"EFFECT OF PRE HARVEST APPLICATION OF SOME CHEMICALS ON POST HARVEST SHELF LIFE OF BANANA (*Musa paradisica* L.) FRUIT CV. GRAND NAINE"

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ABSTRACT

The present investigation on "Effect of pre-harvest application of some chemicals on banana [*Musa paradisica* L.] Cv. Grand Naine" was conducted at Fruit Research Station, Gandevi, Navsari Agricultural University, Navsari (Gujarat) and fruits were brought to P.G. Laboratory, Department of Horticulture, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari (Gujarat) for further evaluation during the year 2006-07. The experiment was laid out in Randomized Block Design with four replications, comprising of five chemicals viz., CPPU (4ppm), 2,4-D (10ppm), KH_2PO_4 (0.5 %), KNO_3 (0.5 %). K_2SO_4 (0.5 %) and control.

From above studies it was evident that among all the chemicals alternated pre-harvest application of CPPU (4ppm) and KH_2PO_4 (0.5 %) were found excellent treatment, which not only extended the shelf life but also increased marketable fruits

percentage, average number of days taken to ripeness, fruit texture and acidity percentage while weight loss due to ripening, TSS content, reducing sugar, non-reducing sugar, total sugar and sugar: acid ratio were reduced during storage period. It also reduced post harvest losses without adversely affecting the quality of banana fruits Cv. Grand Naine.

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CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF PRE-HARVEST APPLICATION OF SOME CHEMICALS ON POST HARVEST SHELF LIFE OF BANANA (*Musa paradisiaca* L.) FRUIT CV. GRAND NAINE"** submitted by Mr. **SOMI RAJESH GANAGADHAR** in partial fulfillment of the requirement for the award of degree of **MASTER OF SCIENCE (HORTICULTURE)** in **FRUIT SCIENCE** of Navsari Agricultural University is a record of bonafide research work carried out by him under my guidance and supervision and the thesis has not previously formed on the basis for the award of any degree, diploma or other similar title.

Major Advisor

Place : Navsari

Date : 5th July, 2008

(C. B. Patel)

DECLARATION

This is to declare that the whole of the research work submitted in this thesis for the partial fulfillment of the requirements for the degree of ***MASTER OF SCIENCE (HORTICULTURE) in FRUIT SCIENCE*** *, is the result of investigation done by the undersigned under the direct guidance and supervision of* ***Dr. C. B. PATEL****, Associate Research Scientist (Fruit), Fruit Research Station, Navsari Agricultural University, Gandevi, Navsari and that no part of the work has been submitted for any other degree so far as a unique research.*

Place : Navsari

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ACKNOWLEDGEMENT

All the praises to my parents as in form of God, as great benevolent and ever merciful. They build the confidence and boldness in me and treated me to survive in all the conditions and also showed the world.

To complete any research task required the cumulative efforts, which have come to me in the form of direct or indirect help from my belovers. My heartful thanks to them, such are:

Indeed there are no words adequate to convey the debt of gratitude and indebtedness to my Major Advisor ***Dr. C. B. Patel, Associate Research Scientist (Fruit), Fruit Research Station, Navsari Agricultural University, Gandevi, Navsari*** *for his most valuable guidance, constant inspiration, personal interest, constructive criticism and sympathetic attitude right from the starting of master programmes to finally guiding for future after completion of master degree.*

My grateful thanks to the members of my Advisory Committee, Dr. J. R. Desai, Associate Research Scientist (Floriculture), Navsari Agricultural University, Navsari, Dr. B. V. Padhiar, Associate Professor of Horticulture, ACHF, Navsari, and Shri H. N. Chhatrola, Assistant Professor of Statistics, for their constant attention, valuable suggestion and continuous inspiration throughout the period of master programme.

I heartily express my gratitude to Dr. Nitin Patel, Dr. V. S. Patel, and Mahida Sir for providing the necessary facilities as well as continuous help during the course of investigation.

I would like to elucidate my hearty thanks to my friends Minalbhai, Munnabhai, Bhakti, Bhaumik Pancholi, Rushabh (Chintu), Hiral, Ashish, Sweta, Jayshree-Jaydip, Satish, Jaymit (Lambu), Bhavesh, Jayesh Limbani, Keyur, Dani, Pankaj, Zala, Bhavin, Ankur, Sandip (Kalu), Sailu, Vikash, Samit, Yogesh, Bhaumik Patel, Rahul, Ujjaval and all other friends for their help and co-operation.

Place: *Navsari*

Date: *5th July, 2008*

(Somi Rajeshkumar Gangadhar)

ABBREVIATIONS

1.	%	Per cent
2.	^{o}C	Degree celsius
3.	*et al.*	*et alibi* (and others)
4.	etc.	et cetra
5.	mg l^{-1}	milligram per liter
6.	ppm	Parts per million
7.	Fig.	Figurs
8.	TA	Titrable acidity
9.	cm	Centimeter
10.	kg	Kilogram
11.	GA	Gibberellic acid
12.	AsA	Ascorbic acid
13.	TSS	Total soluble solids
14.	TBZ	·Thidizuron
15.	NAA	Naphthalene acetic acid
16.	Cv.	Cultivar
17.	ha	Hectare
18.	C.D	Critical differences
19.	C.V	Co-efficient of variances
20.	S.Em	Standard error of mean

21.	CPPU	N-(2-chloro-4-pyridyl)-N'-phenyl urea (Forchlorfenuron)
22.	2,4-D	2,4-Dichlorophenoxy acetic acid
23.	KH_2PO_4	Potassium phosphate
24.	K_2SO_4	Potassium sulphate

INTRODUCTION

I. INTRODUCTION

Banana (*Musa paradisiaca* L.) is a large herbaceous perennial, monocotyledonous and monocarpic crop. Banana belongs to the family Musaceae in the order Scitamineae. Banana is known as "Apple of Paradise". Its origin is the tropical region of South-East Asia. Banana crop have nutritional, medicinal and industrial value. Banana has been associated with man as food and is used for religious work. In addition, banana is one of the most important fruit crops of the world. Indeed, many consider banana is one of man's first food.

In India, banana is fourth important fruit crops in terms of gross value and is exceeded only by paddy, wheat and milk products. It is also a dessert fruit for millions, apart from a staple food owing to its rich and easily digestible carbohydrates with a calorific value of 67-137 per 100g fruit. It is a good source of vitamin A (190 IU per 100g of edible portion) and vitamin C (100mg per 100g) and fair source of vitamin B and B_2. Fruits are also rich source of minerals like magnesium, sodium, potassium, phosphorus and a fair source of calcium and iron. It makes healthy and salt free balanced diet than many fruits. One hectare of banana yields 37.5 million calories of energy as compared to 2.5 million calories from wheat and multifarious uses. About 24 bananas each weighing around 100g would provide the energy requirement (2400 calories per day) of a man (Singh, 2002).

India is the largest banana consumer and producing country in the world followed by Brazil, contributing about 15

percent of the total world production. Among the fruits, banana holds first position in the production and productivity in India. It ranks second in area after mango. In India, annual production of banana is 19.50 million tones from an area of 5.4 lakh hectares spread all over the country (Anon., 2005). Banana covers 12.50 percent of the total area under fruits, contributing nearly one third of total fruit production in the country. In India, Tamil Nadu, Maharashtra, Karnataka, Kerala, Assam and Gujarat are the leading banana producing states. The highest productivity is 62.9 tones/ha in Maharashtra followed by Gujarat (39.9 tones/ha) in the year 2002-03, (Anon., 2004).

In Gujarat, banana covers an area of 49,234 hectares with production of 24,98,776 metric tones. The largest area is covered under Bharuch district with an area of 12,760 hectares with the highest production of 7,01,800 metric tones. Navsari district covers an area of 450 hectares with a production of 22500 metric tones annually (Anon., 2006). Banana is cultivated in the districts Bharuch, Surat, Anand, Narmada, Junagadh, Vadodara, Navsari and Valsad because of favorable agro-climatic conditions and abundant supply of well and canal irrigation water. It is also very important crop of these districts because annual rainfall received in this region is around 70 inches. It is one of the most important fruit crop of South Gujarat region. District wise area and production estimated of banana fruit crop in the year 2005-06 is shown in appendix – I.

India is one of the horticultural rich country of the

world, produces large varieties of fruits and banana is one of these. Since last 50 years a considerable research work has been done in the country on various aspects such as varieties, irrigation, weed management, spacing, post harvest technology etc. for increasing yield and quality of banana fruits.

Hence, from the point of export, it is essential to give a serious thought at the position and status in respect of production of this major commercial fruit of India for follow-up action at national level to boost its export trade.

In recent years the important of plant growth substances, foliar spraying of fertilizers and certain chemicals like K_2SO_4, KH_2PO_4, KNO_3, CPPU and 2,4-D etc. increasing crop production and improving fruit qualities has been greatly realized.

However, the information on the response of above chemicals on yield and qualities of fruits under the agro-climatic conditions of South Gujarat is very limited. An attempt has therefore, been made to investigate the effect of pre harvest application of some chemicals on post harvest self life of banana with following objectives:

1. To evaluate the effect of pre-harvest treatments of some chemicals on shelf life of banana fruits.
2. To study the pre-harvest treatments of some chemicals on physico-chemical changes during storage of banana fruits.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

Today, the practical use of chemicals in horticulture has assumed invariable significance due to revealed capacity of many compounds to exploit many significant mechanisms in plant, which have led to a situation nearly approaching the horticultural revolution. Synthetic growth regulating chemicals are becoming extremely important and valuable in fruit for manipulating growth, flowering, yield and quality of many fruit crops. A broad range of effects of both morphological and physiological effects can be observed by the application of growth regulating chemicals.

A major advent during the past decades was the discovery that fruit size of some crops can be substantially increased by plant growth regulating chemical treatments and the effect is relatively independent of crop load. A reasonably larger fruit size and good quality of banana for getting higher market price and the economic benefits of treatments that reliably improve fruit size and quality can be indeed very substantial.

In present context, the literature on the effect of chemicals on quality of banana has been reviewed in this chapter with the following sub heading.

2.1 Effect of CPPU

2.2 Effect of 2,4-D

2.3 Effect of KH_2PO_4

2.4 Effect of KNO_3

2.5 Effect of K_2SO_4

2.1 Effect of CPPU

Intrieri *et al.* (1992) showed that CPPU increased berry size when applied directly to the clusters, but its effect on ripening pattern was non significant.

Reyonolds *et al.* (1992) conducted an experiment with spraying three levels (0, 1, 10 mg per liter) of either CPPU or the related compound thidiazuron was applied to grape 'Simone' and Summerland Selection 535. Both phenylurea chemicals tended to linearly increase cluster weight while reducing degrees ^{0}Brix, pH, and anthocyanins and increasing titratable acidity.

Retamales *et al.* (1993) stated that CPPU 40 ppm treatments significantly increased berry length, diameter and volume and significantly reduced the length: diameter ratio as compared to the GA_3 treatment. Bunch weight, stalk weight and pedicel diameter increased significantly with increasing CPPU application rate. Fruit soluble solids (^{0}Brix) were not affected. CPPU treatments delayed ripening and hence harvesting dates of grape cv. Sultanina.

Joublan *et al.* (1995) revealed that CPPU + GA_3 application delayed fruit maturation soluble solids content and the soluble solids: acidity ratio and reduced fruit colour intensity of grapes.

LiHong *et al.* (1996) conducted that CPPU applied after full bloom and PDJ applied during berry colour developed increased or improved cluster and berry size, soluble solids content and coloration in cv. Fujimino.

Subhadrabandhu and Iamsub (1996) studied the effect of CPPU (1-(2-chloro-4-pyridyl)-3-phenylurea) on fruit setting of mango cv. Nam Dok Mai and concluded that CPPU has some effects in the early stage of fruit setting in mango and that application at full bloom showed better results than that at 10 days after inflorescence emergence. Abdul *et al.* (1998) found that the combined treatment of CPPU and GA_3 on Fujiminori grape increased berry weight by 75% compared with control and increased weight 5-fold. It also reduced titratable acidity.

Basak (1999) stated that the application of Forchlorfeniron 40 ppm (CPPU) often increased fruit firmness and soluble solids content during storage and reduced the incidence of rotting and shriveling of fruits.

Leao *et al.* (1999) reported that combined treatments of CPPU and GA_3 was effective on ripening, delaying harvest by 8 days. No significant differences were noted in soluble solids content and titratable acidity Perlette grape vines.

Ranpise *et al.* (1999) stated that an application of CPPU + GA significantly affected the yield and quality of grapes. Forchlorfenuron (CPPU) 3 ppm + GA 25 ppm when applied at 3 mm berry size recorded the highest berry diameter (22.2 mm), weight of 10 berries (263.3 g), length (24.70 mm), yield per vine (8.41 kg) and TSS (21.9 ^{0}Brix). However, this treatment delayed the harvesting of grapes by 5-6 days as compare to control to attain optimum TSS. Increasing concentration of CPPU + GA did

not affect the acidity but it was lowest (0.49%) at CPPU 2ppm + GA 25 ppm.

Lie *et al.* (2000) concluded that spraying of 40 mg CPPU per litre twice, at 5 and 20 days after full bloom, markedly increased shoot growth, leaf area, photosynthesis rate and yield, and improved fruit quality; the fruit weight was increased by 1.89 g and soluble solids by 5.7%.

Notodimedjo (2000) studied the effect of NAA, GA_3 [Gibberellic acid] and CPPU [Forchlorfenuron], applied 14 days after blooming, on fruit retention, yield and fruit quality of mango cv. Arumanis in East Java, Indonesia. CPPU (10 ppm) gave the best result in term of increasing fruit retention, number of fruits per cluster and per plant, weight of one fruit, fruit volume and leaf area. No significant differences between the quality of fruits harvested from treated and control trees were observed.

Sugiyama and Yamaki (2000) conducted an experiment on effect of CPPU on fruit set and fruit growth in Japanese persimmon and stated that the yield of marketable fruits after treatment of 5 mg^{-1} was higher than that for untreated trees.

Millan *et al.* (2001) Studied the polyphenol oxidase activity, colour changes and dehydration in Table grape rachis during development and storage as affected by N-(2-chloro-4-pyridyl)-N-phyenylurea and stated that weight loss below 2.1 % were significantly lowest in CPPU treated clusters for 16 days of storage regardless of cluster maturity.

Patil *et al.* (2002) Revealed that both CPPU and TBZ were more effective than GA in maintaining the post harvest quality of grapes, the lowest acidity was achieved with 5 mg L^{-1} CPPU treatment in cv. 'Anab-e-Shahi' while in cv. 'Dilkush' the lowest acidity was in the control berries.

Said (2002) reported that the Sitofix (CPPU) 40 ppm sprayed on apple cv. Anna at full bloom or 3 weeks after full bloom significantly increased fruit weight, flesh firmness, fruit size and the percentage of total soluble solids in both the years.

Huang *et al.* (2003) recorded the average weight of kiwi fruit was 92.5 g and the maximum size is 150 g with the application of CPPU [Forchlorfenuron].

Sabagh and Ahmed (2004) studied the effect of Gibberellic acid (GA_3) and Sitofix (CPPU) on "Anna" apple crop load and fruit quality. The application of CPPU 50 ppm significantly increased the average number of retained fruits per 100 spurs reaching harvest time compared to the other treatments and CPPU at 50 ppm was most effective on fruit firmness.

GuoRong *et al.* (2005) studied the influence of CPPU on fruit inclusion in Jiro and stated that the weight of individual fruit increased: reducing sugar, soluble sugar, the total sugar, TSS content and TSS-acid ratio of fruit increased; the fruit starch decreased; and the ascorbic acid content and soluble tannin contents were not affected much.

Kim *et al.* (2006) studied CPPU application on size and quality of hardy kiwifruit and concluded that a significant

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reduction in the concentrations of total soluble solids (TSS), titratable acids (TA) and ascorbic acid (AsA) in the CPPU treated fruits was recorded.

2.2 Effect of 2, 4-D

Barman and Das (2002) were sprayed varying concentration of gibberellic acid (GA_3, 100, 200, 300 ppm), 2,4-D (10, 20, 30 ppm) and 0.5% KH_2PO_4 + 1% urea sprayed at 5th month and 2nd spray after the last hand opening of the bunch of banana Cv. Barjahaji in Assam, India. Foliar application of 2,4-D at 20 ppm were found the most effective treatment for pulp weight, peel weight, pulp-peel ratio and total soluble solids. Other fruit quality parameters like reducing sugar and total sugar were found maximum with 2, 4-D at 10 ppm.

Geetha and Nair (2002) studied the effect of 2, 4-D, sprayed to fruit at 15, 30 and 45 ppm on the yield and quality of banana cv. Nendran in Kumakarom, Kerala, India. All rates significantly improved fruit length and girth; bunch weight; dry matter yield; pulp-peel ratio; and total soluble solid, total sugar, reducing sugar, sugar-acid ratio, ascorbic acid, nitrogen, phosphorus, potassium, calcium, and magnesium contents. Ripening period and shelf life were reduced with 2, 4-D application.

Barman and baruah (2003) conducted a field experiment at the experimental farm, Department of horticulture, Assam Agriculture University, Jorhat with a view to study the effect of some plant growth substances on yield and quality of banana cv.

Barjahaji. The growth regulators were applied as foliar spray at 5th month after planting and immediately after the last hand opening of the bunch. The highest bunch weight (15.78kg) and highest yield (48.70 t/ha) were found in 2, 4-D at 20 ppm. While the lowest bunch weight (8.50 kg) and lowest yield (26.23 t/ha) were found in the control. Among the quality characters, 2, 4-D at 20 ppm showed superiority in respect of TSS (23.22^{0}Brix) and 2, 4-D at 10 ppm total sugar (20.42%).

2.3 Effect of KH_2PO_4

Ravishankar *et al.* (1989) studied on the effects of foliar sprays of chemicals and nutrients on mango cv. Alphonso and revealed that the percentage of yield in the 'off' year as compared to the previous 'on' year was maximum in KH_2PO_4 (1%) plus urea (1%) treatment and the possibility of obtaining moderate crops even during 'off' year in Alphonso mango through foliar application of KH_2PO_4 (1%) in combination with urea (1%) and KNO_3 (1%) + urea (1%).

Kumar and Reddy (1998) concluded that spraying of KH_2PO_4 + urea delayed fruit maturity by 11 days.

2.4 Effect of KNO_3

Singh *et al.* (1981) studied the effects of foliar spraying of various chemicals on physico-chemical quality of Guava fruits and revealed that all the physical attributes like fruit weight, length and width of the guava fruits were markedly affected. The treatment Calcium nitrate + calcium chloride + potassium nitrate 1% each significantly increased the fruit length, fruit weight and

chemical parameters like TSS, acidity, reducing sugar, total sugar and ascorbic acid which was followed by KNO_3 (1%) spray.

Sharma *et al.* (1990 a) studied influence of foliar sprays of ten year old trees of cv. Langra were sprayed with urea (0, 2 or 4%), KNO_3 (0, 1.5 or 3%) or NAA (0 or 40 ppm), alone or in combination, at the flowering stage, the maximum number of fruits per plant (57), fruit weight (174.9 g), length (9.3 cm), diameter (7.2 cm) and percent pulp (73.8%) were obtained with the 4% urea treatment, followed by the 3% KNO_3 treatment.

They (1990 b) also recorded that the 4% urea, 3% KNO_3 and 40 ppm NAA treatments produces the greatest number of fruits per plant, TSS, non-reducing sugars, total sugars and ascorbic acid contents and lowest acidity.

Bhuyan and Irabagon (1992) studied the effect of application of fertilizer (0, 2, 4 kg complete fertilizer per tree), potassium nitrate sprays (0, 10, 20g per liter of water) and irrigation (unirrigated and irrigated) on the physico chemical characters of Carabao mango at the pomology orchard of central Luzon State University, Munoz, Nueva Ecija, Philippines during June, 1990 to March 1991. Heavier, longer, wider, and thicker fruits were produced by the fertilized, unirrigated trees sprayed with 20g KNO_3 per litre of water. The fruits of trees fertilized and sprayed with 20g KNO_3 per litre of water had increased pH and TSS contents. The trees sprayed with 20 g KNO_3 per litre of water had the highest dry matter; however, higher dry matter percentage

of ripe fruit was obtained from the trees sprayed with 10 g KNO_3 per litre of water.

Oosthuyse (1997) stated that there was no apparent effect of the KNO_3 sprays on Mango fruit quality, ground skin coloration, total soluble solids content, pH or taste on ripening.

Singh and Singh (1998) studied different concentration of potassium nitrate (2,4 and 6 %) and ammonium sulphate (5,10 and 15 %) were sprayed on 12-year-old Sardar guava trees at bloom stage (30th April) and found that maximum flower abscission was recorded when plant received 6 % potassium nitrate (64 %) followed by 15 % ammonium sulphate (59.25 %) and the yield of winter crop was significantly increased with 6 % potassium nitrate (44.0 kg/tree) closely followed by 5 % ammonium sulphate (44.15 kg/tree).

Padem *et al.* (1999) stated that an application of KNO_3 (1%) increased pH of tomato.

2.5 Effect of K_2SO_4

Singh *et al.* (1979) conducted an experiment on effect of potassium sprays on quality of grapes cv. Perlette and stated that the different fruit characters *viz.* average berry weight, juice percentage, reducing sugars, total soluble solids and berry firmness were significantly increased as a result of 1.0% potassium sprays.

Panday *et al.* (1988) studied the foliar application of nutrients and plant growth regulators in Sardar Guava (*Psidium*

guajava L.) and stated that foliar application of 1.0% K_2SO_4 significantly increased fruit weight, fruit yield and cost: benefit ratio followed by urea application.

Shin *et al.* (1989) revealed that an application of 4 sprays of 0.1% K_2SO_4 had no effect on fruit weight, hardiness, soluble solids and total acidity or juice mineral contents.

Ali *et al.* (1991) revealed that the highest TSS as well as total sugar and lowest acidity were obtained with the spraying of K_2SO_4 (1%) followed by borax (0.2%) and the highest cost : benefit ratio of 1 : 9.58 was observed with the spraying of urea (2%) followed by 1 : 6.35 with borax (0.2%) application on guava cv. Allahabad Safeda.

Wittaya (1992) revealed that RPG 2/16 processing guava cultivar gave an average fruit weight of only 110.76 grams, fresh thickness 13.94 mm, fruit cavity diameter 27.56 mm, total soluble solids 7.61 %, pH 4.35 and citric acid 0.34 % with foliar spray of K_2SO_4. Beaumont cultivar gave an average fruit weight 70.32 grams, fresh thickness 7.56 mm, fruit cavity diameter 37.16 mm, total soluble solids 6.05 %, pH 3.70 and citric acid 0.91 % with foliar spray of K_2SO_4 60 gm per tree.

Shin and Lee (1993) studied the effect of potassium compounds as foliar spray on mineral content of leaf and cluster stalk, and on fruit quality in cv. 'Campbell Early' grape and concluded that the soluble solids content of the fruit was significantly increased with K_2SO_4 as compared with control.

Bhatia *et al.* (2001) conducted an experiment on foliar application of nutrients on the yield and fruit quality of winter season Guava cv. L-49, in which K_2SO_4 (0.5, 1.0 and 1.5%), $ZnSO_4$ (0.5, 0.75 and 1.0%), H_3BO_3 (0.3, 0.5 and 1.0%) and water (control) were sprayed on the trees during winter season crops at the stage when the fruit was of walnut size and second after 15 days. The organoleptic rating out of 10 points was the highest (9.0) with K_2SO_4 at 1.5%, the total soluble solids and sugars were more with H_3BO_3 followed by K_2SO_4 and ascorbic acid was found maximum with K_2SO_4 (182 mg per 100gm).

Dutta (2004) studied that the foliar application of K_2SO_4, KCL and KNO_3 at 1 or 2 % on the yield and quality of guava (cv. L-49) in West Bengal, India, during 1998-2000 and stated that spraying of K significantly enhanced the yield and quality of guava. K_2SO_4 at 2 % resulted in the highest fruit weight (101.20 g), fruit length (5.25 cm), fruit diameter (5.92 cm), yield (6.20 kg per plant), and total soluble solid (9.80 ^{0}Brix), total sugar (7.02%) and reducing sugar (3.98%) contents. Potassium reduced the ascorbic acid content but did not significantly affect the titratable acidity of fruits.

MATERIALS AND METHODS

III. MATERIALS AND METHODS

The details of materials used, experimental methods followed and the techniques adopted during the course of this investigation are given below.

An experiment on "Effect of pre harvest application of some chemicals on post harvest shelf life of banana (*Musa paradisica* L.) fruit cv. Grand Naine" was conducted at Fruit Research Station, Navsari Agricultural University, Gandevi during 2005-2006.

3.1 Location

Geographically Gandevi is situated at 21^0 N latitude and 73^0 E longitudes and at an elevation of 7.6 meters above sea level and on the bank of river Vengania. It is 3 km away from Gandevi town.

3.2 Climate

Climatically this region is belong to agroclimatic zone-I heavy rainfall area under agro-ecological situation-III and typically tropical characterized by fairly hot summer, moderate cold winter and more humid and warm monsoon with heavy rain. The maximum temperature of 38^0C in month of April and minimum temperature of 10^0C in the month of January were recorded, annual rainfall is about 1500 to 1800 mm. The monsoon mostly starts from second week of June and ceases during last week of September. Most of the rainfall is received from South-West monsoon concentrating in the month of July and August.

3.3 Application of fertilizers

Banana plant was fed with 300g N_2; 90g P_2O_5; 200g K_2O. Nitrogen and potash were applied at 3rd, 4th and 5th month after planting in three equal splits while complete dose of phosphorus was applied at 3rd months after planting. The soil application method was adopted to give the fertilizer treatments. The fertilizers N, P and K were applied in the form of Urea, Single super phosphate and Murate of potash, respectively. The fertilizers were applied by making shallow ring around the pseudostem and were covered with thin layer of soil and gave irrigation.

3.4 Cultural practices

The cultural practices were adopted according to the recommendation for the cultivation of banana crop. Earthing up was done after completion of fertilizer dose in order to support the plants.

3.5 Experimental details

1. Crop : Banana (*Musa paradisica* L.)
   Cv. 'Grand Naine'
2. Design : Randomized Block Design (RBD)
3. Replications : Four (4)
4. Treatments : Six (6)
5. Treatment details:

T_1 = CPPU (4ppm)

T_2 = 2,4-D (10ppm)

$T_3 = KH_2PO_4$ (0.5%)

$T_4 = KNO_3$ (0.5%)

$T_5 = K_2SO_4$ (0.5%)

T_6 = Control

3.6 Preparation of stock solution

3.6.1 CPPU

In order to prepare 4 ppm CPPU solution, 40 mg of CPPU was dissolved in 10 litre of water.

3.6.2 2, 4-D

To prepare 10 ppm solution of 2,4-D, 100 mg of 2,4-D was dissolved in 10 litre of water.

3.6.3 KH_2PO_4

The required quantity (5.0 g) of KH_2PO_4 was dissolved in water and final volume of 1 litre was made by adding sufficient amount of water.

3.6.4 KNO_3

The required quantity (5.0 g) of KNO_3 was dissolved in water and final volume of 1 litre was made by adding sufficient amount of water.

3.6.5 K_2SO_4

The required quantity (5.0 g) of K_2SO_4 was dissolved in water and final volume of 1 litre was made by adding sufficient amount of water.

3.7 Time of Spray

Two spray of CPPU (4ppm) was applied immediately after and 15 days later last hand opening. One spray of 2, 4-D (10ppm) was applied at 5 days after last hand opening. The rest of treatments i.e KH_2PO_4, KNO_3 and K_2SO_4 0.5 % each were sprayed twice at 5 and 20 days after last hand opening.

3.8 Selection of fruits

During harvesting in the month of August the Banana fruits cv. Grand Naine were selected from Fruit Research Station, Navsari Agricultural University, Gandevi. Bunches of uniform size having cylindrical or nearly cylindrical shape were selected. The bunches contained green, unripe and clean fruits free from scratches, sun burns and fungal or insect damage reaching 70-75% maturity were selected from each treatment for post harvest study.

3.9 Method of storage

The fruits were kept at ambient temperature for ripening in the laboratory of Agricultural Chemistry, ASPEE college of Horticulture and Forestry, Navsari Agricultural University, Navsari having aeration for recording the required observations.

3.10 Chemical analysis

A portion of the pulp from the middle of the fruits was used as per the procedure of Desai and Despande (1975). Fruit pulp was homogenized in a blender and used for chemical analysis.

3.11 Observations recorded

During the storage period, the following observations were recorded at an interval of 3 days up to ripening of fruits.

3.11.1 Physical parameters

1. Ripe fruit percentage
2. Average no. of days taken to ripeness
3. Marketable fruit percentage
4. Fruit texture (kg/cm^2)
5. Weight loss due to ripening (%)

3.11.2 Chemical parameters

1. Total soluble solids (^{0}Brix)
2. Titrable acidity (%)
3. Reducing sugar (%)
4. Non-reducing sugar (%)
5. Total sugar (%)
6. Sugar : Acid ratio (%)
7. Ascorbic acid (Vitamin-C) content (mg/100 g pulp)

3.12 Methodology adopted for recording observation

3.12.1 Ripe fruit percentage

The number of fruits that attained eating ripeness (fruit with greenish yellow colour and soft texture) were counted

periodically and expressed as percentage over total number of fruits.

3.12.2 Average number of days taken to ripeness

The number of days taken in each treatment to attain eating ripeness by all the fruits present in an experimental unit was computed considering the weighted mean.

3.12.3 Marketable fruit percentage

The number of visible sound fruits that could be marketed were counted and expressed as percentage over the total number of fruits.

3.12.4 Fruit texture (kg/cm^2)

The hardiness of the fruit was tested by means of a pocket penetrometer (Fruit Tester FT 327). One fruit was selected and the penetrometer was pierced through the fruit and the pressure required was recorded in kilograms per square centimeter. Each time punctures were made at two locations on fruit surface and their average was considered.

3.12.5 Weight loss due to ripening (%)

Banana hands were weighted on the first day of treatment and their weight was recorded. Subsequently at 3 days interval, their weights was recorded and the loss in weight was expressed as percentage over the initial weight.

3.12.6 Total soluble solids (^{0}Brix)

The total soluble solids of the pulp were recorded by using a hand refrectometer (0-32^{0}Brix). In each treatment, the readings were taken and their average was considered as results.

3.12.7 Acidity (%)

The method described by Ranganna (1979) was adopted for estimation of titrable acidity. The weighted amount of pulp was transferred to a volumetric flask and the volume was made up with distilled water to a known amount. After waiting for thirty minutes, the suspension was filtered through whatman No. 1 filter paper and the filtrate was titrated against standard sodium hydroxide using phenolphthalein as an indicator. Titrable acidity was expressed as percentage malic acid equivalent adopting the following formula;

$$\text{Titrable Acidity \% (as maleic acid)} = \frac{\text{Titre x Normality of alkali}}{\text{Volume of sample tekan for estimation}} \times \frac{\text{Volume made up}}{\text{Weight of sample}} \times \frac{\text{Eq. wt. of maleic acid}}{1000} \times 100$$

3.12.8 Reducing sugar (%)

The titerametic method of Lane and Eynon described by Ranganna (1979) was adopted for estimation of reducing sugars. The method is based on the principle that invert sugar or reducing sugar reduces the copper in the Fehling's solution to red insoluble cuprous oxide. The quantity of sugar in a sample was estimated by determining the volume of unknown sugar solution requires to completely reducing a major volume of Fehling's solution. Before using the mixture (1:1) of Fehling's solution A and B was

standardized against standard glucose for obtaining glucose equivalent and to arrive at a conversion factor.

Procedure

A weighed (20gm) amount of the pulp was taken in a volumetric flask and 2 milliliter of 45 per cent basic lead acetate solution was added for clarification. After 10 minutes, the solution was deleaded by adding potassium oxalate crystal in excess (added till excess of crystals remained undissolved) and the volume was made up to a known amount with distilled water and filtered through Whatman No. 1 filter paper. The filtrate was taken in a burette and titrate against boiling Fehling's mixture (5 ml of Fehling's Solution A + 5 ml of Fehling's solution B) till the blue colour faded. Then 1 ml of methylene blue indicator (1%) was added and the titration was continued till the contents attained a brick red colour and titer value was noted. The percentage of reducing sugar was calculated according to the formula:

$$\text{Reducing sugar (\%)} = \frac{\text{Glucose eq. (0.05)}}{\text{Titre}} \times \frac{\text{Total volume made up}}{\text{Weight of pulp}} \times 100$$

3.12.9 Total sugar (%)

For estimation of total sugar, the filtrate obtained in the above estimation was used. An aliquot from filtrate was taken and to one-fifth of its volume, hydrochloride acid (1:1) was added and the inversion was carried out at room temperature for 24 hours. Subsequently, the content were cooled and neutralized with 40 per cent sodium hydroxide using phenolphthalein as an indicator and the final volume was made. The solution was filtrated through

Whatman No.1 filter paper and titration was carried out using filtrate as detailed for reducing sugar.

The total sugar content was expressed as percentage in term of invert sugars according to the formula:

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

3.12.10 Sugar: acid ratio

From the recorded data of total sugar and acidity, the sugar: acid ratio of the fruit was calculated by dividing the respective data.

3.12.11 Ascorbic acid (Vitamin-C) content (mg/100 g pulp)

Titrimetric method described by Ranganna (1979) was adopted for estimation of the ascorbic acid.

Procedure

Ten grams of homogenized pulp was taken and transferred to 100 ml volumetric flask. The volume was made up with 4% oxalic acid solution. After 30 minutes, the suspension was filtered through Whatman No.1 filter paper. Before actual titration the 2,6-Dichlorophenol indophenol (Dye solution) was standardized by titrating against standard ascorbic acid solution and the dye factor was calculated. Five ml of the aliquot was taken from the filtrate and titrate against standardized dye solution through a burette. The titration was continued till the light pink colour persisted for 15

seconds. The ascorbic acid content was calculated adopting the following formula.

$$\text{Mg of ascorbic acid/100 g Pulp} = \frac{\text{Titrate x Dye factor x Volume Madeup}}{\text{Aliquot of extract taken for estimation} \times \text{Weight or volume of sample taken for estiamtion}} \times 100$$

3.13 Statistical analysis

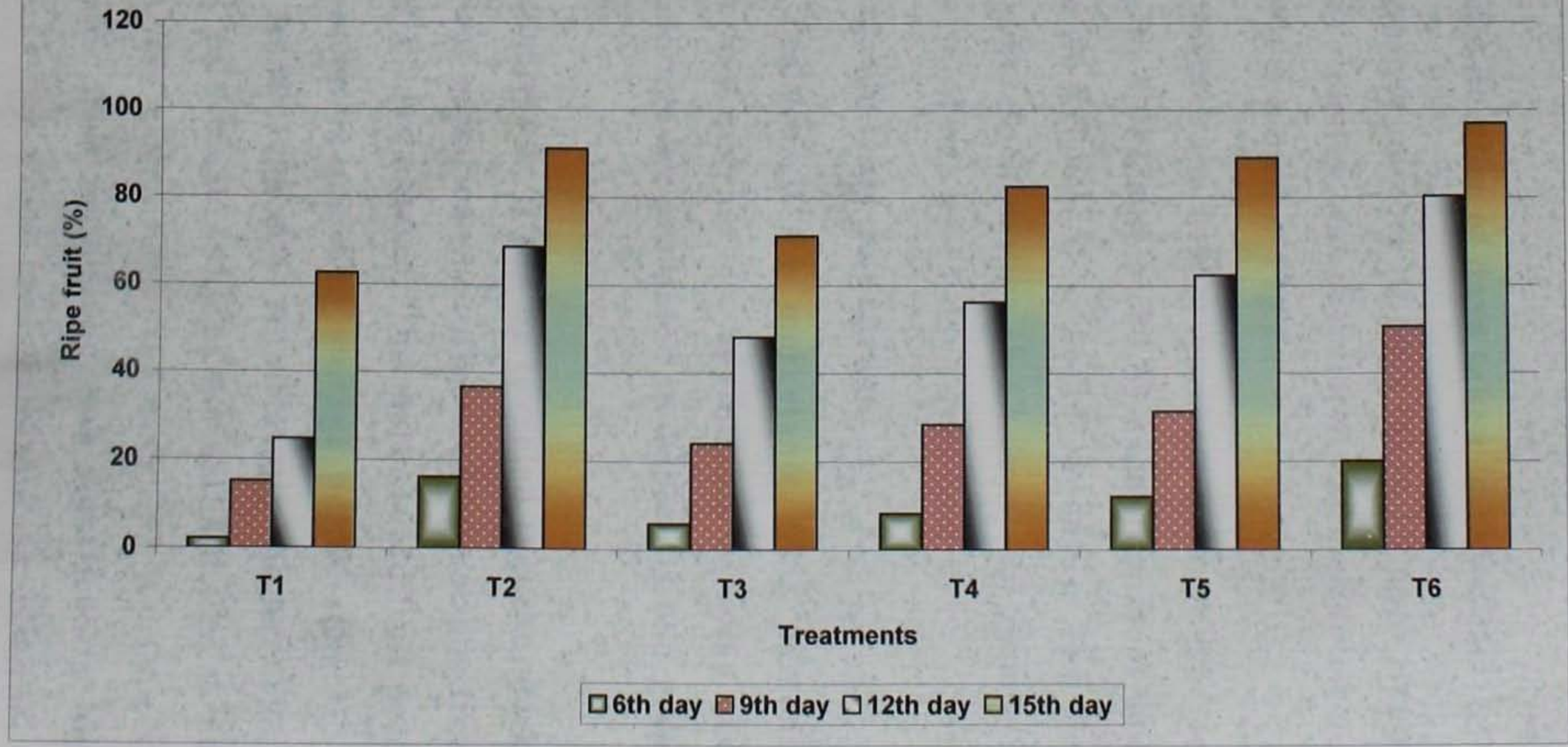
The data collected were analyzed statistically as per the procedure described for Randomized Block Design (RBD) by Panse and Sukhatme (1967) and the treatment means were compared by means of critical differences at 5 per cent level. The data were subjected to statistical analysis on the Department of Agricultural Statistics, N.M. College of Agriculture, Navsari Agricultural University, Navsari.

EXPERIMENTAL RESULTS

Table: 4.1: Effect of pre-harvest application of some chemicals on ripe fruit percentage during storage of banana fruits cv. Grand Naine

Treatments	Ripe fruit (%)			
	6th day	9th day	12th day	15th day
T_1- CPPU 4ppm	2.12	15.17	24.78	62.63
T_2- 2, 4-D 10ppm	16.20	36.73	68.69	91.23
T_3- KH_2PO_4 0.5 %	5.92	24.16	48.25	71.30
T_4- KNO_3 0.5 %	8.30	28.43	56.24	82.63
T_5- K_2SO_4 0.5 %	12.10	31.37	62.30	89.10
T_6- Control	20.12	50.69	80.33	96.97
S.Em. ±	0.114	0.739	1.563	1.513
C.D. at 5%	0.34	2.23	4.71	4.56
C.V.%	2.10	4.75	5.51	3.68

Fig.-1 : Effect of pre harvest application of some chemicals on ripe fruit percentage during storage of banana fruits Cv. Grand Naine



4.1.2 Average number of days taken to ripeness.

The average number of days taken by each treatment to attain 100 percent ripening was calculated and presented in Table-4.2 and graphically depicted in Fig.2.

Significantly the higher numbers of days was recorded for total ripening by CPPU 4ppm (19.33 days) treatment which was remain at par with KH_2PO_4 0.5 % (18.33 days). The untreated fruits (control) were ripen earlier (8.17 days). In general, CPPU 4ppm extends the shelf life by 11 days over control.

4.1.3 Marketable fruit percentage.

Data concerning the marketable fruit percentage as influenced by various pre-harvest application of some chemicals recorded during storage are presented in Table-4.3 and graphically depicted in fig.3.

From Table-4.3, it can be revealed that the markeTable fruit percentage was significantly influenced by various treatments at all stages from 3rd day onward. The markeTable fruit percentage was declined with an increase in storage period. On 3rd day of storage, CPPU 4ppm recorded significantly higher (95.33 %) markeTable fruit percentage, which was statistically at par with KH_2PO_4 0.5 % (92.86 %) and KNO_3 0.5 % (90.33 %). On 6th day of storage, markeTable fruit percentage was significantly higher in CPPU 4ppm (87.13 %) which was followed by KH_2PO_4 0.5 % (78.33 %). The similar trend was observed on 9th and 12th day of

Table: 4.2: Effect of pre-harvest application of some chemicals on Average numbers of days taken to ripeness during storage of banana fruits cv. Grand Naine

Treatments	Average No. of days taken to ripeness
T_1- CPPU 4ppm	19.33
T_2- 2, 4-D 10ppm	13.67
T_3- KH_2PO_4 0.5 %	18.33
T_4- KNO_3 0.5 %	16.67
T_5- K_2SO_4 0.5 %	14.33
T_6- Control	8.17
S.Em. ±	0.410
C.D. at 5%	1.24
C.V.%	5.44

Fig.-2 : Effect of pre harvest application of some chemicals on average number of days taken to ripening during storage of banana fruits Cv. Grand Naine

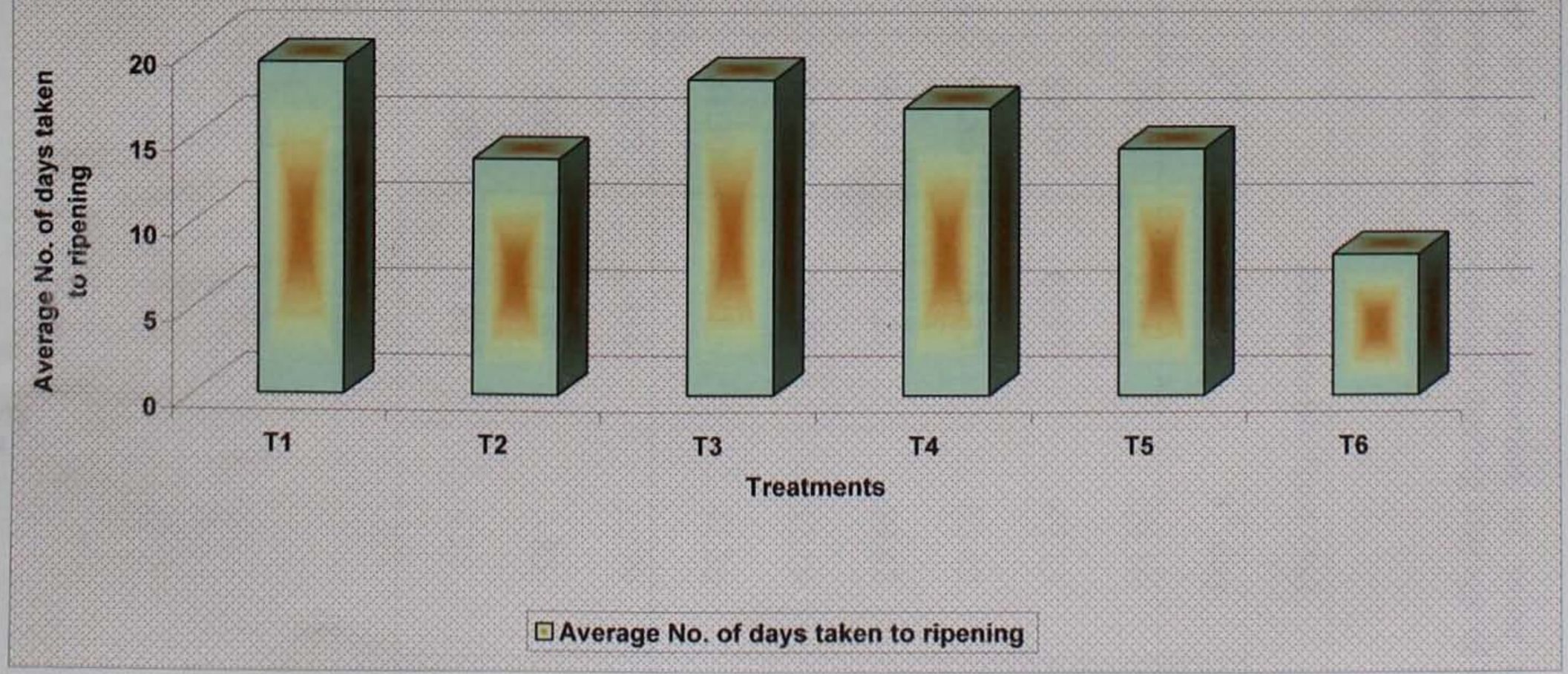
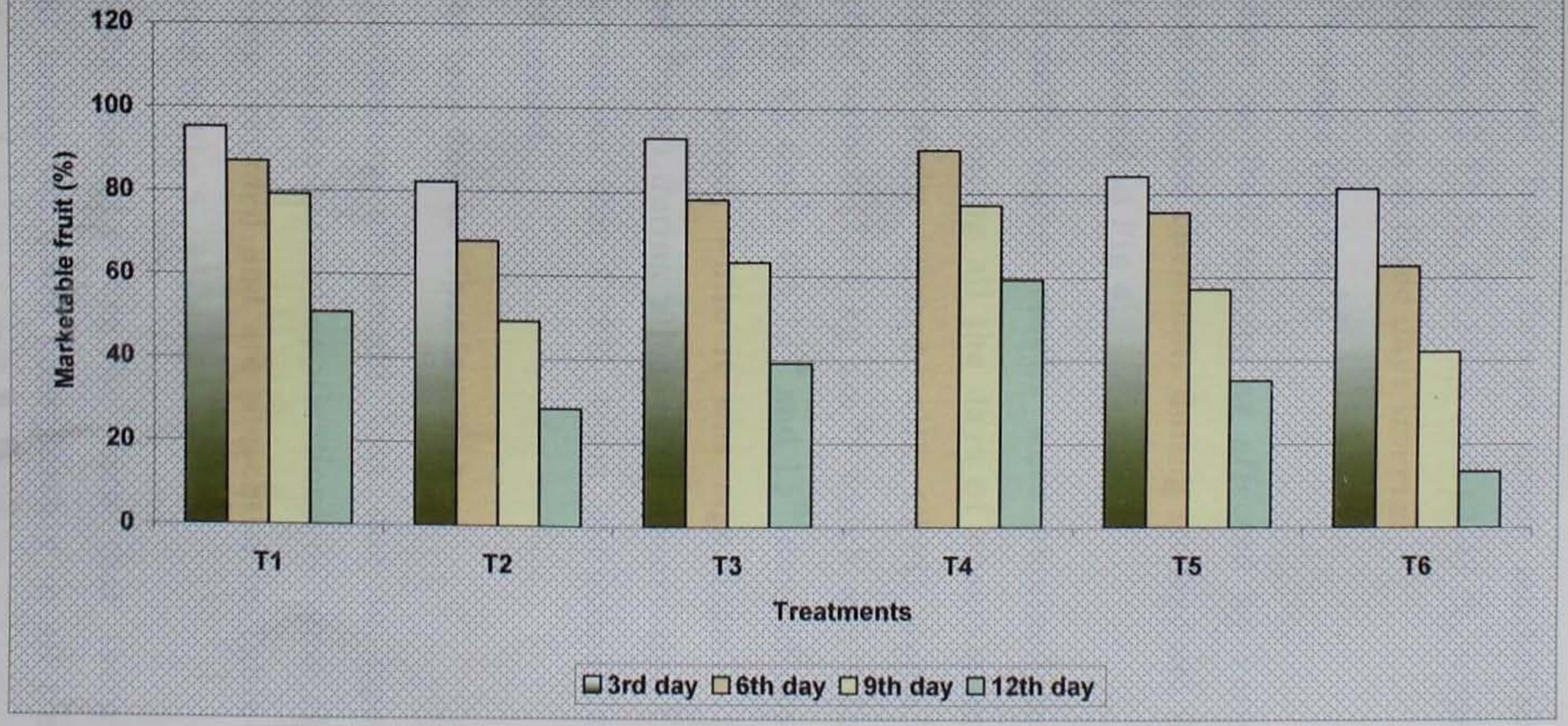


Table: 4.3: Effect of pre-harvest application of some chemicals on marketable fruit percentage during storage of banana fruits cv. Grand Naine

Treatments	Marketable fruit (%)			
	3rd day	6th day	9th day	12th day
T_1- CPPU 4ppm	95.33	87.13	79.16	50.88
T_2- 2, 4-D 10ppm	82.10	68.17	49.13	28.29
T_3- KH_2PO_4 0.5 %	92.86	78.33	63.42	39.29
T_4- KNO_3 0.5 %	90.33	77.21	59.42	37.33
T_5- K_2SO_4 0.5 %	84.23	75.58	57.19	35.33
T_6- Control	81.30	62.83	42.36	13.43
S.Em. ±	1.877	1.454	1.279	0.776
C.D. at 5%	5.66	4.38	3.85	2.32
C.V.%	4.28	3.88	4.38	4.51

Fig.-3 : Effect of pre harvest application of some chemicals on marketable fruit percentage during storage of banana fruits Cv. Grand Naine



storage. Under control fruits showed lower markeTable fruit percentage (81.30 %, 62.83 %, 42.36 % and 13.43 %, respectively) on all days of observation at three days interval.

4.1.4 Fruit texture (kg cm^{-2})

The data on fruit texture as affected by various pre-harvest application of some chemicals during storage are furnished in Table-4.4 and depicted in Fig.4.

Significantly higher results were obtained in treated fruits for fruit texture during all the days of observation. On 9^{th} day of observation, fruits treated with CPPU 4ppm showed significantly higher values (7.14 kg cm^{-2}) which was followed by KH_2PO_4 0.5 % (6.76 kg cm^{-2}). On 12^{th} and 15^{th} days of observation similar results were noted, while it was significantly lower in control (untreated fruits) during all days of observation. It clears from these observations that CPPU 4ppm maintained the fruit texture for longer period.

4.1.5 Weight loss due to ripening (%)

The particulars of weight loss due to ripening as influenced by various pre-harvest applications of some chemicals during storage were recorded and are presented in Table-4.5 and graphically depicted in Fig.5.

From the result it can be seen that there was a significant weight losses increased considerably in all treatments with an increase in storage period. However, the increase had been at a reduced rate in all the treated fruits as compared to control.

Table: 4.4: Effect of pre-harvest application of some chemicals on fruit texture (kg cm^{-2}) during storage of banana fruits cv. Grand Naine

Treatments	Fruit texture (kg cm^{-2})		
	9th day	12th day	15th day
T_1- CPPU 4ppm	7.14	5.21	1.79
T_2- 2, 4-D 10ppm	5.70	4.30	1.38
T_3- KH_2PO_4 0.5 %	6.76	4.81	1.65
T_4- KNO_3 0.5 %	6.11	4.80	1.55
T_5- K_2SO_4 0.5 %	5.80	4.75	1.43
T_6- Control	4.08	3.33	0.79
S.Em. ±	0.120	0.097	0.041
C.D. at 5%	0.36	0.29	0.12
C.V.%	4.03	4.28	5.75

Fig.-4 : Effect of pre harvest application of some chemicals on fruit texture (kg cm^{-2}) during storage of banana fruits Cv. Grand Naine

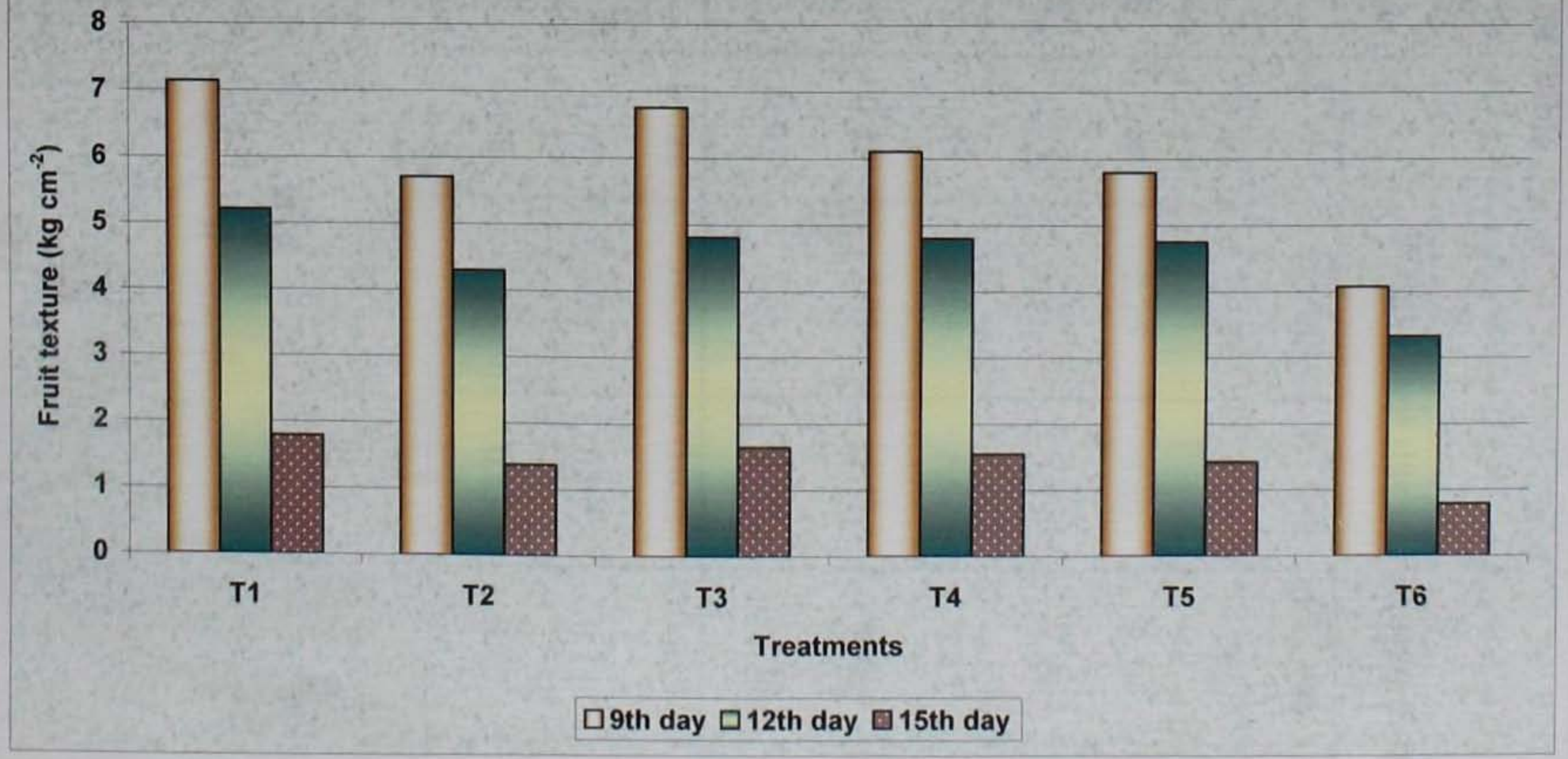
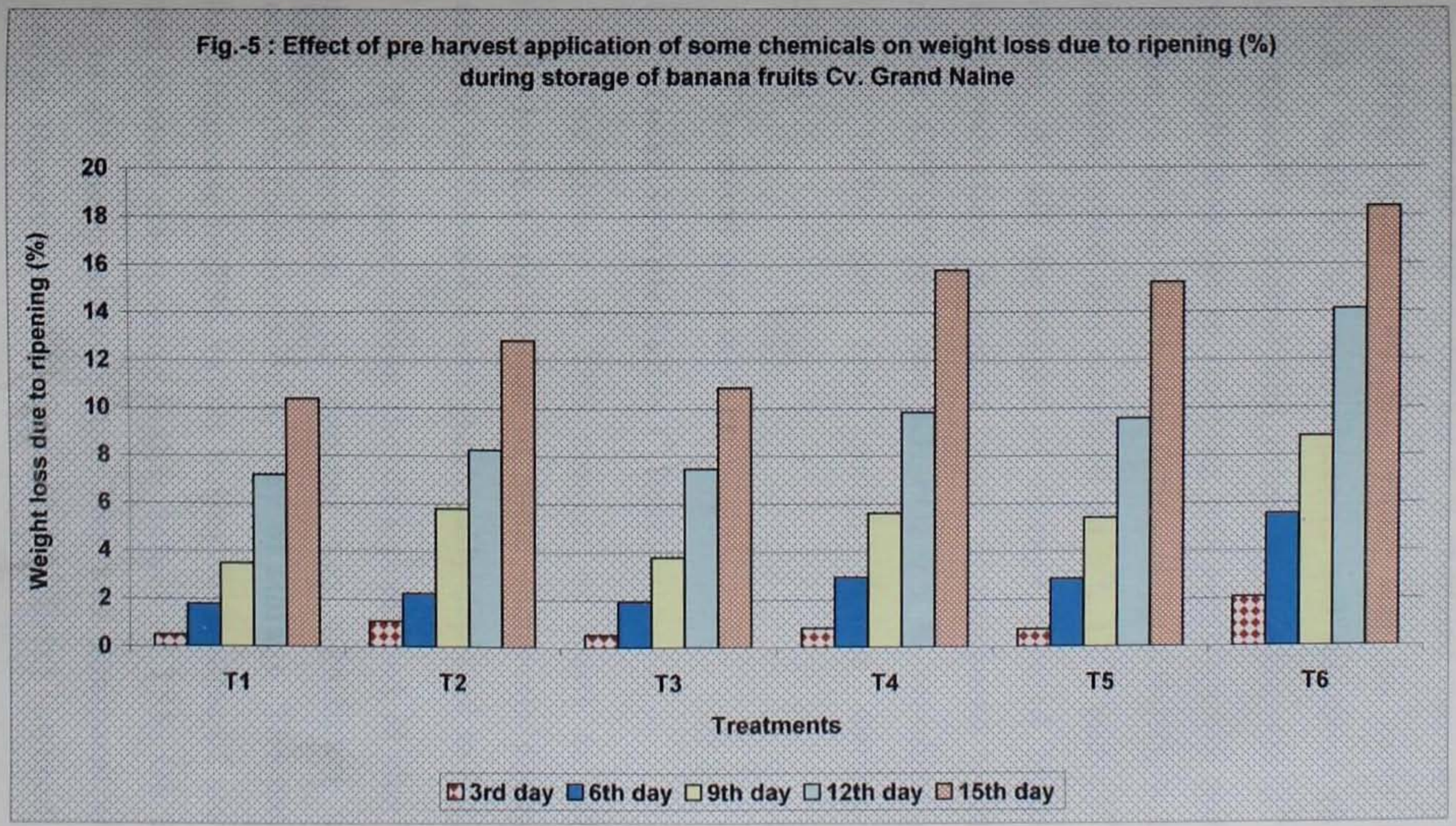


Table: 4.5: Effect of pre-harvest application of some chemicals on weight, loss due to ripening (%) during storage of banana fruits cv. Grand Naine

Treatments	Weight Loss due to ripening (%)				
	3rd day	6th day	9th day	12th day	15th day
T_1- CPPU 4ppm	0.49	1.78	3.49	7.20	10.39
T_2- 2, 4-D 10ppm	1.08	2.25	5.80	8.26	12.82
T_3- KH_2PO_4 0.5 %	0.55	1.92	3.78	7.47	10.86
T_4- KNO_3 0.5 %	0.81	2.94	5.62	9.83	15.75
T_5- K_2SO_4 0.5 %	0.75	2.85	5.42	9.56	15.25
T_6- Control	2.07	5.56	8.81	14.12	18.39
S.Em. ±	0.022	0.027	0.023	0.035	0.037
C.D. at 5%	0.07	0.08	0.07	0.11	0.11
C.V.%	4.68	1.85	0.83	0.75	0.54

Fig.-5 : Effect of pre harvest application of some chemicals on weight loss due to ripening (%) during storage of banana fruits Cv. Grand Naine



From the Table, further it is revealed that on 3rd days of storage, CPPU 4ppm (0.49 %), which was on same bar with KH_2PO_4 0.5 % (0.55 %), was effective and minimize the weight loss as compare to control and other treatments. On 6th days of storage, weight loss due to ripening was significantly minimum in CPPU 4ppm (1.78 %) which was followed by KH_2PO_4 0.5 % (1.92 %). The similar trend was obtained on 9th, 12th, and 15th days of observation. At all the stages of storage, treated fruits showed significant reduction in weight losses as compared to control. In general, the CPPU 4ppm and KH_2PO_4 0.5 % recorded minimum 10.39 and 10.86 per cent weight losses during storage, respectively.

4.2 Chemical parameters

4.2.1 Total Soluble Solids (^{0} Brix)

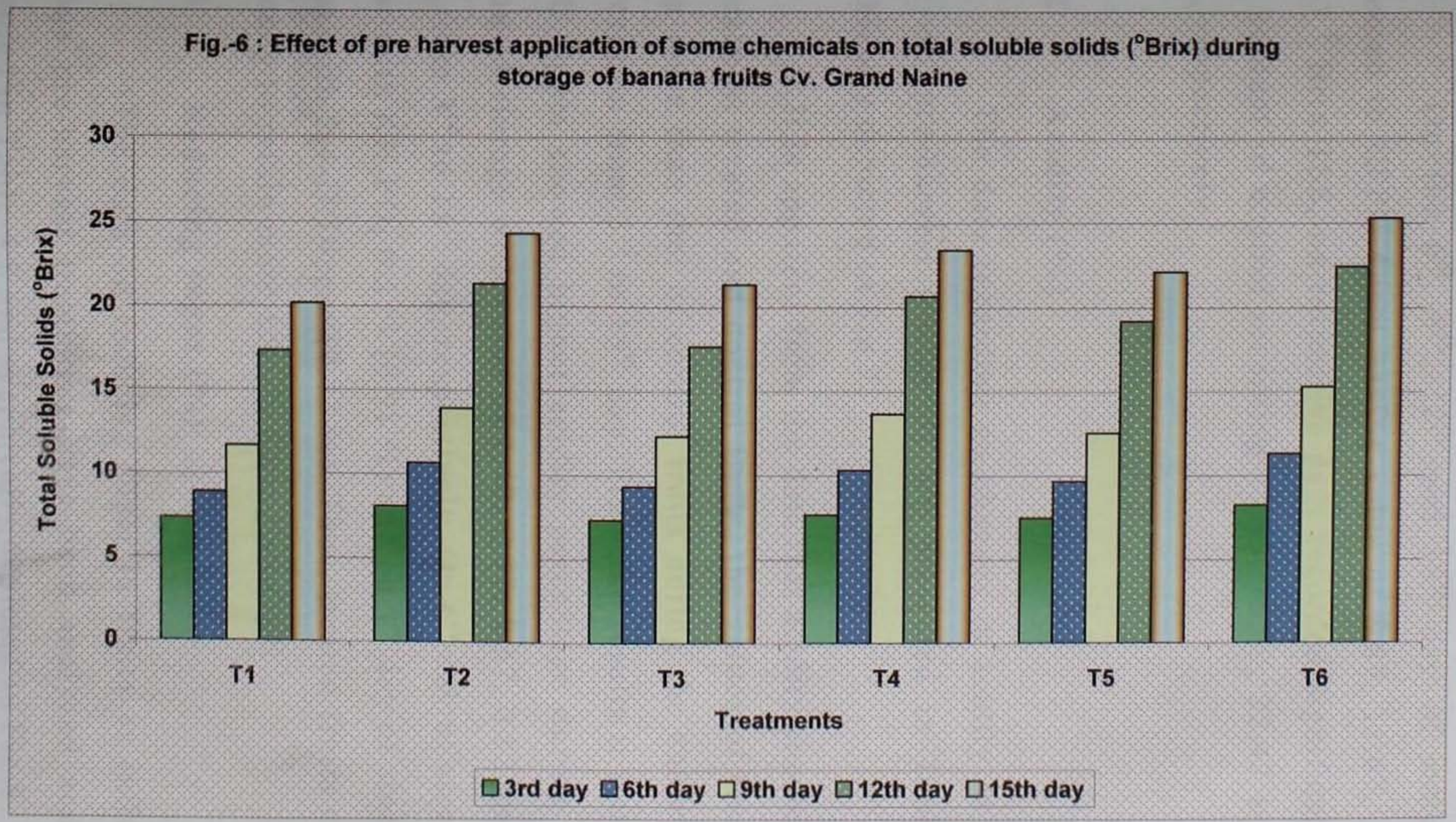
The change in TSS content of fruits as affected by various pre-harvest application of some chemicals during storage are presented in Table-4.6 and graphically depicted in Fig.6.

It is apparent from the data presented in the Table-4.6 that the difference in TSS content was significant under the influence of the treatments on all day of storage. The data showed a constant increase in TSS values during the course of storage with untreated control maintaining higher values of TSS. On 3rd day of storage, in all the treatments, the TSS was comparatively lower than control. However, CPPU 4ppm (7.33 ^{0} Brix) lowered the value of TSS against all the treatments.

Table: 4.6: Effect of pre-harvest application of some chemicals on total soluble solids (^{0}Brix) during storage of banana fruits cv. Grand Naine

Treatments	Total Soluble Solids (^{0}Brix)				
	3rd day	6th day	9th day	12th day	15th day
T_1- CPPU 4ppm	7.33	8.89	11.67	17.34	20.17
T_2- 2, 4-D 10ppm	8.08	10.67	13.93	21.33	24.33
T_3- KH_2PO_4 0.5 %	7.34	9.33	12.33	17.67	21.36
T_4- KNO_3 0.5 %	7.67	10.33	13.68	20.67	23.42
T_5- K_2SO_4 0.5 %	7.49	9.67	12.56	19.18	22.12
T_6- Control	8.26	11.33	15.32	22.47	25.33
S.Em. ±	0.109	0.143	0.282	0.556	0.440
C.D. at 5%	0.33	0.43	0.85	1.68	1.33
C.V.%	2.83	2.85	4.26	5.62	3.86

Fig.-6 : Effect of pre harvest application of some chemicals on total soluble solids (°Brix) during storage of banana fruits Cv. Grand Naine



On the 6th, 9th, 12th and 15th day of storage fruits subjected to CPPU 4ppm having value of 8.89, 11.67, 17.34 and 20.17 ^{0} Brix TSS, on respective days recorded significantly lower TSS content in control recording 11.33, 15.32, 22.47 and 25.33 ^{0} Brix, respectively.

4.2.2 Acidity (%)

The data regarding on changes in acidity in banana to different pre-harvest treatments are presented in Table-4.7 and graphically depicted in Fig.7.

It is apparent from the data that acidity showed constant decrease in treated and control fruits, the values of treated fruits being more than that of control fruits during the entire period of observation from 3rd to 15th day. From the results it was seen that CPPU 4ppm showed higher acidity percentage during the entire period of storage with value of 1.48, 0.97, 0.87, 0.82 and 0.62 per cent from 3rd to 15th day, respectively. On 6th day of storage it was at par with KH_2PO_4 0.5 % (0.91 %) and on 9th day of storage it was at par with 2,4-D 10ppm (0.83 %). Thus, treated fruits exhibited a tendency to retain more acidity during storage.

4.2.3 Reducing sugar (%)

The data on reducing sugar in fruits as influenced by various pre-harvest treatments have been analyzed and data are presented in Table-4.8 and graphically depicted in Fig.8.

Table: 4.7: Effect of pre-harvest application of some chemicals on acidity (%) during storage of banana fruits cv. Grand Naine

Treatments	Acidity (%)				
	3rd day	6th day	9th day	12th day	15th day
T_1- CPPU 4ppm	1.48	0.97	0.87	0.82	0.62
T_2- 2, 4-D 10ppm	1.23	0.89	0.81	0.75	0.52
T_3- KH_2PO_4 0.5 %	1.33	0.91	0.83	0.78	0.58
T_4- KNO_3 0.5 %	0.82	0.76	0.67	0.61	0.42
T_5- K_2SO_4 0.5 %	0.92	0.86	0.72	0.68	0.48
T_6- Control	0.52	0.46	0.41	0.37	0.32
S.Em. ±	0.023	0.020	0.020	0.019	0.011
C.D. at 5%	0.07	0.06	0.06	0.06	0.03
C.V.%	4.32	5.02	5.45	5.74	4.50

Fig.-7 : Effect of pre harvest application of some chemicals on acidity (%) during storage of banana fruits Cv. Grand Naine

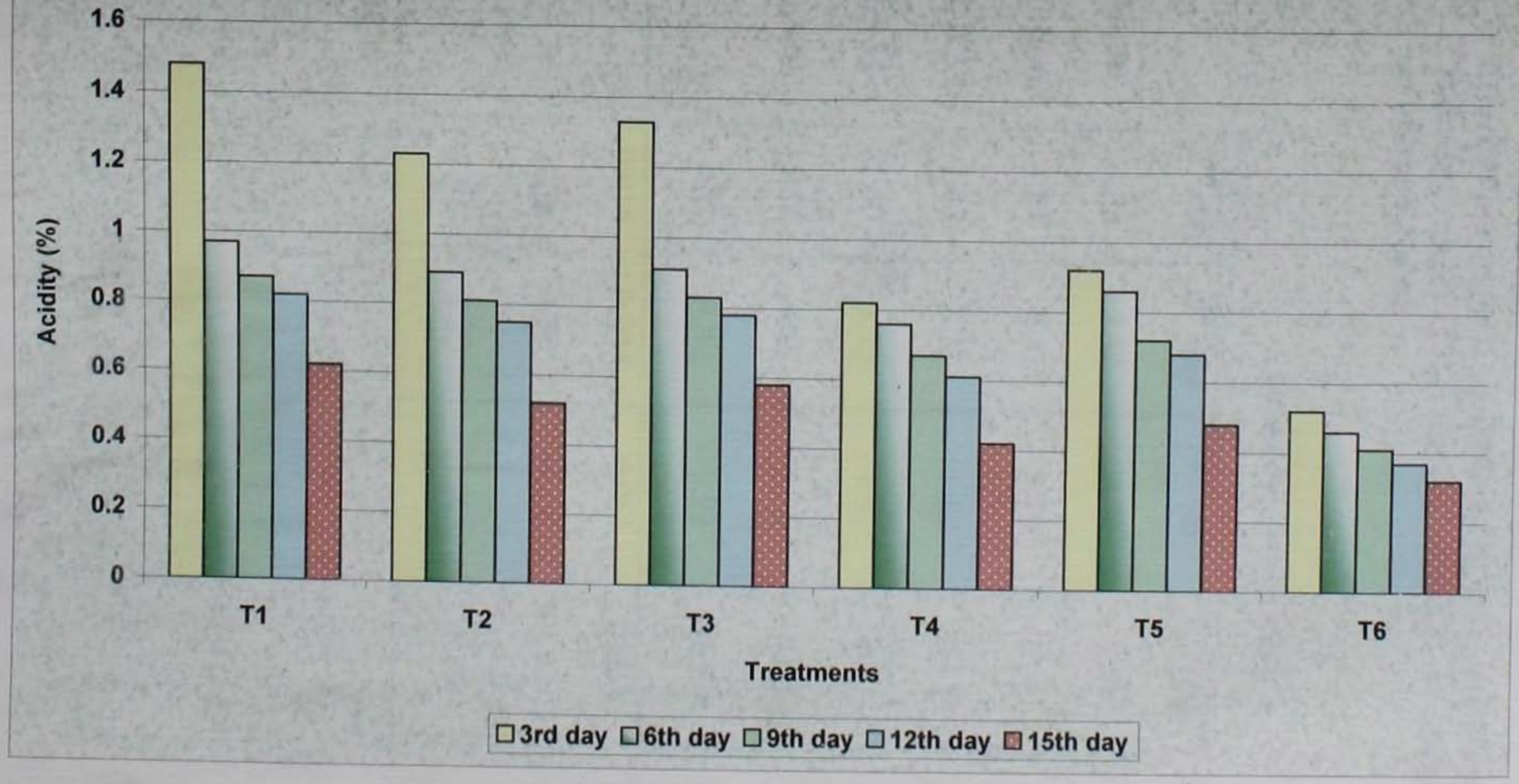
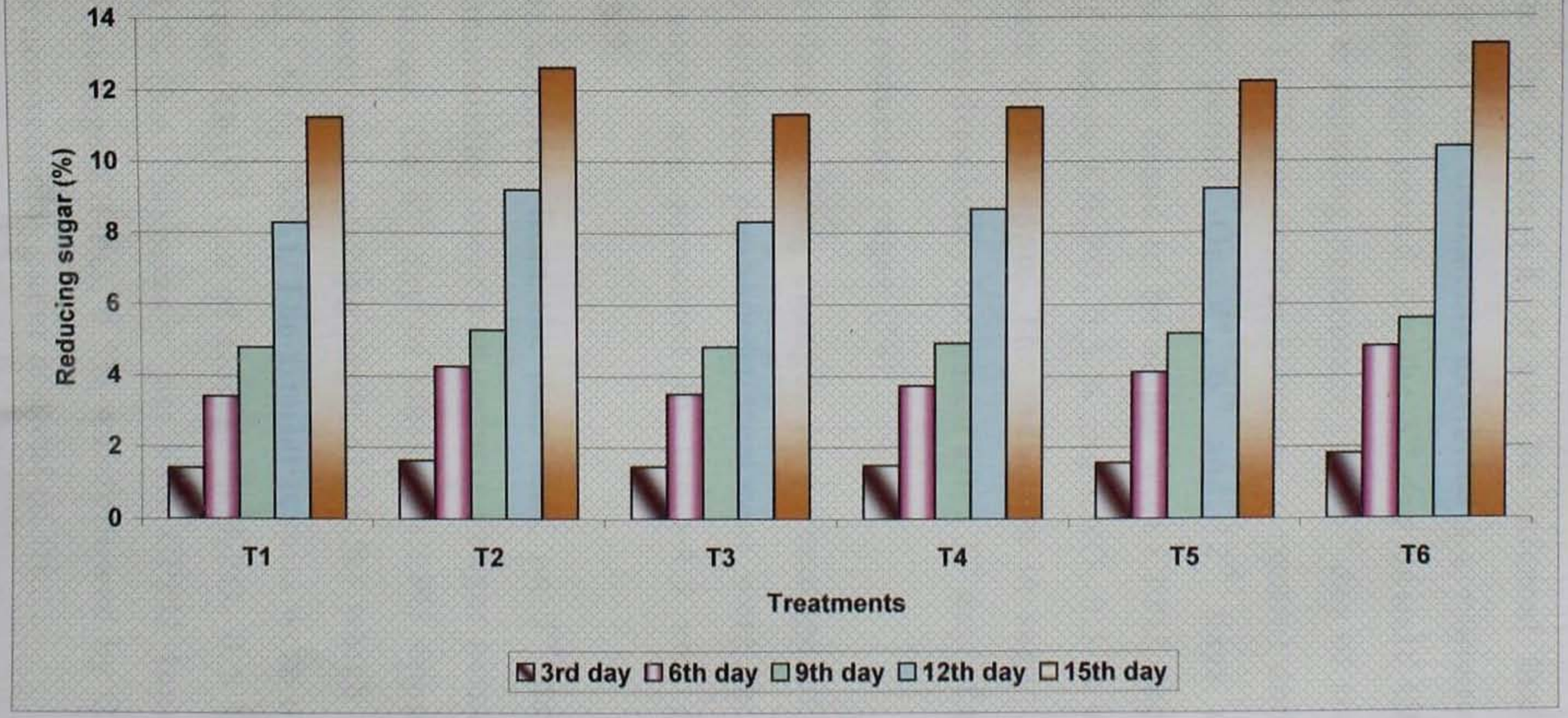


Table: 4.8: Effect of pre-harvest application of some chemicals on reducing sugar (%) during storage of banana fruits cv. Grand Naine

Treatments	Reducing sugar (%)				
	3rd day	6th day	9th day	12th day	15th day
T_1- CPPU 4ppm	1.43	3.42	4.79	8.29	11.25
T_2- 2, 4-D 10ppm	1.64	4.27	5.29	9.21	12.63
T_3- KH_2PO_4 0.5 %	1.47	3.51	4.82	8.33	11.33
T_4- KNO_3 0.5 %	1.50	3.73	4.92	8.67	11.52
T_5- K_2SO_4 0.5 %	1.57	4.11	5.18	9.23	12.22
T_6- Control	1.82	4.82	5.59	10.39	13.24
S.Em. ±	0.016	0.044	0.051	0.103	0.103
C.D. at 5%	0.05	0.13	0.15	0.31	0.31
C.V.%	2.01	2.20	1.99	2.29	1.71

Fig.-8 : Effect of pre harvest application of some chemicals on reducing sugar (%) during storage of banana fruits Cv. Grand Naine



From the Table-4.8, it can be inferred that reducing sugar content in all the treatments exhibited a continuous increase throughout the storage period. On the 3rd day onward CPPU 4ppm maintaining lower reducing percentage till 15th day of storage with value of 1.43 to 11.25 per cent as compare to control during all the stage of storage period. On 3rd, 6th and 12th days of storage KH_2PO_4 0.5 % were found to be at par with CPPU 4ppm. On 9th and 15th day of storage KH_2PO_4 0.5 % and KNO_3 0.5 % were found to be at par with CPPU 4ppm. The reduction in sugar content of untreated fruit was drastically increased after 3rd day of storage.

4.2.4 Non-reducing sugar (%)

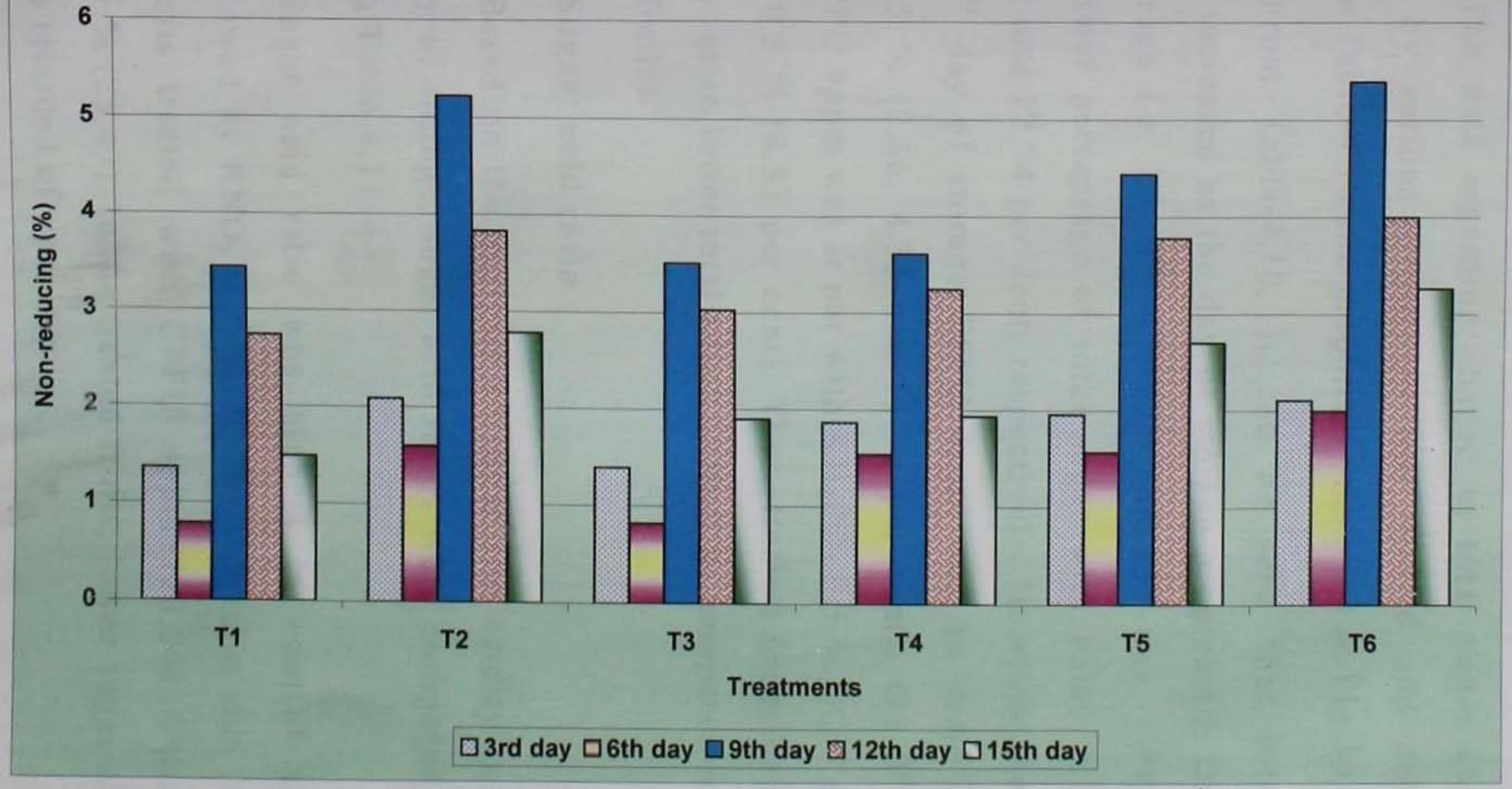
The data showing changes in percentage of acidity in banana due to different pre-harvest treatment were recorded and non-reducing sugar are presented in Table-4.9 and graphically depicted in Fig.9.

It is apparent from the data that, on 3rd day onwards CPPU 4ppm maintaining lower non-reducing sugar percentage, till 15th day of storage. On 3rd day of storage, CPPU 4ppm recorded significantly lower non-reducing sugar (1.36 %) which was at par with KH_2PO_4 0.5 % (1.39 %). The similar results were obtained on 6th day of storage. On 9th day of storage, KH_2PO_4 0.5 % (3.51 %) and KNO_3 0.5 % (3.61 %) were at par with CPPU 4ppm. On 12th and 15th day of storage KH_2PO_4 0.5% was followed by CPPU 4ppm with respect to non-reducing sugar content of fruit.

Table: 4.9 : Effect of pre-harvest application of some chemicals on non-reducing Sugar (%) during storage of banana fruits cv. Grand Naine

Treatments	Non-reducing sugar (%)				
	3rd day	6th day	9th day	12th day	15th day
T_1- CPPU 4ppm	1.36	0.79	3.44	2.74	1.49
T_2- 2, 4-D 10ppm	2.09	1.60	5.22	3.83	2.78
T_3- KH_2PO_4 0.5 %	1.39	0.82	3.51	3.03	1.90
T_4- KNO_3 0.5 %	1.87	1.54	3.61	3.25	1.94
T_5- K_2SO_4 0.5 %	1.96	1.57	4.44	3.78	2.70
T_6- Control	2.11	2.00	5.39	4.00	3.26
S.Em. ±	0.046	0.040	0.071	0.092	0.070
C.D. at 5%	0.14	0.12	0.21	0.28	0.21
C.V.%	5.09	5.74	3.34	5.39	5.95

Fig.-9 : Effect of pre harvest application of some chemicals on non-reducing sugar (%) during storage of banana fruits Cv. Grand Naine



4.2.5 Total sugar (%)

The data regarding change in total sugar content as influenced by various treatments was studied and details are furnished in Table-4.10 and graphically depicted in Fig.10.

From Table-4.10, it can be seen that total sugar percentage increased as the day of storage progressed. On all the day of storage i.e. 3rd, 6th, 9th, 12th and 15th day, CPPU 4ppm recorded lower percentage of total sugar with value 2.78, 4.21, 8.29, 11.03 and 12.74 per cent, respectively. However, on the 3rd, 6th and 12th day of storage CPPU 4ppm was on same bar with KH_2PO_4 0.5 % (2.86, 4.33 and 11.36 per cent). On 9th day of storage, CPPU 4ppm was at par with KH_2PO_4 0.5 % (8.33 per cent) and KNO_3 0.5 % (8.53 per cent). Thus, treated fruits exhibited a tendency to retain lower total sugar content as compared to control (untreated fruits).

4.2.6 Sugar: acid ratio

Based on the analysis of sugar and acidity content on the 15th day of storage, sugar acid ratios were computed and are presented in Table-4.11.

Sugar acid ratio was highest in control treatment (52.07) followed by KNO_3 0.5 % (32.28).The ratio was lowest in case of fruits treated with CPPU 4ppm (20.56) followed by KH_2PO_4 0.5 % (25.47). In the treated fruits, lower sugar acid ratio suggests the retarded of ripening.

Table: 4.10 : Effect of pre-harvest application of some chemicals on total sugar (%)during storage of banana fruits cv. Grand Naine

Treatments	Total sugar (%)				
	3rd day	6th day	9th day	12th day	15th day
T_1- CPPU 4ppm	2.78	4.21	8.29	11.03	12.74
T_2- 2, 4-D 10ppm	3.73	5.87	10.51	13.04	15.41
T_3- KH_2PO_4 0.5 %	2.86	4.33	8.33	11.36	13.23
T_4- KNO_3 0.5 %	3.36	5.27	8.53	11.91	13.46
T_5- K_2SO_4 0.5 %	3.53	5.67	9.62	13.02	14.92
T_6- Control	3.93	6.82	10.98	14.39	16.50
S.Em. ±	0.045	0.061	0.146	0.165	0.144
C.D. at 5%	0.14	0.18	0.44	0.50	0.43
C.V.%	2.67	2.28	3.11	2.65	2.01

Fig.-10 : Effect of pre harvest application of some chemicals on total sugar (%) during storage of banana fruits Cv. Grand Naine

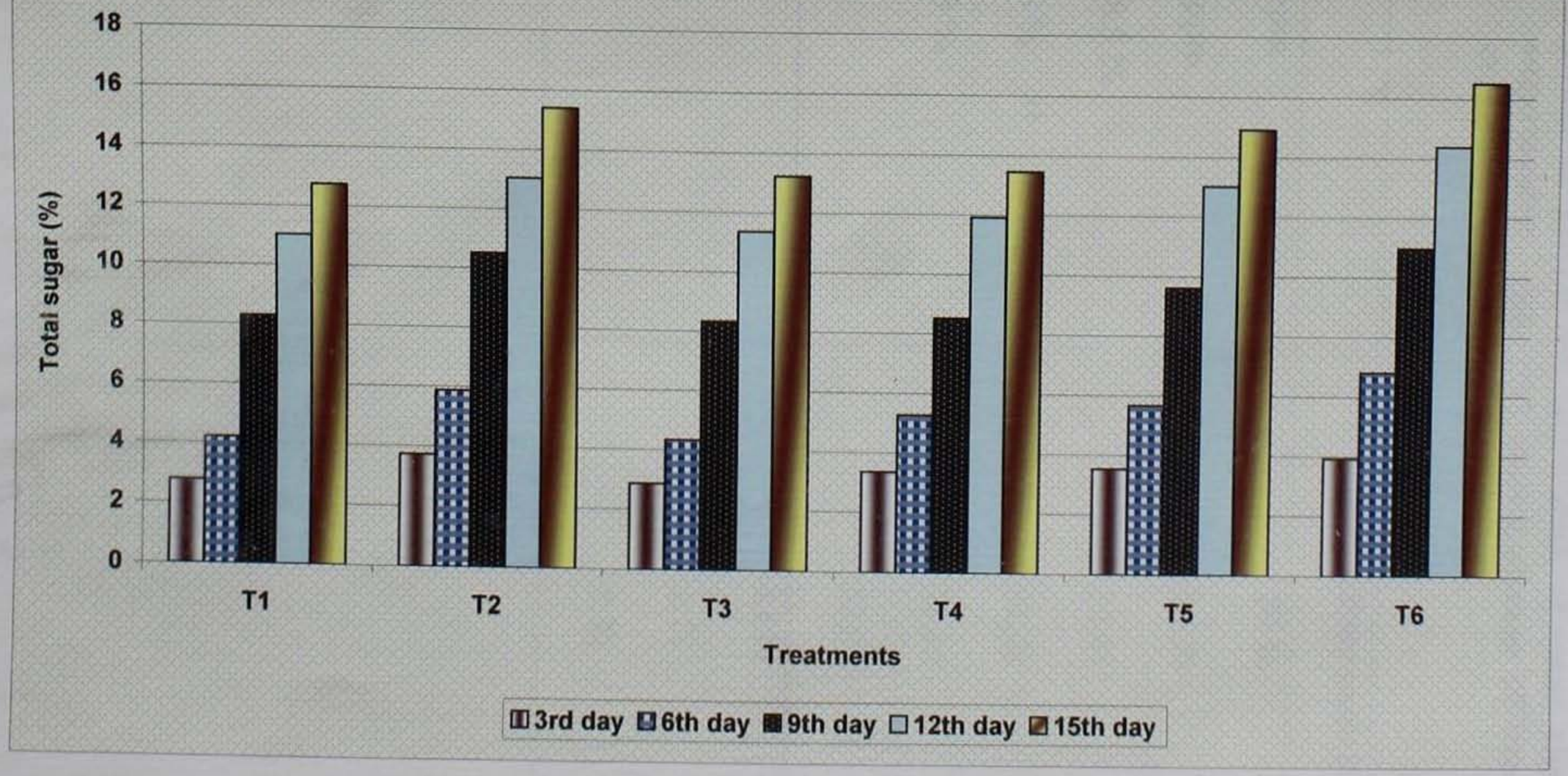


Table: 4.11 : Effect of pre-harvest application of some chemicals on sugar:acidity ratio (%) during storage of banana fruits cv. Grand Naine

Treatments	sugar: acidity ratio (%)
T_1- CPPU 4ppm	20.56
T_2- 2, 4-D 10ppm	26.50
T_3- KH_2PO_4 0.5 %	25.47
T_4- KNO_3 0.5 %	32.28
T_5- K_2SO_4 0.5 %	31.16
T_6- Control	52.07
S.Em. ±	0.899
C.D. at 5%	2.71
C.V.%	5.74

4.2.7 Ascorbic Acid content (mg $100g^{-1}$)

The data on changes in ascorbic acid content in banana due to different pre-harvest treatments are presented in Table-4.12.There was a significant difference in ascorbic acid content among the treatments during storage periods.

It is apparent from the data that ascorbic acid content showed constant increase in treated and control fruits, the values of treated fruits being less than that of control fruits during the entire period of observation from 3^{rd} to 15^{th} day. From the Table-4.12, it was seen that CPPU 4ppm showed lower ascorbic acid content during the entire period of storage with value of 12.18, 12.28, 12.33, 12.35 and 12.40 (mg $100g^{-1}$) from 3^{rd} to 15^{th} day, respectively. The ascorbic acid content in 2,4-D, KNO_3 and K_2SO_4 treated fruits was slightly higher than other treatments.

Table: 4.12 : Effect of pre-harvest application of some chemicals on ascorbic acid content (mg/100gm of pulp) during storage of banana fruits cv. Grand Naine

Treatments	Ascorbic acid content				
	3rd day	6th day	9th day	12th day	15th day
T_1- CPPU 4ppm	12.18	12.28	12.33	12.35	12.40
T_2- 2, 4-D 10ppm	12.30	12.38	12.43	12.45	12.48
T_3- KH_2PO_4 0.5 %	12.23	12.30	12.35	12.38	12.43
T_4- KNO_3 0.5 %	12.35	12.38	12.43	12.48	12.50
T_5- K_2SO_4 0.5 %	12.33	12.35	12.40	12.43	12.45
T_6- Control	12.33	12.40	12.45	12.48	12.53
S.Em. ±	0.040	0.029	0.029	0.042	0.044
C.D. at 5%	0.12	0.09	0.09	0.13	0.13
C.V.%	0.65	0.47	0.47	0.67	0.71

DISCUSSION

V. DISCUSSION

An experiment was conducted using some chemicals with the objectives of retarding ripening, extending the shelf life, improving the quality and minimizing the post-harvest losses of banana cv. Grand Naine. The results obtained in this experiment have been discussed in this chapter as under with different subheadings.

5.1 Physical parameters

5.1.1 Ripe fruit percentage

From Table-4.1, it is evident that ripe fruit percentage was slowed down by CPPU 4ppm and KH_2PO_4 0.5 %. The slow rate of ripening was due to the slow rate of respiration was due to retardation of ripening by counteracting the production of ethylene responsible for ripening activity. Hence, the ripening event like hydrolysis of starch and the activity of respiratory enzymes like paroxidase were reduced. Similar results were obtained by Retamales *et al.* (1993) in grapes, Kumar and Reddy (1998) in banana.

5.1.2 Average number of days taken to ripeness

The perusal of data from Table-4.2 indicated that pre-harvest applications of some chemicals significantly increased average number of days taken to ripeness. Fruits treated with CPPU 4ppm took maximum days for ripening which was at par with KH_2PO_4 0.5 %. These treatments extended the ripening period by 11.16 and 10.16 days, respectively over control. The untreated

control fruits ripen earlier than treated ones. This delay in ripening of treated fruits has been the consequence of slow ripening changes like reduced weight loss and other physiological processes. Reduction in respiration and transpiration activities might have reduced the ripening process. These results are in agreement with Rtamales *et al.* (1993) in grapes, Kumar and Reddy (1998) in banana and Joublan *et al.* (1995) in grape.

5.1.3 Marketable fruit percentage

It is evident from the Table-4.3 that marketable fruit percentage were higher in CPPU 4ppm which was followed by KH_2PO_4 0.5 %. This might be due to higher average number of days taken to ripeness and lower ripe fruit percentage during storage. Reduction in respiration and transpiration activities might have reduced the ripening process and shriveling of skin. These treatments significantly affected and the fruits retained at better marketable quality. Similar results were earlier reported by Sugiyama and Yamaki (2000) in Japanese persimmon.

5.1.4. Fruit texture (Kg cm^{-2})

It is clear from the data presented in Table-4.4 that the fruit pressure i.e. texture was found highest in fruits treated with CPPU 4ppm during storage up to 9^{th}, 12^{th} and 15^{th} days period, evidently due to advancement of ripening, senescence and break down in the later case. This might be due to slow ripening process and higher number of days taken to ripeness. This results are in line with the earlier findings of Basak (1999) in apple, Said (2002) in apple and Sabagh *et al.* (2004) in apple.

5.1.4 Weight loss due to ripening (%)

The data shown in Table-4.5 revealed that the weight loss due to ripening of fruits increased with increase of storage period irrespective of any treatments. However, the increase has been at a reduced rate in all the treated fruits as compared to control. Banana is a climacteric fruit in which the climacteric peak starts after harvest, leading to high respiration rate. This might be due to higher fruit texture, average number of days taken to ripening or secondly it may be due to reduction in transpiration of treated fruit. This result is in accordance with the earlier findings of Millan *et al.* (2001).

5.2 Chemical parameters

5.2.1 Total soluble solids (^{0}Brix)

It is evident from results presented Table-4.6 that the TSS content showed an increase during the storage period. The treatment CPPU 4ppm maintained minimum TSS content at the end of storage period. The minimum accumulation of TSS may be due to reduced rate of hydrolysis of starch and delayed ripening with CPPU 4ppm treatment. These finding are in line with and supported by Kim (2006) in kiwifruit and Reynolds *et al.* (1992) in grape, while TSS content was higher in 2,4-D 10ppm and KNO_3 0.5 %. The increase in TSS content of fruits due to enhanced deposition of solids and also more conversion of organic acid to

sugar. Similar results were earlier reported by Barman and Baruah (2003) in banana, Geetha and Nair (2002) in banana, Dutta (2004) in guava, Sharma *et al.* (1990 b) in mango and Singh *et al.* (1981) in guava.

5.2.2 Acidity (%)

The data showing change in percentage of acidity in banana due to different pre-harvest treatments showed a constant decrease during the storage period. At the end of storage period, CPPU 4ppm retained higher percentage of acidity. The decline in acidity may be attributed to utilization of acids in the process of ripening in the presence of reduced supply of sugar as a substrate of respiration which might be due to lower rate of starch degradation during ripening. The higher level of acidity in CPPU 4ppm treated fruits might be due to less utilization of organic acids in respiration due to controlled ripening. These results are in close proximity with the findings of Reynolds *et al.* (1992) in grape.

5.2.3 Reducing sugar (%)

It can be seen from Table-4.8 that the reducing sugar content of banana fruits was increased with increase in storage of fruits. The content of reducing sugar was lower in fruits treated with CPPU 4ppm and KH_2PO_4 0.5 % during storage period. It may be due to less utilization of reducing sugar in the process of respiration. The accumulation of reducing sugar is a function of starch metabolism, which is slowed in treated fruits as compared to control. While, on the other hand fruits treated with 2,4-D 10ppm showed higher reducing sugar but it was significantly higher in

control. This might be due to mobilization of soluble carbohydrates in fruits and more conversion of organic acids to sugar. Similar results were earlier recorded by Barman and Baruah (2003), Barman and Das (2002) and Geetha and Nair (2002).

5.2.4 Non-reducing sugar (%)

It is evident from results presented in Table-4.9 that the contents of non-reducing sugar was lower in fruits treated with CPPU 4ppm and KH_2PO_4 0.5 % during storage period. The possible reasons and findings are same as above discussed in 5.2.3.

5.2.5 Total sugar (%)

From Table-4.10, it can be revealed that the total sugar contents of fruits were increased with increase in storage period. Total sugar content is one of the most important factors. Total sugar was minimum in fruits treated with CPPU 4ppm and KH_2PO_4 0.5 %. In the present study, the level of total sugar showed an increasing trend during storage. This may be due to the consequence of release of sugar by hydrolysis of starch reserve during the later post-harvest stages. The slower rate of acceleration in CPPU 4ppm treated fruits may be due to slower rate of starch hydrolysis and low rate of respiration and oxidation in treated fruits. On the other hand fruits treated with 2,4-D 10ppm showed higher total sugar content. This might be due to mobilization of soluble carbohydrates in fruits and more conversion of organic acids to sugar. These results are in line with the earlier findings of Barman and Baruah (2003), Barman and Das (2002) and Geetha and Nair (2002).

5.2.6 Sugar : acid ratio

It is evident from Table-4.11 that the sugar acid ratio was lower in treated fruits as compared to control on 15th day of storage. The minimum sugar acid ratio was obtained in fruits treated with CPPU 4ppm and KH_2PO_4 0.5 %. The lower sugar acid ratio suggests the slow down the process of ripening in fruits. Reduction in enzymatic activity like paroxidase through decreased level of ethylene may reduce the conversion of starch to sugar.

5.2.7 Ascorbic acid (mg $100g^{-1}$)

The data showing change in ascorbic acid content in banana due to different pre-harvest treatments showed a non significant effect but constant increase during the storage period. At the end of storage period, CPPU 4ppm retained lower content of ascorbic acid. The decline in ascorbic acid may be attributed to utilization of acids in the process of ripening in the presence of reduced supply of sugar as a substrate of respiration which might be due to lower rate of starch degradation during ripening. The lower level of ascorbic acid in CPPU 4ppm treated fruits might be due to less utilization of organic acids in respiration due to controlled ripening. These results are in close proximity with the findings of Kim *et al.* (2006) in kiwifruit and GuoRong *et al.* (2005) in Jiro.

SUMMARY AND CONCLUSION

VI. SUMMARY AND CONCLUSION

The present investigation on "Effect of pre-harvest application of some chemicals on banana [*Musa paradisica* L.] fruit cv. Grand Naine " was conducted at Fruit Research Station, Gandevi, Navsari Agricultural University, Navsari (Gujarat) and fruits were bring to P.G. Laboratory, Department of Horticulture, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari (Gujarat) for further evaluation during the year 2006-07. The experiment was laid out in Randomized Block Design with four replications, comprising of five chemicals viz., CPPU (4ppm), 2,4-D (10ppm), KH_2PO_4 (0.5 %), KNO_3 (0.5 %) and K_2SO_4 (0.5 %) and control.

The salient features of the results obtained are being summarized below:

1. The ripe banana fruit percentage was significantly affected by the treatments at all stages of storage period. In general it could be observed that the ripe fruit percentage was slowed down by CPPU (4ppm) and KH_2PO_4 (0.5 %) and was accelerated in 2,4-D (10ppm) and control fruits.

2. The treatment CPPU (4ppm) and KH_2PO_4 (0.5 %) treatments significantly extend the average number of days taken to ripeness of banana cv. Grand Naine fruits during storage over control.

3. In the present investigation marketable fruit percentage of banana cv. Grand Naine was significantly higher in fruits treated with CPPU (4ppm) and KH_2PO_4 (0.5 %) while it was lower in untreated fruits during storage.

4. The fruit texture can be maintained for a longer period by CPPU (4ppm) and followed by KH_2PO_4 (0.5 %) during storage.

5. In case of weight loss due to ripening of banana cv. Grand Naine was significantly reduced by CPPU (4ppm) and followed by KH_2PO_4 (0.5 %) during the storage period.

6. In case of chemical parameters, Total Soluble Solids was significantly influenced due to treatments during storage period, while CPPU (4ppm) also gave satisfactory results against all the treatments.

7. The acidity percentage increased with increase in storage period and CPPU (4ppm) retained more acidity than untreated fruits during entire storage period.

8. Among different treatments under study CPPU (4ppm) and KH_2PO_4 (0.5 %) retained lower percentage of reducing sugar, total sugar and non-reducing sugar while, 2,4-D (10ppm) recorded higher percentage of reducing sugar, non-reducing sugar and total sugar at all stages of storage.

9. Thus treated fruits exhibited a tendency to maintain lower sugar: acid ratio (20.56) as compared to untreated fruits. Sugar: acid ratio was lower in CPPU (4ppm) which was followed by KH_2PO_4 (0.5 %).

10. During entire storage period, the ascorbic acid content constant increased in treated banana fruits than control. Over all the higher content of ascorbic acid was recorded by 2,4-D, KNO_3 and K_2SO_4 treatments.

CONCLUSION

From above studies it is evident that among all chemicals alternated pre-harvest application of CPPU (4ppm) and KH_2PO_4 (0.5 %) were found excellent treatment, which was not only extended the shelf life and increase marketable fruits but also reduced post harvest losses without adversely affecting the quality of banana fruits cv. Grand Naine.

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APPENDICES

Appendix– I: District wise area and production of banana in Gujarat– 2005-06

Sr. No.	District	Area (ha.)	Production (MT)
1	Ahmedabad	17.00	323.00
2	Amreli	30.00	900.00
3	Banaskatha	5.00	125.00
4	Bharuch	12760.00	701800.00
5	Narmada	4500.00	270000.00
6	Bhavnagar	284.00	7952.00
7	Dang	10.00	300.00
8	Gandhinagar	3.00	90.00
9	Junagadh	1850.00	49950.00
10	Kutch	707.00	31815.00
11	Kheda	150.00	4500.00
12	Anand	10625.00	454750.00
13	Panchmahal	150.00	4700.00
14	Sabarkantha	75.00	2250.00
15	Surat	10415.00	546523.00
16	Baroda	7023.00	394898.00
17	Valsad	180.00	5400.00
18	Navsari	450.00	22500.00
TOTAL		49234.00	2498776.00

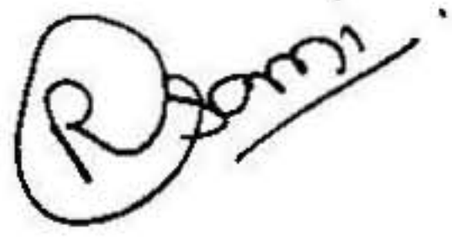
Source:-Directorate of Horticulture, Gandhinagar (Gujarat State)

CERTIFICATE

This is to certify that I have no objection to supply one copy of any part of this thesis at a time to any scientist through reprographic process, if necessary for rendering reference service in a library or documentation centre.

Place : Navsari

Date : 5th July, 2008



(Somi Rajeshkumar Gangadhar)