

**EFFECT OF PREHARVEST APPLICATION OF  
CHEMICALS AND PLANT GROWTH REGULATORS ON  
FRUIT QUALITY AND SHELF LIFE OF MANGO  
(*Mangifera indica* L.) CV. AMRAPALI**

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MASTER OF SCIENCE  
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IN  
FRUIT SCIENCE**

**BY  
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**“Effect of preharvest application of chemicals and plant growth regulators on fruit quality and shelf life of mango (*Mangifera indica* L.) cv. Amrapali”**

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**A B S T R A C T**

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The present investigation on “**Effect of preharvest application of chemicals and plant growth regulators on fruit quality and shelf life of mango (*Mangifera indica* L.) cv. Amrapali**” was carried out during summer season of the year 2016 at Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand. The plants of mango were preharvest sprayed with CaCl<sub>2</sub> 1 %, CaCl<sub>2</sub> 2 %, Ca(NO<sub>3</sub>)<sub>2</sub> 1 %, Ca(NO<sub>3</sub>)<sub>2</sub> 2 %, KNO<sub>3</sub> 1 %, KNO<sub>3</sub> 2 %, GA<sub>3</sub> 25 mg/l, GA<sub>3</sub> 50 mg/l, ethrel 0.1 ml/l and ethrel 0.2 ml/l. Fresh and mature fruits were harvested from trees which was preharvest sprayed with different chemicals and plant growth regulators stored at Post Graduate laboratory and observations of physical and biochemical parameters of fruits were recorded.

The results obtained from present investigation indicated that the different preharvest application of chemicals and plant growth regulators, GA<sub>3</sub> 25 mg/l treatment recorded significantly highest fruit length, fruit diameter and fruit volume at harvest and at fully ripening stage whereas, same treatment also obtained the significantly maximum fruit weight consistently at harvest and every day up to 16<sup>th</sup> day under ambient storage condition. The preharvest application of CaCl<sub>2</sub> 2 % recorded significantly minimum physiological loss in weight consistently during 2<sup>nd</sup> day and every day up to 16<sup>th</sup> day whereas, same treatment recorded significantly highest shelf life of fruit. However, preharvest treated fruits with CaCl<sub>2</sub> 2 % also recorded significantly maximum marketable fruits (%) and minimum spoilage (%) at 13<sup>th</sup> day, 14<sup>th</sup> day, 15<sup>th</sup> day and 16<sup>th</sup> day under ambient storage condition.

In quality parameters, the preharvest application of CaCl<sub>2</sub> 2 % recorded significantly highest total soluble solids, reducing sugar, total sugar, non-reducing sugar, ascorbic acid and minimum acidity consistently at harvest and every three days interval up to last ripening stage *i.e.* 4<sup>th</sup> day, 8<sup>th</sup> day, 12<sup>th</sup> day and 16<sup>th</sup> day under ambient storage condition.

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### CERTIFICATE

This is to certify that the thesis entitled “**Effect of preharvest application of chemicals and plant growth regulators on fruit quality and shelf life of mango (*Mangifera indica* L.) cv. Amrapali**” submitted by **Pradeep Kumar Vishwakarma (Reg. No. 04-2691-2015)** in partial fulfillment of the requirements for the award of the degree of **Master of Science (Horticulture)** in the subject of **Fruit Science of B. A. College of Agriculture, Anand Agricultural University, Anand** is a record of bonafide research work carried out by him under my personal guidance and supervision and the thesis has not previously formed the basis for award of any degree, diploma or other similar title.

**Place: Anand**

**Date: /06/2017**

**(M. M. Masu)**

Major Guide



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### **DECLARATION**

This is to certify that whole of the research work reported in the thesis in partial fulfillment of the requirement for the award of the degree of **Master of Science (Horticulture)** in the subject of **Fruit Science** is the result of investigation done by undersigned under the direct guidance and supervision of **Dr. M. M. Masu**, Assistant Research Scientist, Directorate of Research, University Bhavan, Anand Agricultural University, Anand-388110 and no part of the research work has been submitted for any other degree so far.

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(Pradeep Kumar Vishwakarma)

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## LIST OF ABBREVIATIONS AND SYMBOLS

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&	:	And
@	:	At the rate of
Ca	:	Calcium
GA <sub>3</sub>	:	Gibberellic Acid
CaCl <sub>2</sub>	:	Calcium Chloride
Ca(NO <sub>3</sub> ) <sub>2</sub>	:	Calcium nitrate
S. Em.	:	Standard error of mean
CV	:	Co-efficient of variance
cc	:	Cubic centimeter
cm	:	Centimeter
cv.	:	Cultivar
°	:	Degree
<i>et al.</i>	:	et alii : and others
etc.	:	Etcetera
<i>eg.</i>	:	For example
GA <sub>3</sub>	:	Gibberellic Acid
No.	:	Number
<i>viz.</i>	:	Namley
KNO <sub>3</sub>	:	Potassium Nitrate
%	:	Per cent
/	:	Per
PG	:	Post Graduate
PLW	:	Physiological loss in weight
PGRs	:	Plant Growth Regulators
ppm	:	Parts per million
RH	:	Relative humidity
Sr.	:	Serial
T	:	Treatment
T	:	Tone
<i>i.e.</i>	:	That is
NHB	:	National Horticulture Board
DMI	:	Directorate of marketing & inspection
ed.	:	edition

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# 1. INTRODUCTION

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Mango (*Mangifera indica* L.) is a premier fruit crop of India. It is grown in India for over 4000 years. The fruit is rich in vitamin A and C. The mango is a fleshy stone fruit belonging to the genus *Mangifera* and family Anacardiaceae. 'Indian mango' is the only mango tree commonly cultivated in many tropical and subtropical regions. It is originated in Indo-Burma region. Mango is one of the major fruit crop of Asia and has developed its own importance all over the world (Bose *et al.* 2001). Mango is a national fruit of India because of its excellent flavour, delicious taste, delicate fragrance and attractive colour. It is known as 'King of fruits' (Radha and Mathew, 2007).

India shares about 45.1 % of total mango production in the world. Besides India, mango is commercially cultivated in Pakistan, Bangladesh, Burma, Sri Lanka, Thailand, Vietnam, Malaysia, Philippines, Indonesia, Fiji Islands, Tropical Australia, Egypt, Israel, Sudan, Kenya, Uganda, Tanzania, South Africa, USA, Mexico, Haiti, West Indies, Venezuela and Brazil. In India, the major mango growing states are Uttar Pradesh, Andhra Pradesh, Bihar, Karnataka, Tamil Nadu, Kerala, Maharashtra, Orissa and Gujarat. In India, it is grown in an area of 2.5 million hectare with annual production of 18.43 million tonnes having productivity of 7.3 metric tonnes per hectare (NHB, 2015). Mango is grown in almost all states of India. Andhra Pradesh is leading in total area, whereas, Uttar Pradesh is leading in production and productivity (NHB, 2015). Junagadh, Bhavnagar, Amreli, Valsad, Navsari, Surat and Dangs districts of Gujarat are famous for their excellent quality of mango production. In Gujarat, it is cultivated in an area of 0.14 million ha with production of 1.12 million tonnes with productivity of 7.90 metric tonnes per hectare (NHB, 2015).

The fruit has good nutritional value. Every 100 g pulp of ripe mango fruit contains 80 % water, 11.8 % carbohydrate, 0.6 % protein, 0.1 % fat, 0.7 % fibres, 0.3 % minerals, 13 mg ascorbic acid, 12-23 °Brix total soluble solids, 8.7-17.93 % total sugar, 40 mg vitamin B<sub>1</sub>, 50 mg vitamin B<sub>2</sub>, 0.3 mg vitamin B<sub>3</sub> and 4800 IU vitamin A (Radha and Mathew, 2007 and Bose *et al.*, 2001).

Fruit quality at harvest depends on the combined net effect of energy, water and flow into and out of the fruit. The same principles apply to post harvest quality changes, since continued respiration and transpiration constitute net losses of energy

and water from the harvested fruit that result in quality loss. This quality should be increased by various chemicals and plant growth regulators applied at certain period before harvesting of fruits for proper maintaining the balance of nutrient in the fruit so that fruit quality and shelf life should be maintained for longer duration after harvest (Shewfelt and Prussia, 2009). In harvesting season, there is a glut in of fruits in the market. During this period, farmers cannot get reasonable price so it becomes imperative to prolong the shelf life of fruits in the best interest of farmer's community and consumers as well. The purpose of obtaining maximum profit will be served only if production is supplemented with the similar efforts to minimize postharvest losses and enhance shelf life of mango fruit (Wilson, 2016).

Mango is an inherently perishable fruit and its short shelf life limits strategic selling. During process of distribution and marketing, substantial losses are recorded which range from a slight loss of quality to total spoilage. Post-harvest losses may occur at any point in marketing process from initial harvesting, grading, packaging and transportation from field to storage and storage to assembly point during storage and distribution to final consumer. Causes of losses are many such as physical damage during handling and transport, physiological decay, water loss etc. There are various reasons for post-harvest losses of fruit of mango. Some of them are as mechanical injury, injuries due to thermal shock, disease and pest attack, microbial attacks and physio-biochemical reasons. Under these circumstances, mango growers fail to get remunerative return and also fail to reduce the post-harvest losses during peak season. There are many treatments can be used to maintain quality and increase the shelf life of mango fruit by reducing the post-harvest losses (DMI, 2013).

Plant growth regulators are given considerable importance for regulating the various growth and development process in plant. Now a day, use of plant growth regulators has become more popular in increasing the fruit yield and quality particularly in horticultural crops. The various chemicals and plant growth regulators also decrease the physiological loss in weight and increase the shelf life through delaying ripening process, increase in firmness, reduced respiration, reducing the incidence of physiological disorder and storage rots.

Among various chemicals, calcium is known to be essential plant nutrient involved in a number of physiological processes concerning membrane structure, function and enzyme activity (Jones and Lunt, 1967). Calcium has received considerable attention in recent year due to its desirable effect in delaying ripening

and senescence, increasing firmness, vitamin C and phenolic content, reduce respiration, extending storage life and reducing the incidence of physiological disorder and storage rots. Calcium chloride treatment to fruits protects against post-harvest deterioration by binding with hydrolysis such as galacturonase and promotes shelf life. Further, calcium has been shown to inhibit ethylene production and thus delay ripening (Richardson and Al Ani, 1982). Calcium is essential for structural integrity of both the cell wall and plasma membranes. Calcium treatments have known to delay softening and improve the fruit quality. The preharvest and postharvest application of calcium salts has been used successfully in many fresh fruits to reduce loss of firmness and to slow down the ripening process. It is essential in formation of cell membrane and activator of enzymes (Jain, 2015). Calcium alters intracellular and extracellular processes which retard ripening exemplified by lower rates of colour change, softening, CO<sub>2</sub> and ethylene production, increase in sugar and a reduction in total acid content (Conway *et al.* 1987).

Potassium has also received considerable attention in recent year due to its important function and role in the fruit crops. Important role and functions like stimulate photosynthesis, ultimately increase the synthesis of carbohydrates, oils, fats and proteins. It is also involved in the transportation of photosynthates towards the sink. Potassium enhances the production of protein as well as maintains water potential and thus increases the ability of plants to withstand under stress condition. Potassium has important role in influencing both yield and quality of many fruits. The application of adequate potassium along with nitrogen and phosphorus is well recognized for its contribution to fruit yield and quality responses. Potassium is an important nutrient for fruit weight and quality. Potassium is required for the production and transport of plant sugars that increase the weight of fruit. The highest demand for potassium is just prior to harvest. Potassium promotes more even ripening and enhances skin colour. Because, potassium is very mobile within the plant parts, foliar application of potassium is very effective, especially in later stages of growth (Singh *et al.*, 2008).

Gibberellic acid in proper concentration and at appropriate time have been found to enhance the fruit setting and retention of fruits, increase the yield, size, total yield, quality, decrease fruit drop, increasing sugar content, improve the physico-chemical characteristics and extend the post-harvest life of fruits through modification of various physiological and bio-chemical processes of plant (Pandey and Sinha,

2013). Phenomenal increase in productivity has been achieved in many crops by exogenous application of these chemicals. Gibberellins have been found useful in enhancing fruit retention and improving the size and quality of fruits. Further, Gibberellic acid has antisenescence property and help in maintaining cell wall integration and prevents growth of pathogen in the fruits (Prasad, 2006).

Ethrel (2-Chloroethyl phosphonic acid) releases ethylene gas, a natural combustion from the smudge is the factor triggering the flower induction and fruit retention in mango. The ethylene influences the development of commercial fruit is obvious from a whole range of practices within the horticultural industry throughout the world. It is apparent as ethylene releasing chemicals are used to promote the early development of stone fruits. Early development of many fruits characterized by a high rate of ethylene evolution. It is now well established that ethylene is an important regulator of ripening events (Mattoo and Suttle, 1991). Ethrel treatment at desired concentration hastens the ripening process with uniform colour development (Dhillon, 2013).

A lot of research work has been conducted on production aspect but very few works has been carried out on shelf life and quality. The postharvest losses vary from 17 to 36 per cent in mango. These losses occur at the farm level during harvesting, grading, transport, storage and marketing. The control of these losses alone may contribute a lot for increasing the availability of fruits for the common man. Reduction in adopting qualitatively and quantitative losses could be achieved by harvesting of the fruits at an optimum maturity and adoption of the preharvest treatments. Further, Amrapali is a late cultivar having superior fruit quality; hence it has a great scope for storage. Various treatment like use of plant growth regulators, chemicals, minerals, wax emulsions and wrappers have successfully been tried to prolong the shelf-life of fruits (Desai, 2010).

In mango major postharvest losses is due to the loss of quality due to loss in firmness, physiological weight loss and decay loss. The increase in loss in weight during storage period and shelf life due to upsurge in respiration rate and transpiration process in fruits and it can be minimized by supplementary application of chemicals and plant growth regulators on fruit for maintaining fruit quality and extending the shelf life of fruit (Bisen and Thakur, 2012).

The research based information on preharvest application of different chemicals and plant growth regulators in mango is negligible. Keeping view in mind, the present experiment on “Effect of preharvest application of chemicals and plant growth regulators on fruit quality and shelf life of mango (*Mangifera indica* L.) cv. Amrapali” was carried out with the following objectives.

1. To study the effect of preharvest application of different chemicals and plant growth regulators on fruit quality of mango cv. Amrapali.
2. To study the effect of preharvest application of different chemicals and plant growth regulators on shelf life of mango cv. Amrapali.

## 2. REVIEW OF LITERATURE

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Now a day, the postharvest losses are major and serious problem in India. The postharvest losses in India are estimated to range from 20-40 % in fruit crops that is why a number of postharvest research centres are established in India and have developed various technologies, scientific tools and carried out number of investigations for reducing the postharvest losses and improve the quality and shelf life of fruit crops. Among the various scientific tools like chemicals and plant growth regulators are widely applied for the betterment of the crops. These substances when applied as preharvest sprays have been found to regulate, modify or accelerate various physiological processes of the plant. Mango is medium perishable fruit in nature due to medium respiration rate and ethylene production rate and having a limited shelf life after harvest or ripening. Among these some chemicals and plant growth regulators help in improve the fruit quality and shelf life of mango fruits. However, the different varieties of mango also play a very important role in qualitative fruit production with good shelf life. Therefore, the present investigation was carried out to study the **“Effect of preharvest application of chemicals and plant growth regulators on fruit quality and shelf life of mango (*Mangifera indica* L.) cv. Amrapali”**.

Generally, Calcium chloride ( $\text{CaCl}_2$ ), Calcium nitrate [ $\text{Ca}(\text{NO}_3)_2$ ], Potassium nitrate ( $\text{KNO}_3$ ), Gibberellic acid ( $\text{GA}_3$ ) and Ethrel are more popular and effective. Therefore, they are frequently used in horticultural crops. Proper concentrations of these substances have desirable effect on fruit formation, abscission, cell elongation, apical dominance, delaying ripening and senescence, increase in firmness, vitamin C, sugar content, reduced respiration, extending storage life and reducing the incidence of physiological disorder and storage rots. They improve the physical and chemical characteristics and extend the shelf life of fruits.

An attempt is being made here to present a brief account of some previous studies related to the present investigation in mango and other fruit crops under the following heads.

- 2.1 Effect of Calcium Chloride ( $\text{CaCl}_2$ )
- 2.2 Effect of Calcium Nitrate [ $\text{Ca}(\text{NO}_3)_2$ ]
- 2.3 Effect of Potassium Nitrate ( $\text{KNO}_3$ )
- 2.4 Effect of Gibberellic Acid ( $\text{GA}_3$ )
- 2.5 Effect of Ethrel

## **2.1 EFFECT OF CALCIUM CHLORIDE (CaCl<sub>2</sub>)**

Mahajan and Sharma (2000) conducted an experiment on effect of preharvest application of growth regulator on physico-chemical characteristics and storage life of peach cv. Shan-e-Punjab at PAU, Punjab. They found that the physiological loss in weight of fruit increased with the increase in storage period. The minimum physiological loss in weight (9.3 %) was registered with CaCl<sub>2</sub> 1 % spray followed by CaCl<sub>2</sub> 0.5 %.

Ramakrishna *et al.* (2001) studied the effect of preharvest application of calcium on physico-chemical changes during ripening and storage of papaya at Anantharajupet during the year 1998-99. They observed that preharvest spray of CaCl<sub>2</sub> 1.5 % obtained significantly minimum physiological loss in weight (8.23%) whereas higher shelf life (10.3 days) was recorded with preharvest spray of CaCl<sub>2</sub> 2 % before 15 days of harvest as compared to rest of the treatments.

Rajkumar *et al.* (2006) carried out an experiment on the effect of preharvest application of calcium on storage behaviour, ripening and shelf life of papaya at HCRI, Periyakulam. They reported that significantly maximum total soluble solids (11.80 °Brix), total sugar (7.30 %), shelf life (10 days) and minimum physiological loss in weight (14.39 %) were recorded with preharvest spray of CaCl<sub>2</sub> 2 % before 25 days of harvest as compared to other treatments.

Jawandha *et al.* (2007) studied on the effect of different preharvest treatments on storage of ber at PAU, Ludhiana during the year 2002-03. They revealed that total soluble solid content increased up to 20 days of storage in all the treatments except control. The maximum total soluble solids, total sugar and vitamin-C content were found in CaCl<sub>2</sub> treated fruits after 30 days of storage.

Bhalerao *et al.* (2009) conducted an experiment on the effect of pre-harvest application of different sources of calcium to improve the biochemical qualities of sapota fruits cv. Kalipatti at Navsari during the year 2007. They found that the percent loss in weight in fruits was increased with increase of storage period irrespective of any preharvest treatment. Preharvest sprayed with CaCl<sub>2</sub> 1 % recorded significantly lowest physiological loss in weight and maximum shelf life of sapota fruits.

Singh *et al.* (2012) carried out an investigation on the effect of preharvest chemical treatments and mulching on quality and marketability of mango cv. Dashehari at Pantnagar during the year 2009-10. They indicated that preharvest

application of  $\text{CaCl}_2$  2 % was effective for improving the fruit marketability and decreasing the physiological loss in weight.

Kirmani *et al.* (2013) conducted the research on effect of preharvest application of chemicals and plant growth regulators on storage of plum cv. Santa Rosa under ambient storage condition at SKUAST, J&K during the year 2010-11. They found that preharvest spray of 0.5 %  $\text{CaCl}_2$  before 20 and 10 days expected date of harvest improved the fruit quality during entire storage period. Such fruits exhibited minimum physiological loss in weight (4.53 %) and spoilage (22.11 %) on each sampling date as compared to other treatments.

Karemera and Habimana (2014) studied the effect of preharvest treatment of calcium chloride on post-harvest behavior of mango cv. Alphonso at Bangalore during the year 2011-12. They revealed that spray of 1.5 %  $\text{CaCl}_2$  at 30 days before harvesting found significantly maximum fruit length (9.81 cm.), fruit breadth (8.50 cm.), fruit volume (311.66 ml), fruit weight (315.23 g.) and shelf life (24.33 days) as compared to other treatments.

Kirmani *et al.* (2015) conducted the research on impact of preharvest chemicals application on plum cv. Santa Rosa quality during storage at SKUAST, J&K during the year 2010-11. They found that  $\text{CaCl}_2$  at higher concentration of 0.5 % proved to be the most effective treatment in retaining the fruit quality during entire storage period and  $\text{CaCl}_2$  0.5 % treatment recorded significantly maximum total sugar (9.06 %), reducing sugar (8.04 %), non-reducing sugar (1.47 %), total soluble solids (12.80 %) and ascorbic acid (6.69 mg/100 g pulp).

Prasad *et al.* (2015) studied the effect of preharvest foliar spray of various chemicals on fruit quality of pear cv. Pathernakh at Pantnagar during the year 2013-14. They recorded significantly maximum ascorbic acid (6.46 mg/100 g pulp) with the foliar application of  $\text{CaCl}_2$  1.5 % as compared to other treatments.

## **2.2 EFFECT OF CALCIUM NITRATE [ $\text{Ca}(\text{NO}_3)_2$ ]**

Ramakrishna *et al.* (2001) studied the effect of preharvest application of calcium on physico-chemical changes during ripening and storage of papaya at Anantharajupet. They observed that preharvest spray of  $\text{Ca}(\text{NO}_3)_2$  0.5% before 15 days of harvest improved quality and recorded significantly maximum total sugar (8.99%) and minimum titratable acidity (0.12%) as compared to rest of the treatments.

Saran *et al.* (2004) conducted research work on the effect of preharvest application of different chemicals on shelf life and quality of ber cv. Gola at Jobner during the year 2002. They reported that the preharvest application of  $\text{Ca}(\text{NO}_3)_2$  1 % was most effective treatment which was exhibiting significantly minimum physiological loss in weight (9.86 %), decay loss (6.27 %) and acidity (0.202 %) and maximum total soluble solids (19.08 %), ascorbic acid (82.10 mg/100g pulp), reducing sugar (6.01 %) and total sugar (12.83 %) at the end of storage period.

Jayachandran *et al.* (2005) studied on effect of preharvest sprays of different sources of calcium on shelf life of guava cv. L-49 at Hyderabad during the year of 1999-2000. They revealed that preharvest spray of  $\text{Ca}(\text{NO}_3)_2$  1.0 % before 15 days of harvest recorded significantly minimum physiological loss in weight (14.5 %) and titratable acidity (0.59 %) whereas, calcium nitrate delayed softening and enhanced the shelf life (11.67 days) of fruits as compared to rest of the treatments.

Rajkumar *et al.* (2006) carried out an experiment on the effect of preharvest application of calcium on storage behaviour, ripening and shelf life of papaya at Periyakulam. They reported that the significantly maximum ascorbic acid content (43.42 mg/100 g) and fruit weight (1.373 kg) were recorded with the preharvest spray of  $\text{Ca}(\text{NO}_3)_2$  1.5 % before 25 days of harvest as compared to other treatments.

Bhatt *et al.* (2008) conducted research work on preharvest application of nutrients on yield, quality and shelf life of mango cv. Dashehari at Pantnagar on six year old mango orchard. The results obtained indicated that the significantly minimum physiological loss in weight (30.22 %) was recorded in  $\text{Ca}(\text{NO}_3)_2$  1.0 % treatment up to end of 12<sup>th</sup> day of storage as compared to rest of treatments.

Bhalerao *et al.* (2010) studied the effect of pre-harvest application of different sources of calcium to improve the biochemical qualities of sapota fruits cv. Kalipatti at Navsari during the year 2007. They revealed that reducing sugar increased up to 6<sup>th</sup> day of storage after preharvest treatment of calcium sources. The pre-harvest application of  $\text{Ca}(\text{NO}_3)_2$  0.5 % recorded significantly maximum reducing sugar as compared to rest of the treatments.

Goutam *et al.* (2010) conducted experiment on the effect of preharvest calcium spray on post-harvest life of winter guava at Ludhiana during the year 2006 and 2007. They reported that the significantly minimum physiological loss in weight (5.2 %), spoilage (23.4 %) and titratable acidity (0.28 %) were found with the treatment of  $\text{Ca}(\text{NO}_3)_2$  0.5 % whereas, maximum total soluble solids (9.8 %) and

ascorbic acid (129.1 mg/100 g) were recorded with the treatment of  $\text{Ca}(\text{NO}_3)_2$  1.5 % before 15 days to fruit harvest as compared to rest of the concentrations.

Rajput (2010) carried out an investigation on effect of pre and post-harvest treatments on shelf life and quality of guava fruits cv. Gwalior-27 at Gwalior during the year 2002-04. They revealed that higher concentration of  $\text{Ca}(\text{NO}_3)_2$  2 % had improved the fruit quality and it was recorded the significantly highest total soluble sugar (10.05 %) and ascorbic acid (244 mg/100 g. pulp) which signifies the positive role of calcium nitrate in improving the fruit quality.

Alila and Achumi (2010) conducted experiment on the effect of preharvest chemical treatments on fruit quality of litchi. They concluded that the physical parameters of fruits (fruit weight and fruit diameter) were found to be positively influenced with the application of  $\text{Ca}(\text{NO}_3)_2$  1.5% as preharvest spray. It was also found that minimum loss of weight was recorded compared to all other treatments during the whole storage period.

Bisen and Thakur (2012) studied the effects of preharvest application of calcium nitrate and gibberellic acid on storage behaviour of guava fruits cv. Allahabad Safeda at Jabalpur during the year 2009 to 2011. They found that the weight loss increased with storage period. The rate of weight loss was low during initial period of storage and differences between various treatments as well as control were also narrow but the differences become markedly wider with the increased period of storage. The preharvest spray with  $\text{Ca}(\text{NO}_3)_2$  1.5 % at the time of fruit set, 20 and 10 days prior to harvesting were significantly reduces physiological loss in weight (5.78 %) as compared to rest of the treatments.

Biradarpatil *et al.* (2015) carried out research work on the effect of preharvest treatment of growth regulators and chemicals on storage behavior of seedless grape cv. Sonaka at Arabhavi, Karnataka. They reported that the preharvest spray of  $\text{Ca}(\text{NO}_3)_2$  2 % before 10 days of harvest significantly increases total soluble solids (25.07 %), ascorbic acid (3.28 mg/100 g. pulp), total sugar (24.42 %), reducing sugar (23.00 %) and non-reducing sugar (1.41 %) and significantly decreases the physiological loss in weight (15.02 %) and titratable acidity (0.36 %) as compared to rest of the treatments.

### 2.3 EFFECT OF POTASSIUM NITRATE (KNO<sub>3</sub>)

Gill *et al.* (2005) conducted an experiment on the effect of foliar application of various chemicals on fruit quality of Kinnow mandarin at Ludhiana during the year 1999 and 2000. They noticed that the application of KNO<sub>3</sub> 2.0 % was most effective treatment and recorded significantly maximum total sugar (6.64 %), non-reducing sugar (3.24 %), vitamin-C (25.3 mg/100 gm) and fruit breadth (6.99 cm.) as compared to another treatment.

Gill and Bal (2010) studied the effect of preharvest application of nutrient and growth regulators on quality of guava cv. Sardar. They observed that the preharvest foliar spraying of KNO<sub>3</sub> 1.5 % significantly increased fruit weight (135.4 g), total soluble solids (10.8 %), vitamin C (148.6 mg/100 g) and total sugars (7.80 %) as compared to another concentration of KNO<sub>3</sub>.

Tandel and Patel (2011) conducted a research on the effect of chemicals on growth, yield and economics of mango at Navsari during the year 2005-07. They observed that the foliar spray of KNO<sub>3</sub> 2 % was most effective treatment and it was significantly increasing fruit weight (622.1 g) of mango cv. Rajapuri as compared to rest of the treatments.

Khayyat *et al.* (2012) reported the effect of potassium nitrate spraying on fruit characteristics of 'MalasYazdi' pomegranate at Iran during the year 2009. They found that applied potassium nitrate significantly influences on fruit quality of pomegranate when fruit are in the beginning stage of the growth and development. They also recorded that the foliar spray of KNO<sub>3</sub> 250 mg/L significantly increased total soluble solids (16.18 %), vitamin – C (11.45 mg/100 ml juice), fruit length (69.13 mm) and fruit diameter (75.85 mm) whereas, maximum fruit weight (244 g) and fruit volume (278.5 cm<sup>3</sup>) were found with the treatment of 500 mg/L KNO<sub>3</sub> as compared to other concentrations.

Mandal *et al.* (2012) studied on the pre-harvest application of NAA and potassium nitrate on storage quality of winter guava. They noticed that the increasing trend in the physiological loss in weight and decline trend in acidity during the storage period. The significantly minimum physiological loss in weight and titratable acidity were recorded during storage period with the foliar application of KNO<sub>3</sub> 1.5 % before 15 days of harvest as compared to another concentrations of potassium nitrate.

Elsabagh (2012) conducted an experiment on the effect of spraying of nutrients on fruit "Deglet Nour" date palm cultivar at Gallom Oasis, Egypt during the

year 2009-10. They observed that foliar application of  $\text{KNO}_3$  2 % after hababouk stage improved the quality with significantly maximum total soluble solids (28.00 %) as compared to other treatments.

Sarker and Rahim (2013) carried out an investigation on the yield and quality of mango as influenced by application of various chemicals at BAU, Bangladesh during the year 2006-07. They revealed that the application of  $\text{KNO}_3$  4.0 % was most effective treatment for quality improvement and recorded significantly maximum vitamin C (32.23 mg/100 g pulp) in fruit as compared to other treatments.

Prakash *et al.* (2014) studied on the effect of pre-harvest chemical spray on quality of pomegranate cv. Bhagwa. They were revealed that the maximum sugar content (total sugar and reducing sugar) observed with the higher level potassium application and increased ascorbic acid content was noticed.

Prakash and Balakrishnan (2014) studied on the effect of pre-harvest chemical spray on quality of pomegranate cv. Bhagwa. They revealed that foliar application of  $\text{KNO}_3$  2 % significantly increased fruit weight (363.48 g) and fruit volume (383.12 cc) as compared to other treatment and control.

Prasad *et al.* (2015) conducted experiment on the effect of preharvest foliar spray of various chemicals on fruit quality of pear cv. Pathernakh at Pantnagar during the year 2013-14. They were recorded that preharvest application of 1.5 %  $\text{KNO}_3$  significantly improved the fruit quality and found minimum titratable acidity (0.40 %) and maximum total soluble solids (11.94 %), total sugar (7.73 %) and non-reducing sugar (1.60 %) as compared to other treatments.

Amarcholi *et al.* (2016) studied the impact of chemicals on quality parameters of 'Kesar mango' at Baruch during the year 2013-14 on eight year old orchard. They indicated that the shelf life of Kesar mango fruits stored at ambient temperature were increased by all the treatments. The maximum period of shelf life (17.43 days) was noted in fruit harvested from the trees treated with  $\text{KNO}_3$  1 % as compared to rest of the treatments.

#### **2.4 EFFECT OF GIBBERELIC ACID ( $\text{GA}_3$ )**

Brahmachari and Rani (2000) conducted experiment on the effect of growth substances on fruit drop, yield and physico-chemical composition of litchi fruits at Sabour. They recorded the significantly maximum fruit diameter (3.20 cm), fruit weight (22.30 g) and fruit volume (21.39 cc) with the spray of  $\text{GA}_3$  100 ppm at

panicle emergence, after fruit set and at immature stage as compared to other treatments.

Yadav *et al.* (2001) studied the effect of growth regulators on the yield and quality of winter season guava cv. Lacknow-49. They recorded that gibberellic acid increased the size and improved the quality of fruit. They found significantly maximum fruit weight (142 g), ascorbic acid (180 mg/100 g pulp), total sugar (6.72 %) and minimum acidity (0.38 %) with the foliar application of GA<sub>3</sub> 150 ppm as compared to other concentrations.

Singh *et al.* (2007) carried out the research work on the effect of micronutrients and plant growth regulators on yield and physico-chemical characteristics of aonla cv. NA-10 at Faizabad. They found significantly maximum fruit weight (45.80 g), pulp weight (43.43 g), total soluble solids (10.97 °Brix), reducing sugar (3.03 %), non-reducing sugar (2.14 %) and total sugar (5.17 %) of fruits with the application of 25 ppm GA<sub>3</sub> from the different concentrations of micro-nutrients and plant growth regulators.

Singh *et al.* (2011) studied the effect of various chemicals and growth regulators on fruiting, ripening and chemical traits of phalsa cv. Sharvati at Kanpur during the year 2008-09. They found that the significantly maximum berry diameter (1.12 cm), weight of berry (15.72 g.) and yield per plant (7.88 kg) with the treatment of GA<sub>3</sub> 50 ppm as compared to other treatments.

Bhowmick and Banik (2011) conducted experiment on the influence of preharvest foliar application of growth regulators and micro nutrients on mango cv. Himasagar at Mondouri, West Bengal. They observed significantly maximum fruit length (9.28 cm), breadth (7.31 cm) and weight (283.38 g) were recorded with the foliar application of GA<sub>3</sub> 40 ppm at marble stage as compared to other treatments.

Debnath *et al.* (2011) carried out investigation on the effect of plant growth regulators on yield and quality in phalsa at Rajendranagar during the year 2009-10. They revealed that the GA<sub>3</sub> 100 ppm was significantly effective in improving fruit weight (61.48 g/100 berry) and reducing sugar (18.91 %) with the foliar application at prebloom and post bloom stage as compared to other treatments.

Bisen and Thakur (2012) studied the effect of preharvest application of calcium nitrate and gibberellic acid on storage behaviour of guava fruits cv. Allahabad Safeda at Jabalpur during the year 2009-2011. They found that preharvest spray of GA<sub>3</sub> 100 ppm at the time of fruit set, 20 and 10 days prior to harvesting were

significantly reduces physiological loss in weight (5.65 %) as compared to rest of the concentrations.

Nkansah *et al.* (2012) studied the effect of GA<sub>3</sub> and NAA on fruit retention, yield and quality of mango cv. Keitt during the year 2008-09. They concluded that trees sprays with GA<sub>3</sub> 25 ppm + NAA 25 ppm was the best and most effective treatment for yield (188.2 kg per plant) and improving fruit quality of mango as compared to another treatments.

Jagtap *et al.* (2013) conducted an experiment on the effect of foliar application of plant growth regulators on yield and quality of acid lime cv. Kagzi at Anand during the year 2011. The result revealed that GA<sub>3</sub> 50 mg/l recorded significantly highest yield attributing characters like fruit weight (47.40 g), fruit diameter (4.54 cm) and fruit volume (47.90 cc) and quality attributing characters like total soluble solids (9.58 °Brix) and ascorbic acid (30.41 mg/100 g pulp).

Lal *et al.* (2013) carried out research on the effect of plant growth regulators on fruit growth of guava cv. Allahabad Safeda at Jorhat, Assam during the year 2009. They found significantly maximum fruit length (9.8 cm), fruit girth (10.23 cm), fruit weight (182.0 g) and fruit volume (178.3 cm) were recorded with the preharvest spray of GA<sub>3</sub> 50 ppm as compared to other treatments.

Kacha *et al.* (2014) studied on the performance of various plant growth regulators on yield and quality of phalsa at Junagadh during the year 2006-08. They observed that foliar application of GA<sub>3</sub> 150 ppm significantly reduced acidity (2.55 %) and increased ascorbic acid content (39.20 mg/100 g pulp) as compared to rest of the treatments.

Sharma and Tiwari (2015) carried out experiment on the effect of growth regulators on quality of guava cv. Chittidar at Mandasur, Madhya Pradesh. They found that the significantly maximum total soluble solids (12.6 °Brix), total sugar (10.42%), reducing sugar (5.82 %) and non-reducing sugar (4.60 %) with foliar spray of GA<sub>3</sub> 150 ppm as compared to other treatments.

Uniyal and Misra (2015) conducted experiment on the effect of plant growth regulators on quality of bael cv. Pant Shivani at Pantnagar during the year 2009 to 2011. They recorded significantly maximum total soluble solids (38.12 %) with the preharvest spray of GA<sub>3</sub> 50 ppm as compared to another treatments.

## **2.5 EFFECT OF ETHREL**

Yadav *et al.* (2001) conducted research work on the effect of growth regulators on yield and quality of winter season guava cv. L-49 at Hisar during the year 1994-95. They revealed that the significantly maximum total soluble solids (13.1 %) and total sugar (7.08 %) were recorded with the treatment of ethrel 100 ppm as compared to rest of the treatments.

Aryanpooya and Davarynejad (2010) studied on pre-harvest ethrel spraying effects on post-harvest quality of sour cherry fruits at Iran. They reported maximum soluble solids content (23.82 °Brix) with the preharvest application of ethrel 300 ppm as compared to other concentrations of the ethrel.

Gill and Bal (2010) conducted research work on the effect of preharvest application of nutrient and growth regulators on quality of guava cv. Sardar. They observed that the ethrel treatment improving the quality of fruits with the preharvest foliar spraying of ethrel 400 ppm and it was recorded significantly highest total soluble solids (11.1 %), vitamin C (149.8 mg/100 g) and total sugars (7.98 %) as compared to other treatments.

Jain and Dashora (2010) studied on the effect of different plant bioregulators in relation to fruit quality and yield of guava cv. Sardar at Udaipur. They observed significantly maximum total soluble sugar (15.35%), total sugar (7.53%), reducing sugar (4.36%) and non-reducing sugar (3.01%) with the preharvest foliar spray of ethrel 500 ppm as compared to another treatments.

Singh *et al.* (2011) studied the effect of various chemicals and growth regulators on fruiting, ripening and chemical traits of phalsa cv. Sharvati at Kanpur during the year 2008-09. They revealed that ethrel 1000 ppm treatment recorded significantly maximum total sugar (14.31 %) and minimum acidity content (1.12 %) as compared to another concentration of ethrel.

Vahora (2010) investigated that the effect of different chemicals on yield and quality of mango cvs. Alphonso and Kesar at Navsari. He revealed that foliar application of 200 ppm ethrel was recorded significantly maximum fruit diameter (8.15 cm & 9.73 cm) for both cultivar and showed maximum total sugar (14.03 %) in Alphonso cultivar of mango.

Debnath *et al.* (2011) carried out investigation on the effect of plant growth regulators on yield and quality in phalsa at Rajendranagar during the year 2009-10.

They found significantly highest total soluble solid (25.72 %) was obtained when the bushes were sprayed with the ethrel 500 ppm followed by ethrel 250 ppm as compared to other treatments of plant growth regulators.

Sharma *et al.* (2011) studied the effect of various chemicals and plant growth regulators for induction of flowering and fruiting in unproductive orchard of mango cv. Chausa at KVK, Shimla. They reported that foliar application of ethrel 200 ppm significantly increased fruit weight (190 g) and improve quality of fruits as compared to rest of the treatments.

El-Sayed, M. E. A. (2013) studied the effect of some preharvest treatments on improving fruit quality and marketing of grape cv. "Crimson Seedless" at Egypt during the year 2011 and 2012. He found that preharvest spray of ethrel 100 ppm significantly increases the weight of berries (459 g/100 berries) and length (25.94 mm) as compared to other treatments.

Goswami *et al.* (2013) conducted a research to study the effect of plant growth regulators on quality traits of pomegranate cv. Sinduri at Sardarkrushinagar. They found that application of ethrel 200 ppm was found most effective treatment for improving fruit quality. It was recorded significantly maximum total soluble solids (17.18 %), reducing sugar (10.83 %), non-reducing sugar (1.68 %), total sugar (12.50 %) and ascorbic acid (14.85 %) content as compared to rest of the treatments.

Kacha *et al.* (2014) reported the performance of various plant growth regulators on yield and quality of phalsa at Junagadh during the year 2006-07 and 2007-08. They reported the quality of fruit in terms of total soluble solids (25.23 %), reducing sugar (2.01%) and total sugar (5.74 %) were significantly highest in treatment with the ethrel 1000 ppm followed by ethrel 750 ppm.

### 3. MATERIAL AND METHODS

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The present investigation was carried out on “**Effect of preharvest application of chemicals and plant growth regulators on fruit quality and shelf life of mango (*Mangifera indica* L.) cv. Amrapali**”. The details of materials used, experimental methods and techniques adopted during the course of the investigation have been described in this chapter.

#### 3.1 GENERAL

##### 3.1.1 Experimental site

An experiment was conducted on fourteen years old trees of mango cv. Amrapali established at Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand during summer season of the year 2016.

##### 3.1.2 Treatment Materials

###### 3.1.2.1 Chemicals and plant growth regulators

Chemicals *viz.*, Calcium Chloride ( $\text{CaCl}_2$ ), Calcium Nitrate [ $\text{Ca}(\text{NO}_3)_2$ ] and Potassium Nitrate ( $\text{KNO}_3$ ) and plant growth regulators *viz.*, Gibberellic Acid ( $\text{GA}_3$ ) and Ethrel were obtained from Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand.

#### 3.2 PHYSIOGRAPHIC SITUATION:

##### 3.2.1 Location

Anand, where research experiment was taken has an elevation of 45.1 meter above mean sea level and it is situated at 22° 35' North latitude and 72° 56' East longitudes.

##### 3.2.2 Climate and Weather conditions

The climate of Anand region is semi-arid and sub-tropical type. Winter is mild cool and dry, while summer is hot and dry. October to May are sunny months generally receiving an average of eight hours sunshine per day. Temperature during hot weather commences from starting of March and ends by about middle of June. Winter sets in the middle of October and continues till the end of February. Monsoon is warm and

moderately humid. It commences by the end of June and ends by the middle of September. In this region, monsoon is often erratic and uncertain, in respect of total rainfall and its distribution. The meteorological data on the average weekly maximum and minimum temperature, rainfall and relative humidity recorded at the Meteorological observatory AAU, Anand during experimental period *i.e.* 21<sup>st</sup> March to 11<sup>th</sup> June, 2016 and from 11<sup>th</sup> June 2016 to 27<sup>th</sup> June 2016 at ambient storage condition are given in Appendix-I.

### 3.2.3 Soil characteristics

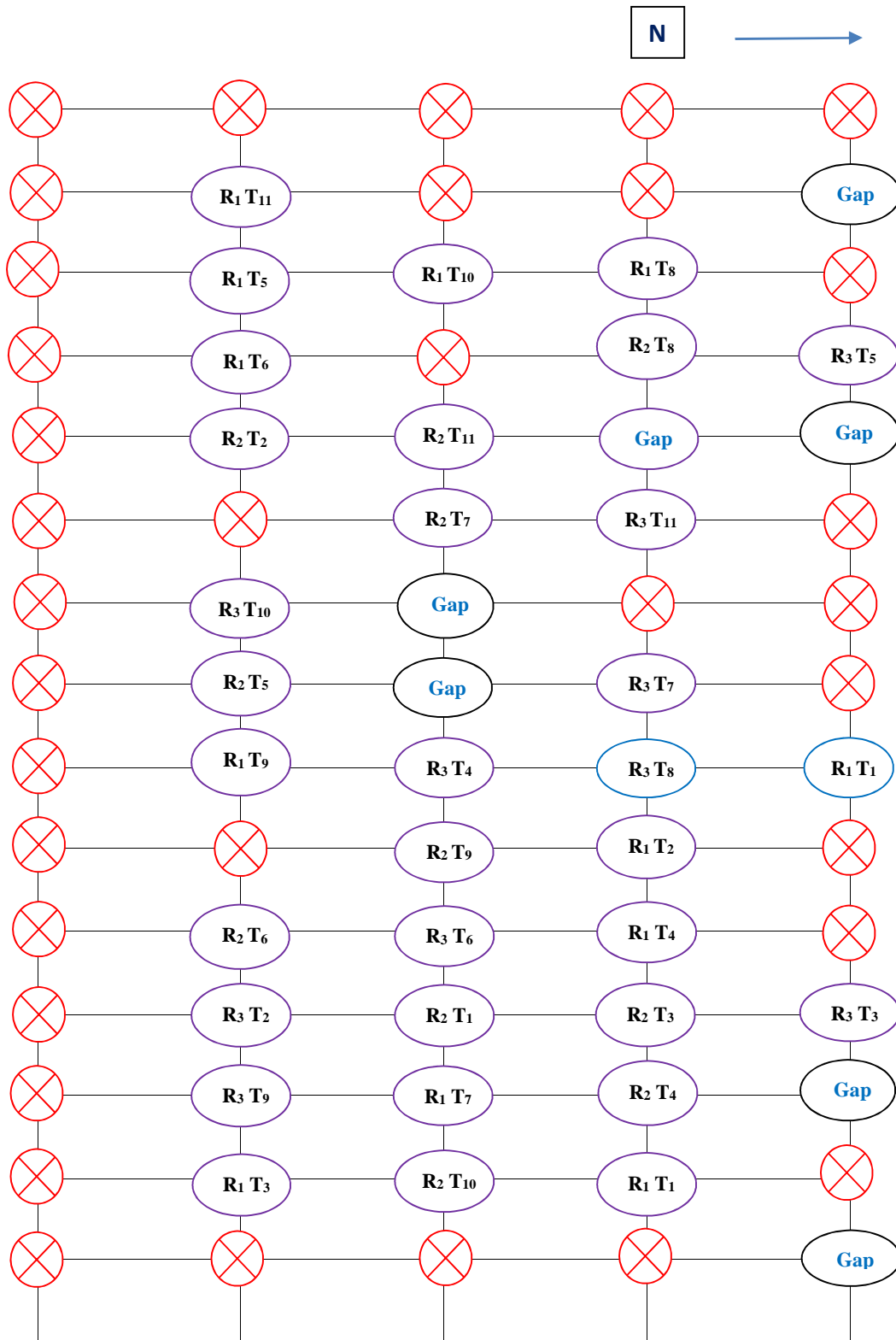
The soil of the experimental site was sandy loam, locally known as “*Goradu*”. Soil responds well to manures and irrigations, so it is suitable for mango cultivation. The water table is more than 10 m in depth. Hence, there is no problem of high water table in the area. A composite soil sample was collected from an experimental plot to a depth of 0-15 cm. The physical and chemical properties of the soil of experimental plot are given in Table -3.1 and 3.2 respectively.




**Table 3.1 Physical properties of the experimental soil**

Sr. No.	Particulars (%)	Value in per cent (0-15 cm depth)	Method of analysis
1	Coarse sand	0.74	International pipette Method (Piper, 1950)
2	Fine sand	80.87	
3	Silt	11.16	
4	Clay	7.23	
5	Textural class	Sandy loam	

**Table 3.2 Chemical properties of the experimental soil**

Sr. No.	Soil characteristics	Value (0-15 cm depth)	Method of analysis
1	Organic carbon (%)	0.34	Walkley and Black’s method (Jackson, 1973)
2	Available nitrogen (%)	0.043	Kjeldahl’s method (Jackson, 1973)
3	Available phosphorus (kg/ha)	42.38	Olsen’s method (Jackson, 1973)
4	Available potash (kg/ha)	275.71	Flame photometric Method (Jackson, 1973)
5	Soil pH (1 :2.5, soil :water ratio)	7.08	Backman ‘s pH meter (Jackson, 1973)
6.	EC (ds/m)(1:2.5, soil :water ratio)	0.29	Solubridge method (Jackson, 1973)



	:	Plants of Amrapali Mango Variety
	:	Preharvest treated plants of mango cv. Amrapali
	:	No Plant

**Fig 3.1 Layout of experimental plot of mango cv. Amrapali**

### **3.3 EXPERIMENTAL DETAILS:**

The details of experiment are given below

**3.3.1 Crop:** Mango (*Mangifera indica* L.)

**3.3.2 Variety:** Amrapali

**3.3.3 Age of tree:** 14 years old (Planting in 2002)

**3.3.4 Spacing:**  $8 \times 8 \text{ m}^2$

**3.3.5 Total number of trees:** 33

**3.2.6 Experimental design:** Completely Randomized Design (CRD)

**3.3.7 Number of repetitions:** 3

**3.3.8 Total number of treatments:** 11

**3.3.9 Number of tree per treatment:** 3

#### **3.3.10 Treatment details**

In this experiment, total 11 treatments were taken as under:

**T<sub>1</sub>:** Calcium chloride ( $\text{CaCl}_2$ ) 1%

**T<sub>2</sub>:** Calcium chloride ( $\text{CaCl}_2$ ) 2 %

**T<sub>3</sub>:** Calcium nitrate [ $\text{Ca}(\text{NO}_3)_2$ ] 1%

**T<sub>4</sub>:** Calcium nitrate [ $\text{Ca}(\text{NO}_3)_2$ ] 2%

**T<sub>5</sub>:** Potassium nitrate ( $\text{KNO}_3$ ) 1%

**T<sub>6</sub>:** Potassium nitrate ( $\text{KNO}_3$ ) 2%

**T<sub>7</sub>:** Ethrel 0.1 ml/l

**T<sub>8</sub>:** Ethrel 0.2 ml/l

**T<sub>9</sub>:** Gibberellic acid ( $\text{GA}_3$ ) 25 ml/l

**T<sub>10</sub>:** Gibberellic acid ( $\text{GA}_3$ ) 50 ml/l

**T<sub>11</sub>:** Control (No spray)

### **3.4 PREPARATION OF CHEMICALS AND PLANT GROWTH REGULATORS**

#### **3.4.1 Calcium Chloride ( $\text{CaCl}_2$ ) 1%**

For preparation of 1 % solution of  $\text{CaCl}_2$ , 10 g  $\text{CaCl}_2$  was weighted and dissolved in 1 liter water. For preparation of 10 liter solution of 1 %  $\text{CaCl}_2$  per treatment, 100 g  $\text{CaCl}_2$  was weighted and dissolved in 10 liter water.

#### **3.4.2 Calcium Chloride (CaCl<sub>2</sub>) 2%**

For preparation of 2 % solution of CaCl<sub>2</sub>, 20 g CaCl<sub>2</sub> was weighted and dissolved in 1 liter water. For preparation of 10 liter solution of 2 % CaCl<sub>2</sub> per treatment, 200 g CaCl<sub>2</sub> was weighted and dissolved in 10 liter water.

#### **3.4.3 Calcium Nitrate [Ca(NO<sub>3</sub>)<sub>2</sub>] 1%**

For preparation of 1 % solution of Ca(NO<sub>3</sub>)<sub>2</sub>, 10 g Ca(NO<sub>3</sub>)<sub>2</sub> was weighted and dissolved in 1 liter water. For preparing 10 liter solution of 1 % Ca(NO<sub>3</sub>)<sub>2</sub> per treatment, 100 g Ca(NO<sub>3</sub>)<sub>2</sub> was weighted and dissolved in 10 liter water.

#### **3.4.4 Calcium Nitrate [Ca(NO<sub>3</sub>)<sub>2</sub>] 2%**

For preparation of 2 % solution of Ca(NO<sub>3</sub>)<sub>2</sub>, 20 g Ca(NO<sub>3</sub>)<sub>2</sub> was weighted and dissolved in 1 liter water. For preparation of 10 liter solution of 2 % Ca(NO<sub>3</sub>)<sub>2</sub> per treatment, 200 g Ca(NO<sub>3</sub>)<sub>2</sub> was weighted and dissolved in 10 liter water.

#### **3.4.5 Potassium Nitrate (KNO<sub>3</sub>) 1 %**

For preparation of 1 % solution of KNO<sub>3</sub>, 10 g KNO<sub>3</sub> was weighted and dissolved in 1 liter water. For preparation of 10 liter solution of 1 % KNO<sub>3</sub> per treatment, 100 g KNO<sub>3</sub> was weighted and dissolved in 10 liter water.

#### **3.4.6 Potassium Nitrate (KNO<sub>3</sub>) 2 %**

For preparation of 2 % solution of KNO<sub>3</sub>, 20 g KNO<sub>3</sub> was weighted and dissolved in 1 liter water. For preparation of 10 liter solution of 2 % KNO<sub>3</sub> per treatment, 200 g KNO<sub>3</sub> was weighted and dissolved in 10 liter water.

#### **3.4.7 Gibberellic Acid (GA<sub>3</sub>) 25 mg/l**

For preparing 10 liter solution of 25 mg/l GA<sub>3</sub> per treatment, first prepared a stock solution of the concentration of gibberellic acid. The required quantity of 250 mg Gibberellic acid weighted separately and dissolved it in 95 per cent ethyl alcohol. After dissolve of the GA<sub>3</sub>, final volume was made up of 10 liter with water in the bucket just before spray.

#### **3.4.8 Gibberellic Acid (GA<sub>3</sub>) 50mg/l**

For preparing 10 liter solution of 50 mg/l GA<sub>3</sub> per treatment, first prepared a stock solution of the concentration of gibberellic acid. The required quantity of 500 mg gibberellic acid weighted separately and dissolved it in 95 per cent ethyl alcohol. After dissolve of the GA<sub>3</sub>, final volume was made up of 10 liter with water in bucket just before spray.

#### **3.4.9 Ethrel 0.1 ml/l**

For preparation of 0.1 ml/l solution of ethrel, 0.1 ml ethrel was measured by measuring cylinder and dissolved in 1 liter water. For preparing 10 liter solution of 0.1 ml/l ethrel per treatment, 1.0 ml ethrel was measured by measuring cylinder and dissolved in 10 liter water.

#### **3.4.10 Ethrel 0.2 ml/l**

For preparation of 0.2 ml/l solution of ethrel, 0.2 ml ethrel was measured by measuring cylinder and dissolved in 1 liter water. For preparing 10 liter solution of 0.2 ml/l ethrel per treatment, 2.0 ml ethrel was measured by measuring cylinder and dissolved in 10 liter water.

### **3.5 APPLICATION OF CHEMICALS AND PLANT GROWTH REGULATORS**

The plant growth regulator *i. e.* gibberellic acid (GA<sub>3</sub>) was sprayed in the form of foliar application as per treatments on trees at marble stage by foot sprayer on 21<sup>st</sup> March 2016 in evening time whereas other chemicals viz. Calcium Chloride (CaCl<sub>2</sub>), Calcium Nitrate [Ca(NO<sub>3</sub>)<sub>2</sub>] and Potassium nitrate (KNO<sub>3</sub>) and plant growth regulators *i. e.* ethrel were sprayed in the form of foliar application as per treatments on trees 20 days before expected harvesting date by foot sprayer on 21<sup>st</sup> May 2016 in the evening time.

### **3.6 Harvesting and selection of fruits**

Mature uniform sized and fresh mango fruits of Amrapali per tree were harvested on 11<sup>th</sup> June 2016 and fruits were kept in the laboratory from harvesting to fully maturity stage. All observations regarding physical and biochemical parameters of fruits were recorded in P. G. laboratory under ambient storage condition.

### **3.7 METHODOLOGY ADOPTED IN RECORDING OBSERVATION**

#### **3.7.1 PHYSICAL PARAMETERS**

##### **3.7.1.1. Fruit length (cm)**

The length of the fruit was taken at harvest (maturity stage) and at fully ripening stage. The length of ten fruits per treatment was recorded in centimeter by using Vernier Calipers. The average fruit length was recorded in centimeter.

##### **3.7.1.2. Fruit diameter (cm)**

The diameter of the fruit was taken at harvest (maturity stage) and at fully ripening stage. The diameters of ten fruits per treatment were recorded in centimeter by using Vernier Calipers. The average fruit diameter was recorded in centimeter.

##### **3.7.1.3. Fruit Volume (cc)**

The volumes of ten fruits per treatment were measured at harvest (maturity stage) and at fully ripening stage by the water displacement method. Fruit was placed in measuring cylinder filled with full of 1 liter water. The fruit was placed in cylinder, the replaced water was measured as volume of fruits in cubic centimeter (cc) and the average fruit volume was calculated.

##### **3.7.1.4. Fruit weight (g)**

The fifteen marketable fruits per treatment were randomly selected and fruit weight was recorded in gram at harvest (maturity stage) and every day up to fully ripening stage by using electrical weighing balance.

##### **3.7.1.5. Physiological loss in weight (%)**

Fruit weight of ten fruits per treatment was recorded at harvest and every day up to fully ripening stage. The loss in weight was calculated by following formula. The loss in weight (on basis of original weight of fruits) expressed in percentage.

$$\text{PLW (\%)} = \frac{\text{Initial fruit weight (g)} - \text{Final fruit weight (g)}}{\text{Initial fruit weight (g)}} \times 100$$

##### **3.7.1.6. Shelf life of fruit (days)**

The shelf life of ten fruits per treatment was recorded by keeping the fruits at room temperature *i.e.* ambient storage condition. Shelf life of fruit was considered as

number of days from harvesting to marketable fruits or optimum eating stage (till the decaying of fruits started).

#### **3.7.1.7. Marketable fruit (%)**

The marketable percentage of fruits was recorded at harvest (maturity stage) and every day up to fully ripening stage under ambient storage by the counting number of fruits which were attained the eating stage by visual observations at room temperature. It was expressed as percentage over the total number of fruits.

#### **3.7.1.8. Spoilage (%)**

The numbers of visibly diseased, rotten and spoiled fruits were counted out from total number of fruits at harvest (maturity stage) and every day up to fully ripening stage under ambient storage condition and it was expressed as percentage basis.

### **3.7.2 QUALITY PARAMETERS**

#### **3.7.2.1 Total Soluble Solids (°Brix)**

Total Soluble Solids (TSS) of fruit was recorded by using hand refractometer. Drop of extracted mango juice was put on the hand refractometer prism (Erma Tokyo A °32) and reading was recorded and expressed in terms of degree °Brix. Five readings were taken in each treatment and their average value was calculated.

#### **3.7.2.2. Reducing sugar (%)**

The titrametric method of Lane and Eynon described by Ranganna (1979) was adopted for estimation of reducing sugar, which is given as under:

#### **Principle of the method**

Invert sugar or reducing sugar reduces copper in the Fehling's solution to red insoluble cuprous oxide. The sugar in a sample was estimated by determining the volume of unknown sugar solution required to completely reduce a measured volume of Fehling's solution.

In advance, the mixture of Fehling's solution A and B (5 ml of A and 5 ml of B) was standardized against standard glucose for obtaining glucose equivalents and to arrive at a conversion factor.

**Procedure**

25 g of the homogenized pulp was taken in 250 ml volumetric flask and 2 ml of 45 per cent basic lead acetate solution added for clarification. After 10 minutes, the solution was de-leaded by adding potassium oxalate crystals in excess and the volume was made up with distilled water up to 250 ml. It was then filtered through Whatman No.1 filter paper. The filtrate was taken in a burette and titrated against boiling Fehling's mixture (5 ml of Fehling's solution A and 5 ml of Fehling's solution B) till the blue colour faded. Then 2-3 drop methylene blue indicator (1 %) was added and then titration continued till the contents attained a brick red colour. At this stage the titrate value was noted and percentage reducing sugar calculated by following formula:

$$\text{Reducing Sugar (\%)} = \frac{\text{Glucose equivalent (0.05) X Total Volume made up}}{\text{Titer X Weight of pulp}} \times 100$$

**3.7.2.3 Total sugars (%)**

For estimation of total sugars, the filtrate obtained in the estimation of reducing sugar was used. The total sugars of the filtrate were estimated by standardized Fehling's solution A and B using methylene blue indicator as per the procedure described below.

**Procedure**

An aliquot of 25 ml from the filtrate was taken and one-fifth of its volume of 5 ml hydrochloric acid (1:1) added and the inversion was carried out at room temperature for 24 hours. Subsequently, the contents were cooled and neutralized with 40 percent sodium hydroxide using phenolphthalein as indicator and the final volume was made up to 100 ml. The solution was filtered through Whatman No. 1 filter paper and then titrated against boiling Fehling's mixture as described earlier.

The percentage of total sugars was expressed as invert sugar according to the following formula.

$$\text{Total Sugar (\%)} = \frac{\text{Glucose eq. Fehling solutions (0.05)}}{\text{Titre taken}} \times \frac{\text{Total volume made up}}{\text{Weight of pulp for inversion}} \times \frac{\text{Volume made up after inversion}}{\text{Aliquot take}} \times 100$$

#### 3.7.2.4 Non-reducing sugar (%)

It was calculated by subtracting the values of the reducing sugar from total sugars of the pulp from each sample separately.

#### 3.7.2.5. Ascorbic Acid (mg/100 g pulp)

The ascorbic acid content in the juice was determined titrimetrically using 2, 6-dichlorophenol indophenol dye described by Ranganna (1979). The dye solution was standardized against vitamin C content.

##### Sample preparation:

It included transfer of 10 g of homogenized sample into a 100 ml volumetric flask. The volume was made up to 100 ml by adding 3 percent oxalic acid solution. A known volume 10 ml of aliquot was drawn and used for titration.

The freshly prepared dye (2, 6-dichlorophenol indophenol) was standardized by titrating against standard Vitamin C (freshly prepared) and the dye factor was calculated.

A known volume (10 ml) of aliquot was taken in to a 100 ml conical flask was titrated against the standardized dye solution. Titration was continued till the light pink colour persists.

The vitamin C content was calculated by using the following formula.

$$\text{Ascorbic Acid (mg/100 g pulp)} = \frac{\text{Titrate value} \times \text{dye factor} \times \text{volume made up}}{\text{Aliquot taken for estimation} \times \text{weight of sample taken}} \times 100$$

#### 3.7.2.6. Acidity

The method described by Ranganna (1979) was adopted. Five gram of the homogenized pulp was taken and transferred to a 100 ml volumetric flask and the volume was made up with distilled water. The solution was centrifuged and the clear supernatant aliquot was taken in a beaker and titrated against standard 0.1 N NaOH

using phenolphthalein as an indicator. The titrable acidity was expressed in terms of percentage citric acid equivalent by adopting following formula.

$$\text{Acidity (\%)} = \frac{\text{Titre} \times \text{Normality of alkali}}{\text{Volume of sample taken}} \times \frac{\text{Volume made up}}{\text{Weight of sample}} \times \frac{\text{Eq. of citric acid}}{1000} \times 100$$

### **3.8 STATISTICAL ANALYSIS**

The data collected on different parameters were subjected to statistical analysis of variance technique as described by Steel and Torrie (1980). The method of “Analysis of Variance” for Completely Randomized Design was used and treatment effects of all the characters were studied by employing ‘F’ test.

Five percent level of significance was used to test the “null hypothesis “for significance of results. The critical difference was calculated where the difference among the treatments was found significant by ‘F’ test. The C.V. percent was also worked out.

## 4. RESULT AND DISCUSSION

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The present investigation on “**Effect of preharvest application of chemicals and plant growth regulators on fruit quality and shelf life of mango (*Mangifera indica* L.)**” carried out during summer season of the year 2016 at Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat. Mature uniform sized fruits per tree were harvested and fruits were kept in laboratory under ambient condition. All observations regarding physical and biochemical parameters of fruits were recorded in Post Graduate laboratory. The data collected on various characters during the experiment were statistically analysed and the results obtained are presented in tables. For the conveniences, the entire chapter has been divided under following sub heads:

### 4.1 PHYSICAL PARAMETERS

### 4.2 QUALITY PARAMETERS

#### 4.1 PHYSICAL PARAMETERS

The data were recorded on physical parameters viz., fruit length (cm), fruit volume (cc), fruit diameter (cm), fruit weight (g), physiological loss in weight (%), shelf life of fruit (days), marketable fruits (%) and spoilage (%) are presented as under:

##### 4.1.1 Fruit length (cm)

The data pertaining to the fruit length of mango were recorded at harvest and at fully ripening stage under ambient storage condition influenced by preharvest application of various chemicals and plant growth regulators are presented in Table 4.1.

The effect of chemicals and plant growth regulators on fruit length of mango was found significant influenced at harvest and at fully ripening stage. Among all the treatments, GA<sub>3</sub> 25 mg/l recorded significantly highest fruit length at harvest (10.20 cm) and at fully ripening stage (10.16 cm) as compared to another treatments. It was statistically at par with treatment of KNO<sub>3</sub> 1 %, ethrel 0.2 ml/l, GA<sub>3</sub> 50 mg/l, Ca(NO<sub>3</sub>)<sub>2</sub> 1 % and Ca(NO<sub>3</sub>)<sub>2</sub> 2 % at harvest and fully ripening stage, whereas the

lowest fruit length at harvest (8.32 cm) and at fully ripening stage (8.29 cm) were recorded in control treatment under ambient storage condition.

The fruits preharvest sprayed with GA<sub>3</sub> 25 mg/l observed significantly highest fruit length at harvest (10.20 cm) which is decreased during storage but remained significantly highest at fully ripening stage (10.16 cm) under ambient storage condition. It might be due to gibberellic acid promotes the cell elongation and cell enlargement of fruit. According to Brahmchari and Rani (2000), GA<sub>3</sub> level in developing cell is low hence, the exogenous applied GA<sub>3</sub> helps to increase its level in different parts of the fruits which ultimate helps its growth. Similar result were also reported by Bhomick and Banik (2011) in mango and Lal *et al.* (2013) in guava.

**Table 4.1 Effect of preharvest application of different chemicals and plant growth regulators on fruit length (cm.), fruit volume (cc.) and fruit diameter (cm.) of mango cv. Amrapali**

Treatments	Fruit length (cm)		Fruit diameter (cm)		Fruit volume (cc)	
	At harvest	At fully ripening stage	At harvest	At fully ripening stage	At harvest	At fully ripening stage
T <sub>1</sub> : CaCl <sub>2</sub> 1 %	9.45 <sup>cde</sup>	9.41 <sup>cd</sup>	6.05 <sup>ab</sup>	6.02 <sup>ab</sup>	126.33 <sup>de</sup>	101.58 <sup>de</sup>
T <sub>2</sub> : CaCl <sub>2</sub> 2 %	9.27 <sup>de</sup>	9.25 <sup>d</sup>	5.53 <sup>c</sup>	5.50 <sup>cd</sup>	124.61 <sup>e</sup>	104.16 <sup>cd</sup>
T <sub>3</sub> : Ca(NO <sub>3</sub> ) <sub>2</sub> 1%	9.83 <sup>abc</sup>	9.80 <sup>abc</sup>	6.13 <sup>a</sup>	6.08 <sup>ab</sup>	127.87 <sup>cde</sup>	104.12 <sup>cd</sup>
T <sub>4</sub> : Ca(NO <sub>3</sub> ) <sub>2</sub> 2%	9.80 <sup>abc</sup>	9.77 <sup>abc</sup>	6.06 <sup>ab</sup>	6.04 <sup>ab</sup>	133.73 <sup>c</sup>	111.29 <sup>b</sup>
T <sub>5</sub> : KNO <sub>3</sub> 1 %	10.05 <sup>ab</sup>	10.01 <sup>ab</sup>	5.44 <sup>cd</sup>	5.41 <sup>de</sup>	148.88 <sup>ab</sup>	129.95 <sup>a</sup>
T <sub>6</sub> : KNO <sub>3</sub> 2 %	9.65 <sup>bcd</sup>	9.62 <sup>bcd</sup>	5.90 <sup>ab</sup>	5.87 <sup>ab</sup>	123.10 <sup>e</sup>	98.22 <sup>e</sup>
T <sub>7</sub> : Ethrel 0.1 ml/l	9.25 <sup>e</sup>	9.21 <sup>d</sup>	5.95 <sup>ab</sup>	5.93 <sup>ab</sup>	115.43 <sup>f</sup>	101.43 <sup>de</sup>
T <sub>8</sub> : Ethrel 0.2 ml/l	9.99 <sup>ab</sup>	9.96 <sup>ab</sup>	5.82 <sup>b</sup>	5.78 <sup>bc</sup>	142.23 <sup>b</sup>	126.33 <sup>a</sup>
T <sub>9</sub> : GA <sub>3</sub> 25 mg/l	10.20 <sup>a</sup>	10.16 <sup>a</sup>	6.16 <sup>a</sup>	6.14 <sup>a</sup>	150.54 <sup>a</sup>	130.62 <sup>a</sup>
T <sub>10</sub> : GA <sub>3</sub> 50 mg/l	9.85 <sup>abc</sup>	9.82 <sup>abc</sup>	5.96 <sup>ab</sup>	5.93 <sup>ab</sup>	131.88 <sup>cd</sup>	107.42 <sup>bc</sup>
T <sub>11</sub> : Control	8.32 <sup>f</sup>	8.29 <sup>e</sup>	5.23 <sup>d</sup>	5.21 <sup>e</sup>	101.02 <sup>g</sup>	77.73 <sup>f</sup>
<b>S. Em. ±</b>	0.12	0.13	0.09	0.09	2.11	1.61
<b>F-test</b>	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
<b>C. V. %</b>	<b>2.22</b>	<b>2.28</b>	<b>2.65</b>	<b>2.65</b>	<b>2.82</b>	<b>2.57</b>

**Note:** Treatment means with the letter/letters in common are not significantly different by Duncan's New Multiple Range Test at 5 % level of significance.

#### 4.1.2 Fruit diameter (cm)

The data pertaining to the fruit diameter of mango were recorded at harvest and at fully ripening stage under ambient storage condition influenced by preharvest



**Plate 4.1 Physical appearance of mango cv. Amrapali fruits preharvest sprayed with different chemicals and plant growth regulators at harvest stage**



**Plate 4.2 Physical appearance of mango cv. Amrapali fruits preharvest sprayed with different chemicals and plant growth regulators at fully ripening stage**



**Fruit length (cm)**



**Fruit volume (cc)**



**Fruit diameter (cm)**



**Fruit weight (g)**

**Plate 4.3 Measurement of fruit length (cm), fruit volume (cc), fruit diameter (cm) and fruit weight (g)**

application of various chemicals and plant growth regulators are presented in Table 4.1.

The chemicals and plant growth regulators were significantly influenced on fruit diameter of mango at harvest and at fully ripening stage. Among all the treatments, GA<sub>3</sub> 25 mg/l had significantly highest fruit diameter at harvest (6.16 cm) and at fully ripening stage (6.14 cm) as compared to another treatments. It was statistically at par with treatment of Ca(NO<sub>3</sub>)<sub>2</sub> 1 %, Ca(NO<sub>3</sub>)<sub>2</sub> 2 %, CaCl<sub>2</sub> 1 %, GA<sub>3</sub>, 50 mg/l, etrel 0.1 ml/l and KNO<sub>3</sub> 2 % at harvest and at fully ripening stage, whereas the lowest fruit diameter at harvest (5.23 cm) and at fully ripening stage (5.21 cm) were recorded in control under ambient storage condition.

Preharvest sprayed with GA<sub>3</sub> 25 mg/l reported significantly maximum fruit diameter at harvest (6.16 cm) which slightly decrease but remain significantly maximum at fully ripening stage (6.14 cm). It might be due to gibberellic acid promotes the cell elongation and cell enlargement of fruit (Jagtap *et al.* 2013).

#### **4.1.3 Fruit volume (cc)**

The data pertaining to the fruit volume of mango were recorded at harvest and at fully ripening stage under ambient storage condition influenced by preharvest application of various chemicals and plant growth regulators are presented in Table 4.1.

The chemicals and plant growth regulators had significant effect on fruit volume of mango at harvest and at fully ripening stage. Among all the treatments, the significantly maximum fruit volume was recorded with GA<sub>3</sub> 25 mg/l at harvest (150.54 cc) and at fully ripening stage (130.62 cc) as compared to another treatments. It was statistically at par with treatment of KNO<sub>3</sub> 1 % and etrel 0.2 ml/l at harvest while, KNO<sub>3</sub> 1 % was also statistically at par at fully ripening stage. The minimum fruit volume at harvest (101.02 cc) and at fully ripening stage (77.73 cc) were recorded in control under ambient storage condition.

The fruits preharvest sprayed with GA<sub>3</sub> 25 mg/l reported significantly highest fruit volume at harvest (150.54 cc) which decreased but remained significantly highest at fully ripening stage (130.62 cc) among all the treatments. It might be due to the increased volume of fruit with GA<sub>3</sub> spray was possibly due to accelerated rate of fruit growth. Exogenous application of GA<sub>3</sub> promoted cell enlargement and cell division. Treated fruits gained more weight and volume also due to increase in cell volume and

greater accumulation of water and foods materials as reported by Brahmachari and Rani (2000) in Litchi fruits. The present investigation is in conformity with the result reported by Singh *et al.* (2009) and Katiyar *et al.* (2008) in guava.

#### **4.1.4 Fruit weight (g)**

The data pertaining to the fruit weight of mango were recorded at harvest and every day up to last ripening stage (at harvest up to 16<sup>th</sup> day) under ambient storage condition influenced by preharvest application of various chemicals and plant growth regulators are presented in Table 4.2.

The chemicals and plant growth regulators showed significant effect on fruit weight of mango at harvest and at everyday up to last ripening stage. Among all the treatments, GA<sub>3</sub> 25 mg/l recorded significantly maximum fruit weight consistently at harvest (170.50 g), 2<sup>nd</sup> day (167.18 g), 3<sup>rd</sup> day (164.14 g), 4<sup>th</sup> day (160.34 g), 5<sup>th</sup> day (158.99 g), 6<sup>th</sup> day (156.38 g), 7<sup>th</sup> day (153.79 g), 8<sup>th</sup> (150.46 g), 9<sup>th</sup> day (147.31 g), 10<sup>th</sup> day (145.02 g), 11<sup>th</sup> day (143.41 g), 12<sup>th</sup> day (142.22 g), 13<sup>th</sup> day (135.37 g), 14<sup>th</sup> day (135.29 g), 15<sup>th</sup> day (132.86 g) and 16<sup>th</sup> day (130.92 g) during storage period. However, GA<sub>3</sub> 25 mg/l treatment was statistically superior over all other treatments at harvest and it was statistically at par with KNO<sub>3</sub> 1 % from 2<sup>nd</sup> day up to 12<sup>th</sup> day and 15<sup>th</sup> and 16<sup>th</sup> day, KNO<sub>3</sub> 1 %, GA<sub>3</sub> 50 mg/l and ethrel 0.2 ml/l at 13<sup>th</sup> day and KNO<sub>3</sub> 1 % & GA<sub>3</sub> 50 mg/l at 14<sup>th</sup> day during storage period. The lowest fruit weight at harvest and everyday up to 16<sup>th</sup> day were found in control under ambient storage condition.

The significantly highest fruit weight was recorded with the preharvest sprayed of GA<sub>3</sub> 25 mg/l at harvest (170.50 g). It might be due to the fact that gibberellic acid promotes the cell elongation and cell enlargement of fruit. Similar result was also reported by Jagtap *et al.* (2013) in Kagzi lime and Lal *et al.* (2013) in guava. The fruit weight decreased gradually during storage period up to 16<sup>th</sup> day but GA<sub>3</sub> 25 mg/l treatment recorded significantly highest fruit weight at harvest subsequently up to last ripening stage.

#### **4.1.5 Physiological loss in weight (%)**

The data pertaining to the physiological loss in weight (%) of mango fruits as influenced by preharvest application of various chemicals and plant growth regulators were recorded at harvest and everyday up to last ripening stage (at 2<sup>nd</sup> day up to 16<sup>th</sup> day) under ambient storage condition are presented in Table 4.3.

There were significant differences in physiological loss in weight due to various chemicals and plant growth regulators of mango fruit at harvest and at everyday up to 16<sup>th</sup> day. Among all the treatments, CaCl<sub>2</sub> 2 % consistently recorded significantly minimum physiological loss in weight of mango fruit at 2<sup>nd</sup> day (1.12 %), 3<sup>rd</sup> day (2.13 %), 4<sup>th</sup> day (4.33 %), 5<sup>th</sup> day (5.43 %), 6<sup>th</sup> day (6.53 %), 7<sup>th</sup> day (7.66 %), 8<sup>th</sup> (9.15 %), 9<sup>th</sup> day (10.26 %), 10<sup>th</sup> day (11.47 %), 11<sup>th</sup> day (12.44 %), 12<sup>th</sup> day (14.35 %), 13<sup>th</sup> day (15.66 %), 14<sup>th</sup> day (16.66 %), 15<sup>th</sup> day (18.48 %) and 16<sup>th</sup> day (19.91 %) as compared to rest of the treatments. However, CaCl<sub>2</sub> 2 % was statistically superior over all the treatments at 2<sup>nd</sup> day, 3<sup>rd</sup> day and 5<sup>th</sup> day, it was statistically at par with the treatment of KNO<sub>3</sub> 2 % and control at 4<sup>th</sup> day, KNO<sub>3</sub> 2 % from 6<sup>th</sup> to 12<sup>th</sup> day, 15<sup>th</sup> day and 16<sup>th</sup> day and KNO<sub>3</sub> 2 % and Ca(NO<sub>3</sub>)<sub>2</sub> 1 % at 13<sup>th</sup> day and 14<sup>th</sup> day during storage period. The maximum physiological loss in weight of mango fruit at 2<sup>nd</sup> day was found in the treatment of CaCl<sub>2</sub> 1 %, ethrel 0.1 ml/l at 3<sup>rd</sup> day and ethrel 0.2 ml/l recorded at 4<sup>th</sup> day and up to 16<sup>th</sup> day under ambient storage condition.

The percent physiological loss in weight indicates the process of ripening in climacteric fruits. The highest percent physiological loss in weight increases the ripening. The percent physiological loss in weight is collective effect of respiration and transpiration process facilitating the ripening as one of the intermediate physiological development phase of the fruit (Pawar and Hashmi 2010). In present investigation, the preharvest spray with CaCl<sub>2</sub> 2 % reduced the percent physiological loss in weight at harvest (1.12 %) subsequently up to last ripening stage as compared to rest of the treatments under ambient storage condition. The decrease in weight loss by application of calcium might be due to its role in the maintenance of the fruit firmness, retardation of respiratory rate and delayed senescence (Yadav *et al.* 2009). Similar view was also reported by Ramkrishna *et al.* (2001) in papaya and Kirmani *et al.* (2013) in plum respectively.

Table 4.2 Effect of preharvest application of different chemicals and plant growth regulators on fruit weight (g) of mango cv. Amrapali

Treatments	Storage period (Days)															
	At harvest	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>	6 <sup>th</sup>	7 <sup>th</sup>	8 <sup>th</sup>	9 <sup>th</sup>	10 <sup>th</sup>	11 <sup>th</sup>	12 <sup>th</sup>	13 <sup>th</sup>	14 <sup>th</sup>	15 <sup>th</sup>	16 <sup>th</sup>
T <sub>1</sub> : CaCl <sub>2</sub> 1 %	137.7 <sup>e</sup>	134.64 <sup>de</sup>	132.45 <sup>fg</sup>	129.93 <sup>fg</sup>	128.54 <sup>ef</sup>	126.57 <sup>ef</sup>	125.08 <sup>ef</sup>	122.32 <sup>ef</sup>	121.44 <sup>ef</sup>	120.03 <sup>ef</sup>	117.27 <sup>fg</sup>	115.05 <sup>fg</sup>	113.63 <sup>cd</sup>	112.01 <sup>ef</sup>	110.94 <sup>cd</sup>	108.30 <sup>de</sup>
T <sub>2</sub> : CaCl <sub>2</sub> 2 %	138.1 <sup>e</sup>	136.28 <sup>d</sup>	134.32 <sup>ef</sup>	132.25 <sup>efg</sup>	130.23 <sup>ef</sup>	128.85 <sup>def</sup>	127.43 <sup>def</sup>	125.36 <sup>def</sup>	123.95 <sup>def</sup>	122.29 <sup>de</sup>	120.92 <sup>def</sup>	117.91 <sup>ef</sup>	115.11 <sup>cd</sup>	113.70 <sup>def</sup>	112.17 <sup>cd</sup>	109.83 <sup>cd</sup>
T <sub>3</sub> : Ca(NO <sub>3</sub> ) <sub>2</sub> 1%	146.2 <sup>d</sup>	143.68 <sup>c</sup>	141.53 <sup>de</sup>	139.13 <sup>de</sup>	135.99 <sup>de</sup>	133.98 <sup>cde</sup>	131.92 <sup>cde</sup>	129.63 <sup>cde</sup>	127.69 <sup>cde</sup>	125.70 <sup>de</sup>	124.03 <sup>cdef</sup>	122.52 <sup>cdef</sup>	121.60 <sup>bc</sup>	119.92 <sup>cde</sup>	117.66 <sup>c</sup>	113.82 <sup>cd</sup>
T <sub>4</sub> : Ca(NO <sub>3</sub> ) <sub>2</sub> 2%	149.3 <sup>d</sup>	146.78 <sup>c</sup>	144.72 <sup>cd</sup>	142.15 <sup>cd</sup>	140.26 <sup>cd</sup>	137.51 <sup>cd</sup>	134.98 <sup>cd</sup>	133.18 <sup>cd</sup>	131.38 <sup>cd</sup>	129.61 <sup>cd</sup>	126.97 <sup>cde</sup>	125.35 <sup>cde</sup>	123.47 <sup>bc</sup>	121.87 <sup>bcdee</sup>	119.17 <sup>bc</sup>	117.53 <sup>cd</sup>
T <sub>5</sub> : KNO <sub>3</sub> 1 %	164.4 <sup>b</sup>	162.63 <sup>a</sup>	158.75 <sup>ab</sup>	156.05 <sup>ab</sup>	153.93 <sup>ab</sup>	151.87 <sup>ab</sup>	147.80 <sup>ab</sup>	145.14 <sup>ab</sup>	143.30 <sup>ab</sup>	141.33 <sup>ab</sup>	138.53 <sup>ab</sup>	137.22 <sup>ab</sup>	134.76 <sup>a</sup>	132.54 <sup>ab</sup>	130.53 <sup>ab</sup>	128.91 <sup>ab</sup>
T <sub>6</sub> : KNO <sub>3</sub> 2 %	138.6 <sup>e</sup>	135.89 <sup>d</sup>	134.52 <sup>ef</sup>	132.51 <sup>ef</sup>	131.11 <sup>ef</sup>	129.58 <sup>def</sup>	128.04 <sup>def</sup>	125.98 <sup>de</sup>	123.84 <sup>de</sup>	122.63 <sup>de</sup>	119.95 <sup>ef</sup>	118.77 <sup>def</sup>	116.95 <sup>bc</sup>	115.58 <sup>cde</sup>	113.06 <sup>c</sup>	111.06 <sup>cd</sup>
T <sub>7</sub> : Ethrel 0.1ml/l	132.4 <sup>f</sup>	130.26 <sup>e</sup>	126.00 <sup>gh</sup>	124.25 <sup>gh</sup>	122.97 <sup>fg</sup>	120.95 <sup>fg</sup>	118.93 <sup>fg</sup>	116.65 <sup>fg</sup>	114.73 <sup>fg</sup>	112.40 <sup>fg</sup>	109.76 <sup>gh</sup>	107.87 <sup>gh</sup>	106.01 <sup>de</sup>	104.27 <sup>fg</sup>	101.73 <sup>de</sup>	99.36 <sup>ef</sup>
T <sub>8</sub> : Ethrel 0.2ml/l	158.4 <sup>c</sup>	155.63 <sup>b</sup>	151.67 <sup>bc</sup>	147.57 <sup>bcd</sup>	145.62 <sup>bc</sup>	143.27 <sup>bc</sup>	140.60 <sup>bc</sup>	136.86 <sup>bc</sup>	134.51 <sup>bc</sup>	133.08 <sup>bc</sup>	130.74 <sup>bc</sup>	128.89 <sup>bc</sup>	125.73 <sup>ab</sup>	123.97 <sup>bcd</sup>	120.67 <sup>bc</sup>	118.65 <sup>bcd</sup>
T <sub>9</sub> : GA <sub>3</sub> 25 mg/l	170.5 <sup>a</sup>	167.18 <sup>a</sup>	164.14 <sup>a</sup>	160.34 <sup>a</sup>	158.99 <sup>a</sup>	156.38 <sup>a</sup>	153.79 <sup>a</sup>	150.46 <sup>a</sup>	147.31 <sup>a</sup>	145.02 <sup>a</sup>	143.41 <sup>a</sup>	142.22 <sup>a</sup>	135.37 <sup>a</sup>	135.29 <sup>a</sup>	132.86 <sup>a</sup>	130.92 <sup>a</sup>
T <sub>10</sub> : GA <sub>3</sub> 50 mg/l	155.8 <sup>c</sup>	153.23 <sup>b</sup>	150.06 <sup>c</sup>	148.13 <sup>bc</sup>	145.59 <sup>bc</sup>	142.74 <sup>bc</sup>	140.21 <sup>bc</sup>	137.18 <sup>bc</sup>	135.03 <sup>bc</sup>	133.08 <sup>bc</sup>	130.54 <sup>bcd</sup>	128.65 <sup>bcd</sup>	126.81 <sup>ab</sup>	124.70 <sup>abc</sup>	120.86 <sup>bc</sup>	119.42 <sup>bc</sup>
T <sub>11</sub> : Control	124.9 <sup>g</sup>	123.29 <sup>f</sup>	121.83 <sup>b</sup>	119.5 <sup>b</sup>	116.9 <sup>g</sup>	115.8 <sup>g</sup>	113.36 <sup>g</sup>	111.93 <sup>g</sup>	109.60 <sup>g</sup>	107.42 <sup>g</sup>	105.0 <sup>b</sup>	103.9 <sup>h</sup>	102.1 <sup>e</sup>	100.4 <sup>g</sup>	96.65 <sup>e</sup>	96.00 <sup>f</sup>
<b>S. Em. ±</b>	1.55	1.68	2.28	2.53	2.68	2.76	2.83	2.86	2.91	2.78	2.91	2.97	3.00	3.16	3.44	3.14
<b>F-test</b>	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
<b>C. V. %</b>	<b>1.83</b>	<b>2.01</b>	<b>2.79</b>	<b>3.15</b>	<b>3.38</b>	<b>3.53</b>	<b>3.68</b>	<b>3.79</b>	<b>3.92</b>	<b>3.81</b>	<b>4.05</b>	<b>4.19</b>	<b>4.33</b>	<b>4.61</b>	<b>5.14</b>	<b>4.78</b>

**Note:** Treatment means with the letter/letters in common are not significantly different by Duncan's New Multiple Range Test at 5 % level of significance.

**Table 4.3 Effect of preharvest application of different chemicals and plant growth regulators on physiological loss in weight (%) of fruit of mango cv. Amrapali**

Treatments	Storage period (Days)														
	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>	6 <sup>th</sup>	7 <sup>th</sup>	8 <sup>th</sup>	9 <sup>th</sup>	10 <sup>th</sup>	11 <sup>th</sup>	12 <sup>th</sup>	13 <sup>th</sup>	14 <sup>th</sup>	15 <sup>th</sup>	16 <sup>th</sup>
T <sub>1</sub> : CaCl <sub>2</sub> 1 %	2.24 <sup>a</sup>	3.85 <sup>c</sup>	5.68 <sup>c</sup>	6.68 <sup>de</sup>	8.11 <sup>bcd</sup>	9.19 <sup>b</sup>	11.22 <sup>bc</sup>	11.85 <sup>c</sup>	12.85 <sup>d</sup>	14.87 <sup>d</sup>	16.48 <sup>bc</sup>	17.51 <sup>cde</sup>	18.68 <sup>def</sup>	19.47 <sup>cd</sup>	21.38 <sup>cd</sup>
T <sub>2</sub> : CaCl <sub>2</sub> 2 %	1.12 <sup>f</sup>	2.13 <sup>h</sup>	4.33 <sup>g</sup>	5.43 <sup>h</sup>	6.53 <sup>g</sup>	7.66 <sup>c</sup>	9.15 <sup>d</sup>	10.26 <sup>d</sup>	11.47 <sup>e</sup>	12.44 <sup>e</sup>	14.35 <sup>d</sup>	15.66 <sup>f</sup>	16.66 <sup>g</sup>	18.48 <sup>d</sup>	19.91 <sup>e</sup>
T <sub>3</sub> : Ca(NO <sub>3</sub> ) <sub>2</sub> 1%	1.76 <sup>d</sup>	3.23 <sup>e</sup>	4.87 <sup>de</sup>	7.02 <sup>bc</sup>	8.40 <sup>bc</sup>	9.80 <sup>b</sup>	11.37 <sup>bc</sup>	12.69 <sup>bc</sup>	14.05 <sup>bc</sup>	15.19 <sup>cd</sup>	16.22 <sup>c</sup>	16.85 <sup>def</sup>	18.00 <sup>efg</sup>	19.55 <sup>cd</sup>	22.18 <sup>bc</sup>
T <sub>4</sub> : Ca(NO <sub>3</sub> ) <sub>2</sub> 2%	1.68 <sup>d</sup>	3.10 <sup>e</sup>	4.81 <sup>ef</sup>	6.07 <sup>f</sup>	7.90 <sup>cd</sup>	9.62 <sup>b</sup>	10.82 <sup>bc</sup>	12.01 <sup>c</sup>	13.19 <sup>cd</sup>	14.95 <sup>cd</sup>	16.04 <sup>c</sup>	17.30 <sup>cde</sup>	18.36 <sup>ef</sup>	20.18 <sup>c</sup>	21.29 <sup>cd</sup>
T <sub>5</sub> : KNO <sub>3</sub> 1 %	1.97 <sup>b</sup>	3.48 <sup>d</sup>	5.12 <sup>d</sup>	6.41 <sup>e</sup>	7.66 <sup>de</sup>	10.13 <sup>b</sup>	11.74 <sup>b</sup>	12.87 <sup>bc</sup>	14.64 <sup>b</sup>	15.77 <sup>bcd</sup>	16.56 <sup>bc</sup>	18.06 <sup>cde</sup>	19.41 <sup>cde</sup>	20.63 <sup>c</sup>	21.62 <sup>cd</sup>
T <sub>6</sub> : KNO <sub>3</sub> 2 %	2.06 <sup>c</sup>	2.72 <sup>f</sup>	4.42 <sup>g</sup>	5.71 <sup>g</sup>	6.71 <sup>fg</sup>	7.74 <sup>c</sup>	9.24 <sup>d</sup>	10.68 <sup>d</sup>	11.56 <sup>e</sup>	13.50 <sup>e</sup>	14.62 <sup>d</sup>	16.65 <sup>ef</sup>	17.67 <sup>fg</sup>	18.78 <sup>d</sup>	20.47 <sup>de</sup>
T <sub>7</sub> : Ethrel 0.1 ml/l	1.63 <sup>ab</sup>	4.83 <sup>a</sup>	6.16 <sup>b</sup>	7.13 <sup>b</sup>	8.66 <sup>b</sup>	10.18 <sup>b</sup>	11.90 <sup>b</sup>	13.35 <sup>b</sup>	15.12 <sup>ab</sup>	17.11 <sup>ab</sup>	18.53 <sup>a</sup>	19.95 <sup>ab</sup>	21.26 <sup>ab</sup>	23.18 <sup>ab</sup>	24.97 <sup>a</sup>
T <sub>8</sub> : Ethrel 0.2 ml/l	1.81 <sup>cd</sup>	4.31 <sup>b</sup>	6.90 <sup>a</sup>	8.13 <sup>a</sup>	9.60 <sup>a</sup>	11.29 <sup>a</sup>	13.65 <sup>a</sup>	15.13 <sup>a</sup>	16.04 <sup>a</sup>	17.52 <sup>a</sup>	18.69 <sup>a</sup>	20.68 <sup>a</sup>	21.79 <sup>a</sup>	23.88 <sup>a</sup>	25.16 <sup>a</sup>
T <sub>9</sub> : GA <sub>3</sub> 25 mg/l	2.00 <sup>bc</sup>	3.79 <sup>c</sup>	6.02 <sup>b</sup>	6.82 <sup>cd</sup>	8.35 <sup>bc</sup>	9.86 <sup>b</sup>	11.81 <sup>b</sup>	13.66 <sup>b</sup>	15.00 <sup>ab</sup>	15.94 <sup>bcd</sup>	16.64 <sup>bc</sup>	18.70 <sup>bc</sup>	20.70 <sup>abc</sup>	22.12 <sup>b</sup>	23.25 <sup>b</sup>
T <sub>10</sub> : GA <sub>3</sub> 50 mg/l	1.70 <sup>d</sup>	3.74 <sup>c</sup>	4.98 <sup>de</sup>	6.60 <sup>de</sup>	8.43 <sup>bc</sup>	10.06 <sup>b</sup>	11.99 <sup>b</sup>	13.37 <sup>b</sup>	14.63 <sup>b</sup>	16.25 <sup>abc</sup>	17.47 <sup>b</sup>	18.65 <sup>bc</sup>	20.04 <sup>bcd</sup>	22.48 <sup>b</sup>	23.41 <sup>b</sup>
T <sub>11</sub> : Control	1.30 <sup>e</sup>	2.35 <sup>g</sup>	4.57 <sup>fg</sup>	6.42 <sup>e</sup>	7.25 <sup>ef</sup>	9.25 <sup>b</sup>	10.40 <sup>c</sup>	12.26 <sup>c</sup>	13.99 <sup>bc</sup>	15.93 <sup>bcd</sup>	16.77 <sup>bc</sup>	18.20 <sup>cd</sup>	19.59 <sup>bcde</sup>	22.63 <sup>ab</sup>	23.14 <sup>b</sup>
<b>S. Em. ±</b>	0.06	0.05	0.08	0.09	0.19	0.30	0.37	0.31	0.35	0.40	0.30	0.45	0.50	0.38	0.43
<b>F-test</b>	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
<b>C. V. %</b>	<b>5.86</b>	<b>2.66</b>	<b>2.59</b>	<b>2.43</b>	<b>4.14</b>	<b>5.50</b>	<b>5.79</b>	<b>4.30</b>	<b>4.39</b>	<b>4.54</b>	<b>3.12</b>	<b>4.31</b>	<b>4.49</b>	<b>3.16</b>	<b>3.29</b>

**Note:** Treatment means with the letter/letters in common are not significantly different by Duncan's New Multiple Range Test at 5 % level of significance.

#### 4.1.6 Shelf life (days)

The result obtained regarding shelf life of fruits under ambient storage condition influenced due to preharvest application of various chemicals and plant growth regulators are furnished in Table 4.4 and also presented in Fig. 4.1.

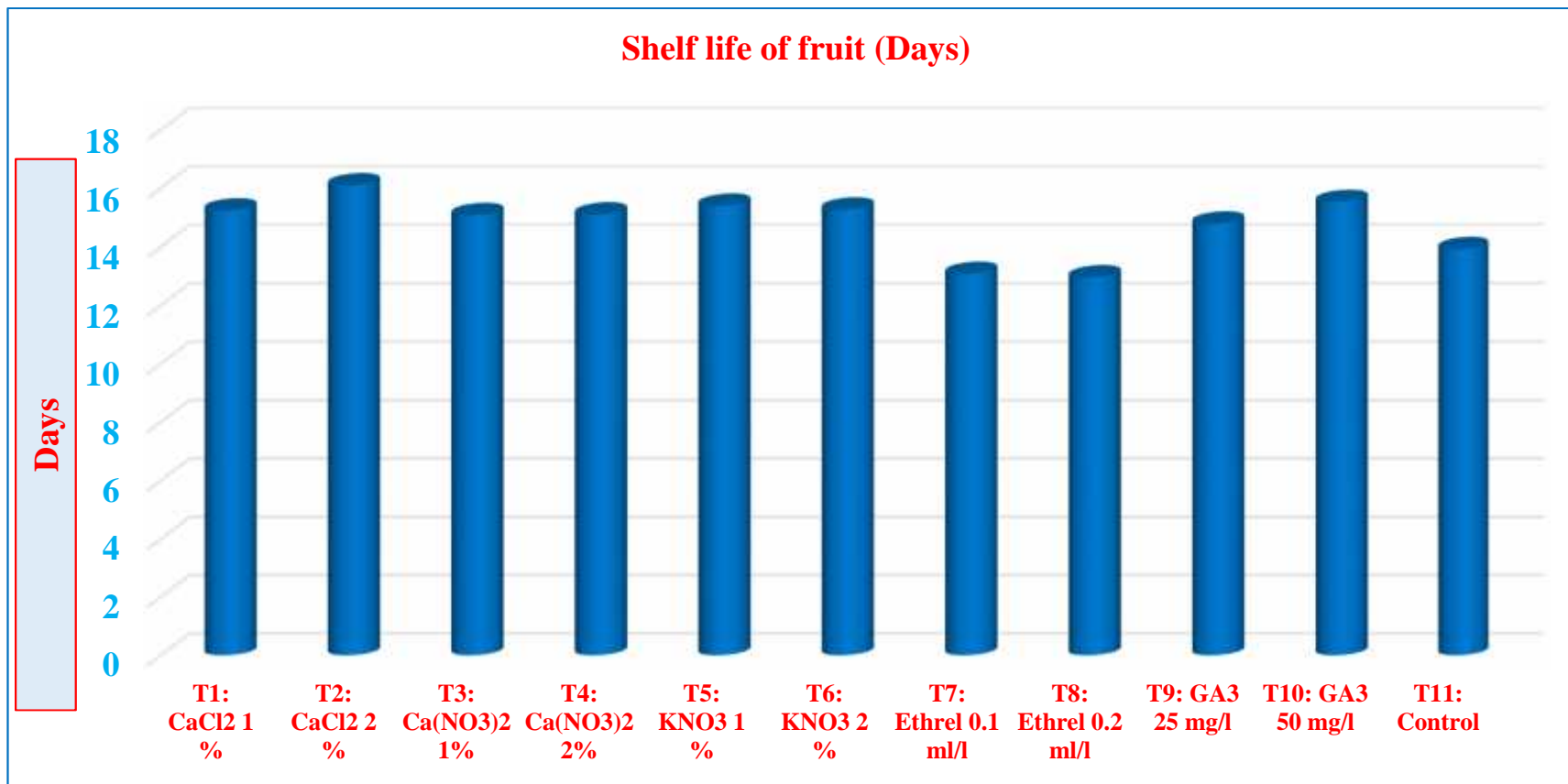
There were significant effect of various chemicals and plant growth regulators observed on shelf life of mango fruit during storage periods.  $\text{CaCl}_2$  2 % was most effective treatment for extending shelf life of mango fruit during storage period among all the treatments and which was recorded significantly maximum shelf life (16.60 days) of fruits as compared to rest of the treatments. It was statistically superior over all other treatments. However, the lowest shelf life (13.45 days) was reported in fruits treated with ethrel 0.2 ml/l.

**Table 4.4 Effect of preharvest application of different chemicals and plant growth regulators on shelf life of fruits (days) of mango cv. Amrapali**

Treatments	Shelf life of fruit (Days)
T <sub>1</sub> : $\text{CaCl}_2$ 1 %	15.74 <sup>bc</sup>
T <sub>2</sub> : $\text{CaCl}_2$ 2 %	16.60 <sup>a</sup>
T <sub>3</sub> : $\text{Ca}(\text{NO}_3)_2$ 1%	15.58 <sup>bc</sup>
T <sub>4</sub> : $\text{Ca}(\text{NO}_3)_2$ 2%	15.60 <sup>bc</sup>
T <sub>5</sub> : $\text{KNO}_3$ 1 %	15.90 <sup>b</sup>
T <sub>6</sub> : $\text{KNO}_3$ 2 %	15.77 <sup>bc</sup>
T <sub>7</sub> : Ethrel 0.1 ml/l	13.57 <sup>e</sup>
T <sub>8</sub> : Ethrel 0.2 ml/l	13.45 <sup>e</sup>
T <sub>9</sub> : $\text{GA}_3$ 25 mg/l	15.29 <sup>c</sup>
T <sub>10</sub> : $\text{GA}_3$ 50 mg/l	16.03 <sup>b</sup>
T <sub>11</sub> : Control	14.42 <sup>d</sup>
<b>S. Em. ±</b>	0.16
<b>F-test</b>	Sig.
<b>C. V. %</b>	<b>1.93</b>

**Note:** Treatment means with the letter/letters in common are not significantly different by Duncan's New Multiple Range Test at 5 % level of significance.

The shelf life of mango fruits was significantly extended when trees were preharvest sprayed with  $\text{CaCl}_2$  2 % (16.60 days) as compared to rest of the treatments under ambient storage condition. As calcium plays a number of roles such as an increase in the fruit firmness which leads benefits like slower ripening and increased the shelf life. The present investigation is in conformity with the results reported by Karemera and Habimana (2014) and Karemera *et al.* (2014) in mango.



**Fig. 4.1 Effect of preharvest application of different chemicals and plant growth regulators on shelf life of fruits (days) of mango cv. Amrapali**

**CaCl<sub>2</sub> 2 %  
Treatment**



**Control  
Treatment**



**At harvest stage**



**4<sup>th</sup> day**



**8<sup>th</sup> day**



**12<sup>th</sup> day**



**16<sup>th</sup> day**

**Plate 4.4 Appearance of preharvest sprayed fruits with CaCl<sub>2</sub> 2 % and control treatment at harvest, 4<sup>th</sup> day, 8<sup>th</sup> day, 12<sup>th</sup> day and 16<sup>th</sup> day under ambient storage condition**

#### 4.1.7 Marketable fruit (%)

The data pertaining to the marketable fruit (%) of mango were recorded at harvest and every day up to last ripening stage (at harvest up to 16<sup>th</sup> day) under ambient storage condition influenced by preharvest application of various chemicals and plant growth regulators are furnished in Table 4.5 and also depicted in Fig. 4.2.

The marketable fruit (%) of mango were significantly influenced by various chemicals and plant growth regulators at harvest and everyday up to last ripening stage. There were 100 % marketable fruits recorded in all the treatments up to 12<sup>th</sup> day of storage periods whereas, fruit sprayed with CaCl<sub>2</sub> 2 % consistently found significantly highest marketable fruit (%) at 13<sup>th</sup> day (90.93 %), 14<sup>th</sup> day (79.55 %), 15<sup>th</sup> day (56.63 %) and 16<sup>th</sup> day (45.16 %) during storage period as compared to rest of the treatments. However, it was statistically at par with treatment of CaCl<sub>2</sub> 1 % at 13<sup>th</sup> day, GA<sub>3</sub> 50 mg/l, GA<sub>3</sub> 25 mg/l, CaCl<sub>2</sub> 1 % at 15<sup>th</sup> day (80.14 %) and GA<sub>3</sub> 50 mg/l, GA<sub>3</sub> 25 mg/l at 16<sup>th</sup> day of storage period. The minimum marketable fruit (%) were

**Table 4.5 Effect of preharvest application of different chemicals and plant growth regulators on marketable fruit (%) of mango cv. Amrapali**

Treatments	Storage period (Days)				
	1 to 12 <sup>th</sup>	13 <sup>th</sup>	14 <sup>th</sup>	15 <sup>th</sup>	16 <sup>th</sup>
T <sub>1</sub> : CaCl <sub>2</sub> 1 %	100	90.10 <sup>ab</sup>	76.67 <sup>b</sup>	54.41 <sup>a</sup>	42.40 <sup>b</sup>
T <sub>2</sub> : CaCl <sub>2</sub> 2 %	100	90.93 <sup>a</sup>	79.55 <sup>a</sup>	56.63 <sup>a</sup>	45.16 <sup>a</sup>
T <sub>3</sub> : Ca(NO <sub>3</sub> ) <sub>2</sub> 1%	100	85.87 <sup>f</sup>	71.95 <sup>e</sup>	42.86 <sup>bc</sup>	36.43 <sup>c</sup>
T <sub>4</sub> : Ca(NO <sub>3</sub> ) <sub>2</sub> 2%	100	86.56 <sup>ef</sup>	73.99 <sup>cd</sup>	44.11 <sup>bc</sup>	34.40 <sup>cd</sup>
T <sub>5</sub> : KNO <sub>3</sub> 1 %	100	87.04 <sup>def</sup>	73.44 <sup>de</sup>	42.48 <sup>c</sup>	32.34 <sup>de</sup>
T <sub>6</sub> : KNO <sub>3</sub> 2 %	100	86.84 <sup>def</sup>	73.81 <sup>cd</sup>	45.45 <sup>b</sup>	33.68 <sup>d</sup>
T <sub>7</sub> : Ethrel 0.1 ml/l	100	86.18 <sup>ef</sup>	74.35 <sup>cd</sup>	43.15 <sup>bc</sup>	30.63 <sup>ef</sup>
T <sub>8</sub> : Ethrel 0.2 ml/l	100	88.22 <sup>cd</sup>	75.12 <sup>bc</sup>	43.05 <sup>bc</sup>	30.00 <sup>f</sup>
T <sub>9</sub> : GA <sub>3</sub> 25 mg/l	100	87.50 <sup>de</sup>	74.51 <sup>cd</sup>	56.26 <sup>a</sup>	43.10 <sup>ab</sup>
T <sub>10</sub> : GA <sub>3</sub> 50 mg/l	100	89.15 <sup>bc</sup>	76.66 <sup>b</sup>	56.55 <sup>a</sup>	43.59 <sup>ab</sup>
T <sub>11</sub> : Control	100	80.14 <sup>g</sup>	68.03 <sup>f</sup>	43.42 <sup>bc</sup>	30.91 <sup>ef</sup>
<b>S. Em. ±</b>		0.44	0.50	0.82	0.68
<b>F-test</b>		Sig.	Sig.	Sig.	Sig.
<b>C. V. %</b>		<b>0.87</b>	<b>1.17</b>	<b>2.96</b>	<b>3.24</b>

**Note:** Treatment means with the letter/letters in common are not significantly different by Duncan's New Multiple Range Test at 5 % level of significance.

recorded in control at 13<sup>th</sup> day (80.14 %), 14<sup>th</sup> day (68.14 %), KNO<sub>3</sub> 1 % at 15<sup>th</sup> day (42.48 %) and ethrel 0.2 ml/l at 16<sup>th</sup> day (30.00 %) under ambient storage condition.

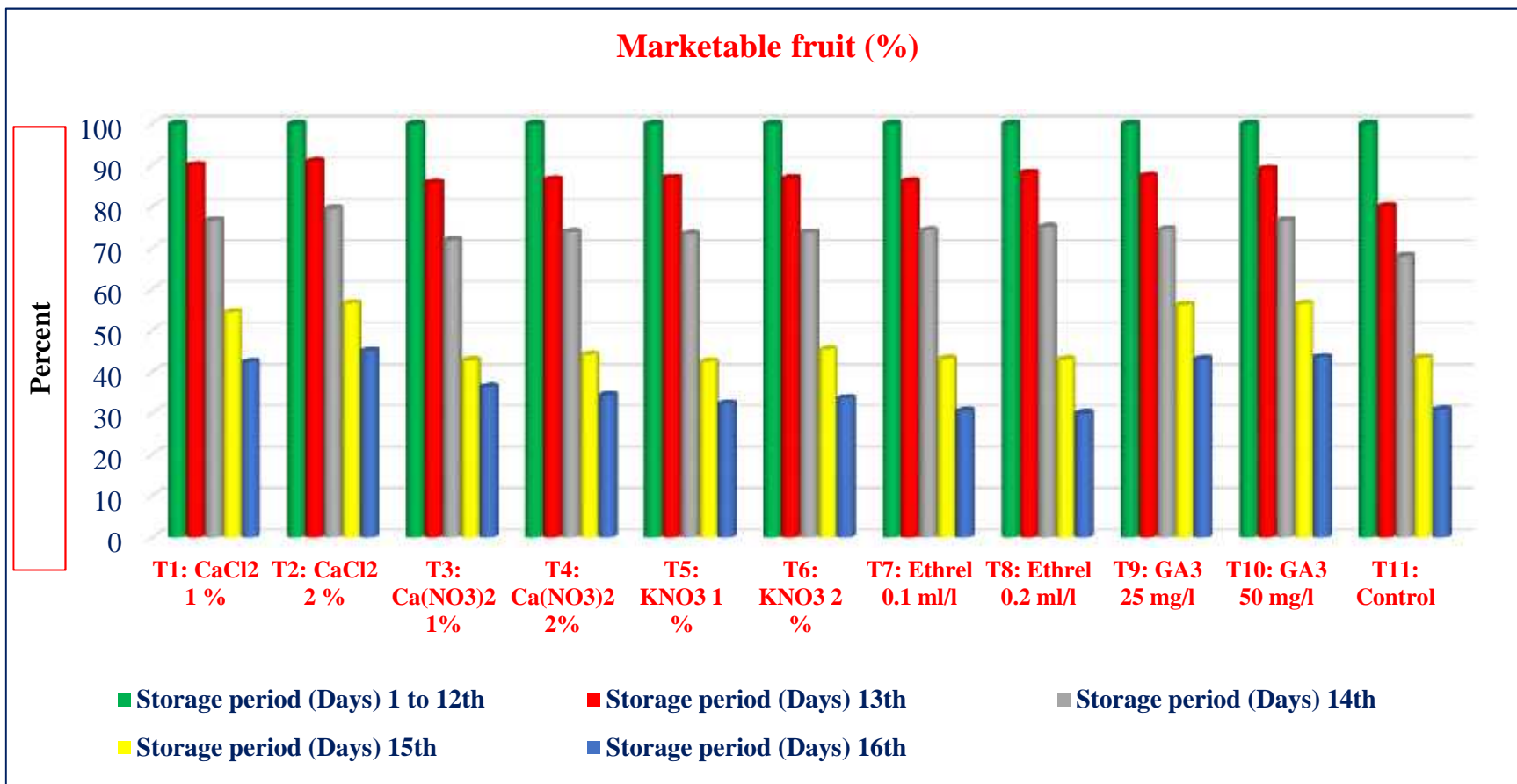
The preharvest applications of CaCl<sub>2</sub> 2 % recorded significantly highest marketable fruit (%) during 13<sup>th</sup> day (95.69 %) up to last ripening stage as compared to other treatments under ambient storage condition. It might be due to calcium decrease the spoiling of fruit by reduction in process of respiration whereas, the calcium plays number of roles such as an increase the fruit firmness which leads benefits like slower ripening and increased the shelf life (Karemera and Habimana 2014). A similar result also found by the Bhusan *et al.*, 2015 in Amrapali and Singh *et al.*, 2012 in Dashehari mango.

#### **4.1.8 Spoilage (%)**

The data pertaining to spoilage (%) of mango were recorded at harvest and every day up to last ripening stage (at harvest up to 16<sup>th</sup> day) under ambient storage condition influenced by preharvest application of various chemicals and plant growth regulators are furnished in Table 4.6.

The data indicated that the effect of chemicals and plant growth regulators was significantly influenced on spoilage (%) of mango at harvest and everyday up to last ripening stage. There were no any spoiled fruit recorded in all the treatments up to 12<sup>th</sup> day of storage periods. Among all the treatments, CaCl<sub>2</sub> 2 % consistently recorded significantly minimum spoilage (%) at 13<sup>th</sup> day (9.07 %), 14<sup>th</sup> day (20.45 %), 15<sup>th</sup> day (43.37 %) and 16<sup>th</sup> day (54.84 %) as compared to rest of the treatments. However, it was statistically at par with treatment of CaCl<sub>2</sub> 1 % at 13<sup>th</sup> day, GA<sub>3</sub> 50 mg/l, GA<sub>3</sub> 25 mg/l & CaCl<sub>2</sub> 1 % at 15<sup>th</sup> day and GA<sub>3</sub> 50 mg/l and GA<sub>3</sub> 25 mg/l at 16<sup>th</sup> day of storage period. The maximum spoilage (%) were recorded in control at 13<sup>th</sup> day (19.86 %) and 14<sup>th</sup> day (31.47 %), KNO<sub>3</sub> 1 % at 15<sup>th</sup> day (57.52 %) and ethrel 0.2 ml/l at 16<sup>th</sup> day (70.00 %) under ambient storage condition.

The spoilage percentage of mango fruits increased as the storage period advanced irrespective of any treatment. Fruits from preharvest spray with CaCl<sub>2</sub> 2 % recorded significantly lowest spoilage at 13<sup>th</sup> day (9.07 %) and up to last ripening stage as compared to other treatments under ambient storage condition. It might be due to calcium compounds significantly thickened the middle lamella of fruit cells owing to increased deposition of calcium pectate and thereby maintained the cell wall rigidity which inhibits the penetration and spread of pathogens in fruits (Gupta *et al.* 1987).



**Fig. 4.2 Effect of preharvest application of different chemicals and plant growth regulators on marketable fruit (%) of mango cv. Amrapali**

These results are in accordance with the findings of Jawandha *et al.* (2009) and Yadav *et al.* (2009) in ber.

**Table 4.6 Effect of preharvest application of different chemicals and plant growth regulators on spoilage fruit (%) of mango cv. Amrapali**

Treatments	Storage period (Days)				
	1 to 12 <sup>th</sup>	13 <sup>th</sup>	14 <sup>th</sup>	15 <sup>th</sup>	16 <sup>th</sup>
T <sub>1</sub> : CaCl <sub>2</sub> 1 %	00	9.90 <sup>fg</sup>	23.33 <sup>d</sup>	45.59 <sup>c</sup>	57.60 <sup>e</sup>
T <sub>2</sub> : CaCl <sub>2</sub> 2 %	00	9.07 <sup>g</sup>	20.45 <sup>e</sup>	43.37 <sup>c</sup>	54.84 <sup>f</sup>
T <sub>3</sub> : Ca(NO <sub>3</sub> ) <sub>2</sub> 1%	00	14.13 <sup>b</sup>	28.05 <sup>b</sup>	57.14 <sup>ab</sup>	63.57 <sup>d</sup>
T <sub>4</sub> : Ca(NO <sub>3</sub> ) <sub>2</sub> 2%	00	13.44 <sup>bc</sup>	26.0 <sup>c</sup>	55.89 <sup>ab</sup>	65.60 <sup>cd</sup>
T <sub>5</sub> : KNO <sub>3</sub> 1 %	00	12.96 <sup>bcd</sup>	26.56 <sup>bc</sup>	57.52 <sup>a</sup>	67.66 <sup>bc</sup>
T <sub>6</sub> : KNO <sub>3</sub> 2 %	00	13.16 <sup>bcd</sup>	26.19 <sup>c</sup>	54.55 <sup>b</sup>	66.32 <sup>c</sup>
T <sub>7</sub> : Ethrel 0.1 ml/l	00	13.82 <sup>bc</sup>	25.65 <sup>c</sup>	56.85 <sup>ab</sup>	69.37 <sup>ab</sup>
T <sub>8</sub> : Ethrel 0.2 ml/l	00	11.78 <sup>de</sup>	24.88 <sup>cd</sup>	56.95 <sup>ab</sup>	70.00 <sup>a</sup>
T <sub>9</sub> : GA <sub>3</sub> 25 mg/l	00	12.50 <sup>cd</sup>	25.49 <sup>c</sup>	43.74 <sup>c</sup>	56.91 <sup>ef</sup>
T <sub>10</sub> : GA <sub>3</sub> 50 mg/l	00	10.85 <sup>ef</sup>	23.34 <sup>d</sup>	43.45 <sup>c</sup>	56.41 <sup>ef</sup>
T <sub>11</sub> : Control	00	19.86 <sup>a</sup>	31.97 <sup>a</sup>	56.58 <sup>ab</sup>	69.09 <sup>ab</sup>
<b>S. Em. ±</b>		0.44	0.50	0.82	0.68
<b>F-test</b>		Sig.	Sig.	Sig.	Sig.
<b>C. V. %</b>		<b>5.89</b>	<b>3.40</b>	<b>2.74</b>	<b>1.87</b>

**Note:** Treatment means with the letter/letters in common are not significantly different by Duncan's New Multiple Range Test at 5 % level of significance.

## 4.2 QUALITY PARAMETERS

The data regarding biochemical parameters of mango fruit *viz.*, total soluble solids (<sup>0</sup>Brix), reducing sugar (%), total sugar (%), non-reducing sugar (%), ascorbic acid (mg/100 g pulp) and acidity (%) were recorded at harvest and everyday up to last ripening stage under ambient storage condition are shown as under:

### 4.2.1 Total Soluble Solids (<sup>0</sup>Brix)

The data pertaining to the effect of chemicals and plant growth regulators on total soluble solids (<sup>0</sup>Brix) of mango at harvest and every three days interval up to last ripening stage are presented in Table 4.7 and also depicted in Fig. 4.3.

The chemicals and plant growth regulators were significantly influenced on total soluble sugar (<sup>0</sup>Brix) of mango at harvest and up to last ripening stage. Among all the treatments, CaCl<sub>2</sub> 2 % recorded significantly maximum total soluble solids

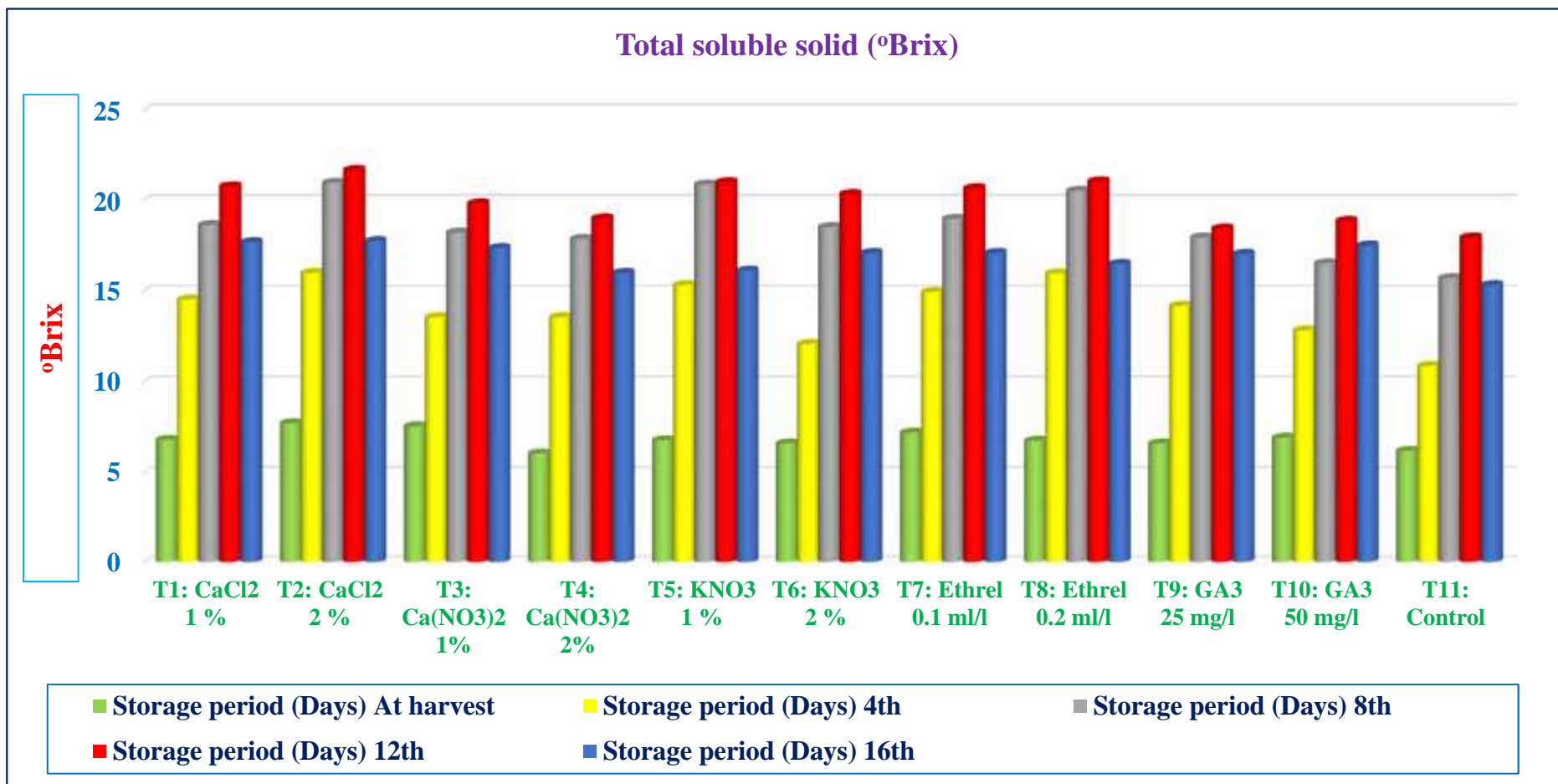
consistently at harvest (7.72 °Brix), 4<sup>th</sup> day (16.00 °Brix), 8<sup>th</sup> day (20.97 °Brix), 12<sup>th</sup> day (21.68 °Brix) and 16<sup>th</sup> day (17.75 °Brix). However, it was statistically at par with the treatment of Ca(NO<sub>3</sub>)<sub>2</sub> 1 % at harvest, ethrel 0.2 ml/l at 4<sup>th</sup> day, KNO<sub>3</sub> 1 % and ethrel 0.2 ml/l at 8<sup>th</sup> day and CaCl<sub>2</sub> 1 %, GA<sub>3</sub> 50 mg/l, ethrel 0.1 ml/l and KNO<sub>3</sub> 2 % at 16<sup>th</sup> day of storage period. The minimum total soluble solids was recorded with the treatment of Ca(NO<sub>3</sub>)<sub>2</sub> 2 % at harvest and in control treatment at 4<sup>th</sup> day, 8<sup>th</sup> day, 12<sup>th</sup> and at 16<sup>th</sup> day under ambient storage conditions.

**Table 4.7 Effect of preharvest application of different chemicals and plant growth regulators on total soluble solids (°Brix) of mango cv. Amrapali**

Treatments	Storage period (Days)				
	At harvest	4 <sup>th</sup>	8 <sup>th</sup>	12 <sup>th</sup>	16 <sup>th</sup>
T <sub>1</sub> : CaCl <sub>2</sub> 1 %	6.80 <sup>cd</sup>	14.53 <sup>cd</sup>	18.64 <sup>bc</sup>	20.77 <sup>bc</sup>	17.70 <sup>ab</sup>
T <sub>2</sub> : CaCl <sub>2</sub> 2 %	7.72 <sup>a</sup>	16.00 <sup>a</sup>	20.97 <sup>a</sup>	21.68 <sup>a</sup>	17.75 <sup>a</sup>
T <sub>3</sub> : Ca(NO <sub>3</sub> ) <sub>2</sub> 1%	7.55 <sup>a</sup>	13.55 <sup>e</sup>	18.22 <sup>cd</sup>	19.83 <sup>d</sup>	17.37 <sup>ab</sup>
T <sub>4</sub> : Ca(NO <sub>3</sub> ) <sub>2</sub> 2%	6.05 <sup>e</sup>	13.55 <sup>e</sup>	17.87 <sup>d</sup>	19.00 <sup>e</sup>	16.00 <sup>d</sup>
T <sub>5</sub> : KNO <sub>3</sub> 1 %	6.77 <sup>cd</sup>	15.33 <sup>ab</sup>	20.88 <sup>a</sup>	21.00 <sup>b</sup>	16.12 <sup>d</sup>
T <sub>6</sub> : KNO <sub>3</sub> 2 %	6.60 <sup>d</sup>	12.08 <sup>g</sup>	18.53 <sup>bc</sup>	20.35 <sup>cd</sup>	17.10 <sup>abc</sup>
T <sub>7</sub> : Ethrel 0.1 ml/l	7.20 <sup>b</sup>	14.94 <sup>bc</sup>	18.98 <sup>b</sup>	20.67 <sup>bc</sup>	17.10 <sup>abc</sup>
T <sub>8</sub> : Ethrel 0.2 ml/l	6.75 <sup>cd</sup>	15.97 <sup>a</sup>	20.53 <sup>a</sup>	21.05 <sup>b</sup>	16.50 <sup>cd</sup>
T <sub>9</sub> : GA <sub>3</sub> 25 mg/l	6.60 <sup>d</sup>	14.18 <sup>de</sup>	17.95 <sup>d</sup>	18.45 <sup>f</sup>	17.05 <sup>bc</sup>
T <sub>10</sub> : GA <sub>3</sub> 50 mg/l	6.92 <sup>bc</sup>	12.83 <sup>f</sup>	16.53 <sup>e</sup>	18.87 <sup>ef</sup>	17.51 <sup>ab</sup>
T <sub>11</sub> : Control	6.20 <sup>e</sup>	10.87 <sup>h</sup>	15.71 <sup>f</sup>	17.95 <sup>g</sup>	15.33 <sup>e</sup>
<b>S. Em. ±</b>	0.09	0.21	0.16	0.16	0.20
<b>F-test</b>	Sig.	Sig.	Sig.	Sig.	Sig.
<b>C. V. %</b>	<b>2.16</b>	<b>2.65</b>	<b>1.49</b>	<b>1.37</b>	<b>2.01</b>

**Note:** Treatment means with the letter/letters in common are not significantly different by Duncan’s New Multiple Range Test at 5 % level of significance.

The effect of preharvest application of different chemicals and plant growth regulators reported significant effect on total soluble solids of fruit and it was recorded significantly highest total soluble solids with the treatment of CaCl<sub>2</sub> 2 % at harvest, 4<sup>th</sup> day, 8<sup>th</sup> day, 12<sup>th</sup> day and 16<sup>th</sup> day. The total soluble sugar increased slowly during storage period up to 12<sup>th</sup> day and declined thereafter. It may be due to the increased in soluble solids content and total soluble sugars caused by hydrolysis of polysaccharides like starch, cellulose and pectin substances in to simpler substances. The change in total soluble solids during storage period might be a result of the transformation of organic compound into total soluble solids throughout the enzymatic activities and



**Fig. 4.3 Effect of preharvest application of different chemicals and plant growth regulators on total soluble solid (°Brix) of mango cv. Amrapali**

reaction under calcium effect (Karemera and Habimana 2014). A similar view was also shared by Kirmani *et al.* (2013) in plum and Yadav *et al.* (2009) in ber fruit.

#### **4.2.2 Reducing sugar (%)**

The data pertaining to reducing sugar (%) of mango fruits as influenced by preharvest application of various chemicals and plant growth regulators are furnished in Table 4.8 and also illustrated in Fig. 4.4.

There were significant effect of various chemicals and plant growth regulators observed on reducing sugar (%) of mango at harvest and every three days interval up to last ripening stage. CaCl<sub>2</sub> 2 % and ethrel 0.2 ml/l treatment recorded significantly maximum reducing sugar (%) at harvest (3.49 %) while, CaCl<sub>2</sub> 2 % treatment obtained significantly maximum reducing sugar (%) at 4<sup>th</sup> day (6.65 %), 8<sup>th</sup> day (7.51 %), 12<sup>th</sup> day (3.62 %), and at 16<sup>th</sup> day (3.12 %) as compared to rest of the treatments. However, CaCl<sub>2</sub> 2 % and ethrel 0.2 ml/l were statistically at par with treatment of ethrel 0.1 ml/l, KNO<sub>3</sub> 2 % and Ca(NO<sub>3</sub>)<sub>2</sub> 2 % at harvest while, CaCl<sub>2</sub> 2 % is also statistically at par with ethrel 0.2 ml/l at 4<sup>th</sup> day, CaCl<sub>2</sub> 1 % and ethrel 0.2 ml/l at 8<sup>th</sup> day, control, ethrel 0.2 ml/l and ethrel 0.1 ml/l at 12<sup>th</sup> day and ethrel 0.1 ml/l and GA<sub>3</sub> 50 mg/l at 16<sup>th</sup> day during storage period. However, the minimum reducing sugar was found in GA<sub>3</sub> 25 mg/l at harvest (2.33 %), control treatment at 4<sup>th</sup> day (4.76 %), 8<sup>th</sup> day (6.15 %), KNO<sub>3</sub> 1 % at 12<sup>th</sup> day (2.51 %) & 16<sup>th</sup> day (2.42 %).

In present study, accumulation of reducing sugar was gradually increased in fruits preharvest treated with chemicals and growth regulators with a slight decline at the end of storage periods and it was significantly highest with CaCl<sub>2</sub> 2 % at harvest, 4<sup>th</sup> day, 8<sup>th</sup> day, 12<sup>th</sup> day and at 16<sup>th</sup> day as compared to rest of the treatments. The initial increase in reducing sugar might be due to the conversion of starch into reducing sugar and later on reduction could be possible due to utilization of sugar in the process of respiration. The percentage of reducing sugar increased slowly during storage period up to 8<sup>th</sup> day and declined thereafter. The increase in reducing sugar might be due to increased rate of starch degradation by amylase activity. The present findings are in agreement with Singh *et al.* (2007) in strawberry. This may be also attributed to the inversion of non-reducing sugars into reducing sugars caused by acid present in fruits. The rate of inversion was rapid initially in all the treatments, which may be due to availability of more substrate for inversion in initial stages. The

**Table 4.8 Effect of preharvest application of different chemicals and plant growth regulators on reducing sugar (%) of mango cv. Amrapali**

Treatments	Storage period (Days)				
	At harvest	4 <sup>th</sup>	8 <sup>th</sup>	12 <sup>th</sup>	16 <sup>th</sup>
T <sub>1</sub> : CaCl <sub>2</sub> 1 %	3.14 <sup>b</sup>	5.85 <sup>de</sup>	7.49 <sup>a</sup>	3.09 <sup>b</sup>	2.96 <sup>b</sup>
T <sub>2</sub> : CaCl <sub>2</sub> 2 %	3.49 <sup>a</sup>	6.65 <sup>a</sup>	7.51 <sup>a</sup>	3.62 <sup>a</sup>	3.12 <sup>a</sup>
T <sub>3</sub> : Ca(NO <sub>3</sub> ) <sub>2</sub> 1%	3.08 <sup>b</sup>	5.62 <sup>f</sup>	6.92 <sup>d</sup>	3.04 <sup>bc</sup>	2.95 <sup>b</sup>
T <sub>4</sub> : Ca(NO <sub>3</sub> ) <sub>2</sub> 2%	3.44 <sup>a</sup>	6.00 <sup>cd</sup>	6.29 <sup>f</sup>	2.71 <sup>c</sup>	2.66 <sup>c</sup>
T <sub>5</sub> : KNO <sub>3</sub> 1 %	3.09 <sup>b</sup>	6.11 <sup>bc</sup>	6.16 <sup>g</sup>	2.51 <sup>d</sup>	2.42 <sup>d</sup>
T <sub>6</sub> : KNO <sub>3</sub> 2 %	3.44 <sup>a</sup>	5.80 <sup>e</sup>	7.35 <sup>bc</sup>	3.03 <sup>b</sup>	2.91 <sup>b</sup>
T <sub>7</sub> : Ethrel 0.1 ml/l	3.47 <sup>a</sup>	6.26 <sup>b</sup>	7.22 <sup>c</sup>	3.50 <sup>a</sup>	3.11 <sup>a</sup>
T <sub>8</sub> : Ethrel 0.2 ml/l	3.49 <sup>a</sup>	6.62 <sup>a</sup>	7.39 <sup>ab</sup>	3.58 <sup>a</sup>	2.93 <sup>b</sup>
T <sub>9</sub> : GA <sub>3</sub> 25 mg/l	2.33 <sup>d</sup>	5.87 <sup>de</sup>	6.71 <sup>e</sup>	2.56 <sup>d</sup>	2.55 <sup>c</sup>
T <sub>10</sub> : GA <sub>3</sub> 50 mg/l	2.81 <sup>c</sup>	5.81 <sup>e</sup>	6.24 <sup>fg</sup>	3.16 <sup>b</sup>	3.00 <sup>ab</sup>
T <sub>11</sub> : Control	2.34 <sup>d</sup>	4.76 <sup>g</sup>	6.15 <sup>g</sup>	3.61 <sup>a</sup>	2.64 <sup>c</sup>
<b>S. Em. ±</b>	0.04	0.05	0.04	0.04	0.04
<b>F-test</b>	Sig.	Sig.	Sig.	Sig.	Sig.
<b>C. V. %</b>	<b>1.96</b>	<b>1.55</b>	<b>1.08</b>	<b>2.18</b>	<b>2.60</b>

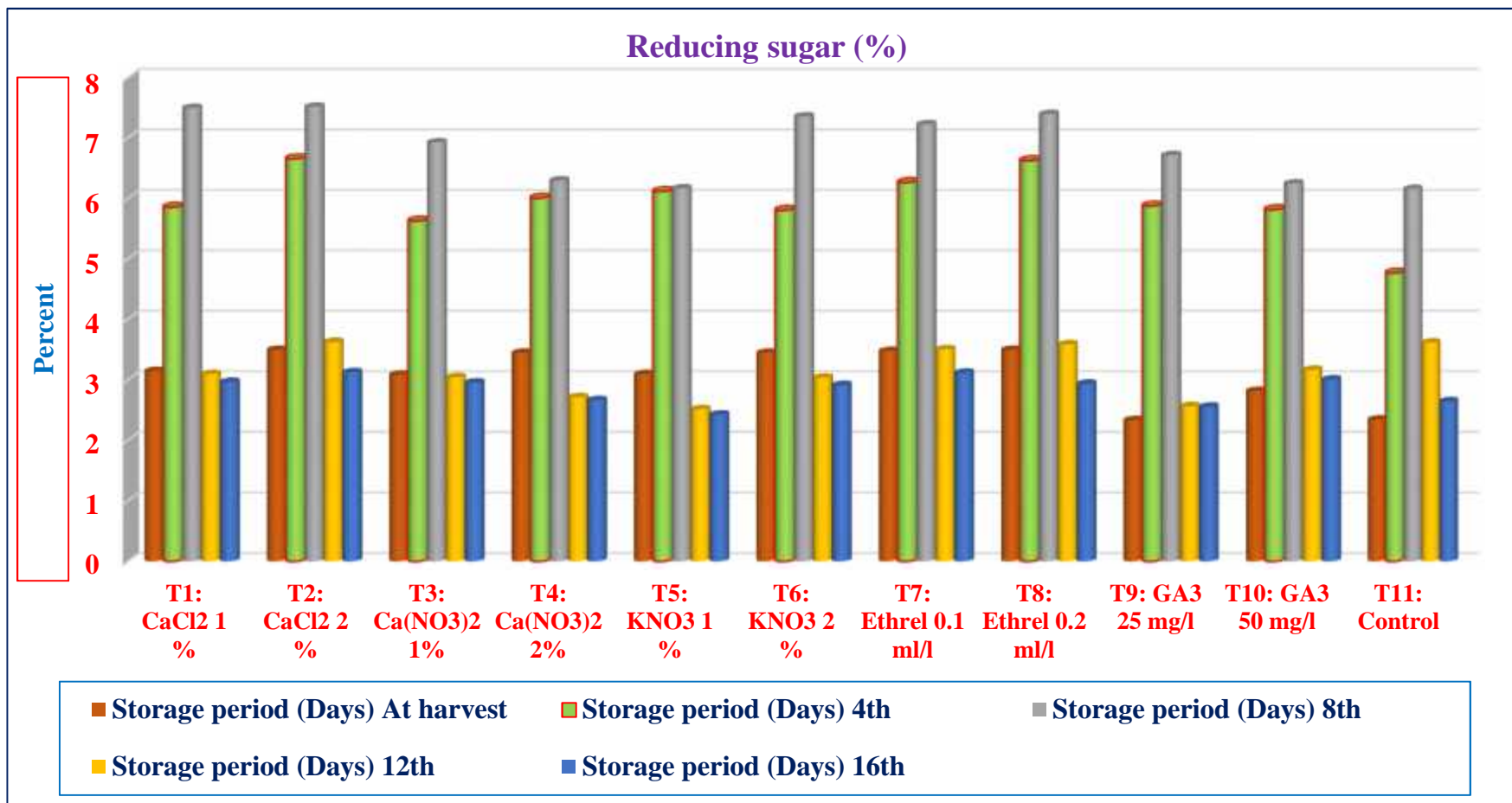
**Note:** Treatment means with the letter/letters in common are not significantly different by Duncan's New Multiple Range Test at 5 % level of significance.

increase in the total reducing sugar content is in line with the finding of Ingle *et al.*, (1982) who reported an increase in reducing sugar content of sapota fruits during ripening. However, decrease in reducing sugar content (%) was also observed due to over ripening of fruits which was utilized during respiration process.

#### 4.2.3 Total sugar (%)

The data pertaining to the effect of chemicals and plant growth regulators on total sugar (%) of mango at harvest and every three days interval up to last ripening stage presented in Table 4.9 and also illustrated in the Fig. 4.5.

The chemicals and plant growth regulators were significantly influenced on total sugar (%) of mango at harvest and up to last ripening stage. Among all the treatments, CaCl<sub>2</sub> 2 % recorded significantly maximum total sugar consistently at harvest (6.30 %), 4<sup>th</sup> day (15.43 %), 8<sup>th</sup> day (18.57 %), 12<sup>th</sup> day (18.95 %) and 16<sup>th</sup> day (18.27 %) during storage period. It was statistically at par with treatment of ethrel 0.2 ml/l, ethrel 0.1 ml/l, Ca(NO<sub>3</sub>)<sub>2</sub> 2 % and KNO<sub>3</sub> 2 % at harvest, ethrel 0.2 ml/l and ethrel 0.1 ml/l at 4<sup>th</sup> day, ethrel 0.2 ml/l at 8<sup>th</sup> day, ethrel 0.1 ml/l at 12<sup>th</sup> day whereas, ethrel



**Fig. 4.4 Effect of preharvest application of different chemicals and plant growth regulators on reducing sugar (%) of mango cv. Amrapali**

0.1 ml/l and ethrel 0.2 ml/l at 16<sup>th</sup> day during the storage period. However, the minimum total sugar were recorded with control treatment at harvest (5.07 %), 4<sup>th</sup> day (11.35 %), 8<sup>th</sup> day (15.01 %), 12<sup>th</sup> day (15.47 %) and 16<sup>th</sup> day (13.21 %) under ambient storage condition.

**Table 4.9 Effect of preharvest application of different chemicals and plant growth regulators on total sugar (%) of mango cv. Amrapali**

Treatments	Storage period (Days)				
	At harvest	4 <sup>th</sup>	8 <sup>th</sup>	12 <sup>th</sup>	16 <sup>th</sup>
T <sub>1</sub> : CaCl <sub>2</sub> 1 %	5.78 <sup>b</sup>	14.34 <sup>b</sup>	17.82 <sup>c</sup>	17.93 <sup>c</sup>	17.97 <sup>b</sup>
T <sub>2</sub> : CaCl <sub>2</sub> 2 %	6.30 <sup>a</sup>	15.43 <sup>a</sup>	18.57 <sup>a</sup>	18.95 <sup>a</sup>	18.27 <sup>a</sup>
T <sub>3</sub> : Ca(NO <sub>3</sub> ) <sub>2</sub> 1%	5.30 <sup>c</sup>	12.66 <sup>d</sup>	17.48 <sup>d</sup>	17.59 <sup>cd</sup>	16.96 <sup>cd</sup>
T <sub>4</sub> : Ca(NO <sub>3</sub> ) <sub>2</sub> 2%	6.24 <sup>a</sup>	13.71 <sup>c</sup>	17.28 <sup>d</sup>	17.44 <sup>d</sup>	17.20 <sup>c</sup>
T <sub>5</sub> : KNO <sub>3</sub> 1 %	5.84 <sup>b</sup>	12.78 <sup>d</sup>	16.17 <sup>f</sup>	16.46 <sup>e</sup>	16.06 <sup>e</sup>
T <sub>6</sub> : KNO <sub>3</sub> 2 %	6.23 <sup>a</sup>	13.56 <sup>c</sup>	16.22 <sup>f</sup>	16.59 <sup>e</sup>	16.29 <sup>e</sup>
T <sub>7</sub> : Ethrel 0.1 ml/l	6.27 <sup>a</sup>	15.04 <sup>a</sup>	18.23 <sup>b</sup>	18.82 <sup>a</sup>	18.18 <sup>ab</sup>
T <sub>8</sub> : Ethrel 0.2 ml/l	6.29 <sup>a</sup>	15.04 <sup>a</sup>	18.38 <sup>ab</sup>	18.34 <sup>b</sup>	18.03 <sup>ab</sup>
T <sub>9</sub> : GA <sub>3</sub> 25 mg/l	5.11 <sup>d</sup>	12.44 <sup>d</sup>	15.98 <sup>f</sup>	16.50 <sup>e</sup>	16.30 <sup>e</sup>
T <sub>10</sub> : GA <sub>3</sub> 50 mg/l	5.38 <sup>c</sup>	13.70 <sup>c</sup>	16.99 <sup>e</sup>	17.22 <sup>d</sup>	16.83 <sup>d</sup>
T <sub>11</sub> : Control	5.07 <sup>d</sup>	11.35 <sup>e</sup>	15.01 <sup>g</sup>	15.47 <sup>f</sup>	13.21 <sup>f</sup>
<b>S. Em. ±</b>	0.04	0.13	0.09	0.12	0.08
<b>F-test</b>	Sig.	Sig.	Sig.	Sig.	Sig.
<b>C. V. %</b>	<b>1.21</b>	<b>1.66</b>	<b>0.95</b>	<b>1.23</b>	<b>0.81</b>

**Note:** Treatment means with the letter/letters in common are not significantly different by Duncan's New Multiple Range Test at 5 % level of significance.

In present study, the preharvest application of CaCl<sub>2</sub> 2 % recorded significantly highest total sugar at harvest, 4<sup>th</sup> day, 8<sup>th</sup> day, 12<sup>th</sup> day and 16<sup>th</sup> day as compared to another treatments which was gradually increased in fruits preharvest treated with chemicals and growth regulators with a slight decline at the end of storage periods. The percentage of total sugar increased slowly during storage period up to 12<sup>th</sup> day and declined thereafter and total sugar was found to increase in calcium chloride treated fruits might be due to slowly conversion to sugar on storage reported by Bhalerao *et al.* (2010) in sapota. Whereas, calcium pectate is important components of the cell wall. Therefore, adequate amount of calcium may help to reduce conversion of acid into sugar reported by Lal *et al.* (2011) in apricot. Similar results were also reported Karemera and Habimana (2014) in mango, Mahajan and Sharma (2000) in peach.

#### 4.2.4 Non-reducing sugar (%)

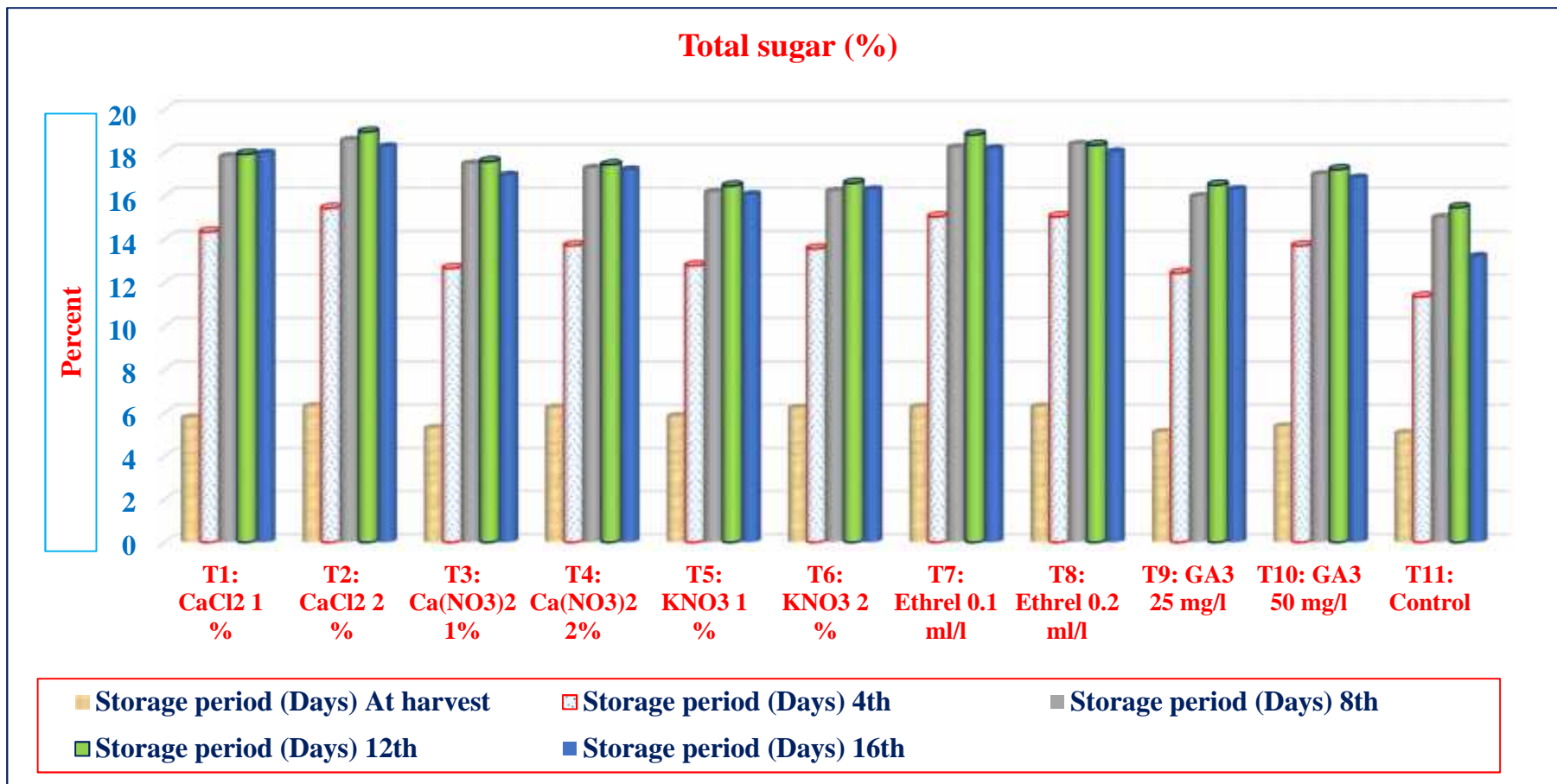
The data pertaining to the effect of chemicals and plant growth regulators was significantly influenced on non-reducing sugar (%) of mango at harvest and every three days interval up to last ripening stage are presented in Table 4.10 and also depicted in the Fig. 4.6.

There were significant effect of various chemicals and plant growth regulators observed on non-reducing sugar (%) of mango at harvest and up to last ripening stage. CaCl<sub>2</sub> 2 % recorded significantly maximum non-reducing sugar (%) consistently at harvest (2.81 %), 4<sup>th</sup> day (8.78 %), 8<sup>th</sup> day (11.06 %), 12<sup>th</sup> day (15.33 %) and 16<sup>th</sup> day (15.15 %) as compared to rest of the treatments. It was statistically at par with treatment of ethrel 0.1 ml/l, ethrel 0.2 ml/l, Ca(NO<sub>3</sub>)<sub>2</sub> 2 %, KNO<sub>3</sub> 2 %, GA<sub>3</sub> 25 mg/l, KNO<sub>3</sub> 1 %, control and CaCl<sub>2</sub> 1 % at harvest, ethrel 0.1 ml/l, CaCl<sub>2</sub> 1 % and ethrel 0.2 ml/l at 4<sup>th</sup> day, ethrel 0.1 ml/l, ethrel 0.2 ml/l and GA<sub>3</sub> 50 mg/l at 8<sup>th</sup> day, ethrel 0.1 ml/l at 12<sup>th</sup> day whereas, ethrel 0.2 ml/l, ethrel 0.1 ml/l and CaCl<sub>2</sub> 1% at 16<sup>th</sup> day during storage period. However, the minimum non-reducing sugar was found in Ca(NO<sub>3</sub>)<sub>2</sub> 1 % at harvest (2.22 %) and control treatment at 4<sup>th</sup> day (6.60 %), 8<sup>th</sup> day (8.86 %), 12<sup>th</sup> day (11.86 %) and 16<sup>th</sup> day (10.57 %) under ambient storage conditions.

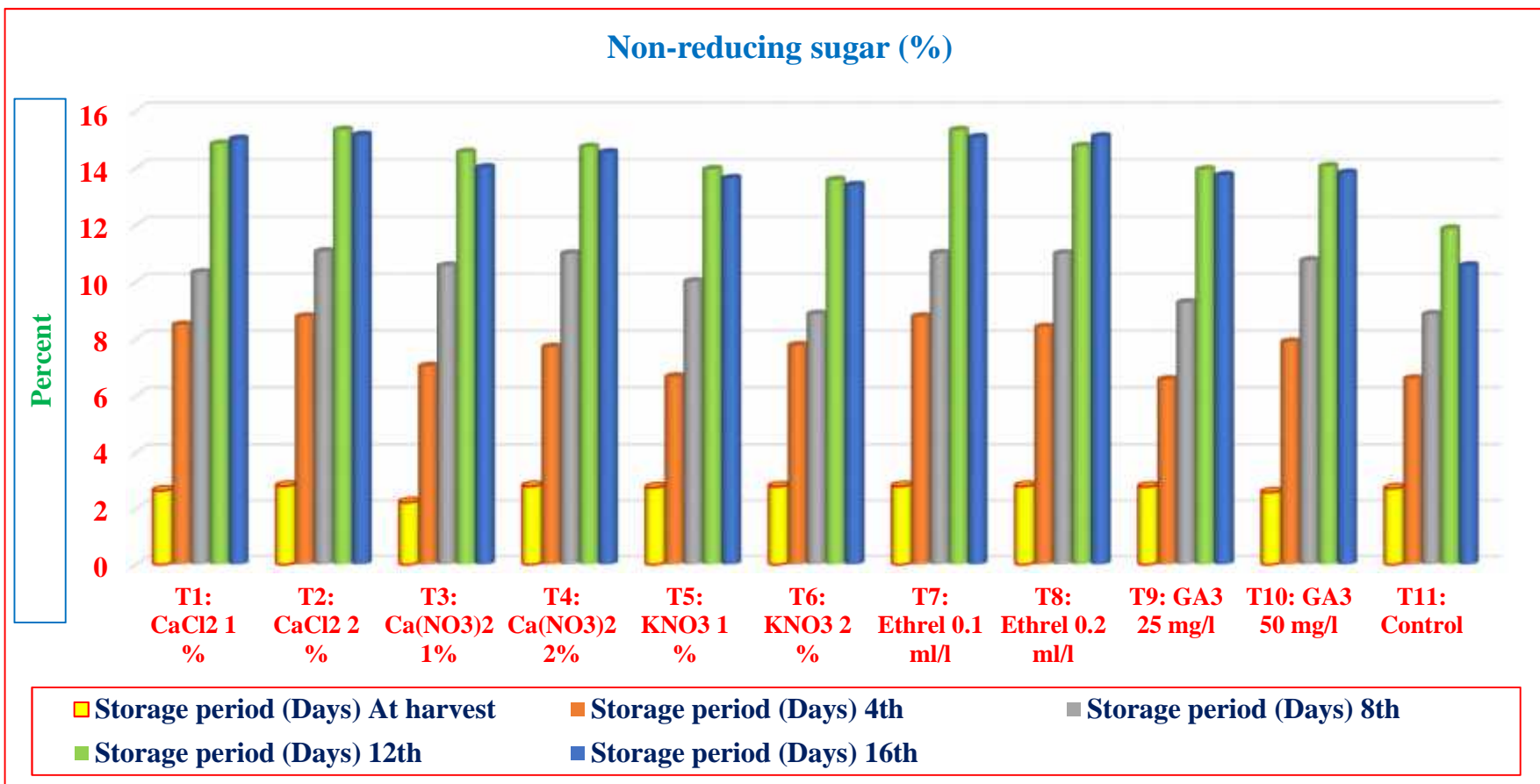
**Table 4.10 Effect of preharvest application of different chemicals and plant growth regulators on non-reducing sugar (%) of mango cv. Amrapali**

Treatments	Storage period (Days)				
	At harvet	4 <sup>th</sup>	8 <sup>th</sup>	12 <sup>th</sup>	16 <sup>th</sup>
T <sub>1</sub> : CaCl <sub>2</sub> 1 %	2.64 <sup>ab</sup>	8.49 <sup>a</sup>	10.33 <sup>cd</sup>	14.84 <sup>b</sup>	15.01 <sup>a</sup>
T <sub>2</sub> : CaCl <sub>2</sub> 2 %	2.81 <sup>a</sup>	8.78 <sup>a</sup>	11.06 <sup>a</sup>	15.33 <sup>a</sup>	15.15 <sup>a</sup>
T <sub>3</sub> : Ca(NO <sub>3</sub> ) <sub>2</sub> 1%	2.22 <sup>c</sup>	7.04 <sup>d</sup>	10.56 <sup>bc</sup>	14.55 <sup>b</sup>	14.01 <sup>c</sup>
T <sub>4</sub> : Ca(NO <sub>3</sub> ) <sub>2</sub> 2%	2.80 <sup>a</sup>	7.71 <sup>c</sup>	10.99 <sup>a</sup>	14.73 <sup>b</sup>	14.54 <sup>b</sup>
T <sub>5</sub> : KNO <sub>3</sub> 1 %	2.75 <sup>a</sup>	6.67 <sup>d</sup>	10.01 <sup>d</sup>	13.95 <sup>cd</sup>	13.63 <sup>de</sup>
T <sub>6</sub> : KNO <sub>3</sub> 2 %	2.79 <sup>a</sup>	7.77 <sup>c</sup>	8.87 <sup>f</sup>	13.57 <sup>f</sup>	13.39 <sup>e</sup>
T <sub>7</sub> : Ethrel 0.1 ml/l	2.80 <sup>a</sup>	8.78 <sup>a</sup>	11.00 <sup>a</sup>	15.32 <sup>a</sup>	15.07 <sup>a</sup>
T <sub>8</sub> : Ethrel 0.2 ml/l	2.80 <sup>a</sup>	8.41 <sup>ab</sup>	10.99 <sup>a</sup>	14.76 <sup>b</sup>	15.10 <sup>a</sup>
T <sub>9</sub> : GA <sub>3</sub> 25 mg/l	2.78 <sup>a</sup>	6.57 <sup>d</sup>	9.27 <sup>e</sup>	13.94 <sup>cde</sup>	13.74 <sup>d</sup>
T <sub>10</sub> : GA <sub>3</sub> 50 mg/l	2.58 <sup>b</sup>	7.89 <sup>bc</sup>	10.75 <sup>ab</sup>	14.05 <sup>c</sup>	13.82 <sup>cd</sup>
T <sub>11</sub> : Control	2.72 <sup>ab</sup>	6.60 <sup>d</sup>	8.86 <sup>f</sup>	11.86 <sup>g</sup>	10.57 <sup>f</sup>
<b>S. Em. ±</b>	0.05	0.16	0.12	0.12	0.08
<b>F-test</b>	Sig.	Sig.	Sig.	Sig.	Sig.
<b>C. V. %</b>	<b>2.98</b>	<b>3.66</b>	<b>2.05</b>	<b>1.52</b>	<b>1.03</b>

**Note:** Treatment means with the letter/letters in common are not significantly different by Duncan's New Multiple Range Test at 5 % level of significance.



**Fig. 4.5 Effect of preharvest application of different chemicals and plant growth regulators on total sugar (%) of mango cv. Amrapali**



**Fig. 4.6 Effect of preharvest application of different chemicals and plant growth regulators on non-reducing sugar (%) of mango cv. Amrapali**

It was observed that the accumulation of non-reducing sugar (%) showed significant difference with respect to treatments and ripening stages of fruit. The preharvest sprayed with CaCl<sub>2</sub> 2 % found significantly highest non-reducing sugar at harvest (2.81 %), 4<sup>th</sup> day (8.78 %), 8<sup>th</sup> day (11.06 %), 12<sup>th</sup> day (15.33 %), and 16<sup>th</sup> day (15.15 %) as compared to rest of the treatments which was gradually increases during storage period up to 12<sup>th</sup> day and declined thereafter. The increase in the non-reducing sugar might be due to the hydrolysis of starch and conversion in the pectin substances from water insoluble to water soluble fractions. The increase in non-reducing sugar during storage was due to the conversion of starch into sugar as reported by Bhalerao *et al.* (2010) in sapota. These results are in accordance with the findings of Karemera and Habimana (2014) in mango and Jawandha *et al.* (2007) in ber.

#### **4.2.5 Ascorbic acid (mg/100 g pulp)**

The data pertaining to the effect of chemicals and plant growth regulators on ascorbic acid (mg/100 g pulp) of mango at harvest and every three days interval up to last ripening are presented in Table 4.11 and also depicted in the Fig. 4.7.

The chemicals and plant growth regulators were significantly influenced on ascorbic acid (mg/100 g pulp) content of mango at harvest and every three days interval up to last ripening stage. Among all the treatments, CaCl<sub>2</sub> 2 % recorded significantly maximum ascorbic acid (mg/100 g pulp) consistently at harvest (51.54 mg/100 g pulp), 4<sup>th</sup> day (45.83 mg/100 g pulp), 8<sup>th</sup> day (42.26 mg/100 g pulp), 12<sup>th</sup> day (39.63 mg/100 g pulp) and 16<sup>th</sup> day (35.42 mg/100 g pulp). CaCl<sub>2</sub> 2 % treatment was statistically superior over all other treatments. However, the minimum ascorbic acid was found with the control treatment at harvest (43.10 mg/100 g pulp), 4<sup>th</sup> day (37.65 mg/100 g pulp), 8<sup>th</sup> day (35.22 mg/100 g pulp) and 16<sup>th</sup> day (25.46 mg/100 g pulp) whereas, the minimum ascorbic acid (31.90 mg/100 g pulp) was recorded with ethrel 0.2 ml/l treatment at 12<sup>th</sup> day under ambient storage conditions.

In present study, the preharvest application of CaCl<sub>2</sub> 2 % recorded significantly highest ascorbic acid (mg/100 g pulp) at harvest (51.54 mg/100 g pulp), 4<sup>th</sup> day (45.83 mg/100 g pulp), 8<sup>th</sup> day (42.26 mg/100 g pulp), 12<sup>th</sup> day (39.63 mg/100 g pulp) and 16<sup>th</sup> day (35.42 mg/100 g pulp) as compared to rest of the treatments which was gradually decreased in fruits preharvest treated with chemicals and growth regulators at the end of storage periods. It might be due to calcium delayed the rapid oxidation of ascorbic acid. The highest retention of ascorbic acid during storage by calcium sprays might be due to

continue synthesis of its precursor like Glucose-6-phosphate during conversion as starch into various sugars and slow rate of oxidation reported by Yadav *et al.* (2009) in ber. These results are in accordance with the finding of Jawandha *et al.* (2007) in ber and Lal *et al.* (2011) in apricot.

**Table 4.11 Effect of preharvest application of different chemicals and plant growth regulators on ascorbic acid (mg/100 g pulp) of mango cv. Amrapali**

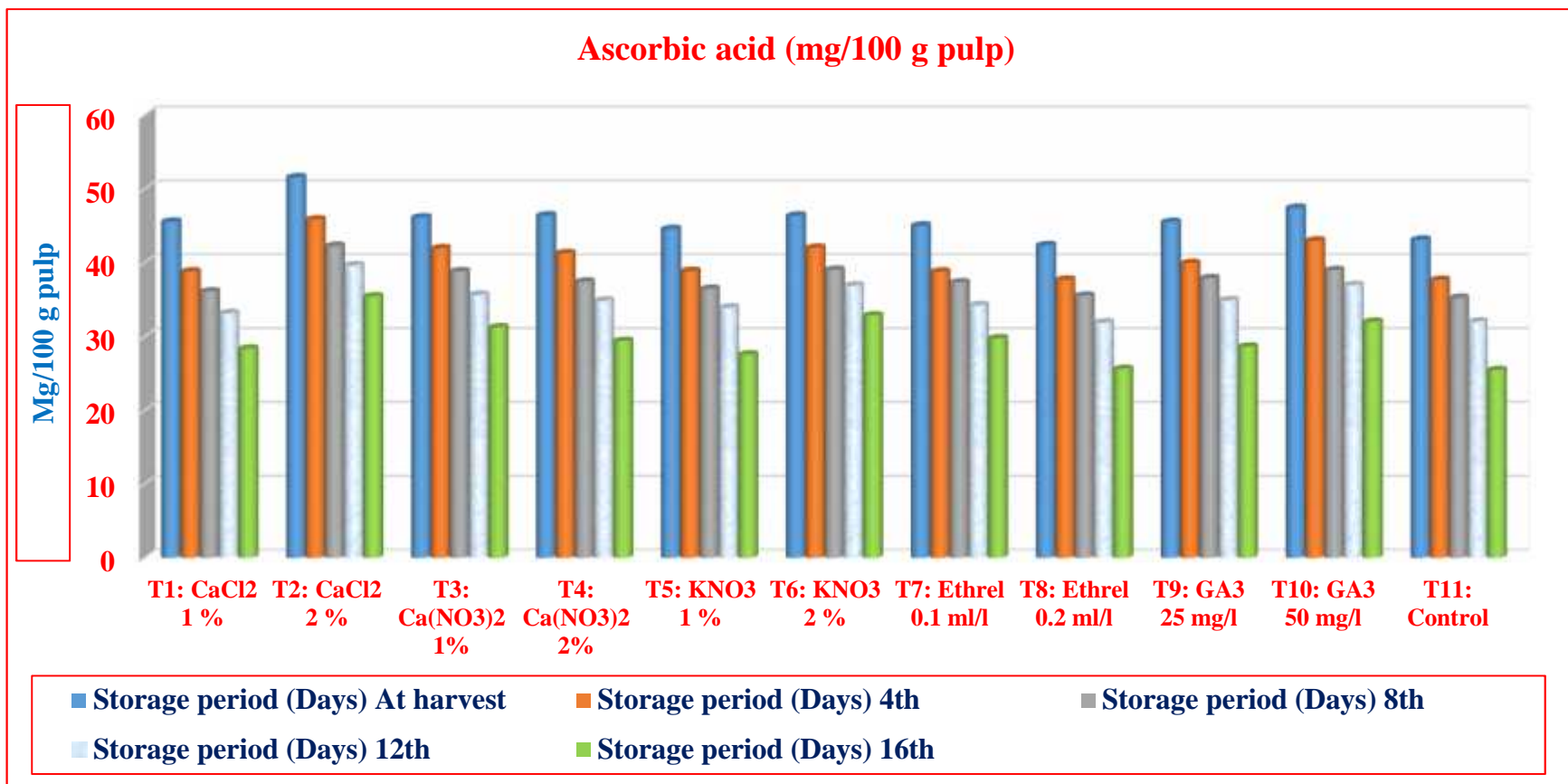
Treatments	Storage period (Days)				
	At harvest	4 <sup>th</sup>	8 <sup>th</sup>	12 <sup>th</sup>	16 <sup>th</sup>
T <sub>1</sub> : CaCl <sub>2</sub> 1 %	45.53 <sup>cde</sup>	38.78 <sup>e</sup>	36.09 <sup>de</sup>	33.15 <sup>g</sup>	28.34 <sup>ef</sup>
T <sub>2</sub> : CaCl <sub>2</sub> 2 %	51.54 <sup>a</sup>	45.83 <sup>a</sup>	42.26 <sup>a</sup>	39.63 <sup>a</sup>	35.42 <sup>a</sup>
T <sub>3</sub> : Ca(NO <sub>3</sub> ) <sub>2</sub> 1%	46.11 <sup>cd</sup>	41.92 <sup>c</sup>	38.82 <sup>b</sup>	35.65 <sup>c</sup>	31.23 <sup>c</sup>
T <sub>4</sub> : Ca(NO <sub>3</sub> ) <sub>2</sub> 2%	46.37 <sup>bc</sup>	41.28 <sup>c</sup>	37.43 <sup>c</sup>	34.85 <sup>de</sup>	29.39 <sup>de</sup>
T <sub>5</sub> : KNO <sub>3</sub> 1 %	44.54 <sup>e</sup>	38.85 <sup>e</sup>	36.44 <sup>d</sup>	33.92 <sup>f</sup>	27.56 <sup>f</sup>
T <sub>6</sub> : KNO <sub>3</sub> 2 %	46.35 <sup>bc</sup>	41.99 <sup>c</sup>	39.03 <sup>b</sup>	36.90 <sup>b</sup>	32.84 <sup>b</sup>
T <sub>7</sub> : Ethrel 0.1 ml/l	45.01 <sup>de</sup>	38.77 <sup>e</sup>	37.33 <sup>c</sup>	34.23 <sup>ef</sup>	29.75 <sup>d</sup>
T <sub>8</sub> : Ethrel 0.2 ml/l	42.34 <sup>f</sup>	37.68 <sup>f</sup>	35.52 <sup>ef</sup>	31.90 <sup>h</sup>	25.60 <sup>g</sup>
T <sub>9</sub> : GA <sub>3</sub> 25 mg/l	45.49 <sup>cde</sup>	39.92 <sup>d</sup>	37.88 <sup>c</sup>	34.90 <sup>d</sup>	28.61 <sup>d<sup>ef</sup></sup>
T <sub>10</sub> : GA <sub>3</sub> 50 mg/l	47.41 <sup>b</sup>	42.98 <sup>b</sup>	39.00 <sup>b</sup>	36.97 <sup>b</sup>	31.98 <sup>bc</sup>
T <sub>11</sub> : Control	43.10 <sup>f</sup>	37.65 <sup>f</sup>	35.22 <sup>f</sup>	32.01 <sup>h</sup>	25.46 <sup>g</sup>
<b>S. Em. ±</b>	0.34	0.28	0.22	0.20	0.37
<b>F-test</b>	Sig.	Sig.	Sig.	Sig.	Sig.
<b>C. V. %</b>	<b>1.27</b>	<b>1.18</b>	<b>1.03</b>	<b>1.01</b>	<b>2.17</b>

**Note:** Treatment means with the letter/letters in common are not significantly different by Duncan's New Multiple Range Test at 5 % level of significance.

#### 4.2.6 Acidity (%)

The data pertaining to the effect of chemicals and plant growth regulators significantly influenced on acidity of mango at harvest and every three days interval up to last ripening stage are presented in Table 4.12 and also illustrated in the Fig. 4.8.

There were significant effect of various chemicals and plant growth regulators on acidity of mango at harvest and every three days interval up to last ripening stage. CaCl<sub>2</sub> 2 % treatment recorded significantly minimum acidity at harvest (0.352 %), 4<sup>th</sup> day (0.258 %), 8<sup>th</sup> day (0.199 %), 12<sup>th</sup> day (0.101 %) and 16<sup>th</sup> day (0.096 %) as compared to rest of the treatments. It was statistically at par with treatment of GA<sub>3</sub> 25 mg/l, ethrel 0.2 ml/l and CaCl<sub>2</sub> 1 % at harvest, GA<sub>3</sub> 25 mg/l at 4<sup>th</sup> day, ethrel 0.2 ml/l, KNO<sub>3</sub> 2 % and GA<sub>3</sub> 25 mg/l at 8<sup>th</sup> day, KNO<sub>3</sub> 2 %, GA<sub>3</sub> 25 mg/l and ethrel 0.2 ml/l at



**Fig. 4.7** Effect of preharvest application of different chemicals and plant growth regulators on ascorbic acid (mg/100g pulp) of mango cv. Amrapali

12<sup>th</sup> day and ethrel 0.2 ml/l, ethrel 0.1 ml/l, KNO<sub>3</sub> 1 % and KNO<sub>3</sub> 2 % at 16<sup>th</sup> day during storage period. However, the maximum acidity was found at harvest (0.474 %) in control whereas at 4<sup>th</sup> day (0.390 %), 8<sup>th</sup> day (0.278 %), 12<sup>th</sup> day (0.177 %) and 16<sup>th</sup> day (0.122 %) were recorded in Ca(NO<sub>3</sub>)<sub>2</sub> 1% treatment under ambient storage conditions.

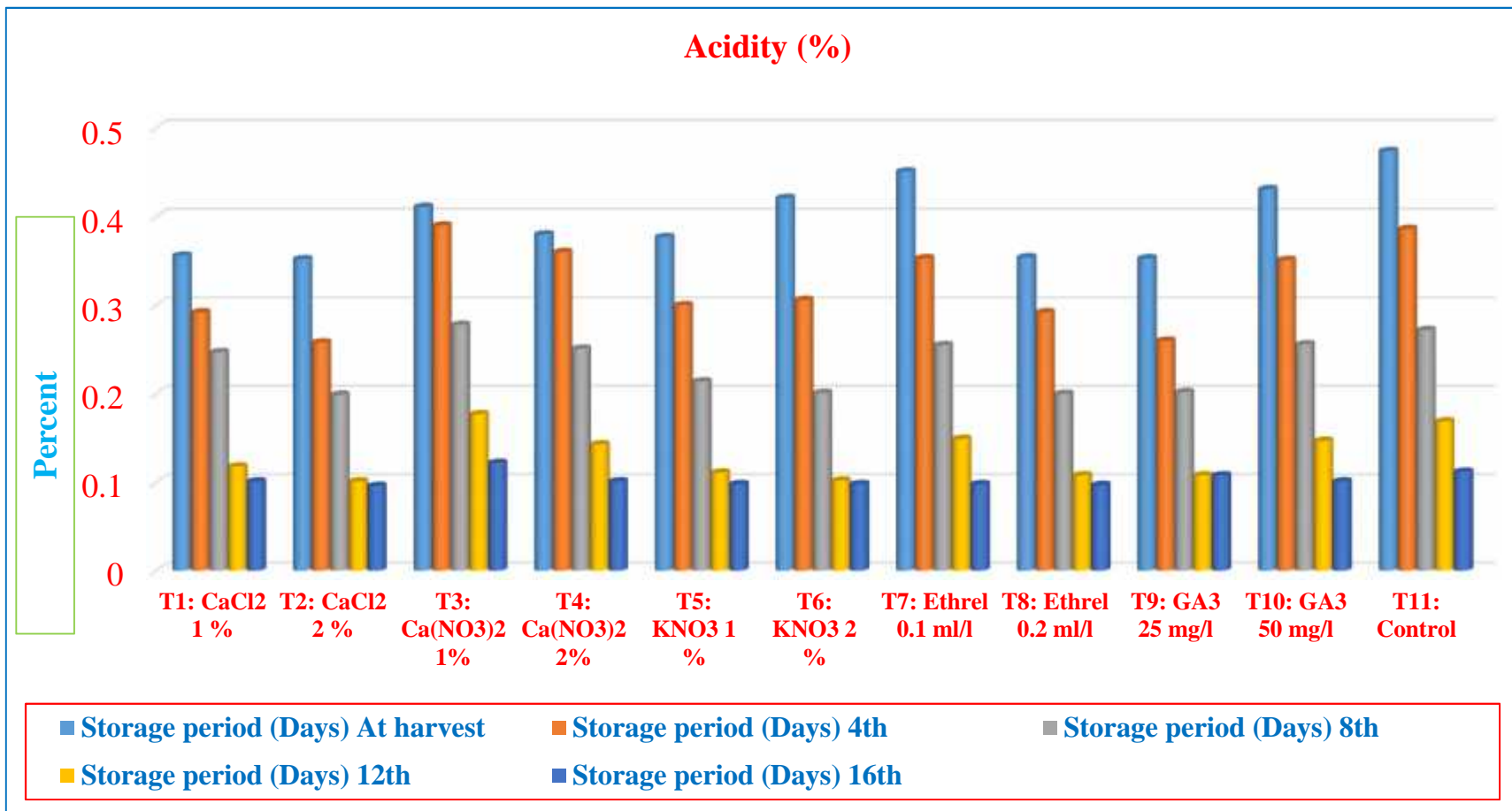
**Table 4.12 Effect of preharvest application of different chemicals and plant growth regulators on acidity (%) of mango cv. Amrapali**

Treatments	Storage period (Days)				
	At harvest	4 <sup>th</sup>	8 <sup>th</sup>	12 <sup>th</sup>	16 <sup>th</sup>
T <sub>1</sub> : CaCl <sub>2</sub> 1 %	0.356 <sup>f</sup>	0.292 <sup>d</sup>	0.247 <sup>c</sup>	0.118 <sup>e</sup>	0.101 <sup>d</sup>
T <sub>2</sub> : CaCl <sub>2</sub> 2 %	0.352 <sup>f</sup>	0.258 <sup>e</sup>	0.199 <sup>e</sup>	0.101 <sup>g</sup>	0.096 <sup>e</sup>
T <sub>3</sub> : Ca(NO <sub>3</sub> ) <sub>2</sub> 1%	0.411 <sup>d</sup>	0.390 <sup>a</sup>	0.278 <sup>a</sup>	0.177 <sup>a</sup>	0.122 <sup>a</sup>
T <sub>4</sub> : Ca(NO <sub>3</sub> ) <sub>2</sub> 2%	0.380 <sup>e</sup>	0.360 <sup>b</sup>	0.251 <sup>bc</sup>	0.143 <sup>d</sup>	0.101 <sup>d</sup>
T <sub>5</sub> : KNO <sub>3</sub> 1 %	0.377 <sup>e</sup>	0.300 <sup>cd</sup>	0.214 <sup>d</sup>	0.111 <sup>f</sup>	0.098 <sup>de</sup>
T <sub>6</sub> : KNO <sub>3</sub> 2 %	0.421 <sup>cd</sup>	0.306 <sup>c</sup>	0.201 <sup>e</sup>	0.102 <sup>g</sup>	0.098 <sup>de</sup>
T <sub>7</sub> : Ethrel 0.1 ml/l	0.451 <sup>b</sup>	0.353 <sup>b</sup>	0.255 <sup>b</sup>	0.149 <sup>c</sup>	0.098 <sup>de</sup>
T <sub>8</sub> : Ethrel 0.2 ml/l	0.354 <sup>f</sup>	0.292 <sup>d</sup>	0.200 <sup>e</sup>	0.108 <sup>f</sup>	0.097 <sup>e</sup>
T <sub>9</sub> : GA <sub>3</sub> 25 mg/l	0.353 <sup>f</sup>	0.260 <sup>e</sup>	0.202 <sup>e</sup>	0.108 <sup>f</sup>	0.108 <sup>c</sup>
T <sub>10</sub> : GA <sub>3</sub> 50 mg/l	0.431 <sup>c</sup>	0.351 <sup>b</sup>	0.256 <sup>b</sup>	0.147 <sup>c</sup>	0.101 <sup>d</sup>
T <sub>11</sub> : Control	0.474 <sup>a</sup>	0.386 <sup>a</sup>	0.272 <sup>a</sup>	0.169 <sup>b</sup>	0.112 <sup>b</sup>
<b>S. Em. ±</b>	0.005	0.003	0.002	0.001	0.001
<b>F-test</b>	Sig.	Sig.	Sig.	Sig.	Sig.
<b>C. V. %</b>	<b>1.97</b>	<b>1.54</b>	<b>1.75</b>	<b>1.71</b>	<b>1.23</b>

**Note:** Treatment means with the letter/letters in common are not significantly different by Duncan's New Multiple Range Test at 5 % level of significance.

Titration acidity of mango fruits declined with the advancement of ripening process of post-harvest treatments. However, the lowest acidity were found in CaCl<sub>2</sub> 2 % treatment at harvest (0.352 %), 4<sup>th</sup> day (0.258 %), 8<sup>th</sup> day (0.199 %), 12<sup>th</sup> day (0.101 %) and 16<sup>th</sup> day (0.096 %) as compared to rest of the treatments. The decrease in the total titratable acidity might be due to increase in the total sugar content of the fruits. At the time of maturity, fruits will be having higher amount of acidity, but as the fruits advance towards ripening, acid content will decrease. These results are in line with findings of Ingle *et al.*, (1982), who observed a decrease in acidity during ripening of sapota fruits.

The acidity of mango fruits generally decreases with advancement of storage period. Decrease in acidity might be attributed to conversion of acids into sugars during respiration. These results are accordance with the findings of Kardum (2004) in fig, Jawandha *et al.* (2007) in ber and Kaundal *et al.* (2000) in plum fruits.



**Fig. 4.8 Effect of preharvest application of different chemicals and plant growth on acidity (%) of mango cv. Amrapali**

## 5. SUMMARY AND CONCLUSION

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The present investigation was carried out on “**Effect of preharvest application of chemicals and plant growth regulators on fruit quality and shelf life of mango (*Mangifera indica* L.) cv. Amrapali**” during *summer* season of the year 2016 at Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat. The experiment was laid out in a Completely Randomized Block Design replicated thrice with eleven treatments *viz.*, T<sub>1</sub>: CaCl<sub>2</sub> 1 %, T<sub>2</sub>: CaCl<sub>2</sub> 2 %, T<sub>3</sub>: Ca(NO<sub>3</sub>)<sub>2</sub> 1 %, T<sub>4</sub>: Ca(NO<sub>3</sub>)<sub>2</sub> 2 %, T<sub>5</sub>: KNO<sub>3</sub> 1 %, T<sub>6</sub>: KNO<sub>3</sub> 2 %, T<sub>7</sub>: ethrel 0.1 ml/l, T<sub>8</sub>: ethrel 0.2 ml/l, T<sub>9</sub>: GA<sub>3</sub> 25 mg/l, T<sub>10</sub>: GA<sub>3</sub> 50 mg/l and T<sub>11</sub>: control.

The fresh and mature fruits were harvested from trees which were preharvest sprayed with different chemicals and plant growth regulators and stored at P G. Laboratory under the ambient storage condition and the observations of physical and biochemical parameters of fruits were recorded.

The results are presented and discussed in the preceding chapters have been summarized under following major heads.

### 5.1 PHYSICAL PARAMETERS

The effect of chemicals and plant growth regulators on fruit length, fruit diameter and fruit volume of mango were found significant influenced at harvest and at fully ripening stage. Among all the treatments, GA<sub>3</sub> 25 mg/l recorded significantly highest fruit length, fruit diameter and fruit volume at harvest and at fully ripening stage as compared to another treatments.

The chemicals and plant growth regulators showed significant effect on fruit weight and physiological loss in weight of mango at harvest and every day up to last ripening stage. Among all the treatments, GA<sub>3</sub> 25 mg/l consistently recorded significantly maximum fruit weight at harvest and every day up to 16<sup>th</sup> day whereas, CaCl<sub>2</sub> 2 % consistently recorded significantly minimum physiological loss in weight at 2<sup>nd</sup> day and every day up to 16<sup>th</sup> day during storage period.

CaCl<sub>2</sub> 2 % was most effective treatment for extending shelf life of mango fruit and which was recorded significantly maximum shelf life during storage period. There were significant influenced by various chemicals and plant growth regulators on marketable fruit (%) and spoilage (%) at harvest and every day up to last ripening stage.

There were 100 % marketable fruits and no any spoilage fruits were recorded in all the treatments up to 12<sup>th</sup> day of storage periods. CaCl<sub>2</sub> 2 % treatment consistently recorded significantly highest marketable fruit (%) and minimum spoilage (%) at 13<sup>th</sup> day up to 16<sup>th</sup> day of storage periods as compared to rest of the treatments.

## **5.2 QUALITY PARAMETERS**

There were significant effect of the preharvest spray of different chemicals and plant growth regulators found on total soluble solids, reducing sugar, total sugar, non-reducing sugar, ascorbic acid and acidity at harvest and every three days interval up to last ripening stage. Among all the treatments, CaCl<sub>2</sub> 2 % treatment consistently recorded significantly highest total soluble solids, reducing sugar, total sugar, non-reducing sugar, ascorbic acid and minimum acidity at harvest, 4<sup>th</sup> day, 8<sup>th</sup> day, 12<sup>th</sup> day and 16<sup>th</sup> day during storage period whereas, ethrel 0.2 ml/l treatment also recorded significantly highest reducing sugar at harvest.

## **CONCLUSION**

The results obtained from present investigation concluded that, GA<sub>3</sub> 25 mg/l treatment recorded highest fruit length, fruit diameter, fruit volume and fruit weight during storage period. Whereas, CaCl<sub>2</sub> 2 % treatment recorded maximum shelf life, marketable fruit (%), total soluble solids, total sugar, reducing sugar, non-reducing sugar and ascorbic acid content of mango fruit while, minimize the acidity, physiological loss in weight and spoilage (%) of fruit under ambient storage condition.

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## APPENDIX -I

**Appendix- I (A):- Weather parameters recorded during the research conducted on field experiment during the year:- 2016**

Date	Bright Sunshine Hours (Hrs)	Temperature ( <sup>0</sup> C)		Wind speed	RH <sub>1</sub> (%)	RH <sub>2</sub> (%)
		Maximum	Minimum			
21/03/2016	9.4	38.5	20.0	6.7	75	17
22/03/2016	10.0	37.5	19.5	4.8	62	15
23/03/2016	10.0	37.8	17.5	3.3	62	12
24/03/2016	10.2	39.8	17.5	2.2	56	19
25/03/2016	9.9	41.0	20.5	2.3	66	31
26/03/2016	6.8	39.8	21.9	3.6	81	24
27/03/2016	8.7	38.5	23.5	4.7	71	29
28/03/2016	9.6	39.0	22.5	5.3	48	15
29/03/2016	9.0	38.8	17.2	2.2	75	13
30/03/2016	10.3	39.0	17.5	2.6	72	11
31/03/2016	10.3	39.8	17.8	2.8	82	25
01/04/2016	9.1	37.4	18.5	2.7	87	38
02/04/2016	10.0	37.5	21.4	3.0	88	29
03/04/2016	8.9	39.2	23.0	2.9	84	31
04/04/2016	9.3	37.9	22.7	5.1	67	30
05/04/2016	8.7	36.6	25.2	5.3	62	39
06/04/2016	10.1	37.0	23.2	5.2	60	28
07/04/2016	8.4	36.0	24.9	5.3	68	25
08/04/2016	8.6	36.5	24.2	5.4	65	23

Date	Bright Sunshine Hours (Hrs)	Temperature ( <sup>0</sup> C)		Wind speed	RH <sub>1</sub> (%)	RH <sub>2</sub> (%)
		Maximum	Minimum			
09/04/2016	10.3	36.8	20.2	4.0	64	24
10/04/2016	10.5	37.2	24.5	4.6	75	31
11/04/2016	9.9	39.0	26.6	7.1	51	20
12/04/2016	10.4	38.1	24.2	5.4	58	22
13/04/2016	10.3	39.0	25.2	5.0	59	15
14/04/2016	10.2	40.0	25.0	4.0	45	15
15/04/2016	11.3	40.2	23.0	3.9	71	32
16/04/2016	11.3	39.4	25.0	5.2	67	22
17/04/2016	10.3	40.2	24.0	5.4	78	24
18/04/2016	11.0	40.0	24.0	6.4	63	32
19/04/2016	8.6	37.0	22.5	3.5	45	29
20/04/2016	10.8	38.5	26.5	4.7	50	28
21/04/2016	10.9	39.0	23.5	4.4	55	30
22/04/2016	11.6	39.0	21.6	5.8	52	37
23/04/2016	11.5	37.8	24.5	6.7	69	36
24/04/2016	11.0	37.2	25.0	6.1	78	37
25/04/2016	11.2	36.0	25.0	5.8	84	36
26/04/2016	6.5	36.0	26.2	3.6	52	36
27/04/2016	0.7	35.0	24.0	2.3	64	24
28/04/2016	11.2	40.2	22.2	4.0	58	21
29/04/2016	11.4	41.8	24.0	3.8	59	25
30/04/2016	10.8	42.2	24.2	4.7	81	28

Date	Bright Sunshine Hours (Hrs)	Temperature ( $^{\circ}$ C)		Wind speed	RH <sub>1</sub> (%)	RH <sub>2</sub> (%)
		Maximum	minimum			
01/05/2016	10.9	40.2	25.2	5.2	80	23
02/05/2016	10.8	41.0	25.0	5.1	83	39
03/05/2016	6.8	40.0	24.5	4.8	84	34
04/05/2016	11.1	40.8	24.7	4.1	63	45
05/05/2016	7.0	38.0	26.3	5.0	66	28
06/05/2016	6.5	39.2	25.5	4.0	71	28
07/05/2016	8.7	39.5	24.9	4.7	84	39
08/05/2016	10.6	38.7	26.5	4.7	83	41
09/05/2016	11.0	40.2	26.4	5.6	88	30
10/05/2016	11.3	40.0	27.5	5.4	57	32
11/05/2016	11.0	41.0	27.0	4.7	70	31
12/05/2016	10.6	42.0	27.8	5.8	71	26
13/05/2016	10.8	42.4	28.0	5.0	59	27
14/05/2016	11.3	43.0	25.0	4.9	58	29
15/05/2016	11.6	41.8	25.5	4.9	64	22
16/05/2016	11.5	43.5	28.0	6.2	67	27
17/05/2016	10.9	42.8	27.0	5.7	85	28
18/05/2016	11.1	43.4	27.8	5.2	66	23
19/05/2016	11.0	44.7	27.6	5.6	69	22
20/05/2016	10.8	44.0	28.5	6.7	84	38
21/05/2016	10.7	41.6	27.8	10.4	78	37
22/05/2016	10.8	40.3	28.0	10.6	77	45

Date	Bright Sunshine Hours (Hrs)	Temperature ( <sup>0</sup> C)		Wind speed	RH <sub>1</sub> (%)	RH <sub>2</sub> (%)
		Maximum	Minimum			
23/05/2016	10.8	38.8	28.3	11.4	74	39
24/05/2016	10.6	40.0	28.8	11.0	70	42
25/05/2016	10.6	39.0	28.5	9.9	78	45
26/05/2016	11.4	39.0	28.0	10.5	81	47
27/05/2016	10.6	39.0	28.0	9.9	78	41
28/05/2016	11.5	39.5	27.7	8.9	75	41
29/05/2016	11.3	39.8	28.0	9.7	77	40
30/05/2016	11.2	38.9	28.6	10.4	73	37
31/05/2016	10.7	40.0	28.8	9.7	72	40
01/06/2016	10.9	39.8	28.6	7.0	73	36
02/06/2016	11.6	39.2	28.5	7.9	69	35
03/06/2016	11.0	40.8	26.0	6.5	85	37
04/06/2016	11.5	42.0	27.8	6.1	72	28
05/06/2016	10.7	43.2	28.5	6.9	69	24
06/06/2016	11.2	44.3	28.8	7.3	83	27
07/06/2016	11.4	43.0	27.5	6.4	71	41
08/06/2016	11.7	40.5	27.5	7.6	71	39
09/06/2016	11.5	40.3	27.8	8.1	78	37
10/06/2016	10.4	40.2	28.5	9.7	76	42
11/06/2016	9.7	39.0	28.0	10.0	74	41

**Appendix-I (B): The details of Weather parameters recorded during the observations taken in the laboratory.**

Date	Temperature (°C)			Mean RH (%)
	Maximum	Minimum	Mean	
11/06/2016	39.0	28.0	33.5	58
12/06/2016	38.8	29.0	33.9	54
13/06/2016	39.9	28.4	34.2	56
14/06/2016	39.8	27.0	33.4	58
15/06/2016	38.0	28.0	33.0	53
16/06/2016	38.7	28.5	33.6	54
17/06/2016	39.5	27.6	33.6	52
18/06/2016	39.0	28.6	33.8	56
19/06/2016	38.5	29.0	33.8	63
20/06/2016	34.0	28.0	31.0	63
21/06/2016	39.6	28.5	34.1	64
22/06/2016	37.8	29.6	33.7	69
23/06/2016	37.0	27.6	32.3	65
24/05/2016	37.8	28.4	33.1	69
25/06/2016	36.8	27.2	32.0	72
26/06/2016	37.0	25.0	31.0	72
27/06/2016	35.0	26.5	30.8	73