EFFECT OF SOME PLANT GROWTH BIOREGULATORS AND FUNGICIDES ON RIPENING AND STORABILITY OF APPLE (*Malus domestica* Borkh.) cv. RED DELICIOUS

THESIS

By

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Submitted in partial fulfilment of the requirements for the Degree of

MASTER OF SCIENCE

in

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(POSTHARVEST TECHNOLOGY)

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In the memory of

My Reverend

Dada ji

Late Sh. Harbhaj Singh

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CERTIFICATE -I

This is to certify that the thesis entitled "Effect of some plant growth bioregulators and fungicides on ripening and storability of apple (*Malus domestica* Borkh.) cv. Red Delicious", submitted in partial fulfilment of the requiremernt for the degree of **Master of Science in Horticulture (Postharvest Technology)** of Dr Yashwant Singh Parmar University of Horticulture & Forestry, is a faithful record of bonafide research work carried out by Mr **Nardev Kumar Thakur** under my guidance and supervision and that no part of this thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of these investigations have been fully acknowledged.

Dated : 28th February, 1991

(S K Chopra)
Major Advisor

CERTIFICATE-II

This is to certify that the thesis entitled **"Effect of some plant growth bioregulators and fungicides on ripening and storability of apple (*Malus domestica* Borkh.) cv. Red Delicious"**, submitted by **Nardev Kumar Thakur** to Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Solan in partial fulfilment of the requirement for the degree of **MASTER OF SCIENCE** in **HORTICULTURE (Postharvest Technology)** has been approved by the student's Advisory Committee after an oral examination of the same in collaboration with the Nominee of the Dean.

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Abbreviations Used

^oC	=	Degree Centigrade
EC	=	Electrical conductivity /bioelectrical conductance
g	=	gram
µl	=	micro litre
m a.s.l.	=	meter above sea level
N	=	Newton
RH	=	Relative humidity
TSS	=	Total soluble solids
mg	=	milli grams
Kg	=	Kilo gram
hr	=	hour
m mhos	=	milli mhos
µg	=	micro gram
WAFB	=	Weeks after full bloom
A.O.A.C.	=	Association of Analytical Chemists
$NADPH_2$	=	Reduced-Nicotinamide adenine dinucleotide phosphate
PLW	=	Physiological loss in weight
nm	=	nano meter
F.W.	=	Fresh weight
BA	=	Benzyl adenine
cm	=	centimeter

Introduction

INTRODUCTION

Apple (*Malus domestica* Borkh.) the most ubiquitous of all the fruits of the world is the most important temperate fruit crop of India with regards to acreage, production, economic value and above all popularity. Apples are mainly grown in India in the three north western Himalayan States viz., Himachal Pradesh , Jammu and Kashmir and hill districts of Uttar Pradesh. The region provides for almost the entire requirement of temperate fruits in the country and horticulture is the mainstay of the people of these states. Of the total apple production of 13.3 lakh tonnes in the country, the contribution of the three states viz., Jammu and Kashmir, Himachal Pradesh and Uttar Pradesh is 7.8, 3.60 and 1.6 lakh tonnes respecrively (Azad, 1987). The growth of apple industry in Himachal Pradesh, in particular has indeed been phenemenal, during the past three decades. Today, apple is the major temperate fruit crop of the State accounting for an area of 0.55 lakh hectares (38 per cent of the total area under fruits) and over 90 per cent of the total fruit production. Apple industry, has thus emerged as the major bulwork of rural economy in this land-locked hill state of India.

Higher yields, are worth little, however, if the harvested crops are not made available to the consumer in good quality. Fleshy fruits and vegetables are perishable commodities, and apple is no exception. Left to the vagaries of nature the fruit loses its consumer acceptability in a very short time. Approximately 30% of the harvested crops per year are lost annually as they move from the farmer to the consumer (Dekazos, 1983). Such losses, for obvious reasons, are much greater in developing countries like India where storage of food is a perennial problem. A sizable reduction also occurs in the nutritive value and general quality of the fruit that reaches the consumer. Such wastage, in addition is reflected in higher consumer prices. Preservation of what has already been produced, therefore, is of prime importance, and assumes considerable economic and social improtance for a country like ours. Millions more can be fed by preventing or minimizing crop losses.

Harvested apples like other fruits and vegetables, are living things and continue to respire and carry on most of the life processes that were predominate just before harvest. It is highly desirable to inhibit their ripening and senescence until they are to be consumed. Ideally, one would like to be able to inhibit the ripening process at will to insure maximum quality at a predetermined time. In practice however, the storage life of fruits and vegetables can be prolonged to a great extent by inhibiting the ripening process either with chemical treatments and/or with precise/judicious management of temperature and storage atomosphere. The span of market availability of apples has in recent years, been considerably extended through scientific techniques of handling and storage. Notwithstanding this development, fruit longevity is determined by its quality at harvest.

Apple fruit is metabolically very active and need to have proper biochemical built up at harvest to withstand long storage to reach the consumer in acceptable condition. Consumers see quality fruits as those that look good, are firm and offer good flavour and nutritive value; they buy on the basis of appearance and feel, and their satisfaction depends upon good quality (Kader, 1983).

Chemical modification of metabolism or ripening brought about by preharvest spray treatments with growth regulators, and the detailed knowledge of the biochemical changes occurring in the early stages of ripening, accumulated over the years, have perhaps been the two most important advances in the field of horticulture since 1971 (Hulme and Rhodes, 1971). In addition to growth regulating substances, effects of many more chemicals and bioregulators have since been investigated and, at least, a few find an established place in the orchard spray schedules. Inorganic nutrients such as calcium have been shown to inhibit specific aspects of abnormal senescence in numerous fruits and vegetables including apples (Shear and Faust, 1975). It has been demonstrated that reduced respiration rate was associated with an increased calcium level in the tissue (Wills and Tirmazi, 1982).

Fungicides improve the storage life of fruits by preventing many pre and postharvest pathological disorders. Many of the infections of sooty blotch, fly specks, fungal rots and other storage diseases take place while the fruit is still attached to the mother tree. These can be effectively controlled by pre and/or postharvest applications of fungicides (Tepper and Yodder, 1982).

The present investigations were undertaken to study the effect of preharvest sprays of some newly developed growth bioregulators and fungicides on the accumulation of calcium, ripening, ethylene evolution and storage quality attributes of Red Delicious apple grown in the high region of Himachal Pradesh.

Review of Literature

REVIEW OF LITERATURE

A review of the current status of knowledge on the effect of some plant growth regulators, bioregulators and fungicides on the ripening and storability of apple is presented under the following sub-heads:

2.1 Growth bioregulators

2.11 Agrostemin:

Agrostemin is an allelopathic bioregulators that is reported to have beneficial effect on plant species, especially agricultural crops. It is claimed to be an extract of corn cockle (*Agrostemma githago*), a common field weed that grows under natural conditions in symbiosis with wheat and other grains (Anonymous, 1987).

Agrostemin is manufactured to a gray-white powder in two formulations by COMMET HANDELSGESELLSCHAFT M.B.H.

Stresemannstrasse 17 D-6240, Konigstein/Taunus, Yugoslavia. Agrostemin Type 1 is for application to seeds & Agrostemin Type 2 exclusively for treating leaves and plant surfaces. Agrostemin is a blend of 39 different plant extracts in a scientifically balanced ratio & its main ingredients are :

Phytohormonal complex:

A. Cytokinin complex

B. Gibberellin complex

C. Auxin (in small parts)

Free amino acids, organic acids and derivatives of organic acids :

Tryptophan ($C_{11}H_{12}N_2O_2$)

Glutamic acid ($C_5H_9NO_4$)

Orcialanine ($C_{10}H_{13}NO_4$)
and other amino acids, as well as organic acids and derivatives of organic acids:

Alantoinic acid ($C_4H_8N_4O_4$)

Alantoin ($C_4H_6N_4O_3$)

Adenine ($C_5H_5N_5$)

Inhibitors:

Derivatives of ABA (abscisic acid), saturated aliphatic hydrocarbons and cyclic inhibitor ($C_8H_{29}N_3O_7$)

Agrostemin is claimed by the manufacturer to be a new concept in the area of plant-supplement, food-bioregulators from the phytohormone family which can be used in conjunction with herbicides, pesticides and fertilizers (Stankovic and Gajic, 1984). According to the product information based on scientific investigation made available by the manufacturers application(s) of Agrostemin is said to result in various beneficial physiological responses such as increased mineral uptake, improved leaf system with increased chlorophyll production, and reduced ripening period by as much as two weeks. In fruits and vegetables it is said to increase the Vitamin C content, weight (upto 20%), firmness, sugar content (upto 2%), and essential amino acids. It is also reported to enhance the fruit colour and increase the fruit size.

It is reported that apple fruits when treated with agrostemin Type-2, increased the colour intensity of the fruit, reduced the maturity period, increased the dry matter content (8-15%), increased the yield (5-15%) and improved the storage longevity of the fruit and thus reducing the loss by 20-30%.

Miele and Tonietto (1984) reported that agrostemin applied to grape vine had no effect on yield or quality of grapes. However, in another experiment, Stankovic and Rajkovic (1984) observed increased photosynthesis, yields and fruit quality in pear when agrostemin was sprayed at the 'mouse ear' stage. Grindberg and Azima (1986) applied agrostemin as a foliar spray to tobacco at the 4-5 leaf stage and observed increased plant height, leaf area and leaf yield.

Agrostemin is reported to increase the N,P,K and Ca uptake when applied as a foliar spray to lucern

(Blazheva and Angelov, 1987). Foliar application of agrostemin to lentils has been reported to exert pronounced effect on seed yield and also increase specific weight (Iliev and Christov, 1987). In another experiment, Hradecka and Peter (1988) observed increased number of grains per ear and higher grain weight in winter rye with application of agrostemin at flowering stage.

2.12 Biozyme and Protozyme

Biozyme and protozyme are the bioregulators which are claimed by the manufacturers to enhance the growth, yield and quality of crops. Biozyme Crop+ is a biotechnology research product from Wockhardt Limited, Bombay, while Protozyme Crop+ is manufactured by A.J. Chemicals, Ahmedabad and marketed by Kisan Brothers Pvt. Ltd., Ahmedabad. According to the manufacturers, these bioregulators are biologically derived nutritional supports intended for application to crops at the vegetative or beginning of the reproductive stages of the plant growth. Their main active ingredients are:

A. Cytokinin and auxin precursors

B. Enzymes and

C. Hydrolysed protein complex

As cytokinins and auxins are brought into close association with plant tissue, several enzymatic processes are affected. The enzyme ribulose diphosphate carboxylase, which initiates the synthesis of carbohydrates from CO_2 and photosynthetically derived

$NADPH_2$, increases the activity and the mass of the photosynthetic product. With increased amounts of biochemical energy now available, more correct structural synthesis of chlorophyll proceeds (Stetler and Laetsch, 1985).

The storage of plant tissues is immediately responsible for several metabolic activities. The degradation of such storage polymers and process of resulting products through glycolysis and the pentose phosphate shunt occurs. This stimulation of tricarboxylic acid cycle which allows metabolites to enter the fatty acid-phospho-lipid-steroid biosynthetic pathways to finally pass through the respiratory cytochrome system, is partially responsible for the ageing process in plant tissues. This entire process can be slowed down in most cases by the application of cytokinin enzyme complexes. Invertase, the enzyme which is responsible for the breakdown of disaccharides into monosaccharides sugars can be halted by the application of plant regulating compounds (Thimann and Wickson, 1958).

Smock et al.(1962) observed that treatment with N^6- benzyladenine of several varieties of apple either before harvest or after harvest at 10-30 ppm accelerated the respiration rate in the pre-climacteric phase but the treatments had no consistent effect on the development of physiological or fungal diseases in storage. BA has also been found to preserve the green colour of the pedicel and flesh appearance of the sweet cherry fruit and reduced the weight loss during storage (Tuli et al., 1962).

Foliar application has been shown to be an effective method of applying bioregulators or nutritional support to plants, particularly when responses within short growing seasons are demanded (Alexander, 1986). Biozyme Crop+ is reported to be the most balanced and specific nutritional support for crop yield and to increase the shelf life as a result of the unique understanding of the plant biochemical demands.

It is claimed by the manufacturers that biozyme offers different advantages; it gives bigger fruit, reduces flower and fruit drop, increases keeping quality of fruits, gives fruits of desired surface colour. When it is applied at pre-harvest stage to apple, peach, plum, cherry and apricot, it offers advantage of uniform maturity, desired surfact colour, and better keeping quality of fruits. Protozyme on the other hand, when applied to the fruit bearing tree like mango, lemon, orange, sweet lime, apple, chikoo, guava, plum and pomegranate etc. at the time of flowering and at fruit set stage is reported to offer various advantages like increased absorptions of nutrieits, increased photosynthesis and nutrient utilization, increased crop quality and size with higher protein, better retention of blooms etc.

Foliar spray of biozyme or protozyme (10,20 or 30 ml/10 litre) to Santa Rosa plum tree has been reported to significantly increase the leaf area, fruit weight and volume (Anonymous, 1990). In another experiment, Sharma (1990) reported that protozyme (1 ml/l, 2 ml/l, 3 ml/l), biozyme (1 ml/l, 2 ml/l and 3 ml/l) increased the fruit weight, TSS and firmness of Red Delicious apples.

2.13. Triacontanol

Paras, a product of Hindustan Lever Limited is a mixture of aliphatic alcohols, including triacontanol and is also known as Mixtalol. It contains 0.5% triacontanol. Paras is reported to increase the rate of photosynthesis and inhibit photorespiration in tomato, barley and rice leaves resulting in higher dry matter production. The increased rate of photosynthesis was attributed to the enhanced carboxylation and phosphorylation activities besides increased chlorophyll content due to Mixtalol application (Menon and Srivastava, 1984). Higher amount of chlorophyll and carotenoids in paddy, maize and tomato with 2 ppm of Mixtalol was reported by Venkataramani et al.(1987).

Triacontanol is a long chain 30 carbon primary alcohol ($CH_3(CH_2)28CH_2OH$) and is derived from alfalfa (*Medicago sativa*). The growth regulatory effects of triacontanol were first reported by Ries et al. (1977) when they observed increase in dry weight and water uptake of rice seedlings treated with crystalline substance isolated from the active fraction of alfalfa meal.

Hamat et al. (1993), observed that

triacontanol applied (1.25 mg/l) as a soil drench 25 ml/plant at transplanting stage, significantly increased early ripening in tobasco pepper. Increased fruit weight, volume and total sugars and reduced total phenol content and acidity was observed when fruits of Santa Rosa plum were treated with 25 ppm triacontanol (Chandel, 1985). Hashim and Lundergan (1985), observed an increase in the fresh weight of strawberries with the application of triacontanol at 2.0 mg/l.

Jindal and Dwivedi (1986) reported a significant increase in weight, volume, sugar, TSS content in fruits of Santa Rosa plum with an application of triacontanol. An increased level of total sugars in plum was observed with the increasing concentrations of TRIA upto 7.5 ppm and Miraculan upto 10 ppm (Barua, 1990). In another experiment conducted by Sharma (1990) increased fruit weight, TSS and firmness of Red Delicious apple was observed with Paras (0.20 ml/l, 0.40 ml/l and 0.50 ml/l). An increased weight and volume of Santa Rosa plum have also been reported by Parmar et al.(1986) with Mixtalol. However, no effect on fruit weight and soluble solids was observed when triacontanol was applied to 'PMR-45' muskmelons (Bosland et al., 1979).

Enhanced nutrient absorption in terms of N,P and K due to triacontanol has been reported in chillies by Miniraj and Shanmugavelu (1987).

In tomato, a significant improvement in fruit quality was observed with the application of 1 ppm triacontanol (Gunasekaran and Shanmugavelu, 1983). Chander (1987) also reported increased fruit size and improved quality of New Castle apricot with the application of 5 ppm triacontanol.

2.14 *Euphorbia royleana* Boiss latex

Defining the latex, commonly called milky juice, Metcalf (1967) reported that the term is used loosely by plant anatomists for fluids with a milky appearance due to the suspension of many small particles in a liquid dispersion medium with a very different refractive index.

The latex of *Euphorbia royleana* Boiss is reported to have strong insecticidal and mulluscidal properties (Sharma, 1982). Uemura and Hirta (1973) and Evans (1973) reported that the active principal responsible for these properties was ingenol, a new class of polyhedric diterpene esters.

The latex is also suspected of having very strong growth regulatory and antitranspirant properties and is thought to be particularly rich in endogenous gibberellins and cytokinins. In what appears to be perhaps the first attempt to ascertain the antisenescence properties of the latex and its potentials in extending the storage life of fruits. Chopra and Khokhar (1985) dipped freshly harvested

Kinnow mandarin fruits in aqueous solution of *Euphorbia royleana* Boiss latex at concentrations ranging between 0.01 to 0.1 per cent in step-ups of 0.025 for 2 minutes, and observed significant increase in ambient storage life with 0.025 and 0.05 per cent applications. However, in another study Chopra et al.,(1985) did not find the latex effective in extending the storage life of fresh button mushrooms (*Agaricus bisporus*) stored at 3^{0} to 5^{0}C in 100 guage polythene bags with 0.5 per cent venting area. Nayital et al. (1990) gave postharvest dip to Red Delicious apple fruits in 0.01% *Euphorbia royleana* latex for 1 minute and observed significant reduction in weight and volume loss and increase in TSS and as well as titratable acidity of fruits during the course of 210 day storage at 0 ± 1^{0}C.

2.2 Fungicides

2.21 Carbendazim (Bavistin):

Mature fruits and vegetables are highly susceptible to invasion by specific pathogenic microorganisms because they are high in moisture and nutrients and are no longer protected by the intrinsic factors. Pathological diseases of fruits and vegetgables can be reduced to a certain extent by maintaining the natural resistance of the host, low storage temperatures, low oxygen atmospheres, and treatments with growth regulators that delay senescence. However, these beneficial practices may not adequately protect the crop from microbial attack, especially during storage or movement of the crop through export market channels. The maximum storage life of many fresh fruits and vegetables can be realized only by treating the product with an antifungal agent before storage in an optimal environment (Eckert, 1983).

The postharvest diseases are due either to contamination and incipient infection that occur during the growing season or to infections through injuries attributable to harvesting, processing, packing and transporting of the produce (Kaul and Munjal, 1982). The losses of fruits and vegetables which may be attributed to postharvest diseases are rarely appreciated by either the producer or the consumer. Measures for controlling postharvest diseases are based upon:(a) prevention of infection, (b) eradication of incipient infection, and (c) retarding the progress of pathogen in the host (Eckert,1975).

Fungicides developed since 1965 have shown a high degree of efficiency against latent infections as well as protective and antisporulant action in controlling certain postharvest diseases (Eckert,1977).To achieve these objectives pre and/or postharvest application of various systemic fungicides and non-systemic fungicides to fruits have been advocated.

Bavistin (methyl-2-benzimidazole carbamate) is a systemic fungicide with prophylactic and curative action and, has been reported to offer excellent promise for reducing losses from blue mould (*Penicillium expansum* Lk. ex. Thom.) and gray mould (*Botrytis cinerea* Pers ex.Fr.), major causes of spoilage during storage and marketing of apple (Hardenburg and Spalding, 1972). Blue mould is reported to be the most prevalent postharvest pathogen in apple (Koffmann et al., 1978). In Himachal Pradesh, this fungus alone was responsible for 55 per cent of the total postharvest losses (Agrawala and Sharma, 1968). Kaul and Munjal (1982) found the blue mould rot (*Penicillium expansum*) to be the most destructive out of 21 postharvest rots reported by them.

Dar and Mukhopadhyay (1976), observed that in fruit dip tests with carbendazim, dicloran and captafol increased the storage life of Red Delicious apples by at least 35 days. Blue mould rot has been reported to be effectively controlled by dipping fruits of apple in bavistin (Dar and Mukhopadhyay, 1977; Vyas and Singh 1977; Kaul, 1982). Ten days increase in shelf-life of inoculated apples was observed by giving a postharvest dip in 2000 ppm bavistin (Vir, 1973). Verma et al., (1982) observed that apple fruits treated with bavistin at 0.2 per cent + 6 per cent wax emulsion, could be stored successfully upto 60 days in the hills of Meghalaya.

Dar and Mukhopadhyay (1976) reported a significant increase in sugar content and in storage life of Red Delicious apples upto 75 days treated with bavistin 0.1-0.3 per cent. Gupta and Sharma (1981) stated that two fortnightly sprays with bavistin before harvest enhanced the keeping quality of Golden Delicious apples by protecting them against storage rots. Similar effects in controlling storage rots was recorded by Hansen and Schadegg (1976). Bavistin effectively protected the fruits from blue mould rot and bitter rot of apple (Ahmed, 1983; Kaith,1987). Use of bavistin as postharvest dips has been reported to completely check the blue mould rot, rhizopus rot and black rot of apple fruit (Chib et al., 1983).

Verma et al. (1986), observed that the field spray of bavistin suppressed the fruit rot upto 80 days, and the fruits of Royal Delicious apple dipped in bavistin resulted in good keeping quality upto 120 days of storage. Two sprays of bavistin, 30 and 15 days before picking have been reported to completely prevent the fruit rot of apple for one month of storage (Zaheer et al., 1986). Cano et al. (1987) reported that postharvest treatment with bavistin increased the carbohydrate content of fruit of Starking and Golden Delicious apple. Nayital et al.(1990) observed that postharvest dip of 500 ppm bavistin given to Red Delicious apple completely checked the fruit rotting upto 210 days of storage at $0 \pm 1^{o}C$. In another study preharvest spray of bavistin 1000 ppm checked the fruit rotting upto 150 days besides increasing the fruit firmness, per cent juice content, TSS, total titratable acidity and fruit calcium content (Dhar, 1987).

2.22 Thiophenate methyl (Topsin-M)

Thiophenate seems to occupy an important position among fungicides since it is not a heterocyclic compound, but instead is a distributed benzene derivative. Both methyl and ethyl thiophenate are broad spectra fungicides having the same antifungal spectrum as benomyl, though on a somewhat lower level of activity. The fungitoxicity as well as systemic action of methyl and ethyl thiophenates may at least in part be attributed to their easy transformation into carbendazim and its ethyl analogue, respectively.

Thiophenate-methyl (1,2-bis (3-methoxy-carbomyl-2-thioureido)-2-aminobenzene) under the trade names Fungo, Topsin-M, Cercobin M, Zyban,Chipco Spot Klean, etc. is a broad spectrum preventive and curative fungicide for use on turf and as a foliar spray to control powdery and downey mildews, Botrytis diseases, numerous leaf and fruit spots, scabs and rots. etc.

Scheer (1974) in a field trial observed that benlate 0.05 per cent and Topsin-M at 0.1 per cent sprayed at 20 days interval gave good control of storage rots of Golden Delicious apple. Verma et al. (1986), reported that the field spray of thiophenate methyl 0.1 per cent increased the TSS and acidity and gave effective control against the fruit rots in apple upto 120 days. Cano et al. (1987) observed that apple fruits treated with benomyl, bavistin, thiophenate-methyl and thiobendazole maintained good keeping quality in storage, though ripening was advanced owing probably to the postharvest treatments.

2.23 Iprodione (Rovral)

Iprodione (3-(3,5-dichlorophenyl)-N-isopropyl-2,4 dioxoimidazolidine-1-carboxamide), marketed under the trade name 'Rovral' is a contact fungicide used for fruit diseases caused by fungi.

Coating of citrus fruits with Waxol and oil emulsions along with rovral has been reported to decrease the decay and thereby, increase the storage life of fruits (Singh and Gupta, 1979; Gupta et al.,1980). Little et al. (1980) stated that the best protection from storage rots was obtained with rovral and imazalil on Granny Smith apples, benlate, rovral and imzalil on Jonathan apple and rovral plus benlate mix on Peckham pear. Laville and Souty (1982) studied the plant pathological aspects of peach and found that rovral was the most effective fungicide against *Rhizopus*, *Monilinia* and *Botrytis* species. Chib et al. (1983) observed that rovral and bavistin were effective against blue mould rot of apple, while rovral was equally effective against *Rhizopus* sp.

Good control of blue mould rot and alternaria rot in apple was observed by the appliction of rovral (Romano et al., 1983; Tak et al.,1985). Raju et al. (1984) obtained good control of fruit infection of chillies (capsicum) caused by *Colletotrichum capsici* with Topsin-M and rovral. Aharoni and Barkai Galon (1987) observed that iprodione (rovral) applied during flowering and fruit development caused a significant reduction in the incidence of fruit decay of strawberries during cold storage and subsequent two days of shelf life. Application of rovral gave good control of *Botrytis cinerea* of pome fruits (Morgat, 1987).

Materials and Methods

MATERIALS AND METHODS

The present investigations on the effect of plant growth bioregulators and fungicides on the ripening and storability of apple (*Malus domestica* Borkh.) cv. Red Delicious were conducted in the Department of Postharvest Technology, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan during 1989-90. Plant material in a private orchard owned by Shri Anant Ram Negi at Halaila (2200 m a.s.l.) near Kotkhai, District Shimla was used for these investigations, and the biochemical analyses were done in the Postharvest Physiology Laboratory and the laboratories of the Department of Soil Science and Water Management and Basic Sciences (Microbiology).

The investigations were carried out in two experiments, each assigned to a block of sixty four and forty trees respectively. Fourteen year old uniform trees of Red Delicious apple on crab apple rootstock were selected for these studies. The trees were maintained under a strictly uniform schedule of cultural operations. The two experiments comprise of sixteen and ten treatments respectively as per details given below:

3.1 Experiment I: Effect of preharvest sprays of growth bioregulators on ripening and storability of apple.

The following treatments were given to the fruits under study:

Treatment Number	Bioregulators	Concentration (ppm)
T_1	Agrostemin	100
T_2	Agrostemin	250
T_3	Agrostemin	500
T_4	Biozyme	500
T_5	Biozyme	750
T_6	Biozyme	1000
T_7	Protozyme	500
T_8	Protozyme	750
T_9	Protozyme	1000
T_{10}	Paras	1000
T_{11}	Paras	2000
T_{12}	Paras	3000
T_{13}	*Euphorbia royleana* latex	100
T_{14}	*Euphorbia royleana* latex	250
T_{15}	*Euphorbia royleana* latex	500
T_{16}	Control	Water spray

Two sprays were given six and three weeks before harvest (14 & 17 WAFB), the first on 30th July and the second on 20th August, 1989.

3.2 Experiment-II: Effect of preharvest sprays of fungicides on ripening and storability of apple.

The following treatments were given to the fruits under study:

Treatment Number	Fungicides	Concentration (ppm)
P_1	Bavistin	500
P_2	Bavistin	1000
P_3	Bavistin	1500
P_4	Topsin-M	250
P_5	Topsin-M	500
P_6	Topsin-M	750
P_7	Rovral	250
P_8	Rovral	500
P_9	Rovral	750
P_{10}	Control	Water spray

The spray was given three weeks before harvest (17 WAFB), on 20th August 1989.

3.3 Preparation of spray material and its application

For making solutions of growth bioregulators and fungicides a weighed amount of the material to be sprayed was dissolved with constant stirring in a small quantity of water (at 55 °C). When fully dissolved, the volume was made to one litre with water to serve as stock solution. Further dilution of the desired concentration were made from the stock solutions prior to use. For Paras, Biozyme, Protozyme and *E. royleana* latex the required dilutions were made in water immediately before use. The solutions were sprayed with the help of foot sprayer.

Spraying was done on a clear and calm day during the morning hours. The spraying was done till the fruits were wet and droplets of solutions started trickling down.

3.4 Storage of fruits

Treated fruits as per layout plan of the experiment were harvested on 12th September 1989 and pre-cooled in the field over night. The fruits were packed in polythene bags with 0.5 per cent venting area and these bags were further packed in standard size Corrugated Fiber Board (CFB) cartons and transported to the main campus of the University within 24 hours of harvesting, where the fruits were stored in the walk-in refrigerated stores of the Department of Post-harvest Technology. The cold stores were maintained at $0 \pm 1^{\circ}C$ and 90-95 per cent relative humidity.

3.5 Physico-chemical analyses

The physio-chemical analyses of the fruits were carried out at 0, 150, 180 and 210 days of storage at $0 \pm 1^{\circ}C$ as per following procedures.

3.51 Fruit size and physiological losses in weight and volume

Fruit size in terms of length and diameter, was recorded with the help of Vernier Callipers and expressed in cm/fruit. The loss of weight and volume was expressed as per cent.

3.52 Specific gravity

The specific gravity of the fruit was determined on the basis of weight and volume by dividing the weight of fruit by its volume.

3.53 Fruit firmness

Firmness was measured with an Effegi Penetrometer-FT 327, which recorded the pressure required to force a plunger of 11 mm in diameter into pared apple flesh. Observations were taken on opposite sides of each fruit and results expressed in Newtons (N).

Newton(N)= Force in Kg X 9.807.

3.54 Per cent juice content

A known quantity of peeled fruit for each treatment was cut into small pieces and the juice was extracted in Usha Shriram Juicer Mixer Grinder. After extraction, the juice was strained through a piece of muslin cloth. The amount of juice obtained was measured in measuring cylinder and the results were expressed as per cent juice content.

3.55 Total soluble solids (TSS)

The total soluble solids were determined with an Erma hand refractometer (0-32% range) by putting a drop of juice on the prism and taking the readings. The results were expressed as per cent soluble solids.

3.56 Titratable acidity

Per cent titratable acidity as malic acid was determined by standard A.O.A.C. method (Horwitz, 1980).

3.57 Fruit calcium content

Thin slices of fruit samples were oven dried to constant weights and ground to a fine powder. Wet digestion, using diacid (nitric acid, 4 parts + perchloric acid, 1 part) was performed (Piper, 1966) and calcium estimation was done on an EEL Flame photometer (Evans Electroselenium Ltd., Halistead, Essex, England). Calcium content was expressed as mg/100 gm fruit, on a dry weight basis.

3.58 Bioelectrical conductance(EC) and pH

A known amount of homogenized fruit extract was taken in a 100 ml beaker and EC was recorded in m mhos/cm on a Elico Model CM-180, Digital conductivity meter (Elico Pvt. Ltd., Hyderabad). The pH of the same extract was recorded with the help of Eltop Digital pH meter Model 3030.

3.59 Total sugars, reducing sugars and non-reducing sugars

Twenty five grams of fruit tissue was macerated and homogenized with distilled water. The volume of homogenate was increased to 250 ml with distilled water. Out of this volume 50 ml was taken for the determination of titratable acidity. The remaining 200 ml extract was neutralized with 1 N NaOH. Ten ml of

45 per cent lead acetate was added to this extract and allowed to stand for 30 minutes followed by filtration and addition of 2 ml of 22 per cent potassium oxalate. Extract was again filtered through Whatman-1 filter paper. From this filtrate 50 ml was drawn and hydrolysed with concentrated HCl and left overnight for the analysis of total sugar. The left ever extract was used for the analysis of reducing sugars.

Reducing sugars and total sugars were determined by A.O.A.C. method (Horwitz, 1980) and results expressed as per cent sugars. The amount of non-reducing sugars was calculated by substracting reducing sugars from total sugar and multiplying the difference with 0.95 and the results expressed as per cent non-reducing sugars.

3.591 Total phenols

Total phenols were determined by the method of Bray and Thorpe (1955) as described below:

One gram of fresh fruit pulp was mascerated with 10 ml of 80 per cent ethanol and filtered through cheese cloth. The residue was washed with 1 to 5 ml of 80 per cent ethanol. 0.2 ml of filterate was taken in graduated 25 ml test tube and to it 1 ml of Folin phenol reagent (1 N) was added followed by 2 ml of 20 per cent sodium carbonate. The contents were thoroughly shaken and heated on boiling water bath for one minute and then cooled in running tap water. The blue solution so obtained was diluted to 25 ml with distilled water.

After 30 minutes, the optical density of the solution was recorded in spectronic-20 colorimeter at 650 nm. Blank was run simultaneously to adjust zero absorbance. Total phenols were calculated against a standard curve of tannic acid. The results were expressed as µg of total phenol per gm fresh weight.

3.6 Physiological characteristics

3.61 Ethylene evolution rate

Ethylene evolution rates of fruits were measured in Gas Chromatograph Shimadzu GC-9A by the method suggested by Wills and Yuln (1989). Weighed quantity of fruits from different treatments were kept in jars for one hour. The ethylene concentration in samples of each of the jar effluents was measured using a gas chromatogram with a Porapak column connected to flame ionization detector. The temeratures standardized with reference to standard gas mixture for column and injection were 60°C and 90°C, respectively. The retention time and sensitivity of the instrument was caliberated at every stage of monitoring ethylene evolution with reference to standard gas mixtures. The results were expressed as µl kg^{-1} hr^{-1} (ppm).

3.62 Fruit respiration rate

The gas flow method as described by Meyer et al. (1966) was employed with slight modifications for the quantitative measurement of respiration (carbon

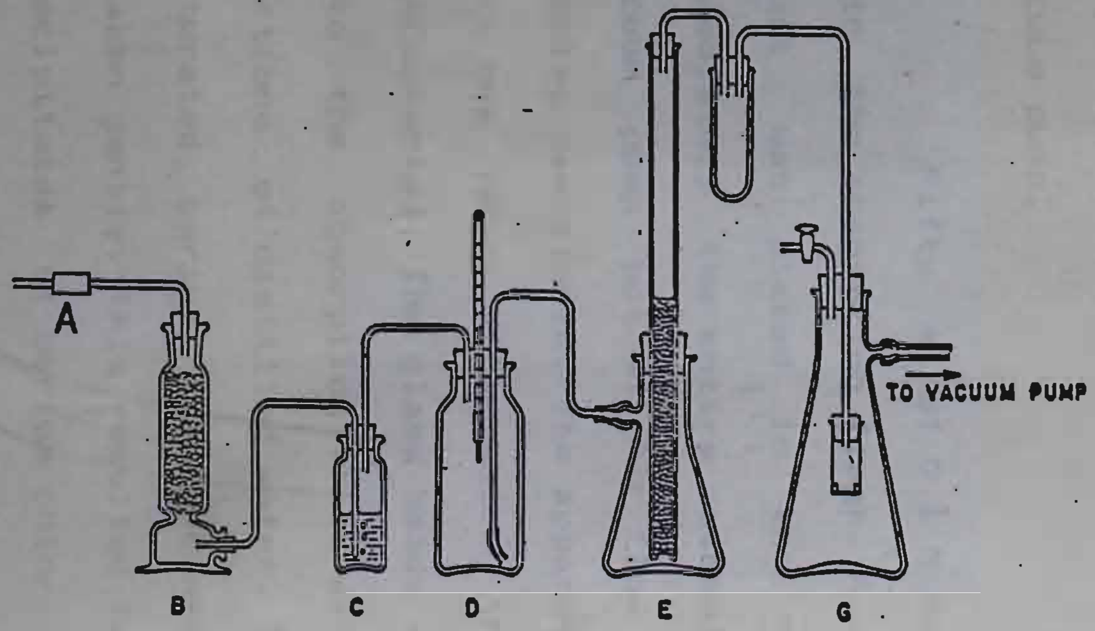

Fig. 1. APPARATUS TRAIN FOR THE MEASUREMENT OF RESPIRATION

A. air flow regulator. B. a large capacity soda-lime tower.
C. check bottle. D. respiration chamber.
E. absorption flask & tower. F. spray trap.
G. suction flask.

dioxide evolved) by the fruit samples. The apparatus considered of a train assembly (Fig.1) in which air at regulated speed passed through a large capacity soda lime bottle into a check bottle containing 20 per cent barium hydroxide. The carbon dioxide free air passed into the respiration chamber in which the respiring fruit samples were held. Therefrom, the air enhanced with carbon dioxide resulting from respiration, passed to the absorption flask and tower, and then into spray trap and finally to the suction flask connected to a vacuum pump.

Fifty ml of 0.1 N sodium hydroxide were put into the absorption flask. A weighed quantity of whole fruit was placed in the respiration chamber and immediately the entire assembly was made air tight and vacuum pump put on. Air flow was regulated at 60-70 bubbles per minute. The apparatus was allowed to operate for one hour after which the absorption flask was disconnected. The glass beads and glass tube were rinsed into the absorption flask with four successive 50 ml portions of distilled water. To this solution 5 ml of saturated barium chloride was added and the contents shaken gently. This resulted in the formation of a white precipitates of barium chloride. The precipitates were allowed to stand for 5 minutes and then 25 ml of 95 per cent ethanol and 4-5 drops of phenolphthalein were added to it. The excess of sodium hydroxide left in the solution was titrated against 0.1 N hydrochloric acid. A blank was also run involving all the steps and reagents except the fruit in the respiration chamber.

CO_2 in milligrams = VxNx22.0

where,

V = difference between plant and experimental titrations in millilitres; and

N = normality of HCl used for titration

3.7 Sensory evaluation

To assess the consumers preference, organoleptic evaluation of fruit from different treatments was conducted by panel of 10 judges, and their scores were averaged. Scoring was done out of total score 100 on the basis of different paraeters like appearance (30), Flavour i.e., Taste (20) + Aroma (20), and texture (30) (Ranganna, 1986).

3.8 Per cent fruit rot

The extent of rotting was recorded at each sampling date under each treatment during storage. The fruits under each treatment were taken out from the boxes and number of rotten fruits were counted. The results were expressed in per centages. The sound fruits were stored in the boxes.

3.9 Statistical analysis

The effects of various treatments on each variable was assessed by the Randomized Block Design and

Experimental Results

EXPERIMENTAL RESULTS

The present study on the "Effect of pre-harvest sprays of some plant growth bioregulators and fungicides on the physical characteristics, biochemical constituents, and incidence of storage rots in Red Delicious apple (*Malus domestica* Borkh.)" held at $0\pm1^{\circ}C$ was conducted during 1989-90. The study was conducted in two experiments of which experiment I relates to the effect of preharvest sprays of plant growth bioregulators, and experiment II to that of fungicides. The parameters of study for the two experiments being identical have been grouped for the sake of brevity and continuity. The results are presented here under:

4.1 Effect on Physical characteristics of fruit

4.11 Fruit size

The data pertaining to the effect of growth bioregulators and fungicides on fruit size are presented in Table 1 (a and b). A perusal of the date reveals that in experiment I all the treatments increased the fruit size in terms of length and diameter compared to control. The largest fruits at harvest were obtained from tree receiving Paras 2000 ppm (T_{11}) closely followed by those from T_1, T_2 and T_{12}. In experiment II, although no treatment could exert any significant influence on fruit size the largest fruits in terms of length and diameter were obtained from F_9 and the smallest from control (F_{10}).

TABLE .1(a)

Expt. I. Effect of preharvest sprays of growth bioregulators on fruit size of Red Delicious apple.

Treatments	Length (cm)	Diameter (cm)
T_1 (Agrostemin 100 ppm)	6.14	6.89
T_2 (Agrostemin 250 ppm)	6.06	6.83
T_3 (Agrostemin 500 ppm)	5.92	6.63
T_4 (Biozyme 500 ppm)	6.01	6.75
T_5 (Biozyme 750 ppm)	5.79	6.49
T_6 (Biozyme 1000 ppm)	5.99	6.47
T_7 (Protozyme 500 ppm)	5.81	6.50
T_8 (Protozyme 750 ppm)	5.82	6.56
T_9 (Protozyme 1000 ppm)	5.86	6.53
T_{10} (Paras 1000 ppm)	5.85	6.54
T_{11} (Paras 2000 ppm)	6.24	6.93
T_{12} (Paras 3000 ppm)	6.02	6.78
T_{13} (<u>Euphorbia royleana</u> latex 100 ppm)	5.75	6.50
T_{14} (<u>Euphorbia royleana</u> latex 250 ppm)	5.77	6.54
T_{15} (<u>Euphorbia royleana</u> latex 500 ppm)	5.78	6.51
T_{16} (Control Water spary)	5.73	6.44
C.D. at 5%	0.14	0.17

TABLE .1(b)

Expt. II. Effect of preharvest sprays of fungicides on fruit size of Red Delicious apple.

Treatments	Length (cm)	Diameter (cm)
P_1 (Bavistin 500 ppm)	5.76	6.50
P_2 (Bavistin 1000 ppm)	5.75	6.46
P_3 (Bavistin 1500 ppm)	5.79	6.52
P_4 (Topsin-M 250 ppm)	5.76	6.51
P_5 (Topsin-M 500 ppm)	5.78	6.51
P_6 (Topsin-M 750 ppm)	5.81	6.54
P_7 (Rovral 250 ppm)	5.77	6.49
P_8 (Rovral 500 ppm)	5.78	6.50
P_9 (Rovral 750 ppm)	5.83	6.56
P_{10} (Control Water spary)	5.74	6.47
C.D. at 5%	N.S.	N.S.

4.12 Physiological loss in fruit weight (PLW)

The data on the physiological loss in fruit weight (PLW) are presented in Table 2 (a and b). In experiment I the PLW was recorded to be the lowest in fruits that had received the preharvest application of *Euphorbia royleana* latex 500 ppm (T_{15}) (Fig. 2(a)). The treatment though being on a par with T_{10}, T_{14} and T_9 was significantly superior to rest of the treatments in this respect. Control fruits on the other hand, recorded the highest physiological weight loss. Interactions between treatments and storage intervals were found to be significant.

In experiment II, in which the effect of pre-harvest sprays of fungicides on the physiological weight loss was appraised, all the treatments resulted in significant reduction in weight loss compared to control except P_7 and P_8 indicating that lower concentrations of Rovral (250 and 500 ppm) were ineffective in reducing the PLW. Bavistin at 1500 ppm (P_3) proved to be the most effective treatment being significantly superior to all other treatments in this respect (Fig. 2(b)). The highest PLW, on the other hand, was recorded in control (P_{10}) fruits. Interactions between treatments and storage intervals were observed to be non-significant.

4.13 Loss in fruit volume

The data on the loss in fruit volume presented in Table 3 (a & b), reveal that in experiment I the

Expt. I

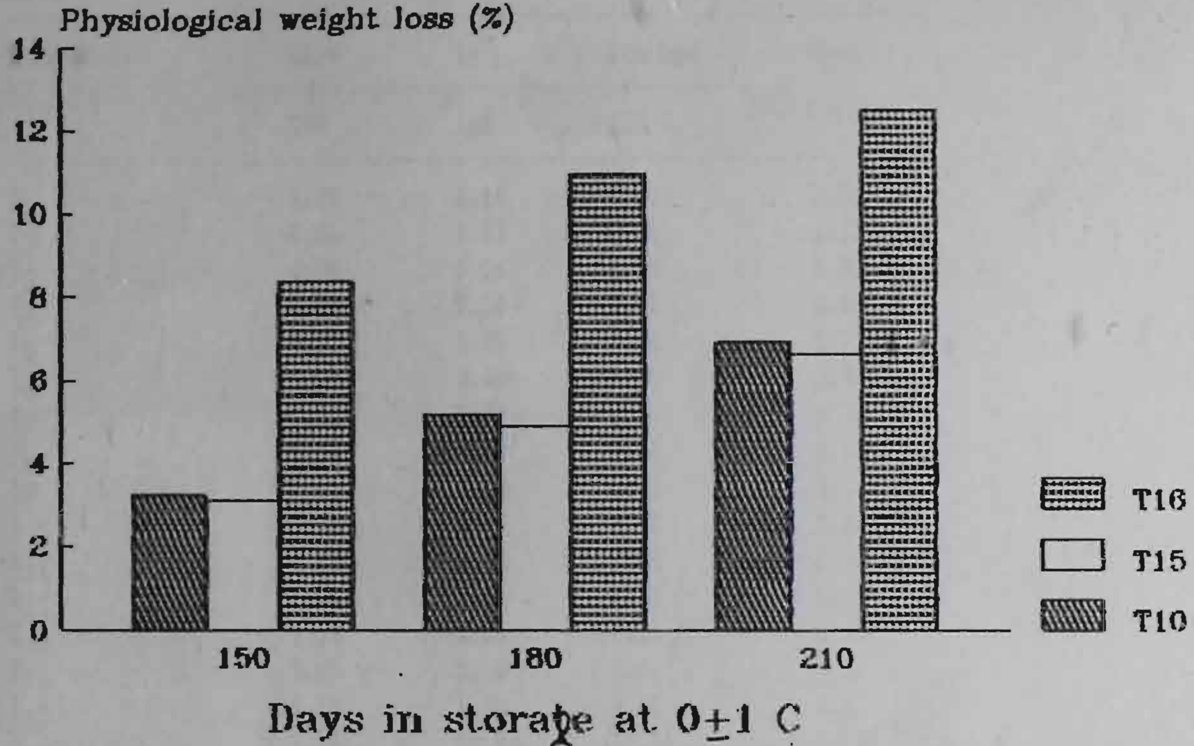

Fig. 2(a) Effect of preharvest sprays of Paras & E. royleana latex on (PLW) of Red Delicious apple fruits.

Expt. II

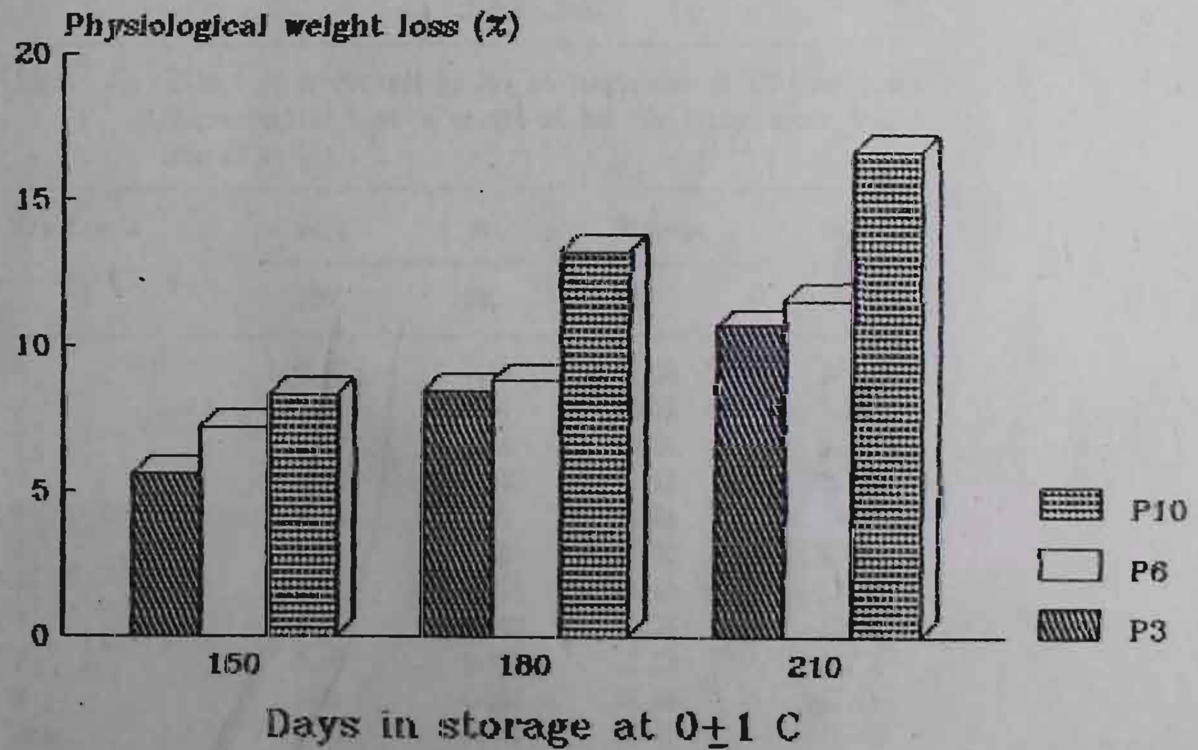

Fig. 2(b) Effect of preharvest spray of Bavistin & Topsin-M on (PLW) of Red Delicious apple fruits.

TABLE .2(a)

Expt.I Effect of preharvest sprays of growth bioregulators on the per cent physiological loss in weight of Red Delicious apple fruits stored at 0 ± 1 °C

Treatments	Days in Storage			Mean
	150	180	210	
T_1	4.78	6.16	9.33	6.76
T_2	4.56	5.73	8.71	6.33
T_3	4.08	5.26	8.15	5.83
T_4	5.02	7.18	8.45	6.88
T_5	4.13	5.90	7.16	5.73
T_6	3.90	5.48	6.96	5.45
T_7	5.15	6.92	8.29	6.79
T_8	4.26	5.72	7.11	5.70
T_9	4.11	5.18	6.82	5.36
T_{10}	3.25	5.19	6.92	5.12
T_{11}	4.12	6.12	8.06	6.10
T_{12}	3.60	5.66	7.51	5.59
T_{13}	4.20	5.25	7.15	5.53
T_{14}	3.65	5.10	6.96	5.24
T_{15}	3.10	4.90	6.60	4.87
T_{16}	8.37	10.96	12.46	10.60
Mean	4.39	6.04	7.91	6.11

C.D.at 5%

Treatments(T)	0.52
Interval (I)	0.23
T x I	0.92

TABLE .2(b)

Expt. II. Effect of preharvest sprays of fungicides on the per cent physiological loss in weight of Red Delicious apple fruits stored at 0 + 1 °C

Treatments	Days in Storage			Mean
	150	180	210	
P_1	8.10	9.66	12.56	10.11
P_2	7.90	9.50	12.12	9.84
P_3	5.60	8.44	10.66	8.23
P_4	9.42	11.03	14.15	11.53
P_5	8.33	9.89	12.86	10.36
P_6	7.20	8.81	11.55	9.19
P_7	10.33	12.12	15.65	12.70
P_8	9.16	11.83	15.36	12.12
P_9	7.98	9.75	13.18	10.30
P_{10}	8.30	13.25	16.66	12.74
Mean	8.23	10.43	13.47	10.71

C.D.at 5%

Treatments(P)	0.72
Interval (I)	0.43
P x I	N.S.

fruits treated with *E. royleana* latex 500 ppm (T_{15}) recorded the lowest per cent loss in volume, the treatment however being on a par with T_{10}, T_{12}, T_{11} and T_{14} but significantly superior to the remaining treatments in this regard. In control fruits (T_{16}), on the other hand, the loss in fruit volume was recorded to be the highest during and at the end of the stipulated 210 days storage. Interactions between the treatments and the storage intervals were recorded to be significant.

In experiment II the lowest fruit volume was recorded in fruits treated with Bavistin 1500 ppm (F_3) the treatment however, being on a par with F_6 and F_5 but significantly superior to rest of the treaments. Compared to control, however, all the treatments were significantly effective in reducing the loss in volume and as expected the highest loss in fruit volume was recorded in control fruits (F_{10}). The interactions between treatments and storage intervals were found to be non-significant.

4.14 Specific gravity

The date on specific gravity of the fruits as affected by various treatments are presented in Table 4 (a and b). It is seen that with the advance in storage period specific gravity recorded a gradual decline, the decrease however, being comparatively abrupt and rather sharp in control fruits.

TABLE .3(a)

Expt.I. Effect of preharvest sprays of growth bioregulators on the per cent physiological loss in Volume of Red Delicious apple fruits stored at 0 ± 1 °C

Treatments	Days in Storage			Mean
	150	180	210	
T_1	3.95	4.99	6.79	5.24
T_2	3.89	4.98	6.75	5.18
T_3	3.82	4.84	6.62	5.09
T_4	4.23	5.39	7.16	5.59
T_5	4.16	5.35	7.08	5.53
T_6	4.08	5.27	7.00	5.45
T_7	4.15	5.38	7.21	5.58
T_8	4.07	5.32	7.10	5.10
T_9	4.02	5.21	7.05	5.43
T_{10}	2.01	4.11	5.92	4.01
T_{11}	2.11	4.27	6.11	4.16
T_{12}	2.08	4.18	6.03	4.10
T_{13}	2.49	4.75	6.45	4.56
T_{14}	2.10	4.35	6.10	4.18
T_{15}	1.98	3.90	5.70	3.86
T_{16}	5.43	7.67	10.35	7.82
Mean	3.41	4.92	6.84	5.06

C.D.at 5%

T	0.68
I	0.41
T x I	1.20

TABLE .3(b)

Expt.II. Effect of preharvest sprays of fungicides on the per cent physiological loss in Volume of Red Delicious apple fruits stored at 0 ± 1 °C

Treatments	Days in Storage			Mean
	150	180	210	
P_1	6.28	7.29	9.48	7.68
P_2	6.18	7.02	9.32	7.51
P_3	5.05	6.13	8.26	6.48
P_4	7.52	8.60	10.60	8.91
P_5	6.44	7.46	7.52	7.14
P_6	5.39	6.39	8.35	6.71
P_7	8.37	9.40	11.54	9.77
P_8	8.22	9.30	11.46	9.66
P_9	6.11	7.21	9.20	7.51
P_{10}	8.38	10.96	13.10	10.81
Mean	6.79	7.98	9.88	8.22

C.D.at 5%

P	0.84
I	0.42
P x I	N.S.

In experiment I fruits with the highest specific gravety at the harvest and during storage were recorded from preharvest treatment with Paras 2000 ppm (T_{11}), the treatment, however, being on a par with T_{15} and T_{12} but significantly superior to rest of the treatments. Control fruits (T_{16}) on the other hand recorded the lowest average specific gravity. Interactions between the treatments and storage intervals were found to be significant.

In experiment II fruit receiving preharvest spray of Bavistin 1500 ppm (P_3) recorded the highest specific gravity at harvest and during subsequent storage closely followed by P_2, P_1, P_6 and P_9 but being significantly superior to the remaining treatments. Control fruits (P_{10}) on the other hand registered the lowest average values for specific gravity. Interactions between treatments and storage intervals were found to be significant.

4.15 Flesh firmness

The data on flesh firmness expressed as puncture force in Newton (N) are presented inTable 5 (a and b). The data reveal a gradual decrease in flesh firmness commensurate with the advance in storage.

It is seen from the Table 5 (a) that fruits with the highest flesh firmness at harvest were obtained from trees receiving pre harvest treatment of *E. royleana* latex 500 ppm (T_{15}). However the highest

TABLE .4(a)

Expt. I. Effect of preharvest sprays of growth bioregulators on the specific gravity of Red Delicious apple fruits stored at $0 \pm 1^{0}C$

Treatments	Days in Storage				Mean
	0	150	180	210	
T_1	0.999	0.963	0.940	0.926	0.957
T_2	0.999	0.970	0.944	0.932	0.961
T_3	1.001	0.979	0.963	0.950	0.973
T_4	1.001	0.966	0.952	0.939	0.964
T_5	1.001	0.961	0.947	0.944	0.963
T_6	1.000	0.962	0.950	0.941	0.963
T_7	1.001	0.967	0.956	0.946	0.967
T_8	1.000	0.961	0.946	0.937	0.961
T_9	0.999	0.960	0.942	0.932	0.958
T_{10}	1.001	0.979	0.966	0.948	0.973
T_{11}	1.002	0.989	0.979	0.962	0.978
T_{12}	1.001	0.989	0.973	0.950	0.978
T_{13}	0.999	0.972	0.958	0.946	0.969
T_{14}	1.000	0.976	0.965	0.951	0.973
T_{15}	1.000	0.987	0.969	0.962	0.979
T_{16}	0.999	0.947	0.934	0.921	0.950
Mean	1.000	0.970	0.955	0.943	0.967

C.D.at 5%

T	0.006
I	0.003
T x I	0.012

TABLE .4(b)

Expt.II. Effect of preharvest sprays of fungicides on the specific gravity of Red Delicious apple fruits stored at $0 \pm 1^{0}C$

Treatments	Days in Storage				Mean
	0	150	180	210	
P_1	1.000	0.951	0.943	0.937	0.958
P_2	1.001	0.959	0.947	0.941	0.962
P_3	1.003	0.963	0.952	0.944	0.965
P_4	1.000	0.945	0.936	0.932	0.953
P_5	0.999	0.945	0.938	0.998	0.952
P_6	1.000	0.952	0.943	0.935	0.957
P_7	0.999	0.940	0.939	0.928	0.953
P_8	1.000	0.947	0.939	0.928	0.953
P_9	1.001	0.958	0.940	0.931	0.957
P_{10}	0.999	0.942	0.929	0.925	0.949
Mean	1.0002	0.950	0.940	0.934	0.955

C.D.at 5%

P	0.009
I	0.004
P x I	0.018

average firmness values during and at the end of stipulated 210 days storage were recorded from fruits receiving Protozyme 500 ppm (T_7) Fig.3(a). The treatment however, was on a par with T_4, T_1, T_{15}, T_{10}, T_8, T_5 and T_{14} but statistically superior to the remaining treatments. Fruits that had received preharvest spray of Paras 3000 ppm (T_{12}) on the other hand recorded the lowest flesh firmness. Interactions between treatments and storage intervals were found to be non-significant.

The experiment II (Table 5 b) the highest flesh firmness at harvest was recorded in fruits from P_8 (Rovral 500 ppm). However, the highest average firmness was recorded from fruits treated with Bavistin 500 ppm (P_1) Fig. 3(b) the treatment however being on a par with the P_4, P_7, P_8, P_2 and P_5 but significantly superior to rest of the treatments. Interactions between treatments and storage intervals were non-significant.

4.2 Effect on Physiological characteristics

4.21 Respiration rate

The data on respiration rates of fruits as affected by various preharvest treatments with growth bioregulators and fungicides during storage are given in Table 6 (a and b).

A perusal of the data in Table 6 (a) reveals that in experiment I fruits treated with Agrostemin 500 ppm (T_3) Fig. 4(a) exhibited a gradual and steady increase and decrease in the respiration rate during the stipulated storage period of 210 days culminating in a respiratory

Expt. I

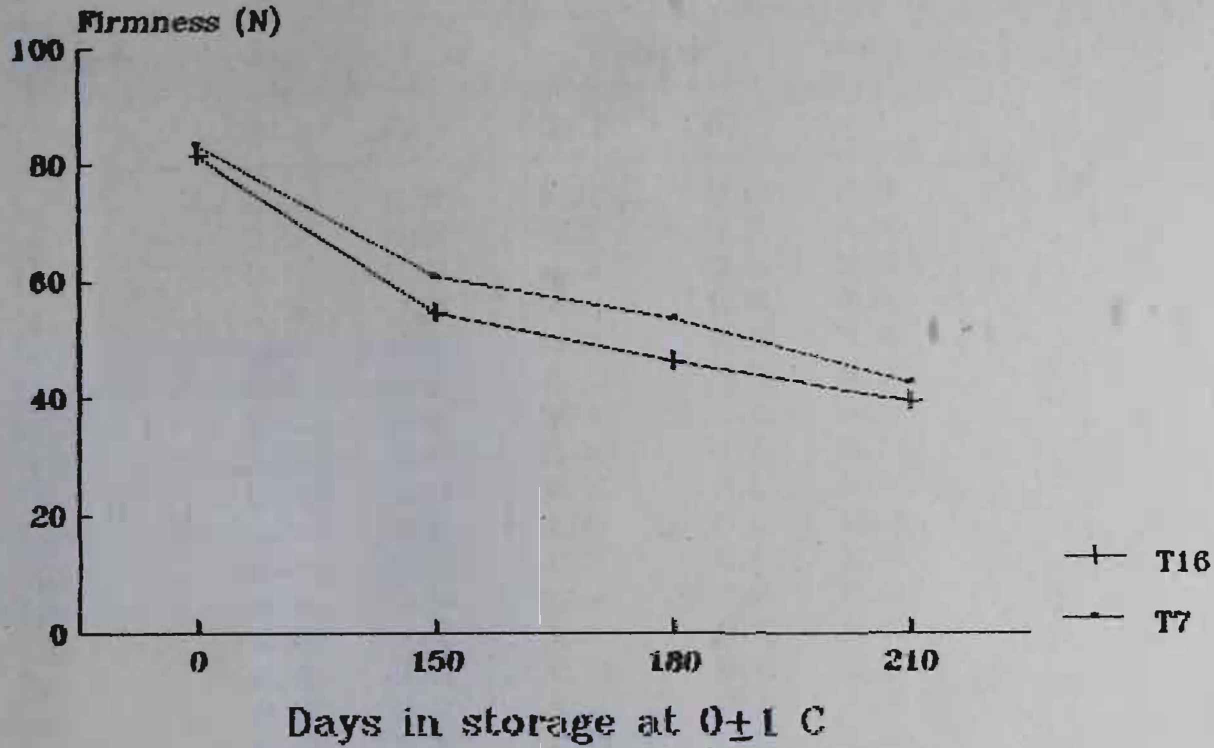

Fig. 3(a) Effect of preharvest sprays of protozyme on firmness of Red Delicious apple fruits.

Expt. II

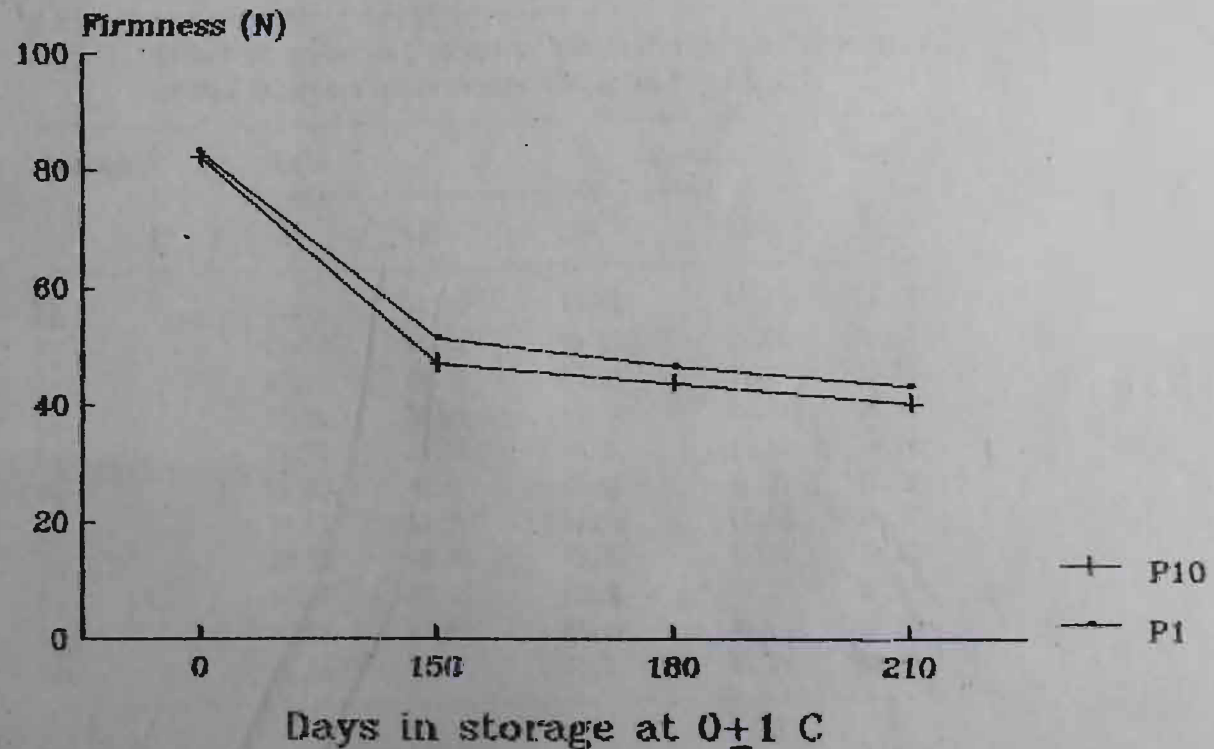

Fig. 3(b) Effect of preharvest spray of Bavistin on firmness of Red Delicious apple fruits.

TABLE .5(a)

Expt.I. Effect of preharvest sprays of growth bioregulators on the firmness(N) of Red Delicious apple fruits stored at 0 ± 1 °C

Treatments	Days in Storage				Mean
	0	150	180	210	
T_1	83.36	57.57	50.21	45.60	59.14
T_2	82.57	56.29	47.76	41.19	56.98
T_3	81.79	54.92	46.09	37.36	55.02
T_4	83.55	57.08	50.51	41.68	58.06
T_5	82.87	57.08	50.51	41.68	58.06
T_6	82.28	55.60	48.15	39.72	56.39
T_7	83.36	60.61	53.35	42.66	60.02
T_8	83.36	58.45	50.01	40.70	58.15
T_9	82.38	56.39	49.03	40.21	56.98
T_{10}	83.06	59.82	51.49	43.15	59.33
T_{11}	81.40	55.11	47.07	40.21	55.90
T_{12}	80.42	53.94	43.64	37.85	53.94
T_{13}	82.87	54.92	46.58	39.72	56.00
T_{14}	83.36	57.37	48.05	41.87	57.66
T_{15}	84.24	60.31	50.11	42.76	59.33
T_{16}	81.59	54.33	45.99	39.23	55.31
Mean	82.65	56.98	48.72	41.09	57.36

C.D.at 5%

T	2.74
I	1.57
T x I	N.S.

TABLE .5(b)

Expt.II. Effect of preharvest sprays of fungicides on the firmness(N) of Red Delicious apple fruits stored at 0 ± 1 °C

Treatments	Days in Storage				Mean
	0	150	180	210	
P_1	83.06	51.49	46.68	43.15	56.10
P_2	81.10	50.01	45.11	41.68	54.43
P_3	80.51	49.03	43.64	41.19	53.55
P_4	83.26	50.01	45.70	40.99	55.02
P_5	81.99	49.03	44.62	40.40	54.04
P_6	81.02	48.07	45.13	41.21	53.86
P_7	79.93	50.51	46.78	41.68	54.72
P_8	83.55	48.05	45.60	41.19	54.62
P_9	81.89	47.56	45.11	40.70	53.84
P_{10}	82.28	47.07	43.64	40.21	53.25
Mean	81.86	49.04	45.21	41.29	54.35

C.D.at 5%

P	2.16
I	1.08
P x I	N.S.

peak towards the end of storage. Treatments T_4, T_{15} and T_8 also demonstrated an almost similar trend. Paras 3000 ppm (T_{12}) treated fruits on the other hand exhibited rather rapid increases and decreases in respiration rate during storage followed only by control fruits (T_{16}). The interactions between treatments and storage intervals were found to be significant.

In experiment II, fruits receiving the pre-harvest treatment of Bavistin at 1000 and 1500 ppm (P_2 and P_3) Fig. 4(b) recorded the lowest respiration rates at the commencement of storage, the values gradually increasing as the storage period advanced, registering a decline towaqrds the end of storage period. Almost similar trend in respiration was observed in fruits receiving Topsin 750 ppm (P_6). Control fruits (P_{10}), on the other hand recorded the lowest respiration rate at the end of storage. Interactions between treatments and storage intervals were found to be significant.

4.22 Ethylene evolution rate

The data on ethylene evolution (μl Kg^{-1} hr^{-1}) by fruits as affected by various preharvest treatments of growth bioregulators and fungicides during storage are presented in Table 7 (a and b).

The data reveal (Experiment I) that fruits that had received preharvest application of Agrostemin 500 ppm (T_3) Fig. 5(a) exhibited a rather steady increase followed by a gradual decline in ethylene evolution rate during

Expt. I

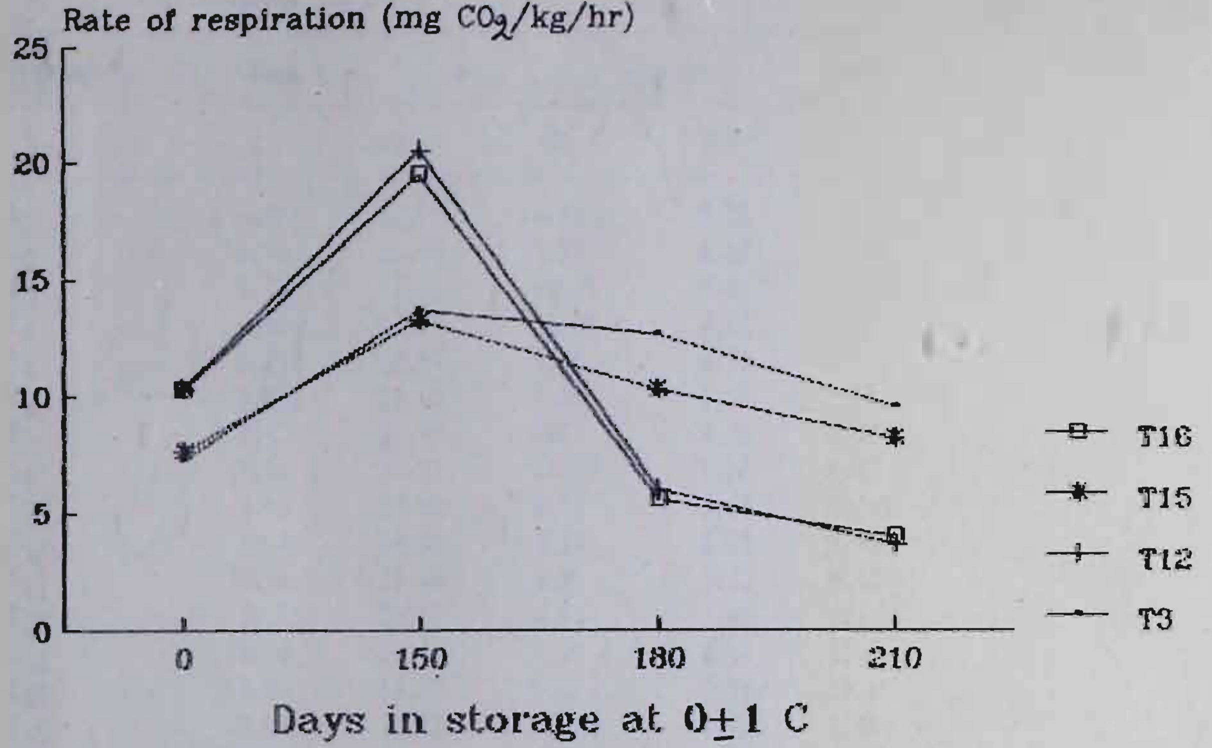

Fig. 4(a) Effect of preharvest sprays of Agrostemin, Paras & E. royleana latex on Respiration rate of Red Delicious apples.

Expt. II

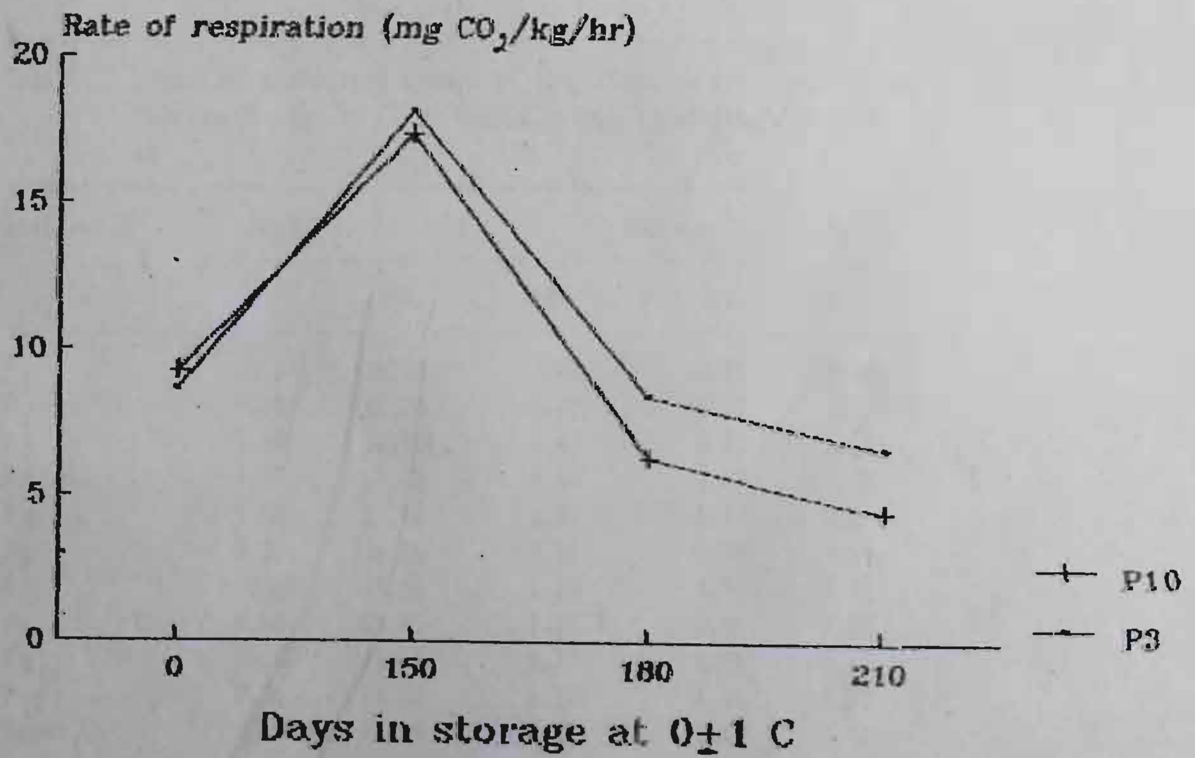

Fig. 4(b) Effect of preharvest spray of Bavistin on Respiration rate of Red Delicious apples.

TABLE .6(a)

Expt.I. Effect of preharvest sprays of growth bioregulators on the respiration rate(mg CO_2 Kg^{-1} hr^{-1}) of Red Delicious apple fruits stored at 0 $\pm$ 1 $^{\circ}C$

Treatments	Days in Storage 0	150	180	210	Mean
T_1	9.84	18.90	6.76	5.32	10.20
T_2	8.90	16.44	9.92	6.68	10.48
T_3	7.33	13.65	12.59	9.51	10.77
T_4	6.50	12.34	10.09	8.67	9.40
T_5	8.25	18.54	8.13	6.78	10.42
T_6	9.83	17.25	7.30	5.57	9.99
T_7	9.43	16.97	6.37	4.70	9.37
T_8	7.54	13.33	10.47	7.60	9.73
T_9	9.03	17.89	6.71	6.79	10.05
T_{10}	10.40	14.60	5.10	3.85	8.49
T_{11}	9.16	17.46	6.95	5.75	9.83
T_{12}	10.31	20.47	6.02	3.66	10.11
T_{13}	9.08	18.43	7.20	6.67	10.34
T_{14}	8.96	16.92	9.27	7.46	10.65
T_{15}	7.67	13.23	10.28	8.18	9.84
T_{16}	10.26	19.43	5.59	4.00	9.82
Mean	8.90	16.61	8.04	6.30	9.97

C.D.at 5%

T	0.41
I	0.20
T x I	0.82

TABLE .6(b)

Expt.II. Effect of preharvest sprays of fungicides on the respiration rate(mg CO_2 Kg^{-1} hr^{-1}) of Red Delicious apple fruits stored at 0 $\pm$ 1 $^{\circ}C$

Treatments	Days in Storage 0	150	180	210	Mean
P_1	10.27	16.30	7.02	5.95	9.88
P_2	9.10	17.25	7.75	6.11	10.05
P_3	8.65	18.16	8.40	6.60	10.45
P_4	9.53	17.23	6.66	4.87	9.57
P_5	9.40	17.46	6.83	5.77	9.86
P_6	9.33	16.36	7.95	5.96	9.90
P_7	10.65	15.56	6.85	4.70	9.44
P_8	9.54	17.40	7.20	5.40	9.88
P_9	10.41	16.35	6.77	4.98	9.63
P_{10}	9.30	17.33	6.31	4.46	9.35
Mean	9.62	16.94	7.17	5.48	9.80

C.D.at 5%

P	0.36
I	0.18
P x I	0.72

storage at 0±1 °C. The fruits from treatments T_{11}, T_{15}, T_4 and T_7 also demonstrated an almost similar trend. Paras 3000 ppm treated fruits (T_{12}), on the other hand, recorded the most rapid and abrupt increases and decreases in the ethylene evolution rates followed in this regard only by control fruits (T_{16}). Interactions between trearments and storage intervals were found to be significant.

In experiment II the ethylene production rate was the lowest in 1500 ppm (F_3) (Fig. 5(b)) at the commencement of storage, the value gradually increasing as the storage period advanced, registering a decline towards the end of 210 days stipulated storage period. Fruits from the treatment F_2 behaved in an almost similar manner. Control fruits (F_{10}), on the other hand, recorded the lowest ethylene production at the end of storage period. Interactions between treatments and storage intervals were observed to be significant.

4.3 Effect on bio-chemical characteristics

4.31. Total Soluble Solids(TSS)

The data in Table 8 (a and b) presents the total soluble solids (TSS) content of the fruits at harvest and during storage as influenced by preharvest treatments of growth bioregulators (Experiment I) and fungicides (Experiment II). The TSS contents, in general, increased as the storage period advanced, tending to decline towards the end of storage, though no

Expt. I

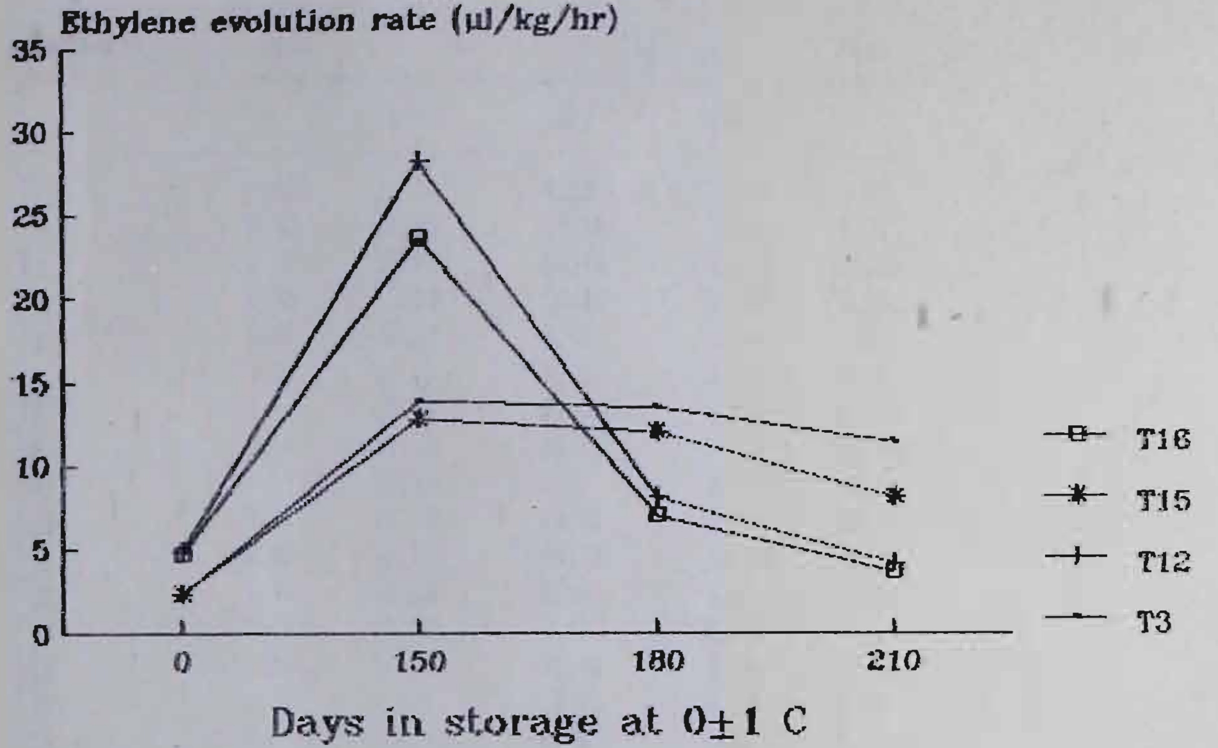

Fig. 5(a) Effect of preharvest sprays of Agrostemin, Paras & E. royleana latex on Ethylene rate of Red Delicious apples.

Expt. II

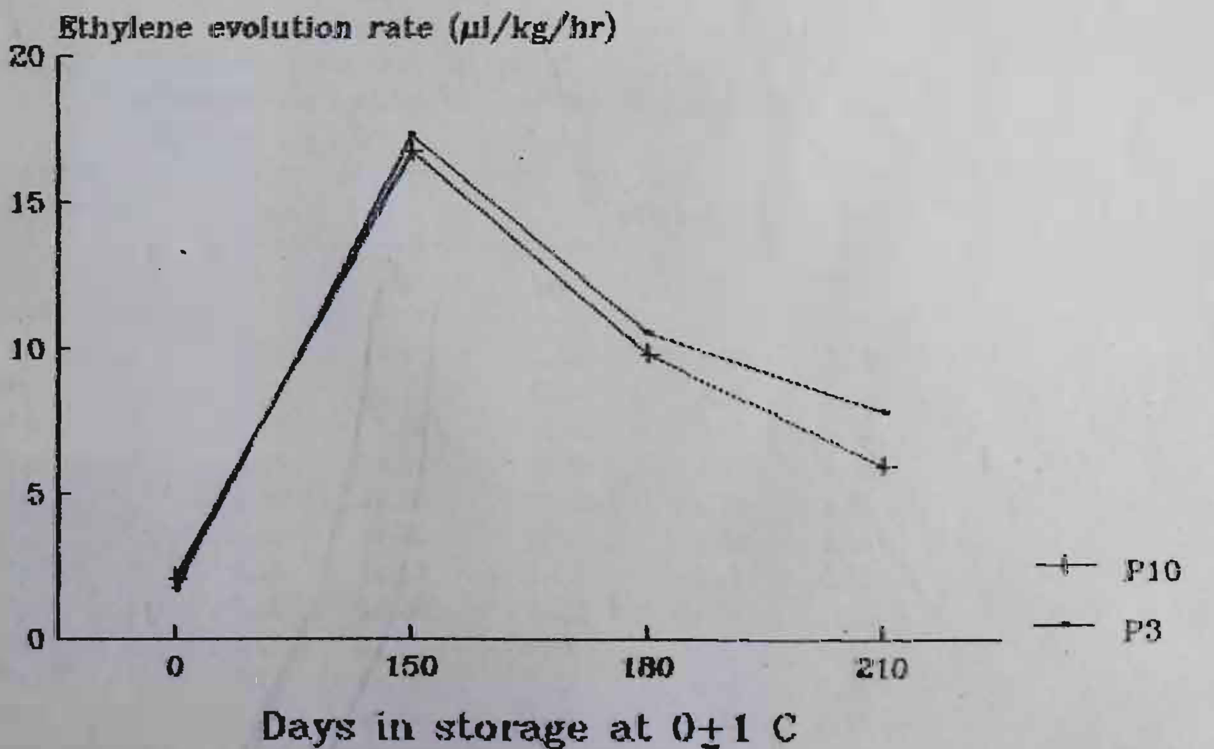

Fig. 5(b) Effect of preharvest spray of Bavistin on Ethylene rate of Red Delicious apples.

TABLE .7(a)

Expt.I. Effect of preharvest sprays of growth bioregulators on ethylene evolution rate ($\mu l\ Kg^{-1}\ hr^{-1}$) of Red Delicious apple fruits stored at $0 \pm 1^{o}C$

Treatments	Days in Storage				Mean
	0	150	180	210	
T_1	4.45	18.45	9.27	5.53	9.42
T_2	3.45	16.80	11.16	7.44	9.71
T_3	2.27	13.90	13.48	11.41	10.20
T_4	1.55	12.23	10.30	8.94	8.25
T_5	3.89	21.11	8.90	5.31	9.80
T_6	2.52	17.33	9.66	6.30	8.95
T_7	2.12	13.04	11.31	8.38	8.71
T_8	3.08	19.28	10.82	7.17	10.09
T_9	3.69	24.54	7.06	6.91	10.55
T_{10}	4.47	22.18	10.23	6.09	10.74
T_{11}	2.03	16.51	14.75	11.23	11.13
T_{12}	4.90	28.18	8.10	4.15	11.33
T_{13}	4.14	22.87	9.92	5.02	10.49
T_{14}	3.45	21.30	10.90	6.50	10.54
T_{15}	2.33	12.76	12.01	8.13	8.81
T_{16}	4.67	23.54	6.98	3.67	9.71
Mean	3.31	18.99	10.30	7.01	9.90

C.D.at 5%

T	0.48
I	0.24
T x I	0.96

TABLE .7(b)

Expt.II. Effect of preharvest sprays of fungicides on ethylene evolution rate ($\mu l\ Kg^{-1}\ hr^{-1}$) of Red Delicious apple fruits stored at $0 \pm 1^{o}C$

Treatments	Days in Storage				Mean
	0	150	180	210	
P_1	2.35	14.45	9.50	6.84	8.28
P_2	2.02	16.12	10.06	7.30	8.87
P_3	1.70	17.30	10.52	7.80	9.33
P_4	2.15	16.51	10.50	7.15	9.08
P_5	2.00	16.18	10.10	6.70	8.75
P_6	1.88	14.08	9.79	6.50	8.06
P_7	3.10	16.12	9.62	6.68	8.88
P_8	2.51	17.28	10.15	6.90	9.21
P_9	3.05	16.77	9.90	6.82	9.13
P_{10}	2.10	16.77	9.82	5.96	8.66
Mean	2.29	16.16	10.00	6.87	8.83

C.D. at 5%

P	0.39
I	0.19
P x I	0.79

definite treatment effect could be discerned.

In experiment I fruits from T_{14}(*E. royleana* latex 250 ppm) were found to exhibit more steady changes in TSS content during storage compared to other treatments, and accounted for the highest value at the end of 210 days storage (Fig. 6(a)). However, at harvest fruits treated with Biozyme 750 ppm (T_5) recorded the highest TSS content. Control fruits (T_{16}), on the other hand, recorded rather rapid increase and decreases in TSS contents during storage exhibiting the lowest values at the end of storage. Fruits from T_1 recorded the highest mean per cent total soluble solids the values however, being on a par with T_7, T_8, T_2 and T_{11}, but significantly superior to rest of the treatments. Interactions between treatments and storage intervals were found to be significant.

In experiment II fruits from P_7 (Rovral 250 ppm) recorded the highest TSS content at harvest. However, fruits receiving preharvest application of Bavistin 500 ppm (P_1) (Fig. 6(b)) recorded more steady changes (increases and decreases) in TSS content compared to other treatments, and accounted for the highest value at the end of 210 days stipulated storage period. Treatments P_2 and P_7 behaved in a manner almost similar to that of P_1. Interactions between treatments and storage intervals were found to be significant.

Expt. I

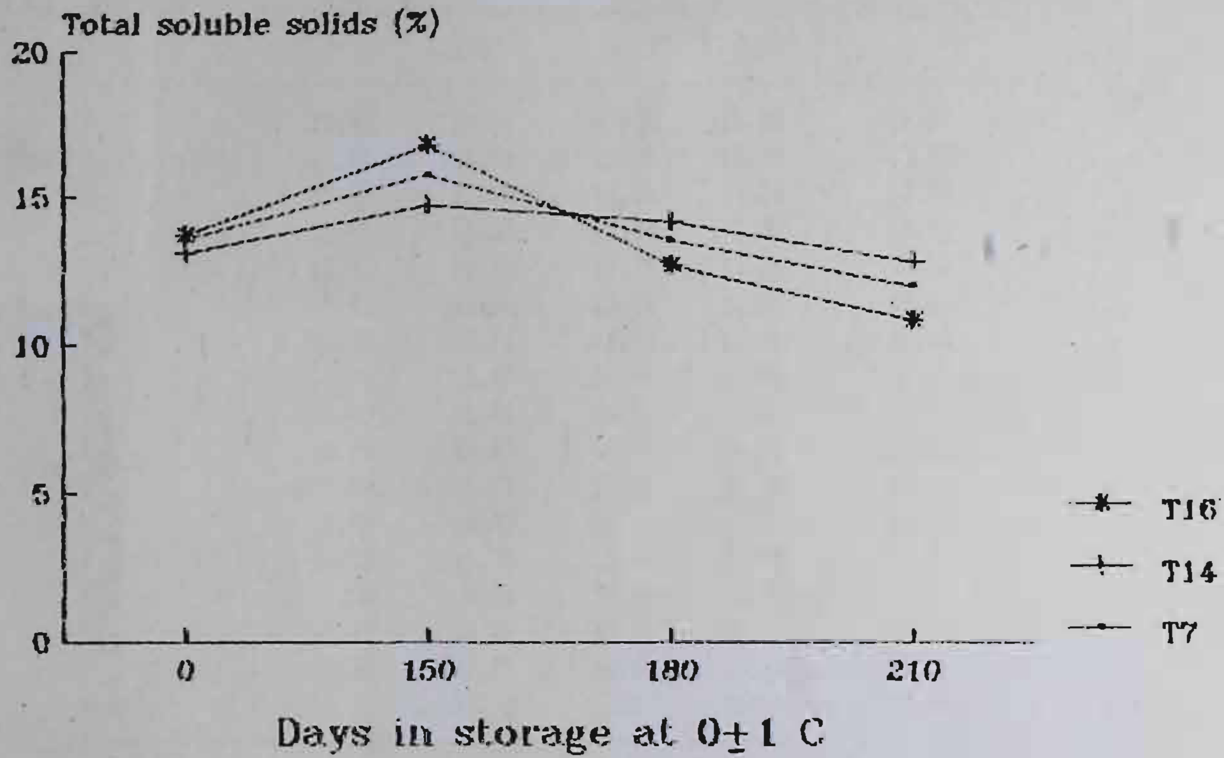

Fig. 6(a) Effect of preharvest sprays of protozyme & E. royleana latex on TSS contents of Red Delicious apple fruits.

Expt. II

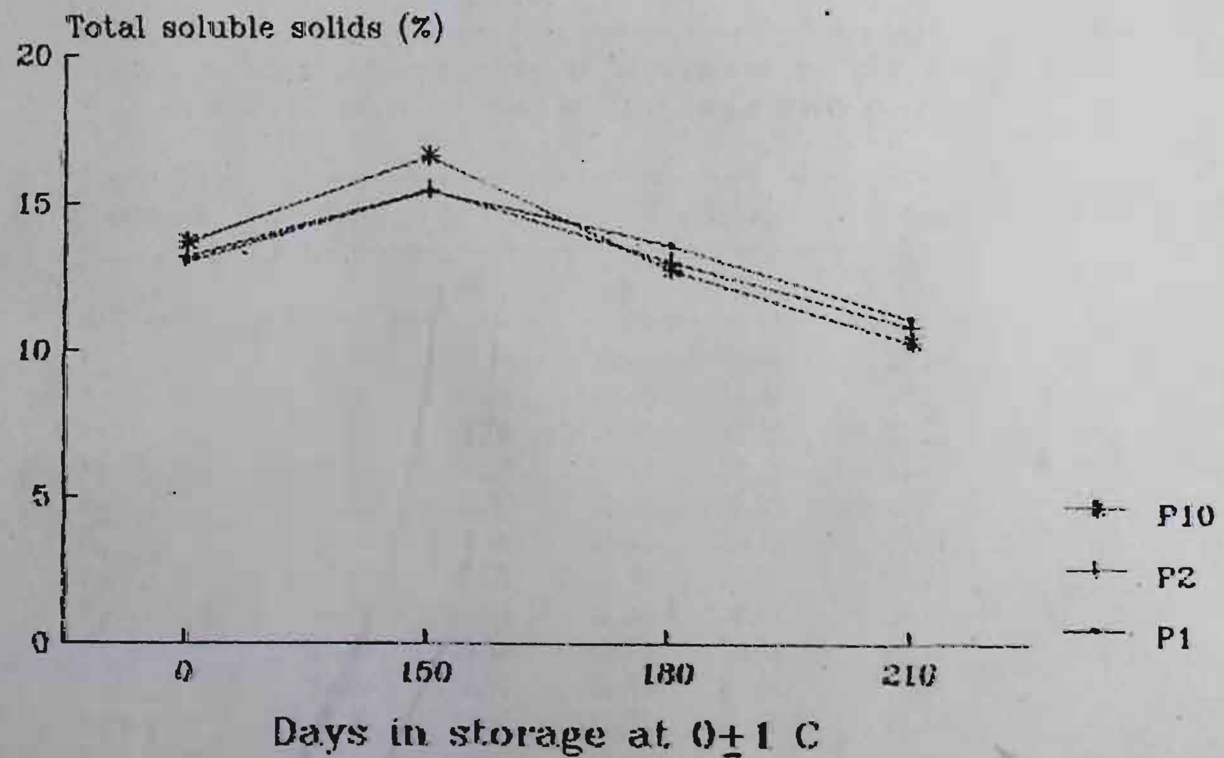

Fig. 6(b) Effect of preharvest spray of Bavistin on TSS contents of Red Delicious apple fruits.

TABLE .8(a)

Expt. I. Effect of preharvest sprays of growth bioregulators on per cent total soluble solids of Red Delicious apple fruits stored at 0 ± 1°C

Treatments	Days in Storage				Mean
	0	150	180	210	
T_1	13.90	16.30	13.40	11.90	13.87
T_2	13.60	15.75	13.25	11.75	13.59
T_3	13.25	15.46	13.15	11.70	13.39
T_4	13.65	15.50	13.10	11.80	13.51
T_5	13.92	15.36	12.75	11.35	13.34
T_6	13.40	15.66	13.20	11.60	13.46
T_7	13.55	15.76	13.50	11.95	13.69
T_8	13.76	15.60	13.25	11.80	13.60
T_9	13.80	15.45	13.10	11.15	13.37
T_{10}	13.70	15.47	12.70	10.95	13.22
T_{11}	13.58	15.85	13.20	11.70	13.58
T_{12}	13.68	15.40	13.00	11.51	13.39
T_{13}	13.35	15.70	13.10	11.45	13.40
T_{14}	13.10	14.70	14.10	12.25	13.54
T_{15}	13.12	15.42	13.25	11.70	13.37
T_{16}	13.70	16.75	12.65	10.80	13.47
Mean	13.57	15.63	13.17	11.58	13.49

C.D. at 5%

T	0.30
I	0.15
T x I	0.60

TABLE .8(b)

Expt.II. Effect of preharvest sprays of fungicides on per cent total soluble solids of Red Delicious apple fruits stored at 0 ± 1°C

Treatments	Days in Storage				Mean
	0	150	180	210	
P_1	13.05	15.47	13.59	11.08	13.30
P_2	13.20	15.50	13.05	10.86	13.17
P_3	13.47	15.78	12.90	10.28	13.11
P_4	13.36	16.20	12.70	10.16	13.10
P_5	13.18	15.97	12.86	10.35	13.09
P_6	12.90	15.86	13.15	10.45	13.09
P_7	14.15	15.25	12.90	10.70	13.25
P_8	13.76	15.44	12.68	10.50	13.09
P_9	13.60	16.10	12.55	10.06	13.08
P_{10}	13.70	16.66	12.76	10.28	13.35
Mean	13.44	15.83	12.91	10.47	13.16

C.D. at 5%

P	0.29
I	0.14
P x I	0.57

4.12 Total sugars

The total sugars content (Table 9 a and b) increased and decreased more rapidly during storage in control fruits (T_{16}) as compared to other treatments. These fruits though recording the highest values for total sugars at harvest, however, registered the lowest content at the end of 210 days storage. Fruits receiving the preharvest treatment of Paras 2000 ppm (T_{11}), on the other hand, registered a gradual increase and decrease in total sugars throughout the storage period and recorded the highest contents at the end of the storage period. Treatments T_{12}, T_3 and T_{15} followed an almost similar trend. The highest mean sugars content was recorded in fruits from T_3, the value, however, being on a par with T_{11}, T_{12} and T_2, but significantly superior to rest of the treatments. Control fruits (T_{16}) on the other hand, recorded the lowest mean total sugars content. Interactions between treatments and storage interval were found to be significant.

In experiment II Bavistin 1500 ppm (P_3) treated fruits were found to have more steady changes in total sugars content compared to other treatments and accounted for the highest value at the end of the stipulated storage period. Control fruits (P_{10}), on the other hand, registered rather sharp increases and decreases in total sugars content recording the lowest sugars content at the end of storage. The highest mean

TABLE .9(a)

Expt.I. Effect of preharvest sprays of growth bioregulators on per cent total sugars of Red Delicious apple fruits stored at $0 \pm 1^{o}C$

Treatments	Days in Storage				Mean
	0	150	180	210	
T_1	9.28	13.61	10.80	9.45	10.78
T_2	9.39	13.73	10.88	9.89	10.97
T_3	9.46	13.91	11.02	10.41	11.20
T_4	8.91	13.71	10.90	9.86	10.84
T_5	9.28	13.68	10.63	9.69	10.82
T_6	9.45	13.32	10.26	9.10	10.53
T_7	9.08	13.72	10.92	9.78	10.87
T_8	9.13	13.65	10.76	9.26	10.70
T_9	8.46	13.27	10.45	8.98	10.36
T_{10}	9.44	13.25	10.94	9.90	10.83
T_{11}	9.30	13.56	11.38	10.48	11.18
T_{12}	9.40	13.48	11.27	10.23	11.09
T_{13}	9.05	12.85	10.85	9.75	10.12
T_{14}	9.15	12.80	10.92	9.88	10.69
T_{15}	9.18	12.76	10.98	9.98	10.72
T_{16}	9.55	13.52	9.66	8.17	10.22
Mean	9.24	13.44	10.79	9.67	10.78

C.D.at 5%

T	0.23
I	0.11
T x I	0.46

TABLE .9(b)

Expt.II. Effect of preharvest sprays of fungicides on per cent total sugars of Red Delicious apple fruits stored at $0 \pm 1^{o}C$

Treatments	Days in Storage				Mean
	0	150	180	210	
P_1	9.15	13.21	10.58	9.70	10.66
P_2	9.22	13.25	10.53	9.90	10.73
P_3	9.32	12.91	10.62	10.04	10.72
P_4	9.69	12.51	9.70	8.41	10.08
P_5	9.55	12.34	9.95	8.49	10.08
P_6	9.45	12.30	10.25	8.74	10.18
P_7	9.17	13.15	10.45	9.13	10.52
P_8	9.10	12.91	10.52	9.60	10.53
P_9	9.02	12.91	10.61	9.75	10.57
P_{10}	9.10	12.87	9.25	8.35	9.82
Mean	9.28	12.84	10.25	9.23	10.40

C.D. at 5%

P	0.40
I	0.20
P x I	0.80

per cent total sugars content were recorded in fruits from P_2, the value however, being on a par with P_3, P_1, P_9, P_8, and P_7. In contrast, control fruits (P_{10}) recorded the lowest mean value for total sugars. Interactions between treatments and storage intervals were found to be significant.

4.33 Reducing sugars

The data on reducing sugars content of fruits given in Table 10(a and b) reveal that the reducing sugars content increased as the storage period advanced, tending to decline towards end of storage. Fruits treated with *E.royleana* latex 500 ppm (T_{15}) recorded the highest mean reducing sugars, the value, however, being on a par with T_3, T_{14} and T_{11} but significantly superior to rest of the treatments. Control fruits (T_{16}), on the other hand, recorded the lowest reducing sugars content and were on a par with T_9 and T_4 in this respect. Interactions between treatments and storage intervals were found to be non-significant.

In experiment II, fruits that had received preharvest application of Bavistin 1500 ppm (P_3) recorded the highest average reducing sugars, the value however, being on a par with P_2 and P_6 but significantly superior to the remaining treatments. Untreated fruits (P_{10}) on the other hand, recorded the lowest average reducing sugars content. Interactions between treatments and storage intervals were found to be non-significant.

TABLE .10(a)

Expt.I. Effect of preharvest sprays of growth bioregulators on the per cent reducing sugars of Red Delicious apple fruits stored at 0 ± 1 °C

Treatments	Days in Storage				Mean
	0	150	180	210	
T_1	6.75	8.67	7.45	7.02	7.48
T_2	6.88	8.88	7.56	6.82	7.53
T_3	7.08	8.92	7.59	7.02	7.65
T_4	6.37	8.77	7.06	7.70	7.23
T_5	6.96	8.80	6.96	6.59	7.33
T_6	7.12	8.70	6.90	6.49	7.30
T_7	7.05	8.75	7.28	6.68	7.44
T_8	7.16	8.70	7.16	6.53	7.39
T_9	6.88	8.59	6.98	6.48	7.23
T_{10}	7.40	8.62	7.18	6.88	7.52
T_{11}	7.02	8.72	7.60	7.01	7.59
T_{12}	7.13	8.66	7.66	6.78	7.56
T_{13}	6.88	8.36	7.32	7.15	7.43
T_{14}	7.15	8.61	7.42	7.25	7.61
T_{15}	7.22	8.64	7.56	7.33	7.69
T_{16}	7.33	8.59	6.60	6.37	7.22
Mean	7.02	8.69	7.27	6.82	7.45

C.D.at 5%

T	0.12
I	0.06
T x I	N.S.

TABLE .10(b)

Expt.II. Effect of preharvest sprays of fungicides on the per cent reducing sugars of Red Delicious apple fruits stored at 0 ± 1 °C

Treatments	Days in Storage				Mean
	0	150	180	210	
P_1	7.00	8.50	7.17	6.80	7.37
P_2	7.02	8.47	7.21	6.90	7.40
P_3	7.06	8.55	7.36	7.02	7.50
P_4	7.40	8.70	6.80	6.47	7.34
P_5	7.44	8.62	6.88	6.50	7.32
P_6	7.46	8.53	7.01	6.62	7.40
P_7	7.11	8.46	7.18	6.39	7.28
P_8	6.94	8.64	7.19	6.45	7.30
P_9	6.88	8.42	7.26	6.50	7.26
P_{10}	7.10	8.65	6.81	6.28	7.21
Mean	7.14	8.55	7.09	6.59	7.34

C.D. at 5%

P	0.11
I	0.05
P x I	N.S.

4.34 Non-reducing sugars

The data on non-reducing sugars content of fruits as affected by various preharvest treatments are presnted in Table 11 (a and b). It is seen that in experiment I fruits receiving the preharvest application of Biozyme 500 ppm (T_4) recorded the highest average non-reducing sugars content. The treatment was, however on a par with T_{11}, T_3 and T_{12} but significantly superior to the rest of the treatments. Fruits from P_{16} (control) on the other hand recorded the lowest average value for non-reducing sugars. Interaction between treatments and storage intervals were found to be significant.

In experiment II fruits treated with Bavistin 1000 ppm (P_2) recorded the highest average non-reducing sugars content. The treatment, however, being on a par with P_9, P_1, P_7, P_8 and P_3 but significantly superior to rest of the treatments. Control fruits (P_{10}) on the other hand, recorded the lowest average non-reducing sugars content. Interaction between treatments and storage intervals were found to be significant.

4.35 Titratable acidity

The data on titratable acidity of the fruits as affected by various preharvest treatments of plant growth bioregulators and fungicides are presented in Table-12 (a and b). It is seen from the data that there was a gradual declining trend in titratable acid contents with the advance in storage period.

TABLE .11(a)

Expt.I. Effect of preharvest sprays of growth bioregulators on the per cent non-reducing sugars of Red Delicious apple fruits stored at 0 ± 1 °C

Treatments	Days in Storage				Mean
	0	150	180	210	
T_1	2.40	4.69	3.18	2.78	3.26
T_2	2.38	4.61	3.15	2.92	3.26
T_3	2.26	4.74	3.26	3.22	3.37
T_4	2.41	4.69	3.65	3.09	3.46
T_5	2.20	4.64	3.49	2.94	3.32
T_6	2.21	4.39	3.19	2.48	3.07
T_7	1.93	4.72	3.46	2.94	3.26
T_8	1.87	4.70	3.42	2.59	3.14
T_9	1.79	4.45	3.30	2.47	3.00
T_{10}	1.94	4.40	3.29	2.87	3.12
T_{11}	2.17	4.60	3.59	3.30	3.41
T_{12}	2.16	4.58	3.43	3.28	3.36
T_{13}	2.06	3.92	3.35	2.47	2.95
T_{14}	1.90	3.98	3.32	2.50	2.92
T_{15}	1.86	3.91	3.25	2.52	2.88
T_{16}	2.11	4.68	2.90	1.71	2.85
Mean	2.10	4.48	3.33	2.75	3.16

C.D. at 5%

T	0.11
I	0.05
TxI	0.23

TABLE .11(b)

Expt.II. Effect of preharvest sprays of fungicides on the per cent non-reducing sugars of Red Delicious apple fruits stored at 0 ± 1 °C

Treatments	Days in Storage				Mean
	0	150	180	210	
P_1	2.04	4.47	3.24	2.75	2.12
P_2	2.09	4.54	3.15	2.85	3.16
P_3	2.15	4.14	3.10	2.87	3.06
P_4	2.17	3.62	2.75	1.84	2.59
P_5	2.00	3.53	2.92	1.89	2.58
P_6	1.89	3.58	3.08	2.01	2.64
P_7	1.96	4.45	3.27	2.77	3.11
P_8	2.06	4.14	3.16	2.99	3.09
P_9	2.03	4.26	3.11	3.09	3.14
P_{10}	1.90	4.01	2.32	1.99	2.55
Mean	2.03	4.07	3.02	2.50	2.90

C.D. at 5%

P	0.12
I	0.06
PxI	0.24

In experiment I fruits that had received the preharvest application of *E. royleana* latex 500 ppm (T_{15}) registered the highest titratable acid content at harvest as well as during storage, recording the highest value for titratable acidity at the end of storage. The treatment, however, was statistically on a par .with T_7,T_4 and T_{13} but significantly superior to the remaining treatments. Control fruits (T_{16}) on the other hand, recorded the lowest average titratable acidity, the value being on a par with T_3 and T_{11} and T_2. Interactions between treatments and storage interval were found to be significant. In experiment II the highest titratable acidscontent in fruits at harvest and during storage were recoeded with Bavistin 500 ppm (P_1) followed by P_4 and P_2, the treatments however being on a par with each other but significantly superior to the remaining treatments in this respect. Control fruits (P_{10}) on the other hand, recorded the lowest mean titratable acids. Interactions between treatments and storage intervals were found to be significant.

pH

The pH of the fruit juice, in general, increased with the advance in storage period. The pH values as influenced by preharvest application of various growth bioregulators and fungicides are presented in the Table 13 (a and b).

In experiment I, fruits which had received the preharvest application of *E. royleana* latex 500

TABLE .12(a)

Expt.I. Effect of preharvest sprays of growth bioregulators on the per cent titratable acidity of Red Delicious apple fruits stored at 0 ± 1 °C

Treatments	Days in Storage				Mean
	0	150	180	210	
T_1	0.248	0.138	0.132	0.080	0.149
T_2	0.237	0.127	0.119	0.066	0.137
T_3	0.227	0.120	0.110	0.058	0.129
T_4	0.259	0.156	0.149	0.099	0.166
T_5	0.252	0.147	0.139	0.086	0.156
T_6	0.240	0.139	0.130	0.079	0.147
T_7	0.276	0.159	0.149	0.102	0.171
T_8	0.252	0.148	0.142	0.090	0.158
T_9	0.237	0.139	0.133	0.080	0.147
T_{10}	0.264	0.138	0.128	0.089	0.156
T_{11}	0.240	0.120	0.112	0.070	0.135
T_{12}	0.229	0.117	0.105	0.065	0.129
T_{13}	0.276	0.153	0.141	0.092	0.166
T_{14}	0.245	0.142	0.132	0.078	0.149
T_{15}	0.288	0.162	0.150	0.112	0.178
T_{16}	0.239	0.119	0.092	0.059	0.127
Mean	0.251	0.139	0.129	0.081	0.150

C.D. at 5%

T	0.012
I	0.006
TxI	0.024

TABLE .12(b)

Expt.II. Effect of preharvest sprays of fungicides on the per cent titratable acidity of Red Delicious apple fruits stored at 0 ± 1 °C

Treatments	Days in Storage				Mean
	0	150	180	210	
P_1	0.246	0.132	0.109	0.073	0.140
P_2	0.234	0.123	0.104	0.068	0.132
P_3	0.227	0.125	0.102	0.060	0.128
P_4	0.240	0.132	0.106	0.065	0.136
P_5	0.222	0.130	0.101	0.060	0.128
P_6	0.228	0.125	0.100	0.058	0.128
P_7	0.245	0.120	0.090	0.060	0.129
P_8	0.236	0.110	0.085	0.051	0.120
P_9	0.228	0.115	0.088	0.050	0.120
P_{10}	0.226	0.113	0.083	0.045	0.117
Mean	0.233	0.122	0.099	0.059	0.128

C.D. at 5%

P	0.008
I	0.004
PxI	0.016

ppm(T_{15}), recorded the lowest average pH, the values however, being on a par with T_4 and T_7 but significantly superior to the remaining treatments. Fruits from control (T_{16}), on the other hand, recorded the highest average pH. Interactions between treatments and storage intervals were found to be non-significant.

In experiment II, fruits treated with Topsin-M 250 ppm (P_4) recorded the lowest pH at harvest, although, Bavistin 500 ppm (P_1) treated fruits registered the lowest mean value. This treatment, however, being on a par with P_2 and P_4 but significantly superior to the rest of the treatments. Control fruits (P_{10}), on the other hand recorded the highest mean pH. The interactions between treatments and storage intervals were recorded to be non-significant.

4.37 Bioelectrical conductance(EC)

The data presented in Table 14 (a and b) show that bioelectrical conductance in general was low in the beginning, increased during the early period of storage, and thereafter declined towards the close of storage.

In experiment I, the highest value for electrical conductance was recorded in fruits treated with Protozyme 1000 ppm (T_9). The treatment though being on a par with T_{15}, T_1 and T_{11} was significantly superior to the rest of them. Control fruits (T_{16}) on the other hand recorded the lowest averave value for electrical conductance. Interactions between treatments and storage intervals were found to be non significant.

TABLE .13(a)

Expt.I. Effect of preharvest sprays of growth bioregulators on the pH of Red Delicious apple fruits stored at 0 ± 1 °C

Treatments	Days in Storage				Mean
	0	150	180	210	
T_1	3.70	4.28	4.35	4.59	4.23
T_2	3.77	4.38	4.56	4.71	4.35
T_3	3.82	4.45	4.66	4.87	4.45
T_4	3.70	4.13	4.23	4.49	4.14
T_5	3.67	4.25	4.38	4.56	4.21
T_6	3.78	4.30	4.50	4.65	4.31
T_7	3.62	4.16	4.30	4.56	4.16
T_8	3.68	4.25	4.37	4.62	4.29
T_9	3.95	4.32	4.46	4.66	4.30
T_{10}	3.60	4.26	4.38	4.52	4.19
T_{11}	3.75	4.38	4.50	4.72	4.34
T_{12}	3.81	4.46	4.68	4.82	4.44
T_{13}	3.75	4.28	4.48	4.52	4.26
T_{14}	3.72	4.35	4.55	4.61	4.33
T_{15}	3.67	4.10	4.19	4.38	4.08
T_{16}	3.87	4.47	4.64	4.97	4.49
Mean	3.73	4.30	4.45	4.65	4.28

C.D. at 5%

T	0.09
I	0.40
TxI	N.S.

TABLE .13(b)

Expt.I. Effect of preharvest sprays of fungicides on the pH of Red Delicious apple fruits stored at 0 ± 1 °C

Treatments	Days in Storage				Mean
	0	150	180	210	
P_1	3.82	4.09	4.16	4.19	4.05
P_2	3.86	4.16	4.20	4.29	4.12
P_3	3.89	4.12	4.26	4.36	4.15
P_4	3.80	4.10	4.22	4.38	4.12
P_5	3.88	4.20	4.29	4.43	4.19
P_6	3.93	4.25	4.34	4.48	4.24
P_7	3.86	4.22	4.41	4.50	4.24
P_8	3.83	4.35	4.48	4.58	4.30
P_9	3.84	4.46	4.50	4.62	4.35
P_{10}	4.07	4.36	4.50	4.62	4.38
Mean	3.88	4.23	4.34	4.44	4.24

C.d. at 5%

P	0.08
I	0.04
PxI	N.S.

In experiment II fruits treated with Bavistin 1500 ppm (P_3), recorded the highest mean value for bioelectrical conductance. The treatment being significantly superior to rest of the treatments in this respect. Control fruits (P_{10}), on the other hand, recorded, the lowest mean EC value. The interaction between treatments and storage intervals were found to be non-significant.

4.38 Total phenols

A perusal of data given in Table 15 (a and b) reveals a general declining trend in total phenols commensurate with the advance in storage period. In experiment I fruits that had received preharvest application of *E. royleana* latex 500 ppm (T_{15}), recorded the highest total phenol content on all the sampling dates and accounted for the highest mean value for total phenols the treatment being significantly superior to all the remaining treatments.Control fruits (T_{16}), on the other hand recorded the lowest mean total phenols. The interactions between treatments and storage intervals were observed to be non-significant.

In experiment II Bavistin 1500 ppm (P_3) treated fruits recorded the highest total phenolics content at harvest and during subsequent storage. The treatment was statistically superior to the rest of the treatments in this respect. Control fruits (P_{10}), on the other hand recorded the lowest average total phenol

TABLE .14(a)

Expt.I. Effect of preharvest sprays of growth bioregulators on the fruit conductance (m mhos/cm) of Red Delicious apple fruits stored at 0 ± 1 °C

Treatments	Days in Storage				Mean
	0	150	180	210	
T_1	4.74	6.80	5.54	5.16	5.56
T_2	4.56	6.65	5.41	4.92	5.38
T_3	4.49	6.70	5.37	4.85	5.35
T_4	4.15	6.59	5.53	5.08	5.34
T_5	4.50	6.50	5.62	5.17	5.45
T_6	4.28	6.42	5.69	5.27	5.41
T_7	4.35	6.40	5.46	4.90	5.28
T_8	4.48	6.47	5.52	4.96	5.36
T_9	4.73	6.89	5.60	5.20	5.60
T_{10}	4.53	6.30	5.41	5.15	5.35
T_{11}	4.75	6.47	5.69	5.25	5.54
T_{12}	4.32	6.24	5.28	5.05	5.22
T_{13}	4.41	6.30	5.55	5.15	5.35
T_{14}	4.37	6.41	5.61	5.25	5.41
T_{15}	4.47	6.61	5.80	5.49	5.59
T_{16}	4.26	6.30	5.33	4.77	5.17
Mean	4.46	6.50	5.52	5.10	5.40

C.D. at 5%

T	0.07
I	0.30
TxI	N.S.

TABLE .14(b)

Expt.II. Effect of preharvest sprays of fungicides on the fruit conductance (m mhos/cm) of Red Delicious apple fruits stored at 0 ± 1 °C

Treatments	Days in Storage				Mean
	0	150	180	210	
P_1	3.95	5.93	4.55	4.26	4.67
P_2	4.00	6.02	4.65	4.30	4.74
P_3	4.12	6.16	4.90	4.34	4.88
P_4	3.82	5.67	4.55	4.66	4.67
P_5	3.88	5.78	4.75	4.19	4.65
P_6	4.01	5.90	4.80	4.15	4.71
P_7	3.82	5.67	4.34	4.20	4.51
P_8	3.95	5.74	4.45	4.10	4.56
P_9	4.06	5.82	4.60	4.24	4.68
P_{10}	3.70	5.60	4.70	3.80	4.45
Mean	3.93	5.83	4.63	4.22	4.55

C.D. at 5%

P	0.09
I	0.40
PxI	N.S.

content. Interactions between treatments and storage intervals were found to be significant.

4.39 Calcium

The data on the calcium contents of fruits as affected by various preharvest treatments of growth bioregulators and fungicides are presented in Table 16 (a and b).

Fruit calcium levels in general, decreased in all the treatments with the advance in storage period. Fruits treated with *E. royleana* latex 500 ppm (T_{15}) recorded the highest calcium content at harvest and during subsequent storage and accounted for the highest average fruit calcium content Fig. 7(a) the treatment proving to be significantly superior to all other treatments in this respect. The lowest average calcium content on the other hand was recorded in control fruits (T_{16}). Interactions between treatments and storage intervals were found to be significant.

In experiment II fruits that had received the preharvest spray of Bavistin 500 ppm (F_1) recorded the highest calcium content at harvest and throughout the storage Fig. 7(b) the treatment (F_1) proving to be statistically superior to the rest of the treatments. On the other hand, control fruits (F_{10}) recorded the lowest average calcium content. Interactions between treatments and storage intervals were recorded to be significant.

content. Interactions between treatments and storage intervals were found to be significant.

4.39 Calcium

The data on the calcium contents of fruits as affected by various preharvest treatments of growth bioregulators and fungicides are presented in Table 16 (a and b).

Fruit calcium levels in general, decreased in all the treatments with the advance in storage period. Fruits treated with *E. royleana* latex 500 ppm (T_{15}) recorded the highest calcium content at harvest and during subsequent storage and accounted for the highest average fruit calcium content Fig. 7(a) the treatment proving to be significantly superior to all other treatments in this respect. The lowest average calcium content on the other hand was recorded in control fruits (T_{16}). Interactions between treatments and storage intervals were found to be significant.

In experiment II fruits that had received the preharvest spray of Bavistin 500 ppm (P_1) recorded the highest calcium content at harvest and throughout the storage Fig. 7(b) the treatment (P_1) proving to be statistically superior to the rest of the treatments. On the other hand, control fruits (P_{10}) recorded the lowest average calcium content. Interactions between treatments and storage intervals were recorded to be significant.

Table 15(a)

Expt. I. Effect of preharvest sprays of growth bioregulators on the level of total phenols (µg/g F.W.) in Red Delicious apple fruit stored at 0 ± 1 C

Treatments	Days in Storage				Mean
	0	150	180	210	
T_1	82.66	51.74	50.72	48.29	58.35
T_2	79.60	49.35	48.58	46.24	55.94
T_3	76.26	48.51	46.71	44.94	54.10
T_4	78.60	53.72	52.11	50.57	58.75
T_5	76.20	50.44	48.22	46.28	55.28
T_6	73.61	48.31	46.43	43.36	52.93
T_7	80.94	54.33	53.63	52.18	60.27
T_8	76.32	51.16	49.33	47.91	56.18
T_9	74.15	49.66	49.93	45.97	54.93
T_{10}	73.57	46.31	44.05	41.32	51.30
T_{11}	83.58	52.35	52.65	48.23	59.20
T_{12}	73.56	47.33	45.15	42.76	52.20
T_{13}	74.35	49.25	45.71	43.21	53.13
T_{14}	80.39	55.29	50.37	46.32	58.09
T_{15}	86.79	61.80	56.80	53.66	64.76
T_{16}	73.06	46.07	43.64	40.50	50.82
Mean	77.73	50.98	49.00	46.36	56.02

C.D. at 5%

T	1.02
I	0.51
TxI	N.S.

Table 15(b)

Expt.II. Effect of preharvest sprays of fungicides on the level of the total phenols (µg/g/F.W.) in Red Delicious apple fruits stored at 0 ± 1 C

Treatments	Days in Storage				Mean
	0	150	180	210	
P_1	93.74	53.16	46.34	31.24	56.12
P_2	96.41	54.45	48.27	32.81	57.98
P_3	100.25	56.26	51.89	36.24	61.16
P_4	91.63	50.37	45.36	31.27	54.66
P_5	93.12	52.08	46.53	31.77	55.87
P_6	93.74	52.40	48.14	32.97	56.81
P_7	92.62	50.25	44.51	30.50	54.97
P_8	93.80	51.59	44.99	30.94	55.33
P_9	94.95	52.67	46.53	31.80	56.49
P_{10}	91.15	50.67	45.50	30.22	54.38
Mean	94.14	52.39	46.81	31.98	56.33

C.D. at 5%

P	1.13
I	0.56
PxI	2.25

Expt. I

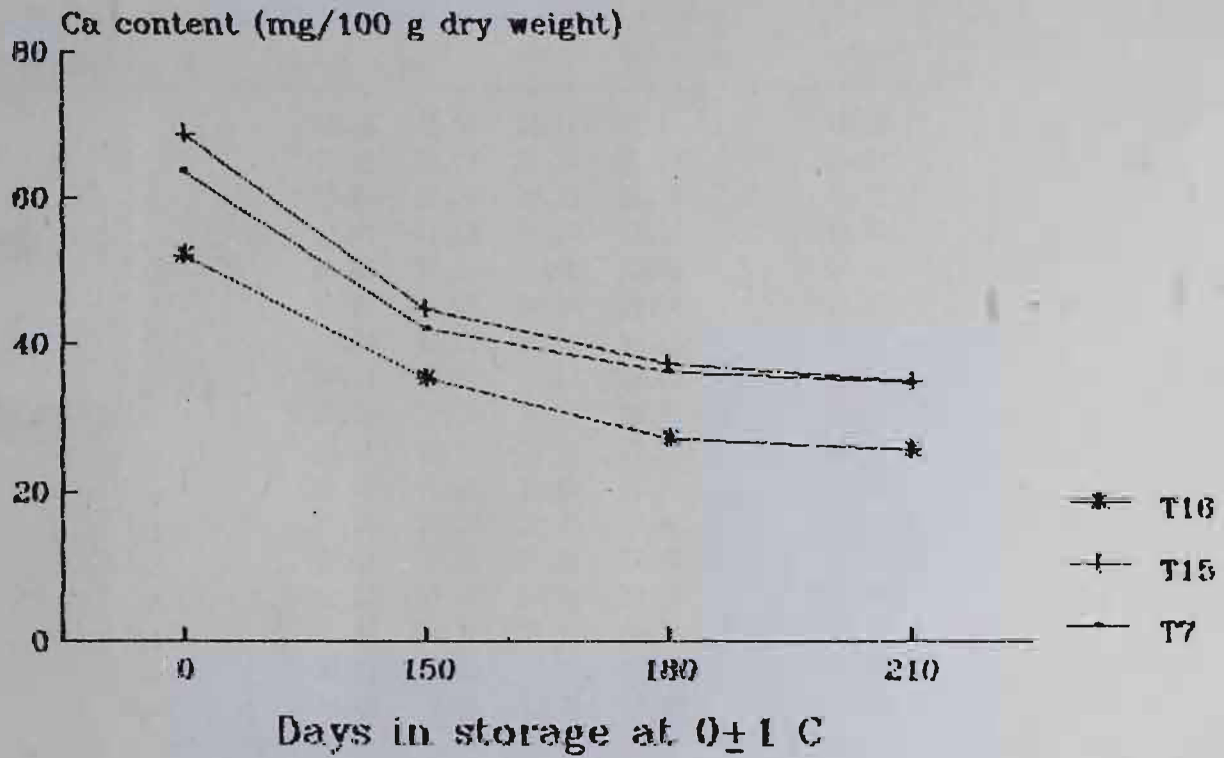

Fig. 7(a) Effect of preharvest sprays of protozyme & E. royleana latex on Calcium content of Red Delicious apple fruits.

Expt. II

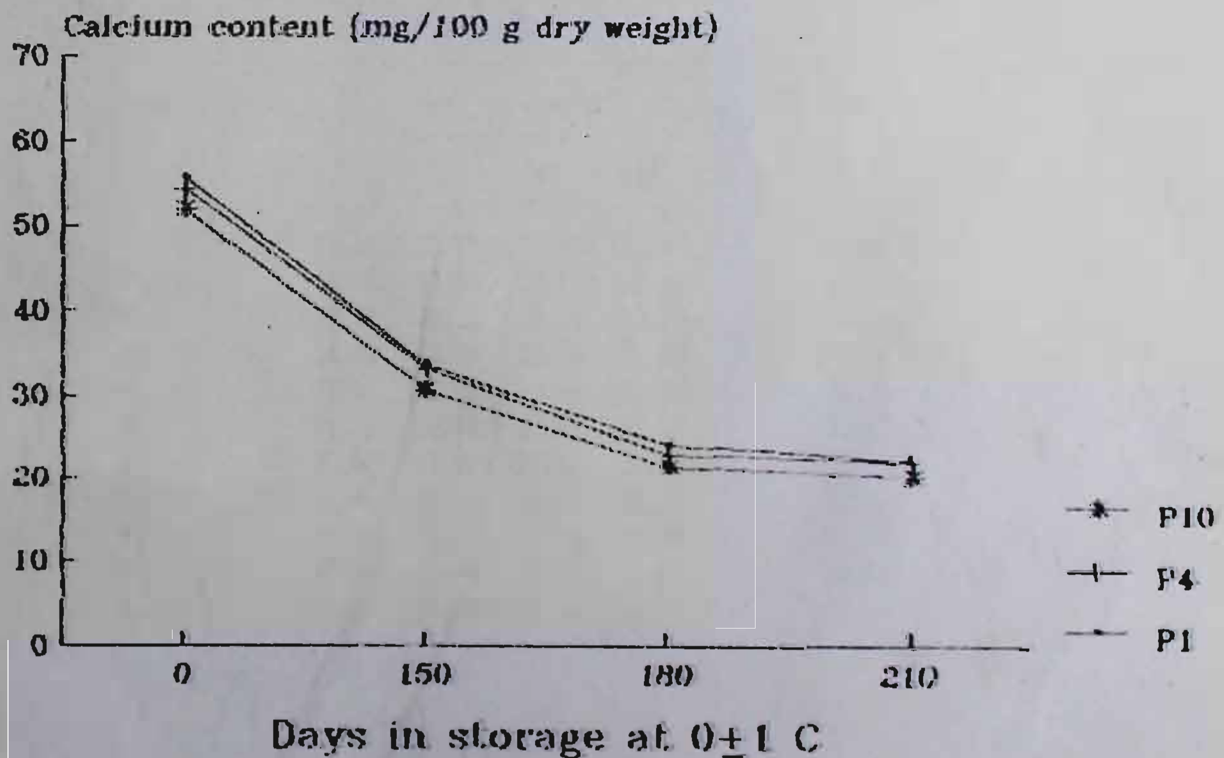

Fig. 7(b) Effect of preharvest spray of Bavistin & Topsin-M on Calcium content of Red Delicious apple fruits.

Table 16(a)

Expt. I. Effect of preharvest sprays of growth bioregulators on the calcium content (mg/100g dry weight) of Red Delicious apple fruits stored at 0 ± 1 °C

Treatments	Days in Storage				Mean
	0	150	180	210	
T_1	58.66	41.00	33.44	31.40	41.13
T_2	57.51	38.07	30.50	28.13	38.55
T_3	53.86	36.26	28.25	26.50	36.22
T_4	62.45	41.66	35.00	32.16	42.82
T_5	61.09	39.50	31.08	30.96	40.66
T_6	56.03	36.69	30.56	28.50	37.95
T_7	63.74	42.18	36.11	34.66	44.17
T_8	60.19	40.64	32.73	30.08	40.91
T_9	57.16	38.26	30.40	28.55	38.59
T_{10}	52.15	33.75	28.90	27.25	35.51
T_{11}	58.76	40.40	33.46	32.37	41.25
T_{12}	53.80	37.58	22.75	27.46	37.15
T_{13}	59.26	38.35	30.54	29.30	39.39
T_{14}	62.33	40.66	34.80	32.15	42.49
T_{15}	68.80	44.75	37.34	34.76	46.41
T_{16}	52.11	35.35	27.10	25.67	35.06
Mean	58.62	39.08	31.87	29.99	39.89

C.D. at 5%

T	1.36
I	0.68
TxI	2.72

Table 16(b)

Expt.II. Effect of preharvest sprays of fungicides on the calcium content (mg/100 g dry weight) of Red Delicious apple fruit stored at 0 ± 1 °C

Treatments	Days in Storage				Mean
	0	150	180	210	
P_1	55.67	33.75	23.98	21.95	33.83
P_2	54.33	32.80	22.79	20.46	32.59
P_3	53.75	32.56	22.26	20.20	32.19
P_4	54.42	33.24	22.78	21.80	33.06
P_5	53.50	31.70	22.96	21.20	32.35
P_6	51.06	31.44	22.86	21.15	31.63
P_7	53.81	31.80	21.80	20.78	32.05
P_8	52.41	31.76	21.46	20.23	31.46
P_9	54.34	32.15	20.84	19.76	31.77
P_{10}	52.00	30.70	21.30	20.00	30.00
Mean	53.54	32.19	22.30	20.76	32.20

C.D. at 5%

P	0.65
I	0.32
PxI	1.30

4.391 Fruit juice content

The data on the per cent juice content of fruit as affected by various preharvest treatments of growth bioregulators and fungicides are given in Table 17 (a and b). A perusal of the data reveals that there was a gradual declining trend in the juice content with the advance in storage.

In experiment I fruits treated with *E. royleana* latex 500 ppm (T_{15}), on an average recorded the highest juice content on all the sampling dates, the treatment being significantly superior to the rest in this respect. Control fruits (T_{16}), on the other hand recorded the lowest juice content at harvest as well as during and at the end of storage. Interactions between treatments and storage intervals were found to be significant.

In experiment II fruits that had received the preharvest treatments of Bavistin 1500 ppm (P_3) recorded the highest average fruit juice content, the treatment proving to be significantly superior to the remaining treatments. The lowest average juice content was recorded in the control fruits (P_{10}). Significant interactions between treatments and storage intervals were observed.

4.4. Effect on Sensory evaluation

The data in respect of sensory evaluation of fruits quality as affected by various preharvest treatments of growth bioregulators and fungicides are presented in Table 18 (a and b)

Table 17(a)

Expt. I. Effect of preharvest sprays of growth bioregulators on the percent juice content in Red Delcious apple fruits stored at 0 ± 1 °C

Treatments	Days in Storage				Mean
	0	150	180	210	
T_1	64.00	55.11	47.33	44.25	52.67
T_2	64.95	56.07	48.69	46.40	54.03
T_3	65.90	58.62	51.88	48.50	56.23
T_4	64.42	59.60	53.08	46.57	55.92
T_5	63.40	58.55	49.73	45.45	54.28
T_6	62.05	57.08	47.57	43.50	52.55
T_7	64.24	58.47	52.66	45.75	55.28
T_8	62.50	56.02	51.04	42.03	52.90
T_9	61.23	56.18	50.46	41.74	52.40
T_{10}	61.10	53.75	45.47	38.75	49.77
T_{11}	65.63	58.75	51.50	43.86	54.94
T_{12}	62.20	52.80	49.52	40.80	51.33
T_{13}	63.15	54.80	47.46	44.39	52.45
T_{14}	67.88	58.15	55.91	44.75	56.67
T_{15}	69.29	61.60	53.23	49.26	58.34
T_{16}	61.31	52.80	45.58	38.67	49.59
Mean	63.95	56.77	50.07	44.04	53.71

C.D. at 5%

T	1.30
I	0.65
TxI	2.60

Table 17(b)

Expt. II. Effect of preharvest sprays of fungicides on the per cent juice content in Red Delicious apple fruits stored at 0 ± 1 °C

Treatments	Days in Storage				Mean
	0	150	180	210	
P_1	62.13	56.71	43.96	42.50	51.33
P_2	64.71	60.53	47.26	46.50	54.75
P_3	66.01	61.75	49.82	47.26	56.21
P_4	65.17	57.45	44.68	42.24	52.38
P_5	63.13	57.27	45.55	42.50	52.11
P_6	63.62	57.03	45.11	43.22	52.25
P_7	64.65	54.98	42.27	41.75	50.91
P_8	63.55	59.66	46.72	44.90	53.71
P_9	63.53	57.61	45.55	43.50	52.53
P_{10}	62.02	54.06	42.67	35.02	48.44
Mean	63.85	57.71	45.36	42.94	52.46

C.D. at 5%

P	1.40
I	0.70
PxI	2.80

Table 18(a)

Expt. I. Effect of preharvest sprays of growth bioregulators on sensory evaluation score of Red Delcious apple fruits stored at 0 ± 1°C

Treatments	Days in Storage				Mean
	0	150	180	210	
T_1	77.00	75.50	62.75	59.25	68.63
T_2	77.50	75.75	63.40	60.75	69.35
T_3	78.00	76.50	64.00	61.00	69.88
T_4	77.75	74.00	63.00	60.50	68.81
T_5	75.75	73.50	61.20	59.75	67.55
T_6	74.00	72.75	60.75	58.50	66.50
T_7	77.50	73.25	62.00	60.75	68.38
T_8	78.50	74.15	62.25	60.25	68.79
T_9	75.50	72.00	61.15	59.50	67.04
T_{10}	74.75	73.00	60.75	58.00	66.63
T_{11}	76.00	74.15	64.30	61.15	68.90
T_{12}	75.00	73.00	61.25	59.50	67.19
T_{13}	76.50	71.25	60.25	58.00	66.50
T_{14}	78.75	72.25	62.25	60.50	68.44
T_{15}	76.50	73.75	63.50	61.75	68.88
T_{16}	73.50	71.00	60.50	58.50	65.88
Mean	76.41	73.49	62.08	69.85	67.96

C.D. at 5%

T	1.20
I	0.60
TxI	2.40

Table 18(b)

Expt. II. Effect of preharvest sprays of fungicides on sensory evaluation score of Red Delcious apple fruits stored at 0 ± 1°C

Treatments	Days in Storage				Mean
	0	150	180	210	
P_1	75.75	74.50	65.50	61.75	69.73
P_2	76.25	75.50	63.75	59.75	68.81
P_3	78.00	77.50	63.75	62.05	70.44
P_4	77.10	74.75	65.05	60.75	69.52
P_5	76.05	74.00	64.25	60.75	68.87
P_6	76.00	76.75	62.25	60.75	68.94
P_7	74.80	74.50	59.50	58.25	66.76
P_8	77.50	74.25	59.25	58.00	67.25
P_9	77.00	74.00	59.80	59.00	67.45
P_{10}	77.00	72.50	58.75	57.50	66.44
Mean	76.59	74.83	62.23	59.90	68.39

C.D. at 5%

P	1.10
I	0.55
PxI	2.20

Table 18(a)

Expt. I. Effect of preharvest sprays of growth bioregulators on sensory evaluation score of Red Delcious apple fruits stored at 0 ± 1 °C

Treatments	Days in Storage				Mean
	0	150	180	210	
T_1	77.00	75.50	62.75	59.25	68.63
T_2	77.50	75.75	63.40	60.75	69.35
T_3	78.00	76.50	64.00	61.00	69.88
T_4	77.75	74.00	63.00	60.50	68.81
T_5	75.75	73.50	61.20	59.75	67.55
T_6	74.00	72.75	60.75	58.50	66.50
T_7	77.50	73.25	62.00	60.75	68.38
T_8	78.50	74.15	62.25	60.25	68.79
T_9	75.50	72.00	61.15	59.50	67.04
T_{10}	74.75	73.00	60.75	58.00	66.63
T_{11}	76.00	74.15	64.30	61.15	68.90
T_{12}	75.00	73.00	61.25	59.50	67.19
T_{13}	76.50	71.25	60.25	58.00	66.50
T_{14}	78.75	72.25	62.25	60.50	68.44
T_{15}	76.50	73.75	63.50	61.75	68.88
T_{16}	73.50	71.00	60.50	58.50	65.88
Mean	76.41	73.49	62.08	69.85	67.96

C.D. at 5%

T	1.20
I	0.60
TxI	2.40

Table 18(b)

Expt. II. Effect of preharvest sprays of fungicides on sensory evaluation score of Red Delcious apple fruits stored at 0 ± 1 °C

Treatments	Days in Storage				Mean
	0	150	180	210	
P_1	75.75	74.50	65.50	61.75	69.73
P_2	76.25	75.50	63.75	59.75	68.81
P_3	78.00	77.50	63.75	62.05	70.44
P_4	77.10	74.75	65.05	60.75	69.52
P_5	76.05	74.00	64.25	60.75	68.87
P_6	76.00	76.75	62.25	60.75	68.94
P_7	74.80	74.50	59.50	58.25	66.76
P_8	77.50	74.25	59.25	58.00	67.25
P_9	77.00	74.00	59.80	59.00	67.45
P_{10}	77.00	72.50	58.75	57.50	66.44
Mean	76.59	74.83	62.23	59.90	68.39

C.D. at 5%

P	1.10
I	0.55
PxI	2.20

Table 18(a)

Expt. I. Effect of preharvest sprays of growth bioregulators on sensory evaluation score of Red Delcious apple fruits stored at 0 ± 1°C

Treatments	Days in Storage				Mean
	0	150	180	210	
T_1	77.00	75.50	62.75	59.25	68.63
T_2	77.50	75.75	63.40	60.75	69.35
T_3	78.00	76.50	64.00	61.00	69.88
T_4	77.75	74.00	63.00	60.50	68.81
T_5	75.75	73.50	61.20	59.75	67.55
T_6	74.00	72.75	60.75	58.50	66.50
T_7	77.50	73.25	62.00	60.75	68.38
T_8	78.50	74.15	62.25	60.25	68.79
T_9	75.50	72.00	61.15	59.50	67.04
T_{10}	74.75	73.00	60.75	58.00	66.63
T_{11}	76.00	74.15	64.30	61.15	68.90
T_{12}	75.00	73.00	61.25	59.50	67.19
T_{13}	76.50	71.25	60.25	58.00	66.50
T_{14}	78.75	72.25	62.25	60.50	68.44
T_{15}	76.50	73.75	63.50	61.75	68.88
T_{16}	73.50	71.00	60.50	58.50	65.88
Mean	76.41	73.49	62.08	69.85	67.96

C.D. at 5%

T	1.20
I	0.60
TxI	2.40

Table 18(b)

Expt. II. Effect of preharvest sprays of fungicides on sensory evaluation score of Red Delcious apple fruits stored at 0 ± 1°C

Treatments	Days in Storage				Mean
	0	150	180	210	
P_1	75.75	74.50	65.50	61.75	69.73
P_2	76.25	75.50	63.75	59.75	68.81
P_3	78.00	77.50	63.75	62.05	70.44
P_4	77.10	74.75	65.05	60.75	69.52
P_5	76.05	74.00	64.25	60.75	68.87
P_6	76.00	76.75	62.25	60.75	68.94
P_7	74.80	74.50	59.50	58.25	66.76
P_8	77.50	74.25	59.25	58.00	67.25
P_9	77.00	74.00	59.80	59.00	67.45
P_{10}	77.00	72.50	58.75	57.50	66.44
Mean	76.59	74.83	62.23	59.90	68.39

C.D. at 5%

P	1.10
I	0.55
PxI	2.20

In experiment I fruits which had received the preharvest application of Agrostemin 500 ppm (T_3) recorded the highest average score for fruit quality. The treatment through being on a par with T_2, T_{11}, T_{15}, T_4 and T_8 was significantly superior to the remaining treatments. Fruits from T_{16} (control) on the other hand recorded the lowest average score for quality. Interactions between treatments and storage intervals were found to be significant.

In experiment II fruits receiving preharvest application of Bavistin 1500 ppm (P_3) were found to record the highest average score for quality. The treatment though being statistically on a par with P_4 and P_1 was significantly superior to the remaining treatments. Control fruits (P_{10}), on the other hand, recorded the lowest average score for quality. Interactions between treatments and storage intervals were found to be significant.

4.5 Effect on per cent rot

The data on fruit rotting percentage recorded on different sampling dates under various treatments are presented in Table 19 (a and b).

In experiment I the per cent rot was recorded to be the lowest in fruits that had received the preharvest application of *E.royleana* latex 500 ppm (T_{15}) during and at the end of storage. The treatment was, however, on a par with T_7, T_{11}, T_{14} and T_{13} but superior to other treatments. The highest per cent fruit rot was recorded in the control fruits (T_{16}). Interaction

Table 19(a)

Expt. I. Effect of preharvest sprays of growth bioregulators on per cent rot of Red Delicious apple fruits stored at 0 ± 1 °C

Treatments	Days in Storage				Mean
	0	150	180	210	
T_1	0.00(0.71)	8.07(2.92)	9.31(3.12)	15.92(4.04)	8.32(2.70)
T_2	0.00(0.71)	9.19(3.11)	12.94(3.66)	19.06(4.41)	10.22(2.97)
T_3	0.00(0.71)	9.51(3.16)	12.26(3.57)	14.77(3.90)	9.13(2.83)
T_4	0.00(0.71)	7.75(2.78)	8.62(3.01)	12.69(3.62)	7.26(2.53)
T_5	0.00(0.71)	9.06(3.06)	12.12(3.55)	13.65(3.76)	8.46(2.77)
T_6	0.00(0.71)	8.73(3.04)	10.37(3.29)	12.12(3.54)	7.89(2.69)
T_7	0.00(0.71)	5.74(2.50)	6.74(2.69)	8.11(2.93)	5.15(2.20)
T_8	0.00(0.71)	10.56(3.32)	12.87(3.65)	16.50(4.10)	9.98(2.94)
T_9	0.00(0.71)	9.44(3.15)	15.31(3.96)	18.50(4.20)	10.81(3.00)
T_{10}	0.00(0.71)	8.50(3.00)	10.31(3.29)	16.12(4.07)	8.73(2.77)
T_{11}	0.00(0.71)	6.25(2.58)	8.35(2.97)	10.53(3.32)	6.27(2.39)
T_{12}	0.00(0.71)	7.50(2.82)	10.25(3.27)	19.81(4.50)	9.39(2.83)
T_{13}	0.00(0.71)	5.50(2.44)	8.29(2.96)	13.87(3.79)	6.91(2.47)
T_{14}	0.00(0.71)	6.00(2.55)	7.81(2.88)	12.25(3.57)	6.51(2.43)
T_{15}	0.00(0.71)	4.00(2.11)	4.74(2.29)	7.50(2.82)	4.06(1.98)
T_{16}	0.00(0.71)	12.75(3.63)	23.85(4.95)	28.32(5.36)	14.23(3.66)
Mean	0.00(0.71)	7.97(2.88)	10.88(3.32)	14.98(3.87)	8.46(2.69)

C.D. at 5%

T	0.14
I	0.07
TxI	0.27

Tabhe 19(b)

Expt. II. Effect of preharvest sprays of fungicides on the per cent rot of Red Delicious apple fruits stored at 0 ± 1 °C

Treatments	Days in Storage				Mean
	0	150	180	210	
P_1	0.00(0.71)	0.00(0.71)	2.08(1.61)	3.12(1.90)	1.30(1.23)
P_2	0.00(0.71)	0.00(0.71)	0.00(0.71)	2.66(1.78)	0.66(0.98)
P_3	0.00(0.71)	0.00(0.71)	0.00(0.71)	0.50(1.00)	0.12(0.76)
P_4	0.00(0.71)	0.00(0.71)	0.00(0.71)	5.71(2.49)	1.43(1.10)
P_5	0.00(0.71)	0.00(0.71)	1.50(1.41)	3.27(1.94)	1.19(1.19)
P_6	0.00(0.71)	0.00(0.71)	0.00(0.71)	1.62(1.46)	0.40(0.90)
P_7	0.00(0.71)	2.54(1.74)	6.75(2.69)	11.60(3.48)	5.22(2.15)
P_8	0.00(0.71)	1.94(1.56)	6.55(2.65)	9.06(3.09)	4.39(2.00)
P_9	0.00(0.71)	3.87(2.09)	5.56(2.46)	7.19(2.77)	4.15(2.01)
P_{10}	0.00(0.71)	8.00(2.91)	21.35(4.67)	28.39(5.37)	14.43(3.41)
Mean	0.00(0.71)	1.63(1.26)	4.38(1.83)	7.31(2.53)	3.33(1.58)

C.D. at 5%

P	0.58
I	0.29
PxI	1.17

Values in parantheses are square root transformed values. $\sqrt{X+0.5}$

between treatments and storage intervals were found to be significant.

In experiment II fruits receiving preharvest application of Bavistin 1500 ppm (P_3) recorded the lowest fruit rot during storage and at the end of storage. The treatment though on a par with P_6, P_2, P_4, P_5 and P_1, was however significantly superior to the remaining treatments. Control fruit (P_{10}) on the other hand recorded the highest fruit rot during and at the end of stipulated storage period of 210 days. Interactions between treatments and storage intervals were found to be significant.

4.6 Correlation studies

Correlations worked out by Karl Pearson's coefficient of correlation method are presented in Table 20 (a and b).

Table 20 (a). Correlation studies of effect of growth bioregulators.

Variable	Variable	r
Respiration	i) Ethylene	+0.17
	ii) Flesh firmness	-0.50*
	iii) Acidity	-0.37
Ethylene evolution	i) Flesh firmness	-0.60**
	ii) TSS	-0.32
	iii) Calcium	-0.49
Flesh firmness	i) TSS	+0.22
	ii) Acidity	+0.79**
	iii) Calcium	+0.69**

It is seen from the table 20 (a and b) that respiration had negative correlation with flesh firmness, acidity and TSS. In case of experiment I the correlation between flesh firmness and respiration was found negative and it was significant at 5% level of significance. Howerer, in experiment II, it was non-significant. There was a weak positive but non-significant correlation of respiration with ethylene.

Table 20 (b). Correlation studies of effect of fungidices.

Variable	Variable	r
Respiration	i) Ethylene	+0.15
	ii) Flesh firmness	-0.05
	iii) TSS	-0.43
Ethylene evolution	i) Calcium	-0.08
	ii) TSS	-0.37
Flesh firmness	i) Acidity	+0.76*
	ii) Calcium	+0.80**
	iii) TSS	+0.20

** Significant at 1 per cent level of significance.

* Significant at 5 per cent level of significance.

Ethylene evolution was negatively correlated with flesh firmness,TSS and calcium. There was a significant negative correlation of flesh firmness with ethylene evolution at 1 per cent level of significance (Experiment I).

Fruit flesh firmness had a positive correlation with TSS, acidity and calcium. The correlation of flesh firmness with calcium was found to be significant in both the experiments at 1 per cent level of significance. Flesh firmness was found to be positively correlated with acidity and was significant at 1 per cent level of significance in experiment I, while in experiment II it was significant only at 5 per cent level of significance. Correlation between flesh firmness and TSS was found to be non-significant in both the experiments.

Discussion

DISCUSSION

The present investigations were undertaken, to study the effect of some newly evolved/developed growth bioregulators and fungicides on accumulation of calcium and on ripening and storability of Red Delicious apple fruits stored at 0±1°C. The results obtained during the course of study are discussed hereunder in the light of available literature.

5.1 Effect on physical characteristics of the fruit:

Most of the treatments improved the fruit size in comparison to the control and the largest fruits were obtained with Paras 2000 ppm (T_{11}). The control fruits on the other hand were of the smallest size. These results are in conformity with those of Hashim & Lundergan (1985) and Chandel (1985) who also observed significant increase in fruit size in strawberries and plums respectively with triacontanol treatments. This increase in fruit size might be attributed to the increased photosynthesis and reduced photorespiration due to the application of triacontanol (Menon and Srivastava, 1984).

A significant decrease in weight, volume and specific gravity of fruits with the advance in storage period was observed in the present study. While lowest per cent loss in fruit weight, volume and decrease in specific gravity was recorded in fruits that had received the preharvest application of *E. royleana* latex 500 ppm (T_{15}) or Paras 1000 ppm (T_{10}), it was the highest in control fruits(T_{16}). The specific gravity was recorded to be the highest in fruits treated with Paras 2000 ppm (T_{11}) and *E.royleana* latex 500 ppm (T_{15}).

The mechanism of water loss from fruits which primarily accounts for the loss in weight and Volume is essentially the same as the evaporation of water. The driving force is the vapour pressure of the moisture in the fruit (ASHRAE, 1972).When it is higher than the vapour pressure in the surrounding air, moisture willbe lost from the fruit to the atmosphere. Fruits in general possess, considerable resistance to moisture loss, as their water vapour pressure is lower than that of the water at the same temperature because of dissolved substances, mostly sugars. Wilkinson (1965) reported that some of the water accounting for fruit weight, may be lost by evaporation and respiration (0.05% per week at 2.8 ^{o}C for apples), but major portion is lost by transpiration (0. 5% per week). All the weight loss in fruits is not due to water loss, for respiration per se and heat of respiration may also account for part of it (Ryall & Pentzer, 1982).

The *E. royleana* latex is suspected of having very strong growth and antitranspirant properties and it is thought to be particularly rich in endogenous gibberellins and cytokinins. In what appears to be perhaps the first attempt to ascertain the anti-senescence properties of the latex and its potential in extending the storage life of fresh fruits. Chopra and Khokhar (1985) dipped freshly harvested kinnow mandarin fruits in aqueous solution of *E. royleana* latex at concentrations ranging between 0.01 to 0.1 per cent in step-ups of 0.025 for 2 minutes and observed significant reduction in PLW and increase in ambient storage life with 0.025 and 0.05 per cent applications. Significant reduction in volume and weight loss were reported in Red Delicious apple treated with *E.royleana* latex. A reduction in physiological loss in weight in fruits treated with Paras 1000 ppm (T_{10}) may attributed to be an increased TSS content of treated fruits. Chandel (1985) and Jindal and Diwevedi (1986) reported significant increase in weight in Santa Rosa plum fruits given preharvest spray of Triacontanol 25 ppm and 4 ppm respectively.

The loss in fruit firmness was observed to be the lowest in fruits receiving preharvest applications of Protozyme or Biozyme 500 ppm each (T_7 and $_4$) and *E. royleana* latex 500 ppm (T_{15}), and the highest in control fruits (P_{10}) .The degree of flesh firmness has been reported to be a fairly good index of storability and stage of ripening in apples as also in many other fruits. Softening of fruits is caused eigher by breakdown of insoluble protopectin into soluble pectin or by hydrolysis of starch (Mattoo et al., 1975) or by cellular disintegration leading to increased membrance permeability. The loss of pectic substances in the middle lamella of the cell wallis perhaps the key step in the ripening process that leads to the loss of cell integrity or firmness (Solomos and Laties, 1973). Firmness had been correlated with soluble polyuronide (probably arising from the middle lamellae and the cell wall) content in apple, and some changes in structure of the glycoprotein or the polyuronide in the middle lamellae may lead to the breakdown of the aggregation between them (Knee, 1974). Fruit firmness is one of the most crucial factors in determining the postharvest quality and physiology of apples and pears (Shear, 1975). With a decrease in fruit firmness the tissue rigidity decreases, firstly as a result of hydrolysis of intercellular pectins, and secondly, cell turgor pressure decreases due to an increase in pemeability of cell membrane to water in the later stages of internal breakdown. The decrease in both the components of fruit firmness, appear to contribute to tissue softening (Pallard, 1975).

The reduced loss in firmness in fruits treated with T_4, and T_7 might be due to the cummulative effects of auxim and cytokinin as the precursors of these growth regulators are present in Biozyme and Protozyme. Higher firmness during the storage has been reported in the auxin treated Red Delicious apple fruits in comparison to control fruits (Garg et al.,1979). Singh (1986) also reported reduced loss of firmness in auxin and kinetin treated Bar tlett pears. The reduced loss on firmness in fruit treated with *E. royleana* latex 500 ppm (T_{15}) is in conformity with the results of Singh (1986) and Nayital (1987) who also observed significant reduction in loss in firmness in *E.royleana* latex treated Bartlett pear and Red Delicious apple fruits during low temperature storage.

5.2. Effect on physiological characteristics of the fruit:

Ethylene evolution rate and respiration rate of fruits in general increased with the advance in storage period tending to level off and declined towards the end of sampling. A similar trend in respiration and ethylene evolution has been reported for different apple cultivars (Fallani et al.,1985; Liu, 1986, and Wang and Steffens, 1987) and avocado (Eaks, 1985).

Fruits treated with Agrostemin 500 ppm (T_3) exhibited rather steadier increases and decreases in ethylene evolution and respiration rates compared to faster increases and decreases in fruits treated with Paras 3000 ppm (T_{12}) and in controls. Advanced early ripening has also been reported in triacontanol treated tobasco pepper fruits (Mamat et al., 1983). Slowing down of respiration and ethylene evolution rates by Agrostemin 500 ppm (T_3) may be attributed mainly to the actions of gibberellin and kinetin which this bioregulator is claimed to contain in adequate amounts. Delayed ripening in different fruits treated with gibberellin and kinetin has also been reported by many other workers (Vendrell, 1970; Gilfillan et al., 1977; Menselise, 1977; Ali-Dinar and Krezdorn, 1976; Abdel Gawad and Rmani, 1974; Gueltat-Reich and Safran, 1973; Madhava Rao and Rama Rao, 1979; Raghava Rao and Chundawat, 1984; Hernandez and Grajeda, 1986).

Kinetins are known to help in maintaining protein synthesis in senescing plant tissues (Solunkhe et al., 1962) and this can be expected to help in retarding the ripening process. Further, endogenous gibberellin, and cytokinins resist the fruit senescence (Sacher, 1973) by opposing the action of ethylene and therefore, exogenous applications of gibberellin and kinetin would seem to offer promising opportunities in the regulation of fruit ripening in a number of fruits, climacteric as well as non-climacteric.

5.3 Effect on bio-chemical characteristics of the fruit:

Total soluble solids (TSS), total sugars, reducing sugars as well as non-reducing sugars contents in general increased with the advance in storage period, tending to level off and registering a declining towards the close of sampling in all the treatments under study. These observations are in accordance with the findings of many other workers who also found an initial increase in these biochemical constituents followed by a decrease in the later stages of storage (Knee, 1975; Roemer, 1982; Recasens et al., 1983; Aeppli, 1984; Sachdeva, 1985; Naquash, 1986, and Nayital 1989, Nayital et al, 1990).

The TSS contents were recorded to be the highest at the end of 210 days storage period in fruits treated with *E. royleana* latex 250 ppm (T_{14}). As regards sugars, the highest per cent total sugars and non reducing sugars were recorded in fruits treated with Paras 2000 ppm (T_{11}). Control fruits (P_{10}) on the other hand recorded the lowest sugar contents. *E. royleana* latex 500 ppm (T_{15}) treated fruits recorded the highest reducing sugar contents at the end of 210 days stipulated storage period.

The increase in total soluble solids and/or sugars in apple during storage may possibly be attributed to the numerous catabolic processes taking place in the fruit preparing it for senescence. Hulme (1958) reported that the percentage of starch in apple increased to a maximum during development on the tree and then decreased, until at harvest very little starch was present. After removal from tree the climacteric rise in respiration occured and the remaining starch disappeared relatively rapidly, while sugars remained at a high level and even registered an increase. He suggested that in addition to starch other sources of sugars in apple were hemicelluloses. With the ripening and advance in storage period of this fruit starch gets hydrolysed into mono-and di-saccharides which in turn may lead to an increase in TSS and sugars, as on complete hydrolysis of starch no further increase occures and subsequently a decline in these constituents is predictable as they alongwith malic acid are the primary substrates for respiration (Panova, 1975; Hribar et al., 1977 and Wills et al: 1980).

Significant increase in TSS contents over control at the end of storage has been reported in *E. roxleana* latex treated Red Delicious apple fruits by Nayital (1987). Also increased total sugars in triacontanol treated plum fruits has been reported by

Chandel (1985); Jindal and Dwivdei (1986), and Barua (1990). That triacontanol application improves fruit quality has been reoorted by Gunasekaran and Shanmugavelu (1983), and Chander (1987). A significant increase in TSS content at the end of storage at $0\pm1^{o}C$, with *E. royliana* latex application has been reported in Red Delicious apple fruit by Mayital (1987). Low temperature has been found to favour the conversion of starch to sugar in apple and reverse is the result with high temperature (Smith et al.,1979). Tsiprush and Kazak (1982), however, observed higher respiration rate and greater loss of sugars in apple after storage.

A general declining trend, rather sharp in the beginning and gradual thereafter, in the titratable acid contents was observed with the increase in storage period. The pH of the juice showed an increasing trend as the storage period progressed and the increases were rather abrupt in the beginning and steady thereafter. The acid loss,however, was recorded to be the lowest in fruits which had received *E. royleana* latex 500 ppm (T_{15}) and Protozyme 500 ppm (T_7) treatments while it was the highest in control fruits. A decrease in titratable acid contents of apple fruit during ripening and storage has also been reported by many other workers (Smock and Neubert, 1950; Istatkov and Stambolic, 1973; Kato et al., 1978; Wills et al., 1980, Recasens et al.,1983;

Aeppli, 1984; Sachdeva, 1985; Naqash, 1986).

The decrease in acidity during ripening or in storage in apples may be attributed to an increase in malate decarboxylating system (Hulme et al., 1963) which in turn requires the synthesis of new RNA and proteins (Rhodes et al., 1968). It has been known for a long time that fruit cells use organic acids such as malic and citric as a respiratory substrate and hence, the decline in their levels during ripening and storage (Ulrich, 1974). A significant reduction in acid loss was reported by Nayital (1990) in *E. royleana* latex treated Red Delicious apple fruits. Reduction in acid loss in fruits treated with Protozyme 500 ppm (T_7) might be due to the effect of auxin synthesized from its precursor present in Protozyme. Reduction in titratable acid loss has also been reported by Kabu (1987) in auxin treated Starking Delicious apple fruits.

For bioelectrical conductance (EC) which reflects the potentiality of electrons in a solution to carry electrical change, a definite trend was noticed during storage. The EC which was quite low in the beginning increased during the early period of storage and then declined towards the close of sampling. The highest mean value of EC was recorded in fruits from Protozyme 1000 ppm (T_9). This treatment was, however, on a par with *E. royleana* latex 500 ppm (T_{15}). According to Ogbadu and Ehlermann (1983) the change from an increase to a decrease of electrical resistance of apple tissue might act as an indicator of internal browning. Significant increase in value of EC was observed in auxin and *E. royleana* latex treated apple fruits in comparison to control fruits (Nayital, 1987).

In the present investigations, total phenols were found to decline coincident with the advance in storage period. This observation if viewed with another related observation that, fruits lose their resistance to various storage disorders and become increasingly susceptible to storage rots with advancing maturity and ripening, suggests a distinct role of phenolic in disease resistance (Ndubizn, 1976). From biochemical stand point, phenols are particularly prominent in fruits where they are important in determining colour and flavour (Van Buren, 1970). The degradation of phenolic was however, observed to take place at a slower pace in the fruits treated with *E. royleana* latex 500 ppm (T_{15}) and Bavistin 1500 ppm (F_3), resulting in a lower per cent rot incidence. Nayital (1987) recorded increased total phenolic content in fruits of Red Delicious apple treated with *E.royleana* latex and Bavistin. A significant increase in total phenol contents has also been reported in Bartlett pear fruits dipped in 1000 ppm Bavistin (Singh, 1986).

That the plant phenolics do have a role to play in disease resistance has been shown by many workers (Farakas and Kiraly, 1962; Mahadevan, 1966). Hulme and Edney (1960) suspected that the susceptibility of fruits to fungal attack could be due to fall in the concentration of chlorogenic acid.

The physiology of plants is influenced profoundly by the level of Ca during growth and development (Jones and Lunt, 1970;Poovaiah, 1979). Increasing the Ca content of apples has been reported to retard the senescence and to reduce physiological disorders during storage (Bangerth et al.,1972; Lau et al., 1983; Poovaiah and Shekhar, 1978;Scott and Wills; 1979) and to reduce the respiratory rate and ethylene production (Bangerth et al. 1972; Faust and Shear, 1972; Liebermann and Wang, 1982; Sams and Cowney, 1984).

In the present study, Calcium content was found to decrease coincident with the advancement in storage period. Calcium content was however, recorded to be highest in fruits treated with *E. royleana* latex 500 ppm (T_{15}) and protogyme 500 ppm (T_7) respectively. Increase of calcium content has been reported in the leaves of Red Delicious apple treated with Biozyme (Sharma. 1990). Increase in the calcium content at harvest has also been reported in Starking Delicious apple fruits treated with kinetin (Kabu, 1987).

The gradual decrease in juice content with the advance in storage period observed in the present study be attributed to an increase in the rate of respiration as observed by Rayneke and Pearse (1945). In the present investigations, highest juice content was observed in fruits treated with *E. royleana* latex 500 ppm (T_{15}), where as the lowest juice content was recorded in control fruits (P_{10}). The highest juice content in fruits treated with T_{15} might be due to the decrease rate of respiration.

5.4 Effect on sensory evaluation

Sensory evaluation score was found to be the highest in the fruits treated with Bavistin 1500 ppm (P_3) and Agrostemin 500 ppm (T_3). Control fruits on the other hand recorded the lowest score. Highest score for quality in fruits treated with T_3 might be due to reduced rates of respiration and ethylene production. In fruits treated with Bavistin 1500 ppm (P_3), the high score for sensory evaluation might be due to its preservative action on the quality of the fruits.

5.5 Effect on per cent rot

The lowest per cent fruits rot was recorded in fruits treated with Bavistin 1500 ppm and 1000 ppm (P_3 and P_2) respectively, where as the highest per cent rot was observed in control fruits. Increased storage life of fruits treated with Bavistin has also been reported by many other workers (Dar and Mukhopadhyay, 1976 and 1977;Vyas and Singh, 1977; Gupta and Sharma, 1981; Kaul, 1982; Verma et al., 1986; Nayital et al., 1990).

5.6 Correlation studies

Firmness was found to have a positive correlation with titratable acidity, TSS and Calcium. Sams and Conway (1984) and Thakur (1989), reported a positive correlation between flesh firmness and fruit calcium levels. Naqash (1986) also reported a positive correlation between flesh firmness and titratable acidity and calcium.

Respiration showed a positive correlation between ethylene and negative correlation with flesh firmness and titratable acidity. Ethylene evolution rate recorded a nagative correlation with flesh firmness, TSS and calcium content.

Summary and Conclusions

SUMMARY AND CONCLUSIONS

The present investigations entitled "Effect of some plant growth bioregulators and fungicides on ripening and storability of apple (*Malus domestica* Borkh.). cv. Red Delicious" were conducted during 1989-90 cropping season, and the results are summarised hereunder:

1. The fruit size in terms of length and diameter was recorded to be the highest with preharvest application of Paras 2000 ppm (T_{11}).

2. The physiological loss in weight (PLW) and volume during storage was the lowest in fruits receiving preharvest sprays of *Euphorbia royleana* latex, 500 ppm (T_{15}) or Paras 1000 ppm (T_{10}), and the highest in control fruits, at the end of 210 day storage.

3. Fruits treated with Paras 2000 ppm (T_{11}) or *E. royleana* latex 500 ppm (T_{15}), recorded the highest specific gravity while those in control (T_{16}), the lowest.

4. The flesh firmness of fruits was recorded to be the maximum with Protozyme 500 ppm (T_7) or Bavistin 500 ppm (P_1) treatments. Control fruits on the other hand, recorded the lowest fruit firmness. Biozyme 500 ppm (T_4) and Paras 1000 ppm (T_{10}), were also fairly effective in reducing the loss of firmness in storage.

5. Agrostemin 500 ppm (T_3), Biozyme 500 ppm (T_4) and *E. royleana* latex 500 ppm (T_{15}), treatments tended to steady the metabolic rates of the fruit as appraised by

respiration and ethylene evolution rates during prolonged storage. Control fruits and those receiving the preharvest application of Paras 3000 ppm (T_{12}) on the otherhand, exhibited a highly fluctuating trend in respiration and ethylene evolution rates registering rather sharp increases and decreases.

6. The total saluble solids (TSS), total sugars, and reducing as well as non reducing sugars, in general, increased with the advance in storage period registering a decline towards the close of sampling. Among growth bioregulators, the highest TSS contents at the end of 210 day storage were recorded in fruits treated with *E. royleana* latex 250 ppp (T_{14}), Protozyme 500 ppm (T_7) and Agrostemin 100 ppm (T_1). In experiment II where the effects of fungicides was appraised the highest TSS contents were rocorded in fruits treated with Bavistin 500 ppm (P_1) and the lowest in control.

7. The titratable acidity in general declined with the advance in storage period. *E. royleana* latex 500 ppm (T_{15}) and Protozyme 500 ppm (T_7) treatments, however, tended to steady the decrease. Of the fungicides Bavistin 500 ppm (P_1) was the most effective treatment in this respect. Control fruits (P_{10}) on the other hand, recorded a sharp decline in the titratable acids, thereby indicating a higher metabolic rate than all other treatments.

8. Similarly the pH of the fruit juice, in general increased as the storage period advanced, *E. royleana*

latex 500 ppm (T_{15}) treatment, however tended to steady this increase. Again, of the fungicides, Bavistin 500 ppm (P_1) proved to be the most effective treatment in this respect. Control fruits, on the other hand, recorded rather sharp increase in the pH with the advance in storage period.

9. The electrical conductivity (EC) of the fruit, in general, was low in the beginning, increased during the early period of storage, peaked at 150 days of storage and declined thereafter. Fruits from *E. royleana* latex 500 ppm (T_{15}) and Protozyme 1000 ppm (T_9) recorded the highest EC among growth biregulators. However, among fungicides, fruits receiving preharvest application of Bavistin 1500 ppm (P_3) recorded the highest mean value for the same.

10. The total phenols and calcium content showed a declining trend commensurate with the advance in storage. *E. royleana* latex 500 ppm (T_{15}), however, tended to steady the decline in phenolics and calcium content, and recorded the highest values during and at the end of storage. Among fungicides Bavistin 1500 ppm (P_3) recorded the highest values for the both. Control fruits on the other hand, recorded the lowest values.

11. Fruit juice content also showed a declining trend commensurate with the advance in storage. *E. royleana* latex 500 ppm (T_{15}), among growth biregulators recorded the highest values for juice content throughout the storage. In experiment II, in which effects of fungicides was appraised, Bavistin 1500 ppm (P_3) treated

fruits, recorded the highest juice contents. Control fruits on the other hand recorded the lowest value.

12. Fruits treated with Agrostemin 250 ppm and 500 ppm (T_2 and T_3) and *E. royleana* latex 500 ppm(T_{15}) recorded the highest on sensory evaluation. In experiment II, fruits treated with Bavistin 1500 ppm and 500 ppm (P_3 and P_1) were of best quality among all the treatments against the fruits of poorest quality from control (P_{10}).

13. The rot percentage during storage was recorded to be the lowest in Bavistin 1500 ppm (P_3) treated fruits. Treating the fruits with Topsin-M 750 ppm (P_6) and Bavistin 1000 ppm (P_2) proved to be equally effective in this regard. The highest per cent rot on the other hand, was recorded in control fruits.

14. Preharvest applications of *E. royleana* latex 500 ppm (T_{15}), Agrostemin 500 ppm (T_3), and Bavistin 1500 ppm and 500 ppm (P_3 and P_1) proved to be most efficacious in increasing the storability of Red Delicious apples. Other treatments, that were also fairly effective in increasing the storability of fruits were Paras 1000 ppm and 2000 (T_{10} and T_{11}), Protozyme and Biozyme at 500 ppm (T_4 and T_7) and Bavistin 1000 ppm (P_2).

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- Apples - Storage Losses - Fungicides
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