STUDIES ON EFFECT OF ETHREL ON RIPENING BEHAVIOUR OF MANGO (*Mangifera indica* L.*)* CV. ALPHONSO

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DIST: - RATNAGIRI (M.S.)
August - 2012

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A thesis submitted to the

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(Agricultural University)

Dist. Ratnagiri (Maharashtra State), India

in partial fulfillment of the requirements for the degree of

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C E R T I F I C A T E

*This is to certify that the thesis entitled "***STUDIES ON EFFECT OF ETHREL ON RIPENING BEHAVIOUR OF MANGO (*Mangifera indica* L.) CV. ALPHONSO***" submitted to the Department of Post Harvest Management of Fruit, Vegetable and Flower crops, Post Graduate Institute of Post Harevst Management, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra state in the partial fulfillment of the requirements for the degree of* **MASTER OF SCIENCE (Post Harvest Management)**, *embodies the results of a piece of bona-fide research carried out by* **Mr. SANDESH ANANTA GODAMBE** *under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma or published in other form. All the assistance and help received during the course of investigation and the sources of literature have been duly acknowledged by him.*

Place: Dapoli

Date: August 2012

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A C K N O W L E D G E M E N T

At this gratifying moment of completion of my research problem, I feel obliged to record my gratitude to those who have helped me. First of all I express my infinite indebtedness and deep sense of gratitude to my beloved parents for continuously providing my spiritual energy, which has inspired me to reach at the highest excellence.

Indeed the words at my command are not adequate to convey the depth of my feeling and gratitude to my honorable major advisor ***Dr. P. P. Relekar,*** *Assistant Professor, Department of Horticulture College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, for his most valuable and inspiring guidance with his friendly nature, love and affection, for his attention and magnanimous attitude right from the first day, constant encouragement, enormous help and constructive criticism throughout the course of this investigation and preparation of this manuscript.*

I feel a great pleasure in getting this proud privilege offering my sincerest and devoted thanks to my Minor advisor ***Dr. K.H. Pujari,*** *Associate Dean Post Graduate Institute of Post Harvest Management, Killa Roha, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli; and other members of my advisory committee* ***Dr. N.B. Gokhale,*** *Incharge, department of biotechnology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, and* ***Dr. J. S. Dhekale,*** *Associate professor, Department of Economics; College of Agriculture, Dapoli for their worthy suggestions, ever willing help and unbiased attitude throughout the course of this investigation.*

I acknowledge with thanks for the facilities provided by the Director of Research, Dr. Balasaheb Sawant Konkan Krishi

Vidyapeeth, Dapoli and the Dean, College of Agriculture, Dapoli during the course of my studies.

My special thanks to ***Dr. J. S. Dhekale,*** *Associate professor, Department of Economics; College of Agriculture, Dapoli for their help in analytical research study. All staff members from the Dept. of Post Harvest management of Fruit, Vegetable and flower crops, Post Harvest Institute of Post Harvest Management and Central Library, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli for their valuable guidance and co-operation throughout the course of my studies.*

The word like thanks should not come in between friends, but it came from the bottom of heart for my beloved, sweet friends Shoaib, Hemant, Ajit, Nikheel, Vinay, Pratik, Prafull, Rohan, Sonya, Dhairyshil, Siddhesh, Viraj, Abhishek, Abhishek[2], Prasad, Swapnil, Gitesh, Prajakta, Bhageshri, Amol, Nagesh Vinod, Sapna, Seema, Sonali, Niha, Ashwini, Sonal, Supriya, Pooja, Tarannum, all my juniors and Rakesh, Priyesh, Khirari, Buva, Kedari, Bappa, Shri, Navdeep other colleagues for their helping and kind co-operation during the course of study.

My vocabulary fails to get words to express deep sense of gratitude and indebtedness to my loving family members for their everlasting love, constant encouragement, prayer support and sacrifice, without which this dream could not have become a reality.

Last, but far from the least, I wish to express my deepest gratitude and sole full respect to 'God', who helped me on every path of life and made every step a great success.

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DEPARTMENT OF POST HARVEST MANAGEMENT OF FRUIT, VEGETABLE AND FLOWER CROPS

POST GRADUATE INSTITUTE OF POST HARVEST MANAGEMENT

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Title of thesis	:	"Studies on effect of ethrel on ripening behaviour of mango (*Mangifera indica* L.*)* Cv. Alphonso"
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Year of submission	:	August 2012

ABSTRACT

The investigation entitled "Studies on effect of ethrel on ripening behaviour of mango (*Mangifera indica* L.*)* Cv. Alphonso" was carried out to study the effect of different concentration of ethrel on mango Cv. Alphonso fruits.

The experiment was conducted in Factorial Completely Randomized Design for different parameters and Completely Randomized Design for sensory evaluation with 5 treatments. The mango fruits Cv. Alphonso were dipped in ethrel with different concentrations ranging from 250 ppm to 1000 ppm for the period of 5 minutes depending upon the treatment.

From the present investigation, it was observed that, as the ethylene treatment triggered the ripening process the ethrel treated fruits recorded lower firmness than the untreated fruits after four days of treatment. There was increasing trend with respect to L*, a* and b* values for colour with increase in the ethrel concentration as well as storage period. The chemical parameters such as TSS, reducing, non-reducing, and total sugars content exhibited an increasing trend while decreasing trend by titratable acidity and ascorbic acid content of the mango Cv. Alphonso irrespective of treatments during storage.

The ripening process could be hastened by treating the fruits with ethrel concentration ranging from 250 to 1000 ppm. However, it was observed that the ethrel treated fruits would lose their shelf life within 12 days after treatment; hence, they must be disposed of within a period of 8 to 10 days after the ethrel treatment. The fruits treated with 750 or 1000 ppm ethrel solution to ripen them within a period of 4 days after treatment. Based on the sensory qualities for flavour and taste and early ripening, the application of ethrel @ 500 ppm found ideal for the early marketing.

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CHAPTER I

INTRODUCTION

Mango (*Mangifera indica* L.), the King of fruits is the most important fruit in the tropical as well as sub tropical region of the world, in which India contributes a major share in area and production (Chanan *et al*; 2005). Mango fruit is rightly known as 'National fruit of India', owing to its nutritional richness, unique taste and flavour, religious and medicinal importance. Mango is the main commercial fruit crop of our country. It is the third widely produced fruit crop of the tropics after banana and citrus. It has originated from South East Asia, the Indo-Burma region, in the foothills of the Himalayans (Mukherjee, 1951).

Mango fruits contain carbohydrates, fatty acids, minerals, organic acids, protein and vitamins. Ripe mango contains moderate levels of vitamin C, but are fairly rich in vitamin A, vitamin B_1 and B_2 (Anonymous, 2009). The ripe mangoes are reported to have 73.0 - 86.7 per cent moisture, 0.5-1.0 per cent protein, 0.1-0.8 per cent fat, 11.6-24.3 per cent carbohydrate, 0.412 per cent calcium, 0.195 per cent phosphorus, 50 ppm iron, 6375-20750 ug/100g β-Carotene, 50ug/100 g riboflavin and 6.8-38.8 mg/100g ascorbic acid, 12.0-23.0 ^{o}Brix TSS and 0.12-0.38 per cent acidity (Anonymous, 2010a).

In India, Uttar Pradesh is a leading mango growing state with 3.62 MT of mango production followed by Andhra Pradesh (3.36), Karnataka (1.77), Bihar (1.33), Gujrat (0.91), Tamil Nadu (0.82), Orrisa (0.64), West Bengal (0.62), Jharkhand (0.42), Kerala (0.38) and Maharashtra (0.33) (Anonymous, 2011).

India exports mango and mango based products to more than 80 countries, so it is an important foreign exchange earner, with an earning of Rs. 20053.96 million from export of 76460.6 tonnes of fresh fruits (Anonymous 2009a) and Rs 7446.1 million from the export of 186197.88 Mt of mango pulp (Anonymous, 2009b).

Due to successful implementation of horticulture plantation through Employment Guarantee Scheme linked with National Horticulture Development Programme from 1990 onwards, area under mango crop has increased at an alarming rate in Maharashtra, currently occupying the maximum area i.e. 0.474 million ha in the country with a total production of over 0.578 million tonnes of mango and productivity is 1.3 tonnes/ha (Anonymous, 2009a).

Konkan is the major and famous Alphonso mango producing region of the west coast of Maharashtra, where it occupies an area of 0.165 million ha which comprises four mango growing districts viz; Thane (23,722 ha), Raigad (46,418 ha), Ratnagiri (66,651 ha) and Sindhudurg (29,809 ha) and is emerging as one of the largest mango growing belts in country. The productivity of mango in Konkan is about 1.7 tonns per ha. which is two to three times

less than the average productivity of the country (Anonymous, 2010b). Konkan region accounts for about 10 per cent of the total area under mango in the country, out of which almost 90 per cent area is covered by the single cultivar only i.e. Alphonso, which is locally called as '*Hapus*'. This variety has major export share to the tune of over 35 per cent of total mango export (Burondkar, 2005). The warm and humid climate throughout the year and rain free season from November to May prevalent in Konkan region is ideal for mango in general and Alphonso in particular. It enjoys virtual dominance both in domestic as well as in international markets due to its typical sugar-acid blend, pleasant aroma, highly appreciable flavour and taste.

Ripening of mangoes is very recent concept in post harvest technology but has a great importance especially in export of mangoes. The need for alternative methods of regulating ripening and senescence is of the utmost importance in conservation and maintenance of quality of this fruit. Therefore, these days' artificial fruit ripening has become a common practice (Siddiqui and Dhua,2009).

Ethrel (2- Chloroethyl phosphonic acid) is well known for induction of early and uniform ripening in a number of fruits including mango. The ethrel treatment brings about post harvest changes such as softening, sweetening and colour changes which are associated with ripeness. The application of ethrel accelerates the ripening process in mango (Siddiqui and Dhua, 2009). General aim of early ripening of mango is to increase the respiration rate which helps to prepare mango fruits for early marketing.

In view of all this, the present investigation "Studies on effect of ethrel on ripening behaviour of mango (*Mangifera indica* L.) Cv. Alphonso" was undertaken with the following objectives,

1. To study the effect of ethrel on ripening of mango Cv. Alphonso
2. To study the effect of ethrel on quality of mango Cv. Alphonso

CHAPTER II

REVIEW OF LITERATURE

This chapter highlights the earlier work done on the "Studies on effect of ethrel on ripening behaviour of mango (*Mangifera indica* L.*)* Cv. Alphonso" under the following headings. The literature on fruits other than mango is also included,

2.1 Effect of ethrel treatment on physical parameters of mango fruits.

2.2 Effect of ethrel treatment on PLW of fruit.

2.3 Effect of ethrel treatment on ripening of mango fruits.

2.4 Effect of ethrel treatment on chemical parameters of mango fruits.

2.5 Effect of ethrel treatment on sensory qualities of mango fruits.

2.1 Effect of ethrel treatment on physical parameters of mango fruits.

2.2.1 Firmness.

Many researchers found that, optimum dose of ethrel induce ethylene (C_2H_4) production, respiration rate and ripening phenomenon which promote the ripening process with significant decrease in firmness of fresh fruits.

Chauhan *et al*. (2012) noticed that the firmness of fruits declined during ripening period in all treatments when the orange fruits were exposed to ethylene gas (150 ppm). for 24 h in ripening chamber and various concentrations of ethephon (250, 500, 750, 1000 ppm) primarily in aqueous solution each for 5 minutes untreated control fruits were hard (260 g-force) and remained unripe, while ethephon (1000 ppm). treated fruits were least firm (44 g force). The fruits treated with ethylene gas (100 ppm) and ethephon (500 ppm) registered adequate firmness of 66 and 64 g force, respectively during ripening period of 28 days.

Dhillon and Mahajan (2011) observed that the treatment with ethylene 100 ppm decreased 'Patharnakh' pears firmness at both ripening environment i.e. 20 ^{0}C and ambient temperature compared to control fruits after 4th, 8th and 12th day of ripening period. All the treatments under both the ripening temperatures showed considerably low fruit firmness after 8th day which was ideal fruit firmness of 13.0 lb force as compared to control with 17.0 lb force. However, below 13.0 lb force showed over ripening after 12 days in treated fruits.

Montalvo *et al.* (2007) found that mangoes Cv. 'Ataulfo' treated with exogenous 100 ppm ethylene had a clear effect on fruit firmness. Firmness was lower (151.01 *N*) in ethylene treated fruits for 6 hours then those treated for 12 hours (124.72 *N*) on 5th day, but changes were more pronounced in control with highest (96.60 *N*) firmness.

When 'Tron' and 'Hoi' mango fruits were drenched for 30 min. in 0.4 per cent and 0.8 per cent ethrel solution and water as control treatment, the flesh firmness of 'Hoi' was maintained higher and longer as compared to 'Tron', but was reduced more at higher concentration of ethrel at 20 ^{0}C and 12 ^{0}C temperature regimes. This indicated the important role of exogenous ethylene on texture change in mango (Hai *et al;* 2009).

Saeed *et al.* (2006) reported that the ethylene (100 ppm) treated banana fruits for 24 hours with relative humidity 65-70% showed lower firmness i.e 2.2 *N* than control fruits with 3.0 *N* firmness.

Sane *et al*. (2005) found that ripening was initiated by exposure to exogenous ethylene (100 μLL^{-1}) for 24 h in a closed chamber and fruits were then allowed to ripen for 6 days at 23 ^{0}C in air. Further, they reported that the firmness of the fruit decreased from 11 to 1N within 2 days of ethylene treatment.

Mahajan *et al*. (2010) recorded that the firmness of banana Cv. Grand nine fruits treated with ethylene gas (100ppm) and ethephon (250, 500, 750, 1000ppm) declined during ripening period. Untreated control fruits were hard (256 g-force) and remained unripe, while ethephon (1000 ppm) treated fruits were least firm (45 g force). The fruits treated with ethylene gas (100 ppm) and ethephon (500 ppm) registered adequate firmness of 67 and 65 g force, respectively during ripening period of 4 days.

Nair and Singh (2003) concluded that all the treatments of exogenous application of ethrel prior to 'Kensington Pride' mango fruit stored at 5 ^{0}C for four weeks significantly ($P \leq 0.05$) reduced fruit firmness, as compared to untreated fruit. Fruit firmness of fully ripe fruit was reduced as the concentration of applied ethrel was inceased.

Nour and Goukh (2010) studied the effect of ethrel in aqueous solutions at 250, 500 and 1000 ppm and ethylene released from ethrel at 250, 500 and 1000 ppm on fruit ripening of white and pink fleshed guava fruits. Fruit flesh firmness of the two guava types showed a progressive decline during ripening. The decline in flesh firmness observed in the untreated fruits was about 15-folds, from the hard mature-green stage (2.17 kg. cm^{-2} shear resistance) to the final soft ripe stage (0.14 kg. cm^{-2}). This was reached in 16 days of storage in both guava types

Lagunes *et al.* (2007) observed that mango Cv. 'Manila' fruits treated with 0.5 and 0.75 ml l^{-1} of ethylene for 6 hours and 12 hours and they found that the ethylene treatment decreased the firmness of fruits. These decreased values of firmness could not reach the level of untreated fruits.

Siddiqui and Dhua (2009) harvested the mango Cv. Himsagar fruits in three different stages viz., 72, 79 and 86 days after fruit set and then fruits were subjected to ethrel (250, 500 and 1000 ppm) treatment. They noticed that firmness of fruits decreased with the ripening of the fruits. Acceptable quality characteristics of Himsagar mangoes were considered as a pulp rupture force of 0.05 to 0.3 Kg/cm^2. Fruits harvested at Stage-2 developed good quality characteristics with 500 ppm. The results showed that, fruits of Stage-2 and Stage-3 undergone complete softening on 9th and 6th day respectively, whereas fruits of Stage-1 showed only limited texture loss with 1000 ppm.

Venkateshan and Tamilmani (2010) reported that firmness of mango Cv. Neelum fruit gradually decreased from the initial stage to the final stage of ripening. The decrease was more in the fruits treated with 200 ppm ethrel than with 100 and 300 ppm ethrel treated fruits and control. The decrease in firmness of 200 ppm ethrel treated fruit was from 25.5 kg/cm^2 at first day to 8.5 kg/cm^2 at 15^{th} day.

William *et al.* (2009) treated mature green mango Cv. 'Keith' fruits with 150-300 ppm ethylene for 15 hours, followed by storage at 23 ^{0}C until they become soft. They found that the ethylene treatment decreased the firmness of fruits. Hence, internal increase of ethylene resulted in loss of firmness.

2.1.2 Colour

Abd (2010) studied the effect of the post harvest treatment of ethrel of 500 ppm concentration for 3 minutes on banana fruits. They found that ripening of banana colour index (5.51) showed more yellow with some green at the end of the fruits shelf life.

Ahmad *et al*. (2006a) studied the ethylene effect its time of exposure, polyethylene packaging, its thickness and the interaction between both on the ripening and quality of ripe banana fruit. Bananas exposed to ethylene treatment were significantly less green than those were not treated with ethylene. Bananas exposed to ethylene treatment for one and two days showed significantly reduced green values than those, which were exposed to ethylene for four

days. Bananas packed in thicker (200 gauge) polyethylene bag showed greater greenness values than those packed in thinner polyethylene bags (100 & 150 gauge).

Ahmad *et al*. (2006b) studied the effect of different humidity levels in the ripening behaviour and quality of ethylene treated and un-treated Banana fruits. Bananas ripened with ethylene treatment were significantly less green than un-treated bananas. Humidity levels did not showed any significant effect on the greenness values, but there was an indication that bananas ripened at higher humidity levels were slightly greener than those, which were ripened at lower humidity levels.

Blankenship and Herdeman (1995) held banana fruits at 18 ^{0}C in all possible combination of 65 per cent, 75 per cent, or 95 per cent relative humidity (RH) before and after gassing. They reported that the peel colour was most affected by humidity after gassing and 95 per cent relative humidity resulted in greener banana with the score of 5.9 for peel colour.

Palou *et al*. (2003) reported that the exogenous ethylene and its concentration may or may not cause colour change in 'Bing' and 'Brooks' cherry fruits. The skin colour was significantly lower in 0.01, 0.1 or 1 µl/L ethylene exposed fruit than control fruit.

Mahajan *et al*. (2009) observed the effect of exposure of green mature banana fruits to ethylene gas at 100 ppm for 24 hour and revealed that, bananas ripened with ethylene treatment were significantly less green than un-treated bananas.

Nour and Goukh (2010) studied the effect of ethrel in aqueous solutions at 250, 500 and 1000 ppm and ethylene released from ethrel at 250, 500 and 1000 ppm was evaluated on fruit ripening of white and pink fleshed guava fruits. Peel color score progressively increased during ripening of both guava types. The untreated white and pink guava fruits reached the full yellow stage (color score 6) in 14 and 15 days. Fruits treated with ethylene liberated from ethrel at 250, 500 and 1000 ppm reached the full yellow stage 6, 7 and 9 days earlier than the untreated fruits, respectively.

Pesis *et al*. (2005) studied ripening behaviour of green, unripe banana hand (Musa spp. AAA group 'Ziv') treated with 100 ppm ethylene for 48 h at 20 ^{0}C and packed in an individual polyethylene (PE) bag. They revealed that, the control unpacked fruits but treated with 100 ppm ethylene were overripe (H^0 = 78.3) after 8 days and the treated banana packed with polyethylene bags having 8 holes generated a nice yellow colour (H^0 =88.8).

Kulkarni *et al*. (2004) observed that the mango fruits Cv. Neelum treated with ethrel had considerable effect and induced early development of yellow colour of peel and pulp of fruit.

2.2.1 Effect of ethrel on Physiological loss in weight (PLW) of fruits.

Many researchers found that ethrel treated fruits had higher weight loss as compared to untreated fruits. The maximum weight loss was recorded towards to the ripe stage as compared to the harvest stage due to physiological processes in fruits i.e. respiration, ethylene production, ripening phenomenon.

Chauhan *et al*. (2012) studied the effect of exposure to ethylene gas in ripening chamber as well as ethephon treatments with various concentrations on PLW of orange fruits. The fruits were exposed to ethylene gas (150 ppm) for 24 hours in ripening chamber and various concentrations of ethephon (250, 500, 750, 1000 ppm) primarily in aqueous solution each for 5 min. They reported that the highest PLW (6.5%) was observed with ethephon 1000 ppm during ripening period of 28 days which was followed by ethephon 750 ppm (5.2%) and these treatments resulted in shriveling, softening and over ripening of fruits and found unsuitable. Ethylene gas (100 ppm) and ethephon (500 ppm) recorded 3.1 and 3.4 per cent weight loss, respectively during ripening period of 28 days leading to adequate ripening and softening of fruits. Lowest Physiological loss in weight (2.5%) was recorded in control fruits and these fruits were green and hard in texture.

Kulkarni *et al.* (2004) observed the effect of the post-harvest dip treatment on mango Cv. Neelum in 500ppm ethrel. It was noticed that the Physiological loss in weight of fruits increased with the progress in storage period. Physiological loss in weight of ethrel treated fruit had shown maximum weight loss (8.7%) while control fruits recorded lower Physiological loss in weight (7.0%) at the end of 12 days storage.

Lagunes *et al.* (2007) reported that mature green ‘Manila’ mango fruits treated with ethylene showed accelerated ripening. The loss in physiological weight of fruit during ripening was significantly higher in ethylene treatments than control. However treatment with $0.5ml^{-1}$ for 6 hours and 0.75 ml^{-1} for 12 hours dose of ethylene reduced weight loss on 2^{nd} day of storage as compared to control.

Mahajan *et al*. (2010) observed the effect of exposure of green mature banana Cv. Grand Naine fruits to ethylene gas at 100 ppm for 24 hour. The fruits were treated with different concentrations of aqueous solution of ethephon (250, 500, 750, 1000 ppm) each for 5 minutes.

The Physiological loss in weight of fruits increased during ripening process. The highest Physiological loss in weight (7%) was observed with ethephon 1000 ppm during ripening period of 4 days, which was followed by ethephon 750 ppm (5.8% PLW) and these treatments resulted in shriveling, softening and over-ripening of fruits and found unsuiatable. Ethylene gas (100 ppm) and ethephon (500 ppm) recorded 3.2 and 3.7 per cent weight loss, respectively during ripening period of 4 days leading to adequate ripening and softening of fruits. Lowest Physiological loss in weight (2.8%) was recorded in control fruits.

Saeed *et al.* (2006) recorded that per cent increase in weight loss was more in ethylene treated banana fruits. The significantly high Physiological loss in weight of 0.40 per cent in ethylene treatments was observed per day of storage, whereas it was significantly low in control treatment i.e. 0.30 per cent per day.

Amer (1990) observed that exposure of 'Tommy atkins' mango fruits to ethylene dose at 1.0 mll^{-1} for 24 hr at 25 ^{0}C exhibited higher per cent loss in weight on 5th day than control.

Charles (1975) reported that mature green 'Carrie' and 'Haden,' mangoes treated with ethylene presented higher weight losses on 5th day than non-ethylene treated fruits.

Dhillon and Mahajan (2011) observed that the physiological loss in weight (PLW) of pear Cv. 'Patharnakh' was significantly higher at ambient temperature as compared to 20 ^{0}C under all the ethylene treatments. It also increased significantly after each storage interval from 4 to 16 days under both the ripening environments. The loss of more than 5 per cent moisture leads to shriveling of fruits and all the treatments showed physiological loss in weight (PLW) beyond this limit after 4 days at ambient ripening storage. The loss in weight was less under control treatment as compared to ethylene treatments up to 8 days of storage indicated that the ripening process of the fruits was not initiated properly.

Montalvo *et al.* (2007) concluded that ethylene treated fruits showed significantly reduced weight loss on 5th, 9th and 13th day of storage as compared to control in mango Cv. Ataulfo.

Hai *et al*. (2009) dipped 'Tron' and 'Hoi' mango fruits for 30 min. in 0.4 and 0.8 per cent ethrel solution and water as control treatment and observed that at 12 ^{0}C, the fruit weight was significantly low as compared to those stored at 20 ^{0}C. Fruit of both cultivars treated with 0.8 per cent ethrel had greater weight loss than other treatments at the same temperature.

Siddiqui and Dhua (2009) in their experiment harvested mango fruits Cv. Himsagar in three different stages viz., 72, 79 and 86 days after fruit set and were subjected to ethrel (250, 500 and 1000 ppm) treatment and further reported that, the loss in weight was more in the treated fruits than control and it increased with increase in the concentration of ethrel as well as with decrease in maturity of fruit from Stage-3 to Stage-1. The fruits of Himsagar mango harvested at Stage-1 showed maximum loss in weight with all treatments while with ethrel 1000 ppm treatment, fruits had maximum mean Physiological loss in weight (10.06%).

2.3 Effect of ethrel treatment on ripening of mango fruits

Kulkarni *et al*. (2004) concluded that all the ethrel treated fruits showed optimum ripening on 8^{th} day of storage in mango Cv. Neelum.

Siddiqui and Dhua (2009) harvested mango fruts Cv. Himsagar at different stages of maturity and treated with ethrel (250 ppm, 500 ppm, 1000 ppm) showed increased ripening at different days in storage, compared to control fruits. They observed that fruit ripening was advanced by 3 to 6 days with ethrel (250 to 1000 ppm) treatments than control.

Singh *et al*. (2012) observed in mango fruits Cv. Amrapali showed that increase in ethrel concentration from 500 up to 1000 ppm, there was significant changes in skin colour i.e. greenish to deep yellow on 6 to 10^{th} day, while yellow colour was recorded on 8th day of storage with 750 ppm ethrel.

Mahajan *et al.* (2010) found in banana fruit on third day a dramatic increase in ripening of fruits and highest ripening percentage (100%) of banana fruit was observed after 4 days with ethylene gas (100 ppm) and ethephon (500 ppm). The improvement in ripening of banana fruits is due to multifunctional nature of ethylene, which triggers a dramatic change during ripening process and ensures faster and uniform ripening in many fruits.

Reyes and Poull (1995) recorded that the guava fruits with increased exposure period to ethylene at 48 hour showed no significant difference with the 24 h exposure period in the rate of fruit skin yellowing. Skin colour measurements (hue angle) on 7th day by ethylene treated immature green fruits were 78.5 and 85.0 for 24 and 48 hour exposure, respectively, whereas non-treated control fruit registered at 64.5. Both ethylene-treated and non-treated mature green and quarter-yellow fruit did not showed any significant difference in skin color development.

2.4 Effect of ethrel treatment on chemical parameters of mango fruit

Earlier research workers found that in general titratable acidity and the ascorbic acid was higher at harvest stage, but it was reduced significantly at ripe stage, whereas the total soluble solids, reducing and total sugars, content was lower at the time of harvest which increased upto ripe stage. TSS, titratable acidity, ascorbic acid, reducing sugars and total sugars content of ethrel treated fruits were highest as compared to untreated one in ripe stage.

2.4.1 Total soluble solids (^{0}Brix)

Das *et al*. (2011) concluded that the mangoes Cv. Alphonso treated with post harvest dipping of ethrel (750 ppm) for 5 minutes at 52 ^{0}C and further storage at ambient conditions, induced early and uniform ripening as against six days in control, and TSS content was 19 ^{0}Brix.

Chauhan *et al*. (2012) treated the orange fruits with ethylene gas (150 ppm). for 24 h in ripening chamber and various concentrations of ethephon (250, 500, 750, 1000 ppm) primarily in aqueous solution each for 5 min. and noticed that, the TSS content of fruits increased during ripening irrespective of treatments. The TSS content of oranges was maximum (19.5%) with ethephon 1000 ppm and lowest (13%) in control fruits.

Dhillon and Mahajan (2011) studied the effect of ethephon (500 ppm, 1000 ppm and 1500 ppm) and ethylene gas (100 ppm) on total soluble solids (TSS %) during ripening in pear. A significant increase in TSS was observed under all the treatments up to 8 days of ripening period and decreased thereafter. The highest (14.04%) level of TSS was noted under fogging 100 ppm and ethephon1500ppm at 20 ^{0}C treatments, closely followed by ethepon 1000 ppm at 20 ^{0}C. These treatments hold better TSS level even 12 and 16 days of ripening period.

Hai *et al*. (2009) observed that the refrigerated storage restricted ripening and limits the effect of ethrel to ripening of ‘Tron’ and ‘Hoi’ fruits. Increasing ethrel concentrations within five days at 12 ^{0}C and three days at 20 ^{0}C induced high soluble solids contents.

Kulkarni *et al*. (2004) studied the effect of post-harvest dip treatment of mango Cv. Neelum in 500 ppm ethrel and showed that, the TSS of ethrel treated fruits increased gradually during ripening and attained maximum 18 ^{0}Brix on the 8th day of storage as against 18 ^{0}Brix for control fruits on the 12th day of storage.

Mahajan *et al.* (2009) observed the effect of exposure of green mature banana Cv. Grand Naine fruits to ethylene gas at 100 ppm for 24 hour and treatments with different concentrations of aqueous solution of ethephon (250, 500, 750, 1000 ppm) each for 5 minutes on composition

of banana. The TSS content of fruits increased during ripening irrespective of treatments. The TSS content of banana was maximum (19%) with ethephon 1000 ppm and lowest (13%) in control fruits.

Montalvo *et al* (2007) exposed the mango var. 'Ataulfo' fruit to 100, 500 or 1000 μll^{-1} ethylene for 6 or 12 h at 25 ^{0}C. The fruit treated with 100 μll^{-1} of ethylene for 12 h reported 16.84 ^{0}Brix TSS. While the other treatments produced smaller soluble solids contents. These differences imply that, fruit treated at lower ethylene concentrations for 12 hours displayed greater rates of ripening for 'Ataulfo' mangoes. All of the treatments reached maximal soluble solids until the end of the storage period.

Nair and Singh (2003) observed that the exogenous application of ethrel (50, 250 and 500 mgL^{-1}) to mango Cv. Kensington resulted in to increased TSS as compared to untreated fruit. TSS of fully ripe fruit increased with increase in the concentration of ethrel applied.

Nour and Goukh (2010) studied the effect of ethrel in aqueous solutions at 250, 500 and 1000 ppm and ethylene released from ethrel at 250, 500 and 1000 ppm on fruit ripening of white and pink-fleshed guava fruits. They reported that, total soluble solids (TSS) progressively increased during ripening of both guava types. The maximum TSS value reached by untreated fruits was 14 per cent in the white and 12 per cent in the pink guavas. That maximum value was reached after 16 days in both types. Ethrel and ethylene treatments differentially increased TSS in the two guava types. Fruits dipped in aqueous solutions of ethrel at 250, 500 and 1000 ppm, reached the maximum TSS value 2, 4 and 6 days earlier than the untreated fruits, respectively, while the fruits treated with ethylene released from ethrel reached the maximum value 6, 7 and 9 days earlier at 250, 500 and 1000 ppm, respectively.

Siddiqui and Dhua (2009) reported that mango Cv. Himsagar harvested in three different stages viz., 72, 79 and 86 days after fruit set and subjected to ethrel (250, 500 and 1000 ppm) treatment showed that the TSS content of fruits increased with the maturity and therefore, Stage-3 had the highest or increased initial TSS contents at harvest. During the storage, the TSS content increased up to 9th day on ripening in all stages with all treatments.

Singh *et al*. (2012) found that the mango Cv. Amrapali fruits treated with ethrel 500 and1000 ppm and ethrel 750 + bavistin 1000 ppm , 2.0 per cent Ca NO_3, bavistin 500 ppm were found significant on 8th day of storage. The TSS level increased and reached maximum (23.3 ^{0}Brix) in the fruits treated with 750 ppm ethrel.

William *et al.* (2009) treated mature green mango Cv. 'Keith' fruits with 150-300 ppm ethylene for 15 hours and they noticed that there was an increase in average TSS for both treated and control mangoes. Treated mangoes had higher average TSS as compared to control. Treated mangoes attained an average brix (14.8 ^{0}Brix) on 2nd days of storage while the control attained 12.8 ^{0}Brix at the end of the storage period.

2.4.2 Titratable acidity (%)

Abd (2010) studied the efficacy of the post harvest treatment of ethrel of 500 ppm concentration for 3 min. in banana. They found titratable acidity of treated fruits (0.201 %) with high as compared to untreated fruits (0.167 %).

Anwar *et al*. (2008) treated green mature mango fruits with ethylene 100 ppm for 48 hour at 28 ^{0}C and 33 ^{0}C with 65 percent RH. They found that the total titrable acidity (TTA) was highest (0.23%) in CBP (corrugated cardboard packaging) fruit naturally ripened at 28±1 ^{0}C as compared with control, while CBP (corrugated cardboard packaging) fruit ripened naturally at high temperature i.e., 33±1^{0}C (T2) showed relatively lower contents of TTA (0.20%) for 15 days storage.

Chauhan *et al*. (2012) concluded that the orange fruits treated with ethylene gas (150 ppm) for 24 h in ripening chamber and various concentrations of ethephon (250, 500, 750, 1000 ppm) primarily in aqueous solution each for 5 min. showed the acidity values were in the narrow range of 0.3 to 0.45 per cent in all the treatments and differences were not statistically significant.

Dhillon and Mahajan (2011) found the effect of ethephon (500 ppm, 1000 ppm and 1500 ppm) and ethylene gas (100 ppm) on acidity of pear. It was observed that, the acid content in pear decreased significantly during ripening under all the ethephon treatments with prolongation of ripening period from 4 to 8 days and increased thereafter. In control fruits, the acid content decreased upto 8 days and slightly increased after 16 days of ripening interval under both 20 ^{0}C and ambient ripening temperature. Lowest acidity level was recorded in 1000 ppm ethephon treatment at 20 ^{0}C after 8 days, while it was highest in control fruits at ambient temperature after 4 days.

Kulkarni *et al*. (2004) observed that the post-harvest dip treatment of mango Cv. Neelum in 500 ppm ethrel decreased the titratale acidity during ripening and the acidity decreased at

faster rate after 8 days in ethrel treated fruits, whereas decreasing trend was observed in control after 12 days.

Lagunes *et al*. (2007) observed the decrease in titratable acidity in treated fruits with 0.5, 0.75, 1.0 mll^{-1}. The mango fruits CV. Manila exposed to 1.0 mll^{-1} of ethylene for 12 or 18 hour were evaluated. Greater differences were noted for treatment with 0.5 and 0.75 mll^{-1} of ethylene.

Mahajan *et al*. (2009) in their experiment exposed the green mature banana Cv. Grand nine fruits to either ethylene gas or treated with different concentrations of aqueous ethephon solution for 5 minutes and reported that the acidity values were in the narrow range of 0.3–0.5 per cent in all the treatments and differences were not statistically significant.

Nair and singh (2003) observed that the exogenous application of ethrel (50, 250 and 500 mgL^{-1}) to mango Cv. Kensington prior to storage at 5 ^{0}C for 4 weeks increased acidity as compared to untreated fruit.

Siddiqui and Dhua (2009) reported that titratable acidity of mango Cv. Himsagar harvested in three different stages viz., 72, 79 and 86 days after fruit set and subjected to ethrel (250, 500 and 1000 ppm) treatment showed decreasing trend at each stage of harvest as maturity progressed. During the storage period of 9 days, titratable acidity decreased to a minimum as fruit ripened. Similar trend was observed in fruits of all stages in all treatments.

Singh *et al*. (2012) treated the mango Cv. Amrapali fruits with ethrel 500 and 1000 ppm and ethrel 750 ppm and prepared minimum acidity (0.17%) was found with ethrel (750 ppm) on 10th day of storage.

2.4.3 Reducing sugars (%)

Dhillon and Mahajan (2011) studied that the effect of ethephon (500ppm, 1000ppm and 1500ppm) and ethylene gas (100ppm) on reducing sugars (%) in pear. It was observed that during ripening the reducing sugars increased initially up to 8 days and decreased thereafter in both the environment in all the fruit ripening treatments. All the ethephon treatments improved reducing sugars content of fruit over control. The level of reducing sugars was higher in 1000 ppm ethephon and 100 ppm ethylene treatments than that of with 500 and 1500 ppm ethephon treatments.

Kulkarni *et al*. (2004) noticed that the mango fruits Cv. Neelum treated with ethrel (500 ppm) showed the increase in reducing sugar which was faster as compared to untreated control fruit. Reducing sugars showed a continuous increasing trend during ripening up to 8 days of

storage in ethrel treated mangoes and declined thereafter. The increase in reducing sugars in mango var. 'Neelum' during ripening could be due to hydrolysis of starch into reducing sugars.

Nair and singh (2003) observed that the exogenous application of ethrel (50, 250 and 500 mgL^{-1}) to mango Cv. Kensington prior to storage at 5 ^0C for 4 weeks, total sugars of the fruit and all treatments of ethrel resulted in increased reducing sugars as compared to the untreated fruit. Untreated fruits exhibited the lowest contents of reducing, non-reducing and total sugars.

2.4.4 Total sugars (%)

Kulkarni *et al*. (2004) reported that the mangoes Cv. Neelum treated with ethrel (500 ppm) showed faster increase in total sugar than the untreated control fruit. Total sugars showed a continuous increase during ripening up to 8 days of storage in ethrel treated mangoes and declined thereafter. The increase in total sugars in mango var. 'Neelum' during ripening could be due to hydrolysis of starch in to reducing sugars.

Nair and Singh (2003 applied ethrel (50, 250 and 500 mgL^{-1}) to mango Cv. Kensington prior to storage at 5 ^0C for 4 weeks and observed that all treatments of ethrel resulted in increased total sugars of the fruit as compared to the untreated fruit. The total sugar content was increased as the concentration of exogenously applied ethrel was increased. Untreated fruit exhibited the lowest contents of total sugars.

Singh *et al*. (2012) found that the mango fruts Cv. Amrapali had maximum sugar content (11.84%) with 750 ppm ethrel treatment at 6th day of storage as compared to other treatment.

Tapre and Jain (2012) noticed that the banana var. 'Robusta' dipped in 500 ppm ethrel (2-chloro ethyl phosphonic acid) solution for 5 min. showed a progressive increase in total sugar content during ripening. During 5th stage of ripening, total sugar content increased up to 13. 38 per cent and at 7th stage of ripening it was up to 18.48 per cent.

2.4.5 Non reducing sugar (%)

Nair and singh (2003) observed the exogenous application of ethrel (50, 250 and 500 mgL^{-1}) to mango Cv. Kensington prior to storage at 5 ^0C for 4 weeks, resulted in increased reducing, non-reducing sugar in all treatments as compared to the untreated fruit. Non-reducing sugars increased as the concentration of exogenously applied ethrel was increased.

2.4.6 Ascorbic acid (mg / 100 g of fruit pulp)

Bal and Kok (2007) studied the effect of 500 and 1000 ppm ethephon on Kiwi fruits of *Actinidia deliciosa* Cv. Hayward. It was observed that the highest ascorbic acid content of 120.33 mg/100 g was recorded in 500 ppm ethrel treatment, while it was the lowest (119.38 mg/100 g) in 1000 ppm ethrel treatment.

Das *et al*. (2011) concluded that the mangoes Cv. Alphonso treated with post harvest dipping of ethrel (750 ppm) for 5 minutes at 52 ^{0}C and storage at ambient conditions, recorded an early and uniform ripening as compared to control, and ascorbic acid content was 33.59mg/100g of pulp.

Kulkarni *et al*. (2004) observed that the ascorbic acid content in mango Cv. Neelum treated with 500 ppm ethrel solution for 5 min. dipping decreased from 70.5 to 23.5 and 13.0 mg/100g in ethrel treated fruits and control, respectively.

2.5 Effect of ethrel on sensory qualities of mango fruits

Kulkarni *et al*. (2004) reported that the ethrel treated fruits showed optimum ripening on 8th day of storage with excellent overall sensory quality in mango fruit Cv. Neelum.

All the treatments of exogenous application of ethrel improved the taste of manog Cv. Kensington fruits as compared to untreated fruit (Nair and Singh; 2003).

Mahajan *et al*. (2010) observed that the banana Cv. Grand naine fruits treated with ethylene gas (100 ppm) recorded 7.8 score on 4th day and were rated as very much acceptable and this treatment was very closely followed by ethephon 500 ppm.

CHAPTER III

MATERIAL AND METHODS

The present investigation on "Studies on effect of ethrel on ripening behaviour of mango (*Mangifera indica* L.) Cv.Alphonso" was undertaken in the Department of Post Harvest Management of Fruit, Vegetable and Flower Crop, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli (M.S.) during the mango season of 2012. The material used and the methods adopted during the investigation are as given below.

3.1 General description

3.1.1 Location

The experimental mango orchard was situated in Education Research Farm, Dept. of Horticulture, College of Agriculture, Dr. B.S.K.K.V, Dapoli. Selected orchard is located at $17^{o}45^{'}$, North latitude and $73^{o}12^{'}$, East longitude and at an elevation of 280 meters above MSL. The climate of Dapoli is warm and humid with the mean annual rainfall of 4721.1 mm, mostly received from 1st June to 15th October.

3.2 Experimental material

Physiologically mature, mango fruits Cv. Alphonso of optimum maturity were harvested in a single day (700 fresh fruits in 10 crates) with 2.5 to 3.5 cm stalk during morning hours (from 9.00 a.m. to 11.00 a.m.) from mango orchard (plot No.11) of Department of Horticulture, College of Agriculture, Dapoli. (M.S.). Harvested fruits were washed with biosafe (4ml/lit.) cleaned with dry muslin cloth, and these fruits were dipped in different concentrations of ethrel as per the treatment for 5 minutes. After the treatment, the fruits were kept at ambient temperature (24 to 29^{0}C. with 65-70 % R.H.) for further investigation. The control fruits were also kept at same environments for comparison. Thirty five fruits for each replication were used for each treatment.

3.3 Experimental details

3.3.1 Experimental Design : Complete Randomized Design (CRD)
3.3.2 Replications : Four
3.3.3 No. of treatments : Five
3.3.4 No. of Fruits / treatment : One hundred and forty

3.3.5 Treatments Details

The fruits were treated with different concentration of ethrel for a dipping period of 5 minutes.

T_1: 250 ppm ethrel dip treatment.

T_2: 500 ppm ethrel dip treatment.

T_3: 750 ppm ethrel dip treatment.

T_4: 1000 ppm ethrel dip treatment.

T_5: Control.

3.4 Observations recorded

3.4.1 Ripening behaviour of fruits:

3.4.1.1 Ripening pattern:

To record the ripening pattern, the fruits were categorized into five groups *viz*;

1) **Green** (harvesting stage),

2) **Turning** (when a slight tinge of yellow colour appeared on the peel),

3) **Half ripe** (when 50 per cent of fruit peel turned yellow),

4) **Ripe** (when fruit peel fully turned yellow).

This ripening pattern under each treatment was studied at 4 days interval at ambient temperature condition.

3.4.1.2 Colour

External colour measured by using colourimeter (konica minolta) and colour values measured were expressed as L* (sharpness), a* (redness) and b* (yellowness)

3.4.1.3 Physiological loss in weight (PLW)

Fifteen fruits were selected from each treatment for studying Physiological loss in weight. The loss in weight was calculated by noting down the difference between two consecutive weights recorded from initial day and every alternate day at ambient temperature.

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

3.4.1.3 Firmness (kg / cm^2)

The Fruit firmness was tested by pocket penetrometer (Fruit Tester F T 327, Italy made). The penetrometer was pierced through the fruit pulp after removing peel and the pressure required was recorded in kilogram per square centimeter in each treatment at every four days interval. The observations on firmness were recorded at two locations on fruit surface and their average was considered for further analysis.

3.4.2 Chemical parameters of fruit

Randomly selected five ripened fruits from each treatment were employed for estimating the following chemical constituents of the fruit.

3.4.2.1 Total soluble solids (^{0}Brix)

Total soluble solids (T.S.S.) were determined with the help of Hand Refractometer (Atago Japan, 0 to 33 ^{0}Brix) and value was corrected at 20^{o}C with the help of temperature correction chart (A.O.A.C., 1975).

3.4.2.2 Titratable acidity (%)

A known quantity of liquid sample pulp was titrated against 0.1 N NaOH solution using phenolphthalein as an indicator (A.O.A.C., 1975). A known sample was blended in mortar and pestle with 20-25 ml of distilled water. It was then transferred to 100 ml volumetric flask, made up the volume and filtered. A known volume of aliquot (10 ml) was titrated against 0.1 N sodium hydroxide (NaOH) solution using phenolphthalein as an indicator (Ranganna, 1997). The results were expressed as per cent anhydrous citric acid.

$$\text{Acidity (\%)} = \frac{\text{Titre x Normality of alkali}}{\text{Volme of sample taken for estimation}} \times \frac{\text{Volume made up}}{\text{Weight of sample}} \times \frac{\text{Eq. Wt. of Malic acid}}{1000} \times 100$$

3.4.2.3

Ascorbic acid (mg / 100 g of fruit pulp)

The ascorbic acid was determined by 2, 6 dichlorophenol indophenol dye method of Johnson (1948) as described by Ranganna (1997). A known quantity of sample was blended with 3 per cent metaphosphoric acid (HPO_3) to make the final volume of 100 ml and then filtered. A known quantity of aliquot was titrated against 0.025 per cent 2, 6 dichlorophenol indophenol dye to a pink colour end point. The ascorbic acid content of the sample was

calculated taking into consideration the dye factor and expressed as mg Ascorbic acid per 100 g fruit pulp (Association of Vitamin Chemist, 1966).

3.4.2.4 Reducing sugars (%)

The reducing sugars were estimated by using Lane and Eynon (1923) method with modification suggested by Ranganna (1997). A known weight (5 g) of sample was blended with distilled water using lead acetate (45%) for precipitation of extraneous material and potassium oxalate (22%) to delead the solution. This lead-free extract was used to estimate reducing sugars by titrating against standard Fehling's mixture (Fehling's A and B) using methylene blue as an indicator to a brick red end point.

$$\text{Reducing sugars (Per cent)} = \frac{\text{Factor} \times \text{Dilution}}{\text{Titre reading} \times \text{Weight of sample taken}} \times 100$$

3.4.2.5 Total sugars (%)

The total sugars were estimated by the same procedure of reducing sugars after acid hydrolysis of an aliquot of deleaded sample with 35 per cent hydrochloric acid, followed by neutralization with sodium hydroxide (40%). This filtrate was used for titration against standard Fehling's mixture (Fehling's A and B) using methylene blue as an indicator to brick red end point (Ranganna, 1997).

$$\text{Total sugars (Per cent)} = \frac{\text{Factor} \times \text{Dilution}}{\times \text{Weight of pulp taken}} \times 100$$

3.4.2.6 Non reducing sugar

Non reducing sugar is calculated by using formula,

Non reducing sugar (%) = Total sugar (%) – Reducing sugar (%)

3.5 Sensory-evaluation:

The ripe fruits were examined for their sensory qualities when they were ripe for assessing the colour, flavour and texture. It was carried out by a panel of 5 judges with 9 point Hedonic scale score (Amerine *et al*, 1965) as given below.

The overall rating was obtained by averaging score of evaluation. The fruits with sensory score of 5.5 and above were rated as acceptable

Organoleptic Score	**Rating**
9	Like extremely
8	Like very much
7	Like moderately
6	Like slightly
5	Neither like nor dislike
4	Dislike slightly
3	Dislike moderately
2	Dislike very much
1	Dislike extremely

3.6 Statistical analysis

The data were recorded on physicochemical and physiological parameters of mango represented as mean of four readings. The data collected on mango were statistically analyzed by using Completely Randomized Design as well as Factorial Completely Randomized Design *adopting analysis of variance techniques as described by Panse and Shukhatme (1995). The treatment difference was tested by 'F' test of significance on the basis of null hypothesis.The appropriate standard error (S.Em. ±) was calculated in each case. The critical difference (C.D.) at 5 per cent level of probability was worked out.*

CHAPTER IV

RESULTS AND DISCUSSION

The present investigation on "Effect of ethrel on ripening behaviour of mango Cv. Alphonso under ambient conditions" was carried out at Department of Post Harvest Management of Fruit, Vegetable and Flower Crops, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. The results of the investigation are presented and discussed in this chapter under following headings.

4.1 Effect of ethrel treatment on physical parameters of mango Cv. Alphonso fruits.

4.2 Effect of ethrel treatment on PLW of mango Cv. Alphonso fruits.

4.3 Effect of ethrel treatment on ripening pattern of mango Cv. Alphonso fruits.

4.4 Effect of ethrel treatment on chemical parameters of mango Cv. Alphonso fruits.

4.5 Effect of ethrel treatment on sensory qualities of mango Cv. Alphonso fruits.

4.1. Effect of ethrel treatment on physical parameter of mango Cv. Alphonso fruits at ambient condition:

4.1.1. Firmness:

Data presented in Table-1 and depicted in Fig-1 regarding firmness of Alphonso mango fruits indicated a decreasing trend in firmness of ethrel treated fruits with increase in ethylene concentration. The variation in firmness due to the treatments, storage and their interaction was statistically significant.

The data presented in Table-1 indicated that the firmness of mango fruits was lowest (0.50 kg/cm^2) in the treatment T_3 i.e. 750 ppm ethrel dip, however, it was statistically at par with other treatments like T_4 and T_3. The treatments T_2 exhibited significantly higher (2.15 kg/cm^2) firmness than the other ethrel dip treatments. The treatments T_5 recorded the highest (3.70 kg/cm^2) firmness of the fruit and significantly superior to rest of the treatments. As the ethrel treatments triggered the ripening process, the ethrel treated fruits became soft and evidently recorded the lower firmness than the untreated control.

Table 1: Effect of ethrel treatment on firmness of mango Cv. Alphonso during ripening at ambient condition

Treatments	Firmness (kg/cm^2)			
	Storage (Days)			
	4	8	12	Mean

T_1	250 ppm ethrel dip	4.92	0.85	0.67	2.15
T_2	500 ppm ethrel dip	1.47	0.75	0.50	0.90
T_3	750 ppm ethrel dip	1.15	0.25	0.12	0.50
T_4	1000 ppm ethrel dip	1.35	0.12	0.10	0.52
T_5	Without ethrel dip i.e.Control	6.67	1.50	1.05	3.07
Mean		*3.11*	*0.69*	*0.49*	
		S.Em. ±		**C.D. at 5 %**	
Dipping period (T)		0.21		0.60	
Storage (S)		0.16		0.47	
Interaction (T X S)		0.37		1.05	

As regards the storage, it was observed that the firmness was decreased from 3.11 to 0.69 kg/cm^2 after 8 days of storage and there after no significant variation in firmness was observed upto 12 days during ripening.

As per the interaction effects, the significantly highest (6.67 kg/cm^2) firmness was noticed in the treatment T_5 i.e. control after 4 days of storage. However, all the treatment were at par with each other during the later period of storage.

The similar observations were recorded by Dhillon and Mahajan (2011) in pear fruits, Saeed *et al.* (2006) in banana fruits, Hai *et al* (2009) in 'Tron' and 'Hoi' mangoes, Nour and Goukh (2010) in white and pink-fleshed guava fruits and Siddiqui and Dhua (2009) in mango Cv. Himsagar fruits.

4.1.2. Effect ethrel treatment on colour of mango Cv. Alphonso at ambient condition.

4.1.2.1 L* value for colour

The data pertains to the L* value for colour of mango Cv. Alphonso fruits are presented in Table 2 and graphically illustrated in Fig. 2. It is observed from the data that the lightness of the ethrel treated mango fruit showed increasing trend with increase the ethrel concentration. The highest (62.32) mean L* value for colour was recorded in the treatment T_4 i.e. 1000 ppm ethrel dip, but it was at par with T_3. However, these treatments were significantly superior to rest of the treatments. The treatments T_1, T_2 and T_5 did not showed any significant variation with respect to mean L* value for colour.

Table 2: Effect of ethrel treatment on L* value for Colour of mango Cv. Alphonso during ripening at ambient condition

Treatments	**L* value for colour**
	Storage (Days)

		4	8	12	Mean
T_1	250 ppm ethrel dip	52.52	63.35	59.35	58.40
T_2	500 ppm ethrel dip	57.97	60.15	56.35	58.15
T_3	750 ppm ethrel dip	56.75	64.02	61.27	60.68
T_4	1000 ppm ethrel dip	63.02	63.75	60.20	62.32
T_5	Without ethrel dip i.e.Control	49.30	53.75	68.55	57.20
Mean		*55.91*	*61.00*	*61.14*	
		S.Em. ±		**C.D. at 5 %**	
Dipping period (T)		0.65		1.88	
Storage (S)		0.51		1.45	
Interaction (T X S)		1.14		3.25	

As regards storage, the L* values for colour of mango fruit increased significantly from 55.91 to 61.00 after 8 days of storage. However, no significant variation in L* value was noticed thereafter upto 12 days of storage at ambient condition.

With respect to interactions between treatment and storage treatment, the treatments T_3 and T_4 were at par with each other and recorded significantly highest (64.02 and 63.75, respectively) L* value for colour after 8 days of storage followed by treatments T_1 and T_2 and the lowest by the treatments T_5 i.e. control. Thus all the ethrel treatments were highest in colour than the control. On the contrary, the ethrel treated fruits showed significantly lower L* value for colour than control due to partial shriveling of the ethrel treated fruits after 12 days of storage at ambient conditions.

4.1.2.2 a* value for colour

The data pertaining to the a* value for colour of Alphonso mango fruits are presented in the Table 3 and graphically illustrated in Fig. 3. It is observed from the data that the ethrel treatments had significant effect on the a* value for colour of the mango fruits Cv. Alphonso.

the treatment T_4 recorded highest (17.35) a* value which was at par with T_1, T_2 and T_3, but significantly superior to the treatment T_5 i.e. control.

Table 3: Effect of ethrel treatment on a* value for colour of mango Cv. Alphonso during ripening at ambient condition

Treatments		a* value for colour			
		Storage (Days)			
		4	8	12	Mean
T_1	250 ppm ethrel dip	3.10	18.65	24.65	15.46
T_2	500 ppm ethrel dip	2.80	19.27	23.95	15.35
T_3	750 ppm ethrel dip	2.25	19.57	26.30	16.04
T_4	1000 ppm ethrel dip	2.87	20.30	28.90	17.35

T_5	Without ethrel dip i.e.Control	9.85	15.95	17.12	14.30
Mean		*4.17*	*18.75*	*24.18*	
		S.Em. ±		**C.D. at 5 %**	
Dipping period (T)		0.74		2.1	
Storage (S)		0.58		1.65	
Interaction (T X S)		1.29		3.69	

With respect to storage, an increasing trend in a* value for colour of mango Cv. Alphonso fruits was noticed with the advancement of the storage period. The mean a* values for colour increased significantly from 9.85 to 24.18 after 12 days of storage.

The interaction effect between treatment and storage were found significant. It is observed that treatment T_4 showed highest (28.90) value which was at par with T_3 (26.30) and significantly superior to rest of the interactions after 12 days of storage.

4.1.2.3 b* value for colour

It is observed from the data presented in Table 4 and depicted in Fig. 4 that the b*value for colour was the highest (52.62) in treatment T_2, but significantly at par with the treatment T_4 i.e. 1000 ppm ethrel dip. The lower (47.00) mean b* value was recorded in treatment T_5 i.e. control, than the treatment T_4, however, it was at par with the treatment T_3 and T_1.

As regards storage, the mean b* value for colour increased from 41.66 to 54.39 after 8 days without any significant variation thereafter upto 12 days of storage.

Table 4: Effect of ethrel treatment on b* value for colour of mango Cv. Alphonso during ripening at ambient condition

Treatments		**b* value for colour**			
		Storage (Days)			
		4	**8**	**12**	**Mean**
T_1	250 ppm ethrel dip	32.50	57.90	54.00	48.13
T_2	500 ppm ethrel dip	48.65	56.10	53.12	52.62
T_3	750 ppm ethrel dip	44.67	53.10	48.65	48.80
T_4	1000 ppm ethrel dip	55.10	50.35	49.05	51.50
T_5	Without ethrel dip i.e.Control	27.40	54.50	59.10	47.00
Mean		*41.66*	*54.39*	*52.78*	
		S.Em. ±		**C.D. at 5 %**	
Dipping period (T)		1.21		3.44	
Storage (S)		0.93		2.67	
Interaction (T X S)		2.09		5.97	

From the interaction effect between treatments and storage, it is observed that treatment T_5 had highest (59.10) b*value after 12 days of storage, but at par with treatments T_1 and T_2. It also seen from the data that the b* value for colour remained constant from 8 days to 12 days of storage irrespective the treatment. The lowest (27.40) b* value for colour was observed in the treatment T_5 but at par with T_1 after 4 days of treatment. Highest b* value for colour development due to 1000 ppm ethrel dip treatment than any other treatment.

Similar result ware also reported by Chauhan *et al*. (2012) in orange, *Abd (2010) in banana, Ahmad et al. (2006)in banana, Mahajan et al. (2009) in banana, Kulkarni et al. (2004) in mango Cv. Neelum and Nour and Goukh (2010) in white and pink fleshed guava.*

4.2. Effect of ethrel treatment on physiological loss in weight of mango Cv. Alphonso fruits at ambient condition:

4.2.1 Physiological loss in weight:

The data on physiological loss in weight of different ethrel dipping treatments during ripening are presented in Table 5 and depicted in Fig 5. It is observed from the data that there was significant variation in physiological loss in weight of Alphonso mango fruits due to the ethylene treatments as well as storage. The interaction effects between treatments and storage were also found to be statistically significant.

Among the treatments, the highest (11.90%) mean physiological loss in weight was observed in treatment T_4 which was significantly superior to all other treatments, followed by T_2 (11.26%), T_3 (10.85%) and T_1 (10.61%). However, the T_5 treatment recorded lowest (8.05%) mean physiological loss in weight of Alphonso mango fruits during storage. It is also evident from the data that physiological loss in weight of Alphonso fruits increased with increase in ethylene concentration. This could be due to the fact that, higher ethylene concentration promoted the physiological processes such as respiration, transpiration which resulted into more physiological loss in weight due to moisture loss.

With respect to storage, the increasing trend in physiological loss in weight was observed during ripening. The physiological loss in weight was increased from 2.30 to 17.85 per cent after 12 days of storage.

Interaction between treatment and storage had significant impact on physiological loss in weight of mango fruits. The highest (19.72%) physiological loss in weight was recorded in treatment T_4 (1000 ppm ethrel dip treatment) after 12 days of storage, while lowest (14.33%) physiological loss in weight in T_5 i.e. control but at par with the treatment T4. Both these

treatments (T_3 and T_4) did not exhibit significant variation and except 6th day of storage, they remained at par with each other throughout the ripening process as per the interaction effects.

Similar finding ware also recorded by Chauhan *et al*. (2012) in orange, Kulkarni *et al.* (2004) in mango fruits Cv. Neelum and also Siddiqui and Dhua (2009) in mango fruits Cv. Himsagar.

Table5: Effect of ethrel treatment on PLW of mango Cv. Alphonso during ripening at ambient condition

Treatments	Physiological loss in weight (%)						
	Storage (Days)						
	2	4	6	8	10	12	Mean
T_1	2.00	5.36	8.93	13.35	16.11	17.90	10.61
T_2	2.53	6.27	9.73	13.98	16.59	18.44	11.26
T_3	2.25	5.69	8.87	13.55	15.88	18.87	10.85
T_4	3.05	6.52	10.45	14.66	16.98	19.72	11.90
T_5	1.66	3.93	6.13	9.77	12.47	14.33	8.05
Mean	2.30	5.55	8.82	13.06	15.61	17.85	
	S.Em. ±				C.D. at 5 %		
Dipping period(T)	0.17				0.50		
Storage (S)	0.19				0.54		
Interaction (T XS)	0.43				1.22		

4.3 Effect of ethrel treatment on ripening pattern of mango Cv. Alphonso at ambient condition

The data presented in Table 6 indicated the ripening pattern of mango fruits at ambient condition. It is seen from the data that, most of the ethrel treated fruits from the treatments T_1 and T_2 were at turning stage (83.33 and 70.33 %, respectively), whereas, the mango fruits from T_3 and T_4 were at either half ripe or ripe stage after 4 days of the ethrel treatment. On the contrary, fruits from the treatment T_5 i.e. control remained green in colour after 4 days of storage. This clearly indicated that ethrel treatment accelerated the ripening process. Moreover, higher the ethrel concentration, faster the ripening was noticed.

At the end of 8th day of storage, all treated fruits were fully ripe, however, untreated fruits were still at turning stage. Thus, mango Cv. Alphonso fruits could be treated with 750 or 1000 ppm ethrel solution to ripen the fruits within a period of 4 days after treatment.

The higher percentage of mango fruits treated with 750 as well as 1000 ppm ethrel (T_3 and T_4, respectively) shriveled after 12 days of storage than that from the treatment T_1 and T_2. A delayed and slower rate of ripening of mango fruits Cv. Alphonso was noticed in the control treatment. It is evident from the data that the ethrel treated fruits would lose their shelf life after

12 days of storage. Hence, they should be disposed off within the period of 8 to 10 days of ethrel treatment.

Similar finding ware also observed by Kulkarni *et al*. (2004) in mango Cv. Alphonso, Siddiqui and Dhua (2009) in mango Cv. Himsagar, Singh *et al*. (2012) in mango Cv. Amrapali, Mahajan *et al*.(2010) in banana and Reyes and Paull (1995) in guava.

4.4. Effect of ethrel treatment on chemical parameter of mango Cv. Alphonso fruits during ripening at ambient condition:

4.4.1 Total soluble solids:

The data on changes in TSS of Alphonso mango during ripening are presented in Table 7 and depicted in Fig. 6.

It is observed form the data that the ethrel dip treatments and storage had significant effect on the TSS of the Alphonso mango fruits. Among all treatments, the highest (20.40 ^{0}Brix) mean TSS was found in T_4 i.e. 1000 ppm ethrel dip treatment, followed by T_3 (19.80 ^{0}Brix) and T_2 (19.42 ^{0}Brix) which were at par with each other. The lowest (12.41^{0}Brix) TSS was recorded in treatment T_5 i.e. control treatment, followed by treatment T_1 (17.28 ^{0}Brix).

The significant increase in TSS content of Alphonso fruits irrespective of the treatments was noticed during storage. The TSS content increased from 14.08 ^{0}Brix to 20.29 ^{0}Brix after 12 days of storage at ambient condition.

Table 7: Effect of ethrel treatment on TSS content of mango Cv. Alphonso during ripening at ambient condition

Treatments		TSS (^{0}Brix)			
		Storage (Days)			
		4	**8**	**12**	**Mean**
T_1	250 ppm ethrel dip	10.10	19.45	22.30	17.28
T_2	500 ppm ethrel dip	15.40	19.25	23.62	19.42
T_3	750 ppm ethrel dip	17.35	21.30	20.75	19.80
T_4	1000 ppm ethrel dip	18.45	23.60	19.15	20.40
T_5	Without ethrel dip i.e.Control	9.10	12.50	15.65	12.41
Mean		*14.08*	*19.22*	*20.29*	
		S.Em. ±		**C.D. at 5 %**	
Dipping period (T)		0.14		0.40	
Storage (S)		0.10		0.31	
Interaction (T X S)		0.24		0.69	

The treatment and storage interaction exhibited significant impact on TSS levels of mango fruit Cv. Alphonso. The highest (23.62^{0}Brix) TSS was recorded in treatment T_2 after 12 days of storage, while lowest (9.10^{0}Brix) TSS was recorded in T_5 treatment after 4 day storage.

The increased T.S.S. might be due to rapid loss of water from fruits and conversion of starch into sugar at faster rate observed in ethrel treated fruits as compared to the control.

These results corroborate well with the Das *et al*. (2011) in mango Cv. Alphonso, Chauhan *et al*. (2012) in orange fruits, Dhillon and Mahajan (2011) in pear fruits, Kulkarni *et al*. (2004) in mango Cv. Neelum, Singh *et al*. (2012) in mango Cv. Amrapali and Mahajan *et al*. (2009) in banana Cv. Grand Naine.

4.4.2 Titratable acidity:

The data regarding the changes in titratable acidity of ethrel treated Alphonso mango fruits during ripening are presented in Table 8 and depicted in Fig. 7.

There was significant difference among the treatments with respect to titratable acidity. The titratable acidity was observed highest (1.25 %) in T_5 i.e. control, followed by T_1 (1.13%). The treatments T_2 and T_3 were at par with each other having acidity percentage as 0.29 and 0.39%, respectively. The lowest (0.21%) titratable acidity was found in T_4 i.e. 1000 ppm ethrel dip treatment.

For storage also, there was significant difference with respect to titratable acidity. The highest (1.20 %) acidity was found after 4 days storage, the lowest (0.17%) acidity was recorded after 12 days storage. A linear decrease in the titratable acidity of mango fruit Cv. Alphonso was noticed during ripening upto 12 days of storage at ambient condition.

Table 8: Effect of ethrel treatment on titratable acidity of mango Cv. Alphonso during ripening at ambient condition

Treatments		**Titratable acidity (%)**			
		Storage (Days)			
		4	**8**	**12**	**Mean**
T_1	250 ppm ethrel dip	2.96	0.30	0.14	1.13
T_2	500 ppm ethrel dip	0.54	0.18	0.15	0.29
T_3	750 ppm ethrel dip	0.31	0.73	0.13	0.39
T_4	1000 ppm ethrel dip	0.25	0.25	0.12	0.21
T_5	Without ethrel dip i.e.Control	1.94	1.47	0.34	1.25
Mean		*1.20*	*0.59*	*0.17*	
		S.Em. ±		**C.D. at 5 %**	
Dipping period (T)		0.03		0.11	

Storage (S)	0.03	0.08
Interaction (T X S)	0.06	0.19

Interaction effects between the treatment and storage was found statistically significant. The treatment T_5 i.e. control recorded the highest (0.34%) titratable acidity while the lowest (0.12%) titratable acidity by the treatment T_4 (1000 ppm ethrel dip treatment) at the end of 12 days of storage.

Due to ethrel treatment, there is an increase in the membrane permeability which permits the acid stored in cell vacuole to respire at faster rate, and it resulted in to the reduction of acidity during ripening.

Results on similar line were also observed by *Abd (2010) in banana fruits, Anwar et al. (2008) in mango fruits packed in corrugated cardboard packaging,* Kulkarni *et al*. (2004) in mango fruits Cv. Neelum, *Mahajan et al. (2009) in banana Cv. Grand nine and* Singh *et al*. (2012) in mango Cv. Amrapali

4.4.3 Reducing sugars:

The data pertaining to the effect of ethrel treatment on changes in reducing content of Alphonso mango fruit during ripening are presented in Table 9 and depicted in Fig. 8. It was observed that there was significant difference among the treatments with respect to reducing sugar content.

Table 9: Effect of ethrel treatment on reducing sugar content of mango Cv. Alphonso during ripening at ambient condition

Treatments		**Reducing sugar (%)**			
		Storage (Days)			
		4	**8**	**12**	**Mean**
T_1	250 ppm ethrel dip	2.20	4.82	9.65	5.55
T_2	500 ppm ethrel dip	3.28	5.61	11.75	6.88
T_3	750 ppm ethrel dip	2.80	6.06	13.00	7.29
T_4	1000 ppm ethrel dip	4.63	9.92	12.75	9.10
T_5	Without ethrel dip i.e.Control	1.23	2.07	3.98	2.43
Mean		*2.83*	*5.70*	*10.22*	
		S.Em. ±		**C.D. at 5 %**	
Dipping period (T)		0.12		0.36	
Storage (S)		0.09		0.28	
Interaction (T X S)		0.22		0.63	

Maximum (9.10%) mean reducing sugar content was observed in the mango Cv. Alphonso fruits treated with 1000 ppm ethrel i.e. treatment T_4 which was statistically higher

than rest of the treatments, lowest (2.43%) reducing sugar content was recorded in T_5 i.e. control.

A significant variation in reducing sugar content of mango Cv. Alphonso fruits was noticed due to storage during ripening at ambient condition. The lowest (2.83%) reducing sugar content was found during 4 days Storage, while maximum (10.22%) reducing sugar was noticed during 12 days of storage. An increasing trend in reducing sugar content irrespective of the treatments was noticed during ripening upto a period of 12 days at ambient condition.

Interaction effects between treatments and storage exhibited significant impact with respect to reducing sugar content in mango Cv. Alphonso fruits. The highest (13.00%) reducing sugars content was recorded in the treatment T_3 of storage, but statistically at par with the treatment T_4 (12.75%) after 12 days of storage, followed by the treatments T_2 (11.75%) and T_1 (9.65%), respectively. The lowest (3.98%) reducing sugar content was observed in T_5 at 12 days of storage. This increase in reducing sugar was mainly due to conversion of starch into sugars during ripening process. Higher reducing sugar content was noticed in ethrel treated mango Cv. Alphonso fruits than untreated control, this could be due to acceleration of ripening process by ethrel resulted into more conversion of starch into reducing during ripening than the control.The resembling results were observed by Dhillon and Mahajan (2011) in pear fruits, Kulkarni *et al*. (2004) in mango fruits Cv. Neelum and Nair and singh (2003) in mango Cv. Kensington.

4.4.4 Total Sugars:

From the data presented in Table 10, it is evident that there was increase in the total sugar content in ethrel treated mango fruits during storage which is depicted in Fig.9. It could be revealed from the data that, there was significant increase in total sugar content due to different treatments. The highest (17.23%) total sugar was found in treatment T_4, followed by the treatments T_3, T_2 and T_1 with 15.85, 13.50 and 12.55 per cent total sugar content, respectively. The lowest (8.74%) total sugar was found in T_5 treatment.

There was significant difference with respect to total sugar content due to storage during ripening of mango Cv. Alphonso fruits. The lowest (8.75%) total sugar content was found during 4 days storage, while maximum (17.13%) total sugar was recorded after 12 days of storage during ripening at ambient condition. A linear increase in the total sugar content of mango Cv. Alphonso fruit was observed during ripening upto a period of 12 days at ambient condition.

Table 10: Effect of ethrel treatment on total sugar content of mango Cv. Alphonso during ripening at ambient condition

Treatments		Total sugar (%)			
		Storage (Days)			
		4	8	12	Mean
T_1	250 ppm ethrel dip	5.58	14.42	17.65	12.55
T_2	500 ppm ethrel dip	7.87	13.84	18.79	13.50
T_3	750 ppm ethrel dip	9.84	16.84	17.88	15.85
T_4	1000 ppm ethrel dip	16.5	18.59	16.62	17.23
T_5	Without ethrel dip i.e.Control	3.99	7.52	14.70	8.74
Mean		*8.75*	*14.24*	*17.13*	
		S.Em. ±		**C.D. at 5 %**	
Dipping period (T)		0.17		0.49	
Storage (S)		0.13		0.38	
Interaction (T X S)		0.30		0.85	

Interaction of treatments and storage had significant influence on total sugar content of mango Cv. Alphonso fruit. It is seen from the data that highest (18.79%) total sugar content was recorded in T_2 at 12 days storage, followed by T_3 (17.88%) and T_1 (17.65%) which were at par with each other. The lowest (14.70%) total sugar content observed in T_5 after 12 days, during ripening of fruit at ambient condition. The increase in total sugar content during ripening could be attributed to hydrolysis of starch into sugars.

Similar result was also recorded by Kulkarni *et al.* (2004) in mango fruits Cv. Neelum, Singh *et al*. (2012) in mango Cv. Amrapali and Tapre and Jain (2012) in banana var. 'Robusta'.

4.4.5 Non-reducing sugars:

The data related to changes in non-reducing sugar content of the ethrel treated Alphonso mango fruit during ripening are presented in Table 11 and graphically illustrated in Fig. 10. It could be revealed from the data that there was significant variation in non-reducing sugar content of mango Cv. Alphonso due to different treatments. The highest (8.13%) non-reducing sugar was found in treatment T_4 which was at par (7.54%) with T_3. The lowest (6.31%) non-reducing sugar content was noticed in T_5 i.e. without ethrel dip (control).

Table 11: Effect of ethrel treatment on non-redusing sugar content of mango Cv. Alphonso during ripening at ambient condition

Treatments	Non-reducing sugar (%)			
	Storage (Days)			
	4	8	12	Mean

T_1	250 ppm ethrel dip	3.38	9.58	8.00	6.99
T_2	500 ppm ethrel dip	4.58	8.23	7.40	6.62
T_3	750 ppm ethrel dip	7.04	10.70	4.88	7.54
T_4	1000 ppm ethrel dip	11.86	8.67	3.87	8.13
T_5	Without ethrel dip i.e.Control	2.76	5.45	10.72	6.31
Mean		*5.92*	*6.90*	*8.53*	
		S.Em. ±		**C.D. at 5 %**	
Dipping period (T)		0.22		0.63	
Storage (S)		0.17		0.49	
Interaction (T X S)		0.38		1.10	

The non-reducing sugar content of mango Cv. Alphonso fruit exhibited significant variation due to storage at ambient condition. An increasing trend in the non-reducing sugar content was noticed during ripening and it was increased from 5.92 to 8.53 per cent after 12 days of storage at ambient condition.

The treatment and storage interaction had significant effect on non-reducing sugar content of ethrel treated alphonso mango fruit. The lowest (2.76%) non-reducing sugar content was recorded after 4 days in treatment T_5, while highest (11.86%) non-reducing sugar content was observed in T_4 after 4 days storage which was at par (10.72%) with T_5 after 12 days storage. At ripe stage, it was highest in T_3 (10.70%) which was at par with T_1 (9.58%) and significantly superior to all the interactions after 8 day of storage. Similar result was recorded by Nair and singh (2003) in mango Cv. Kensington.

4.4.6 Ascorbic acid:

The data regarding the changes in ascorbic acid of ethrel treated Alphonso mango fruit during ripening are presented in Table 12 and depicted in Fig. 11. It is observed from the data that, there was significant difference among the treatments with respect to ascorbic acid content of mango fruits.

The ascorbic acid content was significantly higher (55.35 mg/100g) in T_5, but was at par (55.21 mg/100g) with T_1 i.e. 250 ppm ethrel dip and significantly superior to the rest of the treatments. The treatment T_2 (43.28 mg/100g) and T_3 (44.10 mg/100g) which were at par with each other and significantly lowest (31.91 mg/100g) ascorbic acid content was observed in T_4 i.e. 1000 ppm ethrel dip treatment. It is also noticed from the data that the ascorbic acid content declined with increase in the ethrel concentration. The reduction in ascorbic acid content was more pronounced in ethrel treated mango fruit than that in untreated control. This could be due to the fact that the ethrel treatment triggered the ripening process that resulted into more utilization of ascorbic acid during ripening in treated fruits than the control.

Regarding storage, a significant difference in the ascorbic acid content was noticed due to storage at ambient condition. After 4 days of storage, highest (65.61 mg per 100 g) ascorbic acid was observed, which was decreased to 32.19 mg per 100 g during ripening upto a storage period of 12 days at ambient condition.

Table 12: Effect of ethrel treatment on ascorbic acid content of mango Cv. Alphonso during ripening at ambient condition

Treatments		Ascorbic acid (mg/100 gm)			
		Storage (Days)			
		4	**8**	**12**	**Mean**
T_1	250 ppm ethrel dip	64.92	56.10	44.60	55.21
T_2	500 ppm ethrel dip	56.60	43.36	29.88	43.28
T_3	750 ppm ethrel dip	56.84	43.85	31.60	44.10
T_4	1000 ppm ethrel dip	47.53	34.50	13.72	31.91
T_5	Without ethrel dip i.e.Control	65.61	59.29	41.16	55.35
Mean		*58.30*	*47.42*	*32.19*	
		S.Em. ±		**C.D. at 5 %**	
Dipping period (T)		0.65		1.87	
Storage (S)		0.50		1.44	
Interaction (T X S)		1.13		3.22	

The interaction among the storage and treatment behave significantly with respect to ascorbic acid content. The lowest (13.72 mg per 100 g) ascorbic acid was found during 12 days of storage in the treatment T_4, while highest (65.61 mg per 100 g) ascorbic acid content was noticed after 4 days in treatment T_5. A decline in ascorbic acid content of the mango Cv. Alphonso fruit might be due to utilization of ascorbic acid in the respiration process during ripening at ambient condition.

Data analogous observations were reported by Bal and Kok (2007) in Kiwi fruits, Das *et al*. (2011) in mango Cv. Alphonso and Kulkarni *et al*. (2004) in mango Cv. Neelum.

4.5 Effect of ethrel treatment on sensory quality of mango Cv. Alphonso fruits:

The data regarding the sensory qualities at fully ripened stage of mango fruit Cv. Alphonso are presented in Table 13 and graphically depicted in Fig 12.

The mango fruit ripened with different concentration of ethrel and stored at ambient condition were evaluated for their organoleptic characteristics by a panel of experienced judges on 9 point score card and the results are as below.

4.3.1 Colour

From the data on sensory score for colour of ripe mango fruit Cv. Alphonso presented in Table 13 and depicted in Fig 12, it was observed that the colour of the ripe mango fruit under the treatment T_3 (750 ppm ethrel dipping) was liked by the judges the most, as it fetched the mean maximum score of 8.25, but at par with treatments T_2 and T_4, whereas, the lowest (5.87) score for colour was obtained by the treatment T_5 i.e. untreated fruits in ambient condition, followed by the treatment T_1 i.e. 250 ppm ethrel dip treatment.

The sensory score for colour of mango Cv. Alphonso fruit increased with the increase in ethrel concentration. This could be due to the fact that the ethrel treatment imparted attractive golden yellow colour to the mango fruits, as compared to the fruits from untreated control.

4.3.2 Flavour

The data on sensory score for flavour of ripe mango fruit Cv. Alphonso are presented in Table 13 and depicted Fig 12. The Alphonso mango fruits from treatment T_2 fetched maximum (8.12) mean score, but at par with the treatment T_3 (8.00) and lowest (6.12) score for flavour was obtained by the treatment T_5 i.e. untreated fruits (control), followed by T_2 and T_4. The mango fruits treated with 1000 ppm were slightly overripe, whereas, the untreated fruits (T_5) were under ripe at the time of organoleptic evaluation i.e. 8 days after treatment. Hence, they scored less marks for flavour than those from other treatment.

4.3.3 Taste

The organoleptic scores obtained for taste of mango fruits Cv. Alphonso (Table 13 and Fig.12) varied from 6.50 to 8.12 under the various treatments. The maximum (8.12) mean score was obtained by treatment T_2 which was at par with the treatment T3 i.e. 750 ppm ethrel treatment. Significantly lowest (6.50) sensory score for taste was recorded by the treatments T_1 and T_4 as 7.37 and 7.50 sensory score for taste, respectively. All the treatments were rated as acceptable.

4.3.4 Texture

The data on sensory score for texture of ripe mango fruit Cv. Alphonso are presented in Table 13 and showed in Fig. It was observed that the ethrel treatment did not show any statistically significant effect on the texture property of mango fruits and the results were non-

significant. The treatment T_1 (250 ppm ethrel dip treatment) fetched numerically maximum score of 7.75 for texture and the lowest (7.00) by the treatment T_5 i.e. without ethrel dip treatment.

Table 13: Effect of ethrel treatment on sensory qualities of mango Cv. Alphonso fruits

Treatment		Organoleptic score for				
		Colour	**Flavour**	**Taste**	**Textue**	**Over all acceptability**
T_1	250 ppm ethrel dip	7.37	7.62	7.37	7.75	7.51
T_2	500 ppm ethrel dip	8.12	8.12	8.12	7.62	7.97
T_3	750 ppm ethrel dip	8.25	8.00	7.62	7.37	7.75
T_4	1000 ppm ethrel dip	8.12	7.12	7.50	7.25	7.47
T_5	Without ethrel dip i.e. Control	5.87	6.12	6.50	7.00	6.32
S.Em. ±		7.54	7.39	0.13	7.39	0.12
C.D. at 5 %		0.23	0.23	0.55	0.37	0.53

4.3.5 Overall acceptability

The data presented in Table 13 and depicted Fig. 12 for sensory score for the overall acceptability of ripe mango fruit Cv. Alphonso revealed that the mango Cv. Alphonso fruits from all the ethrel treatments were at par with each other with respect to overall acceptability, but significantly superior to control. Treatment T_2 recorded maximum (7.97) mean score which was superior to control, but at par with the treatments T_1, T_3 and T_4. Significantly minimum (6.32) mean score was recorded by treatment T_5 i.e. untreated treated fruit.

Similar findings were recorded by Kulkarni *et al*. (2004) in mango Cv. Neelum, Nair and Singh (2003) in mango Cv. Kensington and Mahajan *et al*. (2010) in banana Cv. Grand nine.

CHAPTER V

SUMMARY AND CONCLUSION

Mango (*Mangifera indica* L.*)* belonging to family Anacardiaceae is the national fruit of India and rightly known as the 'King of fruits'. Alphonso variety is the premium variety excellent for quality and shelflife, hence, preferred for the export. In the Konkan region, it is cultivated on commercial scale and the economy of Konkan is dependent on the cropping of Alphonso mango. General aim of early ripening of mango is to increase the respiration rate which helps to prepare mango for early marketing. Ethrel (2- Chloroethyl phosphonic acid) is well known for induction of early and uniform ripening in a number of fruits including mango.

The experiment was conducted in Factorial Completely Randomised Design with 5 treatments *viz*., T_1:250 ppm ethrel dip treatment, T_2: 500 ppm ethrel dip treatment, T_3: 750 ppm ethrel dip treatment, T_4: 1000 ppm dip ethrel treatment and T_5: Control (untreated). Physiologically mature, green fruits at 85% maturity (stage 'B') of mango Cv. Alphonso were harvested, washed with biosafe (4 ml/lit.), cleaned with dry muslin cloth, and then dipped in different concentrations of ethrel as per the treatment for 5 minutes. The fruits were placed in CFB boxes and stored at ambient condition.

The important findings of this investigation are summarized and concluded in brief in the following pages.

5.1. Effect of ethrel on physical parameters of mango Cv. Alphonso fruits

1. As the ethrel treatment triggered the ripening process the ethrel treated fruits become soft and recorded lower firmness than untreated control. Irrespective of the treatments firmness of the fruit was decreased after 4 days of the treatment.

2. There was an increasing trend with respect to L*, a* and b* values for colour with increase in the ethrel concentration as well as storage period.

5.2 Effect of ethrel on physiological loss in weight

The physiological loss in weight of mango fruits Cv. Alphonso increased with increase in the concentration of ethrel as higher ethrel concentration accelerated the physiological process like respiration and transpiration resulted into more moisture loss than those treated with lower ethrel concentration. The physiological loss in weight was also found to decline throughout the storage at ambient conditions irrespective of the treatment.

5.3 Effect of ethrel on ripening pattern

1. The ethrel treatment promoted the ripening in mango Cv. Alphonso fruits. Higher the ethrel concentration faster the ripening of mango fruit was observed.

2. The ethrel treated fruits would lose their shelf life 12 days after the period of 8 to 10 days of treatment.

3. The mango Cv. Alphonso fruits could be treated with 750 ppm or 1000 ppm ethrel solution to ripe them within a period of 4 days after treatment.

5.4. Effect of ethrel on chemical parameters of Alphonso mango fruit

1. A significant increase in TSS content of mango fruits Cv. Alphonso was noticed during storage. The mango fruits treated with 1000 ppm ethrel recorded maximum mean TSS and the lowest by the untreated fruits.

2. The mean titratable acidity was significantly lower in all ethrel treated fruits than that of untreated fruits. A liner decrease in acidity was noted irrespective of treatments during ripening upto a period of 12 days at ambient condition.

3. The mango fruits from all ethrel treatments recorded higher reducing, non- reducing as well as total sugar content than the untreated control. All these sugars exhibited an increasing trend during ripening upto a period of 12 days.

4. The ascorbic acid content declined with increase in the ethylene concentration and the decline was more pronounced in ethrel treated fruits than that in untreated control. The reduction in ascorbic acid content irrespective of the treatments was noticed during ripening of mango fruits Cv. Alphonso.

5.5 Effect of ethrel on sensory qualities of mango Cv. Alphonso fruits

Based on the sensory score for colour, flavour, taste, texture and overall acceptability, the ethrel treated fruits were significantly superior to the untreated mango fruits. However, the mango Cv. Alphonso fruits treated with ethrel 500 ppm ethrel concentration recorded significantly higher marks for the flavour as well as for taste than rest of the treatments.

Conclusion:

From the present investigation, it could be concluded that the ripening process could be hastened by treating the fruits with ethrel concentration ranging from 250 to 1000 ppm. However, it was observed that the ethrel treated fruits would lose their shelf life within 12 days after treatment. Hence, they must be disposed off within a period of 8 to 10 days after the ethrel treatment. The fruits might be treated with 750 or 1000 ppm ethrel solution to ripen them within a period of 4 days after treatment. Based on the sensory qualities for flavour, taste and early ripening, the application of ethrel @500 ppm was found to be ideal for the early marketing.

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APPENDIX - I

Temperature and relative humidity recorded at ambient temperature under Dapoli conditions during the course of investigation (2011-12)

Date	Ambient temperature conditions			
	Temperature (^{0}C)		Relative humidity (%)	
	Max.	Min.	Max.	Min.
24.05.12	33.3	22.2	85	72
25.05.12	32.4	22.9	83	67
26.05.12	32.8	23.1	82	66
27.05.12	32.8	23.1	80	72
28.05.12	33.0	22.1	82	76
29.05.12	32.2	22.2	83	88
30.05.12	32.8	22.3	85	74
31.05.12	32.5	21.7	84	82
01.06.12	32.8	22.9	87	81
02.06.12	34	23.5	87	81
03.06.12	35.5	24.9	79	82
04.06.12	33.9	23.7	83	87
05.06.12	34.8	23.7	83	93
06.06.12	33.6	23.7	98	89
07.06.12	27.8	24.5	93	73
08.06.12	32.0	22.9	96	87
09.06.12	30.8	24.6	97	89
10.06.12	31.0	22.9	91	72

APPENDIX – II

ABBREVATIONS USED

SR. NO.	ABBREVIATIONS	MEANING
1.	%	Per cent
2.	@	At the rate of
3.	^{0}Brix	Degree Brix
4.	^{0}C	Degree centigrade
5.	µl/l	Micro liter per liter
6.	a*	Redness
7.	b*	Yellowness
8.	L*	Lightness
9.	Anon.	Anonymous
10.	CBP	Corrugated Cardboard Packaging
11.	C.D.	Critical difference
12.	Cv.	Cultivar
13.	*et al*.	And others
14.	*etc.*	et cetera (and so on)
15.	FCRD	Factorial Completely Randomized Design
16.	Fig.	Figure
17.	g	Gram
18.	h^0	Hue angle
19.	ha	Hectare (Unit of area)
20.	hrs	Hours
21.	*i.e.*	id est (That is)
22.	Kg	kilogram
23.	kg/cm^2	Kilogram per square centimeter
24.	$L\ L^{-1}$	Liter per liter
25.	M. S.	Maharashtra State
26.	MSL	Mean sea level
27.	MT	Million tonnes
28.	mg	Mili gram

29.	mg/g^{-1}	Milligram per gram
30.	mg/l^{-1}	Milligram per liter
31.	ml/l	Milliliter per liter
32.	$ml\ l^{-1}$	Milliliter per liter
33.	NS	Non-significant
34.	PLW	Physiological loss in weight
35.	ppm	Part per million
36.	RH	Relative humidity
37.	S.Em.	Standard error of mean
38.	TSS	Total soluble solids
39.	Var.	Variety
40.	*viz.,*	Videlicet (Namely)

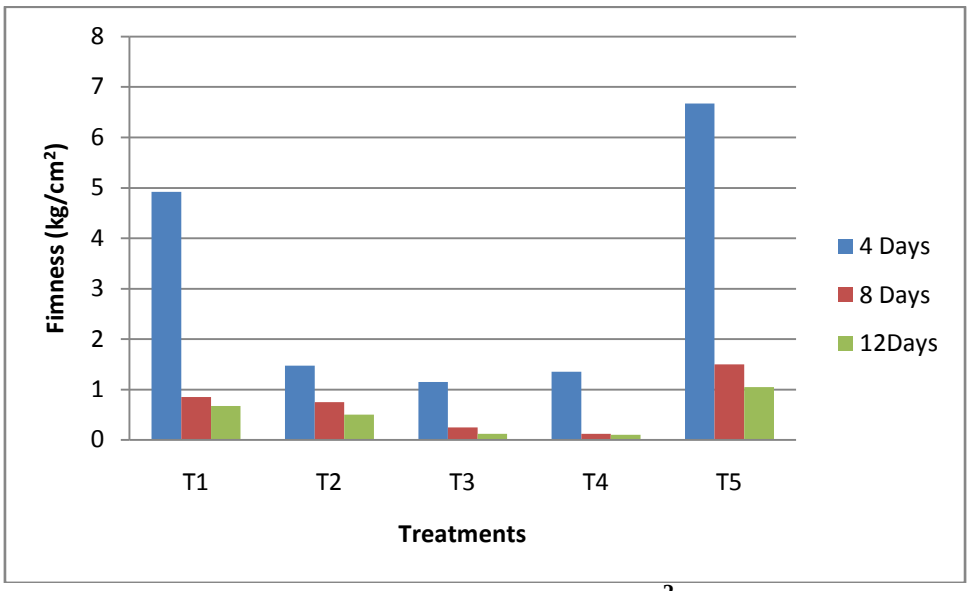

Fig 1 : Effect of ethrel treatment on firmness (kg/cm^2) of mango Cv. Alphonso at ambient condition

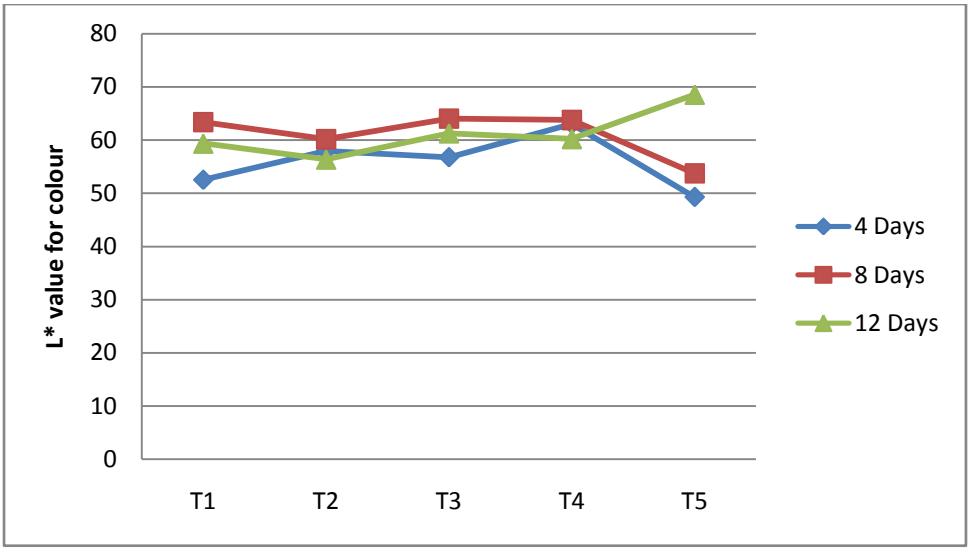

Fig 2: Effect of ethrel treatment on L* value for colour of mango Cv. Alphonso at ambient condition

'L' value represents the lightness of the fruits

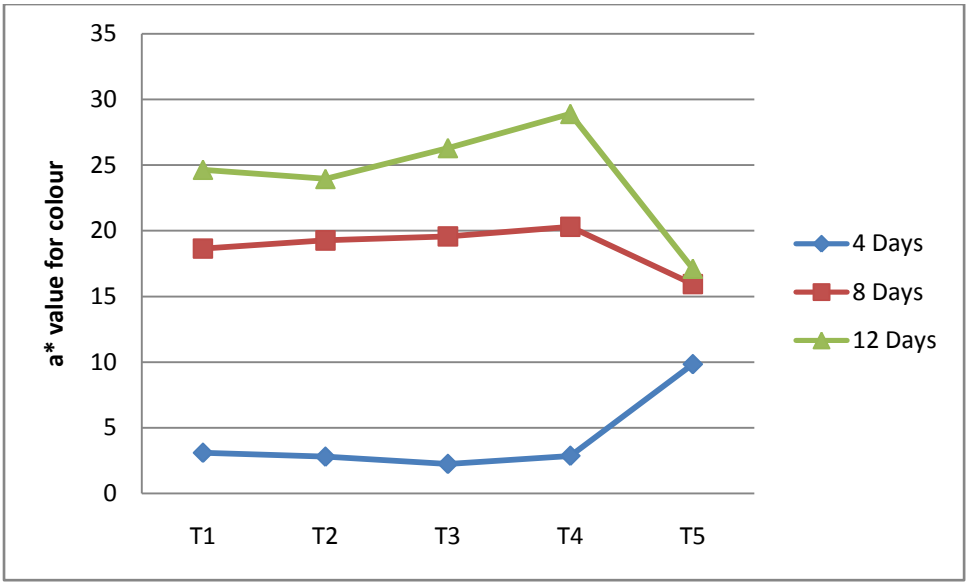

Fig 3: Effect of ethrel treatment on a* value for colour of mango Cv. Alphonso at ambient condition

* 'a*' value values represents redness and green ness of the fruit.
* '+a*' values indicating red colour of fruit.
* '-a*' values indicating green colour of the fruit

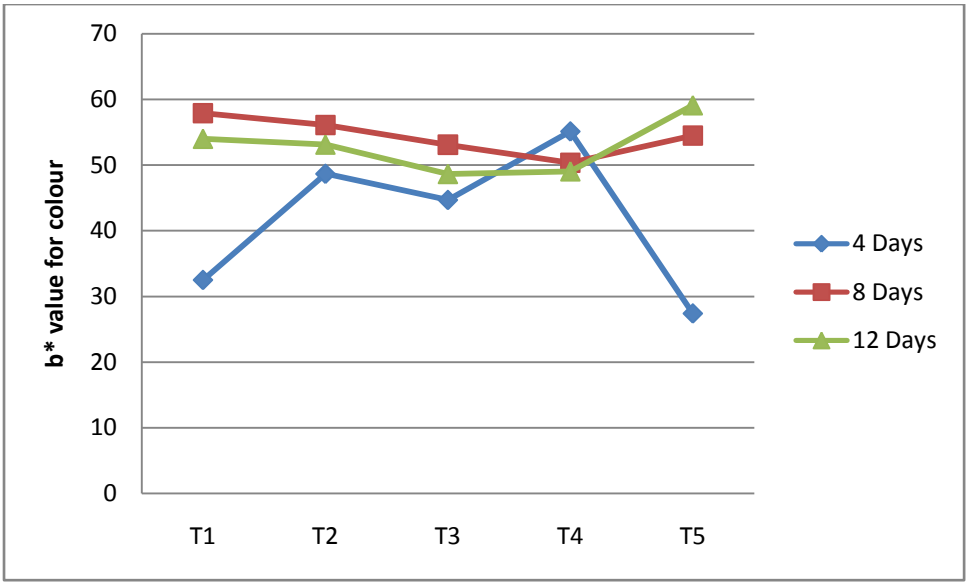

Fig 4: Effect of ethrel treatment on b*value for colour of mango Cv. Alphonso at ambient condition

* 'b*' values represent colour changes from blue to yellow.
* '+b*' values indicating yellow colour of fruits.
* '-b*' values indicating blue colour of fruits.

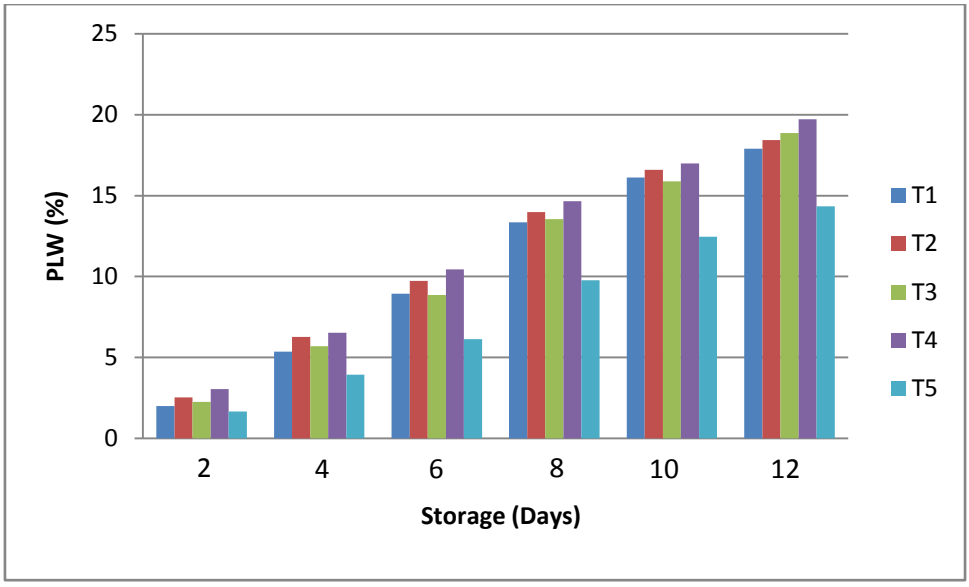

Fig 5 : Effect of ethrel treatment on PLW(%) of mango Cv. Alphonso at ambient condition

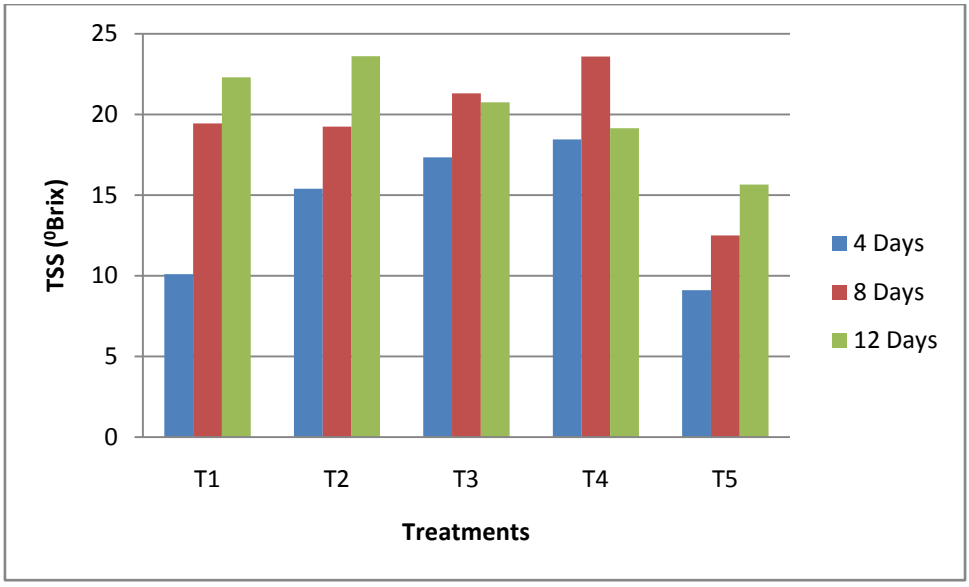

Fig 6: Effect of ethrel treatment on TSS (^{0}Brix) content of mango Cv.Alphonso at ambient condition

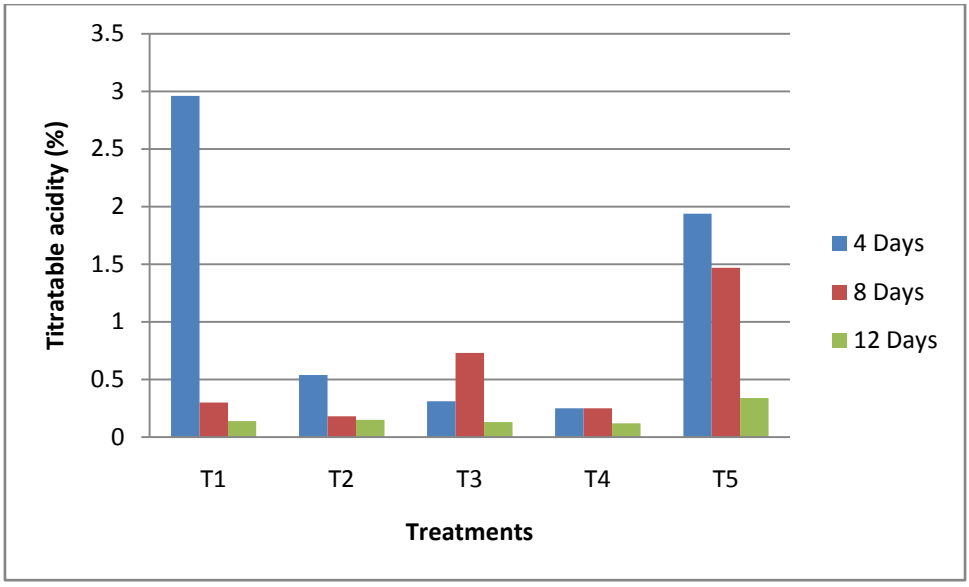

Fig. 7: Effect of ethrel treatment on titratable acidity (%) content of mango Cv. Alphonso at ambient condition

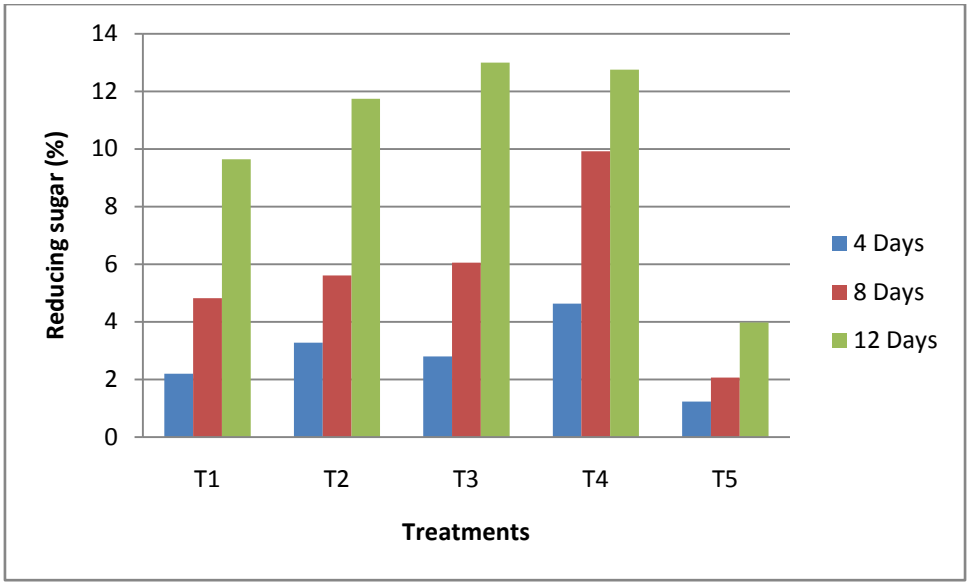

Fig. 8: Effect of ethrel treatment on reducing sugar (%) content of mango Cv. Alphonso at ambient condition

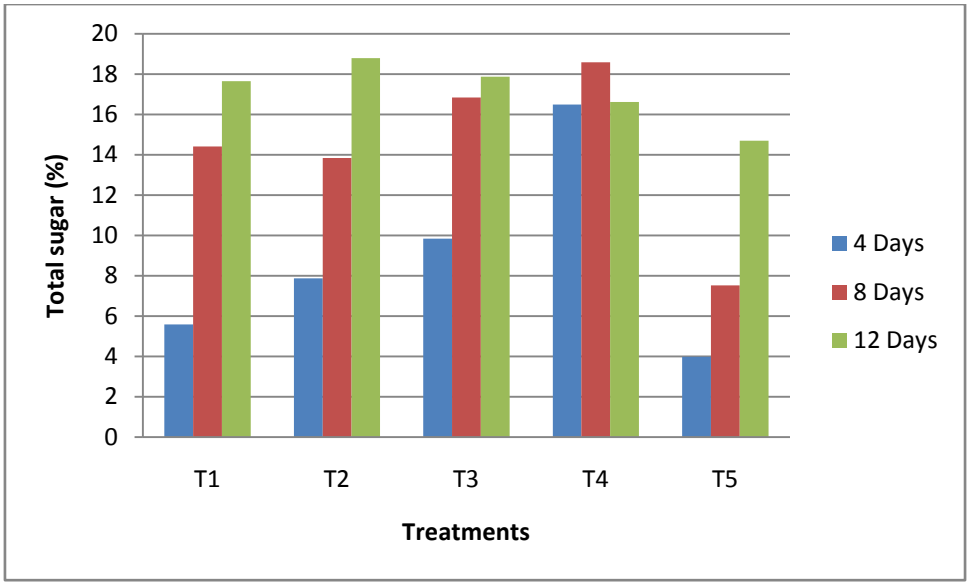

Fig 9: Effect of ethrel treatment on total sugar (%) content of mango Cv. Alphonso at ambient condition

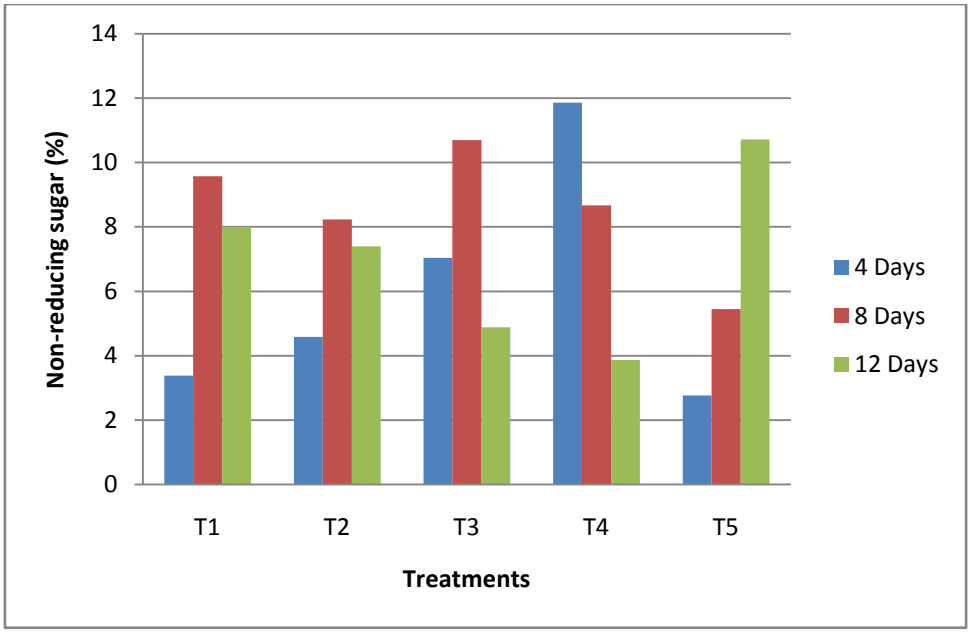

Fig 10: Effect of ethrel treatment on non-redusing sugar (%) content of mango Cv. Alphonso at ambient condition

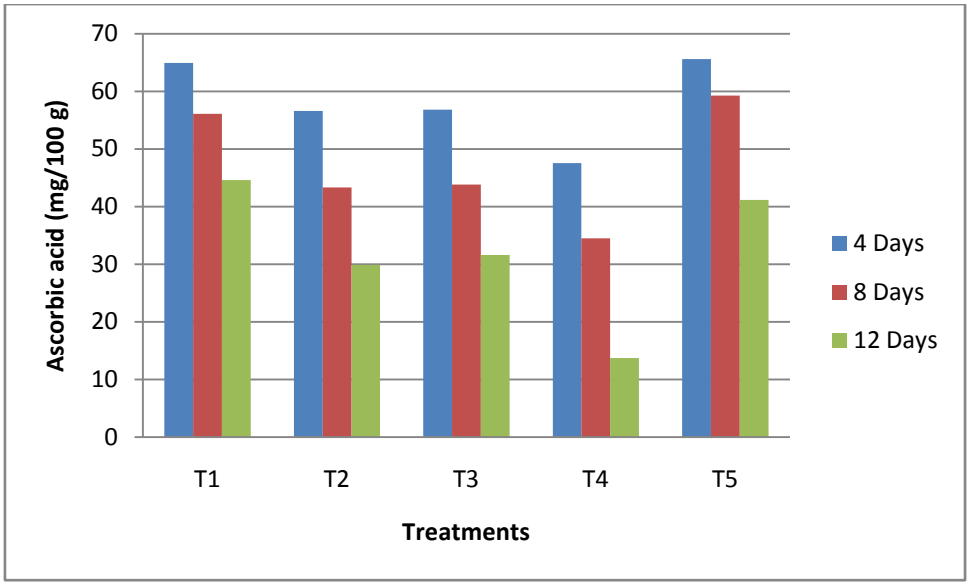

Fig 11: Effect of ethrel treatment on ascorbic acid (mg/100g) content of mango Cv. Alphonso at ambient condition

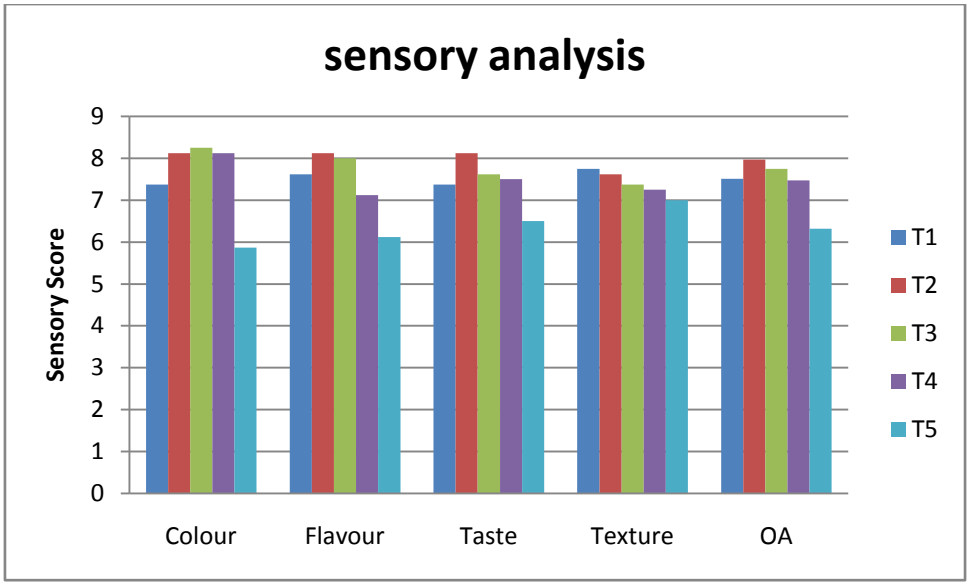

Fig 12.Effect of ethrel treatment on sensory qualities of mango Cv. Alphonso fruits.

Plate 2: Effect of ethrel on ripening behaviour of mango Cv. Alphonso fruits (after 4 days).

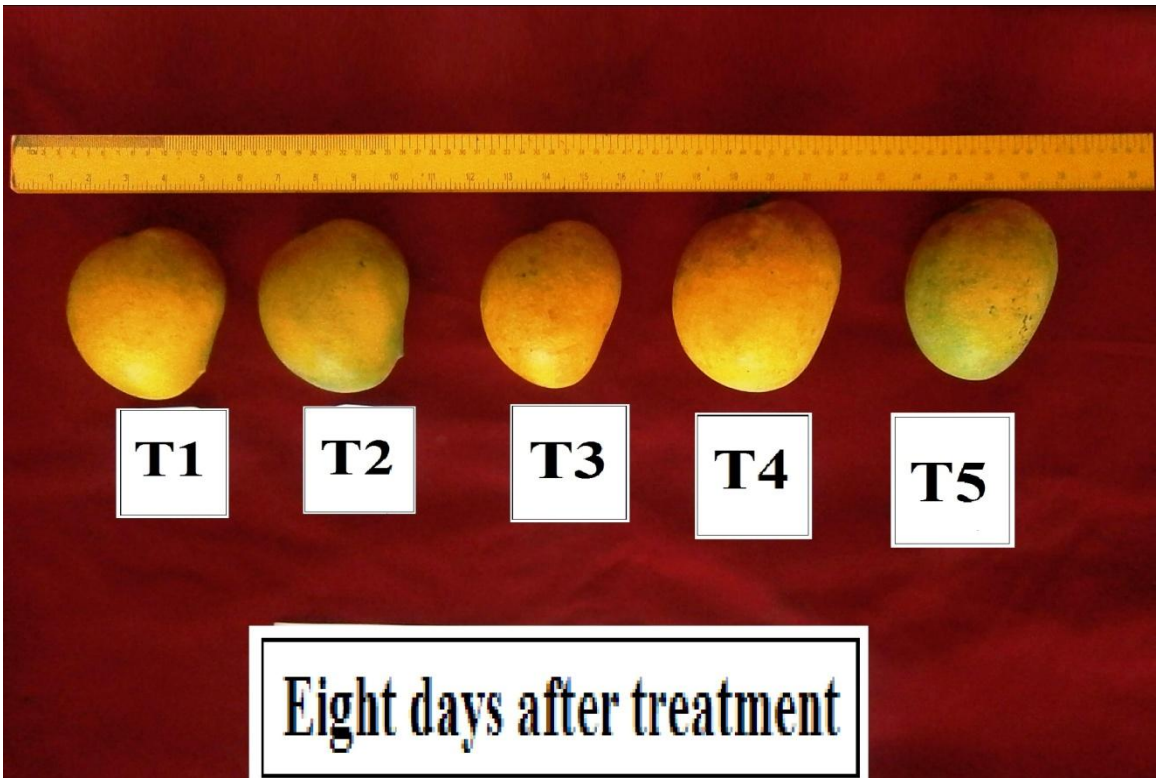

Plate 3: Effect of ethrel on ripening behaviour of mango Cv. Alphonso fruits (after 8 days).

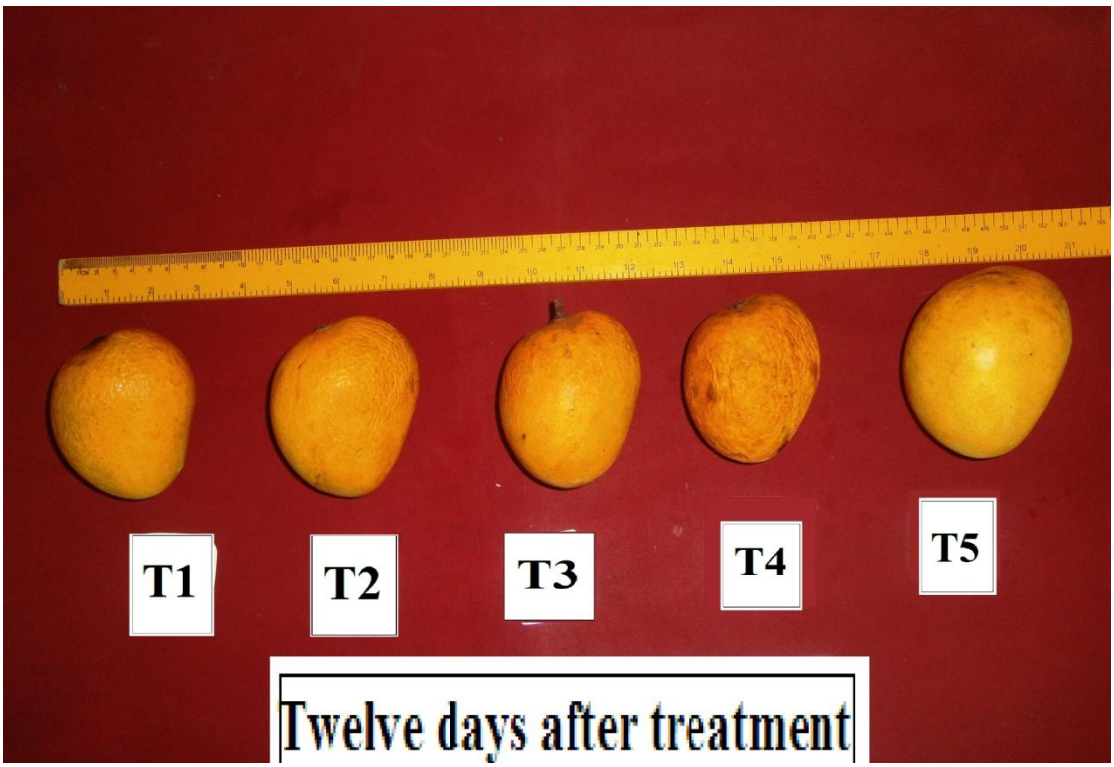

Plate 4: Effect of ethrel on ripening behaviour of mango Cv. Alphonso fruits (after 12 days).

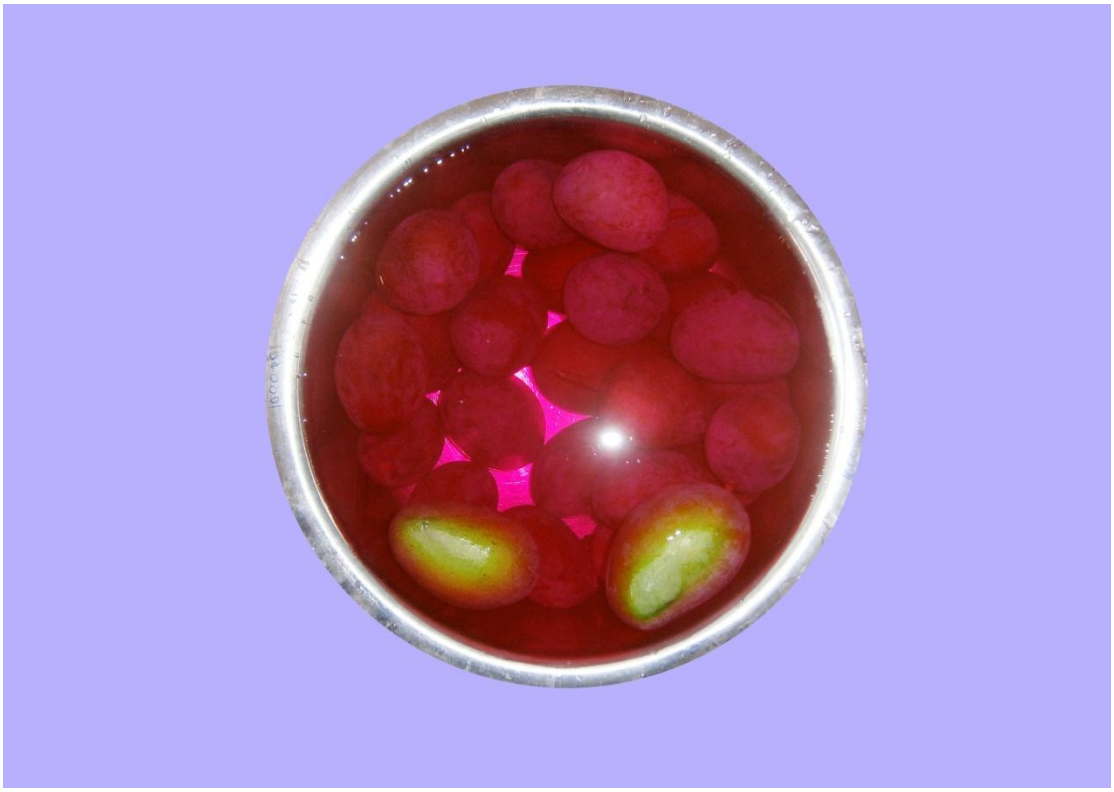

Plate 1: Dipping of mango Cv. Alphonso fruits in ethrel solution.