INFLUENCE OF POST-BUNCHING SPRAYS OF CYTOKININ, POTASSIUM AND CALCIUM ON YIELD AND SHELF LIFE OF BANANA (*Musa* AAB NENDRAN) FRUITS

By

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THESIS

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DECLARATION

I hereby declare that the thesis entitled ***"Influence of post-bunching sprays of cytokinin, potassium and calcium on yield and shelf life of banana (Musa AAB Nendran) fruits"*** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that the thesis entitled ***"Influence of post-bunching sprays of cytokinin, potassium and calcium on yield and shelf life of banana (Musa AAB Nendran) fruits"*** is a record of research work done independently by Miss. T.S. Sindhu under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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Introduction

I. INTRODUCTION

Though banana production surpasses all other fruit crops it is still considered as an orphan crop. Diseases and pests on one side and the diversified system of culture on the other are the chief causes of low productivity and wide gap that exists between the production potential and yield. The prime characters which govern consumer preference and demand in banana are bunch weight and finger characters. A number of factors beginning from the quantitative aspects of the propagule such as size and type of suckers influence these yield characters. In many cases even after fulfilling all recommended management practices the bunch weight remains below standards and the finger size and quality below the limits of normal acceptability.

Another major problem found is the market glut in the season and therefore, advancing the crop harvesting even by a few days by reducing the time taken to maturity helps in adjusting the harvesting in accordance with the requirements so that maximum realisation of the price is achieved.

Normal crop management practices are focussed on edaphic and crop aspects primarily, the yield components. An extra third dimension which is gaining importance in *Musa* is the bunch management which involves management practices applied directly on the bunch.

Simple practises such as bagging / sleeving have proved to be effective in improving yield both quantitatively and qualitatively (Trupin, 1959; Perumal and Adam, 1968; Walker, 1975; Galan-Sauco *et al.*, 1996).

One of the aspects which has received attention is the foliar application of urea. Research work done at our centre has also proved the efficacy of urea in boosting yield and shortening the time to maturity (Ancy, 1997). A major constraint observed in the study was the reduced shelf life, which also limited its application as a full-fledged recommendation.

This project was taken up to solve these problems with the prime objective of increasing the shelf life and improving the bunch size and finger characters primarily by use of a known nutrient, namely, potassium which regulates the various metabolic pathways; secondly by use of a nutrient which acts in preserving the integrity of the cell wall, namely, calcium and thirdly a known anti-senescence plant growth regulator viz., cytokinin.

Standardisation of these treatments will thus help in realising maximum yield with an improvement in the shelf- life.

Review of literature

2. REVIEW OF LITERATURE

Research work on bunch management of banana mostly centers around the aspects such as bagging, male bud pruning, de-handing and use of plant growth regulators. This review attempts to consolidate all the research work done on banana using all the three approaches namely, the use of potassium, calcium, cytokinin and their effects manifested both quantitatively and qualitatively.

2.1 Potassium and bunch management

Innumerable references do exist on effects of soil application of potassium on yield and quality which is not the purpose of this chapter. Its effects have been proved beyond doubt and this chapter is devoted only on the subject of investigation i.e., bunch management.

2.1.1 Yield

The direct effects of potassium salts of gibberellic acid on increasing the yield, length, weight and volume of banana fruits have been reported by Lockard (1975) and that of potassium dihydrogen phosphate by Venkatrayappa *et al.*(1979).

Cleland (1971) and Cocucci and Dalla Rosa (1980) emphasized the role of K^+ as an integral part of the proton extrusion process postulated to induce cell wall acidification and auxin- stimulated growth. In bananas, a slight positive effect of K on the photosynthetic potential; a stronger effect on the actual photosynthesis through the opening / closing speed of stomatae, and a still stronger effect on translocation was confirmed in the study of Martin-Prevel (1981). Cleland (1987) reported that specific ions like Ca^{2+} and K^+ are directly involved in cell wall

expansion. While Ca^{2+} exerts a stiffening effect on the cell wall , K^{+} is attributed to wall loosening events which are initiated by the cleavage of wall bonds bearing an electrical charge, followed by a small increment in visco-elastic extension.

2.1.2 Maturity and ripening.

Potassium salt of GA applied to banana plants three months after planting had no effect on the number of days from flowering to ripening as reported by Lockard (1975). Martin-Prevel (1982) reported that K deficiency or Ca/K imbalance may result in ' yellow pulp' or 'green ripe' problems in banana.

2.1.3 Shelf-life

Sarkar *et al.* (1995) studied the effects of chemicals like potassium metabisulphite, Waxol, Bavistin, GA3, Dithane M – 45, Blitox and NAA on shelf life of Giant Governor bananas and found that they could be retained for 14 days after harvest.

The effects of K on physiological aspects of shelf-life is evident in slowing down the senescence and with a decrease in numerous physiological diseases as reported by Martin-Prevel and Teisson (1980).

2.1.4 Quality parameters

Application of potassium dihydrogen phosphate on banana bunches alone and to the whole plant including the bunches decreased the acidity and increased the strach and sugar contents (Venkatarayappa *et al.*, (1979). Favourable effect of K on free amino acids and the K- stimulated condensation of amino acids into proteins were verified by Martin- Prevel and Teisson (1980) for bananas. The

addition of K more than the necessary level for increasing the yield has also been proved by Martin-Prevel (1984). He opined that beyond limits, it does not automatically result detrimental, as it shows beneficial for quality in many specific cases.

2.2 Calcium

2.2.1 Yield

When bananas cv; Basrai Dwarf were exposed to calcium carbide (10-25 g) the percentage weight loss was lowest with the highest exposure rates (Khan *et al.*, 1977).

Treatment of banana cv. Robusta with a three per cent $CaCl_2$ solution by spraying or quick dipping or dipping for two or five minutes resulted in an increase in pulp: peel ratio as reported by Huddar *et al.* (1989).

Application of calcium chloride under pressure at ordinary temperatures has increased the peel and pulp levels in treated banana fruits (Chandramouli *et al.*, 1991)

2.2.2 Ripening

Controversial reports of calcium carbide on ripening of bananas do exist. In studies of Khan et al. (1977) exposure of harvested light green banana fruits placed in paper-lined baskets to calcium carbide (10-25g) reduced ripening time which was shortest with the highest exposure rates whereas it caused slower ripening in Basrai Dwarf bananas as reported by Singh *et al.* (1979).

Huddar *et al.* (1990) studied the effect of post harvest application of calcium chloride on ripening of banana cv. Robusta and found that calcium chloride treatment has advanced the ripening by two to five days.

When banana cv. Robusta were treated with a three per cent calcium chloride solution by spraying or quick dipping or dipping for two or five minutes, the ripening was enhanced (Huddar *et al.*, 1989).

Results of studies by Chukwu *et al.* (1995) proved that calcium chloride infiltration significantly extended the ripening of banana fruits by three days.

2.2.3 Shelf-life

Extension and reduction of shelf-life of banana have been reported by many workers.

Patil and Magar (1975) observed that in pre-climacteric bananas, calcium hydroxide reduced CO_2 concentration while 1:1 mixture of calcium hydroxide and purafil reduced the concentration of both ethylene and CO_2 and therefore extended the storage life .One percent calcium chloride solution treatment of mature green fruits of banana fruits of cv. Sindihi reduced decay and improved storability of fruits upto twelve days (El-Hammady *et al.*, 1985).

Application of calcium chloride under pressure at ordinary temperatures increased the shelf life of banana fruits (Chandramouli *et al.*, 1991).

Huddar *et al.* (1990) reported that when bananas cv. Robusta were dipped in calcium chloride solution (0.6 %) and then stored at room temperature the shelf-life was reduced. Shelf-life ranged from 8.8 days (6 % $CaCl_2$) to 11.5 days (0.5 %) in comparison to 14.4 days in the control.

2.2.4 Qualitative aspects

El-Hammady (1985) studied the effect of some post harvest treatments on improving the quality of banana fruits of cv. Sindihi and concluded that the best treatment with regard to storability and fruit quality was to spray the fruits with one percent $CaCl_2$ solution before and after storage. Huddar *et al.* (1989) reported that treating banana fruits cv. Robusta with three per cent $CaCl_2$ solution by dipping or spraying reduced firmness, increased TSS, titratable acidity, reducing sugars and total sugars compared with the control .

Huddar *et al.* (1990) confirmed that bananas dipped in six per cent $CaCl_2$ solution showed the lowest firmness and highest titratable acidity, reducing sugar and total sugar contents after fourteen days of storage. Chandramouli *et al.* (1991) observed that dipping banana fruits cv. Robusta in 0.6 % $CaCl_2$ solution resulted in an increase in the rate of softening ,TSS, acidity and sugar.

2.3 Hormonal approaches

This part of the review deals only with growth regulators having anti-senescence capacity and hence the effect of ethrel which promotes senescence is not reviewed. This sub chapter aims only at reviewing the works of growth regulators/bioregulators on yield in relation to anti-senscence capacity.

2.3.1 Growth regulators and yield

The potassium salt of gibberellic acid applied to banana plants three months after planting and to fruits two weeks after flowering markedly increased the plant height, circumference and yield, length, weight and volume of fruits (Lockard, 1975).

Deshmukh and Chakrawar (1980) reported that preharvest application of Ancymidol, GA or Ethrel increased the average weight and size of bunches and weight of fingers. The effect of 2,4-D (10ppm) on size and weight of banana cv. Nendran has been studied by Aravindakshan (1981). Mishra *et al.* (1981) observed that GA_3 at 10^{-4} concentration increased the weight and volume of fingers in young and old bunches of banana.

Chattopadhyay and Jana (1988) reported the effect of growth substances (NAA or GA_3 each at 10, 25 or 50 ppm or 2.4- D or 2,4,5- T each at 5, 10 or 20 ppm) applied to bunches of Giant Governor banana thirty days after emergence, with or without male bud in improving the fruit length, girth, pulp: peel ratio and bunch weight.

Pradhan *et al.* (1988) reported that GA_3 at 100 mg l^{-1} was very effective in increasing bunch and fruit weight and the pulp: peel ratio of banana var.Giant Governor. Sandoval (1988) reported that foliar spray of GA_3 on suckers (100, 300 or 500 mg/l) induced normal leaf development and increased fruit weight.

2.3.2 Maturity and ripening

Murata *et al.* (1965) studied the effect of growth regulators on the ripening of 'Shinzun' bananas and found that the climacteric ascent was hastened by 100 to 1000 ppm 2,4-D.

Controversial reports of enhancing and delaying ripening were reported by several workers.

Dedolph and Goto (1960) observed that when the hands of Dwarf Cavendish banana were cut and dipped in a solution of 2,4-D at 100 ppm, the hands ripended more quickly and uniformly than the other treatments.

Potassium salt of GA applied to banana plants three months after planting had no effect on the number of days from flowering to ripening as reported by Lockard (1975). When Kinetin solution (20 or 100 μM) was infiltrated into freshly cut transverse slices of green banana it enhanced by thirty percent the rates of ethylene evolution and maximal respiration upto 48 hours after slicing, compared with untreated or water- infiltrated control slices (Wade and Brady, 1971).

Vendrell (1970) reported that dipping whole banana fruits in acqueous solution of GA_3 at 10^{-2} to 10^{-3} M delayed ripening, however treatment of slices by vacuum infiltration accelerated it. Awad and Compagno (1973) observed that dipping banana fruits in 50 or 100 ppm GA solution delayed ripening by 2-3 days .

Gottreich and Halvey (1982) observed delayed ripening of Dwarf Cavendish bananas with application of gibberllin. Dipping banana fruits in 10^{-5} M

GA_{4+7} or GA_3 delayed ripening (George and Mariott, 1983). Rao and Chundawat (1986) observed that dipping banana bunches in GA (150ppm) or kinetin (10 ppm) delayed ripening. Prasad and Singh (1993) studied the effect of hormones IAA or GA at 10^{-6} to 10^{-2} on longevity of banana fruits and found that chlorophyll retention was best in fruits sprayed with IAA at 10^{-3} M.

2.3.3 Shelf-life

Aziz and Wahab (1970) compared acetylene, coal gas and 2,4-D for the artificial ripening of bananas and found that bananas treated with 2,4-D at 100ppm were marketable for longer time than those from other treatments.

George and Marriott (1983) reported that dipping banana fruits in 10^{-5} M GA_{4+7} or GA_3 extended storage life by about fifty per cent.

In a study on the effects of certain chemicals on shelf-life of cv. Giant Governor banana Sarkar *et al.* (1995) concluded that fruits could be kept for 14 days after harvest without any deleterious effect on quality when they were treated with GA_3, Blitox, Bavistin or six per cent Waxol.

2.3.4 Quality

Wade and Brady (1971) observed that Kinetin and IBA caused a 'green–ripe ' condition in banana. Chattopadhyay and Jana (1988) studied the effect of growth substances NAA, GA_3, 2,4-D or 2,4,5-T applied to the bunches thirty days after the emergence, with or without a male bud on fruit growth and development of Giant Governor banana. It was found that quality in terms of TSS and sugars was best with GA_3 at 50 ppm.

Sarkar *et al.* (1995) found that banana cv. Giant Governor could be kept without significant effect on their quality for fourteen days after harvest when they were treated with GA_3, Blitox, Bavistin or Waxol.

2.4 Enzymes

Anthon and Spanswick (1986) found that the vanadate-sensitive ATPase (ATPase of the plasmalemma) was stimulated by K^+ at low pH levels. Irradiation of pre-climacteric Dwarf Cavendish bananas at 35 K rad caused a gradual activation of FDPase, which reached a maximal five-fold increase in activity in three days (Surendranathan and Nair, 1971).

Calcium dependent generation of a regulative proteinase was reported by Kauss (1981). It was concluded that the activating enzyme presumed to be a proteinase was not directly stimulated by Ca^{2+} but was the output of a Ca^{2+} dependent process that requires the presence of membranes and result in the release of the activating enzyme. Matsumoto *et al.* (1984) observed an ATPase activity associated with isolated chromatin that was activated fifteen fold by calmodulin in the presence of even very low or at μM concentration levels of calcium.

A general decrease in the activities of the enzymes α amylase, starch phosphorylase, acid phosphatase, peroxidase and catalase due to sprays of kinetin and GA in banana has also been inferred by Desai and Deshpande (1979).

Materials and Methods

3. MATERIALS AND METHODS

The investigations on the "Influence of post-bunching sprays of cytokinin, potassium, and calcium on yield and shelf life of banana (*Musa* AAB Nendran) fruits" were carried out in the Department of Pomology and Floriculture and the Biochemistry laboratory of the College of Horticulture, Vellanikkara.

Experiments were carried out in two distinct and contrasting seasons- first season crop from October, 1997 to September-October, 1998 and second season crop from May, 1998 to February-March, 1999.

Experimental materials

Suckers of 'Chengalikodan' of uniform size and age were selected for various experiments under the study. A secondary selection for uniformity of bunch was done at the time of implementing the treatments. The crop received uniform cultural and management practises as per recommended package of practices (KAU, 1993).

Treatments were enforced on uniform sized plants with bunches of same size, age and number of hands. In all the experiments, the plants except for the control without urea treatment were given bunch stalk feeding / rachis feeding of 30g urea two weeks (14 days) after bunch emergence and prior to the implementation of treatments as per the previously standardised work on 'Bunch stalk feeding of urea in Banana *Musa* (AAB group) Nendran' done at the Department (Ancy, 1997).

The effect of different chemicals was studied as separate experiments as given below.

3.A. Experiment I

Effect of cytokinin on yield and shelf life

Two forms of cytokinin namely, kinetin and benzyl adenine (BA) were each tried at four concentrations of 25 mg l^{-1}, 50 mg l^{-1}, 75 mg l^{-1} and 100 mg l^{-1}. These four concentrations were applied twice at two different intervals. a) two sprays at third and fourth week after bunch emergence (w.a.b.e.) and b) at third and fifth w.a.b.e. Two controls were also taken- an absolute control with bunch stalk feeding of 30 g urea and a control with no spray as per pre-standardised work done at the centre (Ancy, 1997). The four concentration of the two cytokinins each at two defined intervals of application along with two controls formed the eighteen treatments. The experiment was in a CRD which were replicated eight times in the first year and thrice in the second year.

Though only one crop was envisaged under the technical programme an additional crop was taken during another season to confirm the results.

3.B. Experiment II

Effect of post-bunching sprays of potassium and post-harvest application of calcium on yield and shelf life

The effect of potassium and calcium were investigated as separate experiments.

In the case of potassium two salts were tried at three concentrations as follows:

KCl	1) 1 % (0.134 M)
	2) 3 % (0.40 M)
	3) 5 % (0.67M)
K_2SO_4	1) 1% (0.057 M)
	2) 3% (0 .172 M)
	3) 5% (0.287 M)

Two sprays were given, the first at third and fourth week after bunch emergence and the second at third and fifth week after bunch emergence. Two controls were also taken 1) an absolute control with bunch stalk feeding of 30 g urea and 2) control- no spray. The experiment was in a CRD replicated eight times in the first year and thrice in the second year.

In case of potassium and cytokinin the following observations on morphological and yield characters were taken:

1) Length of 'D' finger at weekly intervals
2) Girth \ grade of 'D' finger at weekly intervals
3) Fruit curvature Index
4) Bunch weight at harvest
5) The 'D' finger weight at harvest
6) The 'D' finger weight at maturity
7) Percentage reduction in 'D' finger weight
8) Pulp weight at ripening
9) Peel weight at ripening
10) Percentage pulp weight
11) Percentage peel weight
12) Pulp thickness

13) Peel thickness

14) Days to maturity

15) Days to ripening

16) Shelf life

In the case of calcium the study was restricted to one season from May, 1998 to February-March, 1999 but it involved two experiments. The two different experiments had the same treatments but following two different methodologies.

In the first methodology calcium was given as sprays using the two salts of calcium, namely, calcium chloride and calcium sulphate at different concentrations as follows:

$CaCl_2$. $2H_2O$	1) 1% (0.068 M)
	2) 3% (0.204 M)
	3) 5% (0 .340 M)
$CaSO_4$. $2H_2O$	1) 1% (0 .058 M)
	2) 3% (0.174 M)
	3) 5% (0.291 M)

As in the case of potassium and cytokinin here also two controls were taken i.e. an absolute control with bunch stalk / rachis feeding of 30g urea and another control i.e. no spray. Sprays were effected immediately after harvest. The experiment followed a CRD which was replicated eight times.

The second methodology using vacuum infiltration was done using the same above mentioned treatments i.e. calcium solutions at the three

concentrations. Time and pressure were pre- standardised as six minutes (Plate 1) and 0.5 $kgcm^{-2}$.

Harvested fruits were weighed and vacuum infiltrated in calcium salt solution of concentration as per treatment specification at a pressure of 0.5 $kgcm^{-2}$. The following observations were taken:

1) Bunch weight at harvest and ripening from which percentage reduction in bunch weight was calculated.
2) 'D' finger weight at maturity
3) 'D' finger weight at ripening
4) Percentage reduction in 'D' finger weight at ripening
5) Pulp weight at ripening
6) Percentage pulp weight
7) Pulp thickness at ripening
8) Percentage pulp thickness
9) Peel weight at ripening
10) Percentage peel weight
11) Peel thickness at ripening
12) Percentage peel thickness
13) Days to ripening
14) Shelf life

The percentage reduction in bunch weight was calculated only in case of sprays whereas it was restricted to the finger weight in case of infiltration technique as the facility available could accommodate only finger due to space limitations.

Plate 1 Standardisation of time for calcium infiltration


1
3
6
7
8

The details of all observations of cytokinin, potassium and calcium are detailed below :

3.1 Bunch characters

3.1.1 Time taken to reach maturity

The time taken by the bunches, from complete emergence to the harvest at maturity was counted and expressed in number of days.

3.1.2 Bunch weight at harvest

Bunches were weighed immediately after harvest on a platform balance pre-certified by the Department of Weights and Measures after uniformly cutting the top of the peduncle at a distance of 30 cms from the first hand and apical tip pruned to 10 cm, in all the treatments. The bunch weight was recorded in kilo grams (Kg).

In the case of calcium the bunch weight was also measured at ripening and as the treatments were effected at maturity the differences in weight at ripening was worked out and expressed as percentage reduction in bunch weight.

3.2 Morphological characters of fingers

In the experiment the 'D' finger – middle fruit in the top row of the second hand (Gottreich et al. 1964) was selected for different measurements and analysis.

3.2.1 Length

Length was measured from the base of the finger deleting the pedicel part, along the outer curvature upto and including apex, using twine and scale and expressed in centimeters (cm).

3.2.2 Girth / Grade

Girth / Grade of the finger was taken at the point of maximum thickness adopting the same method as that of length measurement.

3.2.3 Relative Growth Rate (RGR)

The relative growth rate in terms of length and grade was worked out using the standard formula R=1/w.dw/dt (Briggs *et al.*, 1920) where w is the initial length / grade, *dw* is the change in length or grade and *dt* is the time interval.

3.2.4 Fruit Curvature Index (FCI)

The curvature of the fruit was drawn on a paper at weekly intervals by placing it in between two fingers and the FCI was measured using the standard formula,

$$FCI = \frac{F}{C} \times 100$$

where, F is the straight line distance from the tip of the finger to the end of the pedicel measured on the concave side of the fruit and C is the vertical distance from the line to the most curved portion of the convex side of the fruit (Stover and Simmonds , 1987) .

3.2.5 Finger weight at harvest

The weight of the 'D' finger was taken on an analytical balance and expressed in grams (g).

3.3 Ripening

3.3.1 Time taken for ripening

The time taken to reach 100 per cent colour change after harvest as per colour chart given by Stover and Simmonds (1987) was noted and expressed in number of days .

3.3.2 Fruit weight at ripening

Weight of the fruit was taken on an analytical balance and expressed in grams (g).

3.3.3 Percentage reduction in 'D' finger weight at ripening

The percentage reduction in 'D' finger weight at ripening was calculated using the standard formula

$$\frac{\text{D finger weight at maturity} - \text{D finger weight at ripening}}{\text{D finger weight at maturity}} \times 100$$

3.3.4 Pulp thickness

The thickness of the pulp was measured after peeling the fruit using a sharp knife and measuring with a standard vernier calipers, and expressed in centimeters (cm)

3.3.5 Peel thickness

The peel thickness was measured with the help of a vernier calipers and expressed in centimeters (cm).

3.3.6 Pulp weight at ripening

After peeling the fruit, pulp was weighed on an analytical balance and the weight was recorded in grams (g).

3.3.7 Peel weight at ripening

The peel was weighed on an analytical balance and weight was expressed in grams (g).

3.3.8 Shelf life

The time taken to reach twenty five per cent change of colour to black was noted as shelf life and expressed in number of days.

3.4 Biochemical characters

All biochemical qualities were analysed in fruits one day after full colour development.

3.4.1 Total soluble solids

Total soluble solids (TSS) was found out using a hand refractometer having a range from 0 to 32° brix (ERMA hand refractometer).

3 4.2 Acidity

The method described by A.O.A.C. (1980) was adopted. Ten grams of the macerated sample was digested with boiling water and made upto a known volume. An aliquot of the filtered solution was titrated against 0.1 N NaOH using phenolphthalein as indicator. The acidity was expressed as per cent of citric acid

3.4.3 Sugars

3.4.3.1 Total sugars

The total sugar was estimated as per the methods described by A.O.A.C. (1980). Clarified fruit juice of 50 ml was boiled gently after adding citric acid and water. It was neutralised with NaOH and volume made up to 250 ml. The made up solution was titrated with a mixture of Fehling's solution A and B and the total sugar content was expressed in per cent.

3.4.3.2 Reducing sugars

Reducing sugars was estimated by Fehling's solution method (Lane and Eynon, 1943; A.O.A.C., 1980). To ten gram of fruit juice, distilled water was added and after thorough mixing the solution was clarified with neutral lead acetate. Excess lead acetate was removed by adding potassium oxalate and volume was made upto 250 ml. The solution was filtered and an aliquot of this solution was titrated against a mixture of Fehling's solution A and B, using methylene blue as indicator. The reducing sugar was expressed in percentage.

3.4.3.3 Non – reducing sugars

The difference between total sugars and reducing sugars was calculated and expressed as percent of non – reducing sugars.

3.4.4 Urease activity at fruit ripening

Urease activity in the fresh fruit sample was determined as described by Guan (1986). Fresh fruit sample of 0.5g (ripened) was finally ground in a mortar with 30 ml citrate buffer of pH 6.2. This was transferred to a volumetric flask and diluted to 50 ml. Then 10 ml of the homogenate suspension was transferred to a test tube in to which 2 ml of 0.5 per cent urea solution was added and mixed thoroughly. Then, the urease activity was determined by Nessler's reagent colorimetry (Li, 1984). Standard curve was drawn using standard urease enzyme extracted from jack bean, following the above procedure. The activity was recorded in $\mu\ gg^{-1}minute^{-1}$.

3.4.5 Urea at fruit ripening

The residual urea in the fresh fruit sample was determined following the diacetyl colorimetry method of Douglas and Bremner (1970). Here

the extract was analysed for urea by the measurement of red colour formed when the aliquot was heated with diacetyl monoxime and thio- semi carbazide under acidic conditions (phosphoric acid – sulphuric acid medium).

3.4.6 Nitrite nitrogen content in fruits

Nitrite nitrogen in the dried fruit samples were estimated following th methods of Kamphake et al. (1967) and modified by Downes (1978) and then determined the nitrite by diazotisation following the method of Snell and Snell (1949). The nitrite content was measured at 540 nm using UV visible spectro photometer.

3.4.7 Electrolytic leakage

Electrolytic leakage was determined at three defined stages of ripening of the fruits viz., yellow colour stage, 50 percent black stage and 100 percent black stage. Individual fruits were weighed in an analytical balance and then divided into equal halves. The first half was kept in distilled water (250 ml) for four hours and the other half kept in distilled water for eight hours. After four hours and eight hours respectively, the conductivity of water was read using a conductivity bridge and expressed in millimhoscm^{-1}g^{-1}. After four hours and eight hours respectively, uniform fruit core of 1 g was taken from the fruit and heated for thirty minutes in 25 ml of distilled water and conductivity of the holding water was read as mentioned above.

3.4.8 Calcium content in pulp and peel

Diacid digestion of pulp and peel was done separately and sample solution was read in an atomic absorption spectro photometer. Another lot of calcium standard of known calcium concentration was also read and standard

prepared from which the concentration of calcium in the unknown sample was worked out.

3.5Organoleptic evaluation

Sensory evaluation was carried out with the help of a panel consisting of ten members who were asked to evaluate the samples for its overall appearance and taste. This was done at full ripening or full yellow colour stage. A nine point hedonic scale was used for the rating.

3.6 Statistical analysis

The data relating to each character were analysed appropriately either by applying the analysis of variance techniques or the analysis of co-variance as per statistical requirements (Panse and Sukhatme, 1978). Appropriate transformations were also done as per statistical requirements which have been shown in the respective table, prior to applying the analysis of variance techniques as per experimental design wherever necessary. Analysis of covariance taking the number of fingers as covariate was done to avoid any error arising due to the change of number of fingers.

In the case of consumer acceptability, the marks were analyzed by applying the Kruskal Wallis one way analysis by ranks for both visual appearance and taste separately.

Results

4. RESULTS

4.1 CYTOKININ

4.1.1 EFFECT OF CYTOKININ ON LINEAR GROWTH (LENGTH).

The results of the effect of cytokinin on linear growth (length) are presented in Table 1.

The week wise split up starting from the first week of spray are as follows .

4.1.1.1 Third week -end

Kinetin sprayed at 75 mg l^{-1} on third and fourth week revealed the maximum length followed by 25 mg l^{-1} of the same.

In the second season kinetin sprayed at 50 mg l^{-1} during third and fourth week recorded the maximum followed by 25 mg l^{-1} of the same which was at par with most of the kinetin treatments.

4.1.1.2 Fourth week-end

In the first season 75 mg l^{-1} of kinetin recorded the highest length followed by 25 mg l^{-1} of the same and it was on par with many other treatments particularly the treatment using the same chemical applied at third and fourth week and similar concentration applied at third and fifth w.a.b.e.

Kinetin sprayed at 50 mg l^{-I} applied during third and fourth week recorded the highest length in the second season followed by 25 mg l^{-1} of the same.

Table 1 Effect of cytokinin sprays on linear growth (length) in banana cv. 'Nendran'

Treatments	3rd week end		4th week end		RGR 1 week after 1st spray		5th week end		6th week end		RGR 1 week after 2nd spray		8th week end (a)		9th week end (b)		RGR between (a) & (b)		RGR between (b) &2nd spray	
	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season
T_1	20.20	20.33	20.83	20.87	0.027	0.023	21.43	21.43	21.80	21.80	0.030	0.027	22.57	22.53	22.90	22.80	0.013	0.010	0.017	0.015
T_2	20.13	20.37	20.77	20.90	0.033	0.027	21.40	21.47	21.77	21.83	0.030	0.027	22.57	22.57	23.03	22.90	0.020	0.013	0.017	0.016
T_3	20.37	20.23	20.90	20.67	0.023	0.020	21.47	21.17	21.83	21.57	0.027	0.020	22.63	22.30	22.90	22.63	0.013	0.013	0.017	0.016
T_4	20.13	20.07	20.67	20.57	0.023	0.027	21.23	21.07	21.60	21.40	0.023	0.020	22.30	22.17	22.67	22.50	0.017	0.013	0.016	0.015
T_5	20.27	20.17	20.77	20.60	0.020	0.020	21.20	20.99	21.77	21.30	0.023	0.020	22.43	22.30	22.77	22.67	0.013	0.017	0.015	0.016
T_6	20.13	20.23	20.73	20.83	0.030	0.030	21.07	21.20	21.63	21.53	0.027	0.020	22.40	22.40	22.77	22.77	0.017	0.017	0.016	0.015
T_7	20.13	20.00	20.60	20.53	0.023	0.020	20.93	20.90	21.50	21.30	0.027	0.027	22.23	22.23	22.53	22.60	0.010	0.017	0.015	0.016
T_8	20.00	20.10	20.43	20.57	0.023	0.023	20.83	20.90	21.37	21.17	0.023	0.023	22.13	22.13	22.47	22.47	0.013	0.013	0.015	0.015
T_9	20.23	19.57	20.77	20.13	0.023	0.030	21.30	20.63	21.67	21.20	0.023	0.023	22.47	21.67	22.80	22.00	0.013	0.013	0.016	0.016
T_{10}	20.00	19.93	20.53	20.43	0.030	0.030	21.10	20.93	21.50	21.27	0.027	0.023	22.30	21.97	22.67	22.33	0.017	0.017	0.017	0.016
T_{11}	20.20	19.60	20.80	20.13	0.030	0.030	21.40	20.70	21.73	21.03	0.030	0.030	22.50	21.80	22.90	22.20	0.020	0.020	0.017	0.017
T_{12}	19.97	19.77	20.50	20.27	0.027	0.027	21.00	20.80	21.37	21.13	0.020	0.023	22.10	21.93	22.47	22.23	0.017	0.010	0.016	0.016
T_{13}	20.10	19.73	20.50	20.13	0.020	0.020	20.83	20.47	21.37	20.97	0.023	0.020	22.07	21.73	22.47	22.07	0.017	0.013	0.015	0.016
T_{14}	20.03	19.87	20.53	20.33	0.027	0.027	20.90	20.70	21.40	21.20	0.020	0.027	22.10	21.90	22.50	22.20	0.020	0.010	0.015	0.016
T_{15}	20.07	19.70	20.63	20.27	0.027	0.030	20.93	20.63	21.50	21.20	0.027	0.030	22.27	21.93	22.63	22.33	0.017	0.020	0.016	0.017
T_{16}	19.97	19.50	20.43	19.97	0.027	0.023	20.73	20.27	21.23	20.70	0.020	0.023	21.93	21.43	22.23	21.77	0.010	0.013	0.014	0.015
T_{17}	20.00	19.93	20.23	20.20	0.013	0.017	20.47	20.43	20.70	20.67	0.010	0.010	21.13	21.10	26.33	21.30	0.009	0.009	0.009	0.009
T_{18}	20.03	19.97	20.37	20.30	0.017	0.020	20.60	20.60	20.90	20.83	0.013	0.013	21.40	21.37	21.70	21.63	0.010	0.010	0.011	0.011
CD(0.05)	0.20	0.26	0.23	0.26	0.009	0.009	0.20	0.52	0.23	0.32	0.009	0.009	0.23	0.26	0.23	0.23	0.009	0.009	0.005	0.005

T_1 - Kinetin 25 mg l^{-1} 3rd & 4th week after bunch emergence
T_2 - „ 50 „
T_3 - „ 75 „
T_4 - „ 100 „
T_5 - Kinetin 25 mg l^{-1} 3rd & 5th week after bunch emergence
T_6 - „ 50 „
T_7 - „ 75 „
T_8 - „ 100 „
T_9 - BA 25 mg l^{-1} 3rd & 4th week after bunch emergence
T_{10} - „ 50 „
T_{11} - „ 75 „
T_{12} - „ 100 „
T_{13} - BA 25 mg l^{-1} 3rd & 5th week after bunch emergence
T_{14} - „ 50 „
T_{15} - „ 75 „
T_{16} - „100 „
T_{17} - Control without urea
T_{18} - Control with urea

RGR – Relative Growth Rate

4.1.1.3 Relative Growth Rate (RGR) between third and fourth week

In the first season the relative growth rate was highest for kinetin 50 mg l^{-1} given third and fourth week which was significantly superior to all other treatments.

In the second season it was highest for BA treatments ranging from 25- 75 mg l^{-1} applied at third and fourth week and that of 75 mg l^{-1} of same applied at third and fifth week. The RGR was the lowest for control without urea in both the cases.

4.1.1.4 Fifth week- end

Kinetin 75 mg l^{-1} applied at third and fourth week followed by the same at 25 and 50 mg l^{-1} at same time recorded the highest in the first season. 50 mg l^{-1} followed by 25 and 75mg l^{-1} of the same hormone applied at the same time recorded the highest in the second season. The control without urea showed the least growth.

4.1.1.5 Sixth week- end

The trend was the same as that observed at the end of fifth week.

4.1.1.6 RGR one week after second spray

Highest RGR was for kinetin 25 mg l^{-1} and 50 mg l^{-1} applied at third and fourth week and 75 mg l^{-1} applied at third and fifth w.a.b.e. and it was on par with a number of treatments in the first season.

In the second season the highest values were observed in 75 mg l^{-1} of BA applied at third and fourth week followed by 25 and 50 mg l^{-1} applied at third and fourth and 75 mg l^{-1} applied at third and fifth w.a.b.e. Equally effective

were 75 mg l^{-1} of kinetin and 50 mg l^{-1} of BA applied at third and fifth w.a.b.e. Control without urea recorded the lowest RGR in both the seasons.

4.1.1.7 Eighth week -end

The general superiority of kinetin applied at third and fourth w.a.b.e. was clear. 75 mg l^{-1} of same applied during third and fourth week recorded the highest followed by 25 and 50 mg l^{-1} which were at par in the first season whereas 50 mg l^{-1} of the same hormone followed by 25 and 75 mg l^{-1} which were also at par recorded the highest in the second season.

4.1.1.8 Ninth week- end

The overall superiority of 50 mg l^{-1} of kinetin was observed by the end of ninth week, it was followed by 25 mg l^{-1} and 75 mg l^{-1} in both the seasons.

4.1.1.9 RGR between eighth and ninth week

Highest RGR were observed for 75 mg l^{-1} and 50 mg l^{-1} of BA and kinetin both applied at third and fourth week and also for 50 mg l^{-1} of BA applied at third and fifth w.a.b.e. in the first season. . In the second season 75 mg l^{-1} of BA sprayed during third and fourth and third and fifth w.a.b.e. recorded the highest . Control without urea recorded the least RGR in both the seasons.

4.1.1.10 RGR between ninth week and second spray

In the first season kinetin 50 mg l^{-1} sprayed on third and fourth week recorded maximum and it was on par with other treatments except the two controls.

In the second season 75 mg l^{-1} of BA applied at third and fourth week recorded maximum and it was also at par with other treatments except the two controls.

4.1.2 EFFECT OF CYTOKININ ON GRADE (GIRTH)

The effect of cytokinin on grade are presented week wise in Table 2.

4.1.2.1 Third week-end

No significant differences between treatment means were observed in the first season. However, in the second season significant differences were observed. Kinetin 25 mg l^{-1} sprayed at third and fourth w.a.b.e recorded the maximum grade followed by 50 mg l^{-1} of the same.

4.1.2.2 Fourth week-end

50 mg $l^{-1}$of BA followed by 75 and 100 mg l^{-1} of kinetin applied at third and fourth w.a.b.e. recorded the maximum grade in the first season whereas 25 mg$l^{-1}$of kinetin along with 50 mg l^{-1} of the same, both applied at third and fourth w.a.b.e . recorded the maximum . The control without urea recorded minimum grade in both cases.

4.1.2.3 RGR between third and fourth week.

The RGR of fingers in terms of grade was highest for 50 mg l^{-1} of kinetin at third and fourth w.a.b.e .in both seasons. In the first season all treatments of kinetin applied at 75mg l^{-1} and 50 mgl^{-1} and 75 mg l^{-1} of BA at same interval of application and BA at 75 mg l^{-1} applied at third and fifth w.a.b.e were at par .Control without urea recorded the least RGR .

Table 2 Effect of cytokinin sprays on girth/grade in banana cv. 'Nendran'

Treatments	3rd week end		4th week end		RGR 1 week after 1st spraying		5th week end		6th week end		RGR 1 week after 2nd spray		8th week end (a)		9th week end (b)		RGR between (a) & (b)		RGR between (b) &2nd spray	
	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season
T_1	10.03	10.23	10.63	10.73	0.060	0.050	11.33	11.30	11.73	11.67	0.067	0.057	12.53	12.40	12.87	12.77	0.023	0.027	0.035	0.032
T_2	10.03	10.10	10.70	10.73	0.067	0.063	11.37	11.40	11.70	11.80	0.067	0.057	12.43	12.63	12.80	13.00	0.027	0.027	0.033	0.035
T_3	10.20	9.93	10.83	10.47	0.063	0.053	11.47	11.07	11.83	11.50	0.057	0.060	12.57	12.27	12.93	12.67	0.027	0.030	0.032	0.035
T_4	10.23	9.87	10.83	10.43	0.060	0.057	11.43	10.97	11.77	11.37	0.060	0.057	12.43	12.10	12.83	12.47	0.030	0.027	0.031	0.032
T_5	9.97	9.90	10.57	10.50	0.050	0.030	10.93	10.90	11.53	11.43	0.057	0.053	12.30	12.20	12.63	12.60	0.023	0.030	0.031	0.031
T_6	10.17	10.00	10.73	10.57	0.047	0.037	10.77	10.90	11.43	11.50	0.060	0.057	12.53	12.27	12.90	12.67	0.027	0.037	0.040	0.032
T_7	10.10	9.80	10.60	10.33	0.050	0.030	11.00	10.70	11.50	11.30	0.050	0.057	12.27	12.03	12.60	12.37	0.023	0.030	0.029	0.031
T_8	9.90	10.10	10.33	10.60	0.043	0.023	11.03	11.00	11.23	11.60	0.050	0.053	12.00	12.37	12.30	12.67	0.020	0.023	0.023	0.030
T_9	10.13	9.97	10.70	10.47	0.057	0.050	11.30	11.03	11.63	11.37	0.060	0.057	12.37	12.13	12.70	12.43	0.023	0.023	0.031	0.031
T_{10}	10.27	10.00	10.87	10.60	0.060	0.060	11.43	11.13	11.80	11.43	0.053	0.053	12.53	12.27	12.90	12.60	0.027	0.023	0.031	0.031
T_{11}	9.97	10.00	10.53	10.60	0.057	0.060	11.17	11.20	11.53	11.43	0.063	0.060	12.50	12.27	12.90	12.60	0.030	0.023	0.037	0.031
T_{12}	10.03	9.83	10.53	10.33	0.050	0.050	11.13	10.87	11.47	11.17	0.060	0.053	12.23	11.93	12.57	12.27	0.023	0.027	0.030	0.031
T_{13}	9.97	10.03	10.50	10.43	0.053	0.040	10.83	10.73	11.37	11.23	0.053	0.050	12.07	12.07	12.40	12.40	0.027	0.023	0.029	0.031
T_{14}	9.97	10.10	10.53	10.63	0.057	0.053	10.83	11.00	11.40	11.53	0.057	0.050	12.17	12.23	12.47	12.57	0.023	0.023	0.030	0.028
T_{15}	10.33	9.77	10.57	10.33	0.053	0.057	10.93	10.70	11.63	11.20	0.060	0.050	12.43	11.97	12.73	12.37	0.020	0.030	0.033	0.031
T_{16}	10.20	9.90	10.77	10.30	0.057	0.040	11.10	10.67	11.60	11.13	0.043	0.047	12.30	11.90	12.60	12.23	0.020	0.027	0.027	0.028
T_{17}	10.03	9.70	10.27	9.93	0.023	0.023	10.50	10.13	10.70	10.37	0.023	0.020	11.20	10.87	11.40	11.10	0.016	0.023	0.018	0.020
T_{18}	10.10	9.72	10.37	9.97	0.027	0.027	10.63	10.23	10.90	10.57	0.027	0.027	11.50	11.13	11.80	11.40	0.030	0.027	0.033	0.024
CD(0.05)	NS	0.23	0.29	0.23	0.009	0.009	0.43	0.23	0.34	0.23	0.009	0.009	0.32	0.26	0.32	0.23	0.009	0.009	0.009	0.003

T_1 - Kinetin 25 mg l^{-1} 3rd & 4th week after bunch emergence
T_2 - „ 50 „
T_3 - „ 75 „
T_4 - „ 100 „
T_5 - Kinetin 25 mg l^{-1} 3rd & 5th week after bunch emergence
T_6 - „ 50 „
T_7 - „ 75 „
T_8 - „ 100 „
T_9 - BA 25 mg l^{-1} 3rd & 4th week after bunch emergence
T_{10} - „ 50 „
T_{11} - „ 75 „
T_{12} - „ 100 „
T_{13} - BA 25 mg l^{-1} 3rd & 5th week after bunch emergence
T_{14} - „ 50 „
T_{15} - „ 75 „
T_{16} - „100 „
T_{17} - Control without urea
T_{18} - Control with urea

RGR- Relative growth rate

4.1.2.4 Fifth week-end

In the first season 75 mg l^{-1} of kinetin sprayed at third and fourth w.a.b.e revealed maximum grade and in the second season 50 mg l^{-1} of the same hormone showed the maximum grade . In the first season the best treatment was at par with the other concentrations of same hormone at same interval but in the second season it was at par only with the lower doses but not the highest concentration.

In general all the kinetin and BA treatments applied at third and fourth week revealed higher grade. The control without urea recorded least grade.

4.1.2.5 Sixth week-end

The same trend as observed in fifth week was observed in the sixth week also with regard to the treatment showing maximum length. Control without urea recorded the minimum grade.

4.1.2.6 RGR one week after second spray

RGR was observed to be highest for kinetin 50 mg l^{-1} and 25 mg l^{-1} both applied at third and fourth w.a.b.e in the first season. In the second season 75 mg l^{-1} of kinetin and BA applied during third and fourth w.a.b.e recorded the maximum RGR. Control without urea recorded the minimum in both the seasons.

4.1.2.7 Eighth week-end

Kinetin 75 mg l^{-1} applied during third and fourth w.a.b.e was having the highest grade followed by 25 mg l^{-1} of the same in the first season. Kinetin 50 mg l^{-1} followed by 25 mg l^{-1} applied during third and fourth w.a.b.e recorded the highest grade in the second season and these two treatments were at par with each other.

4.1.2.8 Ninth week-end

The data revealed that the same trend observed in the eighth week continued in the ninth week also

4.1.2.9 RGR between eighth and ninth week

Kinetin 100 mg l^{-1} and BA 75 mg l^{-1}, both applied at third and fourth w.a.b.e recorded the highest values in the first season and it was on par with a number of other treatments. In the second season 50 mg $l^{-1}$of kinetin applied third and fifth followed by 25 and 75 mg l^{-1} of the same at third and fourth w.a.b.e were at par with the best.

4.1.2.10 RGR between ninth and second spray

In the first season the RGR at maturity in comparison to that of second spray showed that 50 mg l^{-1} of kinetin applied at third and fifth w.a.b.e followed by 75 mg l^{-1} of BA applied at third and fourth w.a.b.e showed the highest RGR. They were at par with many treatments including the control with urea.

In the second season RGR was highest for treatments 50 and 75 mg l^{-1} of kinetin applied during third and fourth w.a.b.e .The control without urea showed the minimum RGR in both seasons.

4.1.3 EFFECT OF CYTOKININ ON FRUIT CURVATURE INDEX (FCI)

The results of the study on effects of cytokinin on FCI are presented in Table 3.

Table 3 Anocoya showing the effect of cytokinin on Fruit Cutvature Index (FCI) in banana cv. 'Nendran'

Treatment	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week	9th week
T_1 Kinetin 25 mg l^{-1} 3rd & 4th w.a.b.e.	298.01 (371.04)	313.29 (371.04)	392.99 (371.04)	424.17 (371.04)	447.14 (371.04)	489.99 (371.04)	505.07 (371.04)	516.12 (371.04)
T_2 Kinetin 50 mg l^{-1} 3rd & 4th w.a.b.e.	292.04 (359.09)	313.57 (359.09)	366.62 (359.09)	420.80 (359.09)	457.46 (359.09)	502.56 (359.09)	523.14 (359.09)	540.52 (359.09)
T_3 Kinetin 75 mg l^{-1} 3rd & 4th w.a.b.e.	304.18 (353.10)	334.77 (353.10)	396.15 (353.10)	423.67 (353.10)	441.00 (353.10)	462.24 (353.10)	471.48 (353.10)	473.04 (353.10)
T_4 Kinetin 100 mg l^{-1} 3rd & 4th w.a.b.e.	281.59 (304.46)	322.43 (304.46)	362.04 (304.46)	395.31 (304.46)	411.62 (304.46)	451.58 (304.46)	462.15 (304.46)	466.78 (304.46)
T_5 Kinetin 25 mg l^{-1} 3rd & 5th w.a.b.e.	291.60 (333.17)	319.45 (333.17)	375.25 (333.17)	411.30 (333.17)	455.25 (333.17)	491.02 (333.17)	503.12 (333.17)	516.55 (333.17)
T_6 Kinetin 50 mg l^{-1} 3rd & 5th w.a.b.e.	302.22 (330.83)	332.83 (330.83)	379.60 (330.83)	404.53 (330.83)	450.99 (330.83)	504.07 (330.83)	517.00 (330.83)	531.72 (330.83)
T_7 Kinetin 75 mg l^{-1} 3rd & 5th w.a.b.e.	290.98 (335.39)	328.62 (335.39)	370.98 (335.39)	397.21 (335.39)	432.29 (335.39)	458.96 (335.39)	475.06 (335.39)	489.30 (335.39)
T_8 Kinetin 100 mg l^{-1} 3rd & 5th w.a.b.e..	278.45 (334.58)	318.90 (334.58)	369.99 (334.58)	385.70 (334.58)	427.65 (334.58)	455.19 (334.58)	467.69 (334.58)	480.55 (334.58)
T_9 BA 25 mg l^{-1} 3rd & 4th w.a.b.e..	301.96 (317.46)	333.69 (317.46)	385.68 (317.46)	445.20 (317.46)	470.45 (317.46)	502.28 (317.46)	506.76 (317.46)	516.37 (317.46)
T_{10} BA 50 mg l^{-1} 3rd & 4th w.a.b.e.	303.56 (323.04)	330.80 (323.04)	383.11 (323.04)	440.34 (323.04)	460.44 (323.04)	491.95 (323.04)	523.65 (323.04)	541.14 (323.04)
T_{11} BA 75 mg l^{-1} 3rd & 4th w.a.b.e.	310.52 (375.79)	325.06 (375.79)	369.17 (375.79)	413.98 (375.79)	446.09 (375.79)	488.11 (375.79)	513.99 (375.79)	533.99 (375.79)
T_{12} BA 100 mg l^{-1} 3rd & 4th w.a.b.e.	291.79 (318.37)	327.37 (318.37)	378.72 (318.37)	434.37 (318.37)	455.56 (318.37)	486.27 (318.37)	498.52 (318.37)	413.42 (318.37)
T_{13} BA 25 mg l^{-1} 3rd & 5th w.a.b.e.	290.81 (350.98)	318.89 (350.98)	352.71 (350.98)	382.36 (350.98)	431.20 (350.98)	471.38 (350.98)	493.08 (350.98)	512.98 (350.98)
T_{14} BA 50 mg l^{-1} 3rd & 5th w.a.b.e.	301.58 (346.05)	337.34 (346.05)	379.49 (346.05)	404.78 (346.05)	461.00 (346.05)	490.66 (346.05)	506.19 (346.05)	520.57 (346.05)
T_{15} BA 75 mg l^{-1} 3rd & 5th w.a.b.e.	297.01 (350.20)	329.96 (350.20)	382.62 (350.20)	411.81 (350.20)	448.01 (350.20)	482.84 (350.20)	503.47 (350.20)	522.12 (350.20)
T_{16} BA 100 mg l^{-1} 3rd & 5th w.a.b.e.	294.70 (325.31)	328.54 (325.31)	369.57 (325.31)	400.01 (325.31)	435.21 (325.31)	470.82 (325.31)	487.11 (325.31)	506.13 (325.31)
T_{17} Control without urea	284.09 (317.88)	329.45 (317.88)	353.99 (317.88)	376.31 (317.88)	399.35 (317.88)	439.59 (317.88)	450.79 (317.88)	464.53 (317.88)
T_{18} Control with urea	284.91 (322.23)	322.17 (322.23)	365.22 (322.23)	416.18 (322.23)	438.95 (322.23)	469.57 (322.23)	479.53 (322.23)	491.61 (322.23)
CD(0.05)	14.50	17.31	33.51	30.29	32.96	36.45	32.85	33.17

w.a.b.e. - Weeks after bunch emergence Figures in paranthesis indicate the FCI in first week which was taken as covariate in Anocova

4.1.3.1 Second week -end (prior to application)

Highest values for FCI were obtained for 100 mg $l^{-1}$of kinetin applied third and fifth w.a.b.e .

4.1.3.2 Third week- end.

FCI was maximum for BA 50 mg l^{-1} applied during third and fifth w.a.b.e and minimum for kinetin 25 mg l^{-1} applied at third and fourth w.a.b.e.

4.1.3.3 Fourth week-end

Kinetin 75 mg l^{-1} applied during third and fourth w.a.b.e. recorded the maximum FCI and BA 25 mg l^{-1} applied at third and fifth w.a.b.e recorded the minimum .

4.1.3.4 Fifth week-end

Kinetin 50 mg l^{-1} sprayed on third and fourth w.a.b.e recorded maximum FCI values and control without urea recorded minimum.

4.1.3.5 Sixth week- end

BA 25 mg 1^{-1} sprayed on third and fourth week was showing maximum FCI and control without urea recorded minimum FCI.

4.1.3.6 Seventh week -end

Kinetin sprayed at 50 mg l^{-1}on third and fourth week followed by the same concentration of the hormone applied at third and fifth week w.a.b.e recorded the highest FCI values. Control without urea recorded the minimum FCI

4.1.3.7 Eighth week-end

FCI was maximum for 50 mg l^{-1} of BA followed by the same concentration of kinetin, both applied during third and fourth w.a.b.e. Lowest values for FCI were obtained for control without urea.

4.1.3.8 Ninth week end

Same trend as observed in eighth week regarding the highest and lowest FCI was observed in ninth week also

4.1.4 YIELD CHARACTERS

The effect of cytokinin on yield characters are presented in Table 4.

4.1.4.1 Bunch weight

A critical analysis of the data reveal the superiority of 50 mg l^{-1} kinetin applied at third and fourth week after bunch emergence (w.a.b.e.) during both the seasons. In the first year it was at par with the treatment having the same concentration but at a different interval i.e., when applied at third and fifth w.a.b.e. In the second year it was at par with the treatments as in the first year and also with kinetin 25 mg l^{-1}, the latter being the second best treatment. A comparison of the BA treatments alone reveals that 75mg l^{-1} applied at third and fourth week was the best treatment in both seasons, but the best treatments in BA were significantly inferior to the best in kinetin. The control without urea followed by the same with urea gave the lowest yields (Plates 3, 4 and Fig. 1). At higher concentrations of cytokinin black spots were observed on the peel (Plate 2).

4.1.4.2 'D' finger weight at maturity

The best 'D' finger weight was recorded when 50mg l^{-1} kinetin was applied at third and fourth w.a.b.e. This was on par with the same

Plate 2 Effect of higher doses of cytokinin on fingers

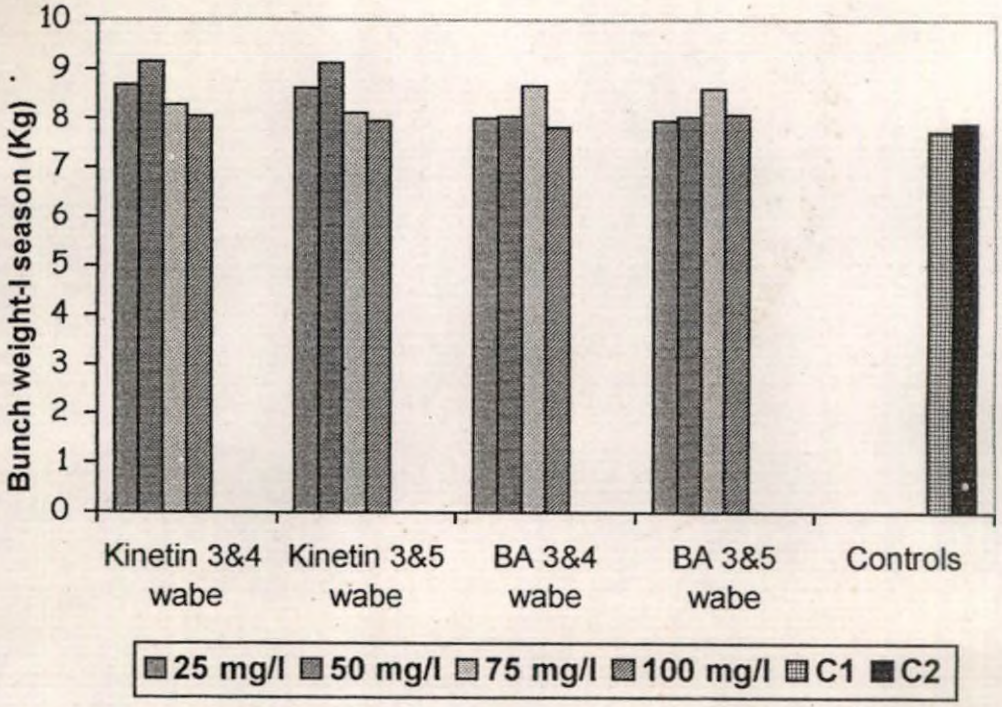

T1
T2
T3
T4
C1
C2


T1
T2
T3
T4
C1
C2

Plate 3 Effect of kinetin sprays on 'D' hand

Plate 4 Effect of BA sprays on 'D' hand

Fig.1 Effect of cytokinin treatments on yield in banana cv. 'Nendran'



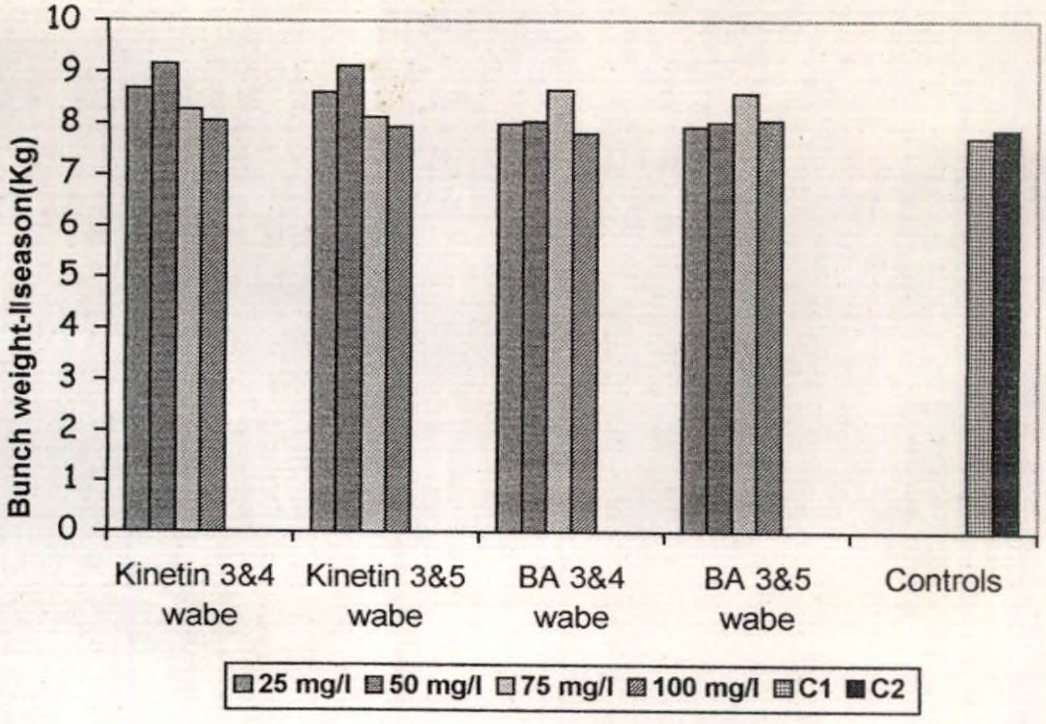


Table 4 Anocova showing the effect of cytokinin sprays on yield attributes in banana cv. 'Nendran'

Treatments		Bunch weight (kg)		D finger weight at maturity (gm)		D finger weight at ripening (gm)		Percentage reduction in D finger weight at ripening	
		I season	II season	I season	II season	I season	II season	I season	II season
T_1	Kinetin 25 kg l^{-1} 3rd & 4th w.a.b.e.	8.68 (53.00)	7.77 (53.00)	183.97 (53.00)	114.63 (53.00)	166.59 (53.00)	86.87 (53.00)	12.06 (53.00)	24.01 (53.00)
T_2	Kinetin 50 mg l^{-1} 3rd & 4th w.a.b.e	9.16 (53.00)	7.78 (52.00)	187.88 (53.00)	115.15 (52.00)	171.12 (53.00)	88.55 (52.00)	11.85 (53.00)	23.13 (52.00)
T_3	Kinetin 75 mg l^{-1} 3rd & 4th w.a.b.e	8.27 (49.00)	7.14 (48.00)	167.46 (49.00)	102.41 (48.00)	152.09 (49.00)	71.94 (48.00)	13.24 (49.00)	29.79 (48.00)
T_4	Kinetin 100 mg l^{-1} 3rd & 4th w.a.b.e	8.05 (49.00)	6.97 (41.00)	166.97 (49.00)	99.19 (41.00)	149.02 (49.00)	67.23 (41.00)	13.39 (49.00)	32.28 (41.00)
T_5	Kinetin 25 mg l^{-1} 3rd & 5th w.a.b.e	8.61 (52.00)	7.66 (54.00)	174.94 (52.00)	115.17 (54.00)	155.81 (52.00)	86.65 (54.00)	13.13 (52.00)	25.02 (54.00)
T_6	Kinetin 50 mg l^{-1} 3rd & 5th w.a.b.e	9.12 (49.00)	7.59 (51.00)	185.32 (49.00)	120.43 (51.00)	159.28 (49.00)	87.21 (51.00)	13.13 (49.00)	28.01 (51.00)
T_7	Kinetin 75 mg l^{-1} 3rd & 5th w.a.b.e	8.12 (49.00)	6.99 (42.00)	164.74 (49.00)	97.95 (42.00)	140.72 (49.00)	65.69 (42.00)	14.48 (49.00)	32.96 (42.00)
T_8	Kinetin 100 mg l^{-1} 3rd & 5th w.a.b.e	7.94 (49.00)	6.42 (43.00)	162.89 (49.00)	93.78 (43.00)	138.72 (49.00)	62.21 (43.00)	14.68 (49.00)	33.76 (43.00)
T_9	BA 25 mg l^{-1} 3rd & 4th w.a.b.e	7.99 (48.00)	7.00 (47.00)	167.74 (48.00)	100.81 (47.00)	143.96 (48.00)	69.85 (47.00)	13.89 (48.00)	30.76 (47.00)
T_{10}	BA 50 mg l^{-1} 3rd & 4th w.a.b.e	8.04 (48.00)	7.11 (45.00)	168.48 (48.00)	101.08 (45.00)	146.77 (48.00)	71.19 (45.00)	12.45 (48.00)	29.83 (45.00)
T_{11}	BA 75 mg l^{-1} 3rd & 4th w.a.b.e	8.66 (50.00)	7.40 (42.00)	170.55 (50.00)	109.16 (42.00)	150.93 (50.00)	76.01 (42.00)	11.36 (50.00)	30.36 (42.00)
T_{12}	BA 100 mg l^{-1} 3rd & 4th w.a.b.e	7.81 (49.00)	6.91 (44.00)	163.18 (49.00)	98.28 (44.00)	137.56 (49.00)	64.83 (44.00)	14.49 (49.00)	34.11 (44.00)
T_{13}	BA 25 mg l^{-1} 3rd & 5th w.a.b.e	7.94 (48.00)	7.19 (40.00)	164.79 (48.00)	94.03 (40.00)	143.77 (48.00)	73.84 (40.00)	12.54 (48.00)	21.36 (40.00)
T_{14}	BA 50 mg l^{-1} 3rd & 5th w.a.b.e	8.02 (48.00)	7.17 (47.00)	166.94 (48.00)	100.91 (47.00)	144.64 (48.00)	76.00 (47.00)	12.71 (48.00)	24.70 (47.00)
T_{15}	BA 75 mg l^{-1} 3rd & 5th w.a.b.e	8.59 (48.00)	7.36 (50.00)	167.96 (48.00)	104.63 (50.00)	149.06 (48.00)	81.74 (50.00)	11.25 (48.00)	21.89 (50.00)
T_{16}	BA 100 mg l^{-1} 3rd & 5th w.a.b.e	8.06 (47.00)	7.03 (43.00)	162.60 (47.00)	130.23 (43.00)	136.76 (47.00)	64.93 (43.00)	14.18 (47.00)	45.20 (43.00)
T_{17}	Control without urea	7.72 (47.00)	5.79 (43.00)	157.52 (47.00)	79.51 (43.00)	133.95 (47.00)	53.82 (43.00)	13.69 (47.00)	27.13 (43.00)
T_{18}	Control with urea	7.87 (47.00)	6.36 (45.00)	161.26 (47.00)	90.18 (45.00)	136.77 (47.00)	59.82 (45.00)	13.91 (47.00)	29.17 (45.00)
CD(0.05)		0.30	0.30	9.71	24.55	9.49	9.61	2.55	7.77

Figures in parenthesis indicate the finger number taken as covariate in Anocova w.a.b.e- weeks after bunch emergence

concentration of kinetin applied at third and fifth w.a.b.e. and with 25 mg l^{-1} kinetin applied at third and fourth w.a.b.e. in the first season (Plate 5).

In the second season 100mg l^{-1} of BA applied at third and fifth w.a.b.e. recorded the maximum finger weight and this was on par with 50mg l^{-1} and 25mg l^{-1} of kinetin applied at third and fourth and third and fifth week and also with 75mg $^{-1}$ of BA applied at third and fourth w.a.b.e. (Plate 6). Control without urea recorded the lowest 'D' finger weight at maturity in both seasons.

4.1.4.3 'D' finger weight at ripening

In both the seasons 50mg l^{-1} of kinetin applied at third and fourth week after the emergence of bunch recorded the highest 'D' finger weight at ripening.

In the first season this was on par with 25mg l^{-1} of kinetin applied at the same time whereas in the second season this was on par with the same concentration of kinetin applied at third and fifth w.a.b.e., 25mg l^{-1} of kinetin applied at both stages and also with 75mg l^{-1} of BA applied at third and fifth w.a.b.e. Control without urea recorded the lowest weight.

Critical analysis shows that average finger weight in most kinetin treatments were higher than that of BA.

4.1.4.4 Percentage reduction in 'D' finger weight at ripening

The lowest finger weight reduction during both the years were observed in 50 mg l^{-1} and 25 mg l^{-1} kinetin applied at third and fourth w.a.b.e. and they were at par with each other.

Plate 5 Effect of kinetin sprays on 'D' finger

Plate 6 Effect of BA sprays on 'D' finger


T1
T2
T3
T4
C1
C2


T1
T2
T3
T4
C1
C2

Kinetin at 100mg l^{-1} followed by 75 mg l^{-1} of the same applied at third and fifth w.a.b.e. recorded the highest percentage reduction in the first year whereas in the second year 100 mg l^{-1} of BA applied at third and fifth week followed by the same but when applied at third and fourth week after bunch emergence recorded highest percentage reduction in finger weight.

4.1.4.5 Pulp weight at ripening

In the first season the highest pulp weight was recorded at 50 mg l^{-1} of kinetin followed by 25 mg l^{-1} sprayed at third and fourth w.a.b.e. which were statistically at par with each other and significantly superior over other treatments (Table 5).

4.1.4.6 Percentage pulp weight

In the first season no significant differences between treatment means were observed. In the second season 25mg l^{-1} of kinetin applied at third and fifth w.a.b.e. recorded maximum followed by the same concentration, but applied during third and fourth week after bunch emergence (Table 5).

4.1.4.7 Peel weight at ripening

The highest peel weights during both the seasons were observed at 50 mg l^{-1} of kinetin sprays applied third and fourth and third and fifth week after bunch emergence. It was on par with other treatments except the control (Table 5).

4.1.4.8 Percentage peel weight

In the first season 100 mg l^{-1} of kinetin applied during third and fourth w.a.b.e. recorded the highest and it was statistically superior to all other

Table 5 Anocova showing the effect of cytokinin sprays on finger characters at ripening in banana cv. 'Nendran'

Treatments		Pulp weight (gm)		Pulp weight expressed as percentage of total fruit weight		Peel weight (gm)		Peel weight expressed as percentage of total fruit weight		Pulp thickness (cm)		Peel thickness (cm)	
		I season	II season	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season
T_1	Kinetin 25 mg l^{-1} 3rd & 4th w.a.b.e.	136.64 (53.00)	60.23 (53.00)	81.58 (53.00)	69.12 (53.00)	29.95 (53.00)	26.64 (53.00)	17.94 (53.00)	30.57 (53.00)	3.20 (53.00)	3.05 (53.00)	0.146 (53.00)	0.138 (53.00)
T_2	Kinetin 50 mg l^{-1} 3rd & 4th w.a.b.e	138.59 (53.00)	58.63 (52.00)	80.85 (53.00)	66.23 (52.00)	32.53 (53.00)	29.92 (52.00)	17.94 (53.00)	33.80 (52.00)	3.29 (53.00)	3.19 (52.00)	0.160 (53.00)	0.149 (52.00)
T_3	Kinetin 75 mg l^{-1} 3rd & 4th w.a.b.e.	122.51 (49.00)	47.46 (48.00)	80.96 (49.00)	65.98 (48.00)	32.53 (49.00)	29.92 (48.00)	19.60 (49.00)	34.29 (48.00)	2.98 (49.00)	2.74 (48.00)	0.147 (49.00)	0.135 (48.00)
T_4	Kinetin 100 mg l^{-1} 3rd & 4th w.a.b.e.	120.36 (49.00)	44.24 (41.00)	80.35 (49.00)	65.77 (41.00)	28.66 (49.00)	22.99 (41.00)	19.15 (49.00)	34.29 (41.00)	2.97 (49.00)	2.79 (41.00)	0.144 (49.00)	0.130 (41.00)
T_5	Kinetin 25 mg l^{-1} 3rd & 5th w.a.b.e.	126.96 (52.00)	60.76 (54.00)	80.90 (52.00)	69.83 (54.00)	28.85 (52.00)	25.89 (54.00)	18.46 (52.00)	30.22 (54.00)	3.07 (52.00)	3.01 (54.00)	0.145 (52.00)	0.137 (54.00)
T_6	Kinetin 50 mg l^{-1} 3rd & 5th w.a.b.e.	127.99 (49.00)	57.78 (51.00)	79.47 (49.00)	65.26 (51.00)	31.29 (49.00)	29.43 (51.00)	19.49 (49.00)	34.73 (51.00)	3.22 (49.00)	3.15 (51.00)	0.158 (49.00)	0.143 (51.00)
T_7	Kinetin 75 mg l^{-1} 3rd & 5th w.a.b.e	112.04 (49.00)	42.27 (42.00)	79.48 (49.00)	64.34 (42.00)	28.68 (49.00)	23.42 (42.00)	20.38 (49.00)	35.67 (42.00)	2.92 (49.00)	2.86 (42.00)	0.144 (49.00)	0.132 (42.00)
T_8	Kinetin 100 mg l^{-1} 3rd & 5th w.a.b.e.	110.84 (49.00)	39.44 (43.00)	79.63 (49.00)	63.14 (43.00)	27.88 (49.00)	22.77 (43.00)	20.11 (49.00)	36.89 (43.00)	2.88 (49.00)	2.85 (43.00)	0.141 (49.00)	0.131 (43.00)
T_9	BA 25 mg l^{-1} 3rd & 4th w.a.b.e	117.46 (48.00)	44.32 (47.00)	81.15 (48.00)	63.48 (47.00)	26.50 (48.00)	25.53 (47.00)	18.48 (48.00)	36.58 (47.00)	2.93 (48.00)	2.86 (47.00)	0.144 (48.00)	0.136 (47.00)
T_{10}	BA 50 mg l^{-1} 3rd & 4th w.a.b.e	119.69 (48.00)	44.05 (45.00)	81.09 (48.00)	62.10 (45.00)	27.08 (48.00)	27.14 (45.00)	18.44 (48.00)	38.27 (45.00)	2.97 (48.00)	2.90 (45.00)	0.147 (48.00)	0.139 (45.00)
T_{11}	BA 75 mg l^{-1} 3rd & 4th w.a.b.e	122.36 (50.00)	48.11 (42.00)	80.87 (50.00)	63.32 (42.00)	28.57 (50.00)	27.90 (42.00)	18.96 (50.00)	36.72 (42.00)	3.18 (50.00)	3.05 (42.00)	0.150 (50.00)	0.142 (42.00)
T_{12}	BA 100 mg l^{-1} 3rd & 4th w.a.b.e	111.45 (49.00)	48.11 (44.00)	80.30 (49.00)	61.52 (44.00)	26.11 (49.00)	24.90 (44.00)	18.79 (49.00)	38.52 (44.00)	2.89 (49.00)	2.79 (44.00)	0.141 (49.00)	0.134 (44.00)
T_{13}	BA 25 mg l^{-1} 3rd & 5th w.a.b.e	117.51 (48.00)	48.96 (40.00)	81.52 (48.00)	66.30 (40.00)	26.26 (48.00)	24.88 (40.00)	18.19 (48.00)	33.70 (40.00)	2.91 (48.00)	2.87 (40.00)	0.186 (48.00)	0.136 (40.00)
T_{14}	BA 50 mg l^{-1} 3rd & 5th w.a.b.e	118.10 (48.00)	50.89 (47.00)	81.02 (48.00)	66.98 (47.00)	26.54 (48.00)	25.11 (47.00)	18.29 (48.00)	33.06 (47.00)	2.94 (48.00)	2.89 (47.00)	0.146 (48.00)	0.137 (47.00)
T_{15}	BA 75 mg l^{-1} 3rd & 5th w.a.b.e	121.00 (48.00)	55.01 (50.00)	81.08 (48.00)	67.31 (50.00)	28.06 (48.00)	26.73 (50.00)	18.90 (48.00)	32.72 (50.00)	3.16 (48.00)	3.06 (50.00)	0.149 (48.00)	0.139 (50.00)
T_{16}	BA 100 mg l^{-1} 3rd & 5th w.a.b.e	110.45 (47.00)	40.38 (43.00)	79.54 (47.00)	62.45 (43.00)	26.31 (47.00)	24.55 (43.00)	25.64 (47.00)	38.13 (43.00)	2.87 (47.00)	2.80 (43.00)	0.141 (47.00)	0.133 (43.00)
T_{17}	Control without urea	109.09 (47.00)	30.38 (43.00)	80.39 (47.00)	52.66 (43.00)	24.86 (47.00)	23.44 (43.00)	18.37 (47.00)	40.49 (43.00)	2.62 (47.00)	2.69 (43.00)	0.133 (47.00)	0.129 (43.00)
T_{18}	Control with urea	111.30 (47.00)	35.29 (45.00)	80.27 (47.00)	55.20 (45.00)	25.47 (47.00)	24.53 (45.00)	18.44 (47.00)	38.42 (45.00)	2.86 (47.00)	2.78 (45.00)	0.140 (47.00)	0.130 (45.00)
CD(0.05)		9.60	9.66	3.81	5.95	2.33	0.98	4.98	4.13	0.20	0.14	0.03	0.002

w.a.b.e. - Weeks after bunch emergence. Figures in paranthesis indicate the finger number taken as covariate in Anocova

treatments. In the second season it was the control with urea which recorded the highest (Table 5).

4.1.4.9 Pulp thickness at ripening

In both the seasons pulp thickness was maximum for kinetin at 50 mg l^{-1} when sprayed at third and fourth and third and fifth w.a.b.e. and 75 mg l^{-1} of BA applied during third and fifth week after bunch emergence.

In both years the control without urea was the most inferior but in the second year it was at par with the control with urea (Table 5).

4.1.4.10 Peel thickness at ripening

In the first season no statistical significance was seen between treatments. However highest peel thickness was observed for 25 mg l^{-1} of BA applied during third and fifth week.

Kinetin at 50 mg l^{-1} sprayed during third and fourth week recorded the maximum in the second season. In both the seasons control without urea recorded minimum peel thickness (Table 5).

4.1.5 EFFECT ON DAYS TO MATURITY, RIPENING AND SHELF LIFE

The data on days to maturity, ripening and shelf life are presented in Table 6.

4.1.5.1 Days to maturity

In both the seasons sprays of 50 mgl^{-1} kinetin at third and fourth w.a.b.e. took more time to reach maturity and those were at par with the same at third and fifth week and 25 mg l^{-1} treatments of the same at both levels of

Table 6 Effect of cytokinin on maturuty, ripening and shelf life in banana cv. 'Nendran'

Treatment	Days to maturity		Days to ripening		Shelf life (days)	
	I season	II season	I season	II season	I season	II season
T_1 Kinetin 25 mg l^{-1} 3rd & 4th w.a.b.e.	69.75	68.00	8.50	7.75	3.69	3.25
T_2 Kinetin 50 mg l^{-1} 3rd & 4th w.a.b.e.	70.50	70.00	8.81	8.25	4.03	3.50
T_3 Kinetin 75 mg l^{-1} 3rd & 4th w.a.b.e.	66.88	65.50	8.31	7.25	3.13	2.83
T_4 Kinetin 100 mg l^{-1} 3rd & 4th w.a.b.e.	65.63	62.50	8.25	6.75	2.94	2.42
T_5 Kinetin 25 mg l^{-1} 3rd & 5th w.a.b.e.	68.75	68.50	8.44	7.75	3.59	3.17
T_6 Kinetin 50 mg l^{-1} 3rd & 5th w.a.b.e.	69.13	69.50	8.69	8.00	3.97	3.33
T_7 Kinetin 75 mg l^{-1} 3rd & 5th w.a.b.e.	65.63	64.50	8.31	8.00	2.97	2.75
T_8 Kinetin 100 mg l^{-1} 3rd & 5th w.a.b.e.	65.50	61.50	8.25	7.00	2.78	2.42
T_9 BA 25 mg l^{-1} 3rd & 4th w.a.b.e.	65.75	64.50	8.25	7.25	2.69	2.75
T_{10} BA 50 mg l^{-1} 3rd & 4th w.a.b.e.	66.50	64.50	8.38	7.75	3.16	2.83
T_{11} BA 75 mg l^{-1} 3rd & 4th w.a.b.e.	67.13	66.00	8.50	8.00	3.63	3.75
T_{12} BA 100 mg l^{-1} 3rd & 4th w.a.b.e.	65.50	64.00	8.19	7.00	2.66	2.50
T_{13} BA 25 mg l^{-1} 3rd & 5th w.a.b.e.	65.63	63.50	8.19	7.00	2.69	2.67
T_{14} BA 50 mg l^{-1} 3rd & 5th w.a.b.e.	66.00	65.50	8.31	7.50	3.53	2.75
T_{15} BA 75 mg l^{-1} 3rd & 5th w.a.b.e.	66.63	66.50	8.44	7.75	3.22	3.67
T_{16} BA 100 mg l^{-1} 3rd & 5th w.a.b.e.	65.38	62.50	8.19	7.00	2.47	2.42
T_{17} Control without urea	70.13	66.00	8.34	7.50	3.13	2.83
T_{18} Control with urea	64.94	61.00	8.06	6.50	2.36	2.50
CD(0.05)	3.97	1.84	0.48	0.89	0.53	0.46

w.a.b.e. - Weeks after bunch emergence

application. In the first year the control without urea was at par with the best treatment but not in the second year.

The control with urea showed marked reduction in time to maturity. However this was at par with some treatments of both hormons at high concentrations.

4.1.5.2 Days to ripening

The data almost showed a similar trend as in the case of time to maturity. The maximum time taken for ripening was observed for kinetin 50 mg l^{-1} applied at third and fourth week followed by the same at third and fifth w.a.b.e. The control with urea revealed a clear-cut reduction in time taken for ripening in both seasons. Between the two seasons of study, all the treatments in the second year showed reduced time for ripening.

4.1.5.3 Shelf life

In the first year 50 mg l^{-1} of kinetin applied at third and fourth week followed by the same at third and fifth week were the best. This was at par with 25 mg l^{-1} sprays of the same and BA at 75 mg l^{-1} during both intervals of application.

Though the trend remained almost the same, the highest shelf life were observed in BA at 75 mg l^{-1} at both intervals of application during the second year. The lowest shelf life was obtained in control with urea in the first season which was at par with highest concentration of BA (100 mg l^{-1}) at both intervals and kinetin applied at third and fifth week in the first year. In the second season the same treatments showed reduction in shelf life but the lowest were in highest

concentration of BA and kinetin (100 mg l^{-1}) at both levels and they were at par with the control with urea.

4.1.6 BIOCHEMICAL ASPECTS

The data on biochemical and quality aspects are presented in Table 7.

4.1.6.1 Urea content at ripening

BA 100 mg l^{-1} applied at third and fifth week after bunch emergence was significantly superior to other treatments except the same concentration applied at third and fourth week. Among the different treatments of kinetin also, the highest concentration of 100 mg l^{-1} at both intervals showed the highest residiual urea content. Kinetin 25 mg l^{-1} followed by 50 mg l^{-1} applied at third and fourth week were significantly inferior to other treatments. The control with urea also showed high residual urea comparable with treatments showing the highest residual content (Fig. 2).

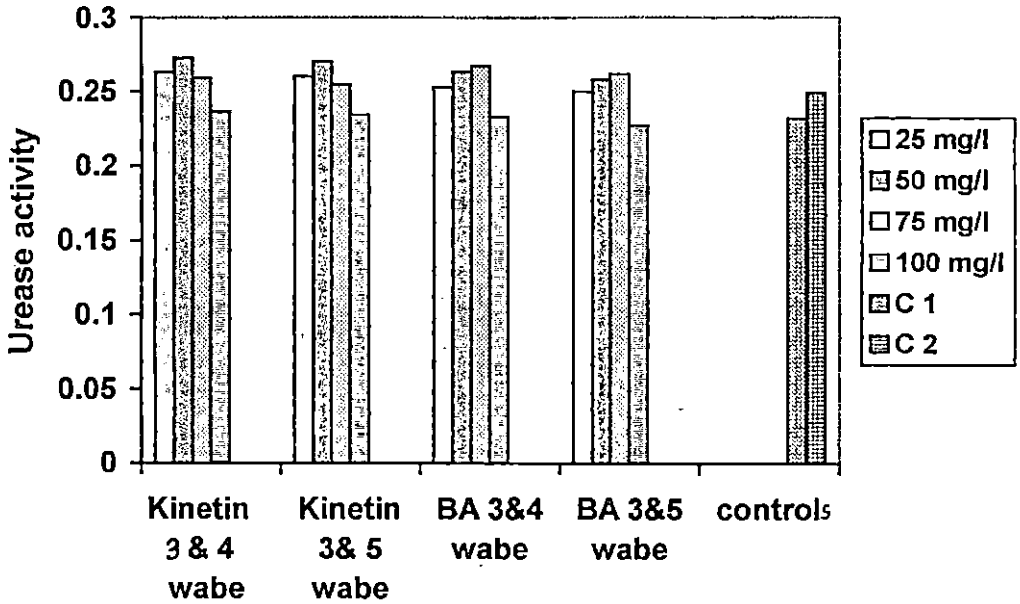
4.1.6.2 Urease activity at fruit ripening

The highest activity was noticed for kinetin 50 mg l^{-1} sprayed at third and fourth week followed by the same concentration sprayed at third and fifth week after emergence of bunch which were at par with all treatments of 25, 50 and 75 mg l^{-1} of BA. The lowest urease activity was observed in the control without urea (Fig. 2).

4.1.6.3 Nitrite nitrogen

The lowest nitrite nitrogen content was recorded in control without urea which were at par with 100 and 75 mg l^{-1} of kinetin applied at third and fifth week after bunch emergence and the control with urea.

'[Fig.2 Effect of cytokinin treatments on urease activity (μ g/g) and urea content (ppm) in banana cv. 'Nendran'



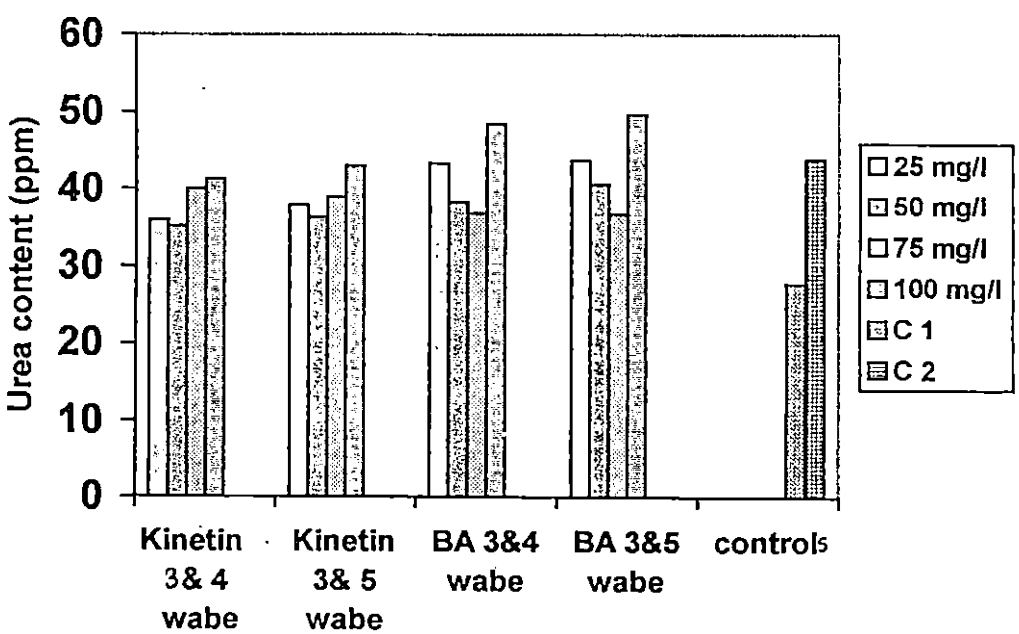


Table 7 Effect of cytokinin on biochemical and quality aspects in banana cv. 'Nendran'

Treatment	Urea content (ppm)	Urease activity (µg/g)	Nitrite N (mM/g)	Acidity (%)	Reducing sugar(%)	Non-reducing sugar (%)	Total sugar (%)
T_1 Kinetin 25 mg l^{-1} 3rd & 4th w.a.b.e.	35.95	0.263	41.33	0.354	11.79	2.51	14.30
T_2 Kinetin 50 mg l^{-1} 3rd & 4th w.a.b.e.	35.09	0.273	49.33	0.342	11.78	2.55	14.32
T_3 Kinetin 75 mg l^{-1} 3rd & 4th w.a.b.e.	39.97	0.259	41.33	0.360	11.67	2.37	14.04
T_4 Kinetin 100 mg l^{-1} 3rd & 4th w.a.b.e..	41.24	0.237	38.67	0.372	11.63	2.37	14.00
T_5 Kinetin 25 mg l^{-1} 3rd & 5th w.a.b.e.	37.93	0.260	29.33	0.363	11.86	2.59	14.44
T_6 Kinetin 50 mg l^{-1} 3rd & 5th w.a.b.e.	36.28	0.270	32.00	0.354	11.80	2.54	14.34
T_7 Kinetin 75 mg l^{-1} 3rd & 5th w.a.b.e.	38.99	0.255	24.00	0.360	11.55	2.51	14.06
T_8 Kinetin 100 mg l^{-1} 3rd & 5th w.a.b.e.	43.00	0.234	21.33	0.366	11.72	2.42	14.14
T_9 BA 25 mg l^{-1} 3rd & 4th w.a.b.e.	43.31	0.253	33.33	0.362	11.15	2.51	13.66
T_{10} BA 50 mg l^{-1} 3rd & 4th w.a.b.e.	38.26	0.263	57.33	0.353	11.76	2.57	14.33
T_{11} BA 75 mg l^{-1} 3rd & 4th w.a.b.e.	36.91	0.267	57.33	0.348	11.82	2.64	14.46
T_{12} BA 100 mg l^{-1} 3rd & 4th w.a.b.e.	48.47	0.233	29.67	0.366	11.78	2.50	14.28
T_{13} BA 25 mg l^{-1} 3rd & 5th w.a.b.e.	43.73	0.250	26.67	0.376	11.22	2.47	13.69
T_{14} BA 50 mg l^{-1} 3rd & 5th w.a.b.e.	40.66	0.258	53.33	0.358	11.76	2.59	14.34
T_{15} BA 75 mg l^{-1} 3rd & 5th w.a.b.e.	36.83	0.262	42.67	0.427	11.81	2.57	14.38
T_{16} BA 100 mg l^{-1} 3rd & 5th w.a.b.e.	49.64	0.227	24.00	0.368	11.74	2.39	14.13
T_{17} Control without urea	27.67	0.232	17.33	0.317	13.21	2.92	16.13
T_{18} Control with urea	43.92	0.249	27.33	0.366	11.98	2.34	14.32
CD(0.05)	4.91	0.029	12.13	0.057	0.23	0.14	0.17

w.a.b.e. - Weeks after bunch emergence

BA 75 mg l^{-1} followed by 50 mg l^{-1} of the same at third and fourth week after bunch emergence recorded the highest content of nitrite nitrogen.

4.1.7 QUALITATIVE CHARACTERS

4.1.7.1 Acidity

Acidity was highest when 75 mg l^{-1} of BA was applied during third and fifth w.a.b.e. It was also significantly superior to all other treatments .The control with urea also registered high acidity percent whereas control without urea showed lowest acidity.

4.1.7.2 Sugars

4.1.7.2.1 Total sugars

Total sugars were the highest for control without urea followed by 75 mg l^{-1} of BA applied at third and fourth week after bunch emergence.

Analysis of the table reveal that in the case of kinetin, higher total sugars were observed at lower concentrations which gradually reduced to the highest concentration of 100 mg l^{-1} whereas in the case of BA, both the highest and lowest concentration recorded lower values irrespective of the interval of application.

4.1.7.2.2 Reducing sugars

The control without urea was significantly superior to all other treatments. Between other treatments there were no significant differences observed.

4.1.7.2.3 Non reducing sugars

The control without urea was significantly superior to all other treatments. Lowest percentage of reducing sugars was observed for control with urea.

4.1.8 EFFECT OF CYTOKININ ON ELECTROLYTIC LEAKAGE

The electrolyte leakage at different stages of ripening are presented in Table 8.

4.1.8.1 Yellow- 4 hours

Many treatments registered low leachate values. Both kinetin and BA from 25 –75 mg l^{-1} at third and fourth w.a.b.e. and kinetin 25 and 50 mg l^{-1} and BA 75 mg l^{-1} at third and fifth w.a.b.e. exuded significantly lower amount of leachates.

4.1.8.2 Yellow-8 hours

Kinetin , 25 and 50 mg l^{-1}applied at third and fourth week and 50 mg l^{-1} applied at third and fifth week along with BA 75 mg l^{-1} applied at both stages exuded minimum leachates, the highest was observed in the control with urea.

4.1.8.3 Yellow - 4 + 1\2 hour boiling

Kinetin.25 and 50 mg l^{-1} applied at both stages and BA 75 and 50 mg l^{-1} applied at third and fourth w.a.b.e. showed the lowest electrolytic leakage values. The control with urea recorded the highest leakage.

Table 8 Effect of cytokinin treatments on electrolytic leakage (mmhos/cm/g) at different stages of ripening in banana cv. 'Nendran'

Treatments		Yellow				50% black				100% black			
		4 hours	8 hours boiling	4+½ hours boiling	8+½ hours	4 hours	8 hours boiling	4+½ hours boiling	8+½ hours	4 hours	8 hours boiling	4+½ hours boiling	8+½ hours
T_1	Kinetin 25 mg l^{-1} 3rd & 4th w.a.b.e.	0.001 (1.14)	0.002 (1.28)	0.002 (1.52)	0.003 (1.63)	0.002 (1.28)	0.002 (1.41)	0.002 (1.52)	0.003 (1.82)	0.002 (1.42)	0.002 (1.52)	0.003 (1.72)	0.003 (1.82)
T_2	Kinetin 50 mg l^{-1} 3rd & 4th w.a.b.e.	0.001 (1.14)	0.002 (1.28)	0.002 (1.52)	0.002 (1.52)	0.001 (1.14)	0.002 (1.41)	0.002 (1.52)	0.003 (1.82)	0.002 (1.28)	0.002 (1.52)	0.003 (1.63)	0.003 (1.82)
T_3	Kinetin 75 mg l^{-1} 3rd & 4th w.a.b.e.	0.001 (1.14)	0.002 (1.41)	0.003 (1.63)	0.003 (1.63)	0.002 (1.38)	0.002 (1.52)	0.003 (1.72)	0.003 (1.82)	0.002 (1.52)	0.002 (1.52)	0.003 (1.72)	0.004 (1.90)
T_4	Kinetin 100 mg l^{-1} 3rd & 4th w.a.b.e.	0.002 (1.41)	0.002 (1.41)	0.003 (1.63)	0.003 (1.63)	0.002 (1.38)	0.002 (1.52)	0.003 (1.72)	0.003 (1.82)	0.002 (1.52)	0.002 (1.52)	0.003 (1.72)	0.004 (1.90)
T_5	Kinetin 25 mg l^{-1} 3rd & 5th w.a.b..e.	0.001 (1.14)	0.002 (1.41)	0.002 (1.52)	0.003 (1.63)	0.002 (1.28)	0.002 (1.41)	0.003 (1.61)	0.004 (1.90)	0.002 (1.52)	0.002 (1.52)	0.003 (1.63)	0.003 (1.82)
T_6	Kinetin 50 mg l^{-1} 3rd & 5th w.a.b..e.	0.001 (1.14)	0.002 (1.28)	0.002 (1.52)	0.003 (1.63)	0.001 (1.14)	0.002 (1.14)	0.003 (1.63)	0.003 (1.82)	0.002 (1.42)	0.002 (1.52)	0.003 (1.63)	0.003 (1.82)
T_7	Kinetin 75 mg l^{-1} 3rd & 5th w.a.b..e.	0.002 (1.41)	0.002 (1.41)	0.003 (1.63)	0.003 (1.28)	0.002 (1.52)	0.002 (1.63)	0.003 (1.72)	0.003 (1.52)	0.002 (1.52)	0.002 (1.63)	0.003 (1.63)	0.003 (1.82)
T_8	Kinetin 100 mg l^{-1} 3rd & 5th w.a.b.e.	0.002 (1.41)	0.002 (1.52)	0.003 (1.63)	0.003 (1.72)	0.002 (1.38)	0.003 (1.61)	0.003 (1.72)	0.004 (1.90)	0.003 (1.63)	0.003 (1.63)	0.003 (1.82)	0.004 (1.90)
T_9	BA 25 mg l^{-1} 3rd & 4th w.a.b.e	0.001 (1.14)	0.002 (1.41)	0.002 (1.52)	0.003 (1.63)	0.002 (1.28)	0.002 (1.41)	0.003 (1.63)	0.003 (1.73)	0.002 (1.28)	0.002 (1.41)	0.003 (1.63)	0.003 (1.82)
T_{10}	BA 50 mg l^{-1} 3rd & 4th w.a.b.e.	0.001 (1.14)	0.002 (1.41)	0.002 (1.52)	0.003 (1.63)	0.002 (1.28)	0.002 (1.41)	0.003 (1.63)	0.003 (1.82)	0.002 (1.52)	0.002 (1.52)	0.003 (1.63)	0.003 (1.82)
T_{11}	BA 75 mg l^{-1} 3rd & 4th w.a.b.e	0.001 (1.14)	0.002 (1.28)	0.002 (1.52)	0.002 (1.52)	0.002 (1.28)	0.002 (1.28)	0.003 (1.63)	0.003 (1.82)	0.002 (1.41)	0.002 (1.52)	0.003 (1.63)	0.003 (1.82)
T_{12}	BA 100 mg l^{-1} 3rd & 4th w.a.b.e	0.002 (1.41)	0.002 (1.52)	0.003 (1.72)	0.003 (1.72)	0.002 (1.38)	0.003 (1.61)	0.003 (1.79)	0.004 (1.90)	0.002 (1.52)	0.002 (1.63)	0.003 (1.79)	0.004 (1.90)
T_{13}	BA 25 mg l^{-1} 3rd & 5th w.a.b.e	0.002 (1.41)	0.002 (1.41)	0.003 (1.63)	0.003 (1.63)	0.002 (1.28)	0.002 (1.52)	0.003 (1.73)	0.003 (1.82)	0.002 (1.52)	0.002 (1.63)	0.003 (1.82)	0.003 (1.82)
T_{14}	BA 50 mg l^{-1} 3rd & 5th w.a.b.e	0.002 (1.41)	0.002 (1.41)	0.003 (1.63)	0.003 (1.72)	0.002 (1.28)	0.002 (1.52)	0.003 (1.63)	0.003 (1.82)	0.002 (1.52)	0.002 (1.52)	0.003 (1.72)	0.003 (1.82)
T_{15}	BA 75 mg l^{-1} 3rd & 5th w.a.b.e	0.001 (1.14)	0.002 (1.28)	0.002 (1.52)	0.003 (1.63)	0.002 (1.28)	0.002 (1.41)	0.003 (1.63)	0.003 (1.82)	0.002 (1.52)	0.002 (1.52)	0.003 (1.63)	0.003 (1.82)
T_{16}	BA 100 mg l^{-1} 3rd & 5th w.a.b.e	0.002 (1.14)	0.002 (1.52)	0.003 (1.72)	0.003 (1.72)	0.002 (1.38)	0.003 (1.61)	0.003 (1.72)	0.004 (1.90)	0.002 (1.52)	0.003 (1.63)	0.003 (1.82)	0.004 (1.90)
T_{17}	Control without urea	0.005 (2.24)	0.006 (2.38)	0.008 (2.89)	0.008 (2.89)	0.005 (2.31)	0.006 (2.52)	0.008 (2.89)	0.010 (3.21)	0.006 (2.44)	0.002 (2.71)	0.013 (3.60)	0.014 (3.74)
T_{18}	Control with urea	0.006 (2.45)	0.006 (2.52)	0.009 (3.05)	0.009 (3.05)	0.005 (2.50)	0.006 (2.52)	0.013 (3.65)	0.014 (3.79)	0.006 (2.52)	0.002 (2.71)	0.015 (3.83)	0.017 (4.08)
CD(0.05)		0.229	0.258	0.316	0.344	0.459	0.287	0.373	0.316	0.287	0.287	0.373	0.316

Figures in paranthesis indicate 'x1000 square root' transformation w.a.b.e. - Weeks after bunch emergence

4.1.8.4 Yellow - 8+1\2 hour boiling

Kinetin 50 mg l^{-1} and BA 75 mg l^{-1} applied at third and fourth w.a.b.e exuded the minimum leakage. All the imposed cytokinin treatments were at par with these. The control with urea exuded the maximum electrolytes.

4.1.8.5 50% Black- 4 hours

Lowest leakage was recorded by 50 mg l^{-1} of kinetin applied at both stages. All treatments of cytokinin were significantly different from the control with urea which showed highest values of leachate.

4.1.8.6 50 % Black - 8 hours

BA 75 mg l^{-1} applied at third and fourth w.a.b.e followed by 25 and 50 mg $l^{-1}$of the same at same interval recorded the lowest leachate. The two controls recorded the highest leakage.

4.1.8.7 50 % Black- 4+1/2 hour boiling

Kinetin 25 and 50 mg l^{-1} applied at third and fourth week recorded the least leakage whereas control with urea recorded the highest.

4.1.8.8 50 % Black – 8+1/2 hour boiling

Kinetin 75 mg l^{-1} applied at third and fifth week followed by 25 mg l^{-1} applied at third and fourth week exuded minimum electrolytes. The control with urea recorded the maximum which was again superior to all other treatments.

4.1.8.9 100 % Black – 4 hours

Kinetin 50 mg l^{-1} and BA 25 mg l^{-1} applied at third and fourth w.a.b.e recorded the minimum leakage. The control with urea recorded the highest values which was at par only with the other controls.

4.1.8.10 100 % Black - 8 hours

All treatments of cytokinin except the two controls were at par. The two controls showed the maximum.

4.1.8.11 100 % Black- 4+1/2 hour boiling

Low leakage values were exhibited in many treatments like 50 mg l^{-1} kinetin at third and fourth week, 25 and 50 mg l^{-1} of the same at third and fifth week, 25 and 75 mg l^{-1} of BA at third and fourth and 75 mg l^{-1} of the same applied at third and fifth w.a.b.e . The highest leakage values were obtained in control with urea.

4.1.8.12 100 % Black - 8 + ½ hour boiling

Minimum leachate values were obtained for all cytokinin treatments which were at par with each other. The highest leakage was again observed in control with urea which was superior to all other treatments.

4.2 POTASSIUM

The results of the study are presented under the following broad headings.

4.2.1 EFFECT OF POTASSIUM SPRAYS ON LINEAR GROWTH (LENGTH) OF FRUIT

The results of the effect of different sprays of potassium on the length of fruits are presented in Table 9.

4.2.1.1 Third week-end

Length was observed highest for 1% K_2SO_4 treatment and this was on par with a number of treatments in the first season. Length was lowest for 1%

Table 9 Effect of potassium on linear growth (length) in banana cv. 'Nendran'

Treatments	3rd week end		4th week end		RGR 1 week after 1st spray		5th week end		6th week end		RGR 1 week after 2nd spray		8th week end (a)		9th week end (b)		RGR between (a) & (b)		RGR between (b) &2nd spray	
	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season
T_1	22.03	19.93	22.63	20.40	0.027	0.027	23.40	20.93	23.73	21.30	0.037	0.023	24.43	22.10	24.77	22.43	0.033	0.013	0.016	0.017
T_2	21.73	19.97	22.50	20.40	0.037	0.030	23.37	20.97	23.77	21.33	0.040	0.027	24.57	22.17	24.97	22.53	0.017	0.017	0.018	0.017
T_3	22.00	20.23	23.07	21.23	0.040	0.033	23.67	21.87	24.07	22.23	0.040	0.030	24.90	23.07	25.27	22.47	0.017	0.020	0.018	0.017
T_4	20.97	19.50	21.57	19.93	0.027	0.023	21.97	20.30	22.63	20.77	0.030	0.023	23.47	21.57	23.83	21.90	0.017	0.013	0.017	0.016
T_5	21.77	19.97	22.47	20.43	0.030	0.027	22.90	20.70	23.53	21.23	0.030	0.023	24.30	22.00	24.67	22.33	0.017	0.013	0.016	0.016
T_6	21.37	20.27	22.27	20.87	0.043	0.030	22.70	21.23	23.57	21.80	0.037	0.027	24.33	22.67	24.73	23.03	0.020	0.017	0.018	0.018
T_7	22.17	20.13	22.97	20.73	0.037	0.030	23.77	21.43	24.33	21.83	0.033	0.033	24.73	22.60	25.20	22.93	0.010	0.013	0.016	0.018
T_8	22.13	20.07	23.13	20.70	0.047	0.033	24.13	21.40	24.57	21.80	0.043	0.033	25.37	22.53	25.77	22.93	0.020	0.020	0.019	0.018
T_9	22.03	20.73	22.90	21.33	0.040	0.030	23.70	21.97	24.13	22.40	0.033	0.030	24.97	23.13	25.37	23.50	0.020	0.017	0.018	0.017
T_{10}	21.93	19.90	22.63	20.40	0.033	0.027	23.03	20.77	23.80	21.37	0.033	0.027	24.60	22.10	24.93	22.43	0.013	0.013	0.017	0.016
T_{11}	21.80	19.93	22.80	20.63	0.047	0.033	23.23	21.00	24.13	21.60	0.037	0.027	24.93	22.40	25.33	22.80	0.020	0.020	0.018	0.017
T_{12}	22.17	20.17	22.90	20.80	0.033	0.033	23.27	21.17	24.03	21.73	0.030	0.027	24.80	25.53	25.20	22.87	0.020	0.013	0.016	0.016
T_{13}	21.47	19.70	21.80	19.90	0.013	0.010	22.00	20.17	22.23	20.40	0.009	0.013	22.63	20.83	22.83	21.03	0.009	0.010	0.008	0.009
T_{14}	21.97	19.67	22.23	19.93	0.020	0.017	22.63	20.23	23.00	20.53	0.020	0.017	23.63	21.03	23.90	21.30	0.010	0.010	0.013	0.012
CD(0.05)	0.52	0.75	0.58	0.72	0.01	0.01	0.52	0.78	0.49	0.78	0.006	0.01	0.49	2.69	0.47	0.75	NS	NS	0.006	0.006

T_1 - Potassium 1% 3rd & 4th week after bunch emergence
T_2 - „ 3% „
T_3 - „ 5% „
T_4 - „ 1% 3rd & 5th week after bunch emergence
T_5 - „ 3% „
T_6 - „ 5% „
T_7 - K_2SO_4 1% 3rd & 4th week after bunch emergence
T_8 - „ 3% „
T_9 - „ 5% „
T_{10} - K_2SO_4 1% 3rd & 5th week after bunch emergence
T_{11} - „ 3% „
T_{12} - „ 5% „
T_{13} - Control without urea
T_{14} - Control with urea

RGR- Relative Growth Rate

KCl sprays applied on third and fifth week in both the seasons. In the second season 5 % K_2SO_4 treatment at third and fourth w.a.b.e recorded the highest.

4.2.1.2 Fourth week- end

In the first season length was highest for 3 % sprays of K_2SO_4 at third and fourth w.a.b.e. This was on par with all sprays of K_2SO_4 and also with 1% and 5 % KCl applied at third and fourth week. In the second season 5 % K_2SO_4 spray applied at third and fourth w.a.b.e recorded the maximum length and control without urea recorded the minimum.

4.2.1.3 RGR between third and fourth week

RGR was the highest for 3 % K_2SO_4 applied during third and fourth and third and fifth w.a.b.e in both first and second season. In the first season it was superior to other treatments whereas in the second season it was at par with 5 % K_2SO_4 and 5 % KCl applied at third and fourth and third and fifth w.a.b.e .In both seasons control without urea recorded the minimum RGR.

4.2.1.4 Fifth week-end

The general improved effect of K_2SO_4 sprays applied at third and fourth w.a.b.e was evident. In the first year 3 % sprays of K_2SO_4 revealed the best and this was at par with other sprays of K_2SO_4 whereas in the second year it was 5 % K_2SO_4 which was the best and it was on par with other concentrations of same chemical applied at the same time . In both the years, control without urea recorded the least growth.

4.2.1.5 Sixth week-end

The effect of K_2SO_4 applied at third and fourth w.a.b.e was again explicit. In the first season the profound effect of 3 % spray was observed which

was on par with other concentrations of same chemicals whereas in the second year it was 5 % which was the best and was at par with 3 % sprays of K_2SO_4. Control without urea was observed to be having minimum length.

4.2.1.6 RGR one week after second spray

The distinct effect of 3 % K_2SO_4 spray applied at third and fourth w.a.b.e could be observed by the end of second spray. In the first year it was significantly superior over other treatments whereas in the second year it was at par with 1 % of same applied at same time.

4.2.1.7 Eighth week-end

3% K_2SO_4 spray given third and fourth week recorded the highest followed by 5 % spray of the same chemical which were at par with each other in the first season whereas in the second season 5 % K_2SO_4 sprays applied at third and fifth week followed by the same concentration of the chemical but applied at third and fourth week recorded the maximum length and these two treatments were superior to all other treatments .

4.2.1.8 Ninth week-end

Maximum length during ninth week was observed for 3 % K_2SO_4 sprays given at third and fourth week followed by 5 % of the same. In the second season 5 % followed by 3 % of K_2SO_4 given at third and fourth week were having more length and they were at par with each other. Control without urea showed the minimum in both cases.

4.2.1.9 RGR between eighth and ninth week

No significant differences were observed between treatment means in both the seasons .

4.2.1.10 RGR between ninth week and second spray

In both the seasons all treatments were significantly superior over the two controls. Again, the distinct influence of 3 % K_2SO_4 sprays applied at third and fourth w.a.b.e was evident . In the first year it was significantly superior over other treatments whereas in the second year it was at par with 1 % K_2SO_4 applied at same time and 5 % KCl applied at third and fifth w.a.b.e.

4.2.2 EFFECT OF POTASSIUM ON GRADE / GIRTH

The effects of potassium on grade of fingers are presented in Table 10.

4.2.2.1 Third week- end

K_2SO_4 prays at 5% applied at third and fifth followed by the same at third and fourth w.a.b.e recorded the highest grade in the first season whereas in the second season it was 3 % followed by 5 % K_2SO_4 applied at third and fifth w.a.b.e which recorded the highest . In both the years it was on par with a number of other treatments.

4.2.2.2 Fourth week-end

In the first year 3 % K_2SO_4 applied on third and fifth week recorded the highest grade and in the second season 5 % KCl sprays applied at third and fourth week followed by 3% K_2SO_4 applied at third and fifth w.a.b.e. recorded the highest grade of fingers . Control without urea and 5 % KCl sprays applied at third and fifth w.a.b.e recorded minimum grade in the first and second season respectively.

Table 10 Effect of potassium on girth/grade in banana cv. 'Nendran'

Treatments	3rd week end		4th week end		RGR 1 week after 1st spray		5th week end		6th week end		RGR 1 week after 2nd spray		8th week end (a)		9th week end (b)		RGR between (a) & (b)		RGR between (b) &2nd spray	
	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season
T_1	10.40	10.40	10.93	11.00	0.053	0.047	11.67	11.50	12.10	11.80	0.063	0.060	12.87	12.53	13.20	12.87	0.034	0.023	0.023	0.030
T_2	10.43	10.37	11.20	11.07	0.073	0.067	11.93	11.70	12.33	12.10	0.067	0.057	13.00	12.87	13.33	13.17	0.032	0.020	0.023	0.032
T_3	10.47	10.07	11.03	11.73	0.080	0.067	11.83	11.43	12.23	11.73	0.070	0.067	13.00	12.50	13.37	12.80	0.035	0.020	0.027	0.032
T_4	10.47	10.40	10.97	10.83	0.050	0.043	11.37	11.20	12.00	11.83	0.053	0.057	12.70	12.63	13.00	12.93	0.029	0.023	0.020	0.031
T_5	10.03	10.13	10.63	10.70	0.060	0.057	11.07	11.03	11.83	11.63	0.060	0.053	12.50	12.47	12.83	12.83	0.035	0.027	0.027	0.032
T_6	10.17	9.80	10.77	10.37	0.060	0.060	11.13	10.77	11.70	11.47	0.057	0.067	12.60	12.27	13.00	12.67	0.033	0.030	0.027	0.035
T_7	10.37	10.40	10.93	10.93	0.060	0.053	11.80	11.67	12.23	12.03	0.073	0.067	13.07	12.80	13.47	13.17	0.038	0.027	0.030	0.034
T_8	10.57	10.30	11.53	11.07	0.093	0.077	12.43	11.83	12.87	12.20	0.080	0.067	13.77	13.00	14.17	13.40	0.037	0.030	0.030	0.035
T_9	10.63	10.30	11.53	11.03	0.087	0.070	12.33	11.70	12.77	12.07	0.070	0.060	13.60	12.83	13.90	12.20	0.035	0.027	0.027	0.033
T_{10}	10.37	10.23	10.97	10.77	0.060	0.053	10.37	11.13	10.97	11.70	0.053	0.053	12.80	12.50	13.17	12.87	0.032	0.033	0.027	0.034
T_{11}	10.63	10.53	11.57	11.57	0.090	0.060	10.63	11.93	11.57	12.63	0.070	0.060	13.57	13.37	13.93	13.73	0.032	0.027	0.030	0.030
T_{12}	10.77	10.50	11.50	11.03	0.067	0.053	10.77	11.47	11.50	12.20	0.070	0.062	13.43	12.97	13.80	13.43	0.032	0.027	0.027	0.033
T_{13}	10.13	10.30	10.33	10.50	0.020	0.020	10.57	10.73	10.83	10.93	0.023	0.023	11.33	11.40	11.53	11.63	0.019	0.023	0.022	0.018
T_{14}	10.30	10.30	10.57	10.53	0.027	0.023	10.83	10.80	11.13	11.13	0.027	0.027	11.73	11.83	12.03	12.10	0.023	0.027	0.028	0.024
CD(0.05)	0.52	0.52	0.55	0.55	0.014	0.014	0.58	0.61	0.58	0.61	0.028	0.014	0.52	0.58	0.52	0.58	0.010	0.010	0.006	0.006

T_1 - Potassium1% 3rd & 4th week after bunch emergence
T_2 - „ 3% „
T_3 - „ 5% „
T_4 - „ 1% 3rd & 5th week after bunch emergence
T_5 - „ 3% „
T_6 - „ 5% „
T_7 - K_2SO_4 1% 3rd & 4th week after bunch emergence
T_8 - „ 3% „
T_9 - „ 5% „
T_{10} - K_2SO_4 1% 3rd & 5th week after bunch emergence
T_{11} - „ 3% „
T_{12} - „ 5% „
T_{13} - Control without urea
T_{14} - Control with urea
RGR - Relative Growth Rate

4.2.2.3 RGR between third and fourth week

In both the seasons RGR was highest for 3 % K_2SO_4 sprays applied at third and fourth w.a.b.e . It was at par with the same concentrations at different timing and 5 % at same timing whereas in the second season it was at par only with the latter.

Control without urea recorded the minimum in the first season whereas 5 % K_2SO_4 applied at third and fifth week recorded the lowest in the second season.

4.2.2.4 Fifth week-end

K_2SO_4 at 3 % sprayed on third and fourth week recorded the highest in the first season and it was at par with the same concentration of the chemical applied at the other interval of spray and also with 5 % sprays of K_2SO_4 applied at same timings . Grade was lowest for 1 % K_2SO_4 applied on third and fifth w.a.b.e in the first season and for control without urea in the second season.

4.2.2.5 Sixth week-end

Highest values for girth were obtained for 3 % K_2SO_4 sprays applied at third and fourth week followed by 5 % sprays of the same chemical in the first season In the second season also the girth was highest for the same concentration of K_2SO_4 but applied during third and fifth w.a.b.e.

In both the seasons the girths were observed to be lowest for control without urea.

4.2.2.6 RGR one week after second spray

In both the seasons 3 % K_2SO_4 sprays followed by 1 % of the same applied at third and fourth w.a.b.e recorded the highest values and control without urea recorded the lowest values.

4.2.2.7 Eighth week-end

In the first year grade was maximum for 3 % K_2SO_4 sprays applied at third and fourth w.a.b.e whereas in the second year it was highest for the same but applied at third and fifth w.a.b.e. The minimum in both the years was in the control without urea.

4.2.2.8 Ninth week-end

In the first season 3 % K_2SO_4 applied at third and fourth followed by the same at third and fifth and 5% at the same interval of spray recorded the highest while in the second season the same concentration of the chemical applied during third and fifth week followed by third and fourth week recorded the highest grade. Control without urea recorded the lowest values for girth.

4.2.2.9 RGR between eighth and ninth week

RGR was the highest for 1 % K_2SO_4 applied at third and fourth w.a.b.e followed by 3 % sprays of the same chemical and lowest for control without urea in the first season. In the second season highest values for RGR were obtained for 1 % K_2SO_4 applied at third and fifth w.a.b.e followed by 3 % sprays of the same applied at third and fourth w.a.b.e and lowest for 5% KCl sprays applied during third and fourth week.

4.2.2.10 RGR between ninth week and second spray

In the first year 3 % and 1% K_2SO_4, both applied at third and fourth w.a.b.e recorded the highest and equal rates of growth and they were at par with other treatments except the two controls and 1 % and 3 % KCl applied at third and fourth week.

In the second season highest values for RGR were obtained for 3 % K_2SO_4 sprays applied during third and fourth w.a.b.e and it was on par with other treatments except the two controls.

4.2.3 EFFECT OF POTASSIUM ON FRUIT CURVATURE INDEX.

Result of the study on effects of potassium on FCI are presented in Table 11.

4.2.3.1 Second week-end (prior to application)

Highest values were obtained for control with urea treatment followed by control with urea and lowest values were observed for 1 % KCl sprays applied on third and fourth

4.2.3.2 Third week -end

Highest FCI was obtained for control with urea followed by 5 % K_2SO_4 applied third and fourth w.a.b.e . Lowest FCI was observed for 1% KCl sprays applied at third and fourth w.a.b.e.

4.2.3.3 Fourth week-end

FCI was maximum for 5% KCl sprays followed by 5 % sprays of K_2SO_4, both applied at third and fifth w.a.b.e. FCI was found minimum for control without urea.

Table 11 Anocova showing the effect of potassium on Fruit Cutvature Index (FCI) in banana cv. 'Nendran'

Treatment	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week	9th week
T_1 KCl 1% 3rd & 4th w.a.b.e.	230.21 (327.72)	306.28 (327.72)	400.18 (327.72)	453.16 (327.72)	502.11 (327.72)	545.88 (327.72)	593.67 (327.72)	622.87 (327.72)
T_2 KCl 3% 3rd & 4th w.a.b.e.	247.25 (345.33)	309.70 (345.33)	388.45 (345.33)	424.62 (345.33)	523.56 (345.33)	561.36 (345.33)	621.03 (345.33)	659.00 (345.33)
T_3 KCl 5% 3rd & 4th w.a.b.e.	279.20 (363.14)	319.19 (363.14)	390.17 (363.14)	468.79 (363.14)	524.49 (363.14)	559.12 (363.14)	648.23 (363.14)	685.17 (363.14)
T_4 KCl 1% 3rd & 5th w.a.b.e.	260.51 (339.78)	309.44 (339.78)	371.95 (339.78)	420.04 (339.78)	499.21 (339.78)	531.26 (339.78)	562.71 (339.78)	590.66 (339.78)
T_5 KCl 3% 3rd & 5th w.a.b.e.	267.00 (331.94)	315.66 (331.94)	387.18 (331.94)	415.27 (331.94)	488.01 (331.94)	532.14 (331.94)	574.01 (331.94)	608.99 (331.94)
T_6 KCl 5% 3rd & 5th w.a.b.e.	266.43 (330.07)	320.48 (330.07)	405.80 (330.07)	441.39 (330.07)	522.87 (330.07)	560.88 (330.07)	612.04 (330.07)	640.40 (330.07)
T_7 K_2SO_4 1% 3rd & 4th w.a.b.e.	249.08 (367.78)	316.65 (367.78)	389.16 (367.78)	495.17 (367.78)	532.20 (367.78)	475.55 (367.78)	610.78 (367.78)	647.58 (367.78)
T_8 K_2SO_4 3% 3rd & 4th w.a.b.e.	253.47 (375.42)	315.90 (375.42)	399.13 (375.42)	496.67 (375.42)	554.24 (375.42)	620.92 (375.42)	668.02 (375.42)	714.69 (375.42)
T_9 K_2SO_4 5% 3rd & 4th w.a.b.e.	273.57 (358.67)	325.08 (358.67)	401.83 (358.67)	491.21 (358.67)	542.91 (358.67)	625.68 (358.67)	681.22 (358.67)	714.12 (358.67)
T_{10} K_2SO_4 1% 3rd & 5th w.a.b.e.	258.44 (330.89)	314.85 (330.89)	393.77 (330.89)	426.29 (330.89)	490.75 (330.89)	534.10 (330.89)	581.89 (330.89)	615.15 (330.89)
T_{11} K_2SO_4 3% 3rd & 5th w.a.b.e.	239.23 (349.83)	318.75 (349.83)	398.76 (349.83)	453.66 (349.83)	543.80 (349.83)	586.55 (349.83)	636.46 (349.83)	673.45 (349.83)
T_{12} K_2SO_4 5% 3rd & 5th w.a.b.e.	286.55 (348.54)	324.02 (348.54)	386.97 (348.54)	417.00 (348.54)	495.66 (348.54)	560.03 (348.54)	612.02 (348.54)	651.07 (348.54)
T_{13} Control without urea	293.41 (332.46)	320.36 (332.46)	349.58 (332.46)	362.99 (332.46)	386.57 (332.46)	406.59 (332.46)	438.16 (332.46)	456.46 (332.46)
T_{14} Control with urea	300.40 (340.01)	337.15 (340.01)	370.63 (340.01)	392.38 (340.01)	424.03 (340.01)	440.99 (340.01)	465.37 (340.01)	486.85 (340.01)
CD(0.05)	41.07	19.53	23.28	32.88	28.11	38.99	44.45	44.44

w.a.b.e. - Weeks after bunch emergence Figures in paranthesis indicate the FCI at first week taken as covariate in Anocova

4.2.3.4 Fifth week-end

FCI was maximum for 3 % sprays of K_2SO_4 and it was at par with 1% and 5 % sprays of the same chemical and also with 5 % KCl, all applied at third and fourth w.a.b.e.

4.2.3.5 Sixth week-end

Highest values of FCI were obtained for 3 % K_2SO_4 applied at third and fourth week and it was on par with the same applied at third and fifth w.a.b.e and also with 1 % and 5 % of the same applied at third and fifth w.a.b.e. Control without urea recorded minimum FCI .

4.2.3.6 Seventh week-end

The treatments 5 % K_2SO_4 followed by 3 % of the same applied during third and fourth w.a.b.e. recorded highest FCI and they were at par with each other. Control without urea recorded the lowest.

4.2.3.7 Eighth week-end

The same trend as in seventh week was observed here also.

4.2.3.8 Ninth week-end

K_2SO_4 sprays at 3 % applied on third and fourth w.a.b.e. recorded the maximum FCI and it was at par with 5 % of the same chemical and 3 % KCl applied at third and fourth w.a.b.e and 3 % K_2SO_4 applied

4.2.4 YIELD CHARACTERS

The data on effects of potassium on yield characters are presented in Table 12.

Table 12 Anocova showing the effect of potassium on yield attributes in banana cv. 'Nendran'

Treatments		Bunch weight (kg)		D finger weight at maturity (gm)		D finger weight at ripening (gm)		Percentage reduction in D finger weight at ripening	
		I season	II season	I season	II season	I season	II season	I season	II season
T_1	KCl 1% 3rd & 4th w.a.b.e.	8.60 (47.94)	7.79 (57.00)	186.19 (47.94)	109.98 (57.00)	158.30 (47.94)	85.98 (57.00)	15.63 (47.94)	20.42 (57.00)
T_2	KCl 3% 3rd & 4th w.a.b.e.	8.94 (49.63)	7.99 (61.33)	195.84 (49.63)	136.38 (61.33)	159.84 (49.63)	97.23 (61.33)	18.27 (49.63)	28.40 (61.33)
T_3	KCl 5% 3rd & 4th w.a.b.e.	9.29 (50.88)	8.55 (62.50)	201.44 (50.88)	146.98 (62.50)	169.78 (50.88)	117.54 (62.50)	15.21 (50.88)	20.05 (62.50)
T_4	KCl 1% 3rd & 5th w.a.b.e	8.73 (45.88)	7.47 (55.00)	181.85 (45.88)	99.73 (55.00)	154.44 (45.88)	77.65 (55.00)	15.03 (45.88)	21.98 (55.00)
T_5	KCl 3% 3rd & 5th w.a.b.e.	8.88 (48.38)	7.57 (63.67)	192.85 (48.38)	110.33 (63.67)	157.87 (48.38)	82.90 (63.67)	17.51 (48.38)	20.71 (63.67)
T_6	KCl 5% 3rd & 5th w.a.b.e.	9.31 (48.88)	8.10 (60.33)	198.95 (48.88)	127.85 (60.33)	165.15 (48.88)	92.22 (60.33)	16.66 (48.88)	27.72 (60.33)
T_7	K_2SO_4 1% 3rd & 4th w.a.b.e.	8.66 (49.13)	8.00 (62.67)	192.66 (49.13)	118.63 (62.67)	161.50 (49.13)	90.98 (62.67)	16.46 (49.13)	23.18 (62.67)
T_8	K_2SO_4 3% 3rd & 4th w.a.b.e.	9.80 (50.00)	9.12 (64.33)	207.25 (50.00)	161.53 (64.33)	171.31 (50.00)	139.36 (64.33)	17.05 (50.00)	14.22 (64.33)
T_9	K_2SO_4 5% 3rd & 4th w.a.b.e.	9.30 (49.13)	8.60 (62.67)	201.90 (49.13)	139.83 (62.67)	168.37 (49.13)	110.85 (62.67)	16.22 (49.13)	19.95 (62.67)
T_{10}	K_2SO_4 1% 3rd & 5th w.a.b.e.	8.63 (50.63)	8.17 (59.00)	185.16 (50.63)	117.03 (59.00)	154.17 (50.63)	89.96 (59.00)	16.35 (50.63)	23.07 (59.00)
T_{11}	K_2SO_4 3% 3rd & 5th w.a.b.e.	9.83 (50.62)	8.84 (63.00)	205.32 (50.62)	156.68 (63.00)	171.37 (50.62)	134.23 (63.00)	16.22 (50.62)	13.08 (63.00)
T_{12}	K_2SO_4 5% 3rd & 5th w.a.b.e.	9.28 (47.63)	8.71 (64.00)	201.54 (47.63)	127.98 (64.00)	166.24 (47.63)	98.26 (64.00)	16.96 (47.63)	23.17 (64.00)
T_{13}	Control without urea	8.39 (48.69)	7.62 (62.33)	179.55 (48.69)	106.63 (62.33)	148.86 (48.69)	75.54 (62.33)	17.77 (48.69)	28.69 (62.33)
T_{14}	Control with urea	8.63 (48.56)	7.91 (63.00)	185.80 (48.56)	122.58 (63.00)	152.95 (48.56)	85.55 (63.00)	18.52 (48.56)	30.95 (63.00)
		0.41	0.69	8.04	11.17	7.88	12.80	1.82	5.59

w.a.b.e. - Weeks after bunch emergence. Figures in paranthesis indicate the number of fingers taken as covariate in Anocova

4.2.4.1 Bunch Weight

A perusal of the data presented in table revealed the overall efficacy of 3 % sprays of K_2SO_4 in both the seasons.

In the first year; the highest yields were obtained in the two treatments at the same concentration. The best results were obtained when sprayed at third and fifth week after bunch emergence (w.a.b.e.) followed by the treatment when sprayed at Third and fourth week. The difference between the two treatments were very small and the above treatments were significantly superior to all other treatments except 5% KCl spray when applied twice, at third and fourth w.a.b.e. (Plate 7)

In the second season also, the 3 % percent sprays proved to be more effective. Highest yields were obtained when sprayed at third and fourth week followed by the same concentration when applied during third and fifth week after bunch emergence (Plate 8 and Fig. 3).

The difference between the best treatments in the first year and second year are comparatively low and is observed at the level of application.

4.2.4.2 'D' finger weight at maturity

The 'D' finger weight at maturity in both the seasons were highest in 3 % sprays of K_2SO_4 when applied at third and fourth and third and fifth w a b e .In the first year they are at par with the two treatments involving 5% K_2SO_4 sprays and also with 5% KCl sprays applied at third and fourth w.a.b.e. but in the second year they were significantly superior over all other treatments (Plates 9 and 10).

Plate 7 Effect of potassium chloride sprays on 'D' hand

Plate 8 Effect of potassium sulphate sprays on 'D' hand


T1
T2
T3
C1
C2

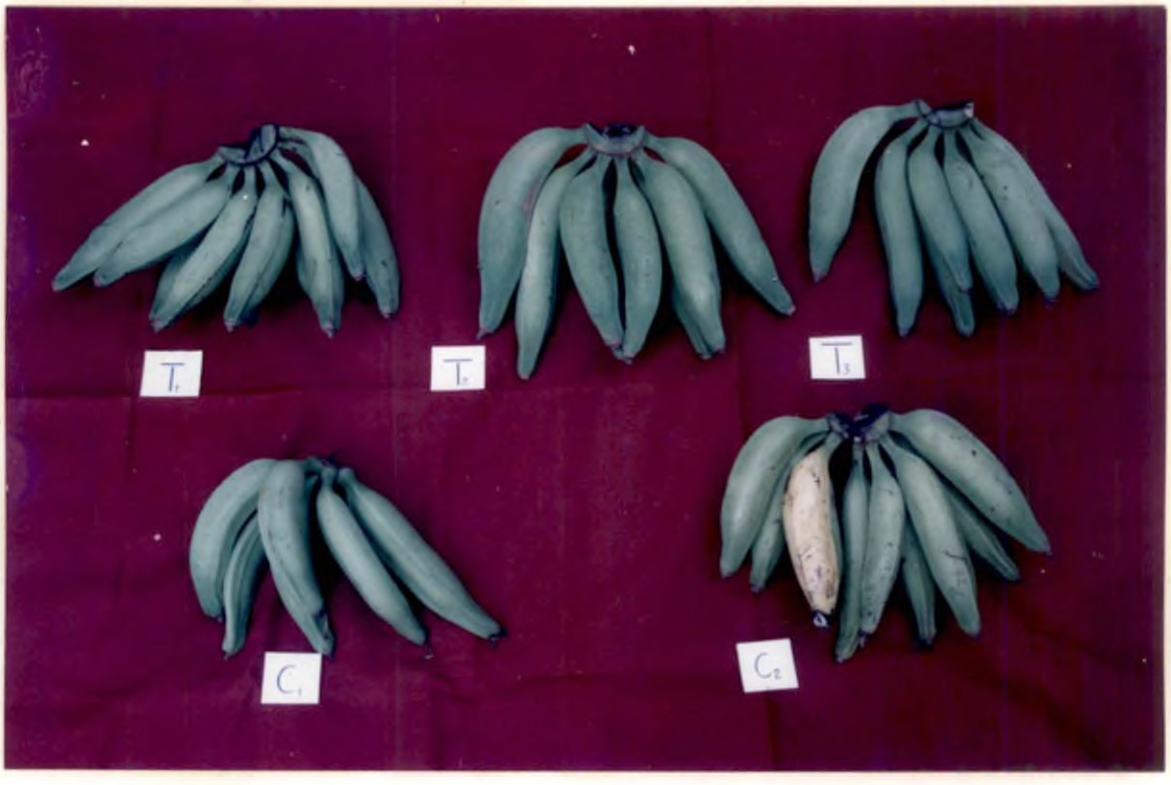
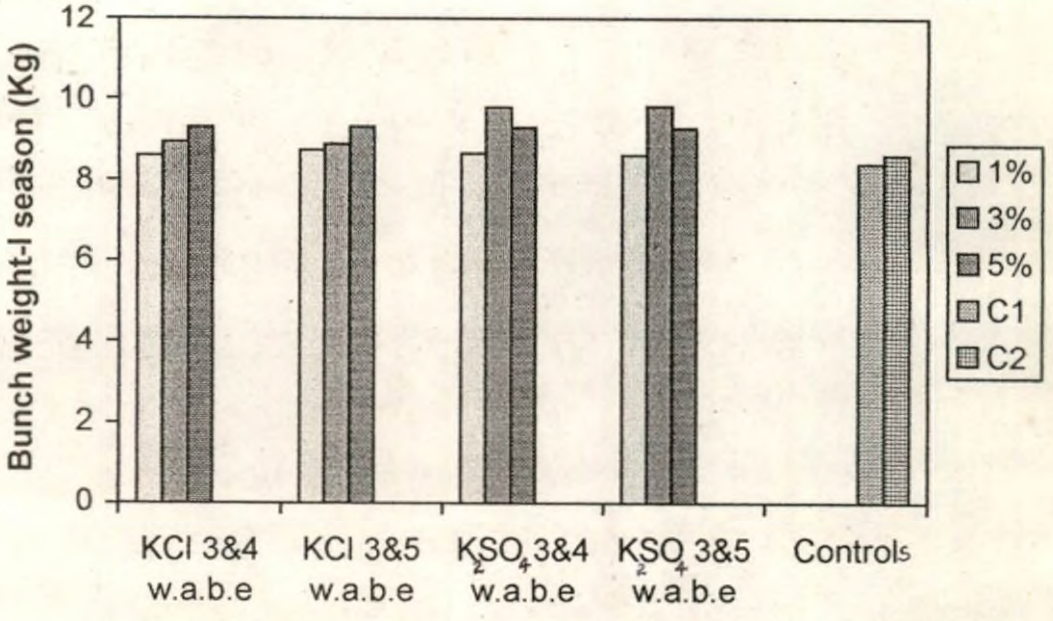

T1
T2
T3
C1
C2

Fig.3 Effect of potassium treatments on yield in banana cv. 'Nendran'



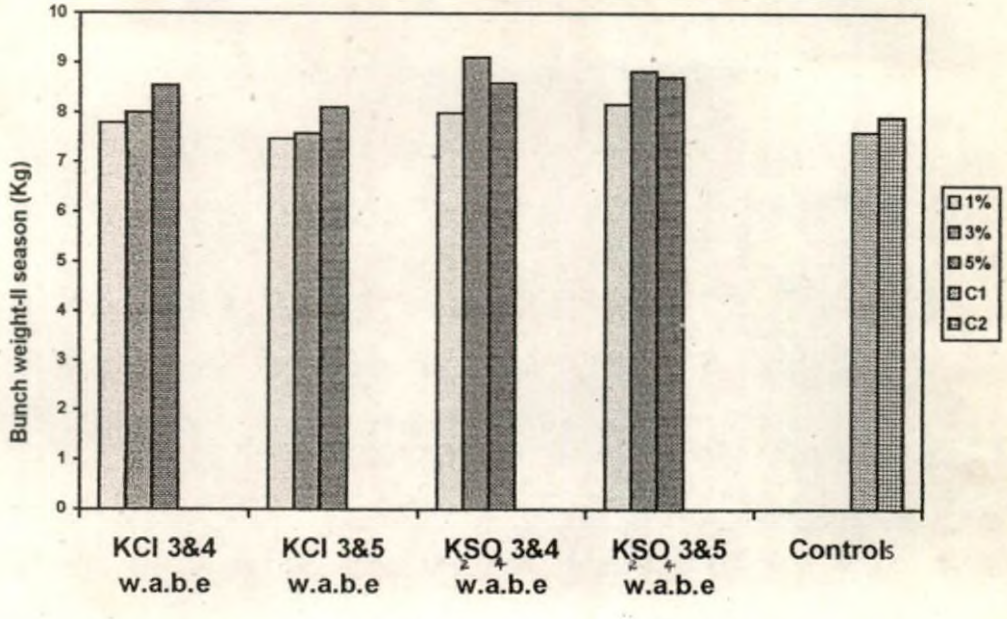


Plate 9 Effect of potassium chloride sprays on 'D' finger

Plate 10 Effect of potassium sulphate sprays on 'D' finger


T1
T2
T3
C1
C2


T1
T2
T3
C1
C2

4.2.4.3 'D' finger weight at ripening

Though the 'D' finger weight at ripening was highest in 3% K_2SO_4 sprays it was significantly superior over all other treatments in the second year whereas it was at par with 5% sprays of K_2SO_4 and KCl in the first year.

4.2.4.4 Percentage reduction in 'D' finger weight

Lowest percentage reduction were observed for 1% KCl spray applied at third and fifth week after bunch emergence. In both the seasons control with urea recorded the highest percentage reduction followed by the control without urea.

4.2.4.5 Pulp weight

The highest pulp weight was recorded at 3% K_2SO_4 spray when applied at third and fourth w.a.b.e. and third and fifth week after bunch emergence. They were at par with 5%sprays of K_2SO_4 and KCl in the first year, but in the second year both the treatments showed clear-cut superiority.

The control without urea recorded the lowest pulp weight in the first season whereas in the second season the above control and 1% KCl spray treatment recorded the lowest pulp weight (Table 13).

4.2.4.6 Percentage pulp weight at ripening

In the first season 5% sprays of K_2SO_4 applied at third and fourth week recorded the highest followed by control with urea. The lowest percentage pulp weight was observed for 1% KCl applied during third and fifth week.

In the second season 3% KCl sprays applied at third and fifth week followed by 3% K_2SO_4 sprays applied at third and fourth week recorded the

Table 13 Anocova showing the effect of potassium on finger characters at ripening in banana cv. 'Nendran'

Treatments		Pulp weight (gm)		Pulp weight expressed as percentage of total fruit weight		Peel weight (gm)		Peel weight expressed as percentage of total fruit weight		Pulp thickness (cm)		Peel thickness (cm)	
		I season	II season	I season	II season	I season	II season	I season	II season	I season	II season	I season	II season
T_1	KCl 1%[1] 3rd & 4th w.a.b.e.	130.22 (47.94)	57.37 (57.00)	82.93 (47.94)	65.53 (57.00)	28.09 (47.94)	28.61 (57.00)	17.89 (47.94)	21.68 (57.00)	3.24 (47.94)	3.13 (57.00)	0.146 (47.94)	0.128 (57.00)
T_2	KCl 3%[1] 3rd & 4th w.a.b.e.	130.73 (49.63)	70.67 (61.33)	81.52 (49.63)	72.01 (61.33)	29.12 (49.63)	26.56 (61.33)	18.20 (49.63)	27.45 (61.33)	3.25 (49.63)	3.18 (61.33)	0.149 (49.63)	0.133 (61.33)
T_3	KCl 5%[1] 3rd & 4th w.a.b.e.	135.71 (50.88)	82.88 (62.50)	79.49 (50.88)	70.28 (62.50)	34.08 (50.88)	34.66 (62.50)	19.96 (50.88)	29.66 (62.50)	3.29 (50.88)	3.31 (62.50)	0.156 (50.88)	0.136 (62.50)
T_4	KCl 1%[1] 3rd & 5th w.a.b.e.	128.48 (45.88)	48.82 (55.00)	83.18 (45.88)	62.53 (55.00)	26.15 (45.88)	28.83 (55.00)	16.88 (45.88)	37.29 (55.00)	3.23 (45.88)	3.05 (55.00)	0.147 (45.88)	0.118 (55.00)
T_5	KCl 3%[1] 3rd & 5th w.a.b.e.	129.75 (48.38)	51.66 (63.67)	81.66 (48.38)	58.77 (63.67)	28.12 (48.38)	31.23 (63.67)	17.60 (48.38)	36.03 (63.67)	3.24 (48.38)	3.16 (63.67)	0.150 (48.38)	0.132 (63.67)
T_6	KCl 5%[1] 3rd & 5th w.a.b.e.	133.77 (48.88)	61.03 (60.33)	80.69 (48.88)	66.04 (60.33)	31.38 (48.88)	31.18 (60.33)	18.93 (48.88)	33.76 (60.33)	3.28 (48.88)	3.21 (60.33)	0.155 (48.88)	0.135 (60.33)
T_7	K_2SO_4 1%[1] 3rd & 4th w.a.b.e.	130.07 (49.13)	59.72 (62.67)	80.81 (49.13)	65.54 (62.67)	31.43 (49.13)	31.26 (62.67)	19.51 (49.13)	34.30 (62.67)	3.38 (49.13)	3.24 (62.67)	0.133 (49.13)	0.138 (62.67)
T_8	K_2SO_4 3%[1] 3rd & 4th w.a.b.e.	138.90 (50.00)	104.75 (64.33)	80.86 (50.00)	75.56 (64.33)	32.41 (50.00)	34.61 (64.33)	18.87 (50.00)	25.01 (64.33)	3.56 (50.00)	3.46 (64.33)	0.148 (50.00)	0.144 (64.33)
T_9	K_2SO_4 5%[1] 3rd & 4th w.a.b.e.	135.25 (49.13)	76.67 (62.67)	79.96 (49.13)	68.50 (62.67)	33.12 (49.13)	34.18 (62.67)	19.61 (49.13)	30.54 (62.67)	3.39 (49.13)	3.43 (62.67)	0.134 (49.13)	0.138 (62.67)
T_{10}	K_2SO_4 1%[1] 3rd & 5th w.a.b.e.	128.32 (50.63)	62.93 (59.00)	82.86 (50.63)	69.89 (59.00)	26.44 (50.63)	27.03 (59.00)	17.07 (50.63)	30.03 (59.00)	3.24 (50.63)	3.38 (59.00)	0.137 (50.63)	0.134 (59.00)
T_{11}	K_2SO_4 3%[1] 3rd & 5th w.a.b.e.	138.41 (50.62)	99.74 (63.00)	80.51 (50.62)	73.28 (63.00)	32.96 (50.62)	34.48 (63.00)	19.16 (50.62)	25.29 (63.00)	3.42 (50.62)	3.33 (63.00)	0.150 (50.62)	0.136 (63.00)
T_{12}	K_2SO_4 5%[1] 3rd & 5th w.a.b.e.	132.86 (47.63)	68.32 (64.00)	79.48 (47.63)	69.57 (64.00)	33.37 (47.63)	29.94 (64.00)	19.99 (47.63)	30.31 (64.00)	3.27 (47.63)	3.46 (64.00)	0.138 (47.63)	0.135 (64.00)
T_{13}	Control without urea	123.06 (48.69)	50.83 (62.33)	83.42 (48.69)	66.09 (62.33)	25.81 (48.69)	24.71 (62.33)	17.51 (48.69)	33.24 (62.33)	3.10 (48.69)	3.01 (62.33)	0.121 (48.69)	0.111 (62.33)
T_{14}	Control with urea	126.82 (48.56)	60.32 (63.00)	83.85 (48.56)	70.70 (63.00)	26.13 (48.56)	25.23 (63.00)	17.21 (48.56)	30.03 (63.00)	3.22 (48.56)	3.11 (63.00)	0.128 (48.56)	0.119 (63.00)
CD(0.05)		6.19	12.10	2.55	5.07	3.77	6.52	2.18	8.16	0.14	0.14	0.03	0.002

Figures in paranthesis indicate finger number taken as covariate in Anocova
w.a.b.e. - Weeks after bunch emergence

highest and these two treatments were at par with each other . Control without urea recorded the minimum (Table 13).

4.2.4.7 Peel weight

Maximum peel weight was observed in 5 % sprays KCl applied at third and fourth w.a.b.e.. In both the seasons it was at par with KCl 5% applied at third and fifth w.a.b.e., all K_2SO_4 sprays at third and fourth and 3% and 5% K_2SO_4 sprays at third and fifth w.a.b.e. in the first year and also with 3% KCl applied at third and fifth week after bunch emergence in the second year. Minimum peel weight was obtained for control without urea treatment (Table 13).

4.2.4.8 Percentage peel weight

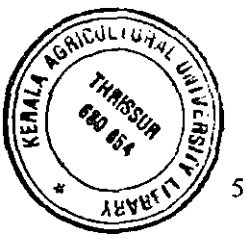
In both the seasons 5% K_2SO_4 sprays applied during third and fourth week recorded maximum. 1% KCl sprayed during third and fourth week recorded minimum in the first year whereas in the second year it was the same but applied during third and fifth week which recorded the lowest (Table 13).

4.2.4.9 Pulp thickness

K_2SO_4 sprays at 3% applied during both stages showed distinct superiority over the other treatments and they were on par with each other in both the seasons. Pulp thickness was seen to be lowest for control without urea treatment (Table 13).

4.2.4.10 Peel thickness

In the first season 5% KCl applied during third and fourth week recorded the maximum whereas in the second season 3% K_2SO_4 sprays applied at



the same stage recorded the maximum .In both the seasons minimum peel thickness was observed for control without urea (Table 13).

4.2.5 EFFECT ON DAYS TO MATURITY, RIPENING AND SHELF LIFE

The effects of potassium on days to maturity, ripening and shelf life are presented in Table 14.

4.2.5.1 Days to maturity

In both the seasons 3% sprays of K_2SO_4 took more time to reach maturity. Maximum time was taken at third and fourth week of application followed by third and fifth week of application. They were at par and significantly superior over all other treatments in the first year whereas they were at par with 5% K_2SO_4 sprays at both stages of application in the second year.

The lowest time taken to maturity in the first year was for KCl at 1% spray applied at third and fifth week after bunch emergence in the first year whereas in the second year it was for the control with urea.

4.2.5.2 Days to ripening

Maximum days to ripening was observed in 3% sprays of K_2SO_4 applied at third and fourth and third and fifth week after bunch emergence and was superior to all other treatments.

The lowest was recorded by the control with urea, which showed a clear-cut significant difference with other treatments in the second year but was at par with same treatments in the first year.

Table 14 Effect of potassium on maturity, ripening and shelf life in banana cv. 'Nendran'

Treatment	Days to maturity		Days to ripening		Shelf life (days)	
	I season	II season	I season	II season	I season	II season
Potassium chloride 1% 3 & 4 w.a.b.e.	63.06	60.33	8.50	8.25	2.63	2.25
Potassium chloride 3% 3 & 4 w.a.b.e.	65.06	63.33	8.75	8.50	2.78	2.50
Potassium chloride 5% 3 & 4 w.a.b.e.	67.06	63.33	8.63	8.75	2.88	2.58
Potassium chloride 1% 3 & 5 w.a.b.e.	61.50	61.00	8.50	8.25	2.53	2.17
Potassium chloride 3% 3 & 4 w.a.b.e.	63.56	63.00	8.75	8.50	2.88	2.25
Potassium chloride 5% 3 & 4 w.a.b.e.	65.88	61.33	8.56	8.50	2.66	2.67
Potassium sulphate 1% 3 & 4 w.a.b.e.	63.38	62.00	8.63	8.50	3.25	2.75
Potassium sulphate 3% 3 & 4 w.a.b.e.	72.69	67.00	9.56	9.25	3.59	3.00
Potassium sulphate 5% 3 & 4 w.a.b.e.	66.19	65.00	8.63	8.75	3.41	2.92
Potassium sulphate 1% 3 & 5 w.a.b.e.	61.75	61.33	8.56	8.50	3.22	2.58
Potassium sulphate 3% 3 & 5 w.a.b.e.	68.63	66.33	9.19	9.00	3.53	2.83
Potassium sulphate 5% 3 & 5 w.a.b.e.	66.31	65.00	8.63	8.75	3.31	2.75
Control without urea	72.00	64.00	8.56	8.50	3.25	2.25
Control with urea	66.88	60.00	8.00	8.00	2.16	1.83
CD(0.05)	3.71	3.53	0.59	0.41	0.45	0.49

w.a.b.e. - weeks after bunch emergence

4.2.5.3 Shelf life

Maximum shelf life was observed in 3% K_2SO_4 spray applied at third and fourth week followed by third and fifth week after bunch emergence and were at par with all K_2SO_4 treatments. The lowest shelf life was in control with urea and it was significantly inferior to other treatments.

4.2.6 BIOCHEMICAL ASPECTS

The effects of potassium on biochemical and quality aspects are presented in Table 15.

4.2.6.1 Urea content at fruit ripening.

The highest urea content (43.92 ppm) was observed in the control with urea which was significantly superior to other treatments and lowest (15.49 ppm) in 3% K_2SO_4 sprays applied at third and fourth w.a.b.e. followed by 5% K_2SO_4 at third and fifth week after bunch emergence, both of which were significantly inferior from other treatments (Fig. 4).

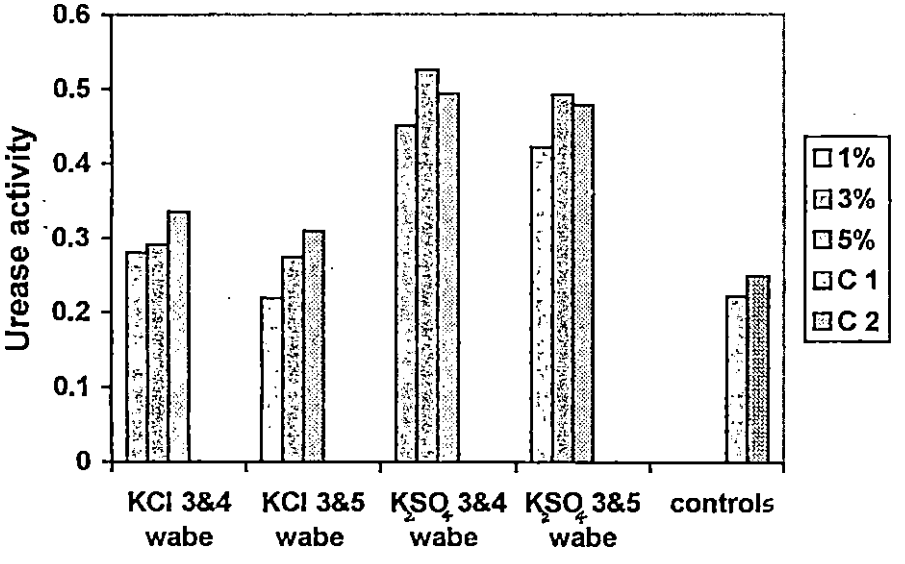
4.2.6.2 Urease activity at fruit ripening

Analysis of the data reveals that the highest urease activity was recorded by 3% K_2SO_4 applied at third and fourth week after bunch emergence, which was significantly superior over other treatments. Control without urea recorded the least (Fig. 4).

4.2.6.3 Nitrite nitrogen

3% sprays of K_2SO_4 recorded the highest content of nitrite nitrogen and this was statistically on par with 1% K_2SO_4 applied third and forth week after bunch emergence and with 3% K_2SO_4 applied on third and fifth week.

Fig.4 Effect of potassium treatments on urease activity (μ g/g) and urea contenf (ppm) in banana cv. 'Nendran'



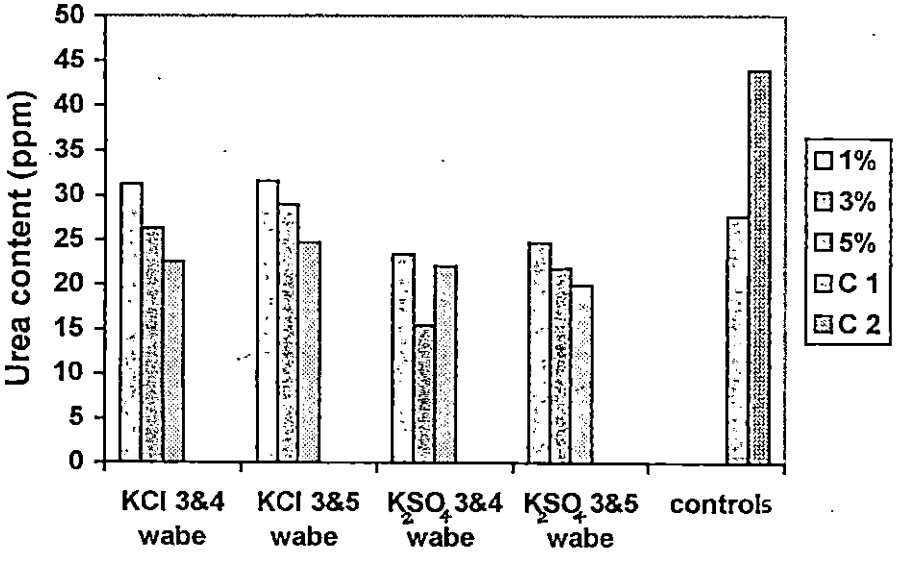


Table 15 Effect of potassium on biochemical and quality aspects in banana cv. 'Nendran'

Treatment	Urea content (ppm)	Urease activity (µg/g)	Nitrite N (mM/g)	Acidity (%)	Reducing sugar(%)	Non-reducing sugar (%)	Total sugar (%)
Potassium chloride 1% 3 & 4th week	31.203	0.280	34.667	0.319	12.237	3.787	16.023
Potassium chloride 3% 3 & 4th week	26.293	0.291	25.333	0.321	12.557	3.847	16.403
Potassium chloride 5% 3 & 4th week	22.557	0.335	50.667	0.316	12.590	3.873	16.463
Potassium chloride 1% 3 & 5th week	31.547	0.262	19.333	0.323	12.393	3.770	16.163
Potassium chloride 3% 3 & 5 w.a.b.e.	28.929	0.275	20.000	0.315	12.577	3.803	16.380
Potassium chloride 5% 3 & 5 w.a.b.e.	24.697	0.315	22.667	0.318	12.407	3.757	16.163
Potassium sulphate 1% 3 & 4 w.a.b.e.	23.397	0.451	60.000	0.318	12.090	3.670	15.760
Potassium sulphate 3% 3 & 4 w.a.b.e.	15.493	0.526	63.333	0.313	12.670	3.527	16.197
Potassium sulphate 5% 3 & 4 w.a.b.e.	22.090	0.495	28.000	0.309	12.883	3.613	16.497
Potassium sulphate 1% 3 & 5 w.a.b.e.	24.690	0.422	42.667	0.318	12.570	3.527	16.097
Potassium sulphate 3% 3 & 5 w.a.b.e.	21.847	0.493	60.000	0.314	12.663	3.567	16.230
Potassium sulphate 5% 3 & 5 w.a.b.e.	19.980	0.478	22.667	0.311	12.863	3.613	16.477
Control without urea	27.667	0.222	14.333	0.317	13.213	2.920	16.133
Control with urea	43.920	0.249	27.333	0.366	11.977	2.340	14.317
CD(0.05)	5.965	0.029	13.582	0.010	0.261	0.174	0.348

w.a.b.e. – weeks after bunch emergence

The control without urea recorded the lowest and this was found to be at par with a number of treatments.

4.2.7 QUALITATIVE CHARACTERS

4.2.7.1 Acidity

Acidity observed was the highest in control with urea and lowest in 5% K_2SO_4 spray applied at third and fourth week after bunch emergence.

4.2.7.2 Sugars.

4.2.7.2 Total sugars.

Analysis of the data showed no much significant difference between the treatment means.

K_2SO_4 5% spray applied at third and fourth week after bunch emergence recorded the highest total sugars followed by the same at third and fifth week after bunch emergence. The lowest sugars were recorded for control with urea, which was significantly inferior to other treatments. The data showed the overall superiority of K sprays at higher concentrations of 3% and 5%.

4.2.7.2.2 Reducing sugars

Highest percentage of reducing sugars was observed in the control without urea which was at par with 3% and 5% sprays of K_2SO_4 applied at third and fourth and third and fifth week after bunch emergence.

4.2.7.2.3 Non reducing sugar

KCl 5% spray at third and fourth week recorded the highest non-reducing sugars and the control with urea recorded the lowest. The overall superiority of K treatment was observed.

4.2.8 EFFECT OF POTASSIUM ON ELECTROLYTIC LEAKAGE

The effects of potassium on electrolytic leakage are presented in Table 16.

4.2.8.1 Yellow - 4 hours

All the treatments proved to be effective in reducing the leakage . Lowest leakage was observed in all treatments of KCl and K_2SO_4 applied at third and fourth w.a.b.e . Highest leakage was recorded for control with urea which was significantly superior to other treatments except the control without urea.

4.2.8.2 Yellow - 8 hours

5 % KCl and 3 % K_2SO_4 applied at third and fourth w.a.b.e exuded out the minimum electrolytes The leakage was maximum in control with urea which was at par with the other controls

4.2.8.3 Yellow - 4+1/2 hour boiling

Lowest leakage was observed for all treatments of K_2SO_4 at third and fourth w.a.b.e and 1 % of the same applied at third and fifth w.a.b.e. Control with urea recorded the highest leakage but this was at par with control without urea.

4.2.8.4 Yellow- 8+1/2 hour boiling

K_2SO_4 at 3 % followed by all concentrations of the same at third and fourth week , 5 % KCl at both intervals and 3 % at third and fourth w.a.b.e exuded the least electrolyte. The control with urea exuded the highest leakage which was at par with the other controls.

Table 16 Effect of different treatments of Potassium on electrolytic leakage (mmhos/cm/g) in banana cv. 'Nendran' at different stages of ripening

Treatments		Yellow				50% black				100% black			
		4 hours	8 hours	4+½ hours boiling	8+½ hours boiling	4 hours	8 hours	4+½ hours boiling	8+½ hours boiling	4 hours	8 hours	4+½ hours boiling	8+½ hours boiling
T_1	KCl 1% 3rd & 4th w.a.b.e.	0.001 (1.14)	0.002 (1.52)	0.003 (1.63)	0.004 (1.91)	0.002 (1.52)	0.002 (1.52)	0.004 (1.91)	0.004 (2.08)	0.003 (1.63)	0.003 (1.82)	0.004 (2.08)	0.005 (2.31)
T_2	KCl 3% 3rd & 4th w.a.b.e.	0.001 (1.14)	0.002 (1.28)	0.003 (1.63)	0.003 (1.82)	0.002 (1.52)	0.002 (1.52)	0.004 (1.91)	0.004 (1.99)	0.003 (1.82)	0.003 (1.82)	0.004 (2.08)	0.002 (1.46)
T_3	KCl 5% 3rd & 4th w.a.b.e	0.001 (1.14)	0.001 (1.14)	0.002 (1.52)	0.003 (1.63)	0.002 (1.52)	0.002 (1.52)	0.003 (1.86)	0.003 (1.82)	0.002 (1.52)	0.002 (1.52)	0.004 (1.91)	0.004 (2.08)
T_4	KCl 1% 3rd & 5th w.a.b.e.	0.002 (1.28)	0.003 (1.63)	0.004 (1.91)	0.005 (2.16)	0.002 (1.28)	0.003 (1.63)	0.006 (2.38)	0.006 (2.38)	0.005 (2.16)	0.006 (2.38)	0.008 (2.78)	0.014 (3.78)
T_5	KCl 3% 3rd & 5th w.a.b.e.	0.001 (1.14)	0.002 (1.41)	0.003 (1.63)	0.004 (1.91)	0.002 (1.28)	0.003 (1.63)	0.004 (2.07)	0.005 (2.23)	0.003 (1.63)	0.003 (1.63)	0.008 (2.78)	0.008 (2.77)
T_6	KCl 5% 3rd & 5th w.a.b.e.	0.002 (1.28)	0.002 (1.28)	0.003 (1.63)	0.003 (1.63)	0.002 (1.28)	0.003 (1.63)	0.003 (1.73)	0.005 (2.16)	0.002 (1.28)	0.003 (1.63)	0.004 (1.91)	0.005 (2.16)
T_7	K_2SO_4 1% 3rd & 4th w.a.b.e.	0.001 (1.14)	0.002 (1.28)	0.002 (1.52)	0.003 (1.82)	0.002 (1.28)	0.002 (1.52)	0.003 (1.82)	0.004 (1.91)	0.002 (1.52)	0.003 (1.63)	0.004 (2.00)	0.005 (2.16)
T_8	K_2SO_4 3% 3rd & 4th w.a.b.e.	0.001 (1.14)	0.001 (1.14)	0.002 (1.52)	0.003 (1.63)	0.001 (1.14)	0.002 (1.28)	0.003 (1.72)	0.003 (1.82)	0.002 (1.41)	0.002 (1.52)	0.004 (1.91)	0.004 (2.08)
T_9	K_2SO_4 5% 3rd & 4th w.a.b.e.	0.001 (1.14)	0.002 (1.28)	0.002 (1.52)	0.003 (1.72)	0.002 (1.28)	0.002 (1.52)	0.003 (1.63)	0.004 (1.91)	0.002 (1.52)	0.003 (1.63)	0.004 (1.91)	0.005 (2.16)
T_{10}	K_2SO_4 1% 3rd & 5th w.a.b.e.	0.002 (1.28)	0.002 (1.28)	0.002 (1.52)	0.004 (1.91)	0.002 (1.28)	0.001 (1.14)	0.004 (1.91)	0.005 (2.16)	0.002 (1.52)	0.003 (1.63)	0.004 (2.00)	0.005 (2.16)
T_{11}	K_2SO_4 3% 3rd & 5th w.a.b.e.	0.002 (1.28)	0.002 (1.28)	0.003 (1.63)	0.003 (1.72)	0.002 (1.28)	0.002 (1.28)	0.004 (1.91)	0.004 (2.00)	0.003 (1.63)	0.003 (1.63)	0.004 (1.91)	0.005 (2.16)
T_{12}	K_2SO_4 5% 3rd & 5th w.a.b.e.	0.002 (1.28)	0.002 (1.28)	0.003 (1.62)	0.002 (1.63)	0.003 (1.63)	0.003 (1.63)	0.004 (1.91)	0.004 (2.08)	0.003 (1.63)	0.003 (1.73)	0.004 (1.91)	0.005 (2.24)
T_{13}	Control without urea	0.005 (2.38)	0.006 (2.38)	0.008 (2.89)	0.008 (2.89)	0.005 (2.52)	0.006 (2.52)	0.008 (2.89)	0.010 (3.21)	0.006 (2.71)	0.007 (2.71)	0.013 (3.60)	0.014 (3.74)
T_{14}	Control with urea	0.006 (2.52)	0.006 (2.52)	0.009 (3.05)	0.009 (3.05)	0.005 (2.52)	0.007 (2.62)	0.013 (3.65)	0.014 (3.79)	0.009 (2.84)	0.007 (2.81)	0.015 (3.83)	0.017 (4.08)
CD(0.05)		0.376	0.348	1.043	0.319	0.348	0.319	0.290	0.261	0.289	0.261	0.203	0.405

Figures in paranthesis indicate 'x1000 square root' transformation
w.a.b.e. - Weeks after bunch emergence

4.2.8.5 50 % Black – 4 hours

Lowest leakage was recorded for 3 % K_2SO_4 applied at third and fourth w.a.b.e. which was significantly superior to other treatments. All treatments were effective in checking the leakage .

4.2.8.6 50 % Black - 8 hours

K_2SO_4 at 1 % followed by 3 % applied at third and fifth week and all concentrations of the same at third and fourth w.a.b.e recorded the minimum leakage . The control with urea and without urea revealed high leakage with maximum in the former.

4.2.8.7 50 % Black – 4+1/2 hour boiling

K_2SO_4 at 5 % and KCl at 5 % applied during both levels of application showed the minimum leakage. The control with urea showed the maximum which was significantly superior to all other treatments followed by the other control.

4.2.8.8 50 % Black - 8+ ½ hour boiling

K_2SO_4 3 % and KCl 5 % applied at third and fourth w.ab.e showed minimum leakage . Control with urea recorded significantly higher leakage followed by control without urea.

4.2.8.9 100 % Black – 4 hours

All treatments of K_2SO_4 applied at third and fourth w.a.b.e and 5 % KCl applied at both intervals showed the minimum leakage. The two controls showed the maximum leakage.

4.2.8.10 100 % Black – 8 hours

K_2SO_4 3 % and KCl 3 % applied at third and fourth week recorded the minimum leakage which was at par with all other treatments except the controls. The control with urea recorded the maximum leakage.

4.2.8.11 100 % Black - 4 +1/2 hours boiling

Lowest leakage was recorded for many treatments particularly all K_2SO_4 treatments, all KCl treatments at third and fourth w.a.b.e and 5 % KCl applied at both intervals. The effects of the k treatments were at par. Highest leakage was observed for the control with urea.

4.2.8.12 100 % Black – 8 +1/2 hour boiling

The same trend as in the case of 50 % black stage was observed in this case also regarding the lowest leakage. The highest was observed for control with urea followed by the other control and 1 % KCl applied at third and fifth w.a.b.e.

4.3 CALCIUM

4.3.A CALCIUM SPRAYS

4.3.A.1 YIELD CHARACTERS

The data on yield characters, ripening and shelf life are presented in Table 17.

4.3.A.1.1 Percentage reduction in bunch weight at ripening

Calcium sulphate spray at 3 % recorded the lowest percentage reduction in bunch weight. Though it was at par with most of the treatments, the differences even with the next best treatment were evident. Highest percentage reduction was observed for the control with urea. Another interesting fact

Table 17 Effect of calcium sprays on yield attributes, ripening and shelf life in banana cv. 'Nendran'

Treatments	Bunch weight at maturity (kg)	Bunch weight at ripening (kg)	Percentage reduction in bunch weight	'D' finger weight at maturity (gm)	'D' finger weight at ripening (gm)	Percentage reduction in 'D' finger weight at ripening	Pulp weight at ripening (gm)	% pulp weight	Peel weight at ripening	% peel weight	Pulp thickness (cm)	% Pulp thickness	Peel thickness (cm)	% peel thickness	Days to ripening	Shelf life (days)
T_1	7.50	6.74	17.28	172.29	149.40	20.45	115.45	80.56	33.95	19.44	2.71	95.82	0.116	4.18	7.56	3.06
T_2	7.30	6.89	6.35	167.73	146.05	15.03	111.08	76.04	34.97	23.96	2.61	94.81	0.140	5.19	7.69	3.06
T_3	7.81	7.26	7.73	172.82	147.51	17.11	112.05	75.77	35.46	24.23	2.59	94.48	0.147	5.52	7.00	3.06
T_4	7.15	6.69	6.88	167.14	148.68	12.49	109.40	73.21	39.28	26.79	2.65	94.35	0.152	5.65	6.69	3.06
T_5	6.82	6.50	5.10	160.72	144.57	11.19	111.27	76.72	33.30	23.28	2.77	95.15	0.135	4.85	6.38	3.25
T_6	6.56	6.14	7.28	159.30	139.53	15.34	95.91	68.96	43.62	31.04	2.26	93.23	0.160	6.77	7.06	3.38
T_7	4.90	3.95	24.36	131.95	106.76	21.02	80.11	74.43	26.65	25.57	2.05	94.54	0.116	5.46	7.88	3.53
T_8	6.66	5.43	24.93	161.95	136.07	24.05	103.82	77.03	30.25	22.97	2.44	94.94	0.124	5.06	6.75	2.34
CD(0.05)	---	---	5.18	----	----	2.27	----	4.33	----	6.78	----	1.11	----	1.11	0.77	0.57

T_1 - Calcium chloride 1%
T_2 - Calcium chloride 3%
T_3 - Calcium chloride 5%
T_4 - Calcium sulphate 1%
T_5 - Calcium sulphate 3%
T_6 - Calcium sulphate 5%
T_7 - Control without urea
T_8 - Control with urea

observed is that in both the compounds tried, 3 % sprays were found to be most effective.

4.3.A.1.2 Percentage reduction in 'D' finger weight at ripening

The same trend observed as in the case of bunch weight was also observed at the finger weight level. Lowest percentage reduction was recorded for 3 % calcium sulphata and highest for control with urea which was also significantly different from all other treatments (Fig. 5).

4.3.A.1.3 Percentage pulp weight

Percentage pulp weight was maximum for 1 % calcium chloride which was at par with the control with urea and 3 % calcium sulphate spray. The minimum percentage pulp weight was observed for 5 % calcium sulphate sprays.

4.3.A.1.4 Percentage peel weight

Percentage peel weight was the highest for 5 % calcium sulphate spray followed by 1 % spray of the same and they were at par with control without urea. Lowest percentage peel weight was observed for 1% spray of calcium chloride.

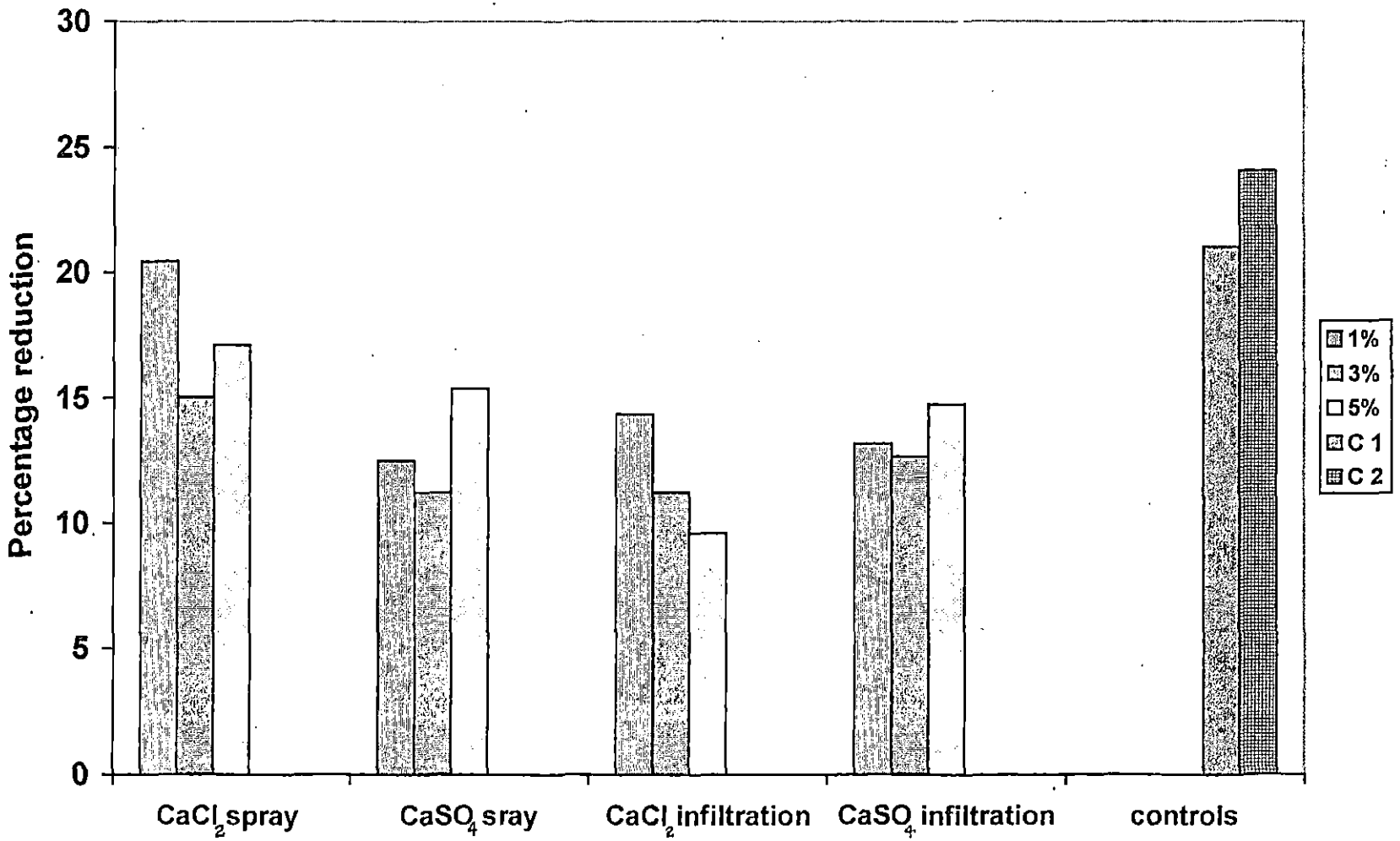
4.3.A.1.5 Percentage pulp thickness

Calcium chloride 1 % recorded the highest followed by 3 % calcium sulphate which were at par with the control with urea . The lowest was observed for 5 % calcium sulphate spray.

4.3.A.1.6 Percentage peel thickness

Percentage peel thickness was maximum for 5% calcium sulphate and this was significantly superior to all other treatments. Another important

Fig.5 Percentage reduction in 'D' finger weight at ripening as effected by sprays and infiltration of calcium



observation was that in the treatments with higher concentrations of calcium the peel thickness were higher. Minimum percentage peel thickness was recorded for 1 % calcium chloride.

4.3.4.2 DAYS TO RIPENING AND SHELF-LIFE

4.3.A.2.1 Days to ripening

Control without urea took more time to ripen and this was at par with 1 % and 3 % calcium chloride sprays. The lowest time taken to ripening was for 1% calcium sulphate spray and control with urea.

4.3.A.2.2 Shelf-life

Control with urea recorded the least shelf-life which was significantly different from other treatments. The rest of the treatments were at par . Maximum shelf life was observed for control without urea followed by 5 % calcium sulphate.

4.3.A.3 BIOCHEMICAL ASPECTS

The data on biochemical and quality aspects are presented inTable 18.

4.3.A.3.1 Urea content at ripening

The 1 % calcium chloride spray followed by 1 % calcium sulphate spray recorded the highest residual urea content which were at par with 5 % calcium sulphate spray and control with urea. Urea content was lowest for control without urea (Fig. 6).

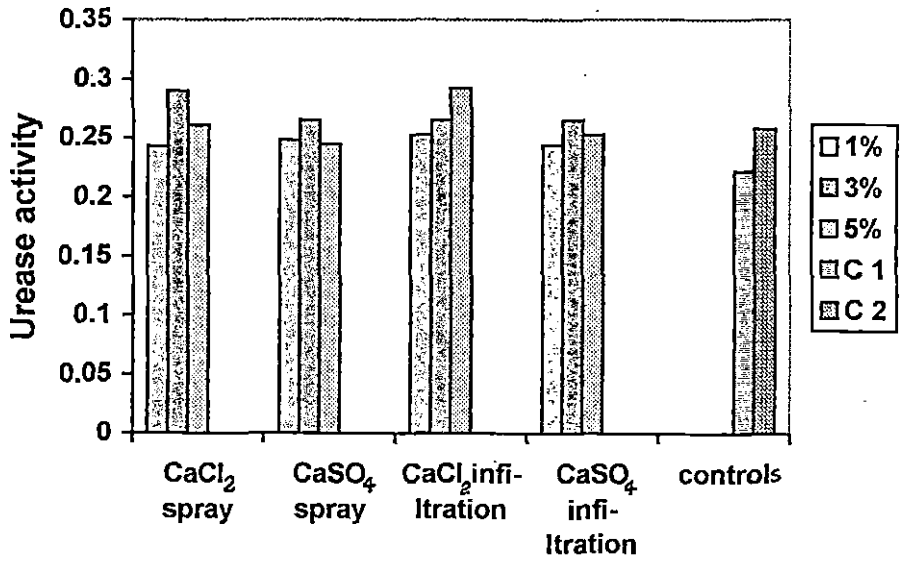
4.3.A.3.2 Urease activity at ripening

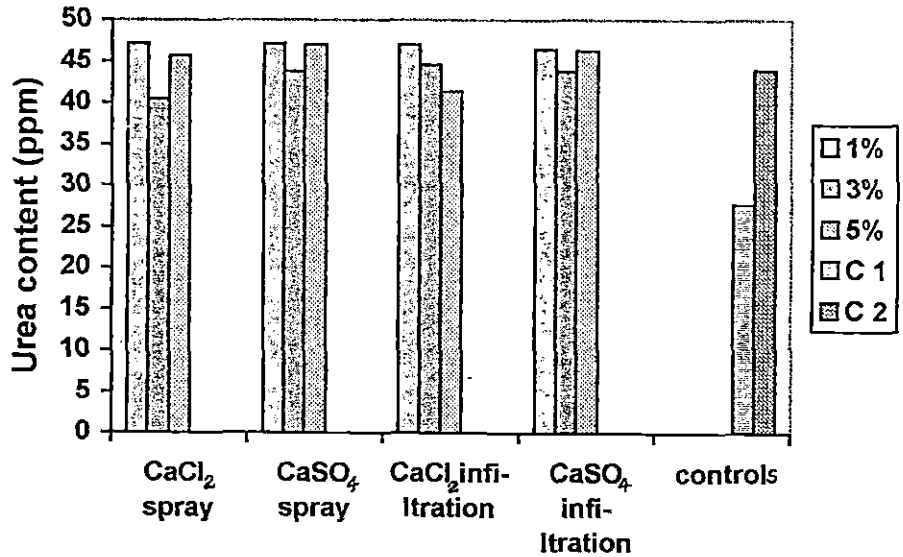
Significant differences between treatment means were observed. Urease activity was highest for 3% calcium chloride which was significantly

Table 18 Effect of calcium sprays on biochemical aspects in banana cv. 'Nendran'

Treatments		Urea content (ppm)	Urease activity (µg/g)	Nitrite N (mM/g)	Acidity (%)	TSS (%)	Ca content in pulp(%)	Ca content in peel(%)
T_1	Calcium chloride 1%	47.17	0.243	22.67	0.372	25.50	0.48	1.61
T_2	Calcium chloride 3%	40.48	0.290	32.00	0.358	26.43	0.45	1.56
T_3	Calcium chloride 5%	45.70	0.261	32.00	0.343	26.83	0.45	1.41
T_4	Calcium sulphate 1%	47.16	0.248	18.67	0.340	26.67	0.84	1.30
T_5	Calcium sulphate 3%	43.81	0.265	20.00	0.334	27.33	0.37	1.11
T_6	Calcium sulphate 5%	47.01	0.245	24.00	0.322	28.33	0.49	1.27
T_7	Control without urea	27.67	0.225	17.33	0.317	28.67	0.32	0.95
T_8	Control with urea	43.92	0.258	27.33	0.366	26.00	0.34	0.94
CD (0.05)		3.87	0.008	9.41	0.030	0.87	0.03	0.09

Fig.6 Effect of sprays and infiltration of calcium on urease activity (μ g/g) and residual urea content (ppm) in banana cv. 'Nendran'





superior to all other treatments. Urease activity was the minimum for control without urea (Fig. 6).

4.3.A.3.3 Nitrite nitrogen

Calcium chloride 3% and 5% recorded the maximum, which were at par with the control with urea and 5 % calcium sulphate. The control without urea recorded the minimum.

4.3.A.3.4 Calcium content in pulp

Calcium content in the pulp was highest for 1 % calcium sulphate and this was superior to rest of the treatments. 5 % calcium sulphate spray recorded the next highest calcium content. Lowest content was noticed in the control with urea.

4.3.A.3.5 Calcium content in peel

Calcium chloride 1 % recorded maximum calcium content in peel followed by 3 % of the same. Calcium chloride sprays generally recorded high peel calcium content. So also all calcium treatments showed a marked increase in peel calcium content compared to the controls.

4.3.A.4 QUALITATIVE ASPECTS

3.A.4.1 Acidity

Acidity was highest for 1 % calcium chloride and it was on par with 3 % and 5 % of the same chemical and also with control with urea. Acidity was lowest for control without urea.

4.3.A.4.2 Total soluble solids

Total soluble solids was highest for control without urea followed by 5 % calcium sulphate. These two treatments were at par and superior to other treatments.

4.3.B CALCIUM INFILTRATION

4.3.B.1 YIELD CHARACTERS

The effects of calcium infiltration on yield, ripening and shelf life are presented in Table 19.

4.3.B.1.1 Percentage reduction in D finger weight at ripening

The control with urea recorded the highest reduction in finger weight followed by control with urea. Lowest percentage reduction observed was for 5 % calcium chloride (9.58%) which was at par with 3% of the same chemical. In general all calcium chloride treatments recorded lower reduction in weight (Fig. 5).

4.3.B.1.2 Percentage pulp weight

Percentage pulp weight was maximum for 1 % calcium sulphate followed by 5 % calcium chloride which was also at par with the other calcium chloride sprays. The lowest pulp percentage was noticed for control without urea.

4.3.B.1.3 Percentage peel weight

The percentage peel weight was highest for the controls which were at par with each other and with 3 and 5 % calcium sulphate sprays. Calcium sulphate 1% recorded the minimum percentage which was also significantly different from other treatments except 5 % calcium chloride spray.

Table 19 Effect of calcium infiltration on yield attributes, ripening and shelf life in banana cv. 'Nendran'

Treatments	D finger weight at maturity (gm)	D finger weight at ripening (gm)	Percentage reduction in D finger weight at ripening	Pulp weight at ripening (gm)	Pulp weight (%)	Peel weight at ripening	Peel weight (%)	Pulp thickness (cm)	Pulp thickness (%)	Peel thickness (cm)	% peel thickness	Days to ripening	Shelf life (days)
T_1	128.50	112.57	14.34	91.37	81.28	21.20	18.72	2.033	94.74	0.113	5.26	8.33	4.50
T_2	118.63	106.77	11.22	85.17	79.80	21.60	20.20	1.963	94.57	0.113	5.43	8.50	4.67
T_3	141.87	132.30	9.58	106.40	82.67	25.90	17.33	2.757	95.74	0.120	4.26	9.50	5.33
T_4	149.53	138.50	13.18	114.26	86.41	24.24	13.59	3.003	96.16	0.120	3.84	7.33	3.17
T_5	147.33	129.06	12.65	97.70	74.52	31.36	25.48	2.600	95.07	0.130	4.93	6.83	3.33
T_6	150.17	129.46	14.73	98.12	74.65	31.34	25.35	2.610	94.83	0.134	5.17	7.67	3.33
T_7	119.98	95.35	24.87	68.00	90.90	27.35	29.10	1.913	93.85	0.124	6.15	8.33	4.33
T_8	147.75	118.40	26.42	87.65	73.83	30.75	26.17	2.073	94.32	0.125	5.68	7.50	2.83
CD(0.05)	---	---	2.28	---	8.42	---	6.69	---	1.53	---	2.53	0.84	0.72

T_1 - Calcium chloride 1%
T_2 - Calcium chloride 3%
T_3 - Calcium chloride 5%
T_4 - Calcium sulphate 1%
T_5 - Calcium sulphate 3%
T_6 - Calcium sulphate 5%
T_7 - Control without urea
T_8 - Control with urea

4.3.B.1.4 Percentage pulp thickness

Percentage pulp thickness was highest for 1% calcium sulphate and was significantly different from the controls. The control without urea recorded the minimum.

4.3.B.1.5 Percentage peel thickness

The peel thickness percentage was highest in the controls. They were at par with all the other treatments except 5% calcium chloride and 1 % calcium sulphate. In general a lower thickness of peel was evident at the highest concentration of 5 % sprays .

4.3.B.2 DAY TO RIPENING AND SHELF-LIFE

4.3.B.2.1 Days to ripening

Calcium chloride 5% treatment took more days to ripen than rest of the treatments. The difference to other treatments were explicit and statistically significant. Calcium sulphate 3 % followed by 5% ripened earliest which was also statistically significant compared to the other treatments

4.3.B.2.2 Shelf life

Calcium chloride 5 % recorded the maximum shelf-life and it was on par with 1 % and 3 % of the same. The least shelf life was observed in control with urea which was significantly superior to all other treatments.

A comparison of the treatments show that sprays of calcium chloride increase shelf life and the more the concentration higher the shelf life was observed in the study. A general reduction in shelf life was also observed with calcium sulphate sprays. Though the reduction was not as much and comparable with the control with urea, it was significantly different from the control without urea.

4.3.B.3 BIOCHEMICAL ASPECTS

The data on biochemical and quality aspects are presented in Table 20.

4.3.B.3.1 Urea content at ripening

Calcium sulphate 3% recorded the maximum residual urea. This was at par with other calcium sulphate sprays and 1% calcium chloride. The control without urea showed the minimum urea content (Fig. 6).

4.3.B.3.2 Urease activity

Urease activity was more for 5 % calcium chloride followed by 3 % of the same and these two treatments were at par with each other . The lowest urease activity was recorded in control without urea (Fig. 6).

4.3.B.3.3 Nitrite nitrogen

Nitrite nitrogen content was observed to be more for control with urea followed by 5 % calcium chloride and they were at par with each other. All other treatments showed more or less same content of nitrite nitrogen.

4.3.B.3.4 Calcium content in pulp

Calcium content in pulp was highest for 5 % calcium chloride and this treatment was superior to all other treatments. This was followed by 3 % calcium chloride and 1 % calcium sulphate which were on par. Lowest content was noticed in control without urea which was at par with the other control and 3 % calcium sulphate spray.

Table 20 Effect of calcium infiltration on biochemical and quality aspects in banana cv. 'Nendran'

Treatments		Urea content (ppm)	Urease activity (µg/g)	Nitrite N (mM/g)	Acidity (%)	TSS (%)	Ca content in pulp(%)	Ca content in peel(%)
T_1	Calcium chloride 1%	46.98	0.253	15.33	0.319	28.90	0.55	1.77
T_2	Calcium chloride 3%	44.53	0.265	16.00	0.314	30.00	0.92	1.76
T_3	Calcium chloride 5%	41.35	0.292	26.67	0.308	31.97	1.09	1.71
T_4	Calcium sulphate 1%	46.42	0.244	16.00	0.324	28.50	0.80	1.25
T_5	Calcium sulphate 3%	43.81	0.265	20.00	0.334	27.33	0.37	1.02
T_6	Calcium sulphate 5%	46.28	0.253	16.00	0.319	30.67	0.45	1.16
T_7	Control without urea	27.67	0.222	17.33	0.318	28.67	0.32	0.95
T_8	Control with urea	43.92	0.258	27.33	0.366	26.00	0.34	0.94
CD (0.05)		4.80	0.030	8.27	0.030	0.99	0.12	0.21

4.3.B.5 Calcium content in peel

Calcium chloride 1 % spray resulted in the maximum calcium content in peel followed by 3 % an 5 % calcium chloride spray. Control with urea had the minimum calcium content in peel. In general all the calcium chloride treatments showed higher content in the peel which decreased with the concentration. The controls registered lower calcium content.

4.3.B.4 QUALITATIVE CHARECTERS

4.3.B.4.1 Acidity

Significant difference between treatment means were noticed. Control with urea recorded the highest and 5 % calcium chloride recorded the least acidity. A critical analysis revealed that higher acidity was observed in calcium sulphate compared to calcium chloride

4.3.B.4.2 Total soluble solids

Calcium chloride sprays at 5 % recorded the highest percentage followed by 1 % calcium sulphate which was at par with 3 % calcium chloride. Control with urea recorded the lowest percentage of total soluble solids which was significantly inferior to all other treatments.

4.3.5 EFFECT OF CALCIUM(SPRAY AND INFILTRATION) ON ELECTROLYTIC LEAKAGE

The data on electrolytic leakage are presented in Table 21.

4.3.5.1 Yellow - 4 hours

Calcium chloride infiltration at 5 % followed by 1% of the same under infiltration and 5 % calcium chloride spray proved most effective in checking the leakage and was at par with 3 % calcium chloride under infiltration

Table 21 Effect of sprays and vacuum infiltration of calcium on electrolytic leakage (mmhos/cm/g) in banana cv. 'Nendran' at different stages of ripening

Treatments		Yellow				50% black				100% black			
		4 hours	8 hours boiling	4+½ hours boiling	8+½ hours	4 hours	8 hours boiling	4+½ hours boiling	8+½ hours	4 hours	8 hours boiling	4+½ hours boiling	8+½ hours
T_1	Calcium choride spray 1%	0.0004	0.005	0.002	0.003	0.003	0.005	0.004	0.004	0.005	0.006	0.005	0.011
		(0.66)	(2.00)	(1.52)	(1.82)	(1.82)	(2.31)	(2.00)	(2.08)	(2.31)	(2.44)	(2.31)	(3.27)
T_2	Calcium choride spray 3%	0.001	0.001	0.002	0.003	0.001	0.001	0.003	0.003	0.002	0.002	0.005	0.006
		(0.80)	(1.14)	(1.52)	(1.82)	(1.14)	(1.14)	(1.82)	(1.82)	(1.52)	(1.52)	(2.31)	(2.52)
T_3	Calcium choride spray 5%	0.003	0.001	0.002	0.002	0.001	0.001	0.005	0.007	0.003	0.003	0.006	0.007
		(0.58)	(0.97)	(1.52)	(1.52)	(1.14)	(0.97)	(2.31)	(2.71)	(1.82)	(1.82)	(2.52)	(2.71)
T_4	Calcium sulphate spray 1%	0.001	0.001	0.006	0.006	0.001	0.001	0.007	0.007	0.002	0.002	0.007	0.007
		(1.14)	(1.14)	(2.51)	(2.52)	(1.14)	(1.14)	(2.71)	(2.71)	(1.52)	(1.52)	(2.71)	(2.71)
T_5	Calcium sulphate spray 3%	0.001	0.001	0.004	0.004	0.001	0.001	0.005	0.005	0.002	0.002	0.007	0.007
		(0.97)	(0.71)	(2.08)	(2.08)	(1.14)	(1.14)	(2.31)	(2.31)	(1.52)	(1.52)	(2.71)	(2.71)
T_6	Calcium sulphate spray 5%	0.002	0.002	0.006	0.007	0.003	0.003	0.007	0.007	0.003	0.002	0.007	0.008
		(1.52)	(1.52)	(2.52)	(2.71)	(1.52)	(1.82)	(2.71)	(2.71)	(1.82)	(1.52)	(2.71)	(2.89)
T_7	Calcium chloride infiltration 1%	0.003	0.001	0.002	0.003	0.002	0.002	0.002	0.004	0.003	0.003	0.003	0.010
		0.58)	(0.58)	(1.52)	(1.82)	(1.52)	(1.52)	(1.52)	(2.08)	(1.82)	(2.82)	(1.82)	(2.08)
T_8	Calcium chloride infiltration 3%	0.004	0.001	0.002	0.003	0.001	0.002	0.003	0.004	0.002	0.002	0.003	0.006
		(0.66)	(0.73)	(1.52)	(1.82)	(1.14)	(1.52)	(1.82)	(2.08)	(1.52)	(1.52)	(1.82)	(2.31)
T_9	Calcium chloride infiltration 5%	0.0002	0.0003	0.001	0.002	0.001	0.001	0.002	0.002	0.001	0.002	0.003	0.007
		(1.48)	(1.52)	(1.14)	(1.52)	(1.80)	(1.14)	(1.52)	(1.52)	(1.14)	(1.52)	(1.82)	(1.82)
T_{10}	Calcium sulphate infiltration 1%	0.001	0.001	0.003	0.006	0.001	0.002	0.005	0.007	0.002	0.002	0.006	0.007
		(1.14)	(0.68)	(1.82)	(2.52)	(1.14)	(1.52)	(2.31)	(2.71)	(1.52)	(1.52)	(2.52)	(2.71)
T_{11}	Calcium sulphate infiltration 3%	0.001	0.002	0.003	0.003	0.001	0.002	0.005	0.007	0.002	0.003	0.005	0.007
		(1.14)	(1.52)	(1.82)	(1.82)	(1.14)	(1.52)	(2.31)	(2.71)	(1.52)	(1.82)	(2.31)	(2.71)
T_{12}	Calcium sulphate infiltration 5%	0.001	0.002	0.003	0.006	0.002	0.002	0.005	0.006	0.003	0.003	0.006	0.008
		(1.14)	(1.41)	(1.52)	(2.52)	(1.52)	(1.52)	(2.31)	(2.52)	(1.82)	(1.82)	(2.52)	(2.71)
T_{13}	Control without urea	0.005	0.006	0.008	0.008	0.005	0.006	0.008	0.010	0.006	0.007	0.013	0.014
		(2.38)	(2.38)	(2.89)	(2.89)	(2.52)	(2.52)	(2.89)	(3.21)	(2.71)	(2.71)	(3.60)	(3.74)
T_{14}	Control with urea	0.006	0.006	0.009	0.009	0.005	0.007	0.013	0.014	0.010	0.007	0.015	0.017
		(2.52)	(2.52)	(3.05)	(3.05)	(2.50)	(2.52)	(3.65)	(3.79)	(3.21)	(2.81)	(3.83)	(4.08)
CD(0.05)		0.261	0.405	0.261	0.230	0.348	0.434	0.203	0.203	0.319	0.261	0.203	0.203

Figures in paranthesis indicate 'x1000 square root' transformation

and 1% calcium chloride spray. The highest leakage was recorded for the control with urea.

4.3.5.2 Yellow – 8 hours

Calcium chloride 1 % followed by calcium sulphate 1 %, both under infiltration recorded minimum leakage values and control with urea recorded the maximum.

4.3.5.3 Yellow- 4+1\2 hour boiling

Lowest electrolytic values were obtained for 5 % calcium chloride infiltration followed by other concentrations of the same and all calcium chloride sprays. The control with urea recorded the lowest leakage.

4.3.5.4 Yellow -8 +1\2 hour boiling

Both 5% calcium chloride spray and 5% infiltration of the same recorded minimum values for leakage which was statistically significant. Highest leakage was observed for control with urea which was statistically significant and superior to all other treatments.

4.3.5.5 50 % black - 4 hours

Calcium chloride 5%, 3 % and 1 % under both methods of application showed minimum leakage while the two controls exuded out the minimum leakage.

4.3.5.6 50 black-8 hours

Calcium chloride spray 5% showed lowest leakage and the two controls showed the highest leakage.

4.3.5.7 50% black- 4+1\2 hour boiling

Calcium chloride infiltration at 1% and 5 % recorded lowest value of electrolytic leakage. The control with urea showed the maximum which was significantly superior to all other treatments.

4.3.5.8 50 % black- 8+1\2 hour boiling

Calcium chloride infiltration at 5 % recorded lowest leachate values. The control with urea recorded highest electrolytic leakage which was significantly higher than the other treatments.

4.3.5.9 100% black- 4 hours

Calcium chloride infiltration at 1 % and 5 % recorded lowest leakage and control with urea recorded the highest which was significantly superior to all other treatments.

4.3.5.10 100% black- 8 hours

Low values were observed for many treatments involving 3 % calcium chloride and all calcium sulphate sprays, 3% and 5% calcium chloride infiltration and 1 % calcium sulphate infiltration. The control with urea recorded highest leakage.

4.3.5.11 100 % black- 4+1\2 hours

Calcium chloride infiltration at all the three concentrations showed minimum leakage whereas the control with urea shows the maximum which registered significantly higher values.

4.3.5.12 100 % black-8+1\2 hour boiling

Infiltration of 5% calcium chloride recorded lowest and control with urea recorded highest electrolytic leakage.

In general calcium chloride infiltration at the three concentrations showed lower electrolytic leakage compared to the other treatments.

4.4 ORGANOLEPTIC EVALUATION

4.4.1 Cytokinin

The test criterion Kruskal Wallis one way anova values by ranks were found to be 29.19 and 29.82 for appearance and taste respectively. The probability values were 0.0001 and 0.027 respectively. The treatments 25 mgl^{-1} and 50mgl^{-1} of both kinetin and BA gave higher scores. Treatments with higher doses of kinetin and BA recorded lower values in case of appearance whereas in case of taste 50 mgl^{-1} and 25 mgl^{-1} of kinetin gave better values.

4.4.2 Potassium

The test criterion Kruskal Wallis one way anova values by ranks was found to be 5.91 for appearance and 6.86 in case of taste and probability values were 0.31 and 0.232 in case of appearance and taste respectively revealing that no significant differences existed between the treatment means or all the potassium treatments were at par and did not make any significant difference in taste and appearance .

4.4.3 Calcium

In case of calcium sprays the test criterion Kruskal Wallis one way anova values for appearance and taste were 5.96 and 7.23 respectively and the probability values for the same were 0.31 and 0.20 respectively which means that

it was not statistically significant or that the treatment could not bring about any significant difference in taste and colour.

In case of vacuum infiltration techniques the corresponding test criterion values of appearance and taste were 22.09 and 12.64 whereas the probability values were 0.0005 and 0.027 respectively.

The calcium chloride infiltration treatments recorded significantly higher values for taste whereas in case of appearance, at the higher concentrations some black spots were observed on the peel .

4.5. ECONOMICS OF BANANA CULTIVATION / HECTARE

CONTROL

Material (Input) cost

		Amount
1. Planting material	@ Rs 3.5/plant	8750.0
2.Manure	@ 10 Kg/plant	10000.0
3. Propping material	@ Rs 12/plant (for3 years)	10000.0
4. Fertilizer		
Urea	@ 413 Kg/ha	1693.0
Super Phosphate	@ 639 Kg/ha	2233.0
MOP	@ 500 Kg/ha	1900.0
5. Plant Protection Chemicals		
Phorate		450.0
Sevin		250.0
Sub Total		**35276.0**

B. Labour Cost (@ Rs 135/ labour)

	No:	
1. Lay out of the field	5	675.0
2. Clearing the land and removal of stumps	25	3375.0
3. Digging the land	25	3375.0
4. Taking pits and bunds	25	3375.0
5. Planting	10	1350.0
6. Mulching	10	1350.0
7. Weeding	10	1350.0
8. Fertilizer application and earthing up	25	3375.0
9. Taking channels and irrigation	8	1080.0
10. Propping	10	1350.0
11. Desuckering	10	1350.0
12. Harvesting	10	1350.0
Sub Total		**23355.0**
GRAND TOTAL		**58361.0**

The economics of the cultivation and returns calculated for the best treatment of each experiment are presented below

TREATMENTS

A. Cost of Chemicals

K_2SO_4 (15 Kg/ha)	@ 6 g/plant	2760.0
Kinetin (25 g/ha)	@ 10 mg/plant	24850.0
$CaSO_4 . 2H_2O$ (25 Kg/ha)	@ 10 g/plant	11850.0

	Urea(75 Kg/ha)	@ 30 g/plant	1350.0	
B. Miscellaneous cost			100.0	6175.0
C. Labour cost		No:		common
Bunch stalk feeding		25	3375.0	cost
	Chemical sprays	10	1350.0	
Total Cost for each Treatment				
1.	Kinetin	58361.0+		
		24850.0		
		6175.0		
		⇨	89656.0	
	Additional cost		31295.0	
2.	K_2SO_4	58361.0+		
		2760.0		
		6175.0		
		⇨	67296.0	
	Additional cost		8935.0	
3.	$CaSO_4.2H_2O$	58361.0+		
		11850.0		
		6175.0		
		⇨	76386.0	
	Additional cost		18025.0	

RETURNS

1. Kinetin (9.16 Kg av. bunch wt.)	@ Rs 10/ Kg**	229000.0
*Control (7.75 Kg av. bunch wt.)	@ Rs10 / Kg	193750.0

Additional returns	35250.0
Incremental benefit cost ratio	**1.13**

2. Potassium (9.80 Kg av. bunch wt.)@Rs10/ Kg**	245000.0
*Control (8.39 Kg. av. bunch wt) @ Rs 10/ Kg	209750.0
Additional returns	35250.0
Incremental benefit cost ratio	**3.95**

*Weights are as observed in the respective control of the experiment

** Rates are as observed in the College of Horticulture, Vellanikkara

Economics of treatments

The cost of cultivating one hectare of banana (control) was Rs. 58361.The average bunch weight recorded per plant was 7.75 Kg which were worked out to Rs 193750/ ha at Rs 10/ Kg.

The kinetin treatment involved an additional cost of Rs 31295 /ha. The bunch weight increased to 9.16 Kg due to the treatment, thereby resulting in an additional return of Rs 35250 /ha. The incremental benefit cost ratio worked out to 1 : 1.14 indicating that the treatment is economically viable.

The potassium sulphate treatment incurred an additional cost of Rs. 8935 /ha. The bunch weight increased from 8.39 to 9.80 due to the treatment, thereby resulting in an additional return of Rs 35250 /ha. The incremental benefit cost ratio worked out to 1 : 3.95, showing that the treatment is economically more viable than the earlier one.

The incremental benefit cost ratio of calcium sprays have not been worked out as the treatments of the same were effected after harvest and hence

the effects were more manifested at the reduction in loss of weight. Further, the loss in reduction was more effective in the infiltration techniques which is not easily recommendable at farmer's level but can be conceived only at an export business level .

Discussion

5. DISCUSSION

The results of the investigation on the "Influence of post bunching sprays of cytokinin, potassium and calcium on yield and shelf life of banana (*Musa* AAB Nendran) fruits" are discussed under the following major heads.

5.1 CYTOKININ

5.1.1 Growth and Relative Growth Rate

The typical functions of cytokinin include cell division and expansion which mark the basic steps in growth. Cytokinin in combination with auxin is known to exhibit a striking quantitative relationship in the regulation of morphogenesis. It is important for the stimulation of RNA (Tepfer and Fosket, 1978; Bevan and Northcote, 1981) and protein synthesis (Stoddart and Thomas, 1982) and induction of enzyme activity (Binns, 1994). The increase in growth and relative growth rate due to cytokinin sprays in the study could be attributed to these factors. Large number of reports beginning from the classic experiments of Skoog and Miller (1957) have shown that organ formation could be controlled by regulating the ratio of auxin: cytokinin. Yet another aspect which would have favourably acted in increasing growth rate is the ability of cytokinin to direct the movement of numerous substances to the areas of the plant treated with this substance or in short, hormone directed transport.

5.1.2 Fruit curvature index (FCI)

In the study FCI was found to be more for cytokinin treatments than the controls. A look at the data reveals beyond doubt that this has been due to the increase in length and grade. Further, the hormone directed transport should have mobilised more nutrients into the fruits thereby straightening the fruits or increasing the FCI.

5.1.3 Yield

Increment in yield consequent to cytokinin application could result from many reasons. Primarily, it could have acted at the cell division and enlargement which are the typical functions of cytokinin. Cell enlargement can be due to cell wall acidification resulting in extension which is brought about by a phytohormone activated proton pump. In the works of Green and Muir (1978) next to auxin substantial growth responses have been reported in case of cytokinins.

In the study of the morphological aspects of finger development in Nendran banana by Kurien et al(unpublished) the cell division stage has been identified as the second and early third week after shooting. As this is the timing of the first spray, the applied cytokinin should have acted in one or more ways as stated above.

Secondly, cytokinins are known to act through promotion of protein and RNA synthesis, and can also prevent the activity of protein and RNA – degrading enzymes. It is reported that even it can restore chloroplast structures and restart chlorophyll synthesis in certain plants (Dyer and Osborne, 1971). In banana the peel contains chloroplast and is known to photosynthesize in the presence of light (Stover and Simmonds, 1987).

A large variety of enzymes are also enhanced by the application of cytokinin which include carboxydismutase, NADP-dependent glyceraldehyde dehydrogenase, ribulose-biphosphate carboxylase, IAA oxidase and nitrate reductase. Though the above enzymes have not been studied, urease enzyme has been found to increase with cytokinin sprays that might have certainly helped in

better utilisation of applied urea which is again revealed by very low residual urea content.

Another major reason for the yield increment should be at the hormone directed transport or movement of the solutes to the areas of the plant treated with these growth substances. Starch filling takes place towards the later stages and applied cytokinin should have enhanced this effect. More detailed studies involving anatomy of the cell and its development at defined physiological stages of finger development is required in this direction.

5.1.4 Shelf life

The increase in shelf life upon cytokinin sprays observed in the study can be due to several reasons. Cytokinins have the ability to delay the rate of chlorophyll disappearance and protein degradation. They have also been proved to reduce in the activity of protein and RNA degrading enzymes. They could suppress the senescence linked changes in respiration rate, and maintain tight coupling in the mitochondria (Tetley and Thiman, 1974). The reduction in several membrane associated activities in the chloroplast which inevitably accompanies senescence have also been reported to be significantly reduced (Thomas, 1975). Cytokinins can restore chloroplast structures and restart chlorophyll functioning. An equally spectacular effect is their ability to direct the movement of numerous substances to areas of the plant treated with these growth substances which is referred to as metabolism directed transport. The most important aspect of this metabolism directed transport is the higher rate of catabolism which has been reported to be due to delay of senescence (Wilkins, 1987). The present study has established the deferral of senescence and hence authenticates this basic concept.

5.1.5 Quality

Compared to the control with urea, some of the treatments showed reduced acidity and almost all the treatments recorded reduced sugar contents than the controls. Enhancement of catabolism should mean production of more organic acids, but observation generated in the study are in the opposite direction. Anabolic processes like formation of starch and similar biomolecules are found to be accumulating in some of the treatments of the present study. Until we know more about the biochemical contents at different stages, it is difficult to explain how acids and sugars were reduced; probably this is one area for future research.

5.1.6 Biochemical characters

5.1.6.1 Urea content and urease activity at ripening

The result of the study revealed less urea content and higher urease activity for cytokinin sprayed samples compared to the control with urea. A higher urease activity coincided with higher bunch and finger grade. It might also have resulted in the better utilisation of urea, thereby resulting in low residual urea content. Though identical studies do not exist, cytokinin has shown to influence the nitrate reductase which means, it can influence better uptake of applied nitrogenous nutrients (Bonner and Varner, 1965).

5.1.6.2 Nitrite nitrogen content.

Some of the treatments showed increased nitrite nitrogen content than the controls while some showed reduced content of nitrite nitrogen. The nitrite nitrogen content might have accumulated in some treatments due to the degradation and inter-conversion of urea owing to the complementary action of urea and cytokinin. Knauer (1970) estimated the maximum safe level of nitrogen

to be 0.1 percent of the dry weight. The values obtained in the study are well below the permissible level of 0.1 percent proposed by him.

5.1.6.3 Electrolytic leakage

The electrolytic leakage was considerably reduced with cytokinin sprays. This can be directly argued to be a result of the anti-senescence effects of cytokinin. The regulation of the integrity of cells, delay in ripening and extended shelf life lead to retention of all solutes without degradation / inter-conversion for a more period. The studies made in the project also showed higher retention of solutes until the very late stage i.e., 100 % black stage.

5.2 POTASSIUM

5.2.1 Growth and Relative Growth Rate

In the study relative growth rate increased with potassium supply. This has been confirmed in the studies of Siddiqi and Glass (1983). Potassium is involved in osmo regulation. A partial replacement of K^+ by other ions is also attributed to its multiple role. However, the specificity of the function is manifested on the delivery of ion to the sight of action. The role of potassium on growth can be explained due to its effects being manifested at different times.

Potassium has a general function in the regulation of water in plant cells. Even under stress it acts in selective way during osmotic adjustments (Bernstein, 1963; Rains, 1972). Another reason should have been the pronounced effects of K^+ in cell wall acidification. An early study of Ordin et al (1956) had already demonstrated an accelerated effect of auxin on growth rate in the presence of K^+ (Hasche and Luttge, 1975) presented data on IAA stimulated proton efflux which was electrochemically balanced by a stoichiometric influx of K^+.

In the absence of K^+, IAA induced growth rate was slowed down and ceased after a few hours. Identical results were also reported by Cleland (1971) and Cocucci and Dalla-Rosa (1980) emphasising the role of K^+ as an integral part of proton extrusion process postulated to induce wall acidification and auxin stimulated growth. K^+ is directly involved in cell wall expansion. The K^+ effect is attributed to cell wall loosening events which are initiated by the cleavage of wall bonds bearing an electrical charge, followed by a small increment in viscoelastic extension (Cleland, 1987). Also the biochemical function of potassium in metabolism accounts for the close relationship between RGR and K^+ transport to the shoot.

5.2.2 Fruit Curvature Index (FCI).

All the potassium treatments increased the FCI compared to the controls. Either an increase in length or a decrease in curvature could increase the FCI. In the study all treatments increased the length and grade of fingers and this should be the reason for the higher FCI.

A previous study on the morpho physiological aspects of finger development in the same clone also showed that bending of the fingers was maximum at early stage which coincided with the stage of cell division . As the cell expands and with mobilisation of solutes, the finger tends to straighten out (Kurien, unpublished) .The results of the study point in this direction. The K applied should have caused cell wall loosening resulting in more expansion and straightening of fingers which should have resulted in higher values of FCI.

5.2.3 Yield

The results of the study revealed the overall positive effects of applied K on yield and the profound influence of the percent K_2SO_4 sprays applied

at third and fourth week after bunch emergence in improving the yield significantly.

The yield increments resulted from potassium sprays due to its high mobility in plant system could be argued from different angles. Potassium is involved in the maintenance of turgor, in synthesis, activation and stabilization of enzyme proteins in meristematic cells and in the continuous pumping of H^+ from the cytosol into the apoplast of the meristematic tissue. The first aspect is the interactive role of ATP, ATPase and K. Fujino (1967) observed an interaction between ATP, ATPase and potassium in the opening of stomata. He proposed that energy in the form of ATP might be utilised to accumalate osmotically active ions such as K and regulate water flow. Fischer (1968) showed a light response that was independent of CO_2 and suggested ATP as the source of energy.

Optimum potassium concentration in the apoplast would result in a high net release of H^+ which inturn should promote the uptake of sugars and amino acids into the cytosol. These osmotically active molecules could have contributed to the osmotic potential and thus to the turgor of meristematic cells. In this way optimum K^+ supply may indirectly favour the establishment of a high turgor (Mengel, 1985). If higher amounts of K are transferred to the sieve tubes in the sink, it may substantially increase the turgor pressure generated by photosynthates loaded into the phloem and thus promote mass flow from source to sink. In banana, K has a slight positive effect on the photosynthetic potential; a stronger effect on the actual photosynthesis through the opening / closing speed of stomataes; and a still stronger effect on translocation of which indirect evidence tends to designate phloem loading as the most decisive step (Martin-Prevel, 1981).

Potassium plays an essential role in supporting maximal rates of protein synthesis. Some of the enzyme systems in the cytoplasm are also K dependent, of which pyruvate kinase is a classic example (Evans and Sorger, 1966).

Yet another important aspect is the complimentary action of K and urea. A finding which rationally supports this logic conclusion is that of Hsiao et al. (1970) who concluded that the level of nitrite was the dominant factor in controlling the activity of nitrate reductase. Though the nature and properties of nitrate reductase has not been studied, the activity of another enzyme, urease has been studied which shows the dominating influence of the enzyme and the resulting reduced residual urea in the fruit.

5.2.4 Shelf life

The effect of K on physiological aspects of shelf life is dominantly favourable both through slowing of senescence and through a decrease of numerous physiological diseases. Ascorbic acid which always follows their increase under K influence slows down the oxidation processes responsible for enzymatic browning and should also interfere against other senescence processes.

5.2.5 Quality

Free sugars increased under the influence of post bunching sprays of K. Translocation of sugars is closely linked with K (Hartt, 1969, 1970) . A decrease in K content reduces translocation by depressing the potential across sieve plates. Any factor that increases transport of K could alter the electro osmotic potential between sieve tubes thereby influencing sugar translocation (Rains, 1972).

K is a major contributor to the osmotic potential and hence fluctuations in the concentration and distribution of this cation can also influence the sucrose partitioning and hence the increase. Changes observed at TSS or sugar level may also have contributed to this difference in partitioning.

Ascrobic acid always follows an increase under K influence. K enhances the first step to starch formation viz., sucrose formation at the expense of reducing sugars. Starch filling in Nendran generally occurs towards the later stages of finger development and this has been confirmed in the studies of Kurien et al (unpublished). Certainly K would have increased the starch filling. K has also been reported to stimulate the condensation of free aminoacids into proteins (Martin- Prevel, 1980).

Regarding the acceptability in texture which is brought about mainly by the pectin content, the influence of increasing K only brings changes in their physio- chemical state, mainly due to the replacement of calcium ions by potassium ions.

Contrary to the generally accepted view point that K increases organic acid content by enhancing its effects on the krebs' cycle, the results of the study revealed that it decreases the acidity. Studies of Venkatarayappa et al. (1979) support the results generated in the present study.

5.2.6 Biochemical characters

5.2.6.1 Urease activity and urea content

In the trial a higher urease activity coincided with higher bunch and finger grade which revealed the complementary action of applied urea and potassium. Previous work done at this centre also reported for the first time the

urease activity in banana fruit and also that high urease activity generally resulted in better utilisation of urea (Ancy, 1997). The conversion of urea into NH_3 and CO_2 should have taken place and NH_3 must have got incorporated into aminoacids, then into proteins via glutamate synthase cycle (Kumar and Abrol, 1990) or the allantoin allantoic acid cycle as per the reports of Calvin et al. (1952).

Actually when there is higher level of urease activity, the urea content should be decreased considerably (Safeena, 1992). This was evident in the previous study as well (Ancy, 1997). The extent to which the nitrogen of he urea is utilised can be known, only if the initial tissues were analysed and had tagged urea been taken up in the study . The results of the early work done at our department also showed that in the best post bunching treatment of urea the residual urea was very low .

5.2.6.2 Nitrite nitrogen content

Nitrite nitrogen content was present only below the critical levels in the banana fruits. In certain treatments, lower urea content resulted in higher nitrite content which should have necessarily risen due to the better absorption of urea.

Nitrite nitrogen is formed from nitrate which causes methemoglobinemia (Wright and Davison, 1964 and Maynard et al., 1976). The toxic levels are not yet reported in fruits. The nitrite nitrogen content observed in the study was low and within the permissible levels of 0.1 per cent (Knauer, 1970) which should have been due to the better utilisation of nitrate nitrogen by the complementary action of K salts and was in line with the views of Hsiao et al. (1970).

The difference between the K_2SO_4 and KCl treatments can be logistically interpreted due to the differences in the anionic charge effects of different ions, the additional roles of sulphur due to SO_4^- ions, the synergism between S and K ions and the bleaching effects of Cl^- ions. The equivalent ionic conductance in aqueous solution of K^+ at 25° C is 74, that of Cl^- is 76 whereas that of $SO4^{2-}$ is 80 which means that in a combination,K_2SO_4 has more mobility (in ionic form) compared to KCl, both acting as an independent free radical (Bassett et al., 1978)

Finally it may be concluded that potassium improved the yield and shelf life of bunches which were given bunch stalk feeding of urea. The study is of maximum practical utility as it is not only capable of boosting yield but also improving the shortened shelf life when urea alone was given.

5.3 CALCIUM

5.3.1 Yield

Percentage reduction in weight was less at ripening in calcium infiltrated fruits compared to calcium sprayed fruits. In both the cases it was better than the control. Calcium is a highly immobile element. Vacuum infiltration under pressure has rendered its movement into the fruit and thereafter should have acted in different ways.

Classically calcium has been associated with cell wall structure and calcium pectate as a material that binds together cell walls of plants (Tagawa and Bonner, 1957 and Rasmussen, 1966)

The influence of calcium on membrane integrity is normally measured by studying the ionic fluxes into and out of the cells. Calcium has been

found to increase potassium absorption capacity (Rains and floyd, 1970) and also prevent leakage of potassium (Wildes and Neales, 1971) and most electrolytes.

Another probable reason is the stiffening effect of calcium on the cell proposed by Caldwell and Haug (1982). This should have also acted in a positive way by preventing weight reduction.. Yet another reason should have been at the protective role of calcium in ion transport and physiological processes beginning from the changes in pH, quenching of hydrogen and toxic ions (Rains, 1972 and Munns, 1965). Calcium also plays a regulatory role in various processes that affect cell functions (Roux and Slocum, 1982; Marme and Dieter, 1983 and Poovaiah and Veluthambi, 1986).

Finally, calcium defers senescence by retaining the membrane integrity (Pooviah and Leopold, 1975)The improved shelf life observed in the study and the reduced leakage of electrolytes proves beyond doubt the deferral of senescence and this should have in total lead to less reduction in weight due to calcium on ripening.

Calcium increases the activity of many enzymes as well, which include α amylase, phospholipases and ATPases (Wyn-Jones and Lunt, 1967). Analysis of fruit has showed urease activity and reduction of the enzyme activity with many calcium treatments, revealing the complementary action of applied urea and calcium. Though no reports of the effect of calcium on urease activity are available, calcium has shown it's influence on nitrate reductase (Paulsen and Harper, 1968).

5.3.2 Shelf life

Though the sprays of calcium were not effective in improving the shelf life of banana fruits, vacuum infiltration under pressure could improve shelf life substantially. The presence of calcium defers senescence by retaining the integrity of the membrane systems (Poovaiah and Leopold, 1973). As the entry of calcium has been proved, its action at preservation of membrane integrity, better retention of ions due to specificity and selectivity brought about by change in ionic fluxes and again its protective role like overcoming the injurious effects of nascent H^+ ions by change in pH (Rains et al., 1964) should have resulted in the deferral of senescence or increase in shelf life.

The residual analysis of the pulp and peel in the study proves that calcium has entered into both tissues. Though the relative levels are higher in the peel, the levels observed in the pulp are fairly high and this should be the major reason in the extension of shelf life.

5.3.3 Quality

Calcium infiltration was found to increase the total soluble solid content of fruits and decrease the acidity. The acceptability of the fruit measured by a panel shows that general acceptability of the fruit has not been reduced but was at par, which could have been by the proven effects of calcium on other physiological processes like (a) Calcium ions can serve a protective function. Calcium protects plants from the injurious effects of hydrogen ions (Rains et al., 1964). (b) Calcium can reduce the effects of other potentially toxic ions present in the environment and (c) the addition of calcium could substantially reduce protein loss and maintain accumulation of the ions required by the fruit.

5.3.4 Urea content and urease activity

The urease activity in calcium sprayed fruits was higher than the infiltrated ones and this should have been the primary reason for the low residual urea content in the fruit.

The pressure under vacuum infiltration may have created unfavourable conditions for the functioning of urease enzyme and thereby resulted in higher urea content in the fruits . The levels of urease and urea observed in the study point in this direction.

5.3.5 Electrolytic leakage

The results of the study particularly the calcium infiltration resulted in reduced electrolytic leakage from fruits. The electrolytic leakage is normally as a result of the loss of membrane integrity and consequent extrusion of ions particularly calcium. Displacement of calcium from the plasma membrane results in increased membrane leakage (Cramer et al., 1985). Membrane leaks to an extent that depends on calcium concentrations .The results of the study has revealed that calcium has been infiltrated into both the pulp and peel . This should have been responsible for the maintenance of the integrity of cell wall.

Ca^{+} brings in alkalinity whereas SO_4^{-} ions brings in acidity in cytoplasmic fluid. In the case of calcium the equivalent ionic conductance at 25° C is 60, that of Cl^{-} is 76 whereas that of $SO4^{2-}$ is 80 which means that in a combination the mobility of $CaSO_4$ in the ionic form should have been better and as obtained in the case of sprays. However, the better values obtained in $CaCl_2$ treatments in infiltration technique can be interpreted at the divalency or monovalency and the electronegativity level which would have been better

better exposed under pressure. In the case of $CaCl_2$ the ratio is 1:2 for Ca^+ and Cl^- and that in $CaSO_4$ is 1:1 for Ca and S. Further, the electronegativity which is the power of the atom to attract electrons depends on a) the size of the atom and b) the tendency of atom to accept or reject electrons is higher in case of Cl^- (2.8) (Laider, 1978).Another possible reason is lesser reduction potential of Cl (+1.36) at 25°C compared to that of S (+2.4) at 25^0C(Bassett et al.,1978). Though the present investigation has not studied these aspects, this is one area for futuristic research.

Summary

6. SUMMARY

The investigations on "Influence of post-bunching sprays of cytokinin, potassium and calcium on yield and shelf life of banana (*Musa* AAB Nendran) fruits" were carried out in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara. The study was investigated during two seasons – first season from October, 1997 to September – October, 1998 and second season from May, 1998 to February – March, 1999.

The main objective of this project has been on attempting to increase the yield and shelf life by bunch management sprays primarily, by use of a known nutrient viz., potassium; secondly by use of a nutrient viz., calcium which acts in preserving the integrity of the cell wall and thirdly a growth regulator viz., cytokinin known for its anti-senescence effects. The results of the study are summarised here.

1. The study emphasized the overall superiority of 3 % K_2SO_4 sprays applied at third and fourth week after bunch emergence over the other treatments of potassium.
2. Yield and yield components like bunch weight and finger characters such as length , grade , and FCI were significantly improved by treatments with potassium ; K_2SO_4 sprays were more effective compared to KCl sprays .
3. Some of the treatments, especially potassium sulphate sprays could delay maturity and ripening compared to the other treatments. The K_2SO_4 sprays could also increase the shelf life.
4. Quality of treated fruits were improved by way of reduction in acidity and increase in sugars.

5. Biochemical analysis of the fruit revealed a higher urease activity in treatments of K with better bunch and finger characters . Low levels of nitrite nitrogen and lower contents of residual urea were also observed.
6. Low electrolytic leakage of fruits gave evidences for improved shelf life.
7. Organoleptic evaluation revealed the consumer acceptability of treated fruits as well.
8. Among the cytokinin treatments 50 mg l^{-1} of kinetin and 75 mg l^{-1} of BA applied at third and fourth week after bunch emergence proved better in terms of yield and shelf life improvement which was as a result of the improved finger characters such as length, grade and FCI.
9. Some of the treatments, especially that of kinetin 50 mg l^{-1} delayed maturity and ripening compared to the controls.
10. The cytokinin treated fruits revealed a reduction in acidity and sugar contents.
11. Electrolytic leakage was higher in control fruits compared to the treated ones.
12. In the case of calcium, infiltration technique was found to be better than sprays for improvement of shelf life . Percentage reduction in fruit weight was less and total soluble solid contents were more for infiltrated fruits.
13. Electrolytic leakage of calcium infiltrated fruits were significantly reduced and this could have been one reason for the increase in shelf life. Analysis of the calcium content in the pulp and peel revealed that calcium content was more in the peel compared to the pulp of treated fruits.
14. The additional incremental benefit cost ratio worked out for best cytokinin treatments was 1: 1.14 and for best potassium treatment was 1: 3.95
15. In short, the study proved its practical utility by improving the yield and shelf life with post bunching sprays of potassium, cytokinin and calcium.

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INFLUENCE OF POST-BUNCHING SPRAYS OF CYTOKININ, POTASSIUM AND CALCIUM ON YIELD AND SHELF LIFE OF BANANA (*Musa* AAB NENDRAN) FRUITS

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ABSTRACT OF THE THESIS

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ABSTRACT

The experiment entitled " Influence of post – bunching sprays of cytokinin, potassium and calcium on yield and shelf life of banana (*Musa* AAB Nendran) fruits" were carried out in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara. The study was investigated during two seasons from 1997 to 1999 with the objective of increasing the yield and shelf life by bunch management sprays in plants which had been given bunch stalk feeding of urea, primarily by use of a nutrient viz., potassium; secondly by use of a nutrient which acts in preserving the integrity of the cell wall viz., calcium and thirdly, a plant growth regulator with known anti-senescence properties viz., cytokinin .

The study emphasized the overall superiority of one percent K_2SO_4 sprays applied at third and fourth week after bunch emergence. Yield and yield components like the finger characters such as length, grade and FCI were improved by the treatments. A delay in maturity and ripening and an extended shelf life were observed.

The quality of treated fruits revealed reduced acidity, increased sugar contents, higher urease activity, lower residual urea and lower levels of nitrite nitrogen. Electrolytic leakage was also less in K treated fruits.

Among the cytokinin treatments 50 mg l^{-1} of kinetin and 75 mg l^{-1} of BA applied at third and fourth week after bunch emergence proved better. Yield and yield parameters i.e., bunch weight and finger characters such as length, grade and FCI were significantly improved by the bunch management

practises involving post- bunching sprays of cytokinin. The kinetin sprays delayed maturity and ripening besides, qualitatively improving the shelf life.

Calcium infiltration technique could reduce the percentage reduction in finger weight significantly and qualitatively increase shelf life. Also an increase in quality by way of reduction in acidity and increase in total soluble solids, especially in calcium infiltration treatments was observed.

The electrolytic leakage of fruits was found to be less in calcium infiltrated fruits and above all, the effective treatments were more acceptable in terms of taste. The calcium content in the pulp and peel were increased due to infiltration. Analysis of the calcium content in calcium treated fruits revealed that calcium content was more in the peel than in the pulp. Sensory evaluation carried out by a taste panel revealed that consumer acceptability of treated fruits was in no way reduced.