BUNCH STALK FEEDING OF UREA IN BANANA *Musa* (AAB group) 'NENDRAN'

By

T. K. ANCY.

THESIS

Submitted in partial fulfilment of the
requirement for the degree of

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Faculty of Agriculture
Kerala Agricultural University

Department of Pomology and Floriculture
COLLEGE OF HORTICULTURE
VELLANIKKARA - THRISSUR
KERALA, INDIA

1997

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Vellanikkara

T.K. ANCY

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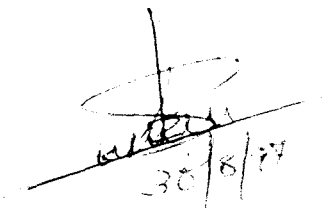

Vellanikkara,

Dr. Sajan Kurien
Chairman, Advisory Committee
Assistant Professor (Pomology & Floriculture)
College of Horticulture
Kerala Agricultural University
Vellanikkara, Thrissur

CERTIFICATE

We, the undersigned members of the Advisory Committee of **Miss. T.K. Ancy** a candidate for the Degree of **Master of Science in Horticulture**, with major in Pomology and Floriculture, agree that the thesis entitled "**Bunch stalk feeding of urea in banana *Musa* (AAB group) 'Nendran'**" may be submitted by Miss. T.K. Ancy in partial fulfilment of the requirement for the Degree.

3/9/97

Dr. Sajan Kurien
Chairman, Advisory Committee
Assistant Professor (Pomology & Floriculture)
College of Horticulture
Kerala Agricultural University
Vellanikkara, Thrissur

Dr. P.K. Rajeevan
(Member, Advisory Committee)
Professor & Head i/c.
(Pomology & Floriculture)
College of Horticulture
Kerala Agricultural University
Vellanikkara, Thrissur

Dr. P.V. Balachandran
(Member, Advisory Committee)
Associate Professor (Agronomy)
Radio Tracer Laboratory
College of Horticulture
Kerala Agricultural University
Vellanikkara, Thrissur

Dr. A. Augustine
(Member, Advisory Committee)
Assistant Professor (Biochemistry)
College of Horticulture
Kerala Agricultural University
Vellanikkara, Thrissur

3/9/97

EXTERNAL EXAMINER

(S. SATHIAMOORTHY)

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Dedicated To My Parents

Introduction

INTRODUCTION

The state of Kerala is known for housing one of the largest biodiversity of *Musa* species particularly the AAB genomic group in the world. So also, there is a lot of diversity in the cultivation aspects. It is grown as a monocrop, intercrop as well as a component of `crop-mix' pattern in homesteads. Again some clones are grown exclusively as a rainfed crop, whereas, others like `Nendran' is grown under irrigated conditions.

Despite being the centre of maximum diversity the production and productivity are very low and demand so high that the state is dependent on flow from across its border. The cultivar `Nendran' is the pick of the varieties and demand so high that the transactions are made even forgetting the quality attributes. It's growing use in traditional baby food preparations, in culinary preparations, its commercial use in the chips industry and for figs, as a vegetable in the raw form and as a major fruit in raw and cooked form is only bound to grow in the years to come. Further extension in the arable area is not possible, if not a remote possibility, and the key answers lie only in increasing productivity.

Evidence of modern cropping practices has no doubt yielded rich positive dividends. In `Nendran' cultivation modern technology is maximum in use, and both labour and capital are highly intensive.

Unlike other crops, where crop husbandry is restricted to soil, crop growth and yield components, *Musa* husbandry deserves an extra dimension of practices focussed on bunch management. Even simple practices like male bud pruning, covering and dehanding have been reported to increase yield. Translocation of nutrients applied in tracer have been monitored in all parts of bunch inflorescence indicating sink mobilisation and competition among hands, fingers, peduncle and male bud. Hence it is imperative to study the effects of retention of male bud, optimise number of fingers and hands such that competition is minimum, yield maximum and quality optimum. So also, irrational placement and sprays of fertilizers on bunch are being followed by some farmers. Hence, a study was undertaken with the precise objectives:

1. To study the effect of bunch stalk feeding and urea sprays on quantitative and qualitative attributes in banana cv. `Nendran'.

2. To standardise the time and method of application of urea, to get maximum return with minimum inputs

3. To study the metabolism of urea feeding in fruits and its impact on post-harvest life of the fruit

The bunch weight and qualitative aspects of the finger determine the consumer preference and market acceptability. So the emphasis of the study has been placed on its influence at the finger level and attributes like length, grade, finger distribution, morphophysiological characters of development and key attributes of palatability.

Review of Literature

2. REVIEW OF LITERATURE

A thorough scanning of available literature on "Bunchstalk feeding of urea in banana (Musa AAB group) 'Nendran'" reveals that studies on the topic of investigationare meagre, if not scanty. Unlike other fruit crops, where crop husbandry is focussed directly on cultural aspects of the plant, banana productivity is also governed by the bunch management practices. It is in this light, that efforts have been made to organise the literature available in *Musa*. Wherever it is limiting, related literature on other fruit crops have also been reviewed under the following major heads.

2.1. Bunch management aspects and yield

Major bunch management practices such as bagging/covering, malebud pruning, dehanding, bunch stalk feeding and spraying growth regulators and urea influence the crop yield to a great extent in banana. The literature on these aspects are reviewed below.

2.1.1 Bagging/sleeving/bunch covering

Bagging or sleeving of banana bunches improves the yield significantly (Trupin, 1959; Perumal and Adam, 1968; and Walker, 1975). Enclosing young banana flowers of cv. Dwarf Cavendish, in a plastic bag increased the number of flowers with a persistent perianth and hence the

yield (Istraeli *et al.*, 1980).. In banana cv. Williams Daniells *et al.*1987 reported a four per cent increase in bunch weight, when polythene covers were used, one week after abscission of the last female flower bracts.

Both sealed and unsealed clean covers under a standard blue/silver cover, with an ethylene absorbent inside increased the weight of the bunches by 37 per cent (Johns and Scott, 1989). Daniells *et al.* (1992) reported that by use of sealed covers the bunch weight increased upto nine per cent and this increased finger length along the entire bunch, whereas there were no promising results, when open covers were used. Studies in cv. Williams using double bunch covers recorded increment in finger weights of the top six hands by four per cent, but did not affect the yield of extra large fruits and appeared not to be worthwhile for all price scenario used (Jones, 1996).

2.1.2 Male bud removal

Various studies have shown that removal of male bud resulted in an increase in the weight of bunches in banana. The favourable effect of trimming male bud after bunch emergence, on bunch weight has been interpreted as the utilisation of energy, otherwise lost for the opening of the flowers for finger development (Simmonds, 1959; Sampaio and Simao, 1970; Walker 1973; Meyer, 1975; Jaramillo, 1982 and Amma *et al.*, 1986).

According to Rodriguez (1974) a 13 per cent gain in bunch weight was recorded in cv. Valery when the male inflorescence was removed at different periods, ie., 10, 30 or 60 days after bunch development. Inflorescence removal at the earliest yielded the best results.

Dry weight analysis indicated that the male bud represented a significantly competing photosynthetic sink (Daniells *et al.*1994 Using tracer techniques, Kurien *et al.* (1996) confirmed that among the various parts , the male bud is the major physiological sink siphoning the highest quantity of applied nutrients.

Contrary, to the above studies, the experiments by Souza *et al.* (1971) and Hasselbach and Idoe (1973) revealed no significant increment in yield.

2.1.3 Dehanding

Removal of the false hand plus one or two of the smallest apical hands improves the yield of the first class fruit (Trupin, 1959; Perumal and Adam, 1968; Walker, 1973). A trial in Congo bananas (Hasselbach and Idoe, 1973 and Stevenson, 1977) and in cv. Palayankodan (Amma *et al.*, 1986) revealed that dehanding treatment did not increase the average bunch weight but it gave better sized fingers.

According to Irizarry and Rivera (1991) Super Plantano (AAB) bunches trimmed to 4 and 5 hands yielded 14680 and 180200 marketable fruits/ha respectively. This represented an yield increase of about 26,000 and 59,400 fruits/ha respectively compared with unpruned controls. Out of the various bunch trimming treatments, retention of 6 hands and removal of the bell produced 35 per cent more extra large fruits.

Instead of increasing the yield, removal of one hand/bunch reduced the yield/bunch by seven per cent and removal of 2 hands/bunch reduced yield by 15 per cent, without any improvement in fruit grades in cv. Williams (Daniells *et al.*, 1987).

Besides reports that dehanding increases yield, the pruned hands can also be used as vegetable. Thus the same bunch serves both as vegetable and fruit.

2.1.4 Growth regulator applications

Only a few experiments are available in this area of research. Deshmukh and Chakrawar (1980) reported that ancymidol at 200 ppm and 2,3,5-T at 100 ppm or Rauza (disugran) at 100 ppm gave best results with regard to increasing the average bunch weight, size of bunch and weight of fingers, in cv. Basrai. According to Aravindakshan (1981) growth regulators if applied as

pre-harvest sprays on 60th day after shooting increases size and weight of fruits of cv. Nendran. The maximum increase in size and weight was obtained by the application of 2, 4-D at 10 ppm. Reports of Pradhan *et al.* (1988) show that Ethrel 0.25 and 0.5 ml/litre and GA_3 at 100 mg/litre were very effective in getting, similar positive results in cv. Giant Governor.

Analysing the cause for increments in size and weight it was inferred that foliar applied GA can influence the source - sink relations in early reproductive development by manipulation of photosynthate production and partitioning (Malik *et al.* 1986). Similarly, innumerable reports on other fruit crops are available.

2.1.5 Bunch stalk feeding

Post shooting application of urea in cv. Giant Governor, has been reported to promote yield (Venkatarayappa *et al.*, 1976). It was inferred that yield increments were due to more availability of urea in aqueous form at later stages and for a prolonged period. Similar positive results were later reported by Buragohain and Shanmugavelu (1986) in banana cv. Vayal vazhai. According to them, a 23 per cent increase in bunch weight was obtained by attaching 10g urea in a polythene bag to the cut stalk end immediately below the bunch 2 days after the male bud was removed.

Translocation of nutrients in the infructuscence of banana Cvs. Poovan, Monthan and Nendran have been reported by various scientists. (Buragohain and Shanmugavelu, 1985 and Shobhana and Aravindakshan, 1989). It was concluded from the experiment that late application of fertilizer to bananas may be beneficial.

On the other hand, Daniells and Bryde (1986) contradicted the concepts of bunch stalk feeding, by pointing out that there was no increase in yield by adopting this technique.

2.1.c Urea sprays and yield

Yield increase consequent to urea sprays was reported as early as 1963 by Pan and later by a number of scientists. Macronutrient sprays are important in plant metabolism, particularly affecting the process of photosynthesis (Humbert and Hanson, 1952). Sharma (1984) reported increased bunch weight and number of fruits/bunch in plants receiving 187.5g N applied to the soil +187.5 g N/plant applied in 12 sprays at 2 weeks interval. Patel (1986) obtained that with pre as well as post shooting sprays of N, P and K and (1.0, 0.5 and 1.0%), an increment in bunch weight was noticed. Likewise, Gandhi (1984) observed increase in yield per plant in Basrai bananas with one and two per cent post shooting urea sprays. Firth (1986) on the other hand reported negative results on these aspects.

Patel and Patel (1987) conducted a study to find out the effect of foliar spray applications of urea on maturity, yield and quality of banana cv. Basrai. The increase in the bunch weight with the concentration of urea was linear. Four per cent urea spray produced heavier bunches (20.57 kg). But number of sprays as well as interaction between concentration of urea and number of sprays were found to be non-significant. Kumar and Shanmugavelu (1986) obtained similar result with two per cent urea, in cv. Robusta.

Experiments by Devi (1991) resulted in a 35 per cent increment in bunch weight (11.5 kg) in Nendran over control by the normal dose of N, P and K at three and five MAP (:10:35:330 g NPK/plant/year) in combination with four foliar sprays 3, 5, 7 and 9 months at two per cent concentration.

In mango, Tiwari and Rajput (1975) as well as Samra *et al.* (1977) with four per cent urea and Singh (1976) with two per cent and four per cent urea recorded higher yield weight per fruit and yield per plant were also influenced by urea spray in the case of guava cv. Sardar (Dwivedi *et al.* 1990). Ten per cent urea spray gave maximum yield and the higher yield was due to less of deblossoming and defruiting. Joolka *et al.* (1991) observed yield increment as a consequence of urea spray at five per cent in almonds

The increase in yield was opined to be due to increase in yield contributing factors such as fruit set and fruit size. Similar results were also reported in lemon by Kumar *et al.* (1988).

In the view of Macks and Clarke (1995), foliar application of urea had no consistent effect on fruit yield and was ineffective when fruit set had been reduced.

2.2 Maturity

2.2.1 Maturity indices

The banana, shooting to harvest varies between clones and generally, range from 80 to 120 days under tropical climate (Stover and Simmonds, 1987). Rate of fruit maturation from shooting depends on temperature provided moisture is not limiting. Inaba *et al.* (1984) revealed that fruits attain maturity about 65 to 105 days after flowering, when organic acids increased markedly and starch content increased. In the views of Gnakri and Kamenan (1990), normal harvesting time of 80-90 days after flowering gave a shelf-life of 3-4 days. Starch grain size, amylose contents, structure as shown by X-ray diffraction, gelatinization temperature, swelling, solubility and sensitivity to α-amylase were similar for fruits harvested at 72 and 83 days after flowering . Chemical composition, particularly, starch content can be used as a maturity indicator for banana harvesting and for better ripening (Sabari *et al.*, 1992).

2.2.2 Days to maturity

All bunch management treatments, like bagging, dehanding, male bud pruning and bunch sprays influence the maturity of bunches.

Earlier reports recorded a shortening of shooting to harvest (3-6 days) wherever bunch covers are used (Berril, 1956; Kunhe and Kritzinger, 1964 and Perumal and Adam, 1968; Ganry, 1975). According to Stevenson (1976) type of bunch covers influence the bunch maturity ie., in winter use of transparent material speeded up the filling and hastening of maturity. Identical results have also been reported by Johns and Scott (1989). Reddy (1989) observed 12 days earlier maturity when 200 gauge polythene sleeves were used in banana cv. Robusta. Daniells *et al.* (1994) are of the view, that bunch maturity obtained in the covered bunches may be due to increase in temperature in and around the bunches.

Beneficial effect of removal of male bud in reducing the days for harvest from shooting have been reported by many workers (Wardlaw 1961; Walker, 1973; Walker 1975., Bhakthavathsalu and Azhakiyamanavalan, 1977 and Amma *et al.* 1986). But no positive results were obtained in cv. Prata by removing the male inflorescence 30-60 days after flowering (Souza *et al.*, 1971).

Dehanding operations also decrease the period from bunch emergence to harvest (Hasselboch and Idoe, 1973; Stevenson, 1977; Amma *et al.* 1986 and Daniells *et al.*, 1987) in various cultivars of banana.

Growth regulator sprays delay the maturity process in fruit crops. Tandros *et al.* (1984) reported that GA_3 10-50 ppm resulted in delayed maturity. Succinic acid 600 ppm, followed by ethephon 300 ppm and GA 200 ppm significantly delayed the bloom in almonds (Joolka *et al.*, 1991).

Bunch stalk feeding of urea treatments recorded 11 days earlier maturity with 10 g urea and 6 days with 15 g urea Buragohain and Shanmugavelu (1986). In general with the increase in concentration of urea, the maturity was progressively delayed (Patel and Patel, 1987) in cv. Basrai. Significantly more number of days (10 days) were required for attaining the maturity under four per cent urea as compared to one and two per cent Gandhi (1984) also reported delayed maturity with four per cent urea in mango.

2.3 Ripening

Different cultural and management treatments on crops bring about alterations in ripening of fruits and its various physical and chemical characters.

Rodriguez (1974) observed no appreciable effect on ripening due to male bud removal in 3 banana cvs. Valery, Grand Nain and Giant Cavendish. Pre-harvest growth regulator sprays on bunches of cv. Basrai, like ancymidol (200 ppm), 2,3,5-T (100 ppm) or Rouza at 100 ppm advanced the ripening by 8-14 days (Deshmukh and Chakrawar, 1980). Four urea sprays at 1,2,3 and 4 per cent concentrations recorded earliest ripening (99.9 days) and latest (103.1 days) with 6 sprays in banana cv. Basrai (Patel and Patel, 1987).

Actually, harvesting triggers ripening (Offem and Thomas, 1993). The post-harvest treatments are having much more influence on ripening in bananas. Treatments with GA and kinetin retarded banana ripening as indicated by higher values for firmness, starch, cellulose and hemicellulose (Desai and Deshpande, 1978 and Parmar and Chundawat, 1984). The results suggest that banana ripening can be controlled chemically. $CaCl_2$ sprays on mature green fruits of Robusta enhance the ripening by reducing the firmness (Huddar *et al.*, 1989).

Ethylene at 0.3-0.4 µ l/l for 24 hours ripens bananas at 25°C. Ripening is accomplished by faster respiration and ethylene production. Increasing the O_2 levels to 13 per cent and decreasing Co_2 improves banana ripening and shortens storage time (Acedo and Baustista, 1993; Dominguez and Vendrell, 1994 and Goburdhun, 1994).

2.4 Quality parameters

Most of the bunch management treatments in banana improves the grade of the fruits both qualitatively and quantitatively.

2.4.1 Morphological aspects of finger development

Bunch sleeving increases the finger length and diameter (Daniells *et al.*, 1987; Johns and Scott, 1989 and Reddy, 1989).

Presence of a male bud in the bunch had an adverse effect on fruit growth and quality (Chattopadhyay and Jana, 1988). So the fruit appearance was markedly improved by tipping of floral remnants in cv. Robusta (Bhakthavathsalu and Azhakiamanavalan, 1977). No such increment in size was noticed in cultivar Peta (Souza *et al.*, 1971).

Dehanding in banana recorded significant improvement in fruit length, thickness and over all grade (Hasselbach and Idoe, 1973; Stevenson, 1977; Amma *et al.*, 1986; Irizarry and Rivera, 1991; Daniells *et al.*, 1992; Irizarry *et al.*, 1994 and Johns, 1996).

According to Aravindakshan (1981) pre-harvest sprays of growth regulators viz., 2,4-D at 10 ppm at 60th day after shooting increases size and quality of fruits in banana cv. Nendran. Reports of Pradhan *et al.* (1988) point

out that ethrel 0.25 and 0.5 ml/l and GA_3 at 100 mg/l were very effective in increasing fruit weight and pulp : peel ratio.

2.4.2 Biochemical aspects

2.4.2.1 Changes with urea sprays

In cv. Basrai different concentration of urea manifested their effects on qualities of fingers. Fruit total sugar was the highest (15%) in plants treated with one per cent urea and in plants receiving two sprays (15.25%). The acidity, in general increased by urea sprays (Gandhi, 1984 and Patel and Patel, 1987). Singh *et al.* (1992) reported that sword suckers of cv. Harichal sprayed with two per cent urea produced fruits with highest TSS (18.9%), sugar (18.66%), ascorbic acid (5.49 mg/100g), protein (1.64%), ash (0.81%), P (32.93 mg/100 g), K (359.23 mg/100 g), Ca (6.76 mg/100 g) and Mg (44.90 mg/100 g) contents. Increase in sugar and ascorbic acid contents was reported by Singh (1976) and Singh *et al.* (1976) in mango and Singh and Rajput (1976) and Dwivedi *et al.* (1990) in guava.

2.4.2.2 Changes due to growth regulator application

In Dwarf Cavendish bananas, the pulp percentage and soluble solid contents were highest with fruits sprayed with 2,4-D at 10 ppm during flowering (Tomi *et al.*, 1970). The fruit quality in cv. Nendran was improved by way of increased TSS, total and reducing sugars by treatments of

Ethrel, 400 ppm, NAA 50 ppm and 100 ppm, 2,4-D 4 ppm and 10 ppm.

Chattopadhyay and Jana (1988) reported increased fruit quality with GA_3 50 ppm spray 30 days after emergence of the inflorescence in Giant Governor. Similar results have also been obtained with ethrel 0.5 ml/litre sprayed at 55 days after flowering (Pradhan *et al.*, 1988).

2.5 Shelf life

Induction of softening in bananas during storage at 20°C and low RH was investigated with respect to endogenous ethylene production. Aziz and Wahab (1970) found out that bananas treated with 2,4-D at 100 ppm for 30 seconds were marketable for longer than those from other treatments. Vaccum infiltration with $GA_{4,7}$ extended the pre-climetric period of fruits by about 47 per cent (George and Marricott, 1983).

Ripening was retarded most effectively and shelf life was extended (2.2 - 2.4 days) in cv. Lacatan by treating the fruits with GA at 150 ppm and Benlate at 50 ppm or with GA at 150 ppm and 6 per cent waxol (Rao and Chundawat, 1986).

In Giant Cavendish bananas, exogenous ethylene pre-treatments, rapidly hastened flesh softening and reduced shelf life (Yambin *et al.*, 1996).

Use of sealed polyethylene tubes and ethylene absorbent allowed a storage life of upto 6 weeks at 20-28°C and 16 weeks at 13°C (Satyan *et al.* (1992). Storage life of the bunches was limited by the presence of high concentration of Co_2 and or ethylene in the atmosphere or the development of bunch stalk rot.

In the case of oranges, Lavon *et al.* (1982) noticed a longer shelf life by spraying a mixture containing one per cent urea, phosphate and GA (10 or 20 ppm).

Materials and Methods

3. MATERIALS AND METHODS

The investigations on "Bunch stalk feeding of urea in banana, *Musa* (AAB group) cv. Nendran" were carried out in Central orchard, attached to the Department of Pomology and Floriculture of the College of Horticulture, Vellanikkara. The preliminary standardisation studies were done, during the period from June, 1996 to August 1996 and the main experiments from August, 1996 to June, 1997. The site, situated at an altitude of 40 M above MSL at 10° 32"N latitude and 76° 16"E longitude. The area enjoys a warm humid tropical climate. The soil type is deep, well drained sandy loam with pH of 5.1. The meteorological data are presented in Appendix I.

Five preliminary experiments were conducted for standardisation of techniques to be followed. The crop for these studies were raised from uniform sized suckers, having similar sized bunches and same number of hands. The crop received uniform cultural and management practices as per the package of practices recommendations of KAU (1993).

3.A Preliminary experiments

The details of the preliminary experiments are given below.

3.A.1 Standardisation of distance

Bunches, two weeks after completion of the female phase, were selected for enforcing the treatments. Male buds were pruned at distances of 4,8,12,16 and 20 cm from the last hand and one without pruning formed the control.

3.A.2 Method of cut

The bunch stalks were uniformly cut at a distance of about 15 cm by adopting different methods viz., wedge, oblique, flat inverted 'v' prickled cuts and no cut which formed the treatments (Fig.1). 10g urea was uniformly tied to the different cut ends.

3.A.3 Standardisation of time of application of urea

To fix up the best time of application of urea, male buds were trimmed at 15 cm from the last hand, using flat cut method and 10g urea was tied to the cut ends. Application was done at 1,4,8,12,16 and 20 days after complete emergence of the bunch. Treatments were enforced immediately after cutting the male bud and also 24 hours after cutting.

3.A.4 Standardisation of dose of urea

The flat cut ends, trimmed at 15 cm from the last hand, were enforced with different doses of urea, viz., 10,20,30,40,50,60,70,80,90 and 100g and compared with a control.

3.A.5 Volume of urea spray

To standardise the exact spray volume, a preliminary study was undertaken with 250, 500, 750 and 1000 ml, spray volume. This was tried at one and five per cent (lowest and highest urea concentrations) on uniform sized two week old bunches.

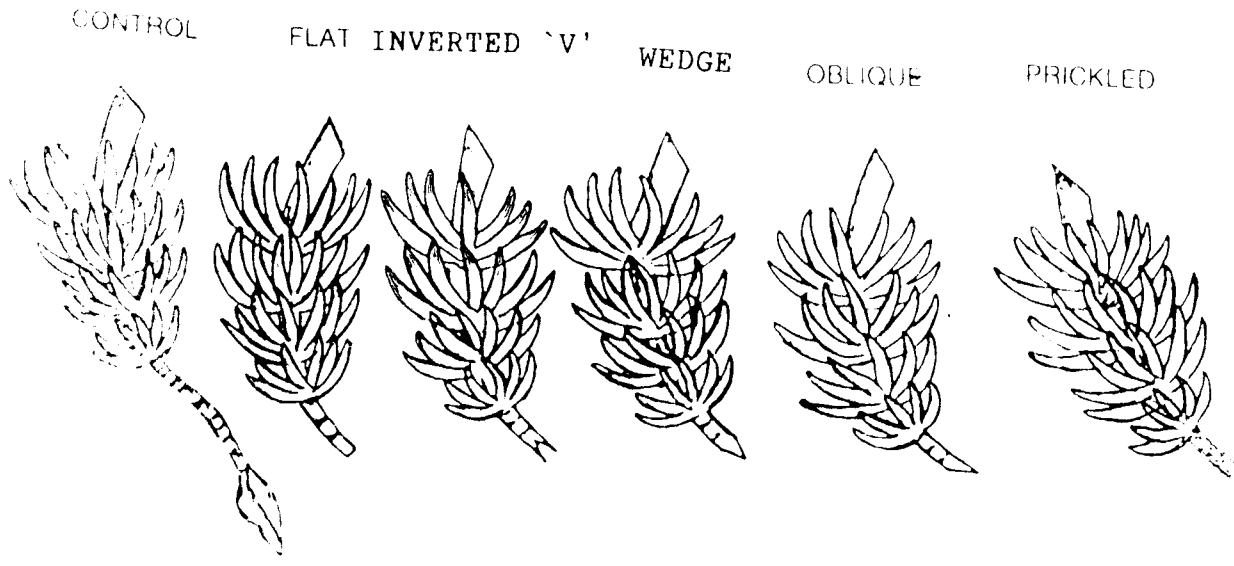


Fig.1 METHODS OF CUT

The data generated in the preliminary experiments were taken into account for the final two experiments.

3.B Experimental materials

Tissue culture plants of 45 days age (Three-leaf stage) were selected for the two experiments, under the study. The banana cv. Nendran, type Nedunendran, was used in the experiments. All readings on biometric and physiological characters were recorded so that maximum care was bestowed to experimental plants. The crop also received uniform cultural and management practices as per package of practices recommendations (KAU, 1993).

Experimental methods

Completely Randomised Design (CRD) was the statistical design adopted. The treatments were enforced on uniform sized plants with bunches of same size, age and number of hands. The bunches were pruned at 20 cm distance from last hand, (pre-standardised from the preliminary experiments) and covered before and after effecting the treatments.

The details of the experiments are given below experiment wise.

3.B.1 Bunch stalk feeding of urea

A combination of urea doses (0,10,20,30,40 and 50 g) and time of male bud pruning (1,2,3 and 4 weeks after

Plate 1 Bunch stalk feeding of urea

complete emergence of the bunch, and no pruning) formed the twenty one treatments. The experiment was replicated twice with a single plant receiving a treatment in a replication. The experiment followed a Completely Randomised Design (CRD) (Plate 1)

3.B.2 Urea sprays

A combination of time (7 stages) and concentration of sprays (5 levels) as given below along with two sets of control ie. no spray and water spray, formed the 37 treatments.

3.B.2.1 Time of urea sprays

1. 3 weeks after emergence of bunch
2. 4 weeks after emergence of bunch
3. 5 weeks after emergence of bunch
4. 2 sprays of 3rd and 4th week after emergence of bunch
5. 2 sprays of 4th and 5th week after emergence of bunch
6. 2 sprays of 3rd and 5th week after emergence of bunch.
7. 3 sprays of 3rd, 4th and 5th week after emergence of bunch

3.B.2.2 Concentrations of urea sprays

1. Urea - 1%
2. Urea - 2%
3. Urea - 3%
4. Urea - 4%
5. Urea - 5%

The experiment was replicated twice, with single plant in a replication receiving the treatments. Each bunch received 250 ml of urea spray (spray volume selected from the preliminary experiments) and maximum care has been taken for spraying so that spray drift towards other plants and into the soil was avoided. The experiment was laid out in Completely Randomised Design.

The physical, morphophysiological and chemical characters of the bunches and fruits were taken, as detailed below:

3.1 Bunch characters

31.1 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 Angularity of bunch

Using the formula, $\frac{D_1 - D_2}{L}$

(Stover and Simmonds, 1987), where D_1= diameter at the level of 1st hand; D_2 = diameter at the level of last hand and L = Length of the peduncle from first to last hand, was measured.

3.1.3 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 cm from the first hand and apical tip pruned to 10 cm, in all the treatments. The bunch weights were recorded in kilograms (kg).

3.1.4 Number of hands at harvest

The number of hands were uniformly maintained at five before enforcing the treatments.

3.1.5 Number of fingers at harvest

Fingers were counted after harvest.

3.2 Morphological characters of fingers

In both the experiments 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 parts, along the outer curvature upto and including apex, using twine and scale and expressed in centimetres (cm).

3.2.2 Girth

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

3.2.3 Fruit Curvature Index (FCI)

The curvature of the fruit was drawn on a paper, at weekly interval by placing a paper, 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 is 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).

3.2.4 Index of pedicel strength

Pedicel strength was measured at weekly interval using the equation, $\frac{L_p}{D_p}$

Where L_p = Length of pedicel and

D_p = Diameter of pedicel (Champion, 1967, Lassoudiere *et al.*, 1974).

3.2.5 Finger weight at harvest

The weight of middle fingers of first hand, second hand and last hand were taken on a kitchen scale balance and expressed in grams (g).

3.2.6 Fullness index

Fullness index of `D' finger was obtained by dividing the weight of finger with the convert length on convex side of the finger.

3.3 Ripening

3.3.1 Time taken for ripening

The time taken to reach 100 percent 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 a analytical balance and expressed in grams (g).

3.3.3 Pulp thickness

The thickness of the pulp was measured after peeling the fruit using a sharp knife with a twine and scale, and expressed in centimetres (cm).

3.3.4 Peel thickness

With the help of a vernier calipers, the peel thickness was measured and noted in centimetres (cm).

3.3.5 Pulp weight

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

3.3.6 Peel weight

The peel was weighed on a analytical balance, and expressed in grams (g).

3.3.7 Pulp/Peel ratio

The ratio was calculated by dividing the pulp weight of the `D' finger with the peel weight.

3.3.8 Shelf life

The time taken to reach 25 per cent decay after 100 per cent colour development was noted as shelf life and expressed in number of days.

3.4 Biochemical characters

All biochemical characters were measured from 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 AOAC (1980) was adopted. Ten grams of the macerated sample was digested with boiling water, and made up to 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 percent of citric acid.

3.4.3 Sugar

3.4.3.1 Reducing sugars

Reducing sugars were estimated by Fehling's solution method (Lane and Eynon, 1943, AOAC, 1980).

To ten gram of fruit juice, distilled water was added. After thorough mixing the solution was clarified with neutral lead acetate and potassium oxalate and made upto 250ml volume. 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.

3.4.3.2 Total sugars

The total sugar was estimated as per the method described by A.O.A.C. (1980). It was expressed as percentage.

3.4.3.3 Non-reducing sugars

The difference between total sugars and reducing sugars was worked out and expressed as percent of non-reducing sugars.

3.4.4 Carotene

The carotene content of dried fruit sample at ripened stage was estimated using a spectro photometer (Milton Roy Co. spectronic 20D) at 438.5 nm after extracting with water saturated n-Butanol by A.O.A.C. (1980).

3.4.5 Urease activity at fruit ripening

Urease activity in the fresh fruit samples was determined as described by Guan(1986).

0.5g fresh fruit sample (ripened) was finally ground in a mortar with 30 ml citrate buffer. 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 into 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 by using urease enzyme, extracted from jack bean, following the above procedure. The activity was recorded in units (μmol NH_3/g/min).

3.4.6 Urea at fruit ripening

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 the red colour formed when the aliquot was heated with diacetyl monoxime and thio-semi carbazide under acidic conditions (Phosphoric acid - sulfuric acid medium.

3.4.7 Estimation of methionine

Methionine an essential amino acid in the ripened fruits was analysed using the method suggested by Sadasivan and Manikam (1992). The procedure was as follows:

1g fresh fruit sample (ripened) was taken and added 6 ml 2N HCl and kept in a autoclave maintained at 15 lb pressure for one hour. Added a pinch of activated charcoal to the hydrolysate and heated to boil. This was filtered and washed with hot water. After neutralising the filtrate

with 10 N NaOH to pH 6.5, the volume was made upto 50 ml with water. 25 ml of the made up solution was transferred to a 100 ml conical flask and added 3 ml 10% NaOH, followed by 0.15 ml sodium nitroprusside. 1 ml of glycine solution was added after 10 minutes and again after 10 minutes 2 ml orthophosphoric was added and shook vigorously. The red colour intensity was read after 10 minutes using a spectrophotometer (Spectronic 20D Milton Roy Company) at 525 nm. Standard Curve was prepared using DL-Methionine.

3.4.8 Nitrite content in fruits

Nitrite in the dried fruit samples were estimated, following the 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 - VIS spectrophotometer.

3.5 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). The basic design was Factorial CRD.

Results

4. RESULTS

The results of the study on "Bunch stalk feeding of urea in banana cv. `Nendran'" are considered experiment wise. The preliminary standardisation techniques are dealt first.

4.A Preliminary standardisation studies

4.A.1 DISTANCE OF CUT

The data on the effect of distance of cut on morphophysiological characters, days to maturity, ripening and bunch weight and finger characters are presented in Table 1.

4.A.1.1 Morphophysiological characters

4.A.1.1.1 Angularity

A perusal of data on angularity of the bunch showed that pruning of male bud at a distance of 20 cm from the last hand (T_5) resulted in maximum angularity to the bunch (0.320) followed by 12 cm cut (T_3). Though the results are not statistically significant it can be inferred that with more retention of bunchstalk showed more angularity (Fig.2).

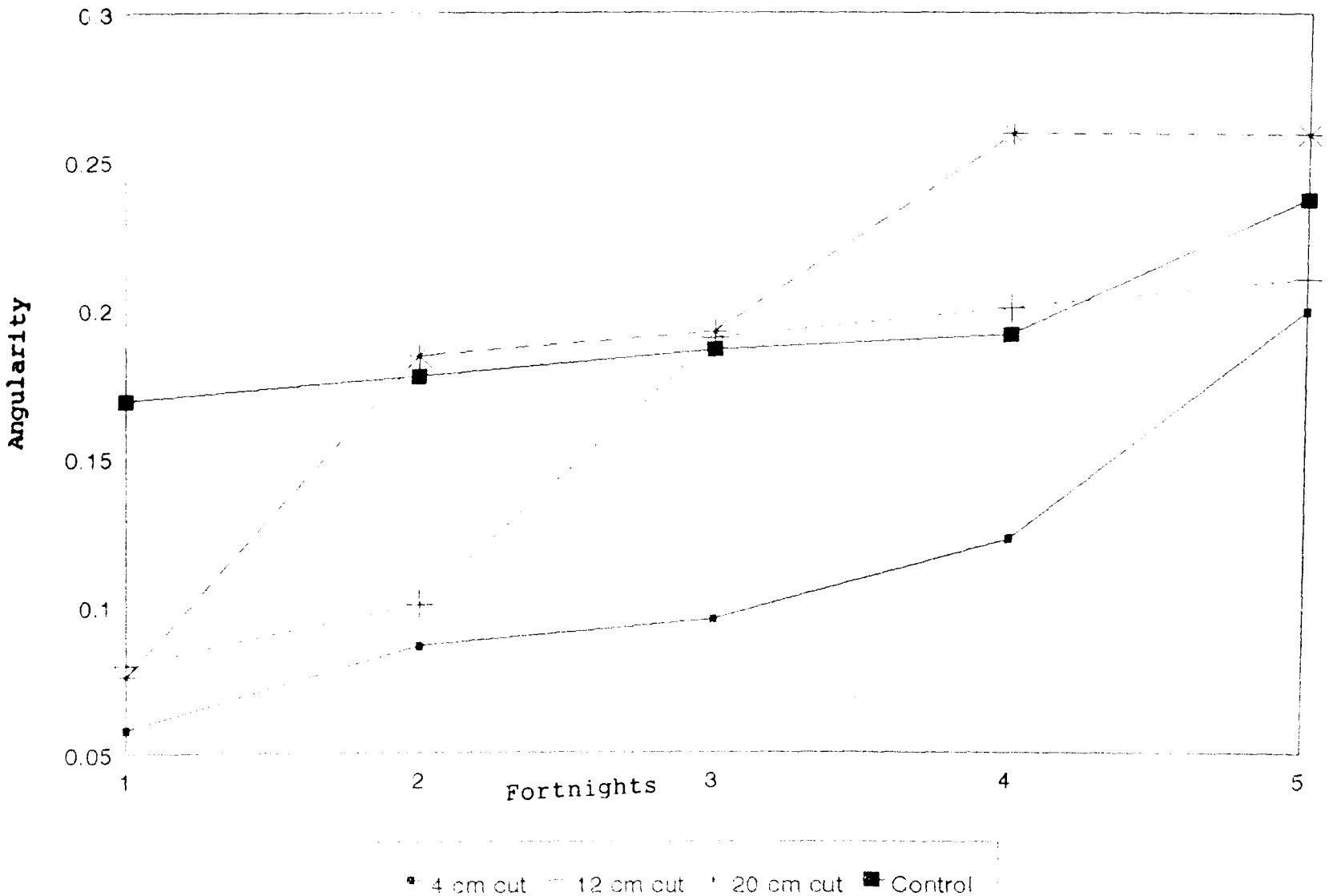
Table 1 Effect of 'distance of cut' on morphophysiological characters and yield attributes in banana cv. 'Nendran'

Trat-ments	ANOVA							ANCOVA			
	Angula-rity	Fruit Curva-ture Index (FCI)	Pedicel strength	Days to harvest	Days to ripening	Shelf life (days)	Filling Index	Bunch weight (kg)	'D' finger weight (g)	Length (cm)	Girth (cm)
T	0.199	1245.75	0.917	73.75	6.0	1.75	6.44	8.88 (46.5)	171.23 (46.5)	26.24 (46.5)	13.43 (46.5)
T	0.172	711.78	0.939	73.25	10.0	2.50	6.31	8.77 (46.75)	167.65 (46.75)	26.73 (46.75)	14.49 (46.75)
T	0.205	2263.78	0.950	72.00	10.5	3.00	7.13	9.54 (43.75)	199.01 (43.75)	27.20 (43.75)	14.85 (43.75)
T	0.191	1301.18	0.875	70.75	11.25	3.00	6.51	9.04 (49.25)	167.97 (49.25)	26.97 (49.25)	13.99 (49.25)
T	0.320	601.55	0.996	70.00	11.25	3.50	6.92	10.17 (45.00)	200.42 (45.00)	28.57 (45.00)	15.16 (45.00)
T	0.177	627.26	0.821	81.00	10.25	3.50	6.61	9.11 (51.25)	173.73 (51.25)	28.29 (51.25)	13.33 (51.25)
(0.05)	NS	NS	NS	2.05 0.69	3.24 1.09	0.683 0.23	NS	NS	10.99 3.6214	NS	0.989 0.3263

T1 - 4 cm cut T3 - 16 cm cut
T2 - 8 cm cut T4 - 20 cm cut
T5 - 12 cm cut T6 - Control (No male bud removing)

(Figures in paranthesis denote the number of fingers taken as a co-variate in ANCOVA)

Fig.2 Effect of distance of male bud removal on angularity (biweekly changes)



4.A.1.1.2 Fruit curvature index (FCI)

Retention of 12 cm of bunchstalk (T_3) showed maximum FCI, signifying its influence on increasing FCI (2263.78). Almost all the applied treatments influenced the FCIs in comparison with the control (T_{6}) (Fig.3)

4.A.1.1.3 Pedicel strength

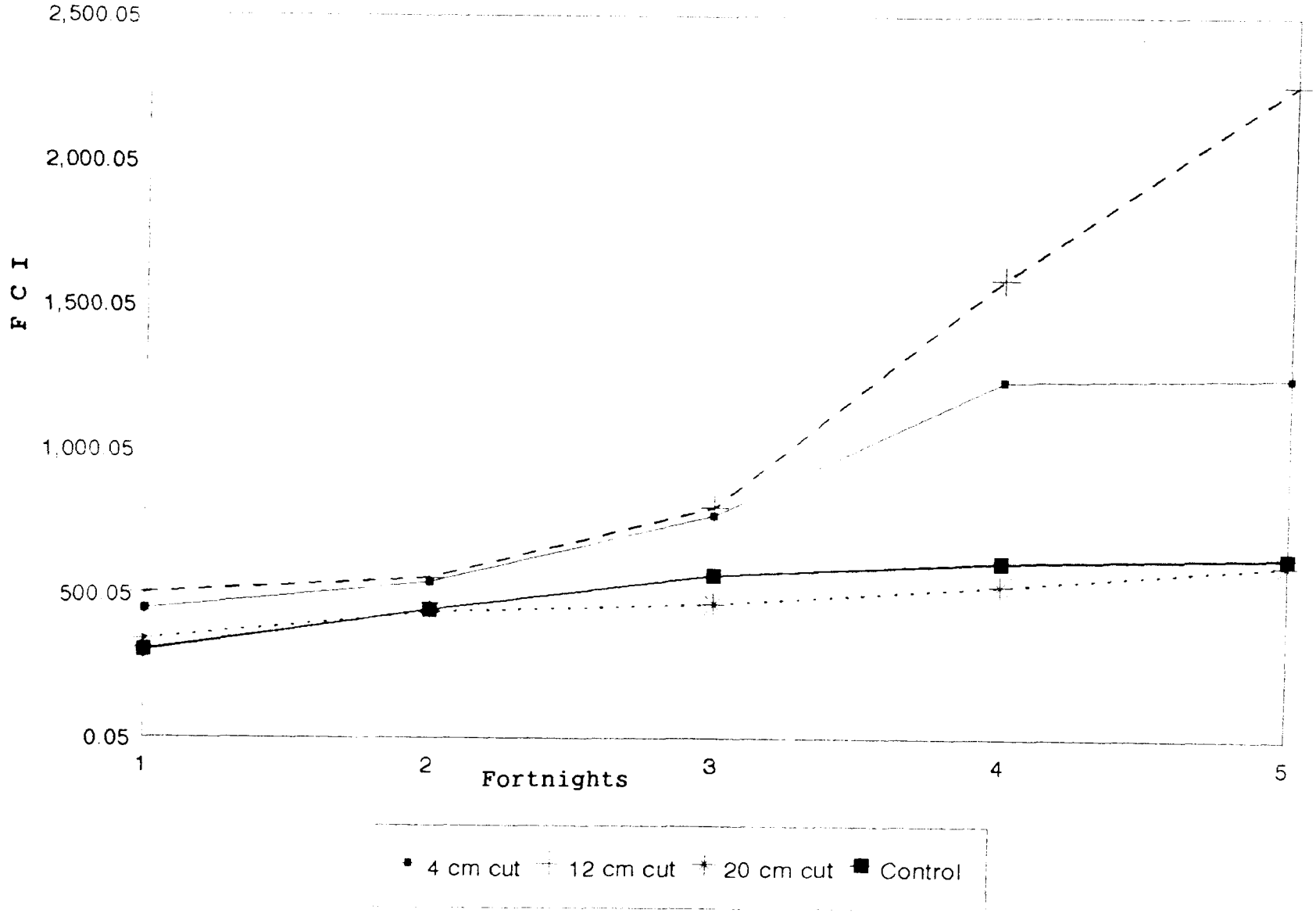
The different treatments of distance of cut influenced the pedicel strength. Though the results were not significant all the treatments recorded a better ratio, revealing its influence on the length of the pedicel or a reduction in the diameter of pedicel. Maximum ratio was observed at maximum retention of bunchstalk.

4.A.1.2 Effect on days to harvest, ripening and shelf-life

4.A.1.2.1 Days to harvest

Male bud pruning at different distances significantly enhanced the maturity. Among various treatments retention of 20 cm and 16 cm bunchstalk (T_5 and T_4) advanced the maturity by 11 and 10.75 days respectively. The control plants (T_6) took maximum time to reach maturity. It could be inferred that retention of male bud increased the time required to attain maturity. However, after removal of the bud, maximum retention of bunch stalk was beneficial for reducing the time to maturity.

Fig.3 Effect of distance of male bud removal on Fruit Curvature Index (FCI) (biweekly changes)



4.A.1.2.2 Ripening

A shorter distance cut, i.e., 4 cm (T_1) from the last hand significantly influence the time taken to ripening. Fruits in this treatment came to ripening earlier (6 days) in comparison to all other treatments and control which were statistically on par with each other.

4.A. 1.2.3 Shelf-life

A critical analysis of data of shelf-life revealed that the means of the treatments differed significantly. Cut at the shortest distance of 4 cm (T_1) resulted a shorter shelf-life (1.75 days) compared to the 20 cm cut (T_7) and control (T_6).

4.A.1.3 Yield character

4.A.1.3.1 Bunch weight

Analysis of data on yield revealed very interesting trends. Though the results were not statistically significant, maximum retention of the bunchstalk (T_5) yielded the highest (10.17 kg), which was 1 kg more than the control and more than 0.6 kg than the second best treatment of bunch stalk retention of 12 cm (T_3) .

4.A.1.3.2 'D' finger weight

Finger weight was the highest, in treatment with maximum retention of bunchstalk of 20 cm (T_5) followed by that of trimming at a distance of 12 cm from last hand (T_3).

They recorded weights of 200.42g and 199.9g respectively and are significantly superior to control (173.73 g). All other treatments recorded lower yields than the control.

4.A.1.3.3 Finger length

In comparison with other character, the length of the finger was not much influenced by the distance of cut. However, like in other case, better length was recorded by maximum bunch stalk retention.

4.A.1.3.4 Finger girth/grade

Fruit girth/grade was affected by all the treatments. All treatments recorded better grade with maximum retention of 20 cm (T_5) of bunch stalk showing distinct superiority and this was statistically at par with bunchstalk retention of 12 cm (T_3).

4.A.1.3.5 Filling index

There was no significant difference between treatment means. However, it could be deduced that retention of 12 cm (T_3) followed by 20 cm (T_5) retention recorded higher filling index than the control.

4.A.2 METHOD OF CUT

The data on effects of different methods of cut on morphophysiological characters, days to maturity, ripening bunch weight, and finger characters are presented in Table 2.

Table 2 Effect of `method of cut' on morphophysiological characters and yield in banana cv. `Nendran'

Trat-ments	ANOVA							ANCOVA			
	Angula-rity	Fruit Curva-ture Index (FCI)	Pedicel strength	Days to harvest	Days to ripening	Shelf life (days)	Filling Index	Bunch weight (kg)	`D' finger weight (g)	Length (cm)	Girth (cm)
T_1	0.122	860.58	0.917	92.00	9.67	3.00	6.87	9.05 (53.33)	177.37 (53.33)	26.79 (53.33)	13.08 (53.33)
T_2	0.212	1916.67	0.778	85.67	6.00	2.67	7.18	9.87 (50.67)	188.54 (50.67)	26.66 (50.67)	13.67 (50.67)
T_3	0.115	4032.38	0.926	78.00	6.33	1.00	6.73	10.25 (51.33)	184.49 (51.33)	27.53 (51.33)	13.99 (51.33)
T_4	0.169	2613.33	0.810	83.00	7.00	2.00	7.52	10.97 (51.00)	196.52 (51.00)	26.17 (51.00)	13.66 (51.00)
T_5	0.183	3011.00	0.833	84.00	8.67	1.67	7.50	11.35 (51.67)	209.14 (51.67)	28.04 (51.67)	13.97 (51.67)
T_6	0.210	9490.00	0.833	83.67	8.00	1.33	7.41	10.64 (47.33)	200.42 (47.33)	26.32 (47.33)	14.11 (47.33)
T_7	0.148	1338.44	0.852	81.00	7.33	1.00	6.99	10.53 (50.67)	186.87 (50.67)	26.66 (50.67)	13.67 (50.67)
CD (0.05)	NS	NS	NS	3.49	NS	0.667	NS	NS	NS	NS	NS
SEm				1.15		0.22					

T1 - Control (with male bud)
T2 - Control cuts
T3 - wedge cut
T4 - Oblique
T5 - Flat cut
T6 - Prickling
T7 - inverted `v'

(Figures in paranthesis denote the number of fingers taken as a co-variate in ANCOVA)

4.A. 2.1 Morphophysiological characters

4.A.2.1.1 Angularity

A higher level of angularity was observed in control cut (T_2) and this was on par with prickling treatment (T_6). The differences between the means of the treatments were not significant.

4.A.2.1.2 Fruit Curvature Index (FCI)

It may be deduced from the data that all the treatments did influence FCI at harvest as all treatments recorded higher values. Among the treatments, prickling (T_6) followed by wedge cut (T_3) gave higher FCI values.

4.A.2.1.3 Pedicel strength

The means of different treatments revealed minor differences with no distinct superiority or inferiority compared to the controls.

4.A.2.2 Effect on time taken to maturity, ripening and shelf-life

4.A.2.2.1 Days to maturity

All treatments influenced significantly the number of days taken to maturity. The wedge shaped cut (T_3), inverted 'v' (T_7) followed by oblique cut (T_4) flat cut (T_5) and pickling (T_5). They took 78,81,83,83 and 84 days to reach maturity and this was much earlier than the control pruning (92 days) and control cut (85-86 days).

4.A.2.2.2 Days to ripening

There was no much differences observed between various treatments. The control with just cut alone (T_2) came earliest to ripening and recorded almost equal values as the wedgeshaped cut (T_3) and oblique cut (T_4) treatments. Maximum days to ripening was observed in no cut control treatment (9.6 days).

4.A.2.2.3 Shelf-life

Methods of cut in with 10g urea placement tied to the cut end, significantly influenced the shelf-life. Methods of cut like wedge cut (T_3)&inverted 'v'(T_7) resulted the shortest shelf-life of 1 day, compared to control (3 days). The two controls (T_1 and T_2) were on par with each other and significantly superior to all other treatments.

4.A.2.3 Yield attributes

4.A.2.3.1 Bunch weight

Though the differences between treatments were not significant, all treatments recorded higher yields than both the controls. The best treatment of flat cut (T_5) recorded 11.35 kg which was 1.5 kg more than control cut and nearly 2.3 kg more than no cut or male bud retention which also recorded the lowest yield (9.05 kg).

4.A.2.3.2 'D' finger weight

Maximum finger weight was observed in treatments with flat cut and prickling. However, the results were not statistically significant.

4.A.2.3.3 Finger length

Though the flat cut and wedge cut recorded better lengths (28.04 and 27.17 cm) than the control (26.8 cm), the results were not significant.

4.A.2.3.4 Fruit girth/grade

As in the case of fruit length, the treatment means of fruit showed no significant difference. Prickling (T_6) resulted in better grade fruits (14. 112 cm) compared to control (13.67 cm). Almost all the treatments recorded better grade than the control.

4.A.2.3.5 Filling index

A critical observation of treatment means revealed that oblique cut (T_4), flat cut (T_5) and prickling (T_6), with urea resulted in higher filling index (7.54, 7.5 and 7.41).

4.A.3 TIME OF APPLICATION OF UREA

The data on effect of time of application of urea on various aspects are presented in Table 3.

Table 3 Effect of 'Time of Application of Urea' on morphophysiological characters and yield attributes in banana cv. 'Nendran'

Treatments	ANOVA							ANCOVA			
	Angularity	Fruit Curvature Index (FCI)	Pedicle strength	Days to harvest	Days to ripening	Shelf life (days)	Filling Index	Bunch weight (kg)	'D' finger weight (g)	Length (cm)	Girth/ Grade (cm)
T_1	0.129	819.87	0.96	91.33	6.0	2.67	7.06	9.99 (50.33)	189.08 (50.33)	26.88 (50.33)	13.32 (50.33)
T_2	0.157	715.67	0.88	85.00	3.0	1.67	7.94	11.26 (49.67)	207.59 (49.67)	26.27 (49.67)	13.58 (49.67)
T_3	0.189	1298.33	0.81	75.00	6.0	1.00	6.75	8.79 (48.0)	164.71 (48.0)	24.73 (48.0)	12.95 (48.0)
T_4	0.137	7523.34	1.015	79.00	2.7	1.33	6.32	9.09 (51.33)	155.48 (51.33)	24.64 (51.33)	13.04 (51.33)
T_5	0.099	8271.77	0.89	76.67	5.7	1.00	7.24	10.51 (53.00)	183.36 (53.00)	26.51 (53.00)	13.34 (53.00)
T_6	0.093	1763.33	0.84	76.67	4.3	1.00	7.17	10.59 (51.33)	195.49 (51.33)	25.64 (51.33)	13.54 (51.33)
T_7	0.165	3500.00	0.87	79.00	4.0	1.00	7.57	11.13 (59.67)	194.89 (59.67)	24.99 (59.67)	13.35 (59.67)
T_8	0.134	2702.67	1.00	78.33	3.3	1.00	7.56	11.67 (59.00)	205.07 (59.00)	27.04 (59.00)	13.87 (59.00)
T_9	0.166	922.43	0.81	78.00	5.3	1.00	7.18	11.82 (53.33)	186.60 (53.33)	25.98 (53.33)	13.83 (53.33)
T_{10}	0.122	1328.70	0.87	78.00	6.0	1.00	7.57	11.51 (53.00)	203.36 (53.00)	26.84 (53.00)	13.50 (53.00)
T_{11}	0.179	4752.77	1.00	76.33	4.7	1.00	7.99	11.97 (56.67)	212.37 (56.67)	26.39 (56.67)	13.75 (56.67)
T_{12}	0.102	7450.00	1.024	78.33	4.7	1.00	8.05	11.88 (52.33)	221.87 (52.33)	27.56 (52.33)	14.35 (52.33)
T_{13}	0.282	9258.33	1.00	75.33	5.3	1.00	7.96	12.12 (54.00)	216.42 (54.00)	27.26 (54.00)	14.48 (54.00)
T_{14}	0.254	4627.77	0.805	81.33	4.7	1.00	8.76	12.75 (51.67)	235.39 (51.67)	27.94 (51.67)	14.50 (51.67)
CD (0.05)	NS	NS	NS	3.33	1.998	0.434	0.927	1.772	33.07	2.00	
SEm				1.15	0.69	0.15	0.32	0.6083	11.3534	0.6868	NS

(Figures in paranthesis denotes the number of fingers taken as co-variate in ANCOVA)
DAE - Days after emergence of bunch
T1 - Control (no cut); T2 - Control cut; T3 - 1 DAE; T4 - 1 DAE+24 hrs; T5 - 4 DAE; T6 - 4 DAE+24 hrs; T7 - 8 DAE; T8 - 8 DAE+24 hrs
T9 - 12 DAE; T10 - 12 DAE+24 hrs; T11 - 16 DAE; T12 - 16 DAE+24 hrs; T13 - 20 DAE; T14 - 20 DAE+24 hrs

4.A.3.1 Morphophysiological characters

4.A.3.1.1 Angularity

Though the results were not significant it could be logically interpreted that higher level of angularity was observed when application of urea was made immediately after the cut 20 days after emergence of the bunch (T_{13}) followed by enforcing the cut on 20th day and applying urea on next day (21st day) (T_{14}) (Fig.4)

4.A.3.1.2 Fruit curvature Index

All treatments revealed a higher FCI compared to the control. From the data it could be deduced that all application after 16 days and 20 days of complete bunch emergence recorded higher FCI. Higher FCI ratios were also observed when application were given, when cut was given one day after bunch emergence and urea placement made effected the next day followed by that enforced 12 days after emergence of bunch (Fig.5)

4.A.3.1.3 Pedicel strength

The time of application did not significantly alter the pedicel strength and treatment means were almost equal to the control.

4.A.3.2 Effect on maturity, ripening and shelf-life

4.A.3.2.1 Day to maturity

The distinct superiority of treatments on days taken to maturity is evident and explicit. All the treatments

Fig.4 Effect of time of application of urea on angularity (biweekly changes)

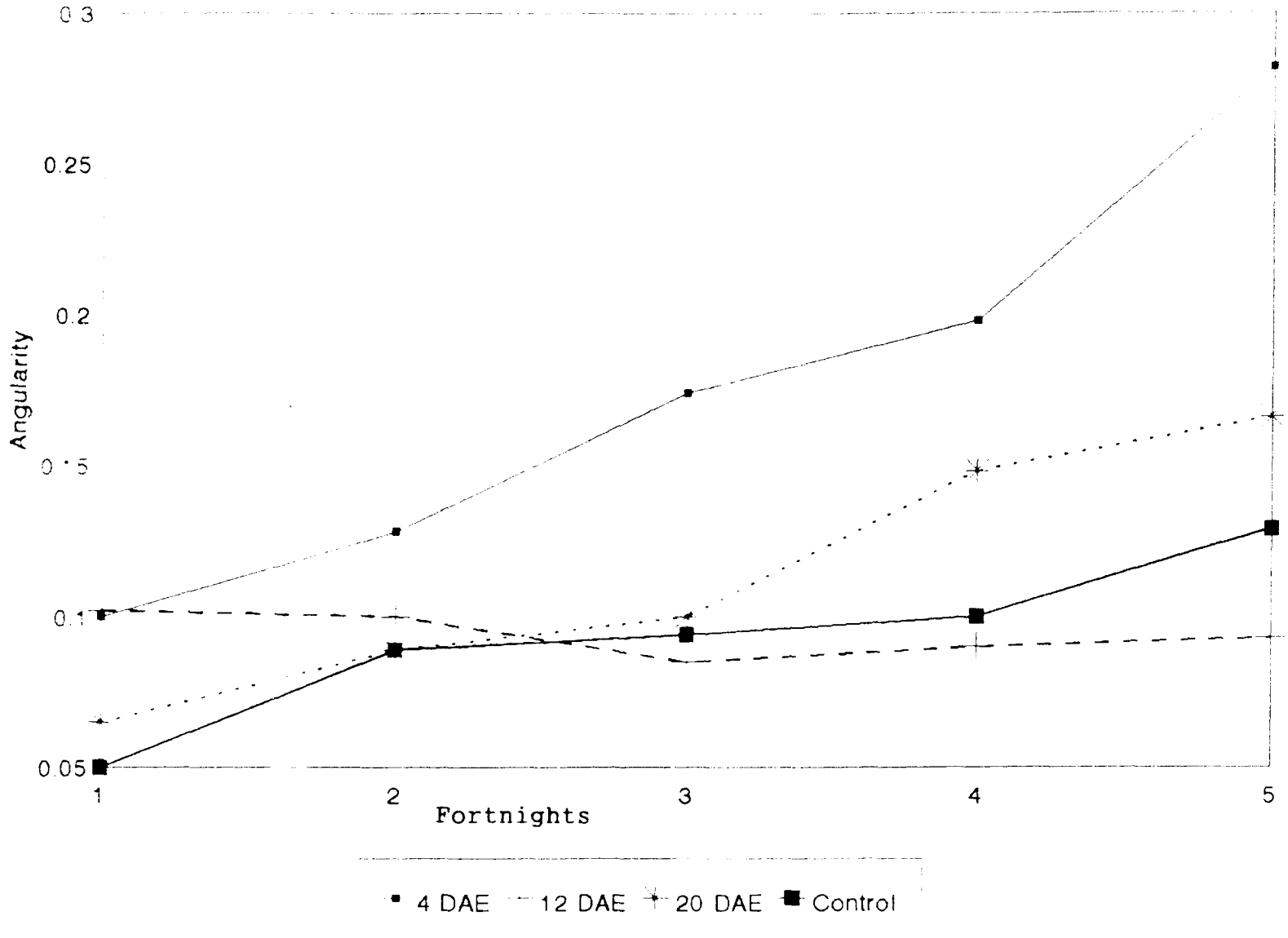
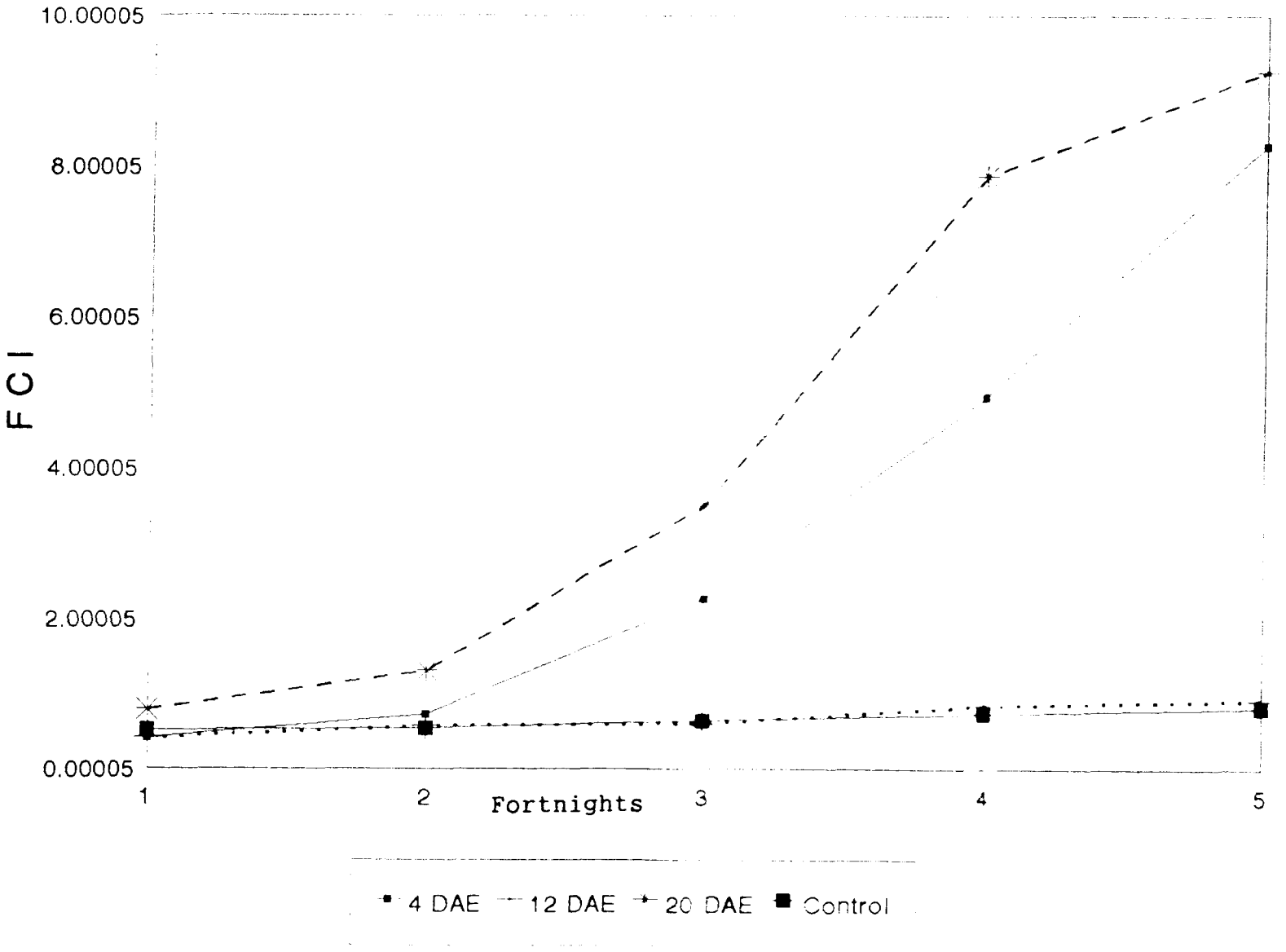


Fig.5 Effect of time of application of urea on Fruit Curvature Index (FCI) (biweekly changes)



recorded lesser days to maturity, were significantly superior compared to control (91 and 85 days) and were at par with each other.

4.A.3.2.2 Days to ripening

The effects of different treatments were distinctly clear. The control with no cut took maximum days to ripen (6 days). The lowest was observed when urea was applied 24 hours after enforcing cut, 1 day after complete bunch emergence (T_4) followed by control cut, enforcing treatments 8 days and 8 day cut + urea placement after 24 hours later and 4 days cut + placement after 24 hrs later (T_7, T_8 and T_6) and were at par with each other and took only 3-4 days for ripening.

4.A.3.2.3 Shelf-life

Tying of urea at the cut ends significantly altered shelf-life. The shelf-life was reduced to 1 day in all the treatments compared to the controls T_1 and T_2 which showed shelf life of 2.67 days and 1.7 days respectively.

4.A.3.3 Yield attributes

4.A.3.3.1 Bunch weight

The differences between treatment means were significant. In general, enforcing treatments 20 Days after emergence (DAE) (T_{14}), 16 DAE, 12 DAE and 8 DAE gave higher yields. Application of treatments 1 DAE yield lower

Plate 2 Effect of time of application of urea on 'D' finger


CONTROL
1 DAY
4 DAYS
8 DAYS
12 DAYS
16 DAYS
20 DAYS

than both controls but 4 DAE resulted in yield reduction compared to control cut (Fig.9).

4.A.3.3.2 'D' finger weight

The treatments showed significance in finger weight. Maximum weight was recorded by cutting 20 days after bunch emergence + application of urea 24 hours later (T_{14}) followed by cutting the male bud 16 DAE + applying urea 24 hours later (T_{12}) and the minimum observed in treatments one DAE (T_3 and T_4). All the other treatments were superior than the control (T_1). The effects of the treatments are given in plate (2).

4.A.3.3.3 Finger length

Length of the fruits were significantly improved when urea was applied, 20 DAE, 16 DAE + application of urea 1 day later and 20 DAE + application of urea 1 day later (27.94, 27.36 & 27.26 cm). The minimum length resulted in enforcement of treatments 1 DAE and 1 DAE + application of urea 24 hours after (T_3 and T_4).

4.A.3.3.4 Finger girth/grade

The later stages of enforcing treatments i.e., 20 DAE (T_{13}), 16 DAE + application of urea 24 hours later (T_{12}) resulted in better grade fruits (14.53, 14.48 and 14.35 cm respectively) in comparison with the two controls, T_1 (13.23 cm) and T_2 (13.58 cm). The minimum grade was observed in treatments effected 1 DAE.

4.A.3.3.5 Filling index

The maximum filling index was recorded by cut imposed 20 DAE + application of urea 24 hours later (T_{14}) which is significantly superior to all other treatments.

4.A.4 DOSE OF UREA

The data on standardisation of dose of urea and its effect on various aspects of yield and major growth and development characters are presented in Table 4.

4.A.4.1 Morphophysiological characters

4.A.4.1.1 Angularity

The least angularity was recorded by T_{10} (80g urea) and the highest angularity by control cut (T_2). Except for the 80g urea placement all treatments above 50g, recorded lower angularity. However, the difference in treatment means were not significant (Fig.6).

4.A.4.1.2 Fruit Curvature Index

Eventhough, sharp differences existed between treatment means. Statistical significance was not observed. The minimum FCI was observed with 90g urea placement (T_{11}) and the lowest value recorded with 10g urea placement (T_3). Control plants (male bud retention + and system control) recorded intermediary values (Fig.7).

Table 4 Effect of 'Doses of urea' on morphophysiological characters and yield attributes in banana cv. 'Nendran'

Tratments	ANOVA							ANCOVA			
	Angularity	Fruit Curvature Index (FCI)	Pedicel strength	Days to harvest	Days to ripening	Shelf life (days)	Filling Index	Bunch weight (kg)	'D' finger weight (g)	Length (cm)	Girth (cm)
T_1	0.240	1703.5	0.75	84.67	4.67	2.0	6.341	4.24 (35.0)	121.67 (35.0)	19.33 (35.0)	11.83 (35.0)
T_2	0.267	1398.17	1.03	76.00	4.33	2.0	7.289	5.72 (35.67)	166.67 (35.67)	22.83 (35.67)	13.00 (35.67)
T_3	0.222	868.52	1.00	67.33	4.33	1.0	7.053	6.52 (33.0)	166.67 (33.0)	23.67 (33.0)	13.50 (33.0)
T_4	0.163	3726.80	0.72	67.00	5.0	1.0	7.119	5.92 (33.33)	161.67 (33.33)	32.67 (33.33)	13.20 (33.33)
T_5	0.149	1315.00	0.88	69.67	5.0	1.0	7.830	7.02 (36.00)	186.67 (36.00)	23.67 (36.00)	14.00 (36.00)
T_6	0.221	1398.07	0.75	66.00	5.67	1.0	7.420	6.67 (35.33)	175.00 (35.33)	23.67 (35.33)	13.17 (35.33)
T_7	0.230	1196.30	0.87	66.00	4.33	1.0	7.497	6.36 (36.00)	175.00 (36.00)	23.33 (36.00)	13.33 (36.00)
T_8	0.148	1069.20	0.79	67.33	4.67	1.0	7.17	6.81 (34.67)	165.00 (34.67)	23.00 (34.67)	13.13 (34.67)
T_9	0.179	8126.67	0.83	66.33	5.67	1.0	6.87	4.78 (30.00)	168.33 (30.00)	24.50 (30.00)	13.17 (30.00)
T_{10}	0.085	1644.35	0.87	66.00	5.00	1.0	7.10	5.78 (35.67)	163.33 (35.67)	23.00 (35.67)	12.83 (35.67)
T_{11}	0.123	12704.8	0.87	65.67	5.30	1.0	7.48	5.54 (32.00)	161.67 (32.00)	22.67 (32.00)	13.17 (32.00)
T_{12}	0.244	912.73	0.79	67.33	5.00	1.0	7.19	5.89 (35.67)	165.00 (35.67)	23.00 (35.67)	13.00 (35.67)
CD(0.05)	NS	NS	0.058	2.51	NS	0.496	NS	1.255	29.85	1.956	0.876
SEm			0.02	0.86		0.17		0.4281	10.23	0.67	0.30

T1 - Control (retension of male bud)
T2 - Control cuts
T3 - 10g urea
T4 - 20g urea
T5 - 30g urea
T6 - 40g urea
T7 - 50g urea
T8 - 60g urea
T9 - 60g urea
T10 - 70g urea
T11 - 80g urea
T12 - 100g urea

(Figures in paranthesis denote the number of fingers taken as a co-variate in ANCOVA

Fig.6 Effect of doses of urea on angularity (biweekly changes)

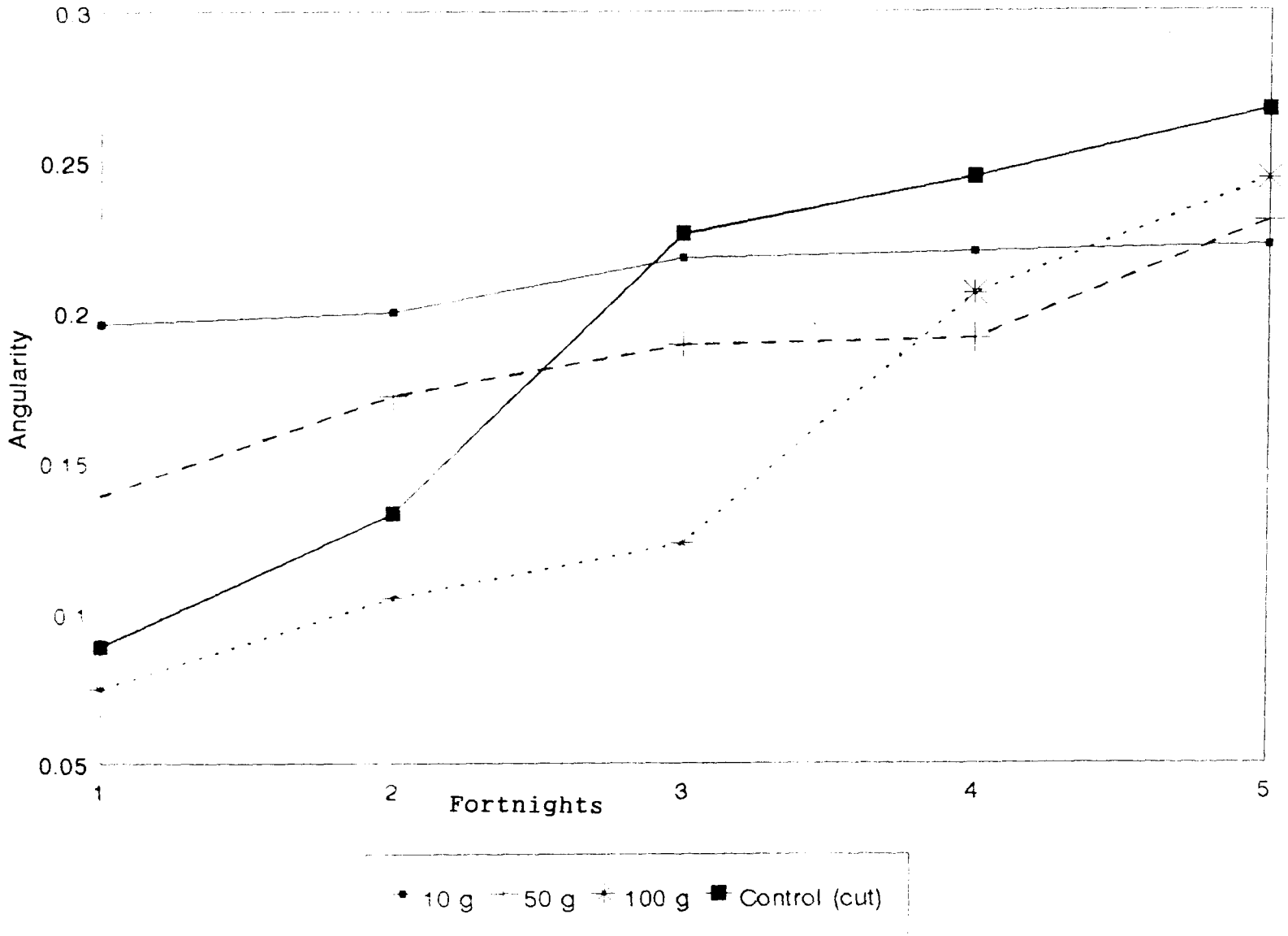


Fig.7 Effect of doses of urea on Fruit Curvature Index (FCI) (biweekly changes)

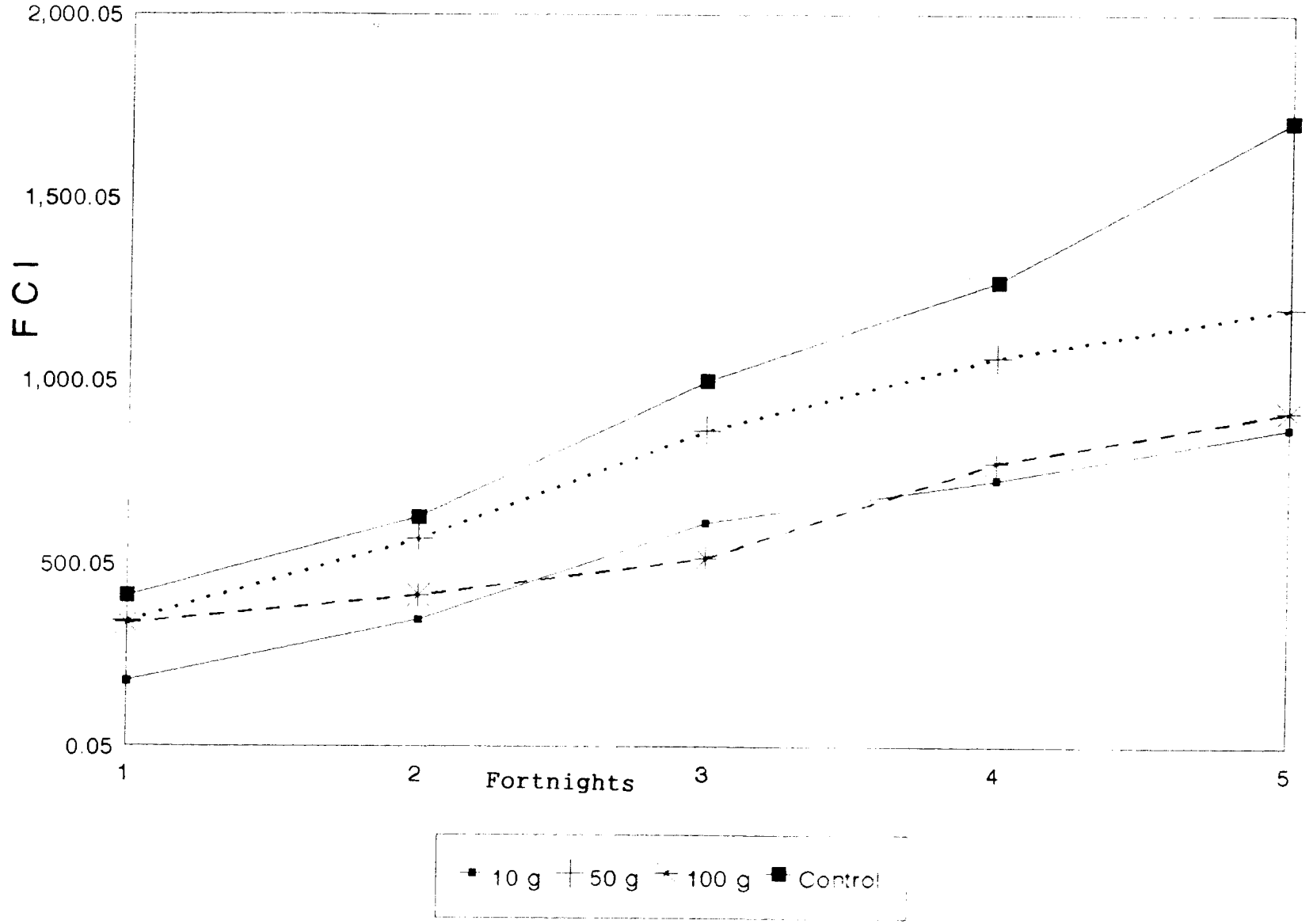


Plate 3 Pre-mature ripening - Impact of higher dose of urea on bunch

4.A.4.1.3 Pedicel strength

The influence of urea doses were significant. The control cut (T_2). 10g urea placement (T_3) and 30g placement (T_5) are on par and resulted in weak pedicel. The best pedicel strength was observed in 20g urea placement (T_4) compared to control.

4.A.4.2 Effect on maturity, ripening and shelf-life

4.A.4.2.1 Days to maturity

The two controls (T_1 and T_2) attained the harvestable stage or maturity later (84 and 76 days) compared to all other treatments. 90g placement (T_{11}) matured at the earliest (65 days). All treatments above 40g urea placement came to maturity earlier.

4.A.4.2.2 Days to ripening

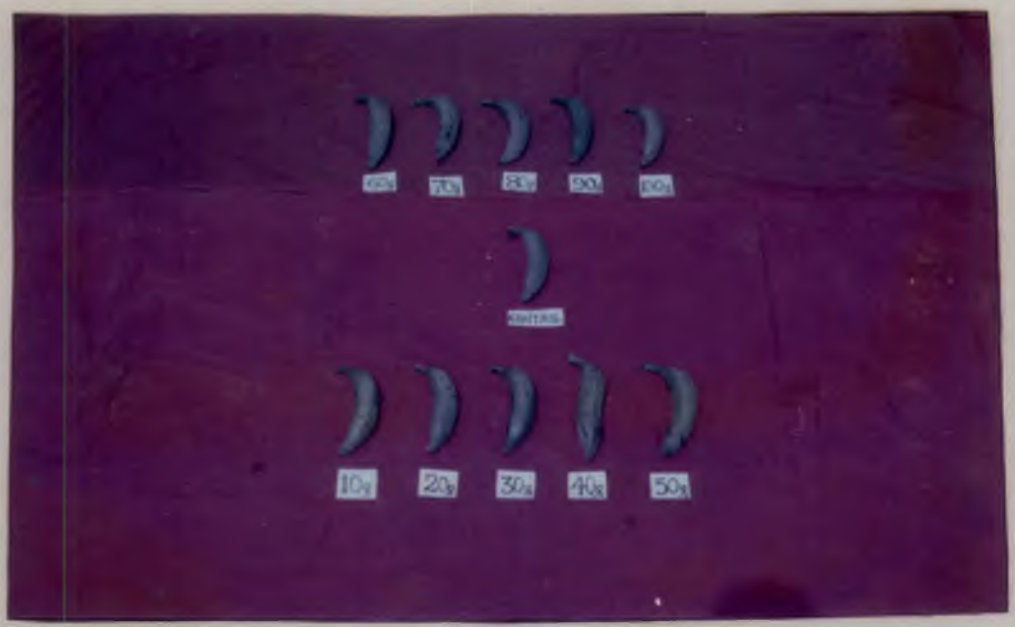
There was not much differences between the treatment means. Another very important aspect observed was that in treatments above the 50g urea placement the terminal hand started to ripen or turn to black colour pre maturely on the plant itself (Plate No. 3).

4.A.4.2.3 Shelf-life

All the urea treatments (10g-100g) resulted in a shelf-life of only one day compared to the controls (T_1 and T_2) of 2 days. Which were significantly superior to the rest of the treatments.

Plate 4 Effect of doses of urea on `D' hand

Plate 5 Effect of doses of urea on `D' finger



4.A.4.3 Yield characters

4.A.4.3.1 Bunch weight

Data showed significant influence of doses of urea on bunch weight. But among the treatment, maximum of 7.03 kg was recorded by 30g urea placement on cut stalk end (T_5) followed by 40g urea placement (T_6) and 10g (T_3) and 60g (T_8) which were on par. However the last treatment was not acceptable due to premature ripening of last hand on the plant. The lowest of 4.24kg was recorded on control (T_1) (Fig.).

4.A.4.3.2 'D' finger weight

The maximum weight of finger (186.67g) was observed in 30g urea placement (T_5) and was on par with all other treatments, except control (T_1), which record only 121.667 (Plate 4).

4.A.4.3.3 Finger length

The maximum finger length was observed in 70g urea placement (T_9) followed by 10g to 40g urea placements. They were on par with all other treatments except with control (T_1) which recorded the lowest finger length of 19.33 cm.

4.A.4.3.4 Finger girth/grade

The best grade of 14 cm was recorded in 30g urea placement (T_5) and was on par with all other treatments. The least was observed in control (T_1) (Plates 4 and 5)

4.A.4.3.5 Filling index

Filling index recorded non-significant difference between treatment means. But in comparison with control (T_1) which was having 6.341, all other treatments recorded higher index values and the most superior treatments were 30g (T_5) and 50g (T_7) urea placement (7.83 and 7.49 respectively).

4.A.5. SPRAY VOLUME OF UREA

The effect of different volumes of urea spray on different characters are presented in Table 5.

4.A.5.1 Morphophysiological characters

4.A.5.1.1 Angularity

The differences in angularity are neither pronounced nor significant. 500 ml spray at 1% concentration (T_5) recorded the least angularity.

4.A.5.1.2 Fruit curvature index (FCI)

Though the differences between treatments were not significant. Spraying 750 ml of 1% urea showed very high FCI values. The lowest was recorded in the control (T_1).

4.A.5.1.3 Pedicel strength

Different volumes of spray at different concentration did not reveal any specific trend.

Table 5 Effect of `Spray volume of Urea' on morphophysiological characters and yield in banana cv. `Nendran'

Treatments	ANOVA							ANCOVA			
	Angularity	Fruit Curvature Index (FCI)	Pedicel strength	Days to harvest	Days to ripening	Shelf life (days)	Filling Index	Bunch weight (kg)	`D' finger weight (g)	Length (cm)	Girth (cm)
T_1	0.241	1703.5	0.833	84.67	3.67	3.00	6.34	4.50 (35)	121.67 (35)	19.5 (35)	11.83 (35)
T_2	0.100	3353.97	1.083	78.33	5.00	3.00	6.93	6.01 (37.67)	165.0 (37.67)	24.17 (37.67)	12.75 (37.67)
T_3	0.134	2048.07	0.867	71.33	4.67	2.67	6.83	6.77 (34.67)	166.67 (34.67)	24.33 (34.67)	12.83 (34.67)
T_4	0.140	2408.51	1.090	76.00	3.33	3.00	7.40	7.17 (38.33)	178.33 (38.33)	24.00 (38.33)	12.67 (38.33)
T_5	0.087	1444.19	0.797	73.33	3.67	2.67	7.02	5.95 (39.33)	165.00 (39.33)	23.50 (39.33)	13.67 (39.33)
T_6	0.228	3004.17	0.817	74.33	4.00	2.67	7.59	6.07 (36.33)	176.67 (36.33)	23.33 (36.33)	12.67 (36.33)
T_7	0.113	6692.97	0.833	72.00	3.00	3.00	6.59	6.95 (37.33)	156.67 (37.33)	23.83 (37.33)	12.83 (37.33)
T_8	0.229	1771.10	1.100	74.67	3.33	2.67	6.37	5.93 (40.33)	155.00 (40.33)	24.67 (40.33)	13.30 (40.33)
T_9	0.176	3110.10	0.963	77.00	3.67	2.67	7.18	6.98 (34.33)	181.67 (34.33)	25.33 (34.33)	13.50 (34.33)
T_{10}	0.224	2691.00	0.917	77.67	3.67	2.67	6.58	6.21 (38.00)	155.00 (38.00)	23.33 (38.00)	12.67 (38.00)
0.05)	NS	NS	NS	1.239	0.973	NS	NS	NS	27.31	2.183	0.737
				0.42	0.33				9.26	0.74	0.25

T1 - Control (no spray)
T2 - Control (water spray)
T3 - 250 ml 1% urea
T4 - 250 ml 5% urea
T5 - 500 ml 1% urea
T6 - 500 ml 5% urea
T7 - 750 ml 1% urea
T8 - 750 ml 5% urea
T9 - 1000 ml 1% urea
T10 - 1000 ml 5% urea

(Figures in paranthesis denote the number of fingers taken as a co-variate in ANCOVA)

4.A.5.2 Effect on maturity, ripening and shelf-life

4.A.5.2.1 Days to maturity

All imposed treatments did effect the number of days taken to maturity and results were statistically significant. As in all other cases, here also, the control (T_1) matured later (84.67 days) compared to the other treatments. 250 ml spray of 1% concentration (T_3) advanced the maturity by 12 days which was on par with 750 ml of 1% spray volume (T_7).

4.A.5.2.2 Days to ripening

Significant difference between treatments were observed in number of days taken to ripening. Spraying 750 ml at 1% concentration (T_7) ripened fruits within 3 days and was on par with spray volumes of 500 ml and 1000 ml. On the other hand, the T_2 (control water spray) took 5 days to ripen.

4.A.5.2.3 Shelf-life

The two controls recorded higher shelf life. Almost all sprays reduced the shelf life but the reduction was not significant.

4.A.5.3 Yield attributes

4.A.5.3.1 Bunch weight

The quantity of spray did influence the bunch weight. The highest bunch weight (7.17 kg) was reported with 250 ml

of 1% urea spray (T_4). In general 250 ml sprays recorded better bunch weights followed by 1000 ml sprays, in comparison with the control which yielded the lowest. The results were however not significant.

4.A.5.3 2 'D' finger weight

One litre of spray at 1% concentration (T_9) gave fingers of 131.67g weight and which was the best and was on par with the other treatments; except the control (121.67).

4.A.5.3.3 Finger length

The data on finger length signifies the distinct influence of urea spray volume on finger length. Compared to control (T_1), which registered an average of 19.5 cm, all the treatments were superior. The longest fingers were observed at 250 ml sprays at 5% (T_4), 750 ml at 5% (T_8) and control cut (T_2). However all treatments except the control (T_1) were on par with each other.

4.A.5.3.4 Finger girth/grade

A general trend of increase in girth was observed with increase in spray volume. 1000 ml sprays at 1% and 5% concentration (T_9 and T_{10}) recorded better grade fruits (13.67 cm) and were on par with 750 ml and 500 ml spray and significantly superior to control (T_1) and other treatments.

4.A.5.3.5 Filling index

Eventhough, no significant difference existed the general superiority of 250 ml and 500 ml sprays were observed.

4.B MAIN EXPERIMENTS

The main experiments which formed the main core of the investigation were based on the results of the preliminary experiments.

4.B.6 Effect of combinations of male bud pruning and doses of urea on quantitative and qualitative characters of yield in banana

4.B.6.1 Morphophysiological characters

Data on morphophysiological characters and days taken to maturity, ripening, shelf life and filling index are presented in Table 6.

4.B.6.1.1 Fruit curvature index (FCI)

A perusal of data reveals that the effects of treatments were not significant. Except 50g urea placement (T_5) done after one week of full emergence of the bunch (999.11) all other FCI did not show much variation from the control.

4.B.6.1.2 Pedicel strength

Eventhough the analysis of the data revealed no significant differences between treatment means, pedicel

Table 6 Effect of 'bunch stalk feeding of urea' on morphophysiological characters in banana cv. 'Nendran'

Treatments	ANOVA					
	Fruit Curvature Index (FCI)	Pedicel strength	Days to maturity	Days to ripening	Shelf life (days)	Filling index
T_1 1 waeb+10g urea	3090.00	0.819	62.5	10.5	2.25	7.9
T_2 " + 0g urea	2500.02	0.813	64.0	8.5	2.0	8.41
T_3 " + 30g urea	1816.67	0.850	71.5	10.0	2.0	10.20
T_4 " + 40g urea	1809.60	0.641	61.0	6.5	2.5	7.95
T_5 " + 50g urea	999.11	0.755	67.5	5.5	1.5	9.42
T_6 2 waeb + 10g	2303.75	0.851	68.5	9.0	2.25	8.77
T_7 " + 20g	3880.00	0.718	77.0	9.5	2.0	8.60
T_8 " + 30g	1800.00	0.683	76.5	10.0	2.5	10.55
T_9 " + 40g	2334.45	0.800	70.5	9.5	2.25	9.38
T_{10} " + 50g	3075.00	0.813	63.0	10.0	2.0	6.78
T_{11} 3 waeb + 10g	2594.45	0.813	68.5	10.0	2.0	8.59
T_{12} " + 20g	3877.47	0.848	69.5	10.5	2.0	9.01
T_{13} " + 30g	2595.39	0.801	71.5	10.5	2.0	8.69
T_{14} " + 40g	2972.62	0.810	64.0	10.0	2.25	9.3
T_{15} " + 50g	2126.67	0.833	76.5	9.0	2.0	9.45
T_{16} 4 waeb + 10g	5275.00	0.750	70.5	10.5	2.5	7.89
T_{17} " + 20g	3316.67	0.648	63.5	8.5	2.0	8.02
T_{18} " + 30g	2738.70	0.592	73.5	5.0	1.5	10.7
T_{19} " + 40g	2817.85	0.752	73.5	8.0	2.0	9.34
T_{20} " + 50g	2815.56	0.722	63.0	7.0	1.75	8.59
T_{21} Control (No pruning/urea)	1226.79	0.775	82.0	8.5	4.0	8.34
CD (0.05)						
W	NS	NS	4.01	NS	NS	NS
D	NS	NS	NS	NS	NS	NS
WxD	NS	NS	8.73	NS	0.794	NS

Waeb - weeks after emergence of bunch/after female phase
W - weeks; D - dose of urea; WxD - Interaction effects

strength was best in 4 weeks + 30g urea placement (T_{18}) and 4 weeks + 20g urea treatment (T_{17}) which recorded value of 0.592 and 0.648 respectively.

4.B.6.2 Effect on maturity, ripening and shelf-life and filling index

4.B.6.2.1 Days to maturity

There was profound influence on days taken to maturity which was also statistically significant. 1 week + 40g urea placement (T_4) recorded the earliest maturity and this was 21 days earlier than control (82 days) and it was on par with 1 week + 10g (T_1), 1 week + 20g (T_2), 1 week + 50g (T_5), 2 week + 10g (T_6), 2 week + 50g (T_{10}), 3 week + 10g (T_{11}), 3 week + 20g (T_{12}), 4 week + 20g (T_{13}) and 4 week + 50g (T_{20}) urea placements.

4.B.6.2.2 Days to ripening

Days taken to ripening was faster in treatment combination of 4 weeks + 30g (T_{18}) followed by 1 week + 50g (T_{16}) urea placements. They ripened within 5-5.5 days but the results were not significant.

4.B.6.2.3 Shelf-life

The data on shelf-life revealed that the differences between treatment means were significant. All the treatments reduced the shelf life. The treatments, 1 week + 50g urea (T_5) and 4 weeks + 30g urea (T_{18}) had a shelf life of only 1.5 days.

In general, the 50 g urea placement showed drastic reduction in shelf life. So also, all treatment combination with 4 weeks pruning showed reduced shelf life.

4.B.6.2.4 Filling index

4 weeks + 30g (T_{18}); 2 weeks + 30g (T_8) and 1 week + 30g (T_3) recorded maximum filling indices of 10.7, 10.55 and 10.2 respectively, but the results were not significant.

4.B.6.3 Yield characters

The data on yield and yield characters are presented in Table 7 are dealt under the following heads.

4.B.6.3.1 Bunch weight

The data on bunch weight are presented in Table 7. The difference between treatment means showed statistical significance. The best results were obtained in treatment combinations of 2 weeks + 30g urea (T_8), followed by 4 weeks + 30g urea (T_{18}) and 3 weeks + 30g urea treatment (T_{13}). The general superiority of 30g treatment was very evident.

Again, all treatment enforced after 2nd week, 3rd week and 4th week gave better yields than control (Fig. 8 9) (Plates 6, 7 and 8)).

Table 7 Bunch stalk feeding of urea and yield attributes in banana cv. 'Nendran'

Treatments	ANCOVA	Finger weight (g)			ANCOVA	
	Bunch weight (kg)	First hand	Last hand	'D' finger	Length (cm) ('D' finger)	Girth (cm) 'D' finger
T_1 1 waeb+10g urea	8.13 (47.0)	185.0	110.0	169.03 (47.0)	21.47 (47.0)	12.99 (47.0)
T_2 " +20g urea	8.78 (50.5)	215.0	135.0	176.06 (50.5)	21.69 (50.5)	13.03 (50.5)
T_3 " + 30g urea	10.79 (48.5)	245.0	165.0	235.60 (48.5)	23.35 (48.5)	13.72 (48.5)
T_4 " + 40g urea	7.97 (45.5)	175.0	100.0	174.94 (45.5)	21.83 (45.5)	12.87 (45.5)
T_5 " + 50g urea	8.85 (40.0)	170.0	150.0	224.95 (40.0)	22.51 (40.0)	13.72 (40.0)
T_6 2 waeb + 10g	10.97 (45.0)	225.0	180.0	212.44 (45.0)	24.08 (45.0)	13.02 (45.0)
T_7 " + 20g	10.04 (52.0)	220.0	160.0	182.87 (52.0)	22.08 (52.0)	13.15 (52.0)
T_8 " + 30g	12.49 (43.0)	230.0	175.0	248.1 (43.0)	24.8 (43.0)	14.06 (43.0)
T_9 " + 40g	11.01 (46.5)	225.0	130.0	225.16 (46.5)	24.01 (46.5)	13.10 (46.5)
T_{10} " + 50g	7.23 (49.5)	180.0	122.0	145.84 (49.5)	22.27 (49.5)	12.45 (49.5)
T_{11} 3 waeb + 10g	8.39 (52.0)	205.0	120.0	172.65 (52.0)	21.08 (52.0)	12.5 (52.0)
T_{12} " + 20g	9.47 (45.5)	195.0	157.0	207.44 (45.5)	22.83 (45.5)	13.12 (45.5)
T_{13} " + 30g	10.01 (49.0)	235.0	145.0	204.48 (49.0)	24.06 (49.0)	13.06 (49.0)
T_{14} " + 40g	9.44 (43.5)	190.0	130.0	201.99 (43.5)	21.24 (43.5)	12.80 (43.5)
T_{15} " + 50g	10.92 (48.0)	240.0	140.0	216.75 (48.0)	23.14 (48.0)	13.23 (48.0)
T_{16} 4 waeb + 10g	10.26 (42.5)	197.5	137.5	184.26 (42.5)	22.57 (42.5)	12.57 (42.5)
T_{17} " + 20g	8.07 (45.5)	170.0	125.0	174.94 (45.5)	21.58 (45.5)	12.87 (45.5)
T_{18} " + 30g	11.02 (48.0)	230.0	132.5	236.75 (48.0)	22.39 (48.0)	14.48 (48.0)
T_{19} " + 40g	9.47 (46.0)	225.0	130.0	206.3 (46.0)	22.04 (46.0)	13.51 (46.0)
T_{20} " + 50g	9.33 (47.0)	215.0	135.0	181.53 (47.0)	21.22 (47.0)	12.99 (47.0)
T_{21} Control (No pruning/urea)	8.04 (43.0)	200.0	105.0	173.13 (43.0)	20.03 (43.0)	12.06 (43.0)
CD (0.05)						
W	NS	NS	NS	NS	NS	NS
D	1.285	NS	NS	S	NS	NS
WxD	NS	NS	43.53	NS	NS	NS

waeb - weeks after emergence of bunch/after female phase
W - weeks; D - dose of urea; WxD - Interaction effects
Figures in paranthesis denotes finger No. taken as the covariate in ANCOVA)

Fig.8 Effect of bunch stalk feeding of urea on bunch weight in banana cv. `Nendran'

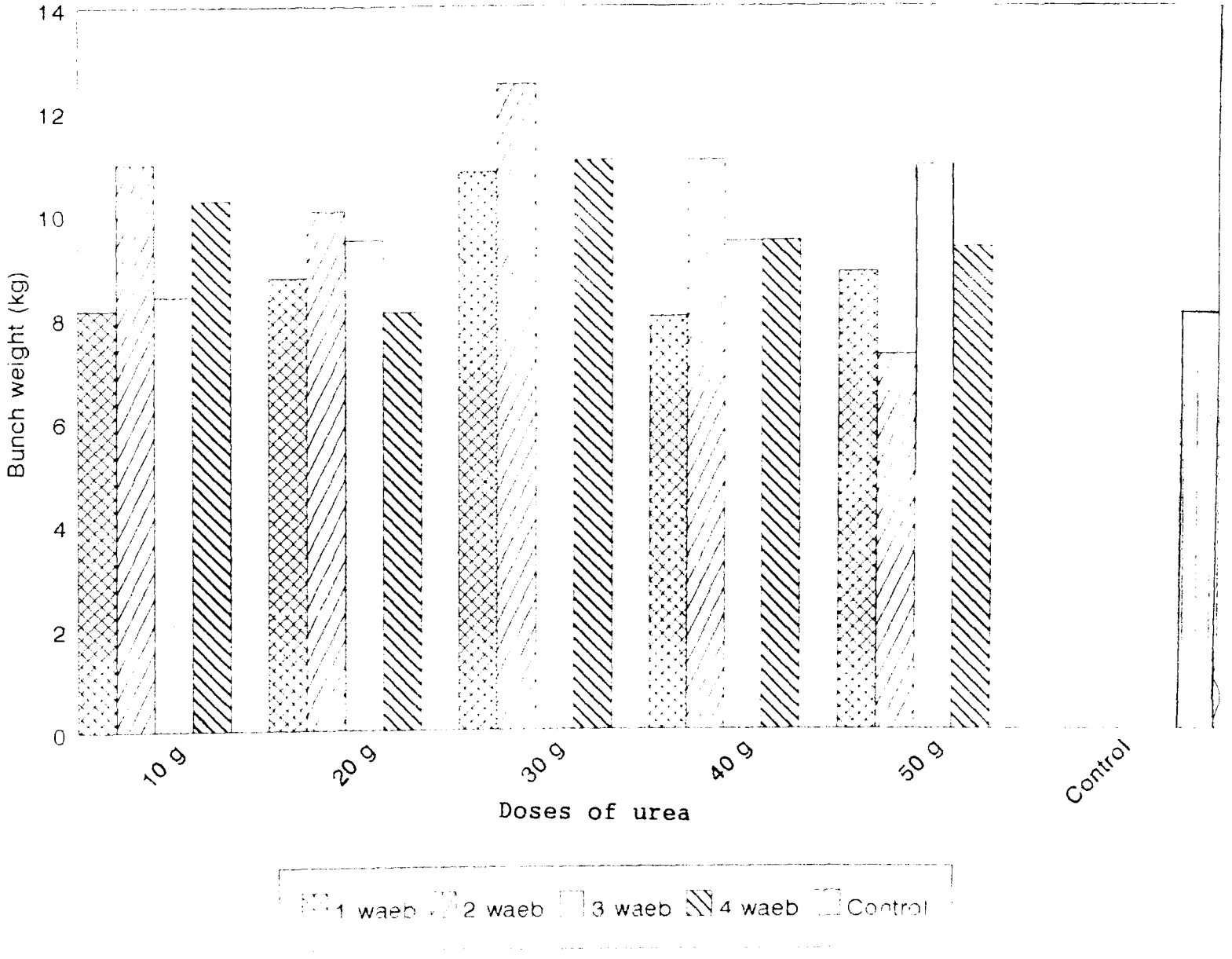


Fig.9 Bar diagram showing yield response with time of application and combinations of urea

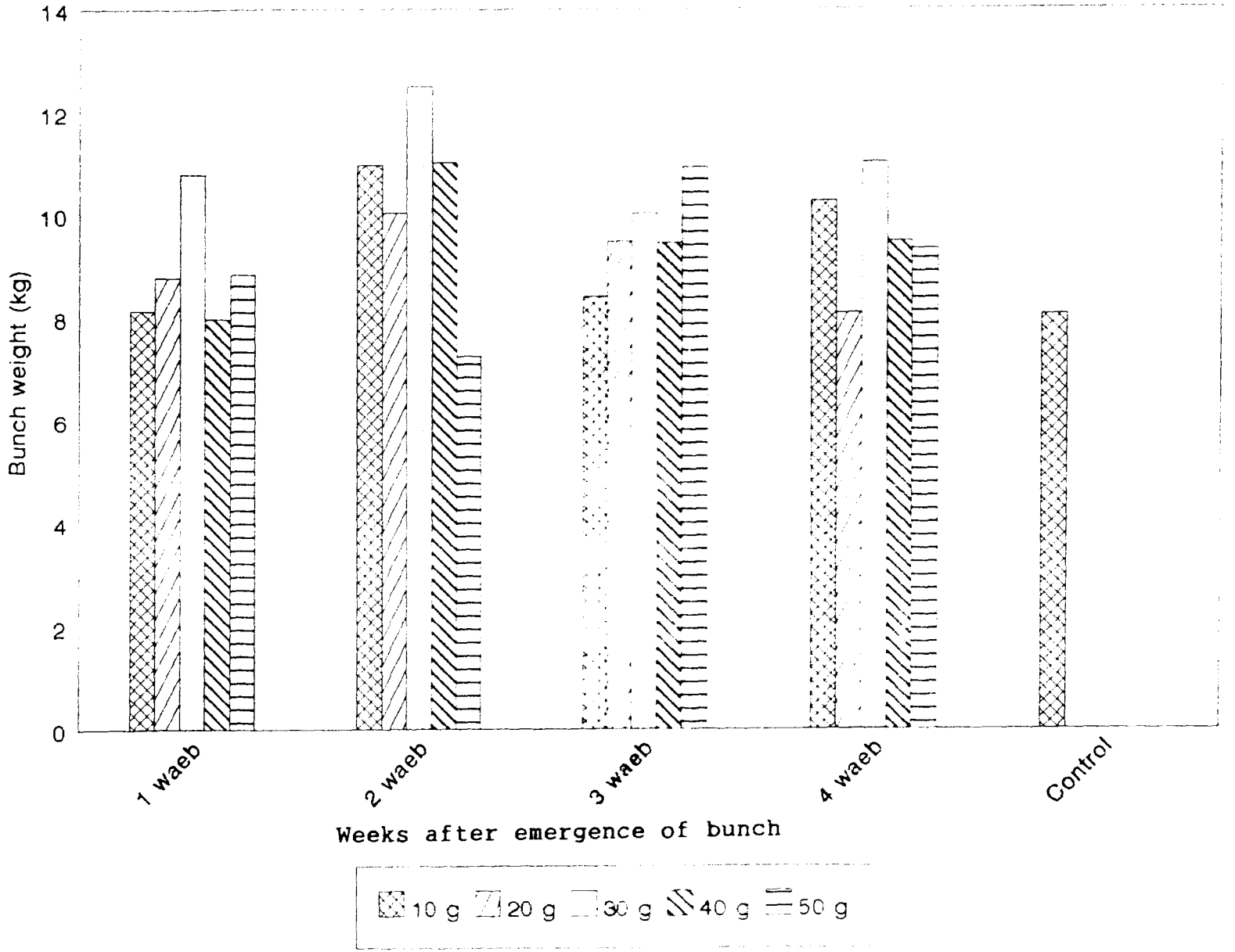
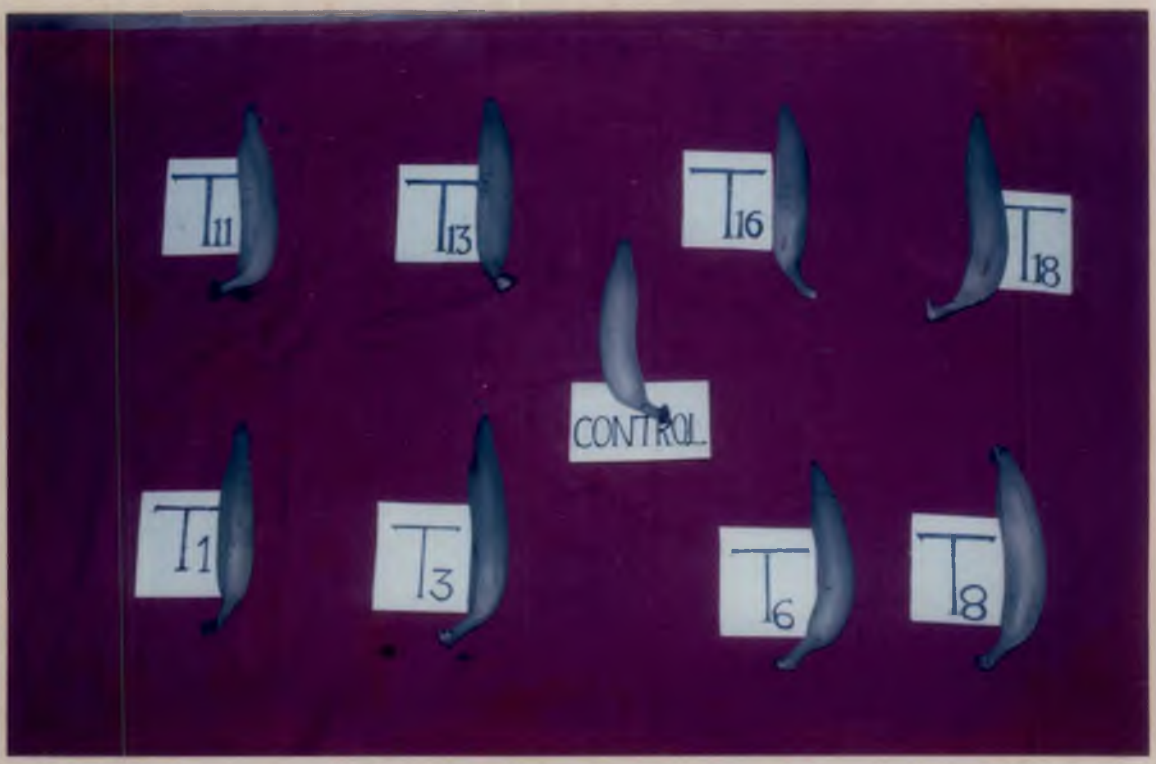


Plate 6 Bunch - Effect of 30 g urea placement at 2 weeks after bunch emergence

Plate 7 Bunch stalk feeding of urea - effect on `D' hand and D' finger

Plate 8 Bunch stalk feeding of urea - effect on `D' finger


T8
CONTROL
T9
T5
T3
T1


T11
T13
T16
T18
CONTROL
T1
T3
T6
T8

4.B.6.3.2 Finger weight

4.B.6.3.2.1 First hand level

Though the difference between treatment means were not significant, the general superiority of 30g treatment was observed.

4.B.6.3.2.2 'D' finger weight

Eventhough, the analysed data revealed no statistical significance, combination treatments of 4 weeks + 30g urea placement, 2 weeks + 30g urea placement and 1 week + 30g urea placement yielded fingers of 240g in comparison with control which recorded only 165g.

4.B.6.3.2.3 Last hand level

Though the fingers of last hand showed significant differences, it was of less consequence. The combination of 2 week + 10g urea placement (T_5) followed by 2 week + 30g (T_8) were the best treatments.

4.B.6.3.3 Length of 'D' finger

The difference between treatment means were not significant. However, the longest ones (24 cm) were obtained in combinations of 2 weeks + 10g urea (T_6), 3 weeks + 30g urea (T_{13}) and 2 weeks + 40g urea placements (T_9). The control measured only 20.01 cm

4.B.6.3.4 Finger girth/grade

Most of the treatments recorded better grade than control. Though not significant the maximum girth was obtained in 4 weeks + 30g (T_{18}) and 2 weeks + 30g urea placement (T_8) which recorded 14.48 cm and 14.06 cm respectively

4.B.6.4 Ripened fruit characters

The data in the different characters are presented in Table 8.

4.B.6.4.1 Ripened fruit weight ('D' finger)

Though the treatment differences were not significant the general superiority of pruning treatments with 30g urea placement was observed. The best treatments were 1 week pruning + 30g followed by 4 week pruning + 30g, 2 week + 30g and 3 week + 30g urea placement

4.B.6.4.2 Pulp weight

Pulp weights of all the treatments revealed significant differences between treatments. Higher pulp weight was again recorded in 30g placements. The best treatments were observed in combinations of above with 2 weeks of pruning, followed by 4 weeks, and 3 weeks and were significantly superior to the control.

Table 8 Effect of 'bunch stalk feeding of urea' on ripened fruit characters in banana cv. 'Nendran'

Treatments	ANOVA					
	Ripened fruit weight (g)	Pulp weight (g)	Peel weight (g)	Pulp/ peel ratio	Pulp thick-ness (cm)	Peel thick ness (cm)
T_1 1 waeb+10g urea	136.28	101.96	33.83	4.02	3.25	0.115
T_2 " + 20g urea	135.23	103.31	31.72	3.27	3.3	0.202
T_3 " + 30g urea	182.32	141.17	41.13	3.52	3.3	0.204
T_4 " + 40g urea	128.14	97.57	30.57	3.24	3.4	0.107
T_5 " + 50g urea	154.71	125.92	28.63	4.54	3.35	0.103
T_6 2 waeb + 10g	157.32	119.61	37.63	3.21	3.35	0.112
T_7 " + 20g	137.24	105.25	26.29	4.12	3.10	0.104
T_8 " + 30g	178.89	148.62	34.90	4.47	3.55	0.105
T_9 " + 40g	152.82	119.83	32.79	3.68	3.23	0.109
T_{10} " + 50g	108.09	83.52	23.04	3.71	2.98	0.111
T_{11} 3 waeb + 10g	148.38	118.65	29.66	3.99	3.35	0.114
T_{12} " + 20g	152.29	122.92	29.31	4.26	3.4	0.108
T_{13} " + 30g	169.54	125.85	43.66	5.42	3.4	0.160
T_{14} " + 40g	154.71	114.36	45.32	2.87	3.1	0.107
T_{15} " + 50g	171.09	129.73	40.54	3.19	3.38	0.116
T_{16} 4 waeb + 10g	125.88	912.905	37.52	2.48	3.25	0.148
T_{17} " + 20g	130.43	89.61	40.82	2.74	2.9	0.163
T_{18} " + 30g	179.52	139.72	42.94	3.24	3.5	0.156
T_{19} " + 40g	172.4	128.79	38.04	3.46	3.4	0.159
T_{20} " + 50g	138.75	111.96	26.32	4.35	3.25	0.103
T_{21} Control (No pruning/urea)	111.65	91.49	20.04	4.55	3.05	0.109
CD (0.05)						
W	NS	NS	NS	NS	NS	NS
D	23.02	16.88	NS	NS	NS	NS
WxD	NS	35.03	NS	NS	NS	NS

Waeb - weeks after emergence of bunch/after female phase
W - weeks; D - dose of urea; WxD - Interaction effects
(Figures in paranthesis denotes finger No. taken as a co variate in ANCOVA)

4.B.6.4.3 Peel weight

No significant differences between treatment means were observed in the case of peel weight. One important observation is that the weights of the peel in all treatments was higher than the control.

4.B.6.4.4 Pulp/peel ratio

The data clearly indicate that the control had a higher ratio. The only treatment which recorded almost similar value was 1 week pruning + 50g urea placement.

4.B.6.4.5 Pulp thickness

High pulp thickness was observed in 30g placement in combination of pruning of stalk 2 weeks and 4 weeks after complete emergence.

4.B.6.4.6 Peel thickness

There was no definite trend or statistical significance observed in case of peel thickness.

4.B.6.5 Qualitative characters

The data are presented in Table 9.

4.B.6.5.1 Acidity

All the treatments except 4th week pruning + 30g urea placement resulted in an increment in acidity compared to control.

Table 9 Effect of `bunch stalk feeding of urea' on quality of fingers in banana cv. `Nendran'

Treatments	ANOVA				
	Acidity (%)	T.S.S. (°brix)	Sugars (%)		
			Reducing	Non-reducing	Total sugars
T_1	0.371	27.1	13.06	0.816	13.87
T_2	0.410	25.7	10.62	2.506	13.12
T_3	0.448	27.5	13.82	2.353	16.17
T_4	0.435	25.0	10.68	0.764	11.44
T_5	0.384	25.7	11.73	2.418	15.61
T_6	0.384	23.8	14.20	0.636	14.84
T_7	0.384	26.0	12.69	0.709	12.87
T_8	0.320	25.6	14.59	0.909	16.58
T_9	0.333	22.6	12.69	0.748	13.44
T_{10}	0.346	25.7	11.80	0.540	12.34
T_{11}	0.299	28.0	14.51	2.590	16.82
T_{12}	0.615	24.2	11.38	0.518	11.892
T_{13}	0.307	28.5	15.51	2.479	17.98
CD (0.05)					
W	NS	NS	NS	NS	NS
D	NS	NS	NS	0.893	NS
WxD	NS	NS	NS	NS	NS

T1 - waeb+10g urea; T4 - 2 waeb+10g urea; T7 - 3 waeb+10g; T10 - 4 waeb+10g
T2 - " +30g " T5 - " +30g " T8 - " +30g T11 - " +30g
T3 - " +50g " T6 - " +50g " T9 - " +50g T12 - " +50g
T13 - Control

*Waeb - weeks after emergence of bunch
W - weeks; D - dose of urea; WxD - Interaction of weks and dose

4.B.6.5.2 T.S.S.

The urea treatments decreased T.S.S compared to control (28.6° brix). When applied in the earlier phases of fruit growth it was found to decrease T.S.S.

4.B.6.5.3 Sugars

4.B.6.5.3.1 Reducing sugars

Highest per cent of reducing sugars was observed in the control. All treatments reduced the quantity but the reduction was much less in early pruning of stalk in combination with urea.

4.B.6.5.3.2 Non-reducing sugars

The early pruning in combinations of 30g and 50g urea and 4 week pruning in combination with 30g gave highest non-reducing sugar per cent which was on par with the control.

4.B.6.5.3.3 Total sugars

The total sugar was maximum in control. All treatments reduced the total sugar content.

4.B.6.6 Biochemical aspects

The data on methionine and carotene content are presented in Table 10, where as data on urease activity, urea and nitrite N are presented in Table 11.

Table 10 Effect of `bunch stalk feeding of urea' on days to maturity, ripening, methionine and carotene content in in banana cv. `Nendran'

Treatments	Days to maturity		Days to ripening		Total time to ripening	Methionine (mg/100 g)	Carotene (ppm)
	Total	After treatment	50%	Full			
T_1	68.5	52.5	7.0	9.0	77.5	21.0	44.89
T_2	76.5	65.5	8.0	10.0	86.5	32.0	27.25
T_3	63.0	48.0	8.5	10.0	73.0	43.5	25.11
T_4	70.5	42.0	9.0	10.5	81.0	44.5	25.15
T_5	73.5	47.5	4.0	5.0	78.5	58.0	21.20
T_6	63.0	44.0	5.5	7.0	70.0	38.5	32.05
T_7	82.0	-	5.5	8.5	89.0	64.0	41.17
CD (0.05)							
W	7.11	NS	NS	NS	NS	NS	4.18
DC	NS	NS	NS	NS	NS	NS	NS
WxD	12.02	NS	NS	NS	NS	NS	14.8

T1 - 2 waeb+10g urea
T2 - " +30g "
T3 - " +50g "
T4 - 4 waeb+10g urea
T5 - " +30g "
T6 - " +50g "
T7 - Control

Waeb - weeks after emergence of bunch
W - weeks after bunch emergence
D - dose of urea
WxD - Interaction effect

4.B.6.6.1 Methionine

The four week pruning of bunch stalk in combination with 10g urea placement and control showed the highest methionine content and recorded almost similar values.

4.B.6.6.2 Carotene

The data on carotene content in ripened dried fruits showed significant difference between treatment means. Urea feeding resulted in a reduction in carotene content except in treatment of 2 weeks pruning + 10g urea placement, where an increase in content was observed.

4.B.6.6.3 Urease activity at fruit ripening

Analysis of data (Table 11) revealed that the highest urease activity, 31.93µmol/NH_3/g/min was recorded by combination of 2 week pruning with 30g urea placement and control fruits recorded the least (7.075µmol NH_3/g/min.). (Fig.10)

4.B.6.6.3 Urea content at fruit ripening

Variations were observed with treatments in the content of urea in fruits. Control fruits also contained urea but its content was very low (47.85 ppm). Combination of 2 week trimming of stalk and 10g urea placement showed the lowest content of 16.36 ppm whereas all other treatments recorded higher values than of control. The highest urea content was observed in 4 week pruning of stalk in combination with 10g urea (Fig.11)

Table 11 Effect of 'bunch stalk feeding of urea' on urease activity, urea content and nitrite N content in banana cv. 'Nendran'

Treatments	Urease activity (µmol NH_3/g/min)	Urea content (ppm)	Nitrite N (ppm)
T_1	24.59	16.36	0.099
T_2	31.94	39.89	0.085
T_3	14.49	68.85	0.156
T_4	10.85	75.66	0.048
T_5	22.67	42.92	0.053
T_6	15.36	68.85	0.100
T_7	7.08	47.85	0.064
CD (0.05)			
W	NS	NS	NS
D	NS	NS	NS
WxD	NS	NS	NS

T1 - 2 waeb+10g urea
T2 - " +30g "
T3 - " +50g "
T4 - 4 waeb+10g urea
T5 - " +30g "
T6 - " +50g "
T7 - Control

*Waeb - weeks after emergence of bunch
W - weeks after bunch emergence
D - dose of urea
WxD - Interaction effect

Fig.10 Effect of bunch stalk feeding of urea on urease activity (μmol NH_3/g/min) in banana cv. `Nendran'

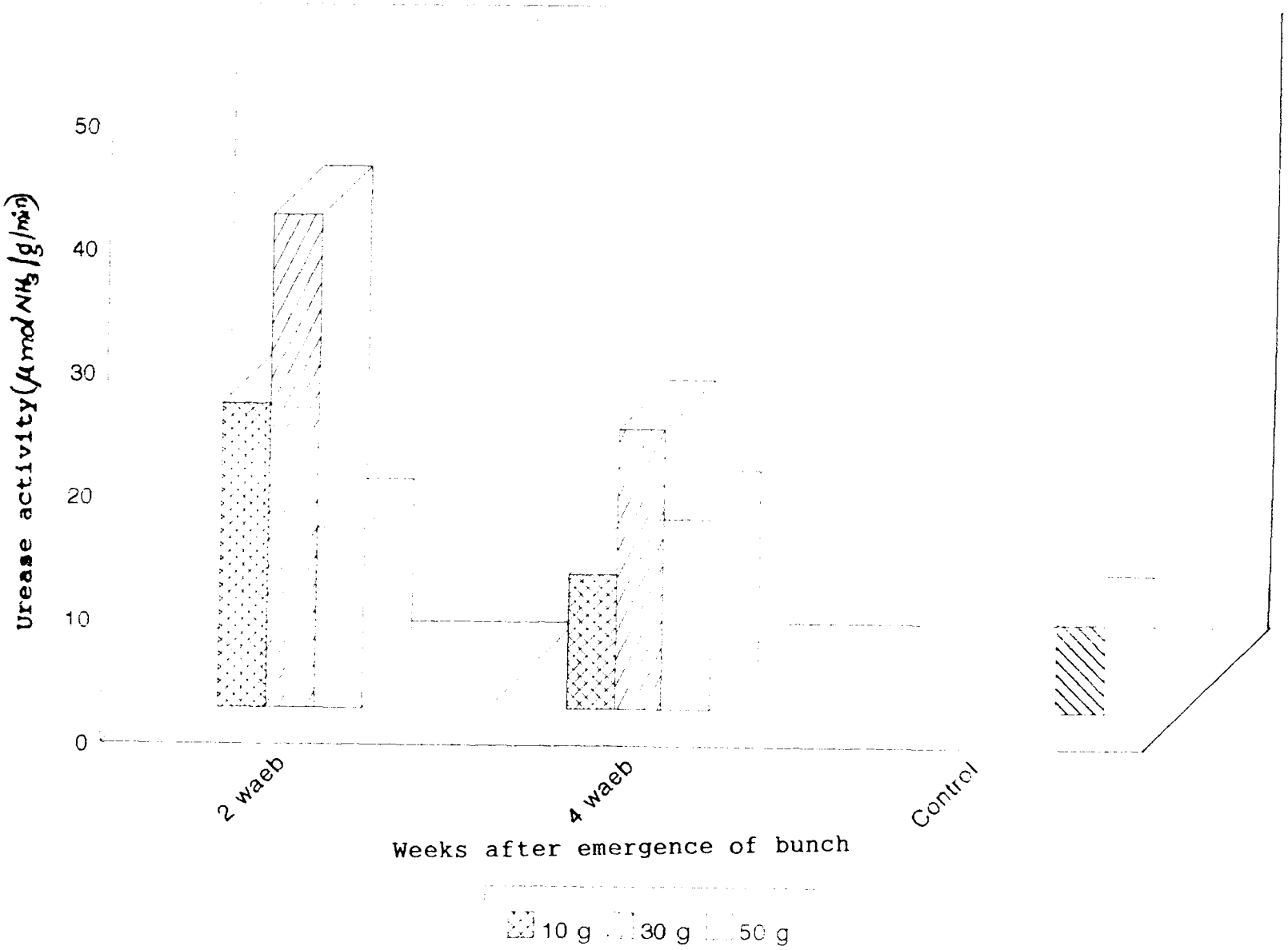


Fig.11 Effect of bunch stalk feeding of urea on urea content (ppm) in banana cv. `Nendran'

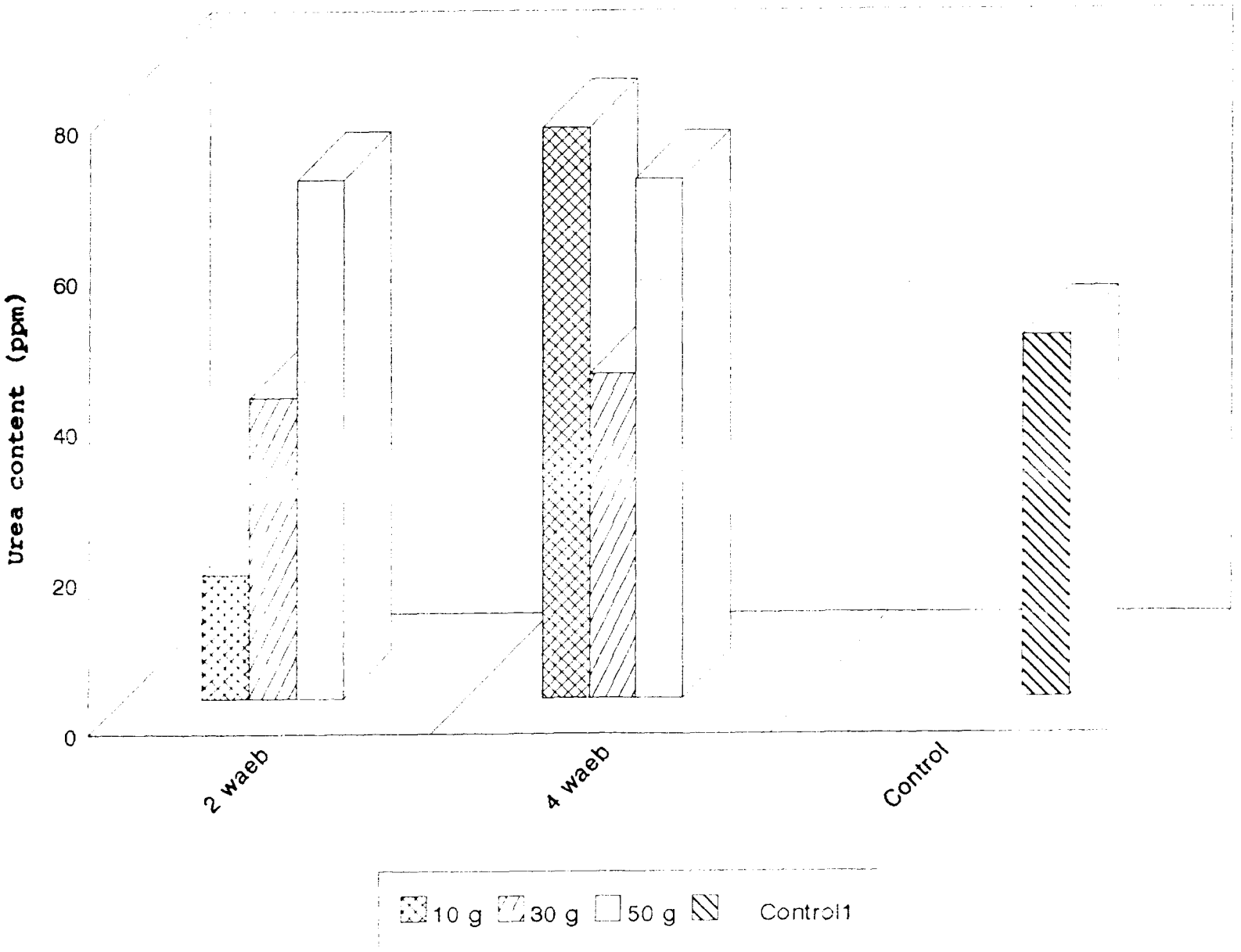
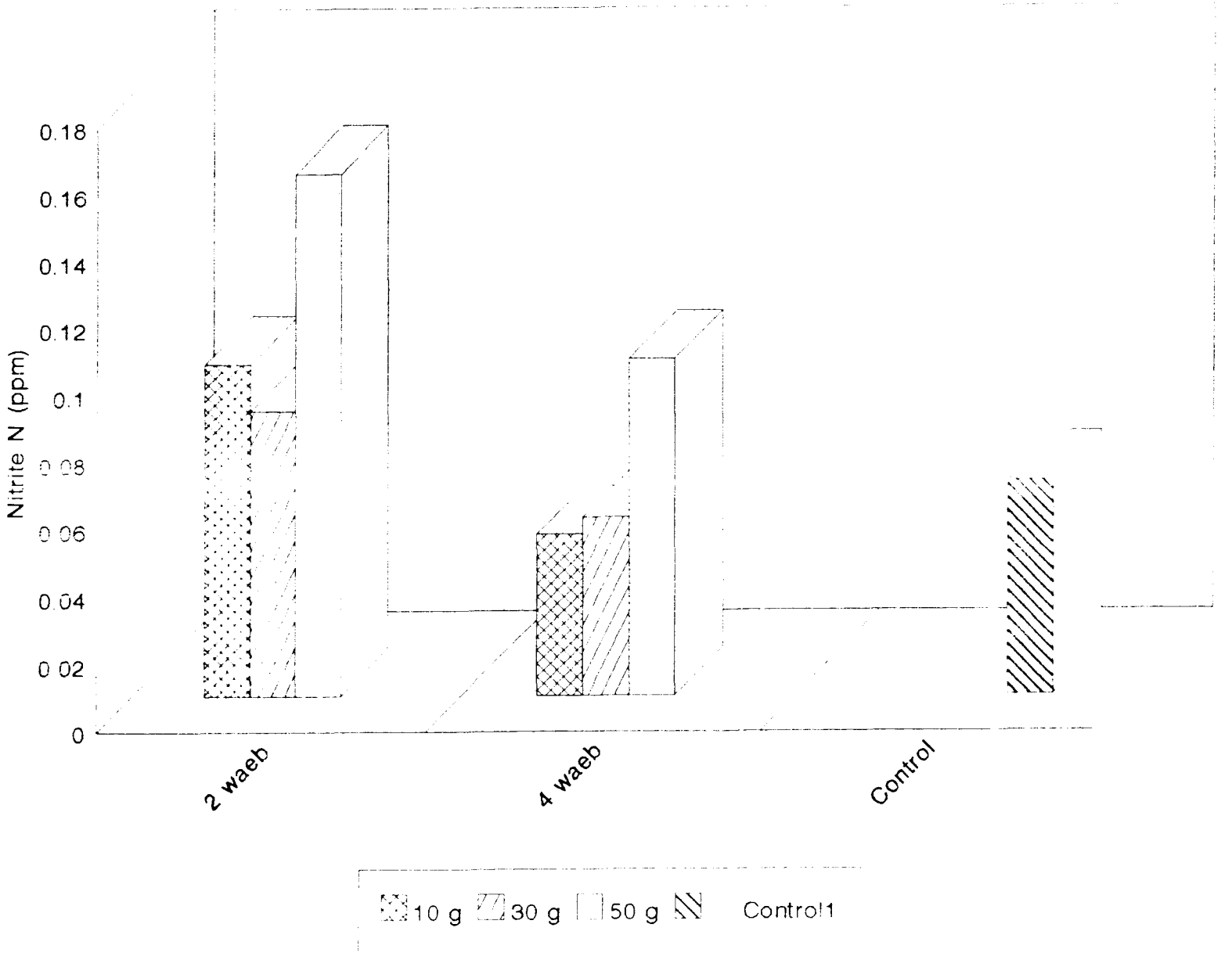


Fig.12 Effect of bunch stalk feeding of urea on nitrite N content (ppm) in banana cv. `Nendran'



4.B.6.6.4 Nitrite N

Analysis of data shows that there existed differences in concentrations of nitrite N, but it was not significant. A combination of 2 week pruning with 50g urea placement showed higher values. A gradation is observed with the nitrite N increasing with urea placements (Fig.12)

4.B.7. UREA SPRAY

4.B.7.1 Morphophysiological characters

The data on effect of urea spray in morpho-physiological characters, maturity, ripening, shelf life and filling index are presented in Table 12.

4.B.7.1.1 Fruit curvature index (FCI)

A perusal of data presented showed differences among the various treatments but no significant differences were observed. The control water spray (T_{37}) recorded the highest value. 3 sprays at 3% concentration recorded the best FCI value of 4550.

4.B.7.1.2 Pedicel strength

Urea spraying had no much influence on altering the pedicel strength and there existed no-significant differences among the treatment means. The lowest pedicel strength was observed in treatments involving 2 sprays of 5 per cent concentration at 4th and 5th week after bunch

Table 12 Effect of `urea spray on morphophysiological characters in banana cv. `Nendran'

Treatments	ANOVA					
	Fruit Curvature Index (FCI)	Pedicel strength	Days to maturity	Days to ripening	Shelf life (days)	Filling index
T_1 3 waeb+1%g urea	3026.43	0.834	76.0	7.5	2.5	10.79
T_2 " + 2% urea	2521.43	0.857	68.5	6.5	1.75	9.75
T_3 " + 3% urea	1516.89	0.803	76.0	6.5	2.00	8.45
T_4 " + 4% urea	1825.39	0.839	76.0	4.5	1.75	9.55
T_5 " + 5% urea	1883.35	0.701	79.5	4.5	2.50	9.65
T_6 4 waeb + 1%	1369.51	0.750	73.5	6.0	1.50	9.14
T_7 " + 2%	1570.13	0.928	73.0	7.5	2.00	9.04
T_8 " + 3%	1519.45	0.833	69.5	5.0	1.50	9.92
T_9 " + 4%	2750.00	0.887	72.0	10.0	2.00	8.69
T_{10} " + 5%	1583.34	0.813	68.0	10.5	2.00	9.62
T_{11} 5 waeb + 1%	1547.65	0.819	79.5	5.5	2.50	9.79
T_{12} " + 2%	3303.85	0.773	73.0	7.0	2.00	9.54
T_{13} " + 3%	3178.00	0.694	77.5	8.5	2.50	7.63
T_{14} " + 4%	2656.67	0.725	77.5	8.0	1.75	9.29
T_{15} " + 5%	1507.74	0.831	76.5	6.5	2.00	9.23
T_{16} 3rd & 4th waeb + 1%	1296.43	0.875	78.5	10.0	2.00	9.07
T_{17} " + 2%	2229.85	0.771	61.0	9.0	2.00	8.85
T_{18} " + 3%	3650.00	0.789	66.0	10.5	2.00	8.92
T_{19} " + 4%	2585.00	0.734	64.0	6.0	2.00	11.55
T_{20} " + 5%	2866.67	0.854	70.5	6.0	1.00	10.53

Contd....

Table 12 contd...

	2481.67	0.70	69.0	8.0	2.0	9.77
T_{21} 4th & 5th waeb + 1%						
T_{22} " + 2%	1826.41	0.863	72.0	9.0	2.0	9.35
T_{23} " + 3%	1972.25	0.845	72.5	7.0	2.5	9.38
T_{24} " + 4%	1208.13	0.729	66.5	11.0	2.0	8.13
T_{25} " + 5%	1427.15	0.973	68.5	7.5	2.0	6.71
T_{26} 3rd & 5th waeb + 1%	2875.00	0.866	79.0	7.0	2.0	9.98
T_{27} " + 2%	1047.78	0.872	77.0	7.0	1.5	8.17
T_{28} " + 3%	2900.00	0.826	72.0	7.5	1.5	8.57
T_{29} " + 4%	2352.10	0.863	69.5	8.0	3.0	9.36
T_{30} " + 5%	2843.75	0.652	69.5	5.0	3.0	10.61
T_{31} 3rd, 4th & 5th waeb + 1%	2015.00	0.764	74.0	6.0	2.5	10.22
T_{32} " + 2%	2477.25	0.757	70.0	6.5	2.0	10.00
T_{33} " + 3%	4550.00	0.764	71.5	6.5	2.0	9.32
T_{34} " + 4%	2910.40	0.823	64.0	5.5	3.0	6.98
T_{35} " + 5%	1166.67	0.875	73.0	7.5	3.0	6.00
T_{36} Control (no spray)	1824.75	0.750	80.5	8.5	4.0	9.17
T_{37} Control (water spray)	6487.50	0.750	82.5	10.0	3.5	9.08
CD (0.05)						
W	NS	NS	2.889	1.328	0.356	0.85
C	NS	NS	2.442	NS	NS	NS
WxC	NS	NS	6.287	3.086	0.800	2.00

Waeb - weeks after emergence of bunch/after female phase
W - weeks; C - concentration of urea; WxC - Interaction effects

emergence (T_{25}). Best pedicel strength was obtained at 5% concentration given as 2 sprays at 3rd and 5th week after emergence (T_{30}).

4.B.7.2 Effect of urea sprays on maturity, ripening, shelf life and filling index

4.B.7.2.1 Days to maturity

Both controls (no spray and water spray) took more days (80.5 and 82.5 days) for attaining the harvestable maturity stage. The earliest maturity was recorded in treatments involving 2 sprays at 3rd and 4th week after emergence of the bunch with 2% spray (T_{17}) followed by 2 sprays at 3rd and 4th week after emergence with 4% concentration (T_{19}) and 4 per cent sprays at 3rd, 4th and 5th week after full emergence of the bunch.

4.B.7.2.2 Days to ripening

Significant difference exist between the treatment means. Earliest ripening was recorded in 2 treatments of sprays at 4% and 5% concentration both enforced after 3 weeks of full emergence (T_4 and T_5) which took only 4-5 days. 2 sprays at 4th and 5th week after bunch emergence at 4 per cent concentration took the maximum of 11 days to attain ripening.

4.B.7.2.3 Shelf-life

Significant differences were observed between treatment means. Out of the 37 treatments, the two

controls are having more shelf-life (4 and 3.5 days) compared to the various treatments. The shortest shelf life of one day was observed in 2 sprays of 5 percent concentration enforced at 3rd and 4th week after emergence of the bunch (T_{20}).

4.B.7.2.4 Filling index

A critical analysis of the data revealed no significant differences among the treatment means. Compared to controls, the highest value of 11.552 was recorded when urea at 4% concentration was sprayed 3rd and 4th week after bunch emergence (T_{19}) followed by one spray of 1% concentration at 3 week after emergence (T_1) which were on par with a number of treatments. The least filling index (6.00) was noted in the case of 3 sprays at 5% concentration (T_{35}) the controls recorded filling indices of 9.17 and 9.08 respectively.

4.B.7.3 Yield attributes

The data on yield attributes are presented in Table 13.

4.B.7.3.1 Bunch weight

A perusal of data reveal the clear influence of various treatments on increasing/decreasing the bunch weights. The treatment means showed significant differences. The highest bunch weight of 11.375 kg was

Table 13 Effect of `urea spray on yield attributes in banana cv. `Nendran'

Treatments	ANCOVA	Finger weight		ANCOVA		
	Bunch weight	First hand	Last hand	`D' finger	Length (cm)	Girth (cm)
T_1 3 waeb+1%g urea	9.84 (46.0)	235.0	180.0	230.36 (46.0)	21.33 (46.0)	13.77 (46.0)
T_2 " + 2% urea	9.37 (40.0)	200.0	145.0	197.55 (40.0)	20.57 (40.0)	12.88 (40.0)
T_3 " + 3% urea	7.90 (46.0)	230.0	135.0	170.36 (46.0)	20.08 (46.0)	12.37 (46.0)
T_4 " + 4% urea	9.29 (49.0)	200.0	145.0	229.27 (49.0)	23.84 (49.0)	13.56 (49.0)
T_5 " + 5% urea	10.69 (46.0)	205.0	130.0	220.18 (46.0)	22.79 (46.0)	14.01 (46.0)
T_6 4 waeb + 1%	7.99 (53.0)	210.0	160.0	187.63 (53.0)	20.47 (53.0)	12.98 (53.0)
T_7 " + 2%	9.39 (54.0)	205.0	145.0	187.45 (54.0)	20.43 (54.0)	12.87 (54.0)
T_8 " + 3%	10.18 (57.5)	245.0	130.0	228.36 (57.5)	22.88 (57.5)	13.67 (57.5)
T_9 " + 4%	10.66 (44.0)	250.0	180.0	206.09 (44.0)	23.74 (44.0)	13.31 (44.0)
T_{10} " + 5%	7.78 (52.0)	210.0	135.0	185.68 (52.0)	19.09 (52.0)	12.16 (52.0)
T_{11} 5 waeb + 1%	9.78 (39.0)	210.0	170.0	192.90 (39.0)	21.65 (39.0)	14.15 (39.0)
T_{12} " + 2%	9.85 (46.0)	230.0	145.0	215.36 (46.0)	22.58 (46.0)	13.02 (46.0)
T_{13} " + 3%	7.06 (50.0)	155.0	122.5	148.72 (50.0)	19.46 (50.0)	12.33 (50.0)
T_{14} " + 4%	9.25 (47.0)	220.0	165.0	194.99 (47.0)	20.99 (47.0)	13.50 (47.0)
T_{15} " + 5%	9.40 (52.5)	215.0	160.0	210.49 (52.5)	22.55 (52.5)	13.15 (52.5)
T_{16} 3rd & 4th waeb + 1%	10.67 (34.5)	205.0	135.0	199.54 (34.5)	22.52 (34.5)	12.98 (34.5)
T_{17} " + 2%	9.23 (46.5)	175.0	135.0	190.18 (46.5)	21.54 (46.5)	13.01 (46.5)
T_{18} " + 3%	8.59 (50.0)	200.0	150.0	196.40 (50.0)	21.75 (50.0)	12.44 (50.0)
T_{19} " + 4%	9.54 (43.0)	230.0	140.0	226.45 (43.0)	19.83 (43.0)	13.58 (43.0)

T_{20} " + 5%	11.26 (50.5)	255.0	200.0	243.72 (50.5)	22.96 (50.5)	13.18 (50.5)
T_{21} 4th & 5th waeb + 1%	8.40 (46.0)	205.0	145.0	220.36 (46.0)	22.58 (46.0)	13.77 (46.0)
T_{22} " + 2%	9.72 (54.0)	220.0	160.0	197.45 (54.0)	20.93 (54.0)	13.02 (54.0)
T_{23} " + 3%	11.17 (47.5)	225.0	175.0	227.31 (47.5)	24.21 (47.5)	14.09 (47.5)
T_{24} " + 4%	9.38 (45.5)	175.0	130.0	195.54 (45.5)	24.02 (45.5)	13.03 (45.5)
T_{25} " + 5%	6.57 (49.0)	150.0	95.0	131.77 (49.0)	19.59 (49.0)	11.31 (49.0)
T_{26} 3rd & 5th waeb + 1%	9.91 (49.5)	222.0	175.0	214.09 (49.5)	21.29 (49.5)	12.70 (49.5)
T_{27} " + 2%	8.12 (49.0)	270.0	130.0	184.27 (49.0)	22.58 (49.0)	13.46 (49.0)
T_{28} " + 3%	10.20 (46.5)	205.0	165.0	180.18 (46.5)	21.64 (46.5)	12.26 (46.5)
T_{29} " + 4%	7.71 (50.0)	200.0	135.0	198.90 (50.0)	21.01 (50.0)	12.79 (50.0)
T_{30} " + 5%	11.38 (46.5)	255.0	165.0	260.18 (46.5)	24.54 (46.5)	14.26 (46.5)
T_{31} 3rd, 4th & 5th waeb + 1%	10.35 (46.5)	235.0	170.0	235.18 (46.5)	23.04 (46.5)	13.66 (46.5)
T_{32} " + 2%	9.01 (37.5)	205.0	125.0	203.45 (37.5)	20.77 (37.5)	13.18 (37.5)
T_{33} " + 3%	9.33 (45.5)	230.0	175.0	205.54 (45.5)	22.12 (45.5)	13.03 (45.5)
T_{34} " + 4%	7.18 (44.5)	165.0	125.0	145.90 (44.5)	21.20 (44.5)	12.65 (44.5)
T_{35} " + 5%	6.44 (49.0)	145.0	110.0	119.27 (49.0)	19.84 (49.0)	11.46 (49.0)
T_{36} Control (no spray)	7.70 (44.0)	185.0	105.0	176.09 (44.0)	19.24 (44.0)	11.27 (44.0)
T_{37} Control (water spray)	7.96 (46.0)	195.0	120.0	180.36 (46.0)	20.08 (46.0)	12.06 (46.0)
CD (0.05)						
W	NS	NS	NS	NS	NS	NS
C	NS	NS	NS	NS	NS	NS
WxC	2.763	NS	50.07	53.15	NS	NS

Waeb - weeks after emergence of bunch/after female phase
W - weeks; C - concentration of urea; WxC - Interaction effects
Figures in parenthesis denote - Finger number taken as a covariate in ANCOVA

recorded at 5% concentration using 2 sprays at 3rd, and 5th week after bunch emergence (T_{30}) followed by 5% concentration sprays at 3rd and 4th week after bunch emergence (T_{20}) (Fig.13 and 14, Plates 9, 10 and 11)

4.B.7.3.2 Finger weights

4.B.7.3.2.1 First hand level

Eventhough data represented no significant differences higher finger weight of 270g was noted at 2% concentration enforced at 3rd and 5th week after bunch emergence (T_{27}) and the next best was at 4% concentration when only one spray was given 4 week after emergence of the bunch (T_9) followed by sprays at 3rd and 4th week after emergence of the bunch with 5% urea concentration (T_{20}). The above treatments recorded finger weights of 255 and 250g respectively.

4.B.7.3.2.2 `D' finger weight

The weights of `D' finger, showed high variations the highest finger weight of 260g were recorded when urea at 5% concentration was sprayed 3rd and 4th week after complete bunch emergence (T_{30}); which was on par with a number of other treatments. Finger weight decreased to the level of 120g when 2 sprays were given at 3,4 and 5 weeks after bunch emergence which was found inferior to the two controls (T_{36} and T_{37}).

4.B.7.3.2.3 Last hand level

The middle finger from the last hand recorded significant differences between treatment means. The maximum finger weight of 200g was obtained when 2 sprays were enforced at 3rd and 4th week after emergence of the bunch at 5% concentration, (T_{20}) which was on par with a number of other treatments (Data shown in Table 13)

4.B.7.3.3 Finger length ('D' finger)

No significant differences exist between different treatments means. Maximum length was recorded at 1% spray using 3 sprays (T_{11}) followed by 2 sprays of 2% at 4th and 5th week which recorded 24.54 and 24.26 cm respectively. The shortest length was recorded at 4% spray enforced 4 weeks after emergence.

4.B.7.3.4 Finger girth/grade

Almost all treatments gave better grade fingers compared to control. Of these, urea spray at 1% concentration, enforced at 5 weeks after bunch emergence (T_{11}) and 2 sprays of 5% concentration done at 3rd and 5th week after emergence (T_{30}) recorded 14.15 cm and 14.26 cm respectively. The poorest grade of 11.32 cm among the treatments was that of enforcement of 2 sprays at 4th and 5th week after bunch emergence with 5% urea concentration (T_{25}).

Fig.13 Bar diagram showing yield response with number of urea sprays

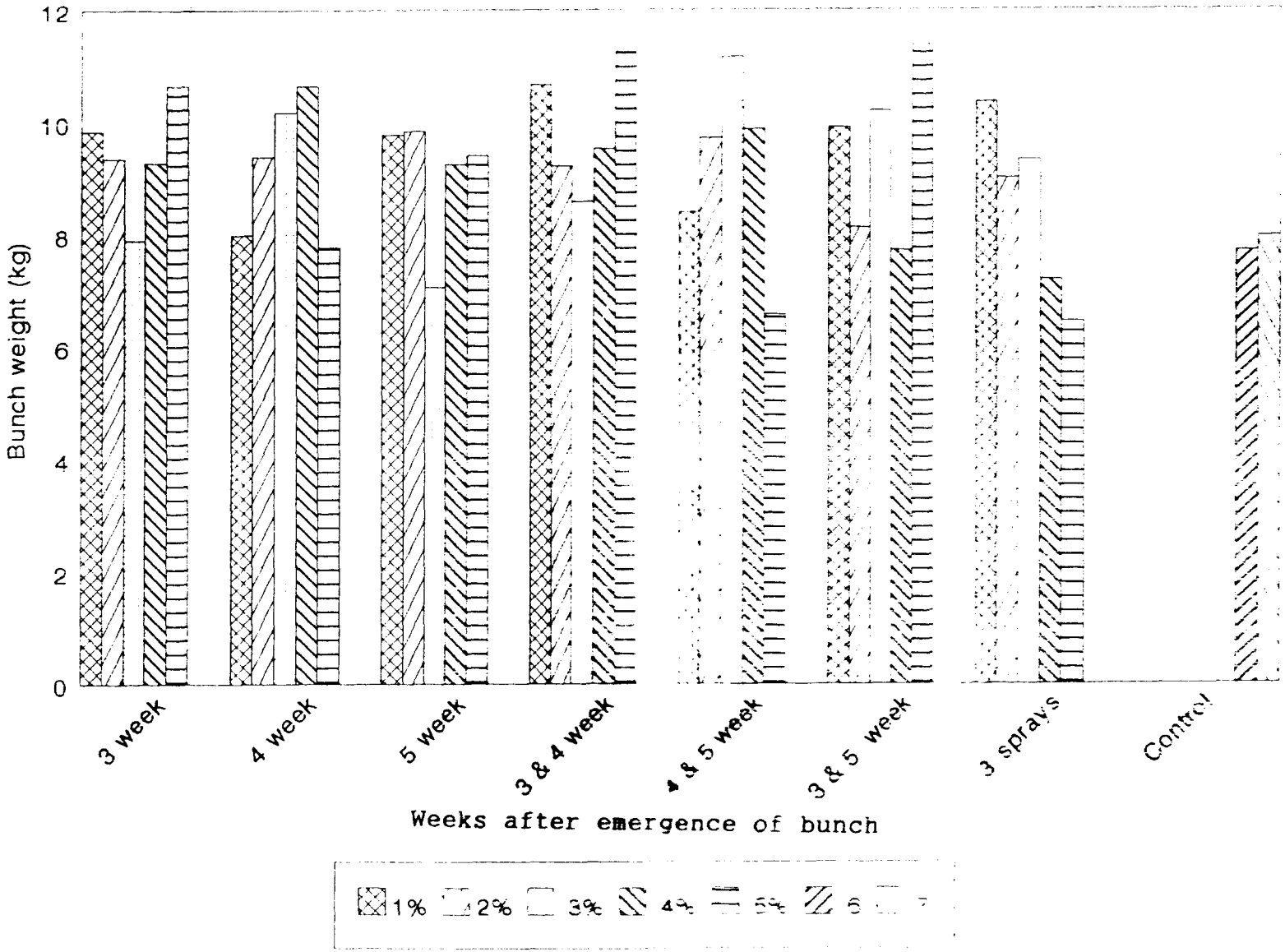


Fig.14 Bar diagram showing yield response with % of urea spray

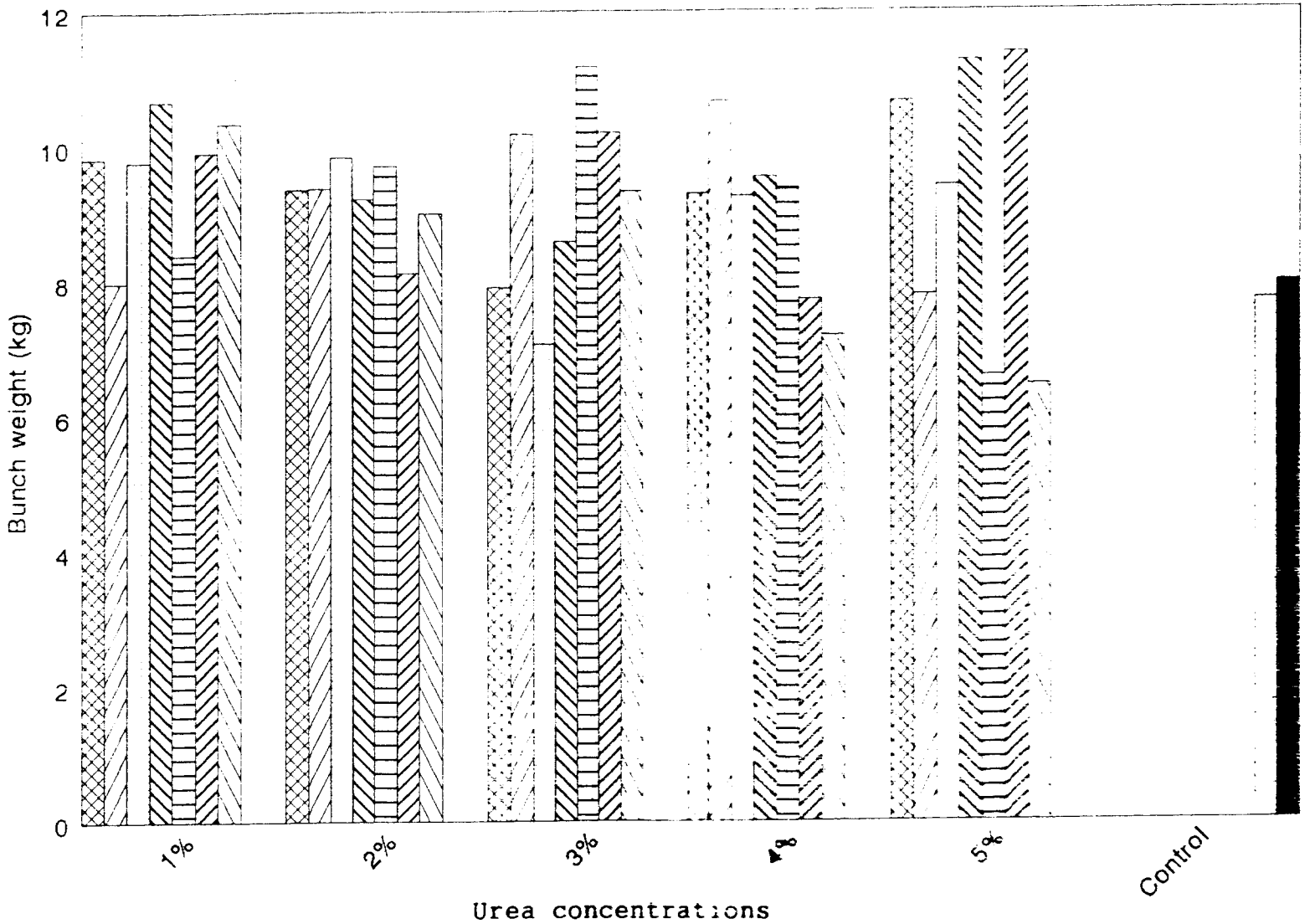


Plate 9 Bunch - Effect of 5% urea spray at 3rd and 5th week after bunch emergence

Plate 10 Urea sprays - Effect on 'D' hand

Plate 11 Urea sprays - Effect on 'D' hand and 'D' finger


T5
CONTROL
T1
T23
T21


CONTROL
T30
T33
T31

4.B.7.4.4 Pulp/Peel ratio

The mean of 2 sprays at 2% concentration at 4th and 5th week after bunch emergence recorded the highest pulp ratio of 4.996 in comparison to control of 4.316. The difference were higher but not significant.

4.B.7.4.5 Pulp thickness

Urea sprays at 3 week after complete bunch emergence with 1% concentration (T_1) and 4% concentration (T_4) and 2 sprays of 1% concentration 3rd and 4th week after bunch emergence (T_{26}) recorded higher thickness of 3.45, 3.45 and 3.55 cm respectively.

4.B.7.4.6 Peel thickness

No much differences resulted due to the treatments. Some of the treatments, like one spray at 3 weeks after emergence of the bunch at 1% concentration (T_1) and sprays of 3% concentration at 4th and 5th week after complete emergence of the bunch (T_{23}) resulted in higher peel thickness of 0.204 and 0.20cm respectively, where as control plants recorded only 0.110 cm and 0.152 cm.

4.B.7.5 Qualitative characters

The data on quality parameters are presented in Table 15.

Table 15 Effect of urea spray on 'quality of fingers' in banana cv. 'Nendran'

Treatments	ANOVA				
	Acidity (%)	TSS (°brix)	Sugars (%)		
			Reducing sugars	Non reducing sugars	Total sugars
T_1 3 waeb + 1% urea	0.358	26.75	12.86	1.549	14.461
T_2 " + 3%	0.499	23.00	14.58	0.369	14.945
T_3 " + 5%	0.371	21.50	12.54	1.931	14.47
T_4 4 waeb + 1% urea	0.371	23.90	11.81	1.909	13.72
T_5 " + 3%	0.379	24.00	10.87	2.196	12.93
T_6 " + 5%	0.397	21.90	10.75	1.881	12.83
T_7 5 waeb + 1% urea	0.422	26.30	15.64	3.212	18.85
T_8 " + 3%	0.346	27.00	13.01	1.132	14.14
T_9 " + 5%	0.486	25.10	16.03	1.13	17.16
T_{10} 3&4 waeb + 1% urea	0.327	26.10	15.05	1.99	17.05
T_{11} " + 3%	0.486	25.30	13.18	1.75	14.92
T_{12} " + 5%	0.371	20.50	10.09	1.21	14.29
T_{13} 4&5 waeb + 1% urea	0.371	25.50	13.28	1.28	14.56
T_{14} " + 3%	0.397	28.30	17.12	0.405	17.52
T_{15} " + 5%	0.538	23.30	15.34	1.64	16.99
T_{16} 3&5 waeb + 1%	0.346	25.00	14.87	1.29	16.11
T_{17} " + 3%	0.435	23.40	14.59	0.99	15.59
T_{18} " + 5%	0.364	22.70	10.71	1.13	11.84
T_{19} 3,4&5 waeb + 1%	0.346	24.10	18.23	0.325	18.58
T_{20} " + 3%	0.397	23.00	13.89	1.918	16.14
T_{21} " + 5%	0.499	25.50	15.59	2.013	17.61
T_{22} Control 1 (water spray)	0.410	27.90	15.93	2.334	18.468
T_{23} Control 2 (No spray)	0.384	27.50	16.09	2.479	17.99
CD (0.05)					
W	NS	NS	NS	NS	NS
C	NS	NS	NS	NS	NS
WxC	NS	NS	NS	NS	NS

W - weeks after bunch emergence; C - concentration of urea; WxC - Interaction

4.B.7.5.1 Acidity

Considering, acidity most of the treatments (urea sprays) resulted in increasing the acidity compared to control (0.384) and highest (0.533%) was noted in the treatment of 2 sprays at 4th and 5th week after emergence of the bunch with 5% concentration (T_{11}). Some of the treatments especially involving the 2 sprays and 3 sprays recorded less acidity than the control plants.

4.B.7.5.2 T.S.S.

T.S.S. content of also varies highly with respect to urea spray. All the sprays except that at 4th and 5th week after been emergence at 3% concentration (T_{14}) resulted in T.S.S. of 28.3° brix which is higher than the control (27.5° brix). The results were however not significant.

4.B.7.5.3 Sugars

7.5.3.1 Reducing sugars

High differences existed among the treatment means. Some of the urea sprays increased the reducing sugars, like one spray after 5 weeks of bunch emergence at 5% concentration (T_9) and 2 sprays at 4th and 5th week after bunch emergence with 3% urea concentration (T_8) and 3 sprays at a level of 1% concentration reported a content of 16.034%, 17.118% and 18.225% respectively.

Table 16 Effect of `urea sprays on maturity, ripening, methionene and carotene content in banana cv. `Nendran'

Treatments	Days to maturity		Days to ripening		Total time to ripening	Methionine (mg/100 g)	Carotene (ppm)
	Total	After treatment	50%	Full			
T_1	76.0	49.5	6.0	7.5	83.5	84.0	42.97
T_2	79.5	42.5	4.5	6.5	86.5	37.5	26.35
T_3	69.5	41.5	4.5	6.5	76.0	103.5	23.26
T_4	68.0	37.0	8.5	10.5	78.5	112.0	43.62
T_5	77.5	41.0	7.0	8.5	86.0	46.5	40.01
T_6	76.5	40.0	5.0	6.5	83.0	92.0	42.18
T_7	66.0	46.0	8.0	10.5	76.5	39.0	53.97
T_8	70.5	43.0	4.0	6.0	76.5	69.0	23.58
T_9	72.5	46.0	5.0	7.0	79.5	45.0	52.02
T_{10}	68.5	45.0	5.5	7.5	76.0	82.0	42.11
T_{11}	71.5	54.0	4.5	6.5	78.0	87.5	27.94
T_{12}	73.0	57.0	4.5	7.5	80.5	52.0	23.64
T_{13}	80.5	-	5.5	8.5	88.5	64.0	42.19
T_{14}	82.5	63.0	7.0	10.0	92.5	42.5	35.96
CD (0.05)							
W	NS	-	NS	NS	-	21.3	NS
C	NS	-	1.07	NS	-	NS	NS
WxC	7.6	-	1.07	NS	-	NS	NS

W - weeks after bunch emergence; C - concentration of urea;
WxC - Interaction; waeb - weeks after emergence of bunch

T1 - 3 waeb + 3% urea
T2 - 3 waeb + 5% urea
T3 - 4 waeb + 3% urea
T4 - 4 waeb + 5% urea
T5 - 5 waeb + 3% urea
T6 - 5 waeb + 4% urea
T7 - 3 & 4 waeb + 3% urea
T8 - 3 & 4 waeb + 5% urea
T9 - 4 & 5 waeb + 3% urea
T10 - 4 & 5 waeb + 5% urea
T11 - 3, 4 & 5 waeb + 3% urea
T12 - 3, 4 & 5 waeb + 5% urea
T13 - Control (no spray)
T14 - Control (water spray)

Table 17 Effect of `urea sprays on urease activity, urea and nitrite N content in banana cv. `Nendran'

Treatments	Urease activity (µmol NH_3/g/min)	Urea (ppm)	Nitrite N (ppm)
T_1	23.85	58.79	0.088
T_2	14.89	65.45	0.065
T_3	30.59	57.11	0.104
T_4	26.95	57.38	0.060
T_5	18.26	43.26	0.088
T_6	36.36	67.28	0.059
T_7	9.03	18.17	0.137
T_8	9.43	28.27	0.102
T_9	12.94	57.06	0.058
T_{10}	14.76	49.17	0.085
T_{11}	34.49	52.86	0.103
T_{12}	20.02	72.87	0.110
T_{13}	7.07	47.85	0.064
T_{14}	27.09	56.72	0.082
CD (0.05)			
W	NS	NS	NS
C	NS	NS	NS
WxC	NS	NS	NS

W - weeks after bunch emergence; C - concentration of urea
WxC - Interaction; waeb - weeks after emergence of bunch

T1 - 3 waeb + 3% urea
T2 - 3 waeb + 5% urea
T3 - 4 waeb + 3% urea
T4 - 4 waeb + 5% urea
T5 - 5 waeb + 3% urea
T6 - 5 waeb + 4% urea
T7 - 3 & 4 waeb + 3% urea
T8 - 3 & 4 waeb + 5% urea
T9 - 4 & 5 waeb + 3% urea
T10 - 4 & 5 waeb + 5% urea
T11 - 3, 4 & 5 waeb + 3% urea
T12 - 3, 4 & 5 waeb + 5% urea
T13 - Control (no spray)
T14 - Control (water spray)

4.B.7.6.2 Carotene

The impact of urea spray on carotene content revealed no significant effects of the different concentrations and number of sprays. The treatments at 3rd week of bunch emergence with 3 per cent urea spray (T_1), 4th week with 5 per cent (T_4), 2 sprays at 3rd and 4th week after emergence of bunch with 3 per cent (T_7), 4th and 5th week with 3 per cent (T_9) were shown higher carotene contents than other treatments.

4.B.7.6.3 Urease activity at fruit ripening

All the treatments resulted in a higher urease activity compared to control (7.075µmol/NH_3/g weight). Among the sprays the highest activity of 36.36µmol/NH_3/g/min was noted in 5 weeks after emergence of the bunch at 5 per cent concentration (T_6) followed by 3 sprays at 3 per cent concentration (T_{11}). The lowest among the treatments was recorded in the 2 sprays schedule of 3rd and 4th week sprays (Fig.15)

4.B.7.6.4 Urea content at fruit ripening

Data presented in Table 17. Show that a highest accumulation of urea recorded when urea at 5 per cent concentration, was applied in 3 sprays. The most intensive treatment recorded urea content of 72.868 ppm/g fruit and the least was observed in 2 sprays of 3rd and 4th week after emergence of the bunch at 3 per cent concentration (T_7) (Fig.16)

Fig.15 Effect of urea spray on urease activity (μmol NH_3/g/min) in banana cv. `Nendran'

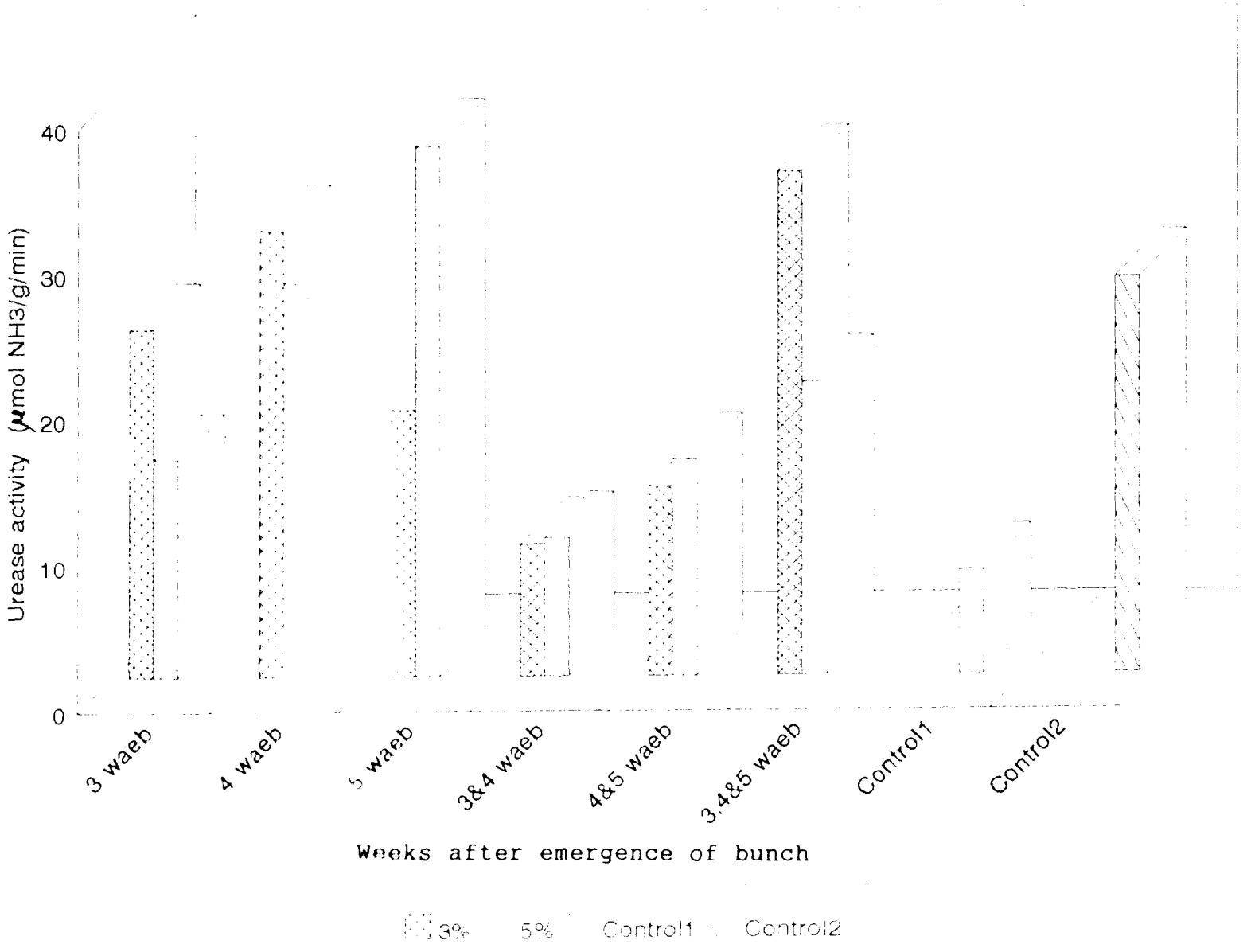


Fig.16 Effect of urea spray on urea content (ppm) in banana cv. `Nendran'

4.B.7.6.5 Nitrite N content

The treatment which reported the least urea content showed the highest nitrite N content of 0.137 ppm with urea sprays done at 3rd and 4th week after bunch emergence at 3 per cent concentration (T_7) the least content of nitrite N was noted in treatments of 2 sprays at 4th and 5th week after emergence of he bunch at 3 per cent concentration (T_9). Control plants also contained some amount of nitrite N.

From the results it may be inferred that in case of bunchstalk feeding, enforcement of 30g urea, two weeks, four weeks and three weeks after completion of female phase, recorded best bunch weight and excellent bunch and finger characters. In case of urea sprays, 5 percent concentration of urea in two sprays i.e., 3rd and 4th week followed by 3rd and 5th week after emergence of the bunch, after female phase were the superior and elite treatments and resulted in better characters both in quantitative and qualitative terms.

Discussion

DISCUSSION

The results of the investigation on "Bunch stalk feeding of urea in banana *Musa* (AAB group) `Nendran'" are discussed under the following major heads.

5.1 Morphological characters

5.1.1 Angularity

From the data generated in the preliminary experiments, it can be confirmed that pruning of male bud at 20 cm from the last hand, 20 days after complete emergence of the bunch and placement of urea <50g and adopting the flat cut increase the angularity of the bunch whereas volumes of urea spray did not effect it.

The increment in angularity is due to the fact that the male bud act as a competitive sink siphoning the highest quantity of applied nutrients. This has been inferred by Kurien *et al* 1996 and this could be the reason for increased yield by male bud removal. Secondly, there could be enhanced translocation of nutrients to the fingers which otherwise lost for the opening of male flowers. This reason was opined by Amma *et al.* 1986.

5.1.2 Fruit Curvature Index (FCI)

Prickling of the peduncle, after removing the male bud at a distance of 20 cm from the last hand, after 16 days or beyond the completion of female phase, tying a maximum dose of 90g and spray volume of 750 ml at one per cent concentration resulted in a higher FCI.

From the main experiments it has been concluded that 10g urea placement at the cut stalk end, four weeks after completion of bunch emergence and 3 sprays of urea at 3rd, 4th and 5th week after bunch emergence at a concentration of 3% resulted in fruits with maximum FCI. More curved fruits obtained when 50g urea placement was done after 1 week of bunch emergence.

Either an increase in length or a decrease in curvature could increase the FCI. The treatments which have registered better length and this could be the reason for the higher FCI. Doses above a critical limit should have hampered the process of absorption and translocation which is the reason for the blackening of the peduncle and pedicel and ripening of fruits, receiving >50g. It is clearly evident from the results of spray, where with even increased frequency but moderate concentration, FCI is best.

5.1.3 Pedicel strength

Male bud pruning and urea treatments reduce the pedicel strength resulting in weak pedicel. In contrast to this, 20g urea placement on the cut stalk end and the control water spray lead to stronger pedicels.

In the main experiments, bunch stalk feeding with 30g urea, 4 weeks after bunch emergence and 2 sprays of 5% concentration at 3rd and 4th week after emergence of the bunch recorded the maximum pedicel strength.

Urea treatment and male bud pruning increased the pedicel length in certain cases and decreased the diameter in others. Any way, both lead to weak pedicel. A second reason is that translocation should have occurred as seen by the quantity of molecular urea absorbed and hence the length increased consequently, reducing pedicel diameter, whereas, certain treatments which recorded maximum pedicel strength showed a balanced increment of diameter of pedicel. Such cases also showed increased grade/girth of the finger.

5.1.4 Filling index

The preliminary experiments signify their superiority in increasing the filling index, by removing the male bud using either oblique or flat cut, 20 days after bunch emergence at distances of 12 cm and above from the last

5.2 Days to maturity

Retention of male bud increased the time required to reach harvestable maturity. It is evident from the results that, trimming the male bud at a shorter distance from the last hand, in V shaped model, 1 day after bunch emergence and placing >40g urea at the cut ends bring about the earliest maturity. Also, spray volumes of 250 and 750 ml at 1% concentration are of similar results

The main experiments are also in the same view. 40g urea placement 1 week after bunch emergence and 2 sprays of 2 and 4% concentration at 3rd and 4th week period advanced the maturity at the earliest.

The anatomical side morphophysiological aspects of finger development of `Nendran' has been examined at length by Kurien *et al.* (unpublished) where it has been observed that the early of is characterised by increased cell division, a mid stage by cell development where a lot of aecrenchymatous cell are observed, followed by the later stage of maturity characterised by increased starch grain filling. At this stage cell enlarges and air space reduced to minimum. The results point to the specific stage of finger development wherein urea placements and spray, should have reduced the length of each phase and increased the starch filling to achieve early maturity. However detailed histological studies can only conclusively prove

this beyond doubt. The method of `V' cut reinforces the concept of maximum surface area for urea placement and fast absorption.

5.3 Days to ripening

Pruning of male bud at the shortest distance from the last hand, using wedge cut method, and enforcing the cut 8 days after female phase completion enhanced the ripening. A spray volume of 750 ml at 1 per cent level also had profound influence on ripening the fruit earlier than other treatments.

The main experiments put forward two conclusions, ie. bunch stalk feeding of urea does not alter the number of days taken for ripening, but urea given as a single spray of 4 and 5 per cent concentration at 3 weeks after bunch emergence reduced the ripening period.

The more proximity of the cut to the last hand lead to an early ripening by easy allocation and translocation of the applied urea. The superiority of urea spray over bunch stalk feeding showed that application of urea in the acqueous form has resulted in better absorption, made the march to senescence faster and in the process hastened ripening. It has already been reported that, tying urea at the rachis make available the urea in acqueous form at

later stages and for a prolonged period (Buragohain and Shanmugavelu, 1986). Among the methods of cut, 'V' cut has its effects on ripening by providing more surface area for absorption of ammonia from urea.

5.4 Shelf life

Male bud pruning at 4 cm length (shortest distance) and urea feeding, adopting any method of cut and doses reduced the shelf life to a greater extent, compared to the control. The different spray volumes had also their influence on enhancing the senescence.

In the main experiment, the least shelf life of 1.5 days recorded in 30 g urea placement at 4 weeks after bunch emergence and 50g after 1 week. In genera, the highest dose of 50g and 4 weeks pruning showed significant reduction, in shelf life. Among the urea sprays, 2 sprays of 5% level, at 3rd and 4th week after complete bunch emergence lead to faster senescence within 1 day.

The easy translocation of nutrients should result in early maturity and hence ripening and senescence. Mobilisation of nutrients, during senescence serves as an essential physiological function, integrating two temporarily and spatially separated events senescence and growth (Ghosh *et al.*, 1995). The enhanced decay can only be logically interpreted to be due to the increased

ethylene production, which is revealed by studies on content of methionine, the basic substrate for the production of ethylene (Mattoo and Aharoni, 1988) and the fast methionine degradation observed in such treatments.

5.5 Yield

Yield is represented by various attributes like bunch weight and finger characters.

5.5.1 Bunch weight

Data generated from the preliminary experiments revealed that male bud pruning at longer distances of 12 cm and above, adopting flat cut method, placement effected 12 days and beyond with optimum dose of 30g enhanced the yield significantly. Also spray volume of 250 ml (at 5% concentration) improved the yield.

In the main experiments, 30g urea placements at 2nd, 4th and fill by 1st and 2nd week and urea spraying at 5% level in 2 sprays of 3rd and 5th week and also 3rd and 4th week after bunch emergence, were superior in their effect on bunch weight. The higher levels of urea also had negative effect on bunch growth.

Urea levels of >50g should have lead to the fast absorption of large quantity nutrients (in the form of NH_3)

by the last hand which in turn should have crossed the critical limits and caused the blackening and rotting and finally yield reduction. The urea content in control was 47.85 ppm and in the treatment combination of 2 week + 30 g was 39.89 and when 50 g was given it is 68.85 ppm respectively revealing that there is a genetic capability of plant to adjust below a limit and above this it results in metabolic disruption. Above a critical limit it would have also affected polyphenol oxidase.

The yield increments resulted from male bud pruning should be argued from different angles. Firstly it would have helped in saving in the utilisation of energy which otherwise is lost for opening of male flowers (Amma *et al.*, 1986). Secondly, maximum and effective channelisation of nutrients to the fruit as retention of male bud makes it the most competitive sink (Kurien *et al.*, 1996) and thirdly due to higher filling index which can be confirmed from the higher values observed in the study.

The urea feeding which in turn influence the final yield, can be explained in view of certain statements. Mothes and Englebrecht (1952) are in the view that in some circumstances, allantoic acid can account all of the ureide nitrogen and according to Mothes, these compounds may assume the role in storage and translocation, which in many plants is performed by aspargine and glutamine. Calvin *et al.* (1952) reported that in plants allantoin and allantoic acid are seemed to be more immediately concerned

with synthesis and use of nitrogen they contain, and they may be derived from glyoxylic acid with urea as a possible donor.

Foliar application of urea, enhanced the urease activity several fold. It was reported by Lakkineni *et al.*, 1995. Complete review of literature has revealed that urease and its activity is for the first time being reported in banana fruits. The plants showing better bunch weight revealed higher urease activity and in turn their capacity and efficiency to hydrolyse the urea and enter into the metabolic pathway. The study opens out the possibility for further research in this line.

5.6 Finger characters

Weight, length and girth (grade) of fingers at harvest and also finger characters at ripened stage are discussed below.

5.6.1 Finger weight

Trimming male bud far from the last hand (20 cm) with a flat cut/prickling after 16 days or beyond bunch emergence with 30g urea placement and also spray volumes of 1000 ml at one per cent and 250 ml at five per cent resulted in maximum finger weight compared to the control plants.

In the main experiments, weight of fingers at first, second and last hand were taken for studying the level of

translocation of nutrients. 30g placement at one week after bunch emergence increased the weight of the first (earliest) hand finger, whereas 10g and 30g, 2 weeks after emergence resulted in better fingers than others in the last hand. The `D' finger weight was maximum, when 30g urea placements were made 1, 2 and 4 weeks after bunch emergence. Among the urea sprays, the orderly effects on first, second and last hand are 2 sprays of two per cent concentration at 3rd and 5th week after emergence, two sprays of five per cent concentration at 3rd and 4th week after emergence of the bunch and 3% spray at 3rd and 4th week after complete emergence. These sprays increased the finger weights than all other treatments.

More filling index due to better nutrient allocation, higher urease activity and accumulation of urea clearly explain the reasons for increase in finger weight.

5.6.2 Finger length

Male bud pruning, 20 cm away from the last hand, either by flat or `V' cut and placing urea 16 days or after that had profound influence on elongation of the fruit. Also maximum dose of 70g and spray volumes of 250 ml at one per cent and five per cent increased the length.

In the main experiments, urea placement, 2 weeks after bunch emergence with doses of 10, 20 and 40g and 3 sprays in 3rd, 4th and 5th week at 1% level gave extra length to the fruit compared to control.

It can be inferred that the utilization of nutrients was more for the cell elongation of the fruit rather than cell multiplication and enlargement resulted in more length than girth. The urease activity also coincided with lengthening of the fruit. Higher concentrations and when frequency of sprays of urea (3 sprays) have adverse effects, by accumulating the highest quantity of urea and also higher amount of nitrite N and once accumulation is high they both prevent further absorption and translocation. This suggestion is in line with the reports of Mitsui and Kurihara (1962). According to them, urea taken up through the rice roots, is converted to ammonium carbonate by urease at a slower rate than it is absorbed. This may result in accumulation of urea prohibiting further urea absorption. In the present study, placement and spray has been given directly on the fruit and this accumulation-translocation concept should hold good in this case also.

5.6.3 Finger girth/grade

The preliminary experiment results on grade as in the case of distance and method of cut and time of application of urea, are same as that of length. But contrary to 70g urea, 30g placement was superior and spraying with 1 or 5% urea using one litre spray volume was the best.

In the main experiments too, 30 g urea placement after 4 weeks and spray of 1% after 5 weeks of bunch emergence are the best. All the single sprays had influence at 4% level.

Higher levels of urea at later stages as well as even smaller quantity immediately after bunch opening lead to inferior finger size. Pruning the male bud and urea feeding before the stage of active cell division and cell elongation influences the fruit development in the negative way. In the final stage of development cell enlargement takes place reducing the air space and then starch filling takes place (Kurien *et al.*, unpublished). It should be inferred in this case that starch filling takes place in the cells which are under developed. Atkins *et al.*, 1975 and Pate 1984 reported that in legumes, during the early stages of fruit growth, a higher proportion of nitrogen enters the fruit through xylem when soluble nitrogen pools are being established for the development of fruits and seeds.

The later application of urea, a nitrogen source, explain the possibility of its involvement in fruit development coinciding or after the stages of cell division, when the early nitrogen pool get exhausted. This should have enhanced the uptake as it can be confirmed from increased absorption of urea and higher urease activity.

5.6.4 Ripened fruit characters

These characters were analysed only in the main two experiments.

5.6.4.1 Ripened fruit weight (`D'finger) and pulp weight

These two characters are related with the `D' finger weight at harvest and the interpretation put forth holds good in these cases as well.

5.6.4.2 Peel weight

All the bunch stalk feeding, treatments and urea sprays except 4 weeks sprays at 3% concentration recorded higher peel weight than control.

During the first month after shooting the peel represents 80 per cent of the total finger weight (Lassoudiere 1977). It has been confirmed by Kurien *et al.* (unpublished) that peel development occurs ahead of the pulp and is a natural adaptation seen in this crop to ensure proper protection of the pulp. Eventhough, the finger weight is increased the nutrients may be translocated in a balanced manner. It should be inferred that the released ammonia from urea, by the urease activity effected the peel weight more efficiently than the control plants.

5.6.4.3 Pulp/peel ratio (PPR)

The main experiments reported the superiority of untreated plants except in urea spray done twice at 4th and 5th week after complete emergence of the bunch at two per cent level. The more peel weight actually lead to the less PPR.

5.6.4.4 Pulp thickness

Urea placement of 30g, 2 weeks after bunch emergence and spraying of 1% and 5% urea 2 times at 3rd and 5th weeks after female phase recorded maximum pulp thickness. Thickness of the pulp is correlated with high value of finger grade and more filling index. The active cell division of pulp is usually observed in `Nendran' 3 weeks after complete emergence. An extra supply and that too in the quick assimilable form should have favoured cell enlargement ensuring faster growth of pulp than peel which should have lead to the increment in thickness.

5.6.4.5 Peel thickness

No definite trend are observed either in increasing or decreasing the thickness. The maximum thickness was noted in 20g and 30g urea placements, 1 week after bunch emergence and in urea sprays at 3rd weeks with one per cent and 4th week with three per cent.

It should be inferredthat early application coincided with the time of peel development thus enhancing peel thickness in all cases.

5.7 Quality

In general, both in urea feeding and spraying acidity was found to be increased. This is in line with the views of Patel and Patel (1987). Coinciding with the increments in acidity, the TSS, reducing, non-reducing and total sugar decreased.

During ripening, the starch get converted into sugars. The reason, for the low sugar content may be the action of urease/urea on hydrolytic enzymes, which in turn should have reduced the starch conversion to sugars. Reducing sugar is normally more when it ripens. Studies have shown that reducing sugar is more and hence explains the reason for early ripening. Reduction in non-reducing sugar has occurred probably due to more conversion of starch to reducing sugar. More detailed studies at different physiological stages is required in this direction to fully explain this finding. Urea sprays are superior in changing quality in relation to bunch stalk feeding. In general, it can be inferred that urea feeding decrease the fruit quality.

5.8 Biochemical characters

5.8.1 Methionine content

The bunch stalk feeding resulted in a lesser methionine content, in comparison with control and in urea sprays there existed higher variation. The least methionine levels were recorded by 3 sprays, at 3% concentration. Some of the treatments like single spray at 3rd week of bunch emergence with three per cent, 4th week with 3 and five per cent , 5th week with five per cent and 2 sprays of five per cent concentration at 4th and 5th week of bunch emergence recorded more methionine than both the controls. A lesser content represented higher ethylene production, hence it could progressively activate the time to senescence. Reports of Lugg and Weller (1948) showed that changes in cysteine and methionine contents occurred decreasing senescence, but no definite progressive changes, occurred. Under conditions of protein synthesis most of the amino acids decreased in amount to such an extent as to be no longer capable of detection, in chromatograms. Innumerable reports on the metabolism of senescence and methionine are already available (Beauchamp and Fridovitch, 1970; Kende and Beumgartner, 1974; Varner and Ho, 1976 and Eskin and Grossman, 1977).

5.8.2 Carotene

Tying of urea as well as sprays resulted in significant reduction in carotene contents, except in two treatments. A decrease in carotene content in lettuce by nitrogen fertilization was reported by Leclerc *et al.*, 1990).

During the ripening process, the chlorophyll degradation occurs and carotene increases in banana (Patil and Magar, 1976). According to Martinoia *et al.*, 1982, large increase in chlorophyllase activity (role in normal chlorophyll turn over) during senescence of leaves and during ripening of fruits. In the early setting of senescence, degradation of chlorophyll should have occurred and it can be concluded that the suppression of chlorophyll synthesis has occurred with urea treatment. In some cases, the suppressed carotenes might have been expressed showing a higher level. The reason for the same can be explained only after detailed analysis.

5.8.3 Urease activity and urea content

Both the main experiments show high variation in urease activity levels. No reference of *in vitro* urease activity of banana has yet been made and probably this is the first study reporting the same.

Reports of urease activity in other crops like wheat (Bradley *et al.*, 1989 and Lakkieine *et al.*, 1995), leafy vegetables (Luo *et al.*, 1993) and in rice (Mitsui and Kurihara, 1962, Saraswathi *et al.*, 1991 and Safeena, 1992) are available.

In bunch stalk feeding a higher urease activity coincided with higher bunch and finger grade which revealed

the possibility of conversion of urea into NH_3 and Co_2. The NH_3 get incorporated into amino acids then into protein via glutamate synthase cycle (Kumar and Abrol, 1990) or by the reports of Calvin *et al.*, by the allantoin and allantoic acid cycle.

Actually when there is a higher level of urease activity, the urea content should be decreased by hydrolysis of urea (Safeena, 1992). But if the substrate concentration is high, a higher molecular absorption may result. Dilley and Walker (1961) observed that apple and peach leaves supplied with ^{14}C labelled urea assimilated this in amino acids, amides, proteins and other soluble compounds within 20 hours. Only a small portion of urea absorbed by the peach remained in the leaves as unhydrated urea. The extent to which the nitrogen of urea is utilised can be known, only if the initial tissues were analysed (Steward and Pollard, 1959).

The study showed that molecular absorption of urea does take place in banana fruits but a further look into its metabolism need to be carried out using tracers like ^{14}C urea or ^{15}N urea.

5.8.4 Nitrite N content

The two main experiments pointed out that, only a very little quantity is present in fruits of banana. In bunch

stalk feeding a higher dose of 50 g resulted in more nitrite N and also there is some correlation between urea content and nitrite N. In certain treatments, lower urea content resulted in a higher nitrite content.

Nitrite N is formed from nitrate which is causing methemoglobiemia (Wright and Davison, 1964). The toxic levels are not yet reported in fruits. In the present study, however the nitrite N (which is actually a total of nitrate and nitrite since nitrate is first converted to nitrite by the procedure and read) recorded is very low and even the control which gave intermediary values almost equal proportion of nitrite N is observed.

The study has proved beyond doubt that all treatments influence the time taken to maturity and ripening and hence opens out another line of immense practical utility. It reveals that application of urea can stagger the crop production and hence avoid market glut and ensure better return with least inputs.

Finally, it may be concluded that the bunch stalk feeding of urea and urea spray after male bud pruning, explained in terms of molecular absorption of urea and *in vivo* urease activity, improves the bunch and finger characters and boost the production and productivity of banana, but reduces shelf life. But further research in this aspect is in need, using tracer techniques.

Summary

SUMMARY

Investigations on "Bunch stalk feeding of urea in banana *Musa* (AAB group) `Nendran'" were carried out in Central Orchard attached to the Department of Pomology and Floriculture at College of Horticulture, Vellanikkara during the period from June 1996 to June 1997. The studies consisted of five preliminary experiments for standardising the techniques, and two main experiments. The experiment was laid out in Completely Randomised Design with two replications. The results of the experiment are summarised below:

1. Male bud pruning and bunch feeding of urea, both have proved their significant influence on improving the morphophysiological features of the bunch. Pruning the bud, a farther distance of 20 cm from the last hand, adopting the flat cut with an optimum dosage of 30 g urea, 2-3 weeks (more specifically 20 days) after complete emergence of the bunch resulted in higher yield with attractive bunch characters.

2. Yield and yield parameters ie., bunch weight/grade, and finger characters are significantly affected by the above mentioned bunch management practices. But the

above mentioned bunch management practices. But an optimum level and time of application ensures the maximum return with minimum inputs.

3. Finger characters especially, length, grade and weight of mature fruits were more emphasised and it is clearly evident from the results that the bunch grade is increased in terms of improving the finger grade. Optimum dose of 30g during the 2nd and 4th week of complete bunch emergence and spraying urea, at two times, ie., 3rd and 5th week after the bunch emergence, which is closely followed by 2 sprays at 3rd and 4th weeks of emergence. Both were superior at 5% concentration level.

4. A significant impact of male bud trimming and urea feeding on advancing the crop even by 1-2 weeks by reducing the time taken to maturity, solve the serious problem of `market glut' to a greater extent and help to realise the maximum price. All the treatments imposed were superior in this respect.

5. Pruning the male bud, closer to the last hand significantly reduces the ripening period (maturity to ripening), but other treatments almost on par with each other.

6. A major defect observed was drastic reduction in case of shelf life. Urea treatments lead to the commencement of deterioration of the fruit within 1-2 days of ripening. Higher doses, greater than 50g urea, cause blackening of the peduncle, followed by early ripening and rotting of last hand in the field itself.

7. There is a reduction in quality observed by urea feeding, but its impact is not significant. Even a slight increase in acidity and lower sugar contents were noticed.

8. Biochemical analysis of the ripened fruit found out a relation with the process of ripening and decay with methionine and carotene contents. Enhanced deterioration is influenced by low methionine level and carotene contents.

9. The study establishes for the first time that urease activity and molecular absorption of urea takes place in the fruit. A higher urease activity was coincided with a better bunch and finger characters. In certain cases a lower accumulation of urea and more urease activity and in others the reverse, due to the higher initial substrate level before the treatments, have occurred. Very low level of Nitrite N accumulation is also reported.

10. A general assay on the net return from urea treatments, show that with a minimum input of 10 paise (cost of 30 g urea) an yield increment of 4.4 kg reported from a bunch compared to the control. However in the preliminary trial which included a control (male bud retention) and a system control (male bud trimmed), the additional yield was 2.8 kg and 1.3 kg respectively. It is concluded from the prevailing price of Rs.15/kg, the additional returns were Rs.66, Rs.42 and Rs.19.5/- respectively.

11. The urea spray also point out its impact on increasing the yield. The experiment which included a control (no spray) and a system control (water spray), the additional yield was 3.7 kg and 3.4 kg respectively and an additional return of Rs.55/- and51/- respectively.

12. Out of the two main treatments, bunch stalk feeding and urea spray, the stalk feeding, resulted in an additional yield of 1.12 kg and return of Rs.16.80/- bunch.

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* Original not seen

Appendix

APPENDIX I

Weather data at monthly intervals during the experimental period (June 1996 - June 1997)

Months	Rainfall	Temperature		Relative humidity	Sun shine (hrs)	Wind speed (km/h)
		Maximum	Minimum			
June 1996	400.3	30.5	23.8	84.5	4.7	3.0
July	588.7	28.8	23.1	89.5	2.7	2.7
August	310.0	29.1	23.6	86.5	3.7	3.0
September	391.6	29.2	237	84.0	4.3	2.7
October	219.3	30.1	22.9	81.5	6.0	2.0
November	22.1	31.5	23.6	71.5	7.1	3.7
December	60.4	30.5	21.8	67.5	6.8	6.4
January 1997	0.0	32.0	22.9	61.5	9.6	6.9
February	0.0	33.9	21.8	60.5	9.3	3.9
March	0.0	35.7	24.0	59.5	9.6	4.0
April	8.2	35.2	24.5	66.5	9.6	3.3
May	63.0	34.4	24.5	72.0	6.7	3.3
June	720.5	31.2	23.0	82.0	5.9	2.7

BUNCH STALK FEEDING OF UREA IN BANANA *Musa* (AAB group) 'NENDRAN'

By

T. K. ANCY.

ABSTRACT OF A THESIS

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Kerala Agricultural University

Department of Pomology and Floriculture
COLLEGE OF HORTICULTURE
VELLANIKKARA - THRISSUR
KERALA, INDIA

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ABSTRACT

The experiment entitled "Bunch stalk feeding of urea in banana *Musa* (AAB group) `Nendran'" was carried out at the Department of Pomology and Floriculture, Vellanikkara during the period of 1996 June to 1997 June with five preliminary and two main experiments. The major objectives of this research was to study the effect of bunch management practices like male bud pruning and urea feeding in banana on yield and quality attributes and also the metabolism of urea in the fruit. The experiment was laid out in a Completely Randomised Design with two replications.

The preliminary experiments had undoubtedly, proved the fact that, pruning the male bud at a distance of 20 cm from the last hand improve the bunch characters and yield.

Urea feeding through the cut and of bunch stalk also had its impact on getting maximum return with minimum inputs. Placement of an optimum dose of 30g urea at the cut stalk end, 3 weeks after the complete emergence of the bunch by adopting the flat cut method increased yields. A higher dose, greater than 50g resulted in negative effects on the quantitative and qualitative aspects of the bunch as well as fingers.

The main experiments on bunch stalk feeding, also reinforced the superiority of 30g placements at 2nd and 4th week after the emergence of bunch, after female phase recording an yield increment of 4.4 kg over the control.

Urea spray, with a spray volume of 250 ml, at 5% concentration, 2 times on a bunch i.e., 3rd and 5th week and also at 3rd and 4th week recorded an yield increment of 3-3.5 kg, compared to the control. Higher doses and more frequency of urea spray resulted in a retearding effect on bunch development.

Bunch feeding with urea did not reduce the quality significantly. But a slight increase in acidity and reduction in sugar content and TSS were noticed.

The urease activity and molecular absorption of urea studies, to a great extent explain the metabolism of urea feeding in banana fruits. However, the rapidly expanding direct application of urea as a fertilizer and results generated in the study points to a re-evaluation of the existing methods, the role of this compound and the manner of its application and assimilation.