REGULATION OF FRUIT SIZE AND MATURITY IN PINEAPPLE

BY
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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Regulation of fruit size and maturity in pineapple" is a record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

We, the undersigned, members of the Advisory Committee of Kumari Baby letha,A.K. a candidate for the degree of Master of Science in Horticulture with major in Horticulture, agree that the thesis entitled "Regulation of fruit size and maturity in pineapple" may be submitted by Kumari Baby letha,A.K. in partial fulfilment of the requirements for the degree.

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INTRODUCTION

INTRODUCTION

Regulation of fruit size and maturity has been of great concern to the fruit grower, ever since fruit culture became established on scientific lines. Although these aspects are primarily controlled by genetic factors, environment and management practices play an important role on them (Gardner et al.,1952). Pineapple which is one of the most important fruits of Kerala is commercially utilized to a major extent for canning purposes and therefore uniformity in fruit size is of paramount importance. For canning purposes the fruit should be of medium size with a fruit weight of 1.5 kg.(Das et al.,1965).

In spite of spectacular achievement obtained in controlling flowering in pineapple by the application of ethrel in recent times (Das et al.,1975 ; Balakrishnan et al., 1978 and Santha,1979), complete uniformity in fruit size in large plantings even under uniform cultural and manurial schedules is seldom achieved in Kerala. Both in the plant crop and especially in ratoons considerable percentage of fruits fall below standard size with the result that their utilization for canning purposes are made difficult. If the smaller fruits could be improved by the application of growth regulators it will have much practical value. Regulation of fruit maturity is

also a desirable practice so that harvesting period could be extended, preventing a possible glut in the market.

A physiological approach viz., through the application of growth regulators has yielded successful results in regulating fruit size and maturity in several fruit crops and also in pineapple. In pineapple among the growth regulators tried NAA has been found to be most effective. Observational trial conducted in the Kerala Agricultural University had also indicated that NAA was effective in increasing the fruit size.

However a proper recommendation of NAA under Kerala conditions based on systematic studies is not available. The present study was initiated with the following objectives.

i. Fixing the optimum time of harvest of fruits.

ii. Studying the effect of alpha-naphthalene acetic acid on fruit size, maturity and quality of fruits.

iii. Studying the effect of alpha-naphthalene acetic acid on size maturity and quality of fruits from plants having different leaf number.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

A brief review of various aspects of regulation of fruit size, maturity and quality of fruits, in pineapple is presented here under.

1. FRUIT MATURITY

Biochemical changes during growth and development of fruits are important factors in fixing the maturity standards of fruits.

Miller and Hall (1953) observed that in mature pineapple, the basal segment was more mature than the middle portion, and this in turn was more mature than the top segment. The result was also confirmed by the progressive decrease in bromelin activity from top to bottom and he observed that the activity of this enzyme decreased with maturity of pineapple. Py (1955) observed that larger the fruit, the shorter was the maturation period. He also found that high N application without K resulted in longer maturation period of fruits.

Tow (1959) reported that close planting or addition of N and K fertilizer delayed maturity, while high leaf P and straw mulching hastened ripening. There was also a negative correlation between the number of days from flower emergence to maturity and the square root of

the mean temperature for 30 days after emergence. Huang (1960) made studies on the picking maturity of the pineapple and found that for use as fresh fruit and for canning, pineapples were to be picked when the flesh turned light yellow colour and flavour not too acid.

Hope (1963) found that the sugar content of the fruits increased continuously throughout the life until it was over ripe, the rate of production was much higher in summer than in the winter fruit. In both summer and winter pineapples, fruit quality as judged by paletability was best when acidity reached its peak. There was also variation in acidity depending upon the climatic conditions and the amount and type of fertilizer used in both summer and winter pineapples. He also found that winter fruits took 185 days to reach the peak of acidity and summer fruits 155 days.

Montonegro (1964) studied ripening of pineapple fruit. Pineapple fruits of the variety 'Perola' were harvested at five stages of ripeness (determined by colour) and analysed for juice per cent, brix and acidity. It was found that by the time the upper part of the fruit had developed yellow centres to its segments, a sharp rise in brix and juice content and a sharp fall in acidity had occured. The juice content remained constant until

the onset of senescence when it increased rapidly. Brix values rose fairly steadly end acidity fell very slightly throughout ripening and senescence. According to him fruits should be harvested at green stage for canning and for immediate marketing the fruits should have an orange tint in the centre and a slight aroma. Anon (1965) reported that the stage of maturity at which pineapple was harvested depended upon its use. Fruits for home use should be picked when 25 per cent yellowing of the fruit attained at which stage the fruits had higher T.S.S. and low acidity.

Singleton and Gortner (1965) showed that variation in ascorbic acid content during development of pineapple fruit was more related to short term weather conditions, and not with the stage of fruit development. It was also found that acidity rose significantly as the fruit matured and 10 days after a peak reached, the fruit was at optimum maturity. Teotia and Bhan (1966) made studies on physical and chemical changes in the variety 'Giant Kew' pineapple during ripening. On the basis of results, he recommended that to obtain high quality, the pineapples should be harvested when the specific gravity is in range of 0.98 to 1.02, the T.S.S. content 14.8 to

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17 per cent, T.S.S/acid ratio 20.83 to 27.24 and when the fruit developed a yellow to brownish colour.

Gortner et al. (1967) enumerated three distinct stages of fruit development based on biochemical changes as prematuration, maturation and senscence. Most of the chemical constituents like starch, total sugars and non-reducing sugar showed a decreasing trend in the prematuration stage. When the fruit reached early maturation, total sugars increased, non-reducing sugar decreased, while starch content remained constant. In the late maturation stage, sucrose and total sugars were more or less constant.

Bowden (1969 a) studied on the ripening of pineapple and he found that there was a relationship between fruit translucency and processing quality of pineapple. With increasing translucency, the pH,total soluable solids/acid ratio, fruit weight and total ester concentration increased and acidity decreased. T.S.S., fresh pigments and palatability increased to a maximum in the medium range of translucency and then decreased with further increase in translucency. So he considered semitranslucent fruits as most suitable for canning.

Mookerji et al. (1969) studied the chemical and physical changes occuring during pineapple fruit development. It was found that there was abrupt changes in the total soluable solids and acidity in the fruit after 110 days of fruit set. The acidity reached a peak on 115th day and thereafter there was a decline. The ascorbic acid content remained constant during earlier stages of maturation, but decreased in later stages. Chadha et al.(1972) studied the biochemical changes associated with growth and development of pineapple variety 'Kew'. The weight of the fruit increased gradually upto 75 days after flowering. Thereafter there was a sharp increase in weight until 150th day after which the weight stabilized. Total soluable solids and acidity increased with maturity, but T.S.S./acidity ratio decreased in the mature stage. The ascorbic acid content decreased in early stages, but did not show any appreciable change in later stages.

Lodh et al. (1973) observed that in 'Kew' pineapple, the prematuretion stage was at 0 to 120 days after flowering, early maturation 120 to 150 days and the late maturation 150 to 165 days. After 165 days ripening and senescence started. They also reported that the concentration of chlorophyll decreased slightly upto 135 days from flowering, thereafter the chlorophyll loss

from the peel became more rapid.

Pantastico (1975) reported the following seven shell colours to determine the various stages of maturity.

No.0. All 'eyes' are green with no trace of yellow.

No.1. Not more than 20 per cent of the 'eyes' are predominantly yellow.

No.2. Not less than 20 percent but not more than 40 per cent of the 'eyes' are predominantly yellow.

No.3. Not less than 65 per cent but more than 55 per cent of the 'eyes' are predominantly yellow.

No.4. Not less than 65 per cent but not more than 90 per cent of the 'eyes' are fully yellow.

No.5. Not less than 90 per cent full yellow but not more than 20 per cent of the 'eyes' reddish-orange.

No.6. 20 per cent to 100 per cent of the 'eyes' predominantly reddish-brown.

No.7. The shell is predominantly reddish-brown and showed signs of deterioration. According to him pineapple with shell colour nos.2 to 4 should be harvested when used for local consumption.

2. EFFECT OF DIFFERENT CHEMICALS ON FRUIT DEVELOPMENT, MATURITY AND RIPENING.

2.1. Fruit development

Clark and Kerns (1942) studied the effect of alpha-naphthalene acetic acid (NAA) sprays on the fruit development of pineapple plants. Spraying was done after the completion of the normal floral differentiation, but prior to actual blossoming. It was found that application of relatively high concentrations as 0.05 per cent produced a marked increase in size and weight of the fruit, while the lower concentrations had no significant effect in comparison with the controls. Application of NAA also resulted in an increase in peduncle length.

Van Overbeek (1946) reported that NAA application resulted in increased fruit weight, while application of 2,4-dichlorophenoxy acetic acid (2,4-D) resulted in a lower average fruit weight as compared to NAA. The low fruit weight was attributed to the adverse effect of 2,4-D on developing young leaves. Miller and Marsteller (1953) reported that application of parachlorophenoxy acetic acid (PCPA) when applied on pineapple fruit 10 days before harvest did not alter fruit size or length.

Hayes (1957) reported that concentrated spray of NAA on fruits several weeks before the normal time of harvesting increased fruit size. Evans (1959) observed that growth promoting substances like NAA, beta-indole butyric acid (IBA), hortamone A, planofix and seradix all exerted a tremendous influence on fruiting of pineapple. By application of these chemicals the fruit weight was increased, but when immature plants were treated fruit weight was reduced. Collins (1960) found that when NAA was applied after fruit formation, the fruits grew larger and the peduncle increased in length and diameter.

Anon (1964) reported increased fruit size by application of NAA. The fruit weight increased progressively as the concentration of NAA increased, reaching the maximum at 200 ppm. There was increase both in length and diameter of fruits. Das (1964) reported that when pineapple plants were treated with NAA alone and in combination with malic hydrazide (MH), the fruits produced were heavier. Fruit volume also increased, but dimensions or fruitlet numbers did not vary markedly. The effect of MH alone was found to be deleterious in that the fruits were undersized.

Barbier (1964) found that the application of sodium beta-naphthoxy acetate (NaNOA) had no effect on fruit characters of pineapple. Das et al. (1965) reported that acetylene and calcium carbide treatment for floral induction in pineapple plants produced undersized fruits with relatively large crowns and long slender peduncles. Dutta (1966) obtained similar undersized fruits with long peduncle by application of alpha-naphthalene acetamide and acetylene.

Ali and Talukder (1965) reported that NAA application resulted in increased fruit weight. Das and Baruah (1967) noticed that when NAA and IAA were applied singly and in combination, there was significant increase in fruit weight, the combined effect being equivalent to that of NAA. The NAA treatment also increased plant height. Kwong and Chiu (1968) observed that when pineapple fruits were sprayed with 100,200,300 and 400 ppm of sodium salt of NAA about two months before fruit ripening, there was significant increase in fruit weight by 10 to 45 per cent and in fruit diameter by about 5 per cent. According to them 300 ppm was the optimum level. The effect of NAA was found to be more on naturally larger fruits. Huang (1968) found that NAA at 10ppm, calcium carbide at 1 per cent and beta-hydroxy ethyl hydrazin (BOH) at 0.25 per cent induced flowering and increased fruit weight.

Bowden (1969 b) reported that when NAA was sprayed on pineapple fruits at 10 weeks, eight weeks and six weeks before the estimated mean harvest date of the unsprayed controls, there was increase in fruit size and weight, fruit length and diameter without altering fruit shape. No significant differences were found in the taper ratio (0.96 to 1.00) or the length ratio (1.36 to 1.44) of the fruits examined. Poignant (1969) again found that application of sodium salt of NAA made 12 to 16 weeks after floral induction treatment with acetylene resulted in increased fruit weight by 15 to 23 per cent, tended to increase fruit length and significantly increased fruit diameter 3 to 9 per cent. The treatment also reduced crown weight and had adverse effect on the production of sucker. According to him the use of these compounds was not advised except under carefully controlled conditions.

Salazar and Rios (1971) reported that applications of ethrel and calcium carbide on pineapple plant resulted in reduced plant height. Calcium carbide treatment also resulted in the production of largest number of abnormal crowns and tended to cause the fruit to topple. Ethrel increased apical fruit diameter and pulp content. Robertson et al.(1971) reported that application of ethrel three weeks before harvesting decreased the yield as

compared to untreated control. The reduction in yield was attributed to shortening of fruit growth period resulting in smaller fruits. Wee and Ng (1971) also reported that when ethrel was applied as a flower inducing chemical, there was slight decrease in fruit length. However, other fruit characters were not altered.

Wee (1971) observed that spraying the developing fruit of the cv.'Singapore Spanish' with a solution of planofix was found to increase fruit weight and diameter. The best time for treatment according to him was six weeks after the appearance of the inflorescence. Huang (1973) conducted studies on the effect of NAA, sodium salt of NAA and IAA at 50,100,200 and 500 ppm on pineapple fruit. He found that when NAA and sodium salt of NAA sprayed one month after flowering increased yield by 11 to 32 per cent. The higher the concentration, the greater was the increase in fruit size. According to him 100 ppm was the optimum rate of sodium salt of NAA.

Gonzalez and Fonticiella (1975) made studies to find out the effect of ethrel on two pineapple varieties, 'Smooth Cayenne' and 'Red Spanish'. Application of ethrel at 20mg/plant even though induced flowering, significantly reduced fruit weight. Gonzalez et al. (1975)

reported the effect of various chemicals such as calcium carbide, various ethephon formulations on pineapple plant. They found that the treatments had little effect on fruit and crown weight, although ethephon tended to produce small fruit with bigger crown and to reduce fruit height.

Norman (1977) observed that application of BOH, calcium carbide and ethephon resulted in the production of cylindrical fruits rather than conical fruits. Chiu and Malek (1978) studied the effect of BOH on plant crop and ratoon crop. With both crops the chemical in all concentrations greatly increased fruit set and yields, but fruit size was reduced. Norman (1978) conducted studies to find out the effect of gibberlic acid (GA_3) at 500 and 1000 mg/litre and NAA at 200 and 300 mg/litre and GA_3 and NAA in combination at 250 + 100 mg/litre and 500 + 150 mg/litre applied to developing ethephon induced cv. 'Sugarloaf' pineapple. All the treatments increased fruit weight and length without altering the fruit shape. NAA alone and in combination with GA_3 reduced crown size. The concentrations of growth regulators had no effect on fruit weight, length, shape and crown size. Fruits sprayed six weeks after emergence produced larger fruits than those treated after 10 weeks. Time of application did not affect the fruit shape and crown size.

Studies conducted by Kerala Agricultural University on the plant crop of pineapple on the effect of planofix on fruit size and maturity showed that planofix at 200 ppm sprayed on fruits, two months after the visible sign of inflorescence, increased fruit weight as compared to control (Anon,1978). Santha (1979) studying on the effect of different growth regulators on flowering and fruit development in pineapple found that, maximum fruit size was obtained by planofix 20 ppm, when used as flower inducing chemical.

2.2. Maturity and ripening

Clark and Kerns (1942) reported that relatively high concentrations of NAA as 0.05 per cent on pineapple fruit resulted in retardation of ripening by about a week. Grossmann (1950) again found that application of NAA several weeks before fruit maturity delayed maturity.

Miller and Marsteller (1953) reported that application of PCPA 10 days before harvest, decreased the amount of physiological break down during ripening. Py (1955) reported that the period between treatment and fruit maturation was on an average 180 days with acetylene, while it was 187 days with NAA. He also observed that the higher the concentration of NAA used, the longer was the maturation period. Shing (1956) found that when NAA was used as a flower inducing agent on

pineapple, it advanced the harvesting season. It was also found that fruits of treated plants ripened more uniformly and fewer pickings were needed. Evans (1959) observed that growth promoting substances such as NAA, IBA, hortomone A, seradix A, planofix, anepal, 2,4-D, dicotox and acetylene exerted a marked influence on ripening of pineapples, particularly at lower concentrations.

Barbier (1964) observed that fruit treatment with sodium salt of NOA had no effect on maturation. Das (1964) found that NAA application prolonged the time from flower differentiation to ripening by about 15 days. He also reported delaying of maturity by a week by application of NAA and MH in combination. NAA was found to be superior than MH. Das et al. (1965) after working on acetylene found that acetylene treatment resulted in accelerated ripening of fruits. Das and Baruah (1967) found that application of NAA and IAA resulted in delayed ripening by about 11 days, but in the case of NAA treatment, ripening of majority of the fruits was completed within a relatively short four weeks period, thus facilitating harvest mechanization. Kwong and Chiu (1968) observed that fruit spraying of NAA about two months before fruit ripening, resulted in delayed fruit maturity upto two weeks in the largest fruit.

Gortner (1969) demonstrated the effectiveness of NAA and 2,4,5-T in markedly reducing the ripening of pineapple fruit and thus extending its marketable life as a fresh fruit. As little as 1 ppm of 2,4,5-T had a noticeable effect and 100 ppm was the optimum for retarding senescence. For NAA 500 ppm was the best level according to him. Bowden (1969 b) reported that NAA treated fruits had to be picked at a greener skin colour than untreated control fruits in order to obtain optimum ripeness. Poignant (1970) found that NAA treatment at 100 ppm immediately after picking the fruits, resulted in prolonged storage life of the fruits even at unfevourable temperetures.

Audinay (1970) found that ethrel treatment of pineapple at various times within four weeks before theoretical picking date resulted in earlier and more homogeneous ripening and a briefer harvest period proportional to the doses of ethrel applied, which ranged from 1 to 8 kg/ha. Salazar and Rios (1971) reported that treatment with calcium carbide at 8 kg/ha and ethrel at 4 and 6 kg/ha resulted in accelerated harvesting. Treated plants could be harvested in 21 days where as the harvest of the control plants exceeded 141 days. Poignant (1971) found that ethrel treatment at 2,1,0.5 and 0.1 kg a.i./ha applied 8 to 15 days before the theoretical picking date

resulted in rapid and homogeneous internal and external fruit colouring, thereby greatly reducing the harvest period. Robertson et al. (1971) found that application of ethrel at 2 and 4 kg a.i./ha to 'Smooth Cayenne' pineapples three weeks before harvesting caused all fruits to ripen 15 and 10 days after application respectively. The untreated control plants were harvested over a 60 days period. According to him, the optimum rate of ethrel was 2 kg a.i./ha. Wee and Ng (1971) reported that when the developing fruits were sprayed with ethrel, 19 weeks after flower induction, the crop required only one major harvest as compared to three with the unsprayed control. The fruits also ripened four weeks earlier. Ethrel also induced uniform ripening within a fruit, thus increasing the number of golden fleshed fruits.

Huang (1973) found that when sodium salt of NAA at 50, 100, 200 and 500 ppm was applied one month after flowering resulted in delayed ripening by 12-16 days. Norman (1977) studied the effect of three concentrations of each of BOH, calcium carbide and ethephon on 'Sugarloaf' pineapple. All the chemicals accelerated fruit maturity, caused uniform fruit ripening regardless of concentration. Norman (1978)

again reported that application of GA_3 and NAA singly and in combination applied to developing fruits of variety, 'Sugarloaf' pineapple significantly delayed fruit maturity, regardless of the concentration applied. Santha (1979) also reported delayed maturity by 50 and 100 ppm planofix when used as a flower inducing chemical.

3. EFFECT OF DIFFERENT CHEMICALS ON QUALITY OF FRUITS

Decrease in total soluable solids due to the application of NAA on pineapple fruits was reported by Clark and Kerns (1942). However, NAA had no effect on translucency and porosity of fruits. Miller and Marsteller (1953) reported that application of PCPA resulted in an increase in ascorbic acid content of the fruits, while T.S.S., acidity and flavour of the juice were not affected. Shing (1956) found that fruits produced as a result of NAA treatment had a high acid content than fruits from untreated control. Barbier (1964) reported that application of sodium salt NOA resulted in an increase in flesh firmness. A general decrease in porosity was also observed by him in treated fruits. Kwong and Chiu (1968) reported that acidity and total sugars were less in NAA treated fruits.

Dutta (1966) studied the effect of growth regulators on quality of pineapple fruits. He reported that fruits from NAA treated plants had a better sugar/acid ratio. Poignant (1969) reported that application of sodium salt of NAA on pineapple fruits caused a large number of surface cracks. The treatment also accelerated internal fruit colour development, increased fruit translucency, reduced fruit sugar by 15 per cent, resulted in less porous fruit. Bowden (1969b) again reported that NAA adversely effected the processing quality of pineapple. There was a marked decrease in T.S.S. and falsh colour, which rendered the fruit less palatable and affected the relationship between skin colour and internal ripeness, increased break strength and reduced porosity. The treatment significantly increased acidity especially when the fruits were treated 10 weeks before harvesting. There was no difference in pH between treated fruits and untreated controls. Poignant (1970) obtained poor quality fruits by the application of 100 ppm NAA on pineapple fruits one month before the theoretical harvest date.

Audinay (1970) reported that ethrel treatment on pineapple fruits resulted in improvement of external

and internal colouration of fruits, while other characteristics of flesh and juice including sugar and acid contents were not affected. Effect of ethrel treatment on quality of fruits was also reported by Poignant (1971). According to him ethrel treatment resulted in rapid and homogeneous internal and external fruit colouration. However, treated fruits were slightly hollow and significantly more acidic. Robertson et al. (1971) again reported that ethrel application lowered the sugar/acid ratio. The reduction in the ratio was due to the reduction in the percentage of sugar content. Wee (1971) noticed that planofix treatment increased acidity, while Huang (1973) reported that sodium salt of NAA lowered the sugar and acid contents of the fruits especially at high dosages. Norman (1977) found that application of growth regulators such as BOH, calcium carbide and ethephon on pineapples planted from crowns increased T.S.S.content, raised titrable acidity and reduced T.S.S/acid ratio. However, in the plants raised from suckers, the chemicals had no effect.

Das et al. (1977) found that ethephon treatment has no effect on T.S.S. and acidity of fruits when applied on plants having different leaf number. Norman (1978) found that GA_3 and NAA singly and in combination when applied on developing pineapple fruits had no effect

on acidity or T.S.S./acidity ratio. The treated fruits produced a deeper yellow juice. GA_3 increased T.S.S., while NAA alone and in combination with GA_3 reduced T.S.S. The different concentrations tried and time of application had no influence on fruit quality.

4. EFFECT OF LEAVES ON FRUIT SIZE AND QUALITY

Van Overbeek (1946) observed close correlation between fruit size and fruit development in pineapple with the number of leaves per plant. He also found that an increase of 11.5 leaves was accompanied by an increase of 1 kg in fruit weight. Py (1953) found that approximately 35 functional leaves were needed to produce a fruit of 1.5 kg and a variation of 10 leaves resulted in a difference of 0.5 kg in fruit weight. Shing (1956) reported that when NAA was applied as a flower inducing agent, the weight of the fruit produced was dependent with the size of the treated plant. Su (1956) reported that fruit yields were correlated with length and width of leaves in the season of rapid growth. He also pointed out that available soil K and leaf K were closely correlated with fruit compactness and yield in pineapple.

According to Kanapathy (1958) the yield of good quality fruits was associated with N 1.2 $\pm$ 0.2 per cent, P 2.2 $\pm$ 0.3 per cent and K 3.2 $\pm$ 4.0 per cent with K/P

ratio as near as possible to 14 in the leaves. Py and Pelegrin (1958) established a close relation between weight of 'D' leaf at the time of growth regulator application and fruit weight harvested. Py and Lossois (1962) working on pineapple confirmed the above theory.

Senewiratne (1964) reported that the initial sucker size had a marked effect on growth and flowering and the largest suckers (31 - 35 leaves) produced harvestable fruits in shortest time. Das et al. (1965) indicated that the leaf number had a close relationship with size and weight of fruits produced. He also found that the response of acetylene and calcium carbide was more on mature plants having large number of leaves as compared to immature plants having low leaf number. Tay et al. (1969) made studies on leaf analysis in relation to yield, sugar and acid contents of the fruits. He observed that there was no correlation between leaf N and yield or the sugar and acid contents of the fruits and in case of leaf P also no consistent correlation was observed in these characters, while the degree of correlation between leaf K and yield, sugar and acid contents of fruits was high.

Godfrey (1970) conducted trials on pineapple and found that maximum fruit yield was associated with 0.35 to 0.40 per cent nitrogen, 0.04 per cent phosphorus and 0.44 per cent potassium in leaves. For maximum fruit length, the K/P ratio should be 10.4 to 11.5. The basal non chlorophyllus section of 'D' leaves was used for analysis. Marchal (1970) found that if nitrogen content in the leaf was above 1 per cent, there was an increase in foliar growth. Foliar growth response was not evident in dry season. The amount of K was shown to have a direct positive effectiveness on fruit acidity, but again this was modified by climate.

Ten and Wee (1973) studied the growth characters and quality of fruits in pineapple and reported that the more vigorous the plant, the higher was the fruit weight with less acidity. Singh and Rameshwar (1974) revealed that plants with low leaf number (26 - 30) produced long stalked small fruits, while those with large leaf number (46-50) produced large fruits with small stalks. Gangadhara Rao et al. (1974) studied the leaf characters of pineapple and observed that leaf number per plant, leaf area index, the fresh weight of 'D' leaf and the crown weight were closely related to yield. According to Subramanian et al. (1974) the application of nitrogen, phosphorus and potassium was

not clearly reflected in the leaf nutrient contents. However, in the 11th month sampling there was significant increase in leaf N,P and K corresponding to N,P and K application. Subramanian et al.(1977) again reported that there was significant relation between leaf N and K in the 5th month after planting with high yield of pineapple.

Chadha et al. (1977) stated that fruit weight was positively correlated with the number of suckers per plant and leaf number one year after planting. He also observed that Juice T.S.S. content was increased by an increase in leaf number both one year after planting and at flowering. Das et al. (1977) found that when flowering and fruiting was artificially induced by ethephon treatment before the plants reached proper stage, the average fruit size and sucker production were adversely affected. They also reported that optimal stage of plant growth for flowering and fruiting was reached when they attained atleast 35 to 39 leaves per plant and by further increase in leaf number there was no beneficial effect. Santha (1979) observed significant correlation between leaf characters and yield and quality of pineapple. Fruit size and quality were found to be positively correlated with the number of leaves possessed by the plants. The fruits produced by higher

leaf group possessed maximum of T.S.S. and sugars. She also found that leaf nutrients influenced on fruit size. The largest fruits were produced by plants having the leaf nutrient status of 1.4 per cent N, 0.08 per cent P and 3.43 per cent K.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present investigations on the various aspects of regulation of fruit size and maturity in pineapple were undertaken in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara during the years 1978 to 1980.

The first ratoon crop of variety 'Kew' maintained at pineapple Research Centre, Vellanikkara was utilized for the study. The crop was planted in May,1976 and it was grown in two rows in trenches with a spacing of 60 cm between rows, 30 cm between plants and 90 cm between trenches, with a planting density of 43080 plants per hectare. The first crop was harvested during March, 1978. After the harvest of plant crop thinning of suckers were done so as to get one sucker per plant for the first ratoon crop. Uniform cultural and manurial practices as per the recommendations of Kerala Agricultural University, were given to the crop.

The investigations consisted of the following aspects.

1. Fixing the optimum time for harvest of fruits.
2. Studying the effect of alpha-naphthalene acetic acid (NAA) on fruit size,maturity and quality.

3. Studying the effect of NAA on size, maturity and quality of fruits from plants having different leaf number.

The detailed procedures adopted for the different aspects of study are given below.

1. FIXING THE OPTIMUM TIME FOR HARVEST

It was necessary to standardize the optimum time of harvest of fruits to ensure uniform maturity. In order to arrive at a proper harvesting index, studies were undertaken during November, 1978.

A total of 400 uniform plants possessing 36 to 40 leaves were marked out. Uniform flowering in these plants was induced by the application of 25ppm ethrel + 2 per cent urea + 0.04 per cent $CaCO_3$ (Anon, 1979). A total of 250 inflorescences which emerged on the same day were finally tagged for detailed observations. First samples of fruits were taken 70 days after inflorescence emergence. Subsequent samples were taken at 10 days interval till 100 days after emergence, thereafter at seven days interval till 128 days after inflorescence emergence and then at two days interval till the fruits turned fully yellow on the plants. At each time of sampling, 10 fruits were harvested from the tagged plants and they were analysed for total soluble solids, acidity, reducing sugars, total sugars, non-reducing sugar and ascorbic acid content.

The sugar/acid ratio and brix/acid ratio were also worked out. The methods of analysis followed are detailed under section 4.

In order to find out the changes in the external colour of the fruits during the course of fruit maturity and to relate the colour development with internal quality, external shell colour of fruits was visually observed at each sampling date. The total number of 'eyes' which were green and also 'eyes' that turned yellow were counted and the percentage of colour development was assessed. The colour development was then expressed as percentage of area coloured or that remained green as adopted by Pantastico (1975).

2. EFFECT OF ∝C NAPHTHALENE ACETIC ACID (NAA) ON FRUIT SIZE, MATURITY AND QUALITY

To study the effect of different concentrations of NAA on size, maturity and quality of fruits and to determine the best stage of its application, detailed investigations were initiated in November 1978. Uniform flowering was induced by giving a combination treatment of 25ppm ethrel + 2 per cent urea + 0.04 per cent $CaCO_3$ (Anon,1979). The experiment was superimposed in split plot design with four replications.

The mainplot consisted of 150 plants and subplots consisted of 30 plants per plot. The treatments consisted of four concentrations of NAA and control. The spraying was done at different stages of fruit development, the details of which are given below.

Treatments - 25 (combination of (A) and (B))

A. Main plot treatments (stages of application of NAA)

i. At inflorescence emergence

ii. One month after inflorescence emergence

iii. Two months after inflorescence emergence

iv. Three months after inflorescence emergence

v. Four months after inflorescence emergence

B. Sub plot treatments (concentrations of NAA and control)

i. 0 ppm (control)

ii. 50 ppm NAA

iii. 100 ppm NAA

iv. 200 ppm NAA

v. 300 ppm NAA

The different concentrations of NAA in solutions (10 - 30 ml) as mentioned above were thoroughly sprayed with a hand atomiser on the inflorescence and fruits as the case may be depending upon the stage of application. The control treatment consisted of water spray.

OBSERVATIONS

The following observations were recorded.

2.1. Fruit characters

2.1.1. Fruit weight

The fruits were harvested at optimum maturity and fruit weight with and without crown was recorded.

2.1.2. Fruit length,girth and breadth

Fruit length and girth in the middle were recorded for each treatment at harvest. The breadth was recorded at three portions namely bottom , middle and top after cutting the fruit into two longitudinal halves.

2.1.3. Crown weight

The weight of the crown was recorded for each treatment.

2.1.4. Canning ratio

Canning ratio was worked out by dividing the length of fruit by breadth in the middle (Pantastico,1975).

2.1.5. L/B ratio

The L/B ratio was worked out by dividing the length of fruit by mean breadth (Pantastico,1975).

2.1.6 Taper ratio

Taper ratio was computed by dividing the breadth of fruit (at top 3/4) by the breadth of the fruit (at bottom 1/4) as adopted by Pantastico (1975).

2.1.7. Time taken from inflorescence emergence to fruit maturity

Days taken from inflorescence emergence to harvesting maturity of fruits were recorded for each treatment.

2.1.8. Qualitative analysis of fruits

The fruits were harvested at optimum maturity and were analysed for total soluble solids, acidity, reducing sugars, total sugars, non-reducing sugar, ascorbic acid content, sugar/acid ratio and brix/acid ratio. The methods in detail are given under section 4.

2.1.9. Fruit development

To study the fruit development, five inflorescences which emerged on the same day were seperately tagged from each treatment. The growth measurements of the fruits at monthly intervals were carried out one month after inflorescence emergence to fruit maturity. The measurements

consisted of length and girth of the fruits.

2.2. Leaf characters

2.2.1. Leaf area

To study the effect of different concentrations and stages of application of NAA on leaf area, measurements of 'D' leaf were recorded at the time of harvest of fruits. The leaf area was worked out by using the formulae, length x breadth x 0.725 (Balakrishnan et al.,1975).

2.2.2. Percentage dry weight of 'D' leaf

The 'D' leaves were pulled out at the time of harvest of fruits in the different treatments and their fresh weights were recorded. The dry weight was obtained by drying the samples in an oven at 70°C till constant weights were obtained. From the fresh weight and dry weight, percentage dry weight of 'D' leaf was worked out.

2.2.3. Leaf analysis

The nutrient status of leaves (N,P and K) were analysed at the time of harvest of fruits for each treatment. Methods of analysis are given in section 4.

3. EFFECT OF NAA ON FRUITS PRODUCED BY PLANTS WITH DIFFERENT LEAF NUMBER

In order to find out whether smaller fruits produced from plants possessing lower leaf number could

be improved by application of NAA, and also to study its effect on plants with higher leaf number, studies were initiated in November,1979 as detailed here under.

The plants were classified into six groups as given below.

Group I	26 - 30 leaves
Group II	31 - 35 leaves
Group III	36 - 40 leaves
Group IV	41 - 45 leaves
Group V	46 - 50 leaves
Group VI	51 - 55 leaves

In all the groups, uniform flowering was induced by the application of combination treatment as mentioned earlier.

A total of 50 fruits in each group were sprayed thoroughly with 300 ppm NAA, one month after inflorescence emergence. Fifty plants were kept as control.

The 'D' leaf characters viz.,length and breadth, leaf area and the fresh weight and dry weight were estimated under each group at the time of NAA application and also at harvest. The 'D' leaves were analysed for N,P and K and carbon content at the time of NAA application and at harvest and C/N ratio was worked out.

Fruit characters such as fruit weight, fruit length, breadth, girth and crown weight were recorded at the time of harvest in all the treatments. Qualitative analysis of fruits was done as per the methods given below:

4. METHODS OF ANALYSIS

4.1. Fruits

Fruits were harvested at optimum maturity for qualitative analysis. Samples were taken from each fruit from three portions namely top, middle and bottom and these were then pooled and macerated in a Warring blender. Triplicate samples were used for analysis of different constituents, as detailed below.

4.1.1. Total soluble solids

Total soluable solids were found out by pocket refractometer and were expressed as percentage.

4.1.2. Acidity

Ten g of the macerated sample were mixed with distilled water and made upto a known volume. An aliquot of the filtered solution was titrated against 0.1N sodium hydroxide using phenolphthalein as indicator. The acidity was expressed as percentage of citric acid (A.O.A.C., 1960).

4.1.3. Reducing sugars

The reducing sugars of the samples were determined as per the method described by A.O.A.C.(1960). To a known

quantity of macerated pulp, distilled water was added. The solution was clarified with neutral lead acetate and deleaded with sodium oxalate and made upto a known volume. The solution was then 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 content of reducing sugars was expressed as percentage.

4.1.4. Total sugars

Total sugars were determined as per the method described by A.O.A.C.(1960). Five ml of concentrated hydrochloric acid was added to a known volume of clarified solution and the same was kept overnight. The solution was then neutralised by adding sodium hydroxide and titrated against Fehling's solution A and B.

4.1.5. Non-reducing sugar

Non-reducing sugar was obtained by substracting the amount of reducing sugars from the total sugars.

4.1.6. Ascorbic acid

Ten g of the pooled sample of the fruit was macerated in a mortar by adding small quantity of two per cent oxalic acid. The solution was made upto a

volume of 100 ml and then filtered. An aliquot of the extract was taken to which an equal volume of two per cent oxalic acid was added. The content was titrated against a standard solution of 2,6-dichlorophenol indophenol dye. The ascorbic acid content of the juice was then calculated and expressed as mg/100 g of the pulp (A.O.A.C.,1960).

4.1.7. Sugar/acid ratio

This was obtained by dividing the total sugars with titrable acidity and this was reckoned as a measure of fruit quality.

4.1.8. Brix/acid ratio

This was arrived at by dividing the brix with titrable acidity.

4.2. Leaf analysis

The nutrient status of the leaves (N,P and K) were analysed at stages mentioned earlier. For analysis, the basal non chlorophyllus section of the 'D' leaf was taken (Godfrey,1970).

4.2.1. Nitrogen

A sample of 0.1g of the powdered material was digested in concentrated sulphuric acid and nitrogen content was estimated by micro-Kjeldahl digestion - distillation

method. (A.O.A.C.,1960).

4.2.2. Phosphorus

One g of the ground sample was digested in 15ml mixture of concentrated perchloric acid, sulphuric acid and nitric acid in the ratio of 1:2:9 and made upto 100ml with distilled water. Phosphorus in 10ml aliquot of this extract was determined using vanadomolybdophosphoric yellow colour method (Jackson,1958).

4.2.3. Potassium

Potassium in an aliquot of the triple acid extract of the sample was determined using flame photometer (Jackson,1958).

4.2.4. Organic carbon

Organic carbon content of the leaves was estimated as per the method suggested by I.S.I. (Anon, 1968) A sample of 0.1g of the finely powdered meterial was transferred to a 250ml reflexing flask. 25ml of 1N potassium dichromate and 25ml of concentrated sulphuric acid were added and the contents were reflexed for six hours, by which time the whole organic carbon was oxidised by the dichromate. The excess dichromate was back titrated with standard ferrous sulphate solution using diphenylamine as

the redox indicator, in the presence of orthophosphoric acid. The C/N ratio was worked out from the percentages of the carbon and nitrogen obtained.

5. STATISTICAL ANALYSIS

The data collected on different characters were subjected to statistical analysis, following the methods of Snedecor and Cochran (1967). Effect of NAA on various leaf and fruit characters were studied by employing the analysis of variance technique. Critical differences were calculated for comparison of treatments. Student's 't' test was employed to compare treated and untreated plants in different leaf groups.

RESULTS

RESULTS

1. FIXING OPTIMUM TIME FOR HARVEST OF PINEAPPLE FRUITS

The data relating to various qualitative changes occuring in pineapple fruit, commencing from 70 days after inflorescence emergence to the time when the fruits turned completely yellow on the plants, are presented in Table 1.

It will be seen from the Table that the T.S.S. and total sugars reached their maximum on 134th day (14.5 and 13.82 per cent respectively), thereafter showing a decreasing trend till the fruits turned completely yellow. In the case of acidity, it increased upto 132nd day and remained constant for two more days. There was a rapid fall in acidity on the 136th day, which continued till 142nd day. The reducing sugar content of fruits increased until 138 days (5.16 per cent) which remained steady thereafter. Non-reducing sugar also showed an increasing trend upto 132 days which again decreased during the later stages. On the other hand, the ascorbic acid content was high when the fruits were immature, which progressively declined upto 138th day, after which period it remained steady. Sugar/acid ratio was maximum on 142nd day. Brix/acid ratio was high in early stages,

Table 1. Qualitative changes during maturation of fruits

Days after inflorescence emergence	T.S.S. (%)	Acidity (%)	Reducing sugars (%)	Total sugars (%)	Non-reducing sugars (%)	Ascorbic acid (mg/100g)	Sugar/ acid ratio	Brix/ acid ratio
70	6.0	0.21	2.10	3.55	1.45	16.85	16.90	28.57
80	7.0	0.31	2.60	4.56	1.96	15.95	14.71	22.58
90	7.5	0.41	3.13	6.30	3.17	12.19	15.37	18.29
100	8.0	0.45	3.33	7.86	4.53	10.88	17.47	17.78
107	9.0	0.50	3.95	9.87	5.92	9.22	19.74	18.00
114	10.5	0.52	4.12	10.81	6.69	8.58	20.79	20.19
121	11.0	0.56	4.26	11.61	7.35	7.58	20.73	19.64
129	13.0	0.61	4.49	12.45	7.96	7.00	20.41	21.31
130	14.0	0.63	4.78	12.98	8.20	6.95	20.60	22.22
132	14.0	0.64	5.05	13.75	8.70	6.95	21.48	21.88
134	14.5	0.64	5.13	13.82	8.69	6.95	21.59	22.66
136	14.5	0.56	5.13	13.80	8.67	6.95	24.64	25.89
138	14.0	0.53	5.16	13.33	8.17	6.75	25.15	26.42
140	13.5	0.50	5.16	13.10	7.94	6.75	26.20	27.00
142	13.5	0.41	5.16	13.00	7.84	6.75	31.71	32.93

Fig. 1 - CHANGES IN T.S.S. AND TOTAL SUGARS IN FRUITS DURING MATURATION

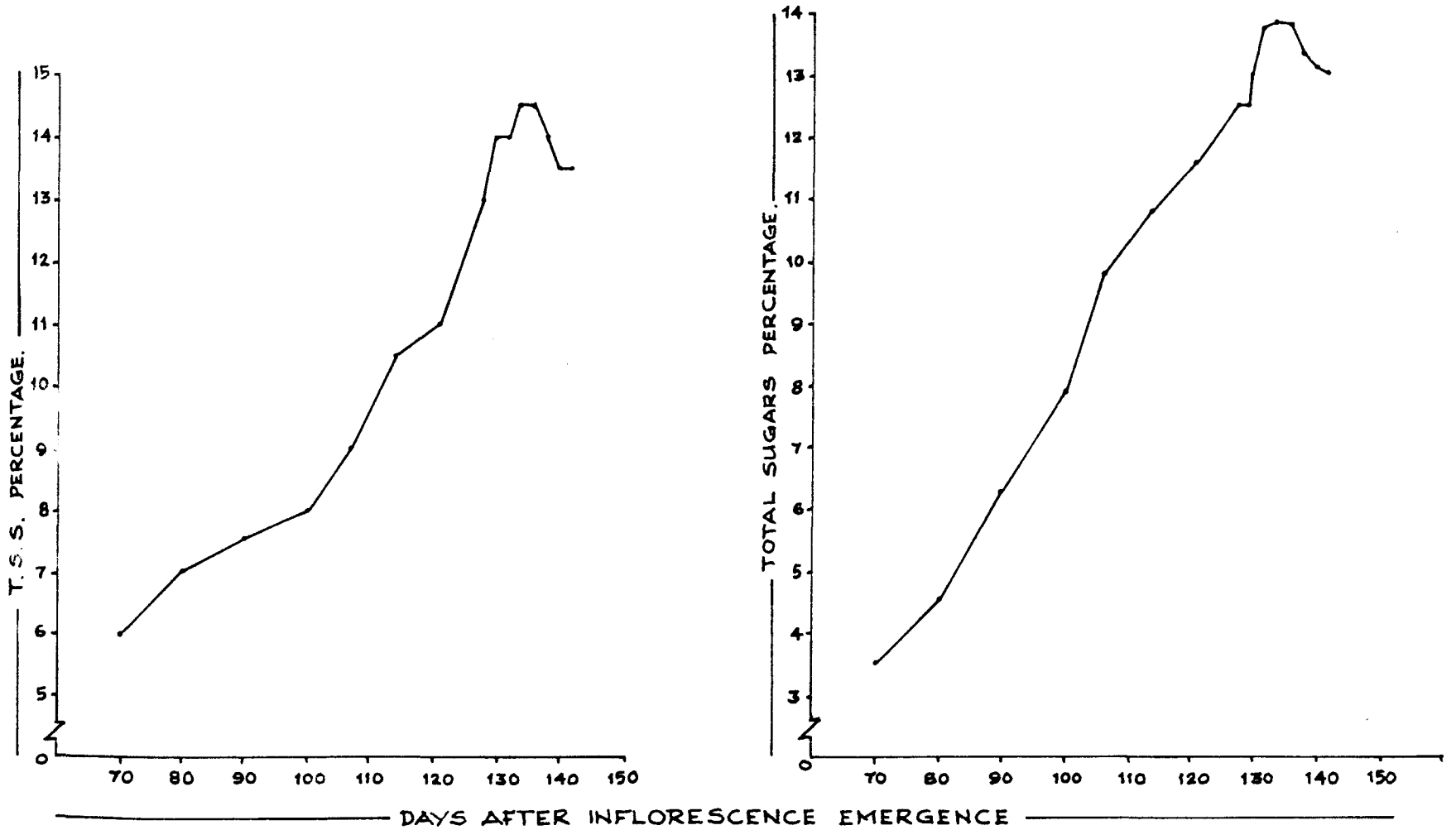
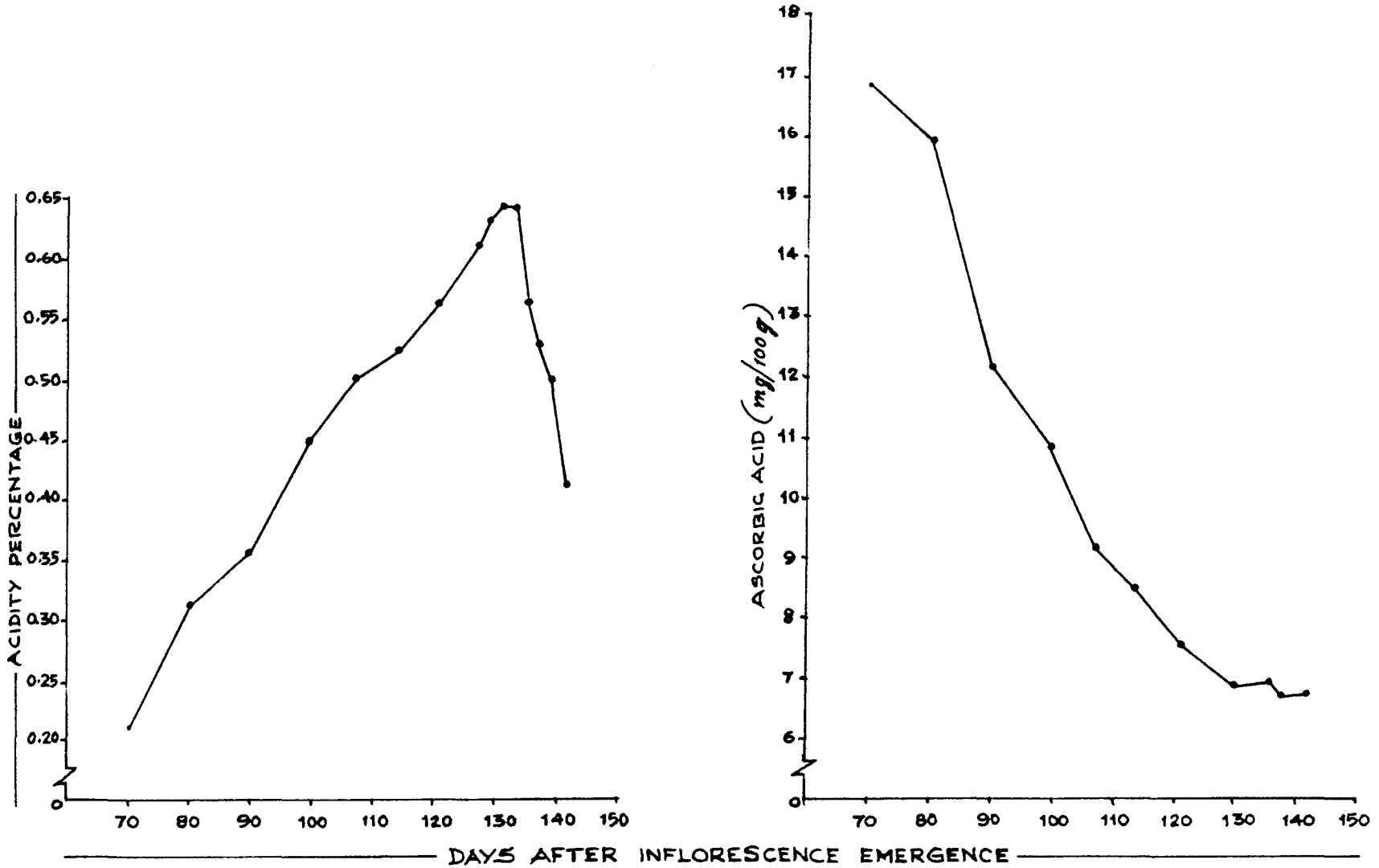


Fig. 2 - CHANGES IN ACIDITY AND ASCORBIC ACID IN FRUITS DURING MATURATION



but decreased as the fruit matured upto 100th day, thereafter showing an increasing trend. Considering the qualitative parameters like T.S.S., acidity and total sugars, the period between 132 to 135 days after inflorescence emergence appeared to be the best time for harvest of fruits (Figs.1 and 2).

The data on the external colour of the fruits (Table 2) showed that fruits remained green upto 128 days. At this time the interspaces of eyes showed traces of yellow at the basal portion of the fruits. Further turning to yellow was rapid which was perceptible from 130th day. It was found that 49.4 per cent of the eyes became yellow on 134th day, at which time the fruits recorded maximum quality in terms of T.S.S., acidity and sugars. On 136th day, 71.6 per cent of the eyes turned yellow, while yellow colouration of fruits reached 89.25 per cent on 138th day, 95.43 per cent on 140th day and 98.84 per cent on 142nd day. The fruits exhibited signs of softening or slight rotting from 140th day at their basal portions which gradually increased thereafter.

Table 2. Changes in shell colour of fruits during maturation

Days after inflorescence emergence	Shell colour of the fruits	Remarks
70	Green	..
80	Green	..
90	Green	..
100	Green	..
107	Green	..
114	Green	..
121	Green	..
128	Green	Traces of yellow at the interspaces of the 'eyes' at the basal portion
130	4.60% of the 'eyes' yellow	..
132	19.80% of the 'eyes' yellow	..
134	49.40% of the 'eyes' yellow	..
136	71.60% of the 'eyes' yellow	..
138	89.25% of the 'eyes' yellow	..
140	95.43% of the 'eyes' yellow	Traces of softening at the basal portion
142	98.84% of the 'eyes' yellow	Further softening and slight rotting at the basal portion.

2. EFFECT OF α-NAPHTHALENE ACETIC ACID (NAA) ON FRUIT SIZE, MATURITY AND QUALITY

2.1. Effect of NAA on Fruit Characters

The data relating to the various fruit characters as influenced by different treatments are given in Tables 3 to 12.

2.1.1. Fruit weight

With respect to fruit weight with crown as well as without crown, the effect due to different concentrations of NAA and also due to interaction were significant, while the effect due to various stages of application was non significant (Table 3, Fig.3). Maximum fruit weight was obtained by 300 ppm NAA (1.86kg) followed by 200ppm (1.77kg). The lowest fruit weight was recorded by 50 ppm NAA and control. With respect to combinations, maximum fruit weight was recorded when NAA at 300 ppm was applied one month after inflorescence emergence (2.16 kg) followed by 200 ppm NAA applied at the same stage and 300 ppm NAA at inflorescence emergence. Between these three treatments the difference was not significant. The treatments, 300 ppm NAA applied two months after emergence, 200 ppm NAA at inflorescence emergence and two months after emergence were found to be on par and were the next best treatments. The treatments

Table 3. Effect of NAA on fruit weight with crown (kg)

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	1.69	1.68	1.57	1.62	1.60	1.63
50	1.66	1.70	1.58	1.66	1.62	1.64
100	1.72	1.73	1.69	1.65	1.57	1.67
200	1.85	2.03	1.82	1.59	1.59	1.77
300	2.00	2.16	1.87	1.67	1.59	1.86
Mean	1.78	1.86	1.71	1.64	1.59	

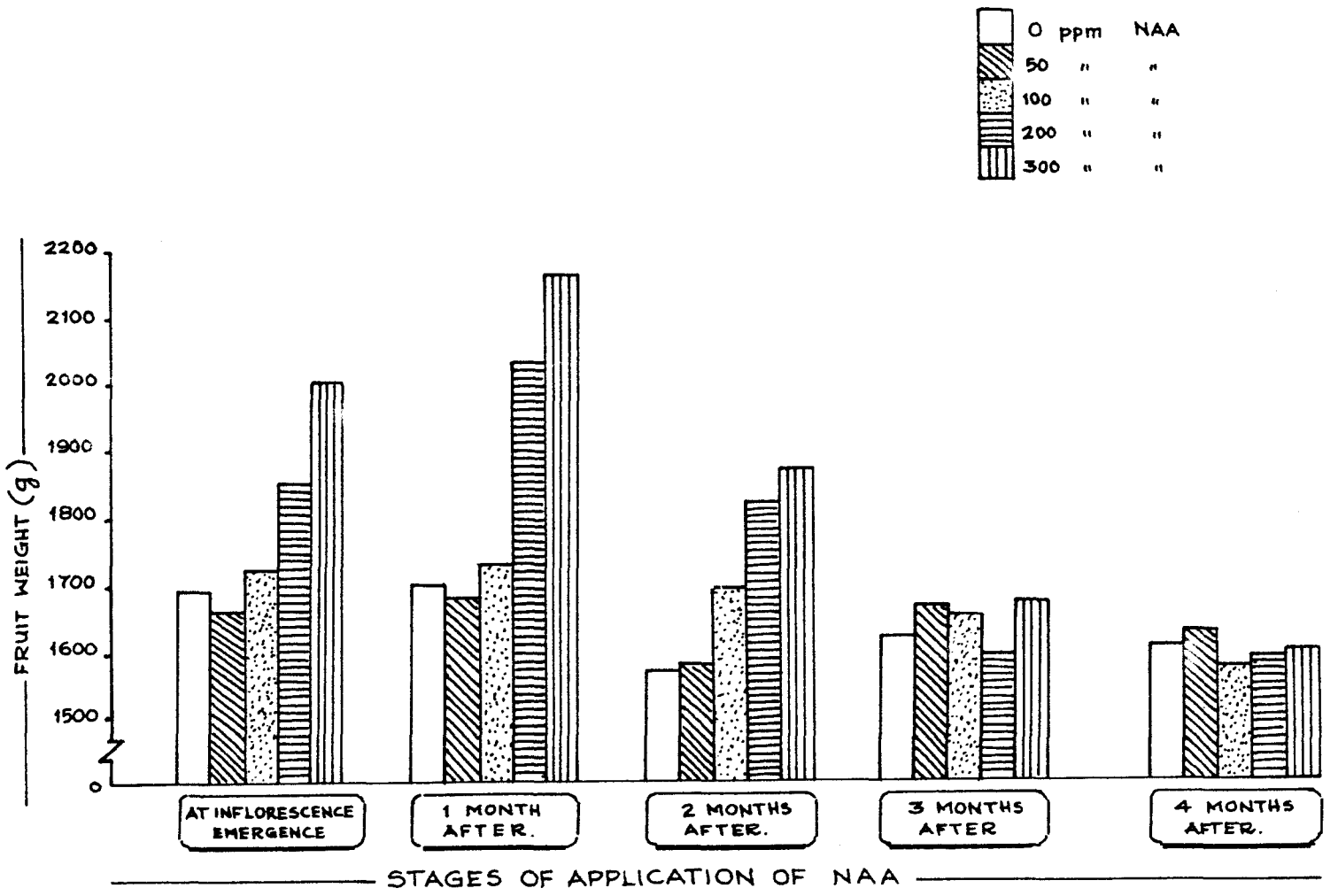
	C.D (5%)	SEm ±
Stages of application	NS	0.08
Concentrations of NAA	0.13	0.04
Combinations	0.29	0.10

Table 4. Effect of NAA on fruit weight without crown (kg)

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	1.51	1.51	1.41	1.44	1.42	1.46
50	1.48	1.54	1.41	1.49	1.45	1.47
100	1.51	1.55	1.53	1.48	1.39	1.49
200	1.63	1.85	1.65	1.42	1.41	1.59
300	1.76	1.97	1.69	1.51	1.42	1.67
Mean	1.58	1.68	1.54	1.47	1.42	

	C.D (5%)	SEm ±
Stages of application	NS	0.08
Concentrations of NAA	0.14	0.05
Combinations	0.30	0.11

Fig. 3 - EFFECT OF NAA ON FRUIT WEIGHT AT HARVEST.



50 ppm NAA and control applied at all stages recorded significantly lower fruit weights.

The effect of NAA on fruit weight without crown also followed a similar trend as in the case of fruit weight with crown (Table 4). Maximum fruit weight was recorded by 300 ppm NAA (1.67 kg) followed by 200 ppm NAA (1.59 kg) which were however found to be on par. The treatments 100 ppm NAA, 50 ppm NAA and control which were on par recorded significantly lower fruit weights. With respect to combinations, maximum fruit weight without crown was recorded when 300 ppm NAA was applied one month after emergence (1.97 kg) followed by 200 ppm NAA applied at the same stage (1.85 kg) and 300 ppm NAA applied at inflorescence emergence stage (1.76 kg) and two months after emergence (1.69 kg). However, these four treatments were found to be on par. The treatments 200 ppm NAA applied at two months after emergence and at inflorescence emergence were superior to control and were the next best treatments. The other treatments did not show significant difference among themselves.

2.1.2. Fruit length

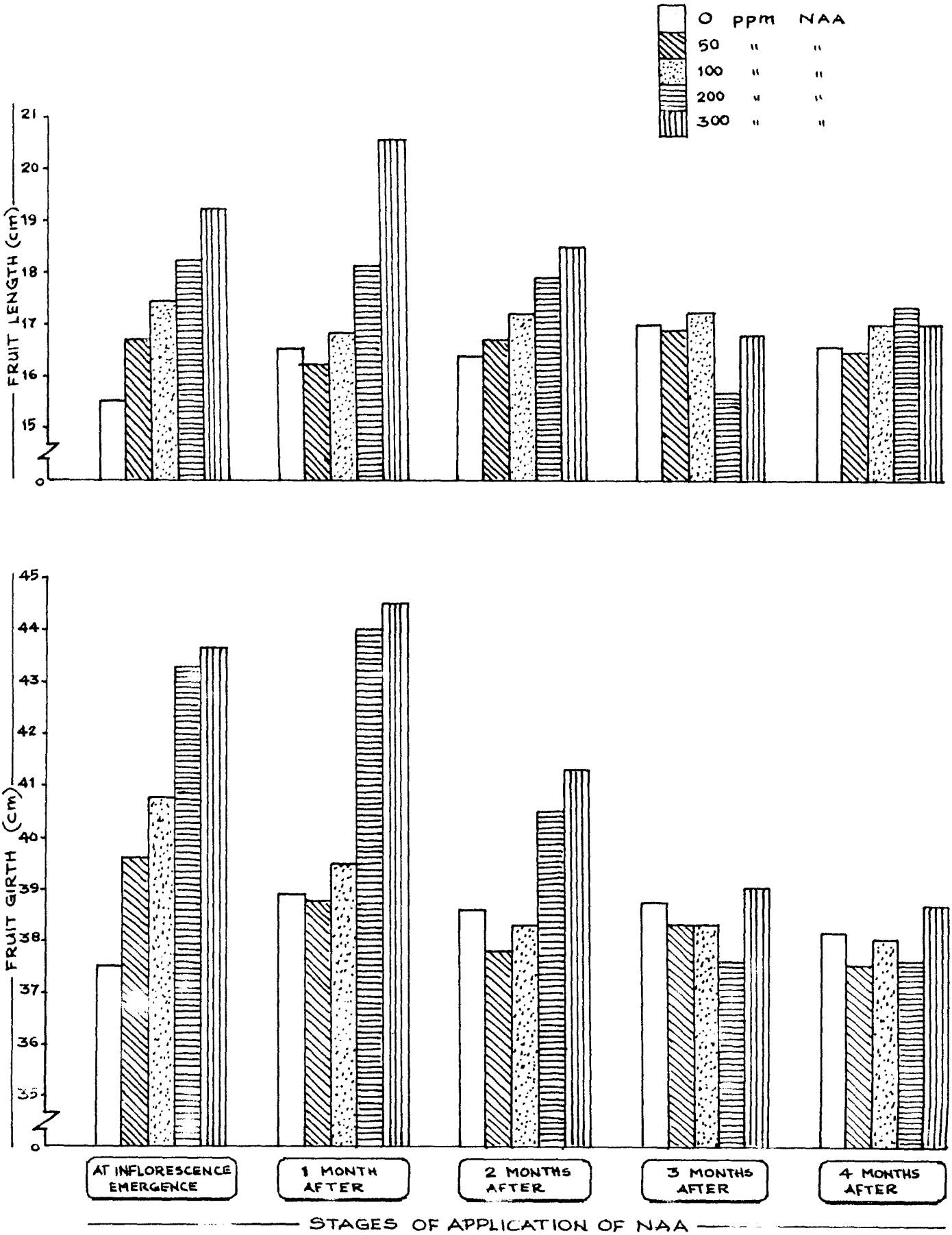
The effect due to different concentrations of NAA and also due to interection was significant (Fig.4). With respect to concentrations of NAA,

Table 5. Effect of NAA on length of fruit (cm)

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	15.53	16.50	16.28	16.90	16.38	16.32
50	16.68	16.20	16.60	16.90	16.28	16.51
100	17.43	16.80	17.13	17.14	16.85	17.07
200	18.17	18.10	17.85	16.60	17.15	17.57
300	19.20	20.48	18.43	16.68	16.85	18.53
Mean	17.40	17.82	17.26	16.82	16.70	

	C.D (5%)	SEm ±
Stages of application	NS	0.32
Concentrations of NAA	0.87	0.31
Combinations	1.94	0.69

FIG. 4- EFFECT OF NAA ON FRUIT LENGTH AND GIRTH AT HARVEST



300 ppm NAA treatment recorded the maximum value (19.53 cm) and was found to be superior to all other concentrationsand control. This was followed by 200 and 100 ppm NAA. Lowest value was recorded by control (16.32 cm). With respect to combinations, 300 ppm NAA sprayed one month after inflorescence emergence was found to give the highest fruit length, and it was found to be on par with 300 ppm NAA applied at inflorescence emergence. The treatments 300 ppm NAA applied at two months after inflorescence emergence, 200 ppm NAA at inflorescence emergence, one month after emergence and two months after emergence had the same effect and were the second best category of treatments. The other treatments including control recorded lower values for fruit length.

2.1.3. Fruit girth

The effect due to various stages of application, concentrations of NAA and interaction were found to be significant (Table 6). Maximum girth was obtained when NAA was applied one month after inflorescence emergence and this stage was found to be on par with NAA applied at inflorescence emergence. This was followed by application of NAA at two months, three months and four months after inflorescence emergence.

Table 6. Effect of NAA on girth of fruit (cm)

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	37.55	38.89	38.63	38.68	38.08	38.37
50	39.58	38.80	37.78	38.33	37.50	38.40
100	40.76	40.53	38.33	38.31	38.00	39.09
200	43.28	44.00	40.53	37.58	37.58	40.50
300	43.65	44.50	41.33	38.98	38.65	41.42
Mean	40.96	41.24	39.32	38.38	37.96	

	C.D (5%)	SEm ±
Stages of application	1.85	0.60
Concentrations of NAA	1.59	0.56
Combinations	3.55	1.25

Between these treatments there was no significant difference. With respect to concentrations of NAA, though maximum girth was obtained by 300 ppm NAA, it was found to be on par with 200 ppm NAA. The treatments 50 and 100 ppm NAA were found to be on par with control and produced lower fruit girth. With respect to combination treatments, there was no significant difference in fruit girth between 300 ppm and 200 ppm NAA applied one month after inflorescence emergence, 300 ppm and 200 ppm NAA applied at inflorescence emergence, and 300 ppm NAA applied two months after emergence. However 300 ppm NAA applied one month after inflorescence emergence tended to record the highest fruit girth. The other treatments were found to be inferior and were on par with control (Fig.4).

2.1.4. Fruit breadth

The fruit breadth was significantly influenced by the different stages of application, concentrations of NAA and also due to interaction. Between the stages of application, NAA applied one month after emergence was found to be superior and on par with NAA applied at inflorescence emergence stage. The other three stages were found to be on par and were inferior.

Table 7. Effect of NAA on breadth of fruit (cm)

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	12.75	13.25	12.90	13.24	11.89	12.81
50	13.19	13.05	11.13	12.48	13.25	12.62
100	13.38	12.75	12.80	12.85	13.13	12.98
200	13.63	14.65	14.08	12.04	13.65	13.61
300	14.50	14.60	14.00	12.74	13.08	13.78
Mean	13.49	13.66	12.98	12.67	13.00	

	C.D (5%)	SEm ±
Stages of application	0.54	0.17
Concentrations of NAA	0.46	0.16
Combinations	1.03	0.36

Regarding the effect of different concentrations of NAA, it was found that fruit breadth obtained by 300ppm NAA and 200 ppm NAA were on par. The treatments 100 ppm, control and 50 ppm NAA recorded lower fruit breadth in the order cited , and they were on par. In respect of combinations, maximum fruit breadth was associated with treatments 200 ppm and 300 ppm NAA applied at one month after inflorescence emergence, and these treatments were on par followed by 300 ppm and 200 ppm NAA applied at inflorescence emergence as well as two months after emergence. The other treatments including control recorded significantly lower values.

2.1.5. Crown weight

The stages of application, the concentrations of NAA and also the interaction effects were significant with respect to crown weight (Table 8). The crown weight was maximum when NAA was applied at inflorescence emergence (205.79 g) which was significantly superior to other stages of application. Later applications of NAA did not significantly influence the crown weight. Between the concentrations, 300 ppm NAA produced a significant increase in crown weight (187.16 g) and this was found to be on par with 200 ppm NAA. The lower concentrations of NAA viz.,100 ppm and 50 ppm were on par with control

Table 8. Effect of NAA on crown weight (g)

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	177.87	169.89	163.46	176.78	175.88	172.16
50	178.78	160.44	168.98	170.82	167.95	169.39
100	206.98	181.32	161.78	173.74	175.80	179.92
200	224.21	179.56	170.72	169.68	171.85	183.20
300	241.11	187.46	175.96	161.15	170.12	187.16
Mean	205.79	175.73	168.78	171.43	174.72	

	C.D (5%)	SEm ±
Stages of application	9.90	3.21
Concentrations of NAA	11.60	4.10
Combinations	25.94	9.17

treatment. In terms of combinations, 300ppm NAA applied at inflorescence emergence was found to produce maximum crown weight (241.11 g) and this was found to be on par with 200 ppm NAA applied at the same stage which was followed by 100 ppm NAA (206.98 g) applied at the same stage. The other treatments did not show any influence on crown weight when compared to control.

2.1.6. Canning ratio

There was no significant effect due to various stages of application or due to different concentrations of NAA on the canning ratio of the fruits.

2.1.7. L/B ratio

In respect of L/B ratio of fruits also there was no significant effect due to various stages of application, due to different concentrations of NAA or due to interaction.

2.1.8. Taper ratio

The taper ratio of fruits also was not significantly influenced by the various treatments tried.

2.1.9. Time taken for maturity of fruits

The data pertaining to the time taken from the emergence of inflorescence to maturity of fruits in the different treatments are furnished in Table 12 and

Table 9. Effect of NAA on canning ratio of fruits

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1 month after	2months after	3months after	4months after	
0	1.22	1.35	1.27	1.28	1.23	1.27
50	1.31	1.25	1.25	1.36	1.24	1.28
100	1.31	1.32	1.34	1.32	1.29	1.32
200	1.36	1.24	1.27	1.30	1.31	1.30
300	1.26	1.35	1.32	1.31	1.29	1.31
Mean	1.29	1.30	1.29	1.31	1.27	

	C.D (5%)	SEm ±
Stages of application	NS	0.03
Concentrations of NAA	NS	0.02
Combinations	NS	0.06

Table 10. Effect of NAA on L/B ratio of fruits

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	1.29	1.37	1.38	1.33	1.29	1.33
50	1.35	1.36	1.36	1.45	1.31	1.37
100	1.39	1.40	1.41	1.39	1.37	1.39
200	1.43	1.31	1.48	1.40	1.24	1.39
300	1.33	1.41	1.46	1.40	1.49	1.42
Mean	1.36	1.37	1.42	1.39	1.34	

	C.D (5%)	SEm ±
Stages of application	NS	0.02
Concentrations of NAA	NS	0.02
Combinations	NS	0.05

Table 11. Effect of NAA on taper ratio of fruits

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	0.93	0.95	0.94	0.94	0.95	0.94
50	0.93	0.96	0.91	0.94	0.96	0.94
100	0.95	0.94	0.96	0.98	0.96	0.96
200	0.94	0.93	0.96	0.93	0.93	0.94
300	0.95	0.96	0.91	0.99	0.96	0.95
Mean	0.94	0.95	0.94	0.96	0.95	

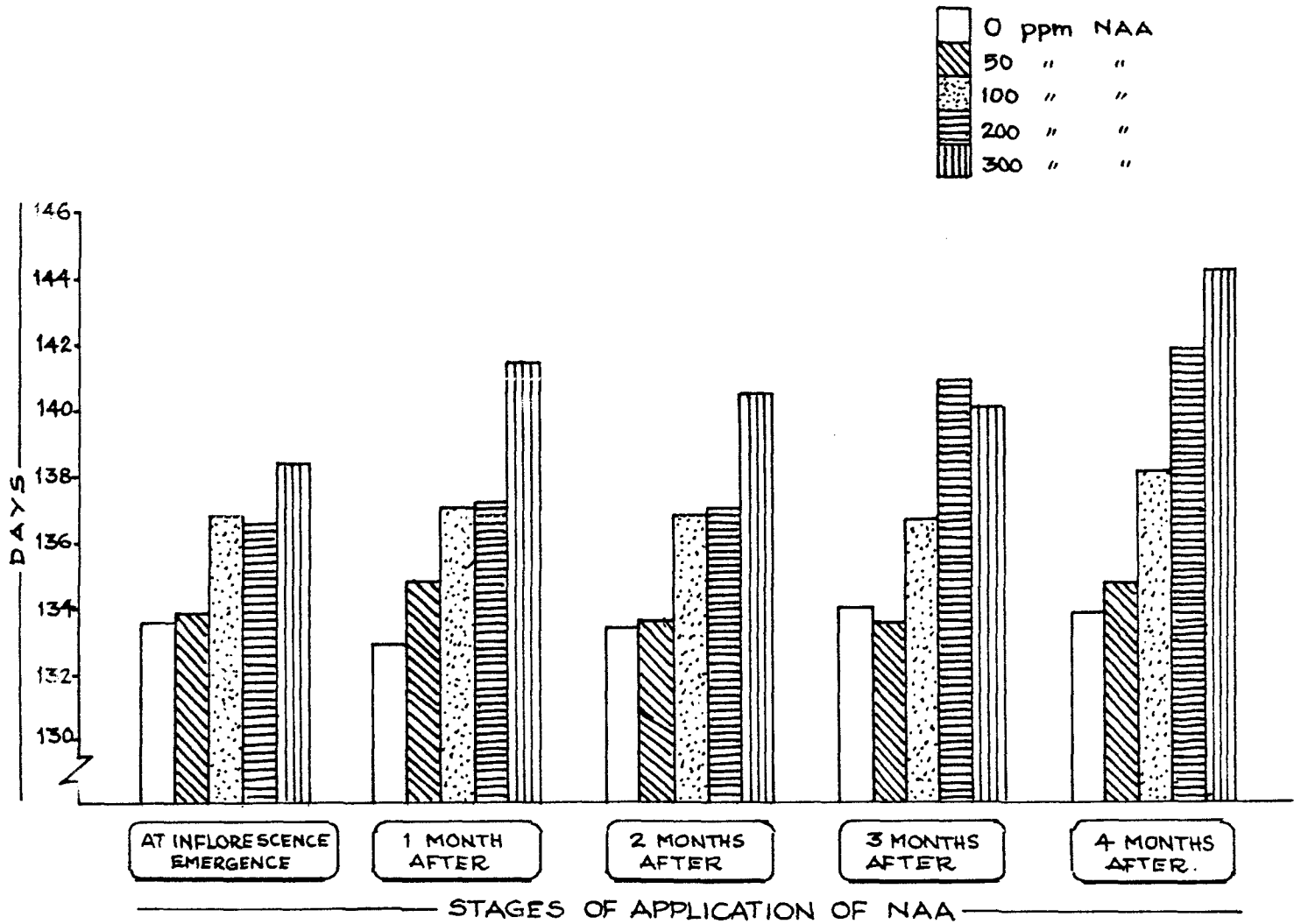
	C.D (5%)	SEm ±
Stages of application	NS	0.01
Concentrations of NAA	NS	0.01
Combinations	NS	0.02

Table 12. Effect of NAA on the time taken for fruit maturity

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	133.6	132.9	133.4	134.0	133.8	133.5
50	133.9	134.9	133.6	133.5	134.7	134.1
100	136.8	137.1	136.9	136.7	138.1	137.1
200	136.6	137.2	137.0	140.9	141.8	138.7
300	138.4	141.5	140.5	140.0	144.1	140.9
Mean	135.9	136.7	136.3	137.0	138.5	

	C.D (5%)	SEm ±
Stages of application	NS	1.05
Concentrations of NAA	2.04	0.72
Combinations	NS	1.61

Fig.5- EFFECT OF NAA ON FRUIT MATURITY



illustrated in Fig.5. It was found that the effect due to different concentrations of NAA alone was significant. Maximum delay in fruit maturity was effected by the application of 300 ppm NAA (140.9 days) and by 200 ppm (138.7 days). Between these two treatments there was no significant difference. The control was found to be on par with 50 ppm NAA which took the least time for fruit maturity (133.5 days).

2.2. Qualitative analysis of fruits

The data on various qualitative characters of fruits in different treatments are presented in Table 13 to 20.

2.2.1. Total soluble solids

The data showed that the effect due to different concentrations of NAA was significant (Table 13), while the stage of application or the interaction did not affect T.S.S. content of fruits. The untreated fruits had maximum T.S.S. content (15.51 per cent) which was on par with 50 ppm NAA. There was no statistical difference between the different concentrations of NAA applied within the range of 100 to 300 ppm.

2.2.2. Acidity

The acidity of fruits was not significantly influenced by different concentrations of NAA or by the

Table 13. Effect of NAA on total soluable solids of fruits (%)

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	15.45	15.33	15.82	14.85	16.10	15.51
50	15.10	15.15	14.95	14.15	15.55	14.98
100	13.90	15.15	14.80	14.65	15.00	14.70
200	14.85	15.00	14.70	13.40	14.90	14.57
300	14.75	14.36	14.10	13.80	14.90	14.38
Mean	14.81	15.00	14.87	14.17	15.29	

	C.D (5%)	SEm ±
Stages of application	NS	0.17
Concentrations of NAA	0.59	0.21
Combinations	NS	0.46

Table 14. Effect of NAA on acidity of fruits (%)

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	0.61	0.69	0.64	0.64	0.63	0.65
50	0.64	0.63	0.59	0.61	0.62	0.62
100	0.67	0.64	0.58	0.68	0.59	0.63
200	0.62	0.61	0.61	0.65	0.60	0.62
300	0.57	0.56	0.58	0.60	0.62	0.59
Mean	0.62	0.63	0.60	0.64	0.62	

	C.D (5%)	SEm ±
Stages of application	NS	0.01
Concentrations of NAA	NS	0.01
Combinations	NS	0.02

stages of application. However, higher value of acidity was recorded by control.

2.2.3. Reducing sugars

The reducing sugar conent of fruits was significantly influenced only by the concentrations of NAA applied. Maximum reducing sugar was recorded by control fruits (5.32 per cent) which was on par with 50 ppm and 100 ppm NAA treatments. The lowest reducing sugar content was recorded by 300 ppm NAA treatment.

2.2.4. Total sugars

As in the case of reducing sugars, the total sugars were also influenced by concentrations of NAA (Table 16). The untreated fruits recorded the maximum total sugars (13.94 per cent) which was on par with the lowest concentration of NAA tried. The total sugars decreased with the increase in concentrations of NAA, 300 ppm recording the lowest value. The treatments 200 and 300 ppm NAA were on par. The effect due to various stages of application and interaction were not significant.

2.2.5. Non-reducing sugar

The non-reducing sugar content was influenced by different concentrations of NAA, while the stages of

Table 15. Effect of NAA on reducing sugars of fruits (%)

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	5.04	4.98	5.08	5.67	5.82	5.32
50	4.56	5.49	5.46	5.16	4.90	5.11
100	5.18	5.17	5.31	5.17	4.59	5.08
200	4.42	5.31	4.96	5.00	4.30	4.80
300	4.60	5.08	5.30	4.81	4.16	4.79
Mean	4.76	5.21	5.22	5.16	4.75	

	C.D (5%)	SEm ±
Stages of application	NS	0.11
Concentrations of NAA	0.29	0.10
Combinations	NS	0.23

Table 16. Effect of NAA on total sugars of fruits (%)

Concentrations of NAA (ppm)	Stages of application					Mean
	At Inflorescence emergence	1month after	2months after	3months after	4months after	
0	13.99	13.93	14.05	13.75	13.99	13.94
50	13.09	13.80	13.40	14.12	13.98	13.66
100	12.80	13.30	14.12	13.12	13.35	13.34
200	12.79	13.27	13.23	12.99	13.12	13.08
300	12.51	12.96	13.05	12.83	11.94	12.66
Mean	13.04	13.45	13.57	13.36	13.25	

	C.D (5%)	SEm ±
Stages of application	NS	0.16
Concentrations of NAA	0.48	0.17
Combinations	NS	0.38

Table 17. Effect of NAA on non-reducing sugar content of fruits (%)

Concentrations of NAA(ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	8.95	8.95	8.97	8.08	8.16	8.62
50	8.53	8.31	7.94	8.96	8.98	8.54
100	7.62	8.13	8.81	7.95	8.76	8.25
200	8.37	7.96	8.27	7.99	8.82	8.28
300	7.91	7.65	7.75	8.02	7.78	7.82
Mean	8.28	8.20	8.35	8.20	8.50	

	C.D (5%)	SEm ±
Stages of application	NS	0.18
Concentrations of NAA	0.51	0.18
Combinations	NS	0.40

application or interaction had no effect. The non-reducing sugar was maximum in the control, which was found to be on par with 50, 100 and 200 ppm NAA treatment. Lowest value for non-reducing sugar was obtained at 300 ppm NAA treatment (7.82 per cent).

2.2.6. Ascorbic acid

The ascorbic acid content of fruits was not affected by various treatments.

2.2.7. Sugar/acid ratio

The data indicated that there was no significant difference due to various treatments on sugar/acid ratio of fruits.

2.2.8. Brix/acid ratio

The brix/acid ratio of fruits did not alter due to various NAA treatments.

2.3. Effect of NAA on fruit development

The data on fruit development in terms of increase in length and girth of fruits are furnished in Table 21.

On the 30th day the fruit length was maximum in the treatment of 300 ppm NAA applied at inflorescence emergence. However on 60th, 90th and 120th days the

Table 18. Effect of NAA on ascorbic acid content of fruits (mg/100g)

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	7.06	7.11	7.23	7.00	6.62	7.00
50	6.86	7.10	7.12	7.56	7.97	7.30
100	6.82	7.55	6.95	7.15	7.68	7.23
200	6.73	6.92	7.48	6.59	6.95	6.93
300	6.72	7.26	6.92	7.17	7.56	7.13
Mean	6.84	7.19	7.14	7.09	7.34	

	C.D (5%)	SEm ±
Stages of application	NS	0.17
Concentrations of NAA	NS	0.15
Combinations	NS	0.33

Table 19. Effect of NAA on sugar/acid ratio of fruits

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	22.93	20.99	21.65	20.33	21.10	21.39
50	20.45	22.11	23.12	24.13	23.15	22.59
100	18.96	21.48	25.12	19.89	23.13	21.72
200	20.63	22.45	22.69	20.18	19.58	21.11
300	21.95	23.54	23.10	21.89	19.92	22.08
Mean	20.98	22.09	23.14	21.28	21.38	

	C.D (5%)	SEm ±
Stages of application	NS	0.67
Concentrations of NAA	NS	0.46
Combinations	NS	1.03

Table 20. Effect of NAA on brix/acid ratio of fruits

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	25.83	22.82	25.31	22.11	26.23	24.46
50	23.89	24.55	25.74	23.83	25.58	24.72
100	21.12	23.87	25.92	21.94	25.92	23.75
200	24.45	24.94	24.59	20.81	21.97	23.35
300	26.27	26.12	24.71	23.41	24.73	25.05
Mean	24.31	24.46	25.25	22.42	24.89	

	C.D (5%)	SEm ±
Stages of application	NS	0.73
Concentrations of NAA	NS	0.43
Combinations	NS	0.97

Table 21. Effect of NAA on fruit development

Stages of application	Concentrations of NAA (ppm)	Days after inflorescence emergence									
		30		60		90		120		Harvest	
		length (cm)	girth (cm)	length (cm)	girth (cm)	length (cm)	girth (cm)	length (cm)	girth (cm)	length (cm)	girth (cm)
At inflorescence emergence	0	10.45	25.75	13.90 (33.01)	35.15 (36.50)	15.25 (9.71)	37.05 (5.41)	15.45 (1.31)	37.45 (1.08)	15.45 (0)	37.45 (0)
	50	10.53	26.43	14.35 (36.28)	36.55 (38.29)	16.20 (11.50)	39.20 (7.25)	16.40 (2.50)	39.50 (0.77)	16.40 (0)	39.50 (0)
	100	10.65	26.33	14.75 (38.50)	37.65 (42.99)	16.55 (12.20)	39.75 (5.58)	17.00 (2.72)	40.18 (1.08)	17.00 (0)	40.18 (0)
	200	11.35	27.05	15.12 (33.22)	39.46 (45.88)	17.35 (14.75)	42.60 (7.96)	17.73 (2.19)	43.15 (1.29)	17.73 (0)	43.15 (0)
	300	11.75	27.35	16.25 (38.30)	39.75 (45.34)	18.70 (15.08)	42.75 (7.55)	19.15 (2.41)	43.50 (1.75)	19.15 (0)	43.50 (0)
One Month after	0	10.73	25.35	14.09 (31.31)	35.25 (39.05)	15.80 (12.14)	38.15 (8.23)	16.40 (3.80)	38.75 (1.57)	16.40 (0)	38.75 (0)
	50	10.25	25.35	13.95 (36.10)	35.05 (38.26)	15.55 (11.47)	38.05 (8.56)	15.85 (1.93)	38.55 (1.31)	15.85 (0)	38.55 (0)
	100	10.66	25.05	14.85 (39.31)	36.26 (44.75)	16.20 (9.09)	38.65 (6.59)	16.60 (2.47)	39.23 (1.50)	16.60 (0)	39.23 (0)

(Contd.)

Table 21. Effect of NAA on fruit development

Stages of application	Concentrations of NAA (ppm)	Days after inflorescence emergence									
		30		60		90		120		Harvest	
		length (cm)	girth (cm)	length (cm)	girth (cm)	length (cm)	girth (cm)	length (cm)	girth (cm)	length (cm)	girth (cm)
At inflorescence emergence	0	10.45	25.75	13.90 (33.01)	35.15 (36.50)	15.25 (9.71)	37.05 (5.41)	15.45 (1.31)	37.45 (1.08)	15.45 (0)	37.45 (0)
	50	10.53	26.43	14.35 (36.28)	36.55 (38.29)	16.20 (11.50)	39.20 (7.25)	16.40 (2.50)	39.50 (0.77)	16.40 (0)	39.50 (0)
	100	10.65	26.33	14.75 (38.50)	37.65 (42.99)	16.55 (12.20)	39.75 (5.58)	17.00 (2.72)	40.18 (1.08)	17.00 (0)	40.18 (0)
	200	11.35	27.05	15.12 (33.22)	39.46 (45.88)	17.35 (14.75)	42.60 (7.96)	17.73 (2.19)	43.15 (1.29)	17.73 (0)	43.15 (0)
	300	11.75	27.35	16.25 (38.30)	39.75 (45.34)	18.70 (15.08)	42.75 (7.55)	19.15 (2.41)	43.50 (1.75)	19.15 (0)	43.50 (0)
One Month after	0	10.73	25.35	14.09 (31.31)	35.25 (39.05)	15.80 (12.14)	38.15 (8.23)	16.40 (3.80)	38.75 (1.57)	16.40 (0)	38.75 (0)
	50	10.25	25.35	13.95 (36.10)	35.05 (38.26)	15.55 (11.47)	38.05 (8.56)	15.85 (1.93)	38.55 (1.31)	15.85 (0)	38.55 (0)
	100	10.66	25.05	14.85 (39.31)	36.26 (44.75)	16.20 (9.09)	38.65 (6.59)	16.60 (2.47)	39.23 (1.50)	16.60 (0)	39.23 (0)

(Contd.)

Table 21. (contd.)

Stages of application	Concentrations of NAA(ppm)	Days after inflorescence emergence									
		30		60		90		120		Harvest	
		length (cm)	girth (cm)	length (cm)	girth (cm)	length (cm)	girth (cm)	length (cm)	girth (cm)	length (cm)	girth (cm)
Three Months after	0	10.65	25.42	14.55 (36.62)	33.96 (33.60)	16.15 (11.00)	37.65 (10.86)	16.48 (2.04)	38.25 (1.59)	16.48 (0)	38.25 (0)
	50	10.88	26.12	14.65 (34.65)	34.25 (31.13)	16.30 (11.26)	37.55 (6.52)	16.70 (2.45)	38.05 (1.33)	16.70 (0)	38.05 (0)
	100	10.65	26.15	14.15 (36.15)	34.65 (32.50)	16.25 (12.97)	37.35 (7.79)	17.05 (3.02)	39.80 (1.21)	17.05 (0)	37.80 (0)
	200	11.05	25.68	14.95 (35.29)	33.45 (30.25)	16.35 (9.36)	36.75 (9.87)	16.60 (1.53)	37.50 (2.04)	16.60 (0)	37.50 (0)
	300	10.80	25.44	14.85 (37.50)	35.45 (39.35)	16.36 (10.17)	38.16 (7.64)	16.98 (3.79)	38.65 (1.28)	16.98 (0)	38.65 (0)
Four Months after	0	10.75	26.15	14.94 (38.97)	34.96 (33.69)	16.05 (7.43)	37.25 (6.55)	16.25 (1.25)	37.80 (1.48)	16.25 (0)	37.80 (0)
	50	10.[illegible]	<5.21	14.65 (38.86)	33.75 (33.88)	16.00 (9.22)	36.40 (7.85)	16.35 (2.19)	37.10 (1.92)	16.35 (0)	37.10 (0)
	[illegible]	10.95	26.15	15.10 (37.90)	34.26 (31.01)	16.35 (8.28)	36.95 (7.85)	16.65 (1.83)	37.85 (1.28)	16.65 (0)	37.85 (0)
	200	10.70	25.65	15.45 (37.95)	34.55 (34.70)	16.75 (8.41)	36.85 (6.66)	17.05 (1.79)	37.40 (1.49)	17.05 (0)	37.40 (0)
	300	10.95	25.85	15.05 (37.44)	34.95 (35.20)	16.54 (9.90)	37.44 (7.12)	16.75 (1.27)	38.20 (2.03)	16.75 (0)	38.20 (0)

Note :- The figures in the parenthesis indicate the incremental percentage increase at each time interval.

Table 21. (Contd.)

Stages of application	Concentrations of NAA (ppm)	Days after inflorescence emergence									
		30		60		90		120		Harvest	
		length (cm)	girth (cm)	length (cm)	girth (cm)	length (cm)	girth (cm)	length (cm)	girth (cm)	length (cm)	girth (cm)
Two Months after	200	10.75	25.98	15.25 (41.86)	38.05 (46.46)	17.55 (15.08)	43.00 (13.01)	18.05 (2.85)	43.75 (1.74)	18.05 (0)	43.75 (0)
	300	10.85	25.60	17.15 (58.07)	39.10 (52.73)	20.15 (17.49)	43.16 (10.38)	20.98 (4.12)	44.15 (2.29)	20.98 (0)	44.15 (0)
	0	10.65	25.58	14.35 (34.74)	34.36 (34.32)	15.90 (14.72)	37.65 (9.58)	16.15 (1.57)	38.35 (1.86)	16.15 (0)	38.35 (0)
	50	11.05	25.12	14.85 (34.39)	33.36 (32.80)	16.05 (8.08)	36.95 (10.76)	16.52 (2.93)	37.54 (1.60)	16.52 (0)	37.54 (0)
	100	10.86	26.65	14.85 (36.74)	33.65 (31.19)	16.45 (10.77)	37.75 (7.70)	16.95 (3.04)	38.24 (1.30)	16.95 (0)	38.24 (0)
	200	10.80	26.05	14.95 (38.43)	34.85 (33.78)	17.00 (13.71)	39.35 (12 .91)	17.48 (2.82)	40.25 (2.29)	17.48 (0)	40.25 (0)
	300	10.95	25.38	14.75 (34.70)	34.75 (36.92)	17.94 (13.19)	40.45 (16.40)	18.40 (2.56)	41.15 (1.73)	18.40 (0)	41.15 (0)

(Contd.)

Table 21. (contd.)

Stages of application	Concentrations of NAA(ppm)	Days after inflorescence emergence									
		30		60		90		120		Harvest	
		length (cm)	girth (cm)	length (cm)	girth (cm)	length (cm)	girth (cm)	length (cm)	girth (cm)	length (cm)	girth (cm)
Three Months after	0	10.65	25.42	14.55 (36.62)	33.96 (33.60)	16.15 (11.00)	37.65 (10.86)	16.48 (2.04)	38.25 (1.59)	16.48 (0)	38.25 (0)
	50	10.88	26.12	14.65 (34.65)	34.25 (31.13)	16.30 (11.26)	37.55 (6.52)	16.70 (2.45)	38.05 (1.33)	16.70 (0)	38.05 (0)
	100	10.65	26.15	14.15 (36.15)	34.65 (32.50)	16.25 (12.97)	37.35 (7.79)	17.05 (3.02)	39.80 (1.21)	17.05 (0)	37.80 (0)
	200	11.05	25.68	14.95 (35.29)	33.45 (30.25)	16.35 (9.36)	36.75 (9.87)	16.60 (1.53)	37.50 (2.04)	16.60 (0)	37.50 (0)
	300	10.80	25.44	14.85 (37.50)	35.45 (39.35)	16.36 (10.17)	38.16 (7.64)	16.98 (3.79)	38.65 (1.28)	16.98 (0)	38.65 (0)
Four Months after	0	10.75	26.15	14.94 (38.97)	34.96 (33.69)	16.05 (7.43)	37.25 (6.55)	16.25 (1.25)	37.80 (1.48)	16.25 (0)	37.80 (0)
	50	10.55	25.21	14.65 (38.86)	33.75 (33.88)	16.00 (9.22)	36.40 (7.85)	16.35 (2.19)	37.10 (1.92)	16.35 (0)	37.10 (0)
	100	10.95	26.15	15.10 (37.90)	34.26 (31.01)	16.35 (8.28)	36.95 (7.85)	16.65 (1.83)	37.85 (1.28)	16.65 (0)	37.85 (0)
	200	10.70	25.65	15.45 (37.95)	34.55 (34.70)	16.75 (8.41)	36.85 (6.66)	17.05 (1.79)	37.40 (1.49)	17.05 (0)	37.40 (0)
	300	10.95	25.85	15.05 (37.44)	34.95 (35.20)	16.54 (9.90)	37.44 (7.12)	16.75 (1.27)	38.20 (2.03)	16.75 (0)	38.20 (0)

Note :- The figures in the parenthesis indicate the incremental percentage increase at each time interval.

Fig. 6.a - EFFECT OF NAA ON FRUIT LENGTH DURING DEVELOPMENT

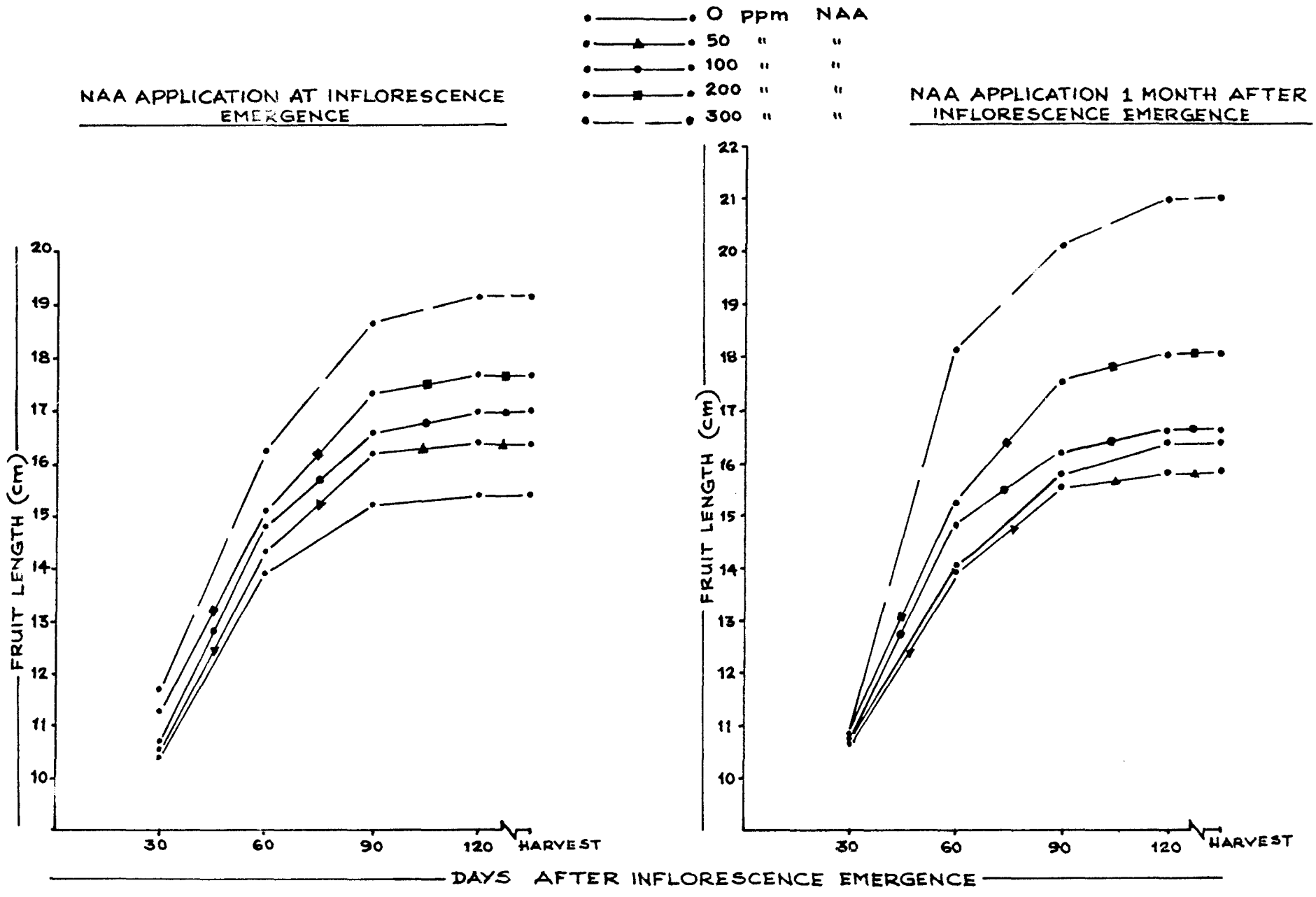
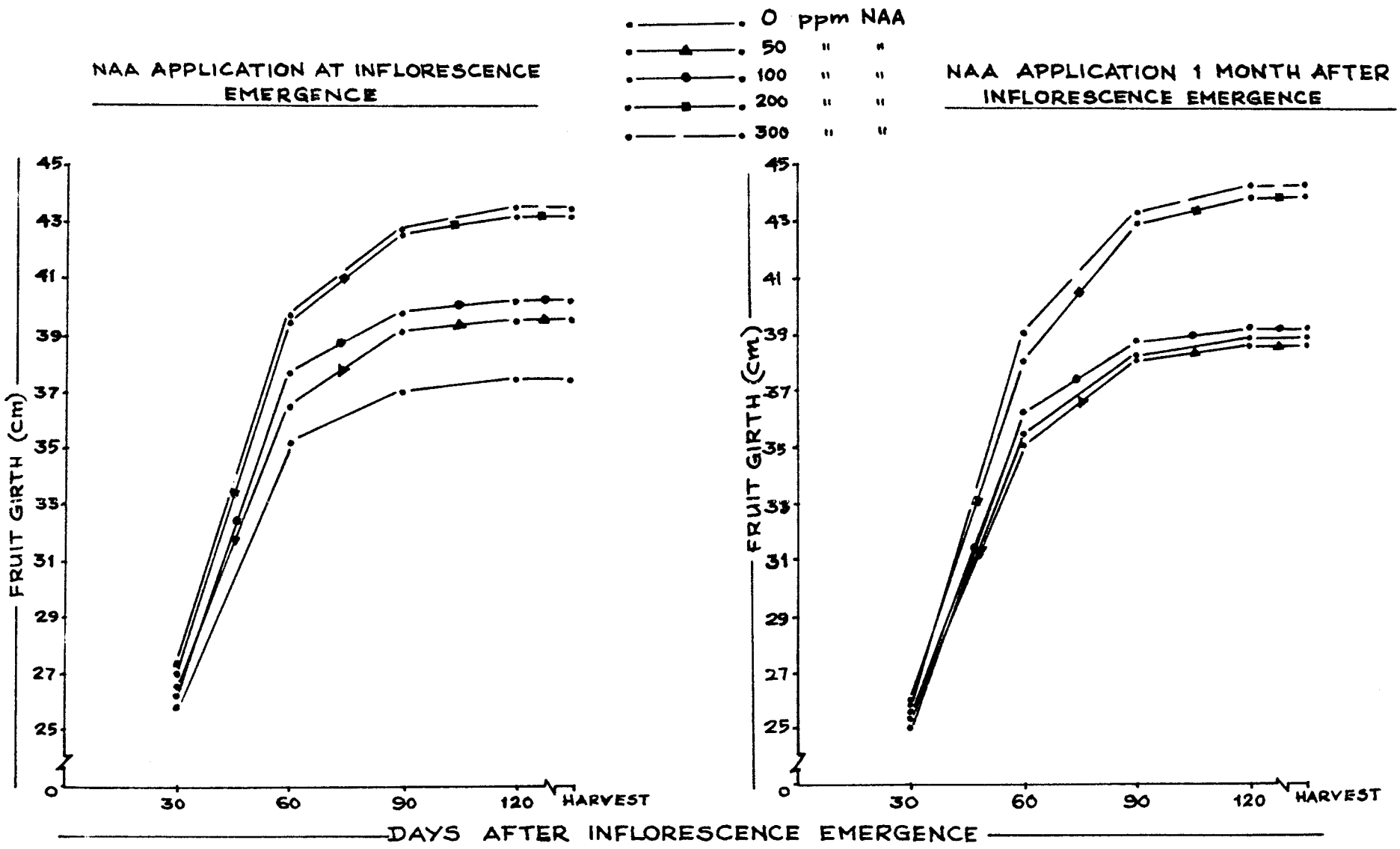


FIG. 6-b- EFFECT OF NAA ON FRUIT GIRTH DURING DEVELOPMENT



treatment of 300 ppm NAA applied one month after inflorescence emergence recorded the maximum fruit length, the percentage increase being 58.07, 17.49 and 4.12 per cent respectively. The next best treatment in terms of increase in length in the above periods was 300 ppm NAA applied at inflorescence emergence stage which was followed by 200 ppm NAA application one month after inflorescence emergence. In terms of girth of fruits, application of NAA 300 ppm at inflorescence emergence recorded the highest values on 30th and 60th days. However on 90th and 120th day, the maximum girth was recorded by 300 ppm NAA treatment one month after inflorescence emergence, the percentage increase being 10.38 and 2.29 respectively. After 120 days there was no development in terms of length and girth of fruits in all treatments. Active phase of fruit development was thus found to be between 30 and 60 days after inflorescence emergence and these were the periods where NAA had significant effects (Figs. 6a and 6b).

2.4. Effect of NAA on leaf characters

The Tables 22 to 27 represent the data on various leaf characters of plants at the time of harvest of fruits. It will be seen that while the treatments did not significantly influence the length, breadth and leaf area of 'D' leaf, there was significant

Table 22. Effect of NAA on 'D' leaf length at harvest (cm)

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	86.10	95.00	96.05	85.80	82.88	89.17
50	81.90	91.08	93.23	80.60	93.93	94.15
100	82.08	88.38	89.13	94.35	80.38	94.86
200	87.43	80.75	89.45	96.00	90.48	96.82
300	89.30	90.33	81.10	92.40	80.35	96.70
Mean	85.36	87.11	87.79	85.93	85.61	

	C.D (5%)	SEm ±
Stages of application	NS	2.78
Concentrations of NAA	NS	1.88
Combinations	NS	4.21

Table 23. Effect of NAA on 'D' leaf breadth at harvest (cm)

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	5.10	4.95	4.89	5.18	5.10	5.04
50	5.18	5.70	5.23	6.12	5.33	5.51
100	5.45	5.15	5.89	5.08	5.38	5.39
200	5.28	5.68	5.40	5.43	4.95	5.35
300	5.35	5.20	5.90	5.83	5.88	5.63
Mean	5.27	5.34	5.46	5.53	5.33	

	C.D (5%)	SEm ±
Stages of application	NS	0.40
Concentrations of NAA	NS	0.50
Combinations	NS	1.11

Table 24. Effect of NAA on 'D' leaf area at harvest (sq.cm)

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	319.11	341.95	339.83	322.94	307.21	326.21
50	307.91	335.87	316.92	357.98	363.57	336.29
100	324.82	330.63	380.24	310.91	313.96	332.11
200	334.92	332.74	350.59	339.12	325.21	336.52
300	346.78	341.74	347.45	391.24	343.12	353.99
Mean	326.71	336.51	346.85	344.44	330.61	

	C.D (5%)	SEm ±
Stages of application	NS	7.55
Concentrations of NAA	NS	5.66
Combinations	NS	12.65

Table 25. Effect of NAA on fresh weight of 'D' leaf at harvest (g)

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	53.75	53.07	52.17	49.92	53.47	52.48
50	50.83	49.43	51.92	51.52	52.41	51.22
100	49.44	50.46	49.69	49.51	47.69	49.36
200	49.60	47.15	50.86	46.16	49.01	48.56
300	47.61	48.72	47.69	44.01	48.49	47.30
Mean	50.22	49.77	50.47	48.22	50.21	

	C.D (5%)	SEm ±
Stages of application	NS	0.94
Concentrations of NAA	2.44	0.86
Combinations	NS	1.93

Table 26. Effect of NAA on dry weight of 'D' leaf at harvest (g)

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	8.37	7.59	7.40	7.45	8.07	7.78
50	7.41	7.74	7.48	8.24	7.04	7.58
100	7.13	7.75	6.65	7.66	7.24	7.29
200	7.34	6.72	6.58	6.13	7.37	6.83
300	6.03	6.51	6.75	6.00	7.20	6.52
Mean	7.26	7.26	6.97	7.10	7.40	

	C.D (5%)	SEm ±
Stages of application	NS	0.23
Concentrations of NAA	0.70	0.25
Combinations	NS	0.55

Table 27. Effect of NAA on percentage dry weight of 'D' leaf at harvest

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	15.49	14.69	14.15	14.88	15.09	14.86
50	14.56	15.40	14.37	16.04	13.49	14.77
100	14.44	16.47	13.38	15.43	14.57	14.86
200	14.74	14.22	12.90	13.23	14.91	14.00
300	12.65	13.01	14.23	15.45	15.03	14.07
Mean	14.38	14.76	13.81	15.01	14.62	

	C.D (5%)	SEm ±
Stages of application	NS	0.40
Concentrations of NAA	NS	0.38
Combinations	NS	0.85

reduction in fresh and dry weight of 'D' leaves with the increase in concentrations of NAA. The control plants possessed 'D' leaves with maximum fresh weight followed by 50 ppm NAA and these two were found to be on par. At 100,200 and 300 ppm NAA , the fresh weight of 'D' leaves reduced significantly and they were on par. With respect to dry weight, maximum value was recofded by control followed by 50 and 100 ppm NAA and these three were on par. The treatments 200 and 300 ppm NAA were found to be on par and recorded significantly lower values in comparison to other treatments.

With respect to the stages of application the effect of treatments on fresh weight and dry weight of 'D' leaves was not significant. There was also no effect due to combination. Similarly the percentage dry weight of 'D' leaves was also not significantly altered by the treatments.

2.5 Leaf analysis

The N,P and K content of the 'D' leaves at the time of harvest of fruits in the different treatments are furnished in Tables 28 to 30

2.5.1. Nitrogen

There was no significant difference in

Table 28. Effect of NAA on nitrogen content of '0' leaf at harvest (%)

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	1.39	1.37	1.33	1.35	1.41	1.37
50	1.33	1.37	1.30	1.38	1.43	1.36
100	1.34	1.33	1.37	1.32	1.35	1.34
200	1.30	1.34	1.32	1.34	1.38	1.34
300	1.27	1.23	1.28	1.33	1.39	1.30
Mean	1.33	1.33	1.32	1.34	1.39	

	C.D (5%)	SEm ±
Stages of application	NS	0.04
Concentrations of NAA	NS	0.04
Combinations	NS	0.09

nitrogen content of 'D' leaves in the plants due to different treatments. However, from the data it is evident that there was an apparent reduction in leaf nitrogen content when 300 ppm NAA was applied, especially one month after the emergence of the inflorescence.

2.5.2. Phosphorus

None of the treatments significantly influenced the Phosphorus content of leaves at harvest.

2.5.3. Potassium

The treatment did not show any significant influence on the potassium content of leaves at the time of harvest. However, a progressive reduction in potassium content was observed with higher concentrations of NAA.

2.5.4. C/N ratio

The various treatments did not show any significant influence on C/N ratio of 'D' leaves at harvest (Table 31).

Table 29. Effect of NAA on Phosphorus content of 'D' leaf at harvest (%)

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	0.10	0.09	0.10	0.11	0.09	0.10
50	0.09	0.11	0.11	0.11	0.10	0.10
100	0.12	0.11	0.11	0.09	0.09	0.10
200	0.09	0.09	0.08	0.10	0.11	0.09
300	0.10	0.09	0.08	0.11	0.12	0.10
Mean	0.10	0.10	0.10	0.10	0.10	

	C.D (5%)	SEm ±
Stages of application	NS	0.007
Concentrations of NAA	NS	0.005
Combinations	NS	0.011

Table 30. Effect of NAA on Potassium content of 'D' leaf at harvest (%)

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	2.56	2.38	2.68	2.43	2.40	2.49
50	2.42	2.46	2.42	2.40	2.61	2.46
100	2.50	2.37	2.59	2.37	2.41	2.45
200	2.48	2.29	2.37	2.33	2.59	2.41
300	2.39	2.26	2.29	2.41	2.43	2.36
Mean	2.47	2.35	2.47	2.39	2.49	

	C.D (5%)	SEm ±
Stages of application	NS	0.06
Concentrations of NAA	NS	0.06
Combinations	NS	0.14

Table 31. Effect of NAA on C/N ratio of 'D' leaf at harvest

Concentrations of NAA (ppm)	Stages of application					Mean
	At inflorescence emergence	1month after	2months after	3months after	4months after	
0	29.03	29.09	32.63	28.46	32.49	30.34
50	30.11	31.18	32.01	30.67	27.32	30.26
100	28.33	27.30	29.69	29.02	29.06	28.68
200	28.78	30.35	28.26	30.60	30.95	29.79
300	31.38	32.63	30.22	33.45	30.97	31.73
Mean	29.53	30.11	30.56	30.44	30.16	

	C.D (5%)	SEm ±
Stages of application	NS	0.99
Concentrations of NAA	NS	0.89
Combinations	NS	2.00

3. EFFECT OF α NAPHTHALENE ACETIC ACID ON SIZE, MATURITY AND QUALITY OF FRUITS FROM PLANTS HAVING DIFFERENT LEAF NUMBER

3.1. Leaf characters of plants in different groups and their nutrient status

The pretreatment data relating to different leaf characters of different groups of plants are presented in Table 32. It will be seen that the length of 'D' leaf was higher in plants possessing higher leaf number upto 41-45 leaves, thereafter showing a decreasing trend. With respect to 'D' leaf breadth, it increased progressively as the leaf number increased. The 'D' leaf area followed the same trend as that of leaf length. The fresh weight and dry weight of 'D' leaf increased progressively with increase in the leaf number. The percentage dry weight of 'D' leaf did not show any definite trend. However, plants possessing 51-55 leaves showed a higher percentage dry weight. The pretreatment data on the nitrogen, phosphorus, and potassium content of leaves showed that in the case of nitrogen and potassium the leaf number had a direct relationship and the highest nitrogen and potassium were recorded by 51-55 leaf group and the lowest by 26-30 leaf group. The leaf number did not exert any

Table 32. 'D' leaf characters and their nutrient status in different leaf groups

Leaf Groups	Length (cm)	Breadth (cm)	Area (sq.cm)	Fresh weight (g)	Dry weight (g)	Percentage dry weight	Nitrogen (%)	Phosphorous (%)	Potassium (%)	C/N ratio
26 - 30 (G_1)	55.62	4.14	166.88	33.64	3.43	10.21	1.54	0.16	2.43	23.49
31 - 35 (G_2)	57.36	4.32	179.90	34 .59	3.64	10.54	1.68	0.18	2.70	23.38
36 - 40 (G_3)	61.36	4.36	194.37	41.41	3.72	8.99	1.77	0.17	3.45	22.17
41 - 45 (G_4)	61.78	4.32	193.77	41.74	3.92	9.39	1.79	0.17	3.46	22.75
46 - 50 (G_5)	52.40	4.78	181.59	42.84	4.30	10.01	1.98	0.15	3.50	20.25
51 - 55 (G_6)	51.28	4.88	181.42	44.80	5.34	11.91	2.06	0.16	3.78	20.53

significant influence on leaf phosphorus content. The C/N ratio of leaves also was not influenced by leaf number.

3.2. Effect of NAA on 'D' leaf characters and their nutrient content

Data relating to the leaf characters at harvest in relation to the application of 300 ppm NAA are furnished in Tables 33 and 34. The treatment effect was not significant in any of the leaf characters studied. However, there was a reduction in fresh weight and dry weight of 'D' leaves at harvest when fruits were treated with NAA, one month after inflorescence emergence.

The data relating to the nutrient content of leaves(N,P and K) at the time of harvest of fruits, after the application of 300 ppm NAA showed that, there was no significant influence due to the treatment of NAA. The influence of leaf number on N,P and K content of leaves which was evident from the pretreatment data was also perceptible at harvest. However, the nitrogen and potassium percentage of leaves tended to decrease when NAA was applied in almost all groups. Treatment of NAA did not show any significant influence on C/N ratio of leaves.

Table 33. Effect of NAA on 'D' leaf characters in different leaf groups

Leaf groups	'D' leaf length (cm)			'D' leaf breadth (cm)			'D' leaf area (Sq.cm)		
	Treated (T)	Control (C)	't'value	Treated (T)	Control (C)	't'value	Treated (T)	Control (C)	't'value
26 - 30 (G_1)	66.90	67.14	0.09^{NS}	4.48	4.60	0.53^{NS}	217.09	224.80	0.46^{NS}
31 - 35 (G_2)	72.58	72.34	0.08^{NS}	4.82	4.92	0.35^{NS}	253.72	259.22	0.24^{NS}
36 - 40 (G_3)	80.26	79.16	0.38^{NS}	5.18	5.08	0.32^{NS}	299.99	291.73	0.49^{NS}
41 - 45 (G_4)	83.48	80.00	1.13^{NS}	5.30	5.10	0.56^{NS}	322.41	301.89	0.72^{NS}
46 - 50 (G_5)	73.76	73.50	0.05^{NS}	5.02	5.20	1.86^{NS}	268.51	278.41	0.92^{NS}
51 - 55 (G_6)	70.80	68.00	1.20^{NS}	5.30	5.48	1.60^{NS}	271.86	269.79	0.25^{NS}

NS Not significant

Table 34. Effect of NAA on fresh weight and dry weight of 'D' leaf in different leaf groups

Leaf groups	Fresh weight of 'D' leaf (g)			Dry weight of 'D' leaf (g)			Percentage dry weight of 'D' leaf		
	Treated (T)	Control (C)	't' value	Treated (T)	Control (C)	't' value	Treated (T)	Control (C)	't' value
26 - 30 (G_1)	31.40	31.60	0.03^{NS}	3.47	3.62	0.63^{NS}	11.54	11.07	1.21^{NS}
31 - 35 (G_2)	34.83	35.35	0.19^{NS}	4.08	4.20	0.59^{NS}	11.59	12.05	0.47^{NS}
36 - 40 (G_3)	40.31	41.69	10.13^{NS}	4.36	4.46	0.21^{NS}	11.00	10.69	0.67^{NS}
41 - 45 (G_4)	41.53	42.03	0.26^{NS}	4.27	4.94	1.87^{NS}	10.28	11.75	1.66^{NS}
46 - 50 (G_5)	42.31	42.58	0.12^{NS}	3.95	4.13	0.69^{NS}	9.37	9.76	0.51^{NS}
51 - 55 (G_6)	44.38	45.08	0.79^{NS}	4.36	4.58	0.67^{NS}	10.33	10.66	0.89^{NS}

NS Not significant

Table 35. Effect of NAA on nutrient content of 'D' leaf in different leaf groups.

Leaf groups	Nitrogen (%)			Phosphorus (%)			Potassium (%)		
	Treated (T)	Control (C)	't'value	Treated (T)	Control (C)	't'value	Treated (T)	Control (C)	't'value
26 - 30 (G_1)	1.16	1.18	0.23^{NS}	0.11	0.10	0.32^{NS}	1.75	1.83	0.86^{NS}
31 - 35 (G_2)	1.34	1.37	0.27^{NS}	0.11	0.10	0.26^{NS}	1.80	1.95	1.40^{NS}
36 - 40 (G_3)	1.35	1.39	0.38^{NS}	0.11	0.12	0.14^{NS}	2.16	2.32	1.68^{NS}
41 - 45 (G_4)	1.35	1.40	0.33^{NS}	0.13	0.12	0.19^{NS}	2.14	2.32	1.78^{NS}
46 - 50 (G_5)	1.48	1.51	0.11^{NS}	0.11	0.12	0.07^{NS}	2.20	2.34	1.41^{NS}
51 - 55 (G_6)	1.50	1.53	1.23^{NS}	0.13	0.12	0.05^{NS}	2.40	2.51	1.38^{NS}

NS Not significant

Table 36. Effect of NAA on C/N ratio of 'D' leaf in different leaf groups

Leaf groups	C/N ratio		
	Treated (T)	Control (C)	't' value
26 - 30 (G_1)	33.77	33.63	0.01^{NS}
31 - 35 (G_2)	31.95	31.82	0.03^{NS}
36 - 40 (G_3)	31.85	30.95	0.13^{NS}
41 - 45 (G_4)	31.52	30.33	0.45^{NS}
46 - 50 (G_5)	31.75	30.25	0.37^{NS}
51 - 55 (G_6)	30.75	30.25	0.25^{NS}

NS Not significant

3.3. Effect of NAA on fruit characters

The data on various fruit characters consequent on the application of NAA 300 ppm one month after inflorescence emergence are presented in Table 37 to 44.

3.3.1. Fruit weight

NAA was found to exert definite influence on fruit weight in all groups of plants (Fig.7). However in the 26-30 leaf group even though there was an increase in fruit size compared to untreated fruits, the fruit size never attained above 1.08 kg. Fruits from 31-35 leaf group when treated with NAA attained the size as that of untreated fruits of 36-40 and 41-45 leaf groups. The weight of the fruits subsequent to NAA treatment in 36-40 leaf group was higher than those produced by 41-45 leaf group and compared well with fruits produced by 46-50 leaf group. Similar effect of NAA was also found in the 46-50 leaf group also.

The fruit weight without crown followed a similar trend as that of fruit weight with crown by the NAA treatment.

3.3.2. Fruit length

The treatment of NAA significantly increased fruit length in all groups of plants except in the last

Table 37. Effect of NAA on fruit weight with crown in different leaf groups (kg)

Leaf groups	Treated (T)	Control (C)
26 - 30 (G_1)	1.08	0.98
31 - 35 (G_2)	1.55	1.32
36 - 40 (G_3)	1.89	1.57
41 - 45 (G_4)	1.88	1.59
46 - 50 (G_5)	2.11	1.87
51 - 55 (G_6)	2.17	1.98

Comparison of data	't' value		't' value
G_1T Vs G_1C	2.36^{*}	G_2T Vs G_4C	1.40^{NS}
G_2T Vs G_2C	4.31^{**}	G_2T Vs G_5C	2.77^{**}
G_3T Vs G_3C	6.72^{**}	G_3T Vs G_4C	4.77^{**}
G_4T Vs G_4C	6.44^{**}	G_3T Vs G_5C	0.33^{NS}
G_5T Vs G_5C	4.70^{**}	G_3T Vs G_6C	2.35^{*}
G_6T Vs G_6C	3.44^{**}	G_4T Vs G_5C	0.23^{NS}
G_1T Vs G_2C	2.29^{*}	G_4T Vs G_6C	2.00^{*}
G_2T Vs G_3C	0.42^{NS}	G_5T Vs G_6C	1.91^{NS}

* Significant at 5% level

** Significant at 1% level

NS Not significant

Table 38. Effect of NAA on fruit weight without cream in different leaf groups (kg)

Leaf groups	Treated (T)	Control (C)
26 - 30 (G_1)	0.94	0.85
31 - 35 (G_2)	1.39	1.17
36 - 40 (G_3)	1.63	1.41
41 - 45 (G_4)	1.71	1.42
46 - 50 (G_5)	1.93	1.70
51 - 55 (G_6)	1.98	1.80

Comparison of data	't' value	Comparison of data	't' value
G_1T Vs G_1C	2.13*	G_2T Vs G_4C	1.14^{NS}
G_2T Vs G_2C	3.50**	G_2T Vs G_5C	2.99**
G_3T Vs G_3C	5.42**	G_3T Vs G_4C	4.68**
G_4T Vs G_4C	4.58**	G_3T Vs G_5C	2.00*
G_5T Vs G_5C	3.68**	G_3T Vs G_6C	2.00*
G_6T Vs G_6C	3.61**	G_4T Vs G_5C	0.31^{NS}
G_1T Vs G_2C	2.30*	G_4T Vs G_6C	2.13*
G_2T Vs G_3C	0.45^{NS}	G_5T Vs G_6C	2.15*

* significant at 1% level
** significant at 5% level
NS Not significant

Fig. 7- EFFECT OF NAA 300 ppm ON FRUIT WEIGHT IN DIFFERENT LEAF GROUPS

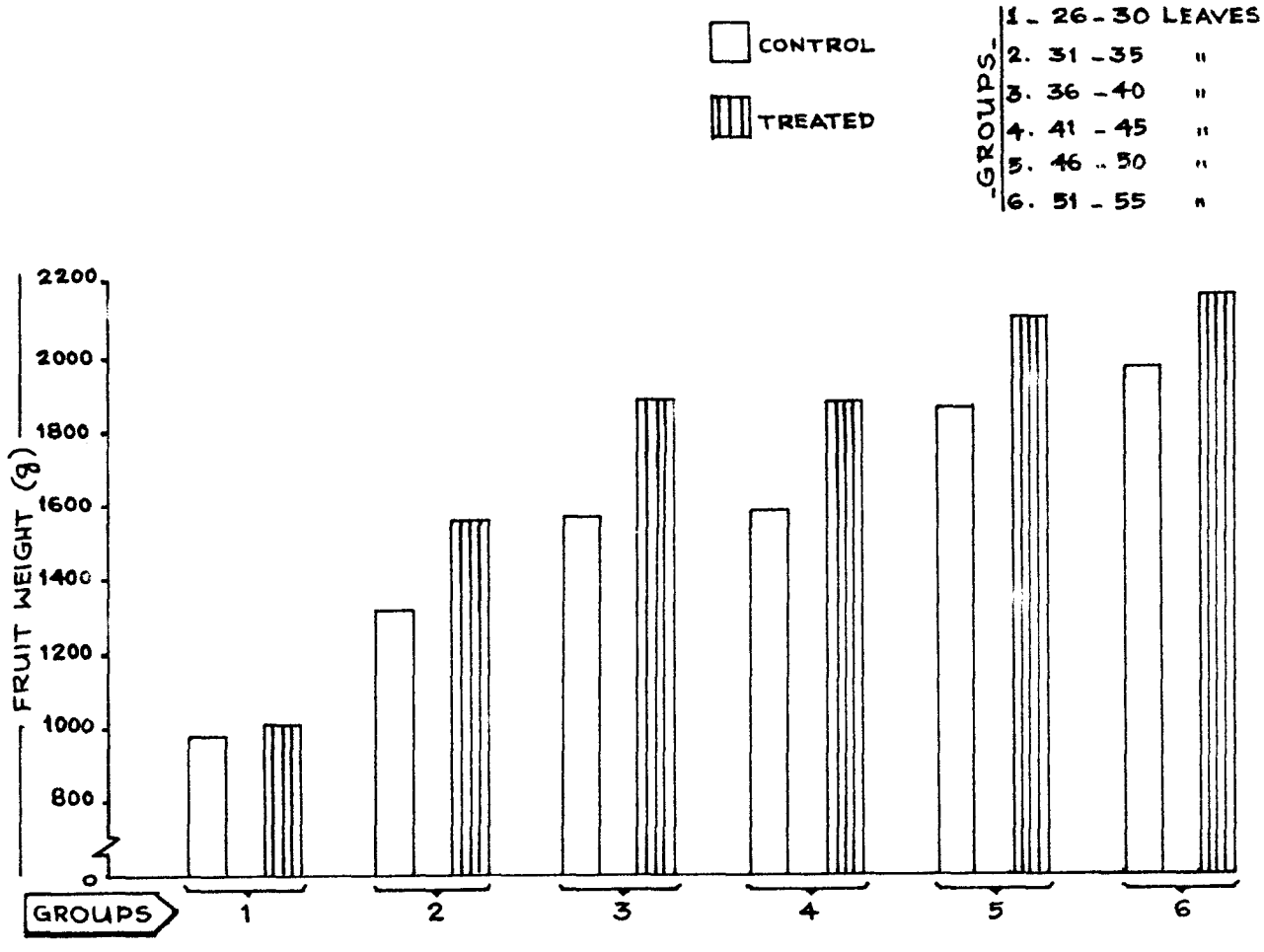


Table 39. Effect of NAA on fruit length in different leaf groups (cm)

Leaf groups	Treated (T)	Control (C)
26 - 30 (G_1)	14.03	12.28
31 - 35 (G_2)	17.00	16.03
36 - 40 (G_3)	18.58	16.98
41 - 45 (G_4)	18.56	17.28
46 - 50 (G_5)	19.53	17.88
51 - 55 (G_6)	19.95	19.05

Comparison of data

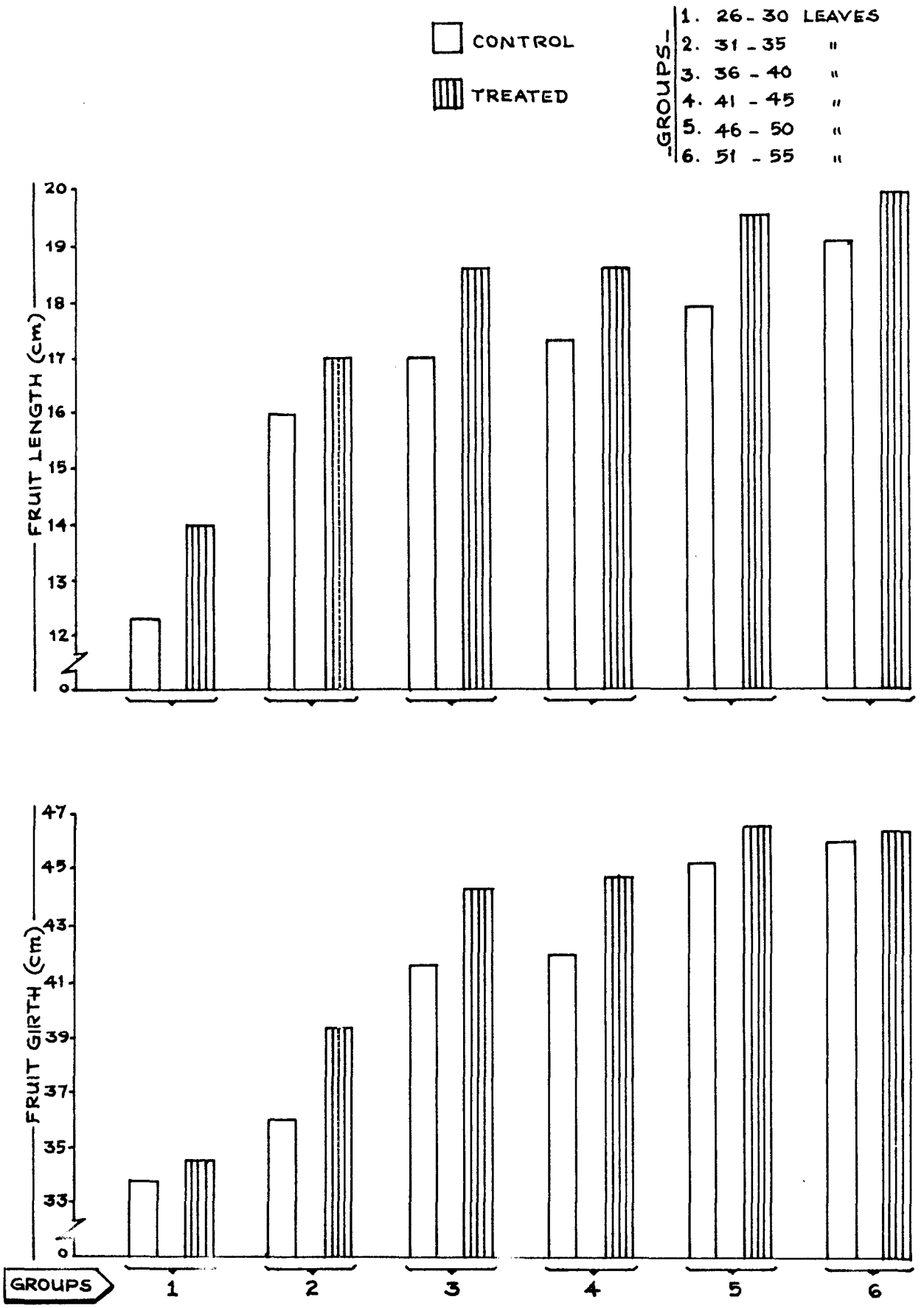
	't' value		't' value
G_1T Vs G_1C	2.91^{**}	G_2T Vs G_4C	0.89^{NS}
G_2T Vs G_2C	2.65^{**}	G_2T Vs G_5C	2.96^{**}
G_3T Vs G_3C	4.25^{**}	G_3T Vs G_4C	2.81^{**}
G_4T Vs G_4C	3.61^{**}	G_3T Vs G_5C	1.92^{NS}
G_5T Vs G_5C	3.93^{**}	G_3T Vs G_6C	2.11^{*}
G_6T Vs G_6C	1.68^{NS}	G_4T Vs G_5C	1.89^{NS}
G_1T Vs G_2C	3.98^{**}	G_4T Vs G_6C	2.00^{*}
G_2T Vs G_3C	0.06^{NS}	G_5T Vs G_6C	1.79^{NS}

* Significant at 1% level

** Significant at 5% level

NS Not significant

FIG. 8 - EFFECT OF NAA 300 ppm ON FRUIT LENGTH & GIRTH IN DIFFERENT LEAF GROUPS



group (51-55 leaf group) (Fig.8). The fruit length had a direct relationship with the leaf number possessed by plants. Maximum fruit length was recorded by plants with 51-55 leaves and the least by 26-30 leaf group. The treatment of NAA did not increase fruit length in the 26-30 leaf group upto the level of fruit length obtained in 31-35 leaf group. But fruits belonging to 31-35 leaf group when treated with NAA could produce fruits of similar length as that of 41-45 leaf group. The fruit length recorded by treated plants of 36-40 leaf group also compared well with the fruit length obtained in the next two higher leaf groups. Similar effect was noticed in the 41-45 and 46-50 leaf groups also.

3.3.3. Fruit girth

The treatment of NAA significantly influenced fruit girth in almost all groups except in the first and last leaf groups (Fig.8). Maximum girth was recorded by 51-55 leaf group (46.50cm) and minimum by 26-30 leaf group (34.55 cm). The effect of NAA on 31-35 leaf group was not so significant enough to achieve the fruit girth produced by untreated plants with 36-40 leaves. However, in 36-40 leaf group, NAA treatment produced fruits of better girth than that produced by 41-45 leaf group, but the girth of fruits did not reach the level as in 46-50 leaf group . In 41-45 leaf group although the

Table 40. Effect of NAA on fruit girth in different leaf groups (cm)

Leaf groups	Treated (T)	Control (C)
26 - 30 (G_1)	34.55	33.79
31 - 35 (G_2)	39.37	36.00
36 - 40 (G_3)	44.35	41.57
41 - 45 (G_4)	44.79	41.96
46 - 50 (G_5)	46.63	45.25
51 - 55 (G_6)	46.50	46.15

Comparison of data

	't' value		't' value
G_1T Vs G_1C	1.85^{NS}	G_1T Vs G_2C	1.92^{NS}
G_2T Vs G_2C	3.90^{**}	G_1T Vs G_3C	5.47^{**}
G_3T Vs G_3C	4.08^{**}	G_2T Vs G_3C	2.18^{*}
G_4T Vs G_4C	4.77^{**}	G_3T Vs G_4C	2.75^{**}
G_5T Vs G_5C	2.76^{**}	G_3T Vs G_5C	2.12^{*}
G_6T Vs G_6C	1.35^{NS}	G_4T Vs G_5C	2.00^{*}
		G_5T Vs G_6C	1.46^{NS}

* Significant at 1% level
** Significant at 5% level
NS Not significant

effect of NAA was significant, it was not able to bring the fruit girth produced by 46-50 leaf group. The fruit girth produced by 46-50 leaf number group compared well with that of produced by subsequent higher group.

3.3.4. Fruit breadth

The fruit breadth was significantly increased by NAA treatment in all the groups (Table 41). The effect of leaf number on the breadth of fruits was also evident, the maximum being recorded by 51-55 leaf number group and the minimum by 26 - 30 leaf group. The effect of NAA on fruit breadth in 26 - 30 and 31 - 35 leaf groups were not significant so as to bring the fruit breadth upto the level of the next higher groups. However, the fruit breadth recorded by treated plants of 36-40 leaf number group compared well with the fruit breadth recorded by fruits in 46-50 leaf group. In the other groups also, the treated fruits compared well with those produced by the next higher leaf group.

3.3.5. Crown weight

The date on crown weight in different groups of plants of both control and treated plants (Table 42) showed that there was no significant difference on crown weight in different groups of plants, due to NAA treatment.

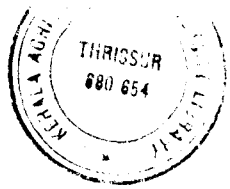


Table 41. Effect of NAA on fruit breadth in different leaf groups (cm)

Leaf groups	Treated (T)	Control (C)
26 - 30 (G_1)	11.78	10.93
31 - 35 (G_2)	13.18	12.71
36 - 40 (G_3)	14.42	13.33
41 - 45 (G_4)	14.54	13.79
46 - 50 (G_5)	14.63	13.93
51 - 55 (G_6)	15.26	14.64

Comparison of data

	't' value		't' value
G_1T Vs G_1C	2.55*	G_2T Vs G_3C	0.89NS
G_2T Vs G_2C	2.62*	G_2T Vs G_4C	3.95**
G_3T Vs G_3C	5.67**	G_3T Vs G_4C	5.96**
G_4T Vs G_4C	4.57**	G_3T Vs G_5C	4.29**
G_5T Vs G_5C	4.52**	G_3T Vs G_6C	2.00*
G_6T Vs G_6C	2.57*	G_4T Vs G_5C	3.81**
G_1T Vs G_2C	3.26**	G_4T Vs G_6C	2.01*
		G_5T Vs G_6C	2.00*

* Significant at 1% level

** Significant at 5% level

NS Not significant

Table 42. Effect of NAA on crown weight in different leaf groups

Leaf groups	Weight of crown (g)		
	Treated (T)	Control (C)	't' value
26 - 30 (G_1)	136.75	126.88	1.32^{NS}
31 - 35 (G_2)	159.50	154.13	0.75^{NS}
36 - 40 (G_3)	160.50	157.25	0.48^{NS}
41 - 45 (G_4)	170.50	166.88	0.94^{NS}
46 - 50 (G_5)	176.38	170.00	0.40^{NS}
51 - 55 (G_6)	188.25	182.75	0.48^{NS}

NS Not significant

3.3.6 Canning ratio

The data on canning ratio of fruits presented in Table 43 showed that in all the groups treated fruits recorded higher canning ratio than untreated fruits. Significant difference was however seen only in fruits belonging to 51-55 leaf group.

3.3.7. L/B ratio

The date relating to L/B ratio of fruits obtained from different groups of plants are given in Table 43. The data revealed that only in the last group (51-55 leaves), the treatment had significant effect. In this group there was significant increase in L/B ratio of the fruits by the treatment applied.

3.3.8. Days taken for fruit maturity

The fruit maturity was significantly delayed by NAA treatment, in all the groups. The treated fruits from 26-30 leaf group took 145.6 days for fruit maturity, while the corresponding untreated fruits took only 138.2 days. Plants with higher leaf number took lesser time for fruit maturity, irrespective of the treatment applied. In the last group (51-55 leaf group) the fruits took 131.2 days for maturity, while the corresponding treated fruits took 135.2 days (Fig.9).

Table 43. Effect of NAA on canning ratio and L/B ratio of fruits in different leaf groups

Leaf groups	Canning ratio			L/B ratio		
	Treated (T)	Control (C)	't' value	Treated (T)	Control (C)	't' value
26 - 30 (G_1)	1.19	1.15	1.55^{NS}	1.27	1.23	1.36^{NS}
31 - 35 (G_2)	1.29	1.27	0.89^{NS}	1.38	1.33	1.90^{NS}
36 - 40 (G_3)	1.34	1.29	1.78^{NS}	1.40	1.35	1.55^{NS}
41 - 45 (G_4)	1.28	1.25	1.27^{NS}	1.35	1.33	0.86^{NS}
46 - 50 (G_5)	1.34	1.29	1.68^{NS}	1.40	1.36	1.47^{NS}
51 - 55 (G_6)	1.34	1.28	2.30^{*}	1.42	1.34	2.65^{**}

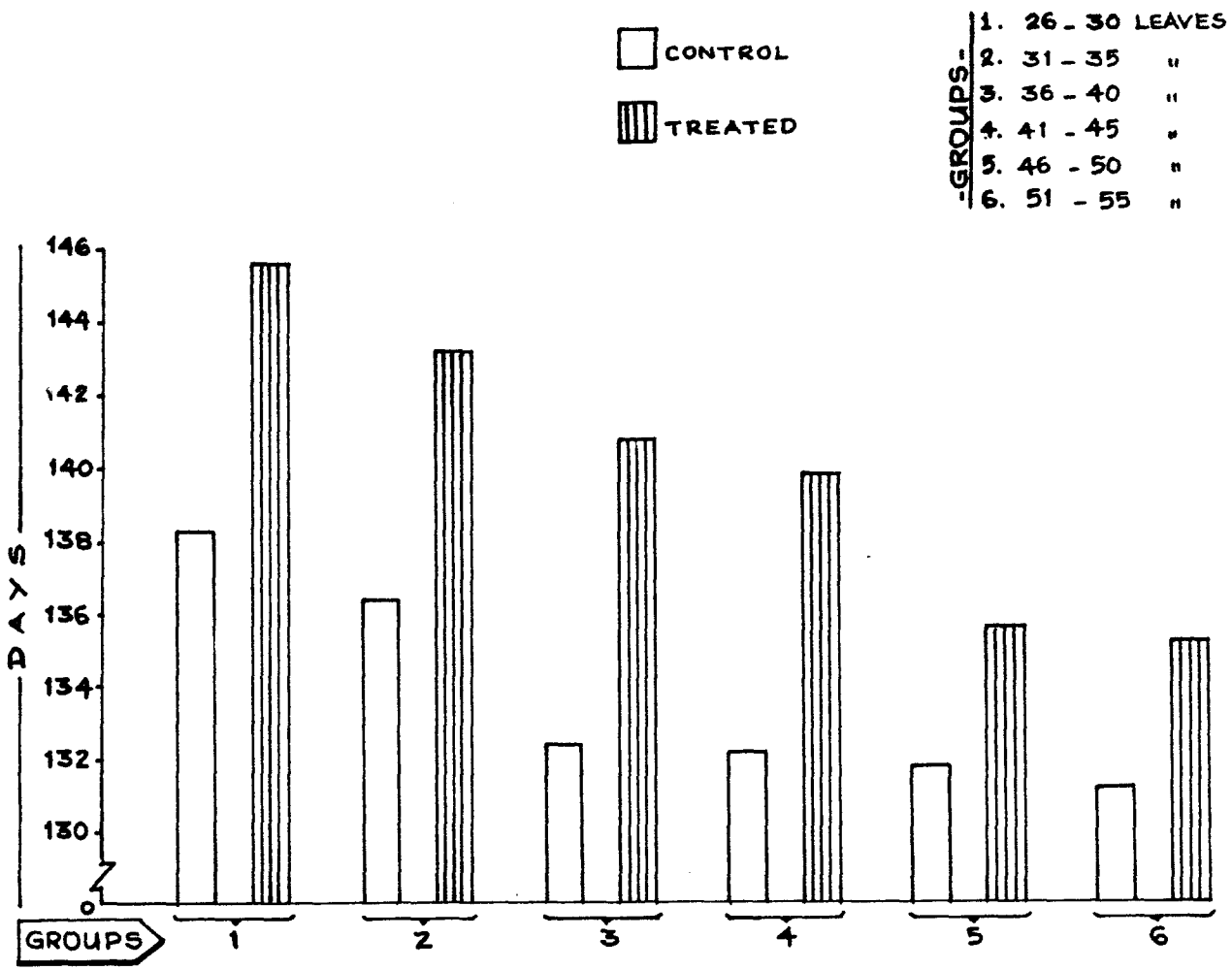
* Significant at 5% level
** Significant at 1% level
NS Not significant

Table 44. Effect of NAA on the time taken for fruit maturity

Leaf groups	Days for fruit maturity		
	Treated (T)	Control (C)	't' value
26 - 30 (G_1)	145.6	138.2	11.71**
31 - 35 (G_2)	143.2	136.4	9.27**
36 - 40 (G_3)	140.8	132.4	11.50**
41 - 45 (G_4)	139.8	132.2	5.67**
46 - 50 (G_5)	135.6	131.8	3.96**
51 - 55 (G_6)	135.2	131.2	4.33**

** significant at 1% level

Fig. 9_ EFFECT OF NAA 300 ppm ON FRUIT MATURITY IN DIFFERENT LEAF GROUPS



3.4. Effect of NAA on fruit quality

Data on the various qualitative characters of the fruits as influenced by NAA treatment in different leaf groups of plants are furnished in Tables 45 to 47. The results are summarized below.

3.4.1. Total soluble solids

NAA treatment resulted in lower T.S.S.content of fruits. However, the effect was significant in the last four leaf groups viz.,36-40, 41-45, 46-50 and 51-55 compared to control. In general it was found that the higher the leaf number the higher was the T.S.S. content of fruits.

3.4.2. Acidity

The acidity of the fruits decreased as the leaf number increased and the minimum acidity was recorded by fruits obtained from 51-55 leaf number group. In the first group (26-30) NAA treatment resulted in significant reduction in acidity of fruits, while in other groups, the effect was not significant.

3.4.3. Ascorbic acid

The ascorbic acid content of fruits did not show any definite trend of variation due to NAA treatment.

Table 45. Effect of NAA on T.S.S., acidity and ascorbic acid content of fruits in different leaf groups

Leaf groups	T.S.S.(%)			Acidity (%)			Ascorbic acid (mg/100g)		
	Treated (T)	Control (C)	't' value	Treated (T)	Control (C)	't' value	Treated (T)	Control (C)	't' value
26 - 30 (G_1)	11.20	12.00	1.55^{NS}	0.64	0.75	3.73^{**}	7.52	7.62	0.12^{NS}
31 - 35 (G_2)	12.25	12.65	0.80^{NS}	0.62	0.66	1.25^{NS}	6.98	6.81	0.17^{NS}
36 - 40 (G_3)	13.84	14.82	2.92^{*}	0.59	0.62	0.94^{NS}	6.85	7.15	0.89^{NS}
41 - 45 (G_4)	13.36	14.54	2.96^{*}	0.58	0.61	0.68^{NS}	6.35	6.45	0.07^{NS}
46 - 50 (G_5)	13.83	15.77	3.03^{*}	0.59	0.59	0.01^{NS}	6.58	6.50	0.05^{NS}
51 - 55 (G_6)	14.68	16.46	4.47^{**}	0.56	0.58	0.25^{NS}	6.56	6.85	0.47^{NS}

* Significant at 5% level
** Significant at 1% level
NS Not significant

3.4.4. Reducing sugars

Eventhough there was a reduction in reducing sugar content of fruits by NAA treatment, the effect was significant only in the highest leaf group.

3.4.5. Total sugars

The data furnished in Table 46 revealed that there was a general reduction in total sugar content of fruits due to NAA treatment in all the groups. Significant effect of NAA was noticed only in 51-55 leaf group. The data also showed that there existed a direct relationship between leaf number and total sugar content of fruits.

3.4.6. Non-reducing sugar

The effect of NAA on non-reducing sugar content of fruits was not significant except in 46-50 leaf group, where the treatment resulted in the reduction of non-reducing sugar.

3.4.7. Sugar/acid ratio

The sugar/acid ratio showed a significant increase with the application of NAA in the first two groups. A general increase in sugar/acid ratio was also noticed with the increase in leaf number.

Table 46. Effect of NAA on sugar content of fruits in different leaf groups

Leaf groups	Reducing Sugars (%)			Total sugars (%)			Non-reducing sugar (%)		
	Treated (T)	Control (C)	't' value	Treated (T)	Control (C)	't' value	Treated (T)	Control (C)	't' value
26 - 30 (G_1)	3.57	3.68	0.61^{NS}	11.92	12.24	1.71^{NS}	8.35	8.56	0.80^{NS}
31 - 35 (G_2)	4.03	4.16	0.87^{NS}	12.21	12.41	0.43^{NS}	8.19	8.25	0.08^{NS}
36 - 40 (G_3)	5.48	5.70	1.09^{NS}	12.75	13.11	0.89^{NS}	7.27	7.41	0.25^{NS}
41 - 45 (G_4)	5.45	5.57	0.44^{NS}	12.99	13.17	1.00^{NS}	7.54	7.60	0.16^{NS}
46 - 50 (G_5)	5.51	5.72	1.19^{NS}	12.80	13.37	1.77^{NS}	7.29	8.05	2.44^{*}
51 - 55 (G_6)	5.77	6.94	2.27^{*}	13.00	14.89	2.49^{*}	7.23	7.95	1.16^{NS}

* Significant at 5% level

NS Not significant

Table 47. Effect of NAA on sugar/acid ratio and brix\acid ratio of fruits in different leaf groups

Leaf groups	Sugar/acid ratio			Brix/acid ratio		
	Treated (T)	Control (C)	't' value	Treated (T)	Control (C)	't' value
26 - 30 (G_1)	17.91	15.83	3.48**	17.58	16.06	1.51NS
31 - 35 (G_2)	19.93	18.66	3.37**	19.89	19.04	0.72NS
36 - 40 (G_3)	21.69	21.11	0.50NS	21.73	22.18	0.39NS
41 - 45 (G_4)	21.88	21.72	0.10NS	21.14	22.09	0.71NS
46 - 50 (G_5)	24.15	25.71	0.97NS	22.73	26.09	1.65NS
51 - 55 (G_6)	23.97	26.17	1.87NS	24.04	27.53	1.96NS

** Significant at 1% level
NS Not significant

3.4.9. Brix/acid ratio

The brix/acid ratio was not influenced by NAA application. In general brix/acid ratio of fruits increased with leaf number.

DISCUSSION

DISCUSSION

The present investigations on the various aspects of regulation of fruit size and maturity on pineapple were mainly aimed at arriving suitable recommendations on the application of NAA for increasing fruit size and altering fruit maturity under conditions prevailing in Kerala.

Absence of a dependable maturity index for harvesting pineapple fruits when they attain maximum quality was greatly felt when the present investigations were initiated. Whether the maturity indices described by Pantastico (1975) based on external colour development held good for pineapple grown in Kerala had to be confirmed by detailed observations. Maturity has been defined as "the stage of fruit development which will ensure the attainment of maximum eating quality and ripening as the post harvest physiological changes by which the fruit attains ripeness" (Lott,1945). Such a distinction between maturity and ripening may not be possible in pineapple where the qualitative maximum of fruits is attained on the plant itself. Harvesting of fruits at a stage when the quality of fruits was maximum, was therefore necessary.

The changes in qualitative parameters like T.S.S., acidity, sugars and ascorbic acid content studied during the course of fruit development showed that the period between 132 and 135 days after inflorescence emergence was the time when fruits attained maximum quality. It was seen that the acidity increased upto 132 days after inflorescence emergence and remained constant for two days after which there was a rapid fall. A fall in acidity after reaching its peak was observed by Hope (1963), Mookerji et al. (1964) and Montonegro (1964). The total sugars and T.S.S. also increased and reached their peak on 134th day. Mookerji et al. (1964) found that under Trichur condition the fruits took 115 -130 days for reaching canning maturity. Chadha et al. (1972) observed that under Bangalore conditions 'Kew' variety of pineapple took 165 days for maturity and that the acidity and T.S.S. increased till the fruits attained full maturity on the plants. The difference in time taken for fruit maturity under Bangalore and Kerala conditions could be attributed to climatic differences. Evidently in Kerala the fruits take lesser time for maturity, possibly due to higher temperature prevailing during the period of fruit development. Early fruit maturity under high temperature has also been reported in pineapple (Yow,1959) and in several other fruits (Winkler,1932 and Gardner et al., 1952). The

ascorbic acid content was high during the initial stages of fruit development, which showed reduction as the fruit matured. Similar results have been observed in pineapple (Mookerji et al.,1964 and Chadha et al.,1972) and in other fruits (Hulme,1971 ; Metzner,1976 and Sharma,1980). The brix/acid ratio was also high in early stages, which decreased upto 100 days, thereafter again showed an increasing trend. High brix/acid ratio in early stages of fruit development has been observed by Singleton and Gortner (1965), Kelley (1971) and Chadha et al. (1972).

The external shell colour of the fruits has been considered as a dependable maturity index in pineapple (Pantastico,1975). In the present study, it was found that the shell colour of fruits remained green upto 128 days. After this, the fruits gradually turned yellow from the basal portion which was observable from 130th day onwards. On 134th day, 49.4 per cent of the eyes became yellow at which time the fruits recorded maximum quality in terms of T.S.S.,acidity and sugars (Tables 1 and 2). Further increase in yellow colour of the shell was no indication of the quality since there was actually deterioration in quality from 136th day. Based on the external colour of the fruits and number of days from inflorescence emergence a dependable maturity index could be arrived at in pineapple.

when the shell colour of the fruits have attained a yellow colouration of about 50 per cent they could be considered mature under Kerala conditions. The fluctuations in the number of days in maturity that may occur due to seasonal differences is a matter of further investigation.

The effect of NAA on fruit development and ultimate fruit size at harvest was conspicuous. Maximum fruit size was recorded by 300 ppm NAA applied one month after inflorescence emergence (vide Table 3). A concentration of 200 ppm applied at the same stage also has a similar effect. The influence of 300 ppm NAA applied at inflorescence emergence and two months after inflorescence emergence was on par and similar to that of 300 ppm applied one month after inflorescence emergence. The increase in fruit size was found to be the net result of increase in weight, length, girth and breadth of fruits by the application of NAA. Several experiments conducted in pineapple by Clark and Kerns (1942), Anon (1964), Kwong and Chiu (1968), Bowden 1969 b), Poignent (1969), Huang (1973) and Norman (1978) have clearly shown the efficacy of NAA application in increasing the fruit size at concentrations ranging 100 ppm to 500 ppm during the early stages of fruit development. Even when NAA was applied for flower induction in pineapple, increased fruit size was observed by several investigators (Van Overbeek, 1946; Py, 1955; Shing, 1956; Das, 1964; Ali and Talukdar, 1965 ;

Das and Baruah,1967 and Santha,1979).

The present study also clearly showed that the more critical period for the application of NAA was between the time of inflorescence emergence and two months after emergence. It would however appear that application of 300 ppm NAA one month after inflorescence emergence was more effective. The studies on fruit development consequent on the application of NAA showed that increased fruit growth noticed after the application of NAA persisted till fruit maturity. However, the increase in fruit growth due to application of NAA was more pronounced during the early stages. The relationship between fruit growth and endogeneous auxin level is well established (Nitsch, 1950). The auxin requirement for developing fruit is more during the early stages. The effectiveness of exogeneous application of NAA in the early stages noticed in the present study and reported by earlier workers could thus be attributed to a supplementary effect of auxins. (Clark and Kerns,1942 ; Anon,1964; Kwong and Chiu 1968 and Norman, 1978). Although application of NAA increased fruit length and breadth, it did not alter fruit shape. This is in agreement with the findings of Clark and Kerns (1942), Ali and Talukdar (1965) and Bowden (1969 b). The development of

crown was conspicuously affected by NAA application especially when it was made at inflorescence emergence in concentrations ranging from 100 to 300 ppm. The crown size increased due to NAA application. The treatment of NAA might have increased the meristematic activity which resulted in increased crown size.

Fruit maturity was delayed by NAA treatments in the present study. A maximum delay of 10 days was obtained by 300 ppm NAA when applied four months after inflorescence emergence. The present study has also revealed the possible use of NAA for delaying fruit maturity at earlier stages of application. The grower could thus extend the period of harvest profitably by the application of NAA in periods of market glut. Delayed maturity by NAA application has been reported by Clark and Kerns (1942), Py (1955) ,Shing (1956), Das (1964), Kwong and Chiu (1968), Poignant (1970), Huang (1973) and Norman (1978). The delayed fruit maturity could be attributed to the prolongation of the sigmoid growth of fruits as noticed in the present study.

The leaf number and their nutrient status have been found to influence the fruit size in pineapple (Van Overbeek,1946 ; Py 1953 ; Su,1956 ; Kanapathy,1958; Das et al.,1965 ; Chadha et al.,1977 and Santha,1979). Whether the application of NAA on fruits could alter the leaf characters was therefore studied. It was found

that the fresh weight and dry weight of 'D' leaves at harvest were reduced by NAA treatment of fruits especially at the highest concentration, indicating a possible mobilization of metabolites from the leaves to the developing fruits. The reduction in leaf N and K noticed in the present study due to NAA treatments also indicated such a possibility. Borthwick et al.(1937) and Stuart (1938) observed increased mobilization of both soluable and insoluable nitrogen from the leaves to the stem of bean plants, when the stems were treated with IAA.

A general reduction in fruit quality due to NAA application was observed in the present study. While there was a reduction in T.S.S. and sugars especially when NAA was applied at higher concentrations, the acidity and ascorbic acid content were not affected. Decrease in T.S.S. and sugar content of fruits due to NAA application was reported by Kwong and Chiu (1968), Bowden (1969 b) and Huang (1973). In the case of acidity contradictory reports have been obtained by different workers. According to Kwong and Chiu (1968) and Huang, (1973) acidity was reduced by NAA application, while Bowden (1969 b) and Wee (1971) reported increased acidity by NAA treatment. On the other hand Norman (1978) reported that NAA application on developing pineapple fruit had no effect on acidity or brix/acid ratio.

The foregoing discussion thus clearly show the effectiveness of NAA at 300 ppm in increasing the fruit size, and delaying the fruit maturity when applied during the early stages of fruit development.

Earlier studies conducted in the Department of Pomology by Santha (1979) had shown that cultural, manurial and other practices remaining uniform, fruit size in pineapple was governed by the number of leaves and their nutrient status. A leaf number of above 35 was found to be optimum for inducing flowering and normal fruit size (Das et al., 1965 and Santha,1979). Whether smaller fruits produced on plants with lower leaf number could be improved by the application of NAA therefore formed another aspect of study in the present investigations.

Interestingly the results of NAA treatment of fruits from different leaf group obtained in the present study were highly significant. In all the groups (Table 37) NAA at 300 ppm applied one month after inflorescence emergence effectively increased fruit size. The smaller fruit size associated with the reduction in leaf number could thus be effectively improved by NAA. However, there appeared to be a critical level of leaves below which NAA could not function properly so as to

bring about a normal fruit size. For instance, in the 26-30 leaf group NAA although increased fruit size did not show a similar effect as in other higher leaf groups. On the other hand in the 31-35 leaf group application of NAA resulted in the production of fruits of normal size of about 1.5kg. The more responsive leaf group to NAA was 36-40. In the case of induction of flowering by the application of etherl also this leaf group was found to be more responsive (Das et al., 1977 and Santha,1979).

The trend of increasing fruit quality with increase in the number of leaves was observed in the present study also and this is in general agreement with the results reported by Santha (1979). Effect of NAA on fruit quality in relation to leaf number showed that there was an apparent reduction in fruit quality in all the groups. In the lower leaf group (26-30 leaves) while the T.S.S. and sugars were not effected, application of NAA significantly reduced acidity. A general reduction in fruit quality due to NAA application was observed in the earlier part of the study also. The delayed fruit maturity noticed in lower groups was further extended by NAA application. The combined effect of NAA and leaves on fruit size, maturity and quality is thus noteworthy.

The results of the present investigations have amply indicated the usefulness of NAA application in increasing fruit size in pineapple. Induction of flowering by ethrel coupled with the application of NAA during the early stages of fruit development could bring about substantial increase in pineapple production.

SUMMARY

SUMMARY

The present investigations were carried out in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara from 1978 to 1980. The conclusions drawn from the study can be summarized as follows.

1. The optimum time of harvest of fruits was found to between 132 and 135 days after inflorescence emergence. At this stage, about 49.4 per cent of the 'eyes' of the fruits turned yellow. The fruits also possessed maximum quality in terms of sugar, T.S.S. and acidity at this time.

2. Application of NAA was found to increase the fruit size, the maximum being effected by 300 ppm NAA applied one month after inflorescence emergence. 200 ppm NAA applied at the same stage and 300 ppm applied at inflorescence emergence and two months after inflorescence emergence had a similar effect

3. Increased crown weight was obtained when NAA at higher concentrations were applied at the time of inflorescence emergence.

4. The time taken for fruit maturity was significantly delayed by NAA application, especially at higher concentrations ranging from 100 to 300 ppm.

5. The fruit quality was noticeably reduced by NAA application. There was reduction in sugars and T.S.S. content of fruits by 100,200 and 300 ppm of NAA. Acidity and ascorbic acid contents were not effected by NAA application.

6. The leaf characters at harvest were not influenced by various treatments, except the fresh weight and dry weight of 'D' leaves, where significant reduction was noticed by NAA treatments.

7. The leaf nutrient content at harvest was not influenced by various NAA treatments. However there was an apperent reduction in leaf N and K with the application of NAA at higher concentrations. The possibility of mobilisation of nutrients due to the application of NAA has been discussed.

8. The present studies also confirmed the influence of leaves on fruit size. NAA 300 ppm applied one month efter inflorescence emergence significantly influenced fruit size in all leaf groups, the effect was mote pronounced in 36-40 leaf group.

9. Fruit maturity was delayed by 300 ppm NAA treatment in all the leaf groups. However the effect was more in lower leaf groups. Fruits from lower leaf groups took more time for maturity, compared to fruits from higher leaf groups.

10. In all leaf groups the fruit quality was reduced by 300 ppm NAA application. Significant reduction in T.S.S. and sugars were noticed especially in higher leaf groups, while in the case of acidity significant reduction was noticed only in the lowest group (26 -30 leaves). The fruits produced from highest leaf group possessed maximum T.S.S. and sugars with low acidity, while the lowest leaf group (26 -30 leaves) produced fruits with low sugar and T.S.S. with higher acidity.

11. The treatment of NAA did not effect significantly the leaf characters or leaf nutrient contents in different leaf groups at the time of harvest.

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* Original not seen.

APPENDIX I

Weather data for the period from November 1978 to May 1980

Month	Temperature (^{o}C)		Relative humidity (%)		Total rainfall (mm)	Number of rainy days per month
	Maximum	Minimum	Maximum	Minimum		
1978						
November	32.5	17.7	97	42	284.2	9
December	32.3	21.6	88	49	43.9	3
1979						
January	34.1	18.6	96	38	Nil	Nil
February	34.8	21.6	96	37	22.0	4
March	36.7	22.3	96	38	3.2	1
April	40.1	21.3	95	33	46.5	4
May	35.7	21.8	97	52	155.1	10
June	35.1	22.0	97	53	722.7	22
July	31.1	21.0	98	68	729.8	28
August	31.4	21.6	97	65	462.6	19
September	32.8	22.6	98	67	208.7	18
October	33.4	22.0	95	45	127.3	16
November	32.9	22.2	96	61	317.4	18
December	32.2	19.4	95	45	Nil	Nil
1980						
January	33.5	18.3	93	30	Nil	Nil
February	37.5	18.3	95	26	0.4	1
March	39.4	21.1	94	28	1.8	1
April	38.1	21.6	97	36	135.3	7
May	35.6	22.7	94	50	126.8	11

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Weather data for the period from November 1978 to May 1980

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December	32.3	21.6	88	49	43.9	3
1979						
January	34.1	18.6	96	38	Nil	Nil
February	34.8	21.6	96	37	22.0	4
March	36.7	22.3	96	38	3.2	1
April	40.1	21.3	95	33	46.5	4
May	35.7	21.8	97	52	155.1	10
June	35.1	22.0	97	53	722.7	22
July	31.1	21.0	98	68	729.8	28
August	31.4	21.6	97	65	462.6	19
September	32.8	22.6	98	67	208.7	18
October	33.4	22.0	95	45	127.3	16
November	32.9	22.2	96	61	317.4	18
December	32.2	19.4	95	45	Nil	Nil
1980						
January	33.5	18.3	93	30	Nil	Nil
February	37.5	18.3	95	26	0.4	1
March	39.4	21.1	94	28	1.8	1
April	38.1	21.6	97	36	135.3	7
May	35.6	22.7	94	50	126.8	11

APPENDIX II

Analyses of variance for effect of NAA on fruit characters

Source	Degrees of freedom	Mean Squares								
		Weight of fruit with crown	Weight of fruit without crown	Crown weight	Length of fruit	Girth of fruit	Breadth of fruit	Canning ratio	L/B ratio	Taper ratio
Total	99									
Block	3	0.06	0.13	617.32	2.66	11.28	0.19	0.012	0.061	0.0053
Stages of application of NAA	4	0.33	0.30	9116.07**	6.22	35.59*	4.45**	0.004	0.009	0.0006
Error (1)	12	0.12	0.13	206.58	2.09	7.20	0.61	0.014	0.012	0.0028
Concentrations of NAA	4	0.59**	0.45**	1238.12**	15.27**	39.11**	4.73**	0.007	0.015	0.0008
Interaction	16	0.20**	0.15**	1431.63**	5.46**	13.82*	1.97**	0.008	0.005	0.0012
Error (2)	60	0.04	0.05	336.53	1.88	6.30	0.53	0.013	0.011	0.0021

* significant at 5% level

** significant at 1% level

APPENDIX II

Analyses of variance for effect of NAA on fruit characters

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Total	99									
Block	3	0.06	0.13	617.32	2.66	11.28	0.19	0.012	0.061	0.0053
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Error (1)	12	0.12	0.13	206.58	2.09	7.20	0.61	0.014	0.012	0.0028
Concentrations of NAA	4	0.59**	0.45**	1238.12**	15.27**	39.11**	4.73**	0.007	0.015	0.0008
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Error (2)	60	0.04	0.05	336.53	1.88	6.30	0.53	0.013	0.011	0.0021

* significant at 5% level

** significant at 1% level

APPENDIX III

Analysis of variance for effect of NAA on fruit maturity

Source	Degrees of freedom	Mean square
		Days from inflorescence emergence to fruit maturity
Total	99	
Block	3	4.52
Stages of application of NAA	4	45.71
Error (1)	12	21.91
Concentrations of NAA	4	126.82**
Interaction	16	8.96
Error (2)	60	10.43

** Significant at 1% level.

APPENDIX IV

Analyses of variance for effect of NAA on fruit quality

Source	Degrees of freedom	Mean squares							
		T.S.S.	Acidity	Reducing sugars	Total sugars	Non-reducing sugar	Ascorbic acid	Sugar/ acid ratio	Brix/ acid ratio
Total	99								
Block	3	0.25	0.0014	0.60	2.21	2.93	2.10	15.32	21.72
Stages of application of NAA	4	1.28	0.0021	0.81	0.89	1.49	1.33	11.99	14.47
Error (1)	12	0.60	0.0033	0.24	0.53	0.65	0.61	8.97	10.59
Concentrations of NAA	4	2.85*	0.0042	1.53**	3.49**	1.67*	0.95	5.49	8.16
Interaction	16	0.51	0.0098	0.39	0.21	0.46	0.38	0.86	1.06
Error (2)	60	0.86	0.0020	0.21	0.56	0.65	0.44	4.24	3.77

* significant at 5% level

** significant at 1% level

APPENDIX V

Analyses of variance for effect of NAA on 'D' leaf characters at harvest

Source	Degrees of freedom	Mean squares					
		Length	Breadth	'D' leaf area	Fresh weight	Dry weight	Percentage dry weight
Total	99						
Block	3	208.11	5.45	3197.94	18.50	1.34	2.42
Stages of application of NAA	4	207.30	3.31	1425.57	19.17	0.50	4.17
Error (1)	12	154.02	3.18	1139.51	17.53	1.10	3.14
Concentrations of NAA	4	76.46	12.21	1577.38	85.05**	4.46**	3.82
Interaction	16	43.90	3.82	728.44	6.16	0.94	3.81
Error (2)	60	70.74	4.92	640.23	14.87	1.21	2.90

** Significant at 1% level

APPENDIX VI

Analyses of variance for effect of NAA on nutrient status of 'D' leaf at harvest

Source	Degrees of freedom	Mean squares			
		Nitrogen	Phosphorus	Potassium	C/N ratio
Total	99				
Block	3	0.018	0.00260	0.023	20.16
Stages of application of NAA	4	0.010	0.00340	0.152	6.00
Error (1)	12	0.040	0.00085	0.083	19.48
Concentrations of NAA	4	0.015	0.00024	0.011	10.75
Interaction	16	0.017	0.00068	0.074	12.26
Error (2)	60	0.030	0.00045	0.074	16.00

REGULATION OF FRUIT SIZE AND MATURITY IN PINEAPPLE

BY
BABY LATHA, A. K.

ABSTRACT OF THESIS

Submitted in partial fulfilment of the requirements

for the degree of

Master of Science in Horticulture

Faculty of Agriculture

Kerala Agricultural University

Department of Horticulture (Pomology & Floriculture and Landscaping)

COLLEGE OF HORTICULTURE

Vellanikkara :: Trichur

1981

ABSTRACT

In spite of spectacular achievement obtained in controlling flowering in pineapple by the application of ethrel in recent times, uniformity in fruit size in large pineapple plantings, even under uniform cultural and manurial schedules, is seldom achieved in Kerala. Both in plant crop and especially in ratoons, a considerable percentage of fruits fall below standard. Regulation of fruit size and maturity will help to increase the fruit size as well as to extend the period of harvest.

The present investigations were carried out in the Department of Pomology, College of Horticulture, Vellanikkara from 1978 to 1980 to study the effect of different concentrations of NAA (0, 50, 100, 200 and 300 ppm) at different stages of application (at inflorescence emergence, one month after inflorescence emergence, two months after inflorescence emergence, three months after inflorescence emergence and four months after inflorescence emergence) on the size, maturity and quality of fruits and also to assess the best time of application of NAA, on pineapple variety, 'Kew'. Uniform flowering was induced by giving a combination treatment of 25 ppm ethrel, 2 per cent urea and

0.04 per cent $CaCO_3$.

Considering the quality parameters like T.S.S., acidity and total sugars, the period between 132 and 135 days after inflorescence emergence appeared to be the best time of harvest of pineapple fruits.

Application of NAA was found to increase the fruit size the maximum being effected by 300 ppm NAA applied one month after inflorescence emergence. 200 ppm NAA applied at the same stage and 300 ppm applied at inflorescence emergence and two months after inflorescence emergence had a similar effect. Maximum delay in fruit maturity was observed by the application of 300 ppm NAA followed by 200 ppm NAA.

There was significant increase in fruit size in different leaf groups when 300 ppm NAA was applied one month after inflorescence emergence. The reduction in fruit size associated with lower leaf number could thus be improved by the application of NAA.