the treatment with *Zn* (0.5 %) showed the significant effect in physico-chemical properties of fruits such as fresh weight, volume, percentage of juice and number of seeds per fruit as well as TSS, acidity and ascorbic acid. Zn might have regulated the semi-permeability of cell walls by which more water would have been mobilized into fruit, thereby increased percentage of juice and volume of seeds and also number of seeds.

Kachave and Bhosale (2007) reported the effect of growth regulators and Zn studied on fifteen year oid kagzi lime orchard treated with NAA (100 and 200 ppm) and GA (50 ppm) and Zn mixture (0.5 %and 1%) singly and in combination. Results revealed that NAA (200 ppm) with Zn (1%) was the best treatment for increasing fruit retention, number of fruits per tree, weight of individual fruit, yield per tree and reducing fruit drop.

2.1.3 Boron

2.1.3.1 Tropical fruits

Rajput *et al.* (1976) reported that, in mango Cv. Langra foliar application of boric acid at various concentrations *viz.,* 0.2, 0.4, 0.6 and 0.8 per cent significantly influenced the growth, flowering, fruiting and fruit quality. However, 0.8 per cent concentration was best in these treatments for obtaining good growth, flowering, fruiting and fruit quality.

Singh *et al.* (1983) reported that, in guava Cv. Lucknow-49, foliar spray of urea (3 %) and boric acid (0.3 %) in combination gave better results with regards to increasing fruit weight, fruit width, TSS and ascorbic acid, than spray of boric acid (0.3 %) alone.

Singh and Chhonkar (1983) reported that, foliar application of boron (0.2 %) recorded more TSS, reducing and non reducing sugars and ascorbic acid than control in guava Cv. Allahabad Safeda. However, zinc gave better results than boron.

Pandey *et al.* (1988) reported that, in Sardar guava, foliar application of borax (0.2 %) gave the maximum fruit weight and beneficial effect on yield and physico-chemical characters of fruits with higher cost benefit ratio.

2.1.3.2 Subtropical fruits

Raval and Leela (1975) reported that, in grapes Cv. Bangalore Blue, berries treated with combination of urea (0.5 %) and boron (0.2 %) were better in quality *viz.,* TSS, reducing and total sugars as compared to boron spray alone at 0.2 and 0.4 per cent.

Rana and Sharma (1979) reported that, in grape Cv. Thompson Seedless vines which were sprayed twice i.e. 1^{st} at pre bloom stage and 2^{nd} after fruit set with 0.025 per cent boron gave highest yield, weight of cluster, volume of cluster, weight of berry, volume of berry, TSS, total and reducing sugars and specific gravity of juice and was followed by the vines sprayed with 0.05 per cent boron.

Sarkar *et al.* (1984) studied the effect of foliar application of mineral elements on cracking of Rose Sented Litchi and reported that, foliar application of boron was the best and significantly effective treatment in reducing fruit drop and fruit cracking with enhanced fruit weight and size and fruit quality, (TSS and total sugars).

Brahmachari *et al.* (1999) studied effect of pre-harvest application of different chemicals on shelf life of litchi Cv. Purbi and reported that, boron spray (0.8 %) exhibited the maximum fruit retention at 9^{th} day of storage and extended the shelf-life of fruits compared to control by reducing physiological loss in weight and decay losses and maintaining various quality parameters.

Ruby Rani and Brahmachari (2001) studied the effect of foliar application of calcium, zinc and boron on cracking and physico-chemical composition of litchi Cv. Purbi and reported that, significantly minimum fruit cracking and increased fruit size, fruit weight, pulp weight were increased and fruit quality in terms of increase in TSS and total sugars but decrease in acidity was also maximum with borax 0.4 per cent.

2.1.4. Magnesium

Bagli *et al.* (1993) studied the effect of foliar application of zinc, magnesium and boron on growth and yield of guava (*Psidium guajava* L.) Cv. Sardar and reported that enhanced physical parameters of fruits i.e. number of fruits per tree and fruit yield per tree.

Singh and Singh (1982) observed that, in guava (*Psidium guajava* L.) Cv. Allahabad Safeda, application of $MgSO_4$ (0.1. 0.2,0.3 and 0.4 %) were effective for promoting physical and chemical attributes of fruits i.e. increasing vitamin C and pectin content.

2.1.5. Water Spray

Upreti and Kumar (1996) studied the effect of mineral nutrient sprays on yield and quality of litchi fruits (*Litchi chinensis* Sonn.) and reported that maximum profit per hectare more than control was earned by spraying water alone. The fruits from water spraying treated were heavier in weight resulting in increasing fruit yield as well as total sugar yield. Thus, water spraying appeared to be more beneficial for obtaining higher yield of good quality litchi fruit Cv. Rose scented. Water spray appeared to have helped in maintaining good turger pressure in the plant organ and provided optimum concentration, so essential for the maintenance of higher rates of metabolic and synthetic activities in leaf and fruit tissues, resulting in the formation of enough edible pulp.

3. MATERIAL AND METHODS

The present investigations entitled,"Studies on micronutrients application on yield and quality of guava under high density planting Cv. Sardar" was carried out at Instructional-Cum-Research Orchard of Department of Horticulture, Central campus, Mahatma Phule Krishi Vidyapeeth, Rahuri during 2012-13.

Geographically, the central campus of Mahatma Phule Krishi Vidyapeeth, Rahuri is located on Ahmednagar-Manmad state Highway No.14. It is situated in the semi-arid zone at 19' -20.973^{0} North latitude and 74'-38.992^{0} East longitude and at an altitude of 541.934 meters above mean sea level. The tract is lying on eastern side of Western Ghats and falls under rain shadow area.

The details of materials used and methods adopted during the present investigations are described in this chapter.

3.1 Experimental details

The experiment was carried out on Ultra High Density Planting guava trees Cv. Sardar during June, 2013 to December, 2013.

1. Year of Start : June, 2012- December, 2013
2. Crop : Guava
3. Variety : Sardar
4. Design : Randomized Block Design
5. Replications : Three
6. Treatments : Ten
7. Number of trees per treatment : Two
8. Spacing : 2 x 2 m .

9. Time of micronutrients: application
   1. At 50 % flowering
   2. One month after 1st spray

3.1.1 Treatment details:

Sr. No.	Treatment	Treatment details
1.	T_1	$Ca(NO_3)_2$ 1 %
2.	T_2	$Ca(NO_3)_2$ 2 %
3.	T_3	$ZnSO_4$ 0.1 %
4	T_4	$ZnSO_4$ 0.2 %
5.	T_5	B 0.3 %
6.	T_6	B 0.4 %
7.	T_7	$MgSO_4$ 0.1 %
8.	T_8	$MgSO_4$ 0.2 %
9.	T_9	water spray
10.	T_{10}	Control

3.1.2 Observations recorded

A. Physical characters

1. Average number of fruits per tree
2. Average weight of fruit (g)
3. Yield per tree (kg)
4. Yield per hectare (tonnes)
5. Equatorial diameter (cm)
6. Polar diameter (cm)

B. Quality characters

Quality parameters were recorded at the time of harvest.

1. TSS (^{0}Brix)
2. Total sugars (%)
3. Reducing sugars (%)
4. Non-reducing sugars (%)
5. Calcium (mg/100g)
6. Ascorbic acid (mg/100g)
7. Pectin (%)
8. Acidity (%)

C. Storage studies

The observations regarding storage studies were recorded on 2nd, 4th, 6th, 8th and 10th day of storage period.

1. Physiological loss in weight (%)
2. General appearance

3.2 Materials

3.2.1 Trees

The experiment was conducted on 4 years old healthy and vigorous plantation. The layout of the experiment is given in Fig.1.

N ↑

R-I	R-II	R-III
T_1	T_4	T_3
T_7	T_{10}	T_7
T_9	T_5	T_4
T_2	T_9	T_6
T_4	T_7	T_9
T_5	T_1	T_2
T_3	T_8	T_{10}
T_8	T_2	T_5
T_{10}	T_6	T_8
T_6	T_3	T_1

Treatments - T_1- Ca $(NO_3)_2$ (1%) , **T_2** -$Ca(NO_3)_2$ (2 %), **T_3**- Zn (0.1%) , **T_4**-Zn (0.2%), **T_5** -B (0.3 %), **T_6** -B (0.4 %), **T_7** -Mg (0.1 %), **T_8**- Mg (0.2 %), **T_9** - (water spray), **T_{10}**- (Control).

Fig.1: Plan of experiment layout

3.2.2 Micronutrients

Analytical grade micronutrients were procured from Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri. Micronutrients as per the treatments i.e. with desired concentrations were sprayed. Complete tree was sprayed till drop with the help of Knapsack Sprayer. First spraying was carried out in 2 August, 2013 and the second spray was given on 3rd Sept 2013.

3.3 Methods

Fruits were harvested in November, 2013 and were analyzed for physico-chemical parameters and shelf life. Five fruits from each treatment unit (tree) were collected and stored at ambient conditions and observations were recorded.

3.3.1 Physical characters

Five fruits from each treatment and from each replication were selected randomly for recording observations on physico-chemical parameters.

a. Average number of fruits per tree

Fruits of each plant under treatment and replication were counted at each harvesting. It was summed up and average number of fruits per tree was computed.

b. Average weight of fruit (g)

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

c. Yield per tree (kg)

The weight of all fruits at each harvest was recorded in kilograms and was summed up for final yield (weight) per ha.

d. Yield per hectare (tonnes)

Total yield per hectare was calculated by multiplying by hectare factor to the yield per tree and yield/ha was computed by,

$$\text{Yield/ha (tonnes)} = \frac{\text{Yield in kg per hectare}}{1000}$$

3.3.2 Quality characters

Five fruits were selected randomly from each unit of the treatment and replication for recording observations. Observations for quality characters were recorded

a. Total soluble solids (^{0}Brix)

The content of total soluble solids in the pulp was measured with the help of Erma Hand Refractrometer (0-32 ^{0}Brix). The observation was recorded at edible maturity stage.

b. Acidity (%)

Acidity was determined by titration with 0.1N sodium hydroxide as described by Ranganna (1986).

A known quantity of solid pulp sample was blended in mortar and pestle with 20-25 ml of distilled water. It was then transferred to 100 ml volumetric flask and filtered. A known volume of aliquot (10 ml) was titrated against 0.1 N sodium hydroxide (NaOH) solution using phenolphthalein as an indicator. The end point is denoted by the appearance of pink colour.

$$\textbf{Acidity} = \frac{\text{Titre x Normality of alkali (0.1 N) x Volume made up x Eq. weight of acid x 100}}{\text{Volume of sample taken for estimation x Volume of sample taken x 1000}}$$

c. Sugars

Total and reducing sugars were estimated by using Lane and Eynon (1960) methods and with modification suggested by Ranganna (1986). A known weight of pulp was blended with distilled water using lead acetate (45 %) for precipitation of extraneous material and potassium oxalate (22 %) to delead the solution. This lead free extract was used to estimate reducing sugars by titrating against standard Fehlings mixture (Fehling A and B in equal proportion) using methylene blue as an indicator to a brick red end point. Total sugars were estimated by the same procedure after acid hydrolysis of an aliquot of de-leaded sample with 3.5 percent hydrochloric acid, followed by neutralization with sodium hydroxide (40 %).

$$\textbf{Total sugars (\%)} = \frac{\text{Factor x Dilution}}{\text{Titre x Volume of juice filtrate}} \times 100$$

$$\textbf{Reducing sugars (\%)} = \frac{\text{Factor x Dilution}}{\text{Titre x Volume of juice filtrate}} \times 100$$

The non-reducing sugars were calculated as difference between total and reducing sugars by using following formula. Non-reducing sugars (%) = Total sugars (%) – Reducing sugars (%).

d. Calcium

Calcium was estimated by using Saini and *et al.* (2006) method. 5- 10 ml of digested aliquat was taken. It was diluted with water and 5 ml NH_4Cl-NH_4OH buffer and 3-4 drops of EBT (Ericrome Black-T indicator) was added in it. Then, it was titrated with EDTA (Ethylene Diamine Tetra Acetate) using 10 ml microburette. Change of colour from red to blue or green marked the end point.

$$\textbf{Ca (mg/100g)} = \frac{\text{ppm} \times \text{dilution}}{10^4}.$$

e. Ascorbic acid

The ascorbic acid was estimated as per the modified procedure of A.O.A.C. (1975). 10 g of pulp was taken and blended with 3 per-cent Meta phosphoric acid. The volume was made 100 ml with 3 per-cent Meta phosphoric acid and it was filtered. 10 ml of aliquat was taken and titrated against 2,6 dichlorophenol indophenol dye solution. The dye was standerdised against the pure vitamin C solution. The ascorbic acid content in terms of mg/100 g of pulp was calculated by multiplying burette reading with 6.756.

f. Pectin

Pectin was estimated by using Saini *et al.* (2006) method. 25 g of the sample was taken in one litre beaker. Then, 400 ml of water was added in it and boiled for one hour. Evaporated water was replaced by addition of distilled water and cooled it. It was transferred to 500 ml volumetric flask. Then, it was filtered through Whatman No. 4 filter. Then, 100 ml of filtrate was taken in two beakers. 300 ml of water was added in it. After that 10 ml of 1N NaOH solution was added in it and kept for night. 50 ml of 1N acetic acid was added in it. Then, 25 ml 1N $CaCl_2$ was added in it and waited for one hour. Then, boiled for one minute and filtered through Whatman No. 4 filter. Then, filter was dried in petri dish in oven. A few drops of silver nitrate solution were added in it. The white precipitates (on filter paper in a petridish) in an oven, dried and weighed again.

$$\textbf{Pectin (mg/100g)} = \frac{\text{Wt. of Ca pectate} \times 100}{\text{Wt. of the sample.}}$$

3.3.3 Storage characters

Ten fruits were randomly selected from each treatment and were kept under ambient conditions for ripening. Observations were recorded at 2 days interval.

a. Physiological loss in weight (PLW) (%)

The initial weight of these fruits was recorded. Observations on weight loss at 2 days interval till non-marketable stage were recorded. The physiological loss in weight of fruits was calculated by subtracting the final weight from the initial weight. The loss in weight was calculated and percentage was worked out.

b. General appearance

The appearance of the fruit was judged by surface colour. Firmness was determined by thumb pressure as firm, firm ripe and soft – ripe. The ripeness was evaluated in terms of optimum or over ripe on the basis of texture, flavour and eating quality of fruits.

3.4 Statistical analysis and interpretation of data

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

4. EXPERIMENTAL RESULTS

The results of the investigation "studies on micronutrients application on yield and quality of guava under high density planting Cv. Sardar are presented in this chapter.

4.1. Yield and yield contributing characters

The data revealed significant differences due to various treatments with respect to average number of fruits per tree, average weight of fruit, yield per tree and yield per hectare. However, non significant differences were recorded is polar and equatorial diameter of the fruit.

Table 1. Effect of different micronutrients on yield and yield contributing characters of guava Cv. Sardar.

Sr. No.	Treatment	Average number of fruits per tree	Average weight of fruit (g)	Yield per tree (kg)	Yield per ha (t)	Equatorial diameter of fruit (cm)	Polar diameter of fruit (cm)
T_1	$Ca(NO_3)_2$ (1%)	101.67	218.87	22.25	55.63	7.83	9.33
T_2	$Ca(NO_3)_2$ (2%)	98.77	216.87	21.43	53.59	7.88	9.21
T_3	$ZnSO_4$ (0.1%)	83.00	194.57	16.16	40.41	7.50	8.88
T_4	$ZnSO_4$ (0.2%)	87.93	199.93	17.56	43.89	7.60	7.95
T_5	Boron (0.3%)	90.67	205.73	18.64	46.59	7.68	8.07
T_6	Boron (0.4%)	87.67	218.47	19.18	47.94	7.88	8.14
T_7	$MgSo_4$ (0.1%)	88.33	198.23	17.49	43.73	7.33	7.92
T_8	$MgSo_4$ (0.2%	93.67	212.47	19.87	49.68	7.70	7.40
T_9	Water Spray	71.67	185.60	13.29	33.22	7.36	6.97
T_{10}	Control	67.03	174.17	11.70	29.24	7.25	6.80
	S.E. ±	3.86	9.22	1.10	2.75	0.25	0.23
	CD at 5 %	11.47	27.39	3.27	8.17	N.S.	N.S.

4.1.1. Average number of fruits per tree

The data presented in Table 1, with respect to average number of fruit per tree revealed that the maximum number of fruit per tree (101.67) was recorded in the treatment T_1 [Ca $(NO_3)_2$ (1%)] and was at par with T_2 [Ca $(NO_3)_2$ (2%)] (98.77). Treatments T_8 [$MgSO_4$ (0.2%)] (93.67), T_5 [Boron (0.3%)] (90.67), T_7 [$MgSO_4$ (0.1%)] (88.33), T_4 [$ZnSO_4$ (0.2%)] (87.93), T_6 [Boron (0.4%)] (87.67) and T_3 [$ZnSO_4$ (0.1%)] (83.00) were at par with each other. While the minimum number of fruit (67.03) was observed in the treatment T_{10} (Control) and was at par with the treatment T_9 (Water Spray) (71.67).

4.1.2. Average weight of fruit (g)

The data pertaining to average weight of fruit are presented in Table 1. The maximum weight of fruit (218.87 g) was recorded in the treatment T_1 [Ca $(NO_3)_2$ (1%)] followed by the treatment T_6 [Boron (0.4%)] (218.47 g). While treatments T_2 [Ca $(NO_3)_2$ (2%)] (216.87 g), T_8 [$MgSO_4$ (0.2%)] (212.47 g) and T_5 [Boron (0.3%)] (205.73 g) were at par with each other. Whereas, the minimum weight of fruit (174.17 g) was observed in the treatment T_{10} (Control) followed by the treatment T_9 (Water Spray) 185.60 g. The treatments T_3 [$ZnSO_4$ (0.1%)] (194.57 g), T_7 [$MgSO_4$ (0.1%)] (198.23 g) and T_4 [$ZnSO_4$ (0.2%)] (199.93 g) were at par with each other.

4.1.3. Yield per tree (kg)

With respect to yield per tree revealed that the maximum yield of fruits per tree (22.25 kg) was recorded in the treatment T_1 [Ca $(NO_3)_2$ (1%)] followed by the treatment T_2 [Ca $(NO_3)_2$ (2%)] (21.43 kg) and were at par with each other. The treatments T_8 [$MgSO_4$ (0.2%)] (19.87 kg), T_6 [Boron (0.4%)]

(19.18 kg), T_5 [Boron (0.3%)] (18.64 kg), T_4 [$ZnSO_4$ (0.2%)] (17.56 kg), T_7 [$MgSO_4$ (0.1%)] (17.49 kg) and T_3 [$ZnSO_4$ (0.1%)] (16.16 kg) were at par with each other. The minimum yield of fruits per tree (11.70 kg) was recorded in the treatment T_{10} (Control) and was at par with the treatment T_9 (Water Spray) (13.21 kg).

4.1.4. Yield per hectare (tonnes)

The data on yield per hectare is presented in Table 1. Significantly highest fruit yield was recorded in the treatment T_1 [Ca $(NO_3)_2$ (1%)] (55.63 t) which was at par with the treatment T_2 [Ca $(NO_3)_2$ (2%)] (53.59 t). While the treatments T_6 [Boron (0.4%)] (47.94 t), T_5 [Boron (0.3%)] (46.59 t), T_4 [$ZnSO_4$ (0.2%)] (43.89 t), T_7 [$MgSO_4$ (0.1%)] (43.73 t) and T_3 [$ZnSO_4$ (0.1%)] (40.41 t) were at par each other. The minimum yield per hectare (29.24 t) was recorded in the treatment T_{10} (Control) and was at par with the treatment T_9 (Water Spray) (33.32 t).

4.1.5. Equatorial diameter of fruit (cm)

The observations on equatorial diameter are presented in Table 1. The data revealed that, there were no significant difference regarding the equatorial diameter. However, the maximum diameter (7.88 cm) was recorded in the treatment T_2 [Ca $(NO_3)_2$ (2%)] followed by the treatments T_6 [Boron (0.4%)] (7.88 cm), T_1 [Ca $(NO_3)_2$ (1%)] (7.83 cm), T_8 [$MgSO_4$ (0.2%)] (7.70 cm), T_5 [Boron (0.3%)] (7.68 cm), T_4 [$ZnSO_4$ (0.2%)] (7.60 cm), T_3 [$ZnSO_4$ (0.1%)] (7.50 cm), T_9 [Water Spray] (7.37 cm) and T_7 [$MgSO_4$ (0.1%)] (7.33 cm). Whereas, the minimum diameter (7.25 cm) was recorded in treatment T_{10} (Control).

4.1.6. Polar diameter of fruit (cm)

The observations on polar diameter are presented in Table 1. The data revealed that, there was no significant difference regarding the polar diameter. However, the maximum diameter (9.33) was recorded in the treatment T_1 [Ca $(NO_3)_2$ (1%)] followed by the treatments *viz;* T_2 [Ca $(NO_3)_2$ (2%)] (9.21 cm), T_3 [$ZnSO_4$ (0.1%)] (8.88 cm), T_6 [Boron (0.4%)] (8.14 cm), T_5 [Boron (0.3%)] (8.07 cm), T_4 [$ZnSO_4$ (0.2%)] (7.95 cm), T_7 [$MgSO_4$ (0.1%)] (7.92 cm), T_8 [$MgSO_4$ (0.2%)] (7.40 cm), and T_9 [Water Spray] (6.97 cm). The minimum diameter (6.80 cm) was recorded in treatment T_{10} (Control).

4.2. Quality characters

The observation on quality parameters namely TSS, total sugars, reducing sugars, non reducing sugars, calcium content, ascorbic acid, pectin content and acidity are presented in Table 2.

4.2.1. Total soluble solids (^{0}Brix)

The observations on TSS of guava pulp at ripe stage are presented in Table 2.

Table 2. Effect of different micronutrients on quality characters of guava Cv. Sardar

Sr. No.	Treatment	TSS (^{0}Brix)	Total Sugars (%)	Reducing Sugars (%)	Non reducing Sugars (%)
T_1	Ca $(NO_3)_2$ (1%)	11.56	7.62	5.16	3.67
T_2	Ca $(NO_3)_2$ (2%)	11.28	7.60	4.46	3.63
T_3	$ZnSO_4$ (0.1%)	10.04	7.10	4.43	2.85
T_4	$ZnSO_4$ (0.2%)	10.21	7.14	4.02	2.93
T_5	Boron (0.3%)	10.47	6.00	3.81	2.74
T_6	Boron (0.4%)	11.30	6.54	4.44	2.87
T_7	$MgSO_4$ (0.1%)	11.72	7.81	4.54	3.96
T_8	$MgSO_4$ (0.2%)	11.66	7.50	5.95	2.90
T_9	Water Spray	11.42	6.65	5.95	0.70
T_{10}	Control	10.42	6.45	5.34	1.02
	S.E. $\pm$	0.30	0.36	0.11	0.10
	CD at 5 %	0.87	1.06	0.34	0.31

Table 3. Effect of different micronutrients on quality characters of guava Cv. Sardar

Sr. No.	Treatment	Calcium (Ca) mg/100g	Ascorbic acid mg/100g	Pectin (%)	Acidity (%)
T_1	$Ca(NO_3)_2$ (1%)	3.85	205.53	0.64	0.51
T_2	$Ca(NO_3)_2$ (2%)	3.81	203.12	0.59	0.50
T_3	$ZnSO_4$ (0.1%)	2.68	202.63	0.48	0.62
T_4	$ZnSO_4$ (0.2%)	2.54	207.13	0.50	0.61
T_5	Boron (0.3%)	2.86	206.48	0.57	0.57
T_6	Boron (0.4%)	2.74	207.10	0.55	0.55
T_7	$MgSO_4$ (0.1%)	3.09	212.98	0.60	0.57
T_8	$MgSO_4$ (0.2%)	2.86	200.93	0.60	0.48
T_9	Water Spray	2.70	199.94	0.48	0.65
T_{10}	Control	2.43	197.96	0.49	0.64
	S.E. $\pm$	0.09	2.17	0.02	0.01
	CD at 5 %	0.28	6.44	0.05	0.04

The data presented in Table 2, with respect to TSS revealed that, the maximum TSS (11.72) was recorded in the treatment T_7 [$MgSO_4$ (0.1%)] and was at par with the treatments T_8 [$MgSO_4$ (0.2%)] (11.66), T_1 [$Ca(NO_3)_2$ (1%)] (11.56), T_9 [Water Spray] (11.42), T_6 [Boron (0.4%)] (11.30) and T_2 [$Ca(NO_3)_2$ (2%)] (11.28). whereas, the treatments T_5 [Boron

(0.3%)] (10.47), T_{10} (Control) (10.42), and T_4 [$ZnSO_4$ (0.2%)] (10.21) were at par with each other. The minimum TSS (10.04) was recorded in the treatment T_3 [$ZnSO_4$ (0.1%)].

4.2.3. Total sugars (%)

The data presented in Table 2, with respect to total sugars revealed that, the maximum total sugars (7.81) was recorded in the treatment T_7 [$MgSO_4$ (0.1%)] and was at par with the treatments T_1 [Ca $(NO_3)_2$ (1%)] (7.62), T_2 [Ca $(NO_3)_2$ (2%)] (7.60), T_8 [$MgSO_4$ (0.2%)] (7.50), T_4 [$ZnSO_4$ (0.2%)] (7.14) and T_3 [$ZnSO_4$ (0.1%)] (7.10). The minimum total sugar (6.00) was observed in the treatment T_5 [Boron (0.3%)]. The treatments T_{10} (Control) (6.45), T_6 [Boron (0.4%)] (6.54) and T_9 (Water Spray) (6.65) were at par with each other.

4.2.4. Reducing sugars (%)

The data presented in Table 2, with respect to reducing sugars revealed that, the maximum reducing sugars (6.09) was recorded in the treatment T_9 (Water Spray) was at par with the treatment T_8 [$MgSO_4$ (0.2%)] (5.95). The treatment T_{10} (Control) (5.34) was at par with T_1 [Ca $(NO_3)_2$ (1%)] (5.16). While treatments T_7 [$MgSO_4$ (0.1%)] (4.54), T_2 [Ca $(NO_3)_2$ (2%)] (4.46), T_6 [Boron (0.4%)] (4.44) and T_3 [$ZnSO_4$ (0.1%)] (4.43) were at par with each other. Whereas, the minimum reducing sugar (3.81) was observed in the treatment T_5 [Boron (0.3%)] and was at par with the treatment T_4 [$ZnSO_4$ (0.2%)] (4.02).

4.2.5. Non reducing sugars (%)

The observations on non reducing sugars are presented in Table 2. The data revealed that, the maximum non reducing sugars (3.96) was recorded in the treatment T_7 [$MgSO_4$ (0.1%)]

followed by treatments T_1 [Ca $(NO_3)_2$ (1%)] (3.67), T_2 [Ca $(NO_3)_2$ (2%)] (3.63) were at par with each other. The treatments T_4 [$ZnSO_4$ (0.2%)] (2.93), T_8 [$MgSO_4$ (0.2%)] (2.90), T_6 [Boron (0.4%)] (2.87), T_3 [$ZnSO_4$ (0.1%)] (2.85) and T_5 [Boron (0.3%)] (2.74) were at par with each other. Whereas, the minimum non reducing sugar in (1.95) was recorded in the treatment T_{10} (Control) and was at par with the treatment T_9 (Water Spray) (2.30).

4.2.5. Calcium (mg/100g pulp)

The data presented in Table 2, with respect to calcium revealed that, the maximum calcium (3.85) was recorded in the treatment T_1 [Ca $(NO_3)_2$ (1%)] and was at par with the treatment T_2 [Ca $(NO_3)_2$ (2%)] (3.81). The treatments T_7 [$MgSO_4$ (0.1%)] (3.09), T_5 [Boron (0.3%)] (2.86), and T_6 [Boron (0.4%)] (2.74) were at par with each other. While the minimum calcium (2.43) was recorded in the treatment T_{10} (Control) followed by the treatment T_4 [$ZnSO_4$ (0.2%)] (2.54). Whereas, T_3 [$ZnSO_4$ (0.1%)] (2.68) and T_9 (Water Spray) (2.70) were at par with each other.

4.2.6. Ascorbic acid (mg/100g pulp)

The data presented in Table 2, with respect to ascorbic acid revealed that, the maximum ascorbic acid (212.98) was recorded in the treatment T_7 [$MgSO_4$ (0.1%)] followed by the treatments T_4 [$ZnSO_4$ (0.2%)] (207.13), T_6 [Boron (0.4%)] (207.10), T_5 [Boron (0.3%)] (206.48) and T_1 [Ca $(NO_3)_2$(1%)] (205.53) were at par with each other. The minimum ascorbic acid (197.96) was recorded in the treatment T_{10} (Control) which is followed by the treatment T_9 (Water Spray) (199.94). While treatments T_8 [$MgSO_4$ (0.2%)] 200.93, T_3 [$ZnSO_4$ (0.1%)]

202.63 and T_2 [Ca $(NO_3)_2$ (2%) 203.12 were at par with each other.

4.2.7. Pectin (%)

The data presented in Table 2, with respect to pectin, revealed that, the maximum pectin (0.64) was recorded in the treatment T_1 [Ca $(NO_3)_2$ (1%)] and was at par with the treatment T_8 [$MgSO_4$ (0.2%)] (0.60). While treatments T_7 [$MgSO_4$ (0.1%)] (0.60), T_2 [Ca $(NO_3)_2$ (2%)] (0.59), T_5 [Boron (0.3%)] (0.57) and T_6 [Boron (0.4%)] (0.55) were recorded at par with each other. Whereas, the minimum pectin (0.48) was recorded in the treatment T_9 (Water Spray) followed by treatment T_3 [$ZnSO_4$ (0.1%)] (0.48). The treatment T_{10} (Control) (0.49), and T_4 [$ZnSO_4$ (0.2%)] (0.50) were recorded at par with each other.

4.2.8. Acidity (%)

The data presented in Table 2, with respect to acidity revealed that, the maximum acidity in (0.65) was recorded in the treatment T_9 (Water Spray) followed by treatments T_{10} (Control) (0.64), T_3 [$ZnSO_4$ (0.1%)] (0.62), and T_4 [$ZnSO_4$ (0.2%)] (0.61) were recorded at par with each other. The treatments T_7 [$MgSO_4$ (0.1%)] (0.57), T_5 [Boron (0.3%)] (0.57) and T_6 [Boron (0.4%)] (0.55) were at par with each other. While the minimum acidity in (0.48) was recorded in the treatment T_8 [$MgSO_4$ (0.2%)] followed by treatments T_2 [Ca $(NO_3)_2$ (2%)] (0.50) and T_1 [Ca $(NO_3)_2$ (1%)] (0.51). Treatments T_8 [$MgSO_4$ (0.2%)], T_2 [Ca $(NO_3)_2$ (2%)] (0.50) and T_1 [Ca $(NO_3)_2$ (1%)] (0.51) were observed at par with each other.

4.3. Storage parameters

4.3.1. Physiological loss in weight (%)

Physiological loss in weight of fruits, stored at ambient conditions was calculated by substracting final weight from initial weight and it is expressed in percentage. The data relating to PLW was recorded at 2 days interval of storage and is presented in Table 4.

Table 4. Effect of different micronutrients on storage characters of guava Cv. Sardar (PLW)

Sr. No.	Treatment	2 Days	4 Days	6 Days	8 Days	10 Days
T_1	Ca $(NO_3)_2$ ((1%)	4.01	7.42	10.92	15.41	17.53
T_2	Ca $(NO_3)_2$ (2%)	3.72	6.41	10.85	15.05	16.41
T_3	$ZnSO_4$ (0.1%)	3.50	7.35	15.89	21.59	-
T_4	$ZnSO_4$ (0.2%)	3.75	7.23	15.94	21.61	-
T_5	Boron (0.3%)	5.50	10.48	15.82	21.31	-
T_6	Boron (0.4%)	5.86	10.95	14.97	19.17	
T_7	$MgSO_4$ (0.1%)	4.27	9.84	13.85	15.99	
T_8	$MgSO_4$ (0.2%)	4.70	9.92	14.41	18.96	22.26
T_9	Water Spray	5.75	11.40	17.42	-	-
T_{10}	Control	6.22	12.89	19.08	-	-

	S.E. ±	0.13	0.23	0.43	0.16	0.01
	CD at 5 %	0.39	0.68	1.28	0.47	0.05

At 2nd day of storage the minimum PLW (3.50) was observed in treatment T_3 [$ZnSO_4$ (0.1%)] and was followed by treatment T2 [Ca $(NO_3)_2$ (2%)] (3.72). Whereas, treatments T_3 [$ZnSO_4$ (0.1%)], T_2 [Ca $(NO_3)_2$ (2%)] and T_4 [$ZnSO_4$ (0.2%)] were at par with each other. Treatment T_1 [Ca $(NO_3)_2$ (1%)] (4.01) was at par with treatment T_7 [$MgSO_4$ (0.1%)] (4.27) and T_8 [$MgSO_4$ (0.2%)] (4.70). The treatments T_5 [Boron (0.3%)] (5.50), T_9 (Water Spray) (5.75) and T_6 [Boron (0.4%)] (5.86) were at par with each others. While the maximum PLW was recorded in treatment T_{10} (Control) (6.22).

At 4th day of storage the significantly minimum PLW (6.41) was recorded in the treatment T2 [Ca $(NO_3)_2$ (2%)] followed by the treatment T_4 [$ZnSO_4$ (0.2%)] (7.23). Whereas, treatments T_3 [$ZnSO_4$ (0.1%)] (7.35) and T_1 [Ca $(NO_3)_2$ (1%)] (7.42) were at par with each other. Treatments with respective value of PLW T_7 [$MgSO_4$ (0.1%)] (9.84), T_8 [$MgSO_4$ (0.2%)] (9.92) and T_5 [Boron (0.3%)] (10.48) were at par with each other. While treatment T_6 [Boron (0.4%)] (10.95) and was at par with the treatment T_9 (Water Spray) (11.40). The maximum PLW was recorded in the treatment T_{10} (Control) (12.89).

On the 6th day of storage the fruit from the treatments T_{10} (Control) and T_9 (Water Spray) were not of marketable quality. Among the various treatments the minimum PLW in (10.85) was recorded in the treatment T2 [Ca $(NO_3)_2$ (2%)] and was at par with the treatment T1 [Ca $(NO_3)_2$ (1%)] (10.92). While treatments T_7 [$MgSO_4$ (0.1%)] (13.85), T_8 [$MgSO_4$ (0.2%)]

(14.41) and T_6 [Boron (0.4%)] (14.94) were at par with each other. The maximum PLW was recorded in the treatment T_4 [$ZnSO_4$ (0.2%)] (15.94) and was at par with the treatments T_3 [$ZnSO_4$ (0.1%)] (15.89) andT_5 [Boron (0.3%)] (15.82).

At 8th day of storage the minimum PLW (15.05) was recorded in the treatment T2 [Ca $(NO_3)_2$ (2%)] and was at par with the treatment T1 [Ca $(NO_3)_2$ (1%)] (15.41), it was followed by the treatment T_7 [$MgSO_4$ (0.1%)] (15.99). The treatment T_8 [$MgSO_4$ (0.2%)] (18.96) was at par with the treatment T_6 [Boron (0.4%)] (19.17). Whereas, the maximum PLW was recorded in the treatment T_4 [$ZnSO_4$ (0.2%)] (21.61) and was followed by treatment T_3 [$ZnSO_4$ (0.1%)] (21.59). While treatments T_4 [$ZnSO_4$ (0.2%)], (21.31). T_3 [$ZnSO_4$ (0.1%)] (21.59) and T_5 [Boron (0.3%)] (21.31)were at par with each other.

At 10th day of storage studies on weight basis data observations was possible only in treatments T2 [Ca $(NO_3)_2$ (2%)] (16.41), T1 [Ca $(NO_3)_2$ (1%)] (17.53) and in T_8 [$MgSO_4$ (0.2%)] (22.26). The maximum PLW (22.26) was recorded in treatment T_8 [$MgSO_4$ (0.2%)] and it was the minimum (16.41) in the treatment T2 [Ca $(NO_3)_2$ (2%)].

4.3.2. General appearance

The general appearance of fruit was evaluated at 2 days interval. The effect of various treatments on general appearance of fruit is presented in Table 5 and depicted Plates 1 to 6.

Table 5. Effect of different micronutrients on general appearance of guava Cv. Sardar

Sr.No.	Treat.	Storage period (Days)				
		2	4	6	8	10
T_1	Ca $(NO_3)_2$ (1%)	Green, moderately firm	Light green, edible firm ripe	Yellowish green, optimum ripe, soft	Yellow, optimum ripe, soft	Yellow, fully ripe, soft
T_2	Ca $(NO_3)_2$ (2%)	Green, moderately firm	Light green, edible firm ripe	Yellowish green, optimum ripe, soft	Yellow, optimum ripe, soft	Yellow, fully ripe, soft
T_3	$ZnSO_4$ (0.1%)	Light green, moderately firm	Yellowish green, edible firm ripe	Light yellow, optimum ripe, soft	Unattractive, yellow, fully ripe, very soft	-
T_4	$ZnSO_4$ (0.2%)	Light green, moderately firm	Yellowish green, edible firm ripe	Light yellow, optimum ripe, soft	Unattractive, yellow, fully ripe, very soft	-
T_5	Boron (0.3%)	Attractive green, moderately firm	Light green, edible firm ripe	Light yellow, optimum ripe, soft	Unattractive, yellow, fully ripe, very soft	-
T_7	$MgSO_4$ (0.1%)	Green, moderately firm	Green, edible firm ripe	Attractive light yellowish green, optimum ripe, soft	Attractive, yellow, fully ripe, Soft	Unattractive, yellow, fully ripe, very soft
T_8	$MgSO_4$ (0.2%)	Green, moderately firm	Green, edible firm ripe	Attractive light yellowish green, optimum ripe, soft	Attractive, yellow, fully ripe, Soft	Unattractive, yellow, fully ripe, very soft
T_9	Water Spray	Yellowish green, optimum ripe, soft	Unattractive, yellow, fully ripe, very soft	-	-	-

5. DISCUSSION

The results of the field experiment conducted during June, 2013 to December, 2013 to study the "Studies on micronutrients application on yield and quality of guava under high density planting Cv. *Sardar*" are discussed in this chapter.

5.1. Yield and yield contributing parameters

Yield contributing parameters *viz.,* average number of fruit, average weight of fruit, yield per tree and yield per hectare are discussed under this heading.

5.1.1. Average number of fruit per tree:

The maximum number of fruit per tree (101.67) was recorded in the treatment T_1 [Ca $(NO_3)_2$ (1%)] and was at par with T_2 [Ca $(NO_3)_2$ (2%)] (98.77) (Table 1). While the minimum number of fruit (67.03) was observed in the treatment T_{10} (Control) and was at par with the treatment T_9 (Water Spray) (71.67). These results are in agreement with results of Nakasone and Paull (1998). This might be due to the effect of foliar application of calcium as a micronutrient during transition (period I) and fruit setting (continued for 45 days after anthesis) growth and development stages (simple sigmoid curve) of guava.

5.1.2. Average weight of fruit (g)

The maximum weight of fruit (218.87) was recorded in the treatment T_1 [Ca $(NO_3)_2$ (1%)] followed by the treatment T_6 [Boron (0.4%)] (218.47). Whereas, the minimum weight of fruit

(174.17) was observed in the treatment T_{10} (Control) followed by the treatment T_9 (Water Spray) (185.60). Increase in weight with calcium might be due to enhanced absorption of water and mobilization of sugar in expanded cell and increased volume of intercellular space in the pulp as reported by Rani and Brahmachari (2001).

5.1.3. Yield per tree (kg) and yield per hectare (tonnes)

Yield is the product of average number of fruits per tree and average weight of fruit of the tree. The maximum yield of fruit per tree (22.25 Kg), yield per hectare (55.63 t) respectively (22.25), (55.63) was recorded in the treatment T_1 [Ca $(NO_3)_2$ (1%)] followed by the treatment T_2 [Ca $(NO_3)_2$ (2%)] respectively (21.43) (53.59) and were at par with each other. These results are in agreement with results of Wali *et al* (2006). The increased fruit size (length and diameter) as the yield contributing parameters might be due to supply of nutrients in available form. While the minimum yield of fruit per tree (Kg), yield per hectare (t) respectively (11.70), (29.24) was recorded in the treatment T_{10} (Control) and was at par with the treatment T_9 (Water Spray) respectively (13.29), (33.22). This might be due to less supply of nutrients in available form during transition (growth period I) and fruit setting (continued 45 days after anthesis, (growth period I). Wali *et al* (2006).

5.1.4. Equatorial diameter of fruit (cm) and polar diameter of fruit (cm)

There were no significant differences regarding the equatorial diameter and polar diameter of fruit. However, the maximum equatorial diameter, polar diameter of fruit respectively (7.88), (9.33) was recorded in the treatment T_2

[Ca $(NO_3)_2$ (2%)], T_1 [Ca $(NO_3)_2$ (1%)]. Whereas, the minimum equatorial diameter, polar diameter respectively (7.25), (6.80) were recorded in treatment T_{10} (Control). The supply of calcium salts increases the equatorial diameters and polar diameters of fruit it might be due to application of calcium which attributed to more Ca in fruit and increased the fruit size as length and diameter by increasing the cell density in the cortex area of fruit as reported by Singh and Rajput (1991), Rani and Brahmachari (2004) in mango.

5.2. Quality characters:

The observation on quality parameters namely TSS, total sugars, reducing sugars, non reducing sugars, calcium content, ascorbic acid, pectin content and acidity are presented in Table 2.

5.2.1. Total soluble solids (^{0}Brix)

The maximum TSS (11.72) was recorded in the treatment T_7 [$MgSO_4$ (0.1%)] followed by treatment T_8 [$MgSO_4$ (0.2%)] (11.66). This might have been due to magnesium being an integral part of the chlorophyll, resulting in increased photosynthetic rate of treated plants and thus increased the various soluble solids of the fruits (Singh and Singh, 1982). While the minimum TSS (10.04) was recorded in the treatment T_3 [$ZnSO_4$ (0.1%)] followed by treatment T_4 [$ZnSO_4$ (0.2%)] this might be due low photosynthetic activity in the chlorophyll.

5.2.2. Total sugars (%) and non reducing sugars (%)

The maximum total sugars, non reducing sugars respectively (7.81), (3.96) were recorded in the same treatment T_7 [$MgSO_4$ (0.1%)] followed by treatment T_1 [Ca $(NO_3)_2$ (1%)]

respectively (7.62), (3.67) this might be due to activation of the various metabolic processes particularly carbohydrates and phosphorus metabolism. The role of magnesium as an activator of a number of enzymes including transphosphorylases (7), dehydrogenases and carboxylases which might have enhanced the various metabolites of the fruits (Singh and Singh, 1982). While the minimum total sugar, non reducing sugar (6.00), (1.95) respectively were observed in the treatment T_5 [Boron (0.3%)], T_{10} [control] respectively.

5.2.3. Reducing sugars (%)

The maximum reducing sugars (6.09) was recorded in the treatment T_9 (Water Spray) was at par with the treatment T_8 [$MgSO_4$ (0.2%)] (5.95) this might be due to water spray appeared to have helped in maintaining good turger pressure in the plant organ and provided optimum concentration, so essential for the maintenance of higher rates of metabolic and synthetic activities in leaf and fruit tissues, resulting in the formation of enough edible pulp (reducing sugar) (Upreti and Kumar, 1996.). Whereas, the minimum reducing sugar (3.81) was observed in the treatment T_5 [Boron (0.3%)] and was at par with the treatment T_4 [$ZnSO_4$ (0.2%)] (4.02).

5.2.4. Calcium (mg/100g pulp)

The maximum calcium (3.85) was recorded in the treatment T_1 [$Ca(NO_3)_2$ (1%)] and was at par with the treatment T_2 [$Ca(NO_3)_2$ (2%)] (3.81) this might due deposition of added Ca in the peel and pulp as reported by (Ramakrishna *et al,* 2001). While the minimum calcium (2.43) was recorded in the treatment T_{10} (Control) followed by the treatment T_4 [$ZnSO_4$ (0.2%)] (2.54).

5.2.5. Ascorbic acid (mg/100g pulp)

The maximum ascorbic acid (212.98) was recorded in the treatment T_7 [$MgSO_4$ (0.1%)] followed by the treatments T_4 [$ZnSO_4$ (0.2%)] (207.13). This might be due to magnesium sulphate was most effective in promoting physical, chemical different sugar fractions and vitamin C (Ascorbic acid)attributes of fruit (Singh and Singh, 1982.). The minimum ascorbic acid (197.96) was recorded in the treatment T_{10} (Control) followed by the treatment T_9 (Water Spray) (199.94).

5.2.6. Pectin (%)

The maximum pectin (0.64) was recorded in the treatment T_1 [Ca $(NO_3)_2$ (1%)] and was at par with the treatment T_8 [$MgSO_4$ (0.2%)] (0.60) this might be due to increased pectin retention in calcium guava fruits (Chandra *et al,* 1994). Whereas, the minimum pectin (0.48) was recorded in the treatment T_9 (Water Spray) followed by treatment T_3 [$ZnSO_4$ (0.1%)] (0.48).

5.2.7. Acidity (%)

The maximum acidity in (0.65) was recorded in the treatment T_9 (Water Spray) followed by treatments T_{10} (Control) (0.64) similar results are observed in the findings of (Jayachandran *et al*, 2005). While the minimum acidity (0.48) was recorded in the treatment T_8 [$MgSO_4$ (0.2%)] followed by treatments T_2 [Ca $(NO_3)_2$ (2%)] (0.50) and T_1 [Ca $(NO_3)_2$ (1%)] (0.51).

5.3. Storage parameters

Biochemical changes in fruits after harvest are continuous and lead to fruit softening and spoilage. If these changes could be reduced to certain degree, the storage life of fresh fruits can be effectively increased and spoilage can be reduced. It is evident that, earlier application of micronutrients resulted in better tomorrow i.e. increasing the shelf life of fruit.

The data relating to physiological loss in weight, general appearance was recorded at 2 days interval of storage.

The minimum PLW (16.41) throughout the storage period was recorded in T_2 [Ca $(NO_3)_2$ (2%)]. The PLW was less in calcium treated fruits. The application of calcium salts showed beneficial effect on post-harvest life of fruits.

Application of calcium salts like Ca $(NO_3)_2$ might have helped in higher retention of firmness. Pre-harvest treatments might have added Ca in peel and pulp. This might be responsible to increase firmness and maintain structure and function of cell wall leading to enhancing the shelf life (Ramkrishna *et al.* 2001).

Delayed ripening of fruits with calcium due to its role in reducing enzymatic activities was reported by Sharma *et al.* (1996). Singh *et al.* (1987) reported that, calcium application controlled the disintegration of mitochondria, endoplasmic reticulum and cytoplasmic membrane and thus helped in retarding the respiration rate, leading to increase in shelf-life.

Pre-harvest application of calcium salts or compound on various fruits recorded minimum physiological loss in weight with reduced rate of respiration and enzymatic activities and thus helped in improving shelf life as reported by Singh *et al.* (1987) and Singh *et al.* (1993) in mango, Bhanja and Lenka (1994) in sapota and Ramkrishna *et al.* (2001) in papaya.

The general appearance of fruits was better in the treatments T_1 and T_2 (i.e. attractive, green and optimum firmness ripe) than other treatments. It is in accordance with Singh *et al.* (1993) who reported that, calcium treated fruits exhibited a reduced rate of respiration at harvest and during storage which prolonged the shelf life by improving general appearance.

The general appearance of fruits was better in calcium treated fruits which increased the marketing value. This is in accordance with Singh *et al.* (1993) in mango and Lakshmana and Reddy (1999) in sapota.

It was observed that, fruit were fully ripe on 4^{th} day in control and on 6^{th} day of storage in other treatments. The loss in weight of harvested fruits till full ripening is reported by many workers. The maximum PLW (19.08) on 6^{th} day was recorded in T_8 (control) and it was the minimum (10.85 %) in T2 [Ca $(NO_3)_2$ (2%)]. The minimum PLW (15.01 %) was recorded in T2 [Ca $(NO_3)_2$ (2%)] and the maximum (21.61 %) was recorded in T_4 [($ZnSO_4$ (0.2%)] for 8^{th} day of storage.
The minimum PLW (16.41 %) was recorded in T2 [Ca $(NO_3)_2$ (2%)] and the maximum PLW (22.26 %) was recorded in T_8 [$MgSO_4$ (0.2%)] for 10^{th} day of storage. This indicated that, in minimizing PLW and increasing shelf life calcium plays an important role.

6. SUMMARY AND CONCLUSION

6.1. Summary

The present investigation entitled, "Studies on micronutrients application on yield and quality of guava under high density planting Cv. Sardar" was carried out at Instructional Cum-Research Orchard, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth., Rahuri during June, 2013- December, 2013.

The field experiment was laid out in Randomized Block Design with ten treatments with three replications. Application of micronutrients viz. [$Ca(NO_3)_2$ (1%)], [$Ca(NO_3)_2$ (2%)], [Zn (0.1%)], [Zn (0.2%)], [B (0.3%)], [B (0.4%)], [Mg (0.1%)], [Mg (0.2%)] and Water Spray was carried out at 50 % flowering and one month after first spray.

Fruits were harvested in November, 2013 and were analyzed for physico-chemical parameters and shelf life. Five fruits from each treatment unit (tree) were collected and stored at ambient conditions and observations were recorded.

The results obtained with respect of yield and yield contributing parameters, quality parameters and storage analysis are summarized as below.

6.1.1. Yield and yield contributing parameters

The data revealed significant differences due to various treatments with respect to average number of fruits per tree, average weight of fruit, yield per tree and yield per hectare.

However, non significant differences were recorded is polar and equatorial diameter of the fruit.

The treatment T_1 [Ca $(NO_3)_2$ (1%)] recorded maximum number of fruit per tree (101.67), average weight of fruit (218.87 g), yield of fruits per tree (22.25 kg) and per ha (55.63 tonnes), polar diameter of fruit (9.33 cm) and maximum equatorial diameter (7.88 cm) was recorded in the treatment T_2 [Ca $(NO_3)_2$ (2%)].

The minimum numbers of fruit per tree (67.03), average weight of fruit (174.17g), yield of fruits per tree (11.70 kg) and per ha. (29.24 tonnes), equatorial diameter of fruit (7.25 cm) and polar diameter of fruit (6.80 cm) were recorded in T_{10} i.e. control.

6.1.2. Quality parameters

Different quality parameters like TSS, acidity, total sugars, reducing sugars and non-reducing sugars were influenced due to various treatments.

The statistically significant differences with respect to TSS, total sugars, reducing sugars, non- reducing sugars, calcium, ascorbic acid, pectin content and acidity were recorded.

The maximum TSS (11.72^{0}Brix), total sugars (7.81 %), non-reducing sugars (3.96 %) and the ascorbic acid (212.98mg/100g) were recorded in T_7 [$MgSO_4$ (0.1%)], maximum calcium (3.85 mg/100g) and pectin content (0.64 %) were recorded in T_1 [Ca $(NO_3)_2$ (1%)]. However, maximum reducing sugar (6.09 %) was recorded in T_9 [Water Spray] and minimum acidity (0.48%) was recorded in T_7 [$MgSO_4$ (0.1%)]

The minimum TSS (10.04^{0}Brix) was recorded in

T_3 [$ZnSO_4$ (0.1%)], total sugars (6.00 %) and reducing sugars (3.81 %) were recorded in T_5 [Boron (0.3%)]. The minimum non-reducing sugars (1.95 %), calcium (2.43 mg/100g) and ascorbic acid (197.96 mg/100g) were recorded in T_{10} (control). However, minimum pectin content (0.48 %) and maximum acidity (0.65 %) were recorded in T_9 (Water Spray).

6.1.3 Storage parameters

The data revealed statistically significant differences in PLW up to 10 days of storage.

The minimum PLW (16.41 %) throughout the storage period was recorded in T_2 [Ca $(NO_3)_2$ (2%)].The application of calcium salts showed beneficial effect on post-harvest life of fruits.

The general appearance of fruits was better in T_1 [Ca $(NO_3)_2$ (1%)], T_2 [Ca $(NO_3)_2$ (2%)] and T_8 [$MgSO_4$ (0.2%)] than other treatments.

6.2. Conclusion:

Foliar application of [Ca $(NO_3)_2$ (1%)] was beneficial in improving yield and yield contributing parameters.

Micronutrients application at 50% flowering and one month after first spray is beneficial for increasing yield and quality of guava under high density planting Cv. Sardar.

The shelf life was influenced by various treatments. The fruits under the treatment T_2 [Ca $(NO_3)_2$ (2%)] showed minimum PLW on 8^{th} day however, it was at par with T_1 [Ca $(NO_3)_2$ (1%)].The general appearance was yellow, optimum ripe, soft and hence increased the shelf life and marketability.

Thus, it could be concluded that, foliar application of [Ca $(NO_3)_2$ (1%)] was beneficial in improving yield and quality of guava Cv. Sardar.

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*** Originals not seen**

8. APPENDIX

Weekly mean weather at MPKV., Rahuri during January to December, 2013

Month	Met. week	Temperature (°C)		Relative humidity (%)		Sunshine hrs.	Rainfall (mm)	Rainy days
		Max.	Min.	Morn.	Even.			
Jan	1	31.3	11.2	56	31	08.6	00	00
	2	26.1	10.1	49	31	09.0	00	00
	3	30.4	11.7	50	32	09.2	00	00
	4	30.2	13.5	62	32	08.2	00	00
	5	31.7	15.9	68	33	06.3	00	00
Feb	6	30.9	15.2	59	35	07.8	00	00
	7	31.9	14.5	54	31	08.4	00	00
	8	33.4	12.5	53	20	09.9	00	00
	9	33.8	13.6	40	26	10.2	00	00
March	10	35.1	13.6	46	16	09.5	00	00
	11	35.4	17.2	43	20	08.6	00	00
	12	36.5	16.5	36	16	08.9	00	00
	13	36.5	18.0	51	21	08.4	00	00
April	14	37.6	16.8	50	14	09.4	00	00
	15	39.0	20.2	49	14	09.3	00	00
	16	37.0	16.2	55	20	10.1	00	00
	17	38.9	21.7	51	18	10.4	00	00
	18	40.8	22.7	42	15	10.6	00	00
May	19	40.1	21.8	62	25	10.6	00	00
	20	39.3	24.4	47	21	7.2	5.4	1
	21	39.0	23.7	57	25	9.1	00	00
	22	38.1	23.5	58	30	09.7	00	00

June	23	34.3	23.2	76	48	05.1	36.2	2
	24	30.9	24.5	78	61	01.4	9.0	1
	25	31.8	22.7	76	64	04.4	14.6	4
	26	30.6	22.8	77	61	1.9	18.6	1
July	27	31.4	23.0	78	61	03.4	11.8	1
	28	29.9	22.7	78	69	01.2	8.6	1
	29	26.8	21.8	90	85	0.3	65.2	5
	30	29.0	22.5	85	57	02.2	22.8	2
	31	28.2	21.9	81	70	03.0	21.2	2
Aug	32	29.6	21.8	79	64	02.4	1	00
	33	30.2	22.1	78	59	03.3	2.6	1
	34	29.2	21.8	79	64	04.2	13.4	1
	35	31.5	20.4	78	50	06.9	00	00
Sep	36	32.3	19.7	79	50	06.8	54	1
	37	31.4	22.0	82	60	05.8	46.6	5
	38	29.6	21.5	84	60	03.1	45.8	2
	39	30.5	21.1	80	56	04.3	00	00
Oct.	40	31.9	21.2	82	58	06.4	28.2	2
	41	31.1	20.0	77	57	06.7	65.8	3
	42	32.0	20.1	75	46	08.5	00	00
	43	31.2	19.6	68	56	08.2	5.2	1
	44	31.4	16.8	63	48	09.3	00	00
Nov.	45	32.4	14.3	65	28	09.7	00	00
	46	31.8	13.5	69	27	09.6	00	00
	47	30.7	11.3	66	28	09.4	41.8	1
	48	31.2	15.3	72	36	07.2	00	00
Dec.	49	29.0	13.5	72	38	07.4	00	00
	50	28.7	7.4	74	25	09.4	00	00
	51	29.5	9.6	55	28	09.5	00	00
	52	29.1	13.9	67	34	08.0	00	00

9. VITA

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A candidate for the degree

of

MASTER OF SCIENCE (HORTICULTURE)

in

FRUIT SCIENCE

2014

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