EFFECT OF GROWTH REGULATORS AND CERTAIN FORMULATIONS ON BUNCH DEVELOPMENT IN BANANA VAR. PALAYANKODAN

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Effect of growth regulators and certain formulations on bunch development in banana var., Palayankodan" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Vellanikkara,
15, November 1983.

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CERTIFICATE

Certified that this thesis, entitled "Effect of growth regulators and certain formulations on bunch development in banana var., Palayankodan" is a record of research work done independently by Shri.RAJENDRAN, P. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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To my parents

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Introduction

INTRODUCTION

Banana is the most important commercial fruit crop grown in Kerala. The state ranks first in the country with respect to the area on this crop, which accounts for 49.6 thousand hectares (Anon., 1983). However, according to the statistics available, the total production of banana is only 312.3 thousand tonnes, which is very low compared to the yields obtained in other states of the country. Although several factors like the wide range of varieties grown, cultivation ranging from rainfed to irriated conditions, back-yard semiperennial system of growing, inadequate cultural and manurial practices adopted and the incidence of pests and diseases could be generally attributed to the poor yield, the cause for the low yield in exact terms have not been identified. Inspite of the best management, the average bunch weight of banana under large scale plantations continue to be very low.

The number of functional leaves and the total leaf area at various stages of plant growth have a great bearing on the development of fruits in banana. Earlier studies conducted in the Department of Pomology, College of Horticulture have shown that the total leaf area is considerably reduced at the time of bunch development due to reduction in the number of functional leaves caused by physiological and disease factors. Increasing the surface area of the individual

leaves by the application of growth regulators and supplementing nutritional requirements through foliar means appeared to be a possible method to increase the photosynthetic and nutrient absorption efficiency of the plants.

The banana cultivar 'Palayankodan' belonging to the genomic group AAB is the most popular variety grown in Kerala under conditions ranging from irrigated pure crop to rainfed intercrops. The average yield of this variety especially under rainfed or partially irrigated conditions is low. Methods to increase the bunch weight of the widely grown 'Palayankodan' cultivar will ultimately go a long way in increasing the total production of banana in the state. The methods so developed would be extended to other varieties also after suitable experimentation.

The investigations reported in the present thesis were therefore taken up with the following main objectives.

1. To find out the effect of growth regulators like 2,4-D and NAA at different concentrations along with a nutrient formulation namely 'Navras Banana Special' on vegetative growth as well as leaf area increase through foliar applications.

2. To find out the effect of the applications of the above auxins and chemical formulations at the vegetative phase as well as during the early stage of development of bunches on yield and bunch characters.

3. To assess the influence of the growth regulators and 'Navras' on the ultimate fruit quality.

Review of Literature

REVIEW OF LITERATURE

Efforts to improve crop yield and quality by the use of growth regulants and chemical formulations have assumed importance both in the research field and commercial crop production. The literature available on these aspects in banana seems to be scanty. This chapter presents a brief review of available literature on the response of banana and some other important crops to the application of growth regulators and nutrients as sprays.

1. Effect of 2,4-D on growth and development

1.1. Growth and vegetative characters

Increased plant height was observed by Takahashi and Nakayama (1961) when tomato plants were sprayed with aqueous solution of 10 ppm 2,4-D. Khalil (1965) studied the effect of 2,4-D on height and growth of maize and found that maize seeds soaked in 5 to 20 ppm 2,4-D for 24 hours showed marked increased in height of plants. Mehrotra et al.(1970), however, observed that application of 2,4-D had no influence on increasing the height, number of branches and leaves per plant in tomato.

According to Chauhan and Bordia (1971), application of 2,4-D (2.5 to 5 ppm) as pre-sowing seed treatment in cabbage did not show any variation in the height of plants over control.

Significant increase in plant height and dry weight have been observed due to application of 2,4-D, either alone or in combination with nitrogen, on two weeks old bean seedlings (Rathore and Wort, 1971). El-saod et al. (1976) reported that 2,4-D treatment at 5 ppm increased the fresh and dry weight of leaves in tomato whereas higher concentrations (10 to 20 ppm) retarded growth. Das and Swain (1977) opined that growth regulators like 2,4-D had significant effect on vegetative growth of pumpkin.

1.2. Flowering, maturity and ripening

Spray application of sodium salt of 2,4-D at concentrations from 100 to 500 ppm were effective in flower induction in Peurto Rico and Yellow Jersey sweet potatoes (Howell and Wittwer, 1955). In Yellow Jersey variety, maximum number of flowers was produced at 100 ppm while higher concentrations were toxic. Khalil (1965) reported that maize seeds soaked in 2,4-D (5 to 20 ppm) for 24 hours did not show significant effect on date of flowering. A similar trend was observed by Chauhan and Bordia (1971) in cabbage. They found that application of 2,4-D (2.5 to 5 ppm) did not alter the time taken for head formation in cabbage.

Increased flower production have been reported by Jayanandam et al. (1976) in chillies by three sprays of 2,4-D at 100 ppm. Early flowering due to 2,4-D application was

reported by Singh (1979) in Kagzi lime. Haribabu and Rajput (1982) also observed early flowering in Kagzi lime when zinc and 2,4-D either alone or in combination were sprayed on the trees.

Reduction of fruit weight, earlier maturity and early ripening by 2,4-D application in pineapple have been reported by Evans (1959). Singh et al. (1959) observed that application of 2,4-D (10 to 40 ppm) six weeks after full bloom, did not bring about any effect on delaying or hastening the fruit growth and maturity in mango. According to Shanmughavelu et al. (1969), application of 2,4-D at 5 and 10 ppm caused seven to eight days earliness in maturity of grapes. Tomi et al. (1970) also reported earlier maturity of 'Dwarf Cavendish' bananas when 2,4-D (10 to 40 ppm) and GA (10 to 20 ppm) were applied either separately or together at various times between flowering and a month before harvest. Srivastava et al. (1971) and Srivastava et al. (1973) found early maturity of fruits by eight to twelve days and enhanced fruit colour development in apricots and peaches due to 2,4-D application. But in sweet lime, Kumar et al. (1975) reported delayed fruit maturity due to 2,4-D sprays (5 to 20 ppm) at full bloom stage.

Pal et al. (1977) found that the rate of fruit growth was enhanced by foliar application of 2,4-D at concentrations ranging from 10 to 20 ppm in Kinnow mandarin.

Studies by Anbazhagan (1978) revealed that 2,4-D sprays at 10 and 25 ppm on three cultivars 'Poovan', 'Monthan' and 'Nendran' advanced the maturity of bunches appreciably, especially at 25 ppm. Rahman and Siddique (1963) sprayed 2,4-D at 5 and 10 ppm on 90 days old brinjal plants and found that the maturity of fruits was hastened by six to ten days compared to the control.

Mature, but unripe 'Cavendish' bananas treated with 2,4-D markedly accelerated the ripening (Blake and Stevenson, 1956). According to Dedolph and Goto (1960), 'Dwarf Cavendish' banana hands dipped in 2,4-D 200 ppm solution for five seconds resulted in quicker and uniform ripening. Randhawa and Sharma (1962) reported delayed degreening in sweet oranges by 2,4-D application at full bloom and one week thereafter. Hastened ripening of sapota fruits was reported by Lakshminarayana et al. (1967) by application of 2,4-D at 100 ppm on trees, ten days before harvest. Aziz and Wahab (1970) observed that uniform early ripening of bananas could be achieved when treated with 2,4-D at 1000 ppm for 30 seconds.

Banana dipped in 2,4-D solutions at concentrations between 10^{-5} to 10^{-2}M showed increased ethylene production and advanced ripening, at all the concentrations tried (Vendrell, 1970). Harvested fruits of guava dipped in 2,4-D solution

(200 ppm) for five seconds showed maximum acceleration of ripening (Saha, 1971). "Three quarters full" hands of 'Dwarf Cavendish' bananas when dipped in solutions of 2,4-D and 2,4,5-T at concentrations in the range of 25 to 3000 ppm and held at room temperature (28-33°C), ripened after six days at concentrations above 250 ppm.(Sadasivam and Muthuswamy, 1972). In Egyptian limes, delayed colour development due to 2,4-D treatments at 5 to 30 ppm has been observed by Salem et al. (1974).

Das and Mahapatra (1976) reported advanced ripening of sapota fruits by the application of 2,4-D. Dipping mango fruits in a solution of 2,4-D (40 ppm) for five minutes, significantly delayed the rate of ripening of the fruits (Garg et al., 1976). 'Dwarf Cavendish' banana bunches when sprayed with 2,4-D or 2,4,5-T each at 500 to 1000 ppm and covered with polythene for two days followed by partial covering for three days resulted in uneven ripening (Rizk et al., 1976).

1.3. Fruit characters and yield

Randhawa et al. (1959) found increased fruit set in sweet lime as influenced by 2,4-D (10 to 20 ppm) application, with no considerable increase in fruit size. Singh et al. (1959) observed that application of 2,4-D (10 to 40 ppm) significantly increased the fruit size in 'Fazri' variety of mango, the most

effective being 10 ppm concentration. 2,4-D treatments at full bloom and one week thereafter, produced mature fruits of larger size in sweet oranges especially at 5 ppm (Randhawa and Sharma, 1962). Increased fruit length was observed by Chadha and Singh (1963) when 2,4-D was sprayed on 'Langra' mango. Randhawa and Dhuria (1965) reported significant increase in fruit size by the application of 2,4-D at 10 and 20 ppm in sweet lime.

In sweet orange, Sharma and Randhawa (1967) reported increased fruit size by the application of 2,4-D at 20 ppm. The investigations by Bajwa and Mishra (1969) also revealed that 2,4-D sprays at 50 to 100 ppm increased the fruit size in apricot. 'Dwarf Cavendish' bananas sprayed with 2,4-D (10 to 40 ppm) and GA (10 to 20 ppm) either separately or together at various times between flowering and a month before harvest attained maximum finger weight. The pulp percentage at both temperatures increased with storage duration and were highest with fruits sprayed with 2,4-D 10 ppm during flowering (Tomi et al., 1970).

Srivastava et al. (1971) opined that the fruit weight, volume and stone size were not affected by 2,4-D sprays in apricot. According to Veera and Das (1971), treatments with 2,4-D from the bud differentiation until the fruits were 2 to 3 cm in diameter increased the size and weight of mango fruits.

In 'Mosambi' orange, maximum fruit weight was observed when the trees were sprayed at flowering with 2,4-D 20 ppm (Singh and Gupta, 1972). Mayura et al. (1973) observed increased fruit size when 'Dashehari' mango fruits of pea size were sprayed with 2,4-D at fortnightly intervals till harvest. 2,4-D sprays increased fruitset in cherry, but the fruits were parthenocarpic and average weight was lesser compared to control (Nyeki, 1973). In peach cv. 'Alexander', Srivastava et al. (1973) observed increased fruit length, when 2,4-D was applied at pit hardening stage. Das and Narayana (1974) reported that the greatest increase in fruit size was obtained when the branches of orange cvv Mosambi were sprayed with 2,4-D at 10 ppm.

Ivanova (1975) reported increased yields in raspberry when 2,4-D was sprayed at 40 ppm at flowering. Increased fruit size due to 2,4-D application was reported in ber by Singh and Singh (1976), in plum by Mishra and Dhuria,(1977), in mandarins by Pal et al. (1977) and in Nagpur Santra by Sinha et al. (1977). Anbazhagan (1978) found that 2,4-D especially at 25 ppm, appreciably increased the bunch weight, size and weight of individual fingers, pulp and peel weight and pulp/peel ratio of the three banana cultivars viz. 'Poovan', 'Monthan' and 'Nendran'.

Aravindakshan (1981) observed that growth regulators applied as pre-harvest sprays, 60 days after shooting, increased the size and weight of fruits in bananas. The maximum increase in size and weight was resulted by application of 2,4-D at 10 ppm. A significant increase in length of fruits compared to control in all treatments, was also observed.

1.4. Fruit quality

Improved fruit quality in terms of sugars and acidity was reported by Singh et al. (1959) in 'Fazri' variety of mango by the application of 2,4-D at 10 to 40 ppm. 2,4-D sprays at 5 to 15 ppm at full bloom and one week after that, did not show any appreciable effect on the physico-chemical qualities of sweet oranges (Randhawa and Sharma, 1962). According to Randhawa and Dhuria (1965), fruit quality in respect of sugars and acidity was appreciably improved by the application of 2,4-D at 10 to 20 ppm in sweet lime. Bajwa and Mishra (1969) reported that 2,4-D sprays at 50 or 100 ppm did not affect the TSS or acidity of fruits in apricots. However, they claimed that highest solids to acid ratio could be obtained due to 2,4-D application. Shanmughavelu et al. (1969) observed marked increase in TSS and sugars and general reduction in acidity due to 2,4-D sprays at two and five ppm on grapes.

In 'Dwarf Cavendish' bananas, Tomi et al. (1970) found highest soluble solids content in fruits sprayed with 2,4-D 10 ppm during flowering. Saha (1971) inferred that application of 2,4-D (100 to 200 ppm) on harvested fruits of gauva did not bring about any significant favourable change in reducing sugars, ascorbic acid content or acidity. Improvement in fruit colour along with increased TSS and ascorbic acid content due to 2,4-D treatments has been reported in apricot variety 'Kaisha' by Srivastava et al. (1971). Teaotia et al. (1971) found that application of 2,4-D (10 to 30 ppm) had an appreciable effect on the quality of apples with respect to the juice percentage along with increase in ascorbic acid content. Veera and Das (1971) reported increased acidity, TSS and ascorbic acid content when the fruits of mango cv. 'Banganapalli' were treated with 40 ppm 2,4-D. Chundawat and Randhawa (1972 and 1973) also reported increased sugars and ascorbic acid content due to 2,4-D sprays at full bloom in grape fruit. Increased sugars, ascorbic acid and TSS and reduced total acidity were observed in mango with 2,4-D sprays by Mayura et al. (1973). Veera and Das (1973) found maximum ascorbic acid content and lowest acidity in fruits of litchi sprayed with 2,4-D.

Kumar et al. (1975) opined that 2,4-D at 5 to 20 ppm increased the TSS and ascorbic acid contents in sweet lime.

Investigation carried out by Das and Mahapatra (1976) revealed that 2,4-D treatment had significant effects on TSS, total sugars, reducing sugars, ascorbic acid, titrable acidity and calcium pectate content of sapota fruits. Singh and Singh (1976) reported increased TSS content in 2,4-D treated ber fruits. Sinha et al. (1977) reported that the fruit quality was improved, in 'Nagpur santra', by 2,4-D (10 to 20 ppm) sprays.

Anbazhagan (1978) was of the opinion that 2,4-D treatments had a favourable effect on TSS of banana fruits. It also slightly improved the total sugar content. Acidity of fruits was reduced and sugar acid ratio was increased especially at 25 ppm. Aravindakshan (1981) reported that the quality of 'Nendran' banana fruits was improved by way of increased TSS, total and reducing sugars by treatments with 2,4-D at 4 and 10 ppm.

2. Effect of NAA on growth and development

2.1. Growth and vegetative characters

Chhonkar and Singh (1959) and Choudhury and Singh (1960) reported that soaking of tomato seedlings in NAA solutions resulted in increased plant growth. Foliar application of NAA at concentrations ranging from 5 to 10 ppm also resulted in increased plant height in tomato (Singh and Upadhyay, 1967). Increased vegetative growth in cucumber was observed with NAA

treatments (100 and 200 ppm) by Choudhury and Pathak (1959). Application of NAA on pineapple, after fruit formation, resulted in considerable increase in the length and diameter of peduncle (Collins, 1960). Reduced branching in soybeans by NAA treatment at pre-floral stage was reported by James et al. (1965). Investigations by Das and Baruah (1967) revealed that application of NAA significantly increased the height of pineapple plants.

Treatment with NAA 25 ppm on tomatoes by Mehrotra et al. (1970) showed no significant increase in plant height compared to the control. However, NAA applications showed a general increase in number of branches and leaves per plant. Mathur (1971) inferred that foliar application of NAA at fortnightly intervals on onion transplants at 100 to 300 ppm resulted in gradual increase in plant height, with concentrations of the growth regulator. Application of NAA at 10 and 15 ppm has been reported to increase spread of plants, height and number of leaves in Knol-Khol by Prasad and Chaturvedi (1973). Singh et al. (1975) reported that NAA 100 ppm significantly decreased the main shoot length compared to control in summer squash. According to Kamruddin et al. (1978), the treatment combination of GA_3 and planofix (NAA 10 ppm) was found to be most effective in increasing the plant height in tomato. Dubey (1983) reported enhanced elongation of vine and production

of lateral branches in sponge gourd at higher concentrations (100 and 200 ppm) of NAA.

2.2. Flowering, maturity and ripening

Chhonkar and Singh (1959) observed early flowering in tomato when seeds were treated with NAA. Induction of early and uniform flowering by the application of NAA has been reported in pineapple also (Anon., 1964, Das 1964). On the other hand, James et al. (1965) observed that NAA sprays at pre-floral stage in soybean delayed the flowering. Delayed flowering was also observed by Rylski (1972) in sweet pepper by plant spray of NAA 50 to 150 ppm.

Groszman (1950) and Py (1955) reported that the application of NAA several weeks before normal fruit maturity, delayed maturity in pineapple. Earlier fruit maturity was reported by Hartmann (1952) in olive by spraying NAA at full bloom. NAA applied for flower induction in pineapple also advanced the maturity and harvesting season of pineapple (Shing, 1956). According to Singh et al. (1959), NAA treatments did not have any effect on hastening or delaying maturity in mango. Delayed maturity by NAA application in pineapple has been reported by Das and Baruah (1967) and Kwong and Chiu (1968) also. Shanmughavelu et al. (1969) observed that NAA 10 to 100 ppm applied on grapes had no influence the fruit maturity.

Srivastava et al. (1971) observed early maturity of apricot by NAA treatments. NAA alone or in combination with GA_3 significantly delayed fruit maturity in pineapple, regardless of the concentration tried (Norman, 1978). According to Gunjate et al. (1979), there was no significant difference in the number of days required for flowering from planting, or from flowering to harvest, by spraying NAA at 20 ppm in pineapple. However, Babylatha (1981) found that NAA significantly delayed the time taken for fruit maturity especially at higher concentrations ranging from 100 to 300 ppm in pineapple. Delayed harvest of pineapple fruits due to NAA 100 to 150 ppm was also reported by Vieira and Gadelha (1982).

Clark and Kerns (1942) reported retardation of ripening by about a week in pineapple due to NAA treatment whereas Shing (1956) observed early, uniform ripening. Evans (1959) also reported that NAA and planofix exerted a marked influence on ripening of pineapple especially at lower concentrations. Poignant (1970) sprayed pineapple with 100 ppm NAA immediately after picking and found prolonged storage life of the fruits, even at unfavourable temperatures. Huang (1973) reported that application of NAA and sodium salt of NAA one month after flowering resulted in delayed ripening of fruits by 12 to 16 days in pineapple. 'Dwarf Cavendish' banana hands dipped in solution of 500 ppm NAA for five seconds showed quicker and

uniform ripening (Dedolph and Goto, 1960). Mishra and Dhuria (1976) observed that NAA 10 to 20 ppm did not affect the storage life of apple.

2.3. Fruit characters and yield

Quentin and Ralph (1957) reported that spray application of NAA and other growth substances in combinations significantly increased fruit size in sweet cherries. Increased fruit size, weight and yield due to NAA and 'Planofix' application in pineapple have been reported by several workers (Evans, 1959; Anon., 1964; Bowden, 1969; Wee, 1971; Huang, 1973; Anon., 1976; Babylatha, 1981; Vieira and Gadelha, 1982).

Mishra and Sharma (1972) reported that NAA did not show any significant effect on fruit retention, fruit weight or fruit size in low fruit setting sweet cherry cv. 'Black Heart', whereas NAA and planofix applied 26 days before harvest significantly increased fruit weight, diameter and fruit length in apple (Misra and Dhuria, 1976) and in plum (Misra and Dhuria, 1977). NAA (200 and 300 ppm) alone or in combination with GA_3 significantly increased the fruit length and weight in pineapple (Norman, 1978).

NAA applied as pre-harvest sprays 60 days after shooting increased bunch weight in banana var. 'Nendran' (Aravindakshan, 1981). Length and weight of individual fruits were also

significantly increased over the control. NAA 100 ppm showed highest pulp/peel ratio. Dubey (1983) observed maximum increase in fruit length at 200 ppm when NAA was applied on sponge gourd.

2.4. Fruit quality

Shing (1956) reported that the acid content of NAA treated pineapples increased, while Chhonkar and Singh (1959) reported increased ascorbic acid and sugar contents by NAA sprays in tomato. Singh et al. (1959) observed maximum brix and ascorbic acid content in mango when NAA 20 ppm was applied six weeks after full bloom. According to Dutta (1966), fruits from NAA treated plants had a better sugar/acid ratio in pineapple. But Kwong and Chiu (1968) found a reduction in acidity and total sugars by NAA treatments in pineapple.

Application effects of NAA on the processing quality of fruits in pineapple by decreasing the TSS content and reducing flesh colour has been reported by Bowden (1969). Srivastava et al. (1971) opined that NAA at 30 ppm and 50 ppm considerably reduced acidity of apricots. According to Huang (1973), sodium salt of NAA reduced the sugar content and acidity, especially at higher concentrations, in pineapple. In litchi, Veera and Das (1973) observed significant decrease in acidity over control by the application of NAA at 40 ppm Das et al. (1974) reported that there was no significant increase in TSS, acidity or brix/acid ratio by pre-harvest

spray of NAA at 50 and 100 ppm in 'Cheema Sahebi' grapes. However, NAA (40 ppm) considerably increased TSS in plum (Mishra and Dhuria, 1977). Higher juice percentage and sugar content were observed by Sinha et al. (1977) by the application of NAA in 'Nagpur santras'.

Dipping fruits for one minute in 25 ppm NAA was found to be superior to all other treatments with respect to fruit quality in 'Thompson Seedless' grapes (Desai et al., 1980). Siddiqui and Chakrawar (1980) reported that NAA at 25 ppm recorded highest TSS in 'Bangalore Purple' grapes. Aravindakshan (1981) studied the effect of NAA on fruit quality of 'Nendran' banana and found that quality was improved by way of increased TSS, total and reducing sugars by NAA 50 ppm.

3. Effect of 'Navras Banana Special' on growth and development

'Navras Banana Special' is a liquid formulation which contains all essential plant nutrients, vitamins and growth hormones. Published research works on the effect of this chemical formulation on banana are lacking. However, the available literature on this chemical and combination effect of nutrients and growth regulators on various crops are reviewed on this section.

3.1. Growth and vegetative characters

2,4-D along with micronutrients when applied on two weeks old green bush bean seedlings significantly increased the height, dry weight, leaf number and total leaf area of plants (Rathore and Wort, 1971). Thimmegowda et al. (1974) reported that 'Navras' at 0.25 per cent sprayed on cowpea plants before flower initiation, resulted in increased height of plants over control. Puttaswamy et al. (1975) observed significant increase in height of rice plants when 'Navras' at 0.25 pef cent was applied as two to four foliar sprays along with basal application of NPK. But there was no significant influence on the number of shoots due to the treatments. Thimmegowda et al. (1975) observed that 'Navras' in general stimulated plant growth when applied at concentrations between 0.25 per cent and 0.75 percent in groundnut. Gowda et al. (1976) also observed significant increase in plant height and number of shoots with one to three sprays of 'Navras' along with basal application of NPK in rice. Puttaswamy et al. (1976 a) could not find significant increase in height of 'Purna' ragi by application of 'Navras'. In groundnut, Puttaswamy et al. (1976 b) observed significant increase in total dry weight of 'Navras' treated plants. According to Thimmegowda et al. (1976) 'Navras' application (0.25 per cent) has favoured the plant performance through increasing plant height and cane weight in sugarcane.

Das and Swain (1977) recorded increased growth of pumpkin by the application of growth regulators in combination with nitrogen. Murthy and Gowda (1977) are of the opinion that 'Navras' at 0.25 per cent applied twice along with basal application of nitrogen, significantly increased leaf number in tobacco. Kamruddin et al. (1978) reported significant increase in number of branches due to the application of different combinations of nitrogen and growth regulators on tomato.

Nagarajan (1982) reported the effect of 'Navras' on robusta banana. When 'Navras Banana Special' at 0.5 per cent was applied as foliar sprays six to eight times during vegetative growth of plants, it resulted in healthy growth and broader and longer leaves in banana.

3.2. Flowering, maturity and ripening

Studies on the effect of nitrogen in combination with growth regulators by Kamruddin *et al.* (1978) revealed that all different combinations increased flowering in tomato. Singh (1979) observed earlier flowering in Kagzi lime when a combination of nitrogen and growth regulators were applied as foliar spray. Haribabu and Rajput (1982) also reported earlier flowering in Kagzi lime due to combined application of Zinc and 2,4-D.

Nagarajan (1982) reported that 'Robusta' banana sprayed with 'Navras' came to harvest by 14 months after planting compared to the control which took 1½ years under Bangalore conditions.

3.3. Fruit characters and yield

Dhillon and Singh (1965) reported that urea spray combined with 2,4-D and 2,4,5-T resulted in significantly higher fruit retention and thereby increased yields in 'Nagpuri' mandarins. 2,4-D along with micronutrients applied on two weeks old bush bean seedlings increased the production of green pods (Rathore and Wort, 1971). Increased fruit retention and yield were observed by Hoda et al. (1973) when 2,4-D and NAA were sprayed on litchi after the foliar application of zinc sulphate.

Increased seed weight, number of seed per pod, percentage seed filling and 100 seed weight were obtained when 'Navras' was applied on cowpea (Thimmegowda et al., 1974). Hoda et al. (1975) reported that maximum increase in fruit size and volume was resulted when a combination of one per cent zinc and 10 ppm NAA was sprayed on litchi. Puttaswamy et al. (1975) reported increased paddy yields due to 'Navras' application. Setty et al. (1975) found that 'Navras' at 0.25 per cent and 0.5 per cent enhanced cotton yields. The foliar nutrient 'Navras' sprayed at

0.5 per cent concentration gave maximum yield of potatoes (Thimmegowda et al., (1975). However, there was no significant difference in yield between 0.25 per cent and 0.5 per cent concentrations. Thimmegowda et al. (1975) reported a significant increase in yield of wheat also, as influenced by 'Navras' sprays. Significant increase in pod weight, kernel weight and total yields have been reported by Thimmegowda et al. (1975) as the result of foliar application of 'Navras'. Gowda et al. (1976) reported better yields in paddy by soil application of NPK combined with three sprays of 'Navras' at 0.25 per cent.

Increased yields and yield components have been reported by Puttaswamy et al. (1976 a) in ragi, by Puttaswamy et al. (1976 b) in groundnut and in sugarcane by Thimmegowda et al. (1976). Better yields due to 'Navras' application at 0.25 per cent have been observed by Murthy and Gowda (1977) in tobacco. Balakrishnan et al. (1978) reported that 25 ppm ethrel + 2 per cent urea + 0.04 per cent $CaCO_3$ treatment was better than ethrel alone even at higher concentrations (100 to 1000 ppm), in increasing the yield of pineapple. In tomato, Kamruddin et al. (1978) reported increased number of fruits per plot due to application of Nitrogen and various growth regulators in various combinations. In cowpea, groundnut, sugarcane, paddy, wheat, potato, cotton, ragi and soybean, increased yields to the tune of 25 per cent have been obtained when 'Navras' was sprayed at critical stages of growth (Anon., 1979).

According to Nagarajan (1982), six to eight sprays of 'Navras' at 0.5 per cent concentration resulted in bigger bunches, more number of hands per bunch, more number of fingers per hand and bigger and uniform fingers in'Robusta' banana. Padole (1982) also reported higher yields due to combined application of nitrogen, phosphorus and NAA in groundnut.

3.4. Fruit quality

Dhillon and Singh (1965) observed that urea spray combined with growth regulators and soil application of ammonium sulphate did not show appreciable difference in quality of Nagpuri mandarins. Rathore and Wort (1971) found that 2,4-D sprayed in combination with micronutrients, increased the ascorbic acid content of ripe seeds of bush bean. Hoda *et al*. (1975) reported better fruit quality as influenced by zinc and NAA sprays in litchi. Das and Swain (1977) opined that nitrogen sprayed with growth regulators helped growth, yield and eating quality of pumpkin fruits.

Materials and Methods

MATERIALS AND METHODS

The investigations to assess the effect of different growth regulators and certain formulations on growth, yield and fruit qualities of banana variety 'Palayankodan' were carried out in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara, Trichur during the year 1982-'83.

'Palayankodan', the most popular cultivar of banana in Kerala, which is mainly grown as a rainfed crop was selected for the study. This variety comes under the subgroup 'Poovan' with genomic status AAB.

Three months old suckers of uniform size (1.5 to 2 kg) were selected for planting and were cut back to a height of 60 cm before planting.

Field preparation

The land was dug well and levelled. Pits of size 50 cm^3 were taken at a spacing of 2.13 m x 2.13 m. The suckers were planted on 21st May, 1982. A basal application of 15 kg farm yard manure was done and 2.5 kg of green leaves was incorporated into each pit. 25 g of thimet granule was applied into the pits before planting as a prophylatic measure against rhizome weevils and banana aphids.

Uniform cultural operations and crop management as recommended by Kerala Agricultural University were adopted (Anon., 1981). The crop was irrigated at weekly intervals from December to March.

Experimental design and layout

The experiment was laid out adopting the randomised block design, with 13 treatments and three replications. There were six plants in each plot with two rows of three suckers each planted at 2.13 m x 2.13 m spacing. Necessary border rows were also provided. The layout plan is given in Fig.1.

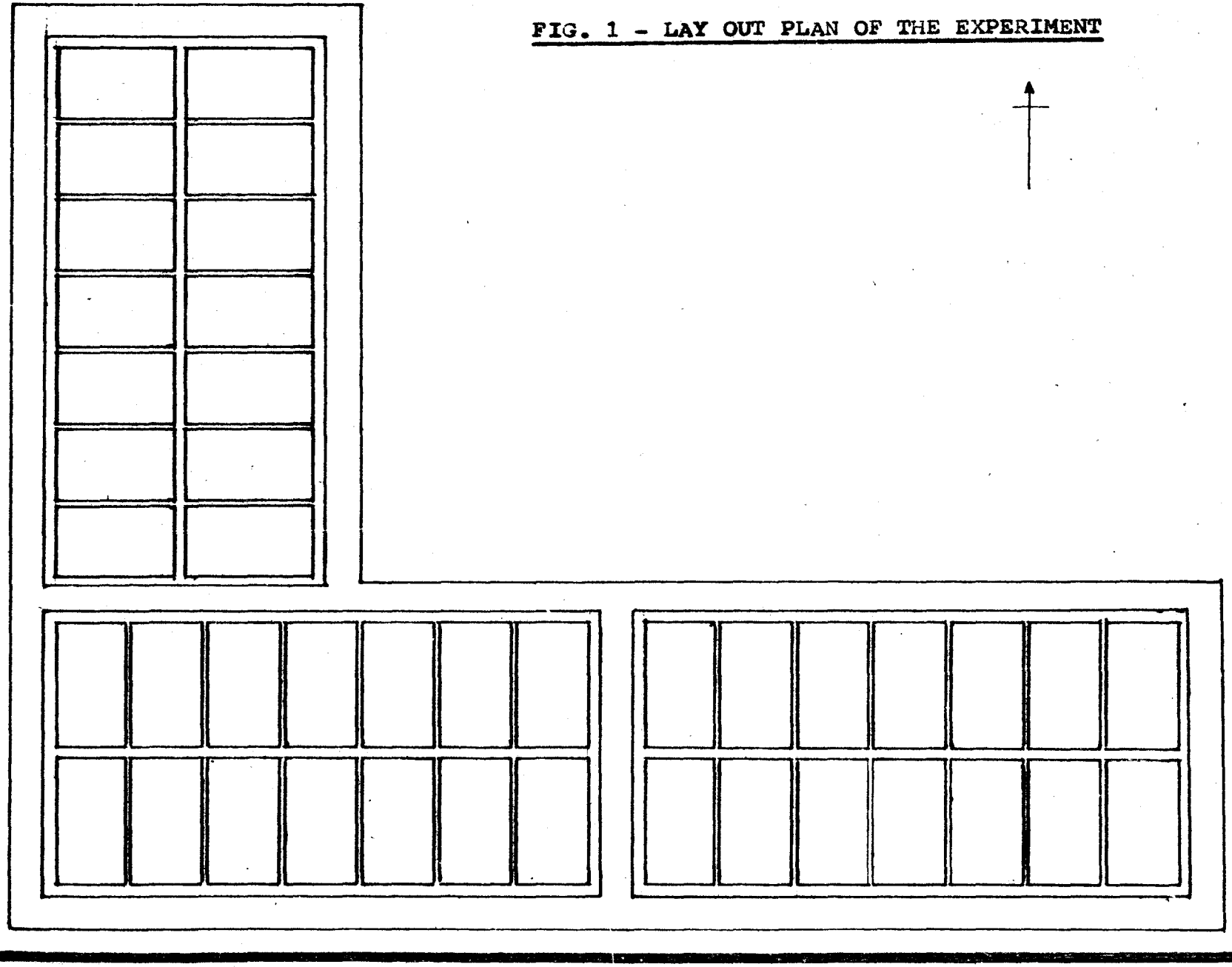
Treatments

Growth regulators and formulations employed in the study comprised of the following:

1. 2,4-D (2,4-dichlorophenoxy acetic acid) - 98% pure.
2. 'Navras Banana Special' - A commercial formulation of Panchajanya Enterprises, Bangalore which contains all essential plant nutrients including micronutrients, in addition to vitamins and 2,4-D as the growth promoting factor.
3. NAA (Naphthalene acetic acid) - 100% pure.

Four levels each of 2,4-D, NAA and 'Navras Banana Special' as detailed below were tried for the study.

FIG. 1 - LAY OUT PLAN OF THE EXPERIMENT



T1	2,4-D	5 ppm
T2	2,4-D	10 ppm
T3	2,4-D	15 ppm
T4	2,4-D	20 ppm
T5	NAA	20 ppm
T6	NAA	30 ppm
T7	NAA	40 ppm
T8	NAA	50 ppm
T9	Navras Banana Special	0.25 per cent
T10	Navras Banana Special	0.50 per cent
T11	Navras Banana Special	0.75 per cent
T12	Navras Banana Special	1.00 per cent
T13	Control	Water spray.

Spraying with different levels of the growth regulators and formulation was done at two stages of plant growth (three months after planting and four months after planting). On the completion of female phase of bunch development, the growth regulators and 'Navras Banana Special' were sprayed on bunches. Altogether three sprayings were thus given in each treatment.

Preparation and application of growth regulators and 'Navras Banana Special'

Measured quantities of the growth regulators were taken and dissolved in 5 ml of absolute alchohol. The stock solutions were diluted with water so as to give the required concentration. In the case of 'Navras', the solution was diluted in water directly to give the required concentrations. Teepol was used as wetting agent. The solutions were sprayed

on the leaf surfaces in the case of plant spray and on bunches in the case of bunch sprays using a Knapsac sprayer. Care was taken to prevent the drift of chemicals to other treatments by using screens made of polythene sheets supported by wooden frames.

Observations

1. Morphological characters

Observations on various morphological characters were recorded from 90th day of planting to shooting adopting the method suggested by Yang and Pao (1962).

1.1. Plant characters

1.1.1. Height

The height of the plant was measured from the base of the psuedostem at ground level to the axil of the youngest leaf and recorded in cm.

1.1.2. Girth

Girth of the psuedostem was measured at 20 cm from the ground level.

1.1.3. Number of leaves

The number of fully opened functional leaves present at each observations were recorded.

1.1.4. Petiole length

Length of petiole was measured from the psuedostem to the base of the lamina.

1.1.5. Length of lamina

Lamina length was measured from its base to the tip.

1.1.6. Width of lamina

Lamina width was measured at the broadest point in the middle region.

1.1.7. Total leaf area per plant

The leaf area of each functional leaf was calculated by the formula given by Murray (1960). (Leaf area = Length x Breadth x 0.8). The total leaf area of the plant was then worked out.

1.1.8. Duration of the crop

The number of days taken for shooting and days from shooting to harvest were recorded. From these the total number of days from planting to harvest were computed.

1.1.9. Sucker production

The number of suckers per plant was recorded as and when they were produced till shooting. However, these suckers were not allowed until shooting. After the emergence of inflorescence, one sucker per plant was retained.

1.2. Bunch characters

The bunches were harvested when they were fully mature as indicated by the disappearance of angles; that is, "round full" (Simmonds, 1959). The following observations were recorded on bunches.

1.2.1. Weight of the bunch

Weight of the bunch including the peduncle was recorded.

1.2.2. Length of the bunch

Length of the bunch was measured from the point of attachment of the first hand to that of the last hand.

1.2.3. Number of hands and fingers

The number of hands per bunch and total number of fingers in each bunch were recorded.

1.2.4. Mean weight of a hand

Weight of each hand on bunch was recorded and the mean value calculated.

1.2.5. Mean number of fingers per hand

The second hand of the bunch was selected as the representative hand and number of fingers were recorded.

1.2.6. Mean weight of a finger

The middle fruit in the top row of the second hand (from the base of the bunch) was selected as the representative finger (Gottreich et al., 1964) for finding out the mean weight, length and girth of the fingers. The weight of this representative finger was recorded as the mean weight of a finger. Weight of the finger was measured using a top loading automatic electric balance and expressed in g.

1.2.7. Length and girth of the finger

Length of the finger was measured from the point of attachment with the pedicel to the tip and the girth at the mid portion (at the point of maximum thickness) using a fine thread and a scale.

2. Qualitative analysis of fruits

The fruits collected from well ripe bunches were used for quality analysis. The middle fruit in the top row of second hand was selected as the representative sample. Samples were taken from each fruit from three portions viz. top, middle and bottom and the three samples were then pooled and macerated in a Waring blender. Triplicate samples were used for analysis of different constituents as detailed below.

2.1. Sugars

2.1.1. Reducing sugars

The reducing sugars of the sample were determined as per the method suggested by A.O.A.C.(1960).

A known quantity of macerated pulp was thoroughly mixed in distilled water. The solution was clarified with neutral lead acetate and deleaded with potassium oxalate and made up to a known volume. The solution was then filtered and an aliquot of this solution was titrated against a mixture of

Fehling's A and B solutions using methylene blue as indicator. The reducing sugar was expressed as percentage.

2.1.2. Total sugars

The total sugars were estimated as per the method described by A.O.A.C.(1960). 5 ml.of concentrated hydrochloric acid was added to a known volume of clarified solution prepared as stated earlier and the same was kept over night. The solution was then neutralised by adding sodium hydroxide and titrated against a mixture of Fehling's A and B solutions. The total sugar was expressed as percentage.

2.1.3. Non reducing sugars

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

2.2. Total soluble solids

Total soluble solids were determined by sing a pocket refractometer and were expressed as percentage.

2.3. Titrable acidity

The method described by A.O.A.C.(1960) was adopted for determination of titrable acidity. 10 g of the macerated sample was digested with boiling water and made upto a known volume. An aliquot of the filtered solution was titrated

against 0.1 N. NaOH using phenolphthalein as indicator. The acidity was expressed as percentage of citric acid.

3. Leaf analysis

The nutrient contents in leaves viz. nitrogen, phosphorus and potassium at maximum vegetative phase were analysed. Leaf samples were prepared from cross section of 2.5 cm from both laminae and midrib from the middle portion of all the leaves.

3.1. Nitrogen

Nitrogen content of the leaf sample was estimated by Microkjeldahl digestion-distillation method (A.O.A.C., 1960).

3.2. Phosphorus

One gram of the ground sample was digested in 50 ml of a mixture of concentrated perchloric acid, sulphuric acid, and nitric acid in the proportion of 1:2:9 and the volume made up to 100 ml with distilled water and filtered. Phosphorus in an aliquot of this extract was determined colorimetrically using Vanadomolybdophosphoric yellow colour method (Jackson, 1958).

3.3. Potassium

Potassium in an aliquot of the tripple acid extract of the sample was determined using a flamephotometer (Jackson, 1958).

4. Statistical analysis

The data on different aspects studied were subjected to statistical analysis whereever possible following the methods of Snedecor and Cochran (1967). The mean values were worked out for different parameters and all the characters of different treatments were analysed by the analysis of variance technique. Critical differences were calculated for the comparison of means. Simple correlation for various characters with yield was also worked out. With regard to the effect of 'Navras Banana Special' on yield, quadratic response functions were fitted to find out the optimum dosage.

Results

RESULTS

The results of the investigators to find out the effect of 2,4-D, NAA and 'Navras Banana Special' on various aspects of plant growth and yield are presented below.

1. Vegetative parameters

1.1. Height of psuedostem

The data relating to the effect of 2,4-D, NAA and 'Navras' on the mean height of psuedostem at the early vegetative phase, late vegetative phase and at shooting are presented in Table 1.

It was found that there was no significant difference in the effects of the treatments tried on the height of psuedostem. The mean height of plants at shooting ranged from 242.11 cm for 2,4-D at 5 ppm to 267.56 cm that for NAA at 20 ppm.

1.2. Girth of psuedostem

The girth of psuedostem (vide Table 2) showed significant difference between treatments only at shooting; the highest value being recorded by 2,4-D at 20 ppm (60.44 cm) followed by 'Navras' at 0.5 per cent (59.50 cm). The lowest psuedostem girth was recorded in control (52.33 cm). Treatments, T_{12}, T_5, T_2, T_8, and T_6 (Navras 1 per cent, NAA 20 ppm, 2,4-D 10 ppm, NAA 50 ppm and NAA 30 ppm respectively)

Table 1. Mean height of psuedostem in cm at various stages of growth for different treatments.

Treatments		Stages of plant growth		
		Early vegetative phase	Late vegetative phase	Shooting
T1	2,4-D 5 ppm	110.33	176.11	242.11
T2	2,4-D 10 ppm	108.67	174.22	244.11
T3	2,4-D 15 ppm	111.94	173.22	253.56
T4	2,4-D 20 ppm	116.45	192.56	253.00
T5	NAA 20 ppm	108.72	188.16	267.56
T6	NAA 30 ppm	107.33	191.22	256.11
T7	NAA 40 ppm	111.34	185.33	261.66
T8	NAA 50 ppm	115.72	193.50	261.89
T9	'Navras' 0.25%	109.72	168.00	254.89
T10	'Navras' 0.50%	107.39	189.33	245.44
T11	'Navras' 0.75%	108.72	167.00	251.00
T12	'Navras' 1.00%	110.11	173.55	252.66
T13	Control	111.06	170.67	244.67
C.D. (5%)		N.S.	N.S.	N.S.
SEm±		60.21	163.68	116.16

Table 2. Mean girth of psuedostem in cm at various stages of plant growth for different treatments.

Treatments		Stages of plant growth		
		Early vegetative phase	Late vegetative phase	Shooting
T1	2,4-D 5 ppm	27.17	43.61	56.72
T2	2,4-D 10 ppm	28.11	43.56	55.28
T3	2,4-D 15 ppm	28.45	43.66	59.11
T4	2,4-D 20 ppm	28.94	46.94	60.44
T5	NAA 20 ppm	25.89	45.50	54.78
T6	NAA 30 ppm	26.25	46.61	56.50
T7	NAA 40 ppm	27.33	45.22	57.63
T8	NAA 50 ppm	29.50	47.78	56.28
T9	'Navras' 0.25%	26.95	42.33	57.56
T10	'Navras' 0.50%	27.67	46.22	59.50
T11	'Navras' 0.75%	27.72	41.11	58.44
T12	'Navras' 1.00%	27.89	42.33	53.50
T13	Control	28.78	41.44	52.33
C.D. (5%)		N.S.	N.S.	4.21
SEm±		3.80	14.40	6.23

were on par with control whereas treatments, T_8, T_6, T_1, T_9, T_7, T_{11}, T_3 and T_{10} were on par with T_4 (2,4-D 20 ppm).

1.3. Number of functional leaves

Significant difference was observed between treatments with respect to the number of functional leaves, only at shooting (Table 3). Higher concentration of 2,4-D (20 ppm), and 'Navras' at 0.25 per cent, 0.5 per cent and 0.75 per cent recorded significantly higher number of functional leaves than control. However, these four treatments were statistically on par.

1.4. Total leaf area

The total leaf area as influenced by the treatments at the three stages of growth are presented in Table 4.

The total leaf area at late vegetative phase and at shooting showed significant effect due to the treatments tried. At late vegetative phase, plants sprayed with 2,4-D at 20 ppm, 'Navras' at 0.5 per cent and 2,4-D at 5 ppm showed significantly higher leaf area (10.63 m^2, 10.02 m^2 and 9.29 m^2 respectively) compared to control (7.92 m^2). Among these, 2,4-D (20 ppm) treated plants recorded the maximum leaf area which was significantly superior to all the treatments except 'Navras' at 0.5 per cent.

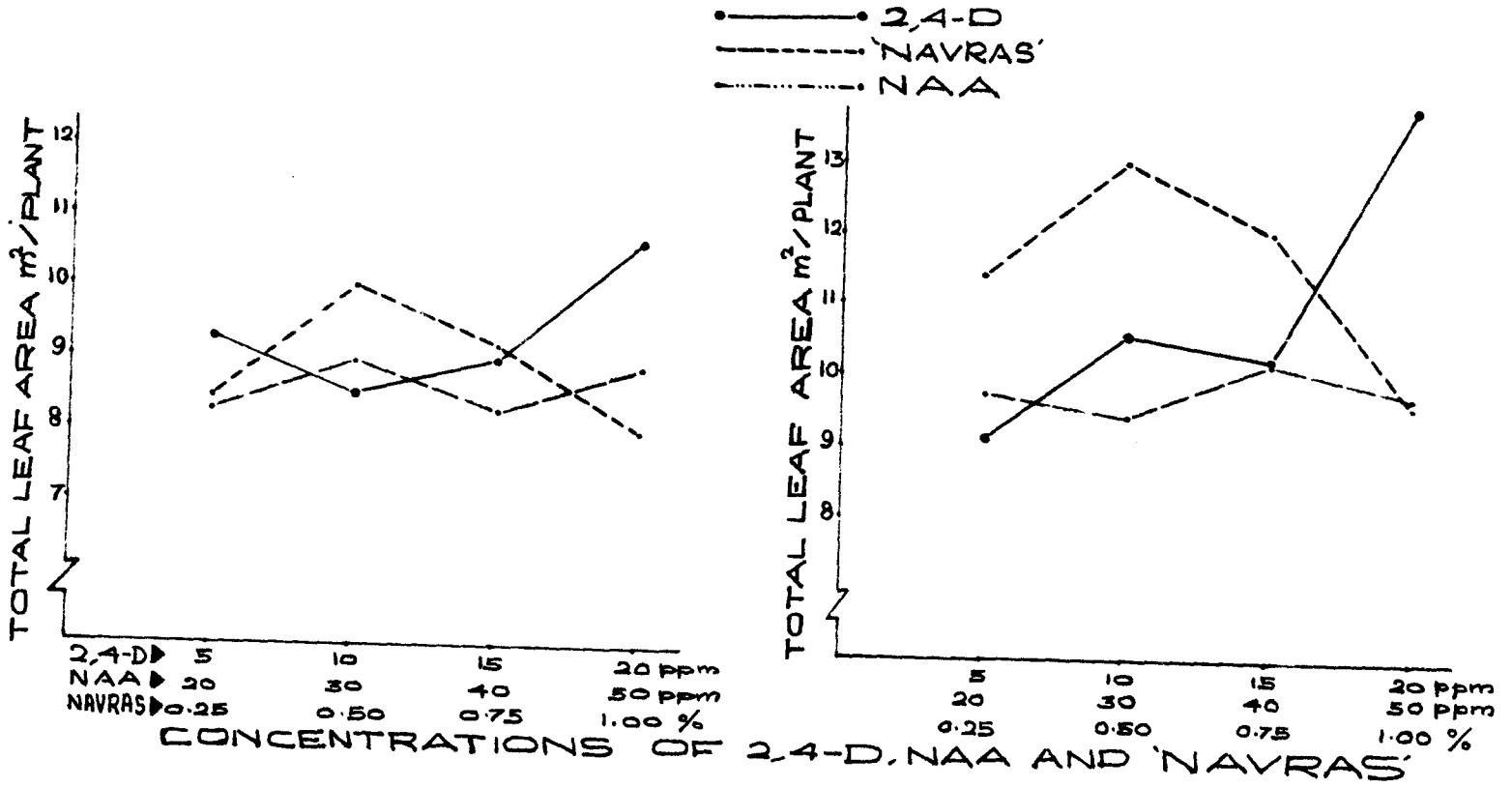
Table 3. Mean number of functional leaves at various stages of plant growth for different treatments.

Treatments		Stages of plant growth		
		Early vegetative phase	Late vegetative phase	Shooting
T1	2,4-D 5 ppm	6.22	10.89	9.56
T2	2,4-D 10 ppm	6.44	10.89	11.11
T3	2,4-D 15 ppm	6.22	10.44	10.67
T4	2,4-D 20 ppm	6.22	11.33	12.89
T5	NAA 20 ppm	6.67	10.78	10.33
T6	NAA 30 ppm	7.00	11.11	10.11
T7	NAA 40 ppm	6.67	10.55	11.00
T8	NAA 50 ppm	6.44	10.66	10.11
T9	'Navras' 0.25%	6.22	10.89	11.44
T10	'Navras' 0.50%	6.44	11.22	12.33
T11	'Navras' 0.75%	6.89	11.11	11.89
T12	'Navras' 1.00%	6.33	10.22	10.22
T13	Control	6.34	10.44	9.89
C.D. (5%)		N.S.	N.S.	1.51
SEm±		2.16	0.46	0.80

Table 4. Total leaf area per plant in square metre at various stages of plant growth for different treatments.

Treatments		Stages of plant growth		
		Early vegetative phase	Late vegetative phase	Shooting
T1	2,4-D 5 ppm	2.90	9.29	9.07
T2	2,4-D 10 ppm	2.99	8.49	10.53
T3	2,4-D 15 ppm	2.96	8.96	10.19
T4	2,4-D 20 ppm	3.10	10.63	13.73
T5	NAA 20 ppm	2.77	8.29	9.70
T6	NAA 30 ppm	3.25	8.95	9.38
T7	NAA 40 ppm	3.21	8.26	10.13
T8	NAA 50 ppm	3.26	8.87	9.68
T9	'Navras' 0.25%	2.85	8.46	11.40
T10	'Navras' 0.50%	3.17	10.02	12.99
T11	'Navras' 0.75%	2.61	9.20	12.03
T12	'Navras' 1.00%	3.07	7.96	9.57
T13	Control	3.18	7.92	8.96
C.D. (5%)		N.S.	1.29	1.52
SEm±		--	0.59	0.82

FIG. 2 - EFFECT OF 2,4-D, NAA AND 'NAVRAS BANANA SPECIAL' ON TOTAL LEAF AREA AT VARIOUS STAGES OF GROWTH IN BANANA.



At shooting, 2,4-D at 10 and 20 ppm and 'Navras Banana Special' at 0.25 per cent, 0.5 per cent and 0.75 per cent recorded significantly higher leaf area over control. The maximum leaf area was recorded by plants treated with 2,4-D at 20 ppm (13.73 m^2) and the minimum in control (8.96 m^2).

1.5. Leaf length

The data on the mean length of leaves as given in Table 5 showed significant difference between treatments at shooting. The treatments 2,4-D at 20 ppm, 'Navras' at 0.5 per cent and 0.75 per cent which were on par, recorded significantly greater length of leaf compared to control. The maximum leaf length was recorded with 2,4-D at 20 ppm (183.82 cm).

1.6. Breadth of leaf

The breadth of leaf at shooting was not significantly affected by the different treatments tried (Table 5).

1.7. Length of petiole

The data on petiole length at shooting presented in Table 5, showed no significant difference due to various treatments.

1.8. Sucker production

Sucker production at shooting did not show significant difference among the treatments (Table 6).

Table 5. Leaf length, leaf breadth and petiole length at the time of shooting for different treatments.

Treatments		Mean length of leaf.	Mean breadth of leaf	Mean petiole length
T1	2,4-D 5 ppm	174.53	72.50	33.69
T2	2,4-D 10 ppm	175.38	72.61	33.23
T3	2,4-D 15 ppm	176.77	73.50	33.78
T4	2,4-D 20 ppm	183.82	77.25	35.29
T5	NAA 20 ppm	177.99	74.01	35.26
T6	NAA 30 ppm	173.07	72.33	32.77
T7	NAA 40 ppm	175.88	72.14	34.28
T8	NAA 50 ppm	174.05	74.27	34.32
T9	Navras 0.25%	179.41	75.86	35.08
T10	Navras 0.50%	181.03	75.80	34.33
T11	Navras 0.75%	180.29	73.96	33.81
T12	Navras 1.00%	178.57	73.33	35.94
T13	Control	174.62	71.74	35.75
C.D. (5%)		5.48	N.S.	N.S.
SEm±		10.56	7.06	5.35

Table 6. Mean number of suckers produced at shooting for different treatments.

Treatments	Number of suckers
T1 2,4-D 5 ppm	4.33
T2 2,4-D 10 ppm	2.89
T3 2,4-D 15 ppm	4.11
T4 2,4-D 20 ppm	3.44
T5 NAA 20 ppm	3.00
T6 NAA 30 ppm	3.11
T7 NAA 40 ppm	3.45
T8 NAA 50 ppm	3.22
T9 'Navras' 0.25%	3.22
T10 'Navras' 0.50%	3.22
T11 'Navras' 0.75%	3.44
T12 'Navras' 1.00%	3.78
T13 Control	3.44
C.D. (5%)	N.S.
SEm±	0.51

2. Flowering and maturity

Data on the number days required from planting to shooting, shooting to harvest and planting to harvest are presented in Table 7.

With respect to the number of days taken from planting to shooting, treatments with 2,4-D at 20 ppm recorded the minimum duration (241.22 days) whereas the maximum number of days for shooting was recorded with NAA application at 50 ppm (264.44); their effects being significantly different from the control. Effect of other treatments were not significant and did not vary from the control or between themselves. However, the effect due to different concentrations of 2,4-D as well as 'Navras' were statistically on par.

It was interesting to note that there was no significant variation between treatments with regard to the days taken from shooting to harvest which ranged from 94.44 days for 2,4-D 20 ppm to 109.33 days for NAA 50 ppm.

The levels of 2,4-D except 5 ppm significantly decreased the number of days from planting to harvest compared to control; the least being recorded with 2,4-D at 20 ppm (335.67 days). NAA at 50 ppm concentration significantly delayed the duration from planting to harvest (372.78 days). Lower concentration of 2,4-D (5 ppm) or NAA (20,30 and 40 ppm) and different levels

Table 7. Effect of different treatments on duration of the crop (mean number of days).

Treatments		Planting to shooting	Shooting to harvest	Total duration (Planting to harvest)
T1	2,4-D 5 ppm	246.11	102.00	348.11
T2	2,4-D 10 ppm	244.45	99.67	344.11
T3	2,4-D 15 ppm	245.44	97.78	343.22
T4	2,4-D 20 ppm	241.22	94.44	335.67
T5	NAA 20 ppm	260.11	105.11	365.22
T6	NAA 30 ppm	256.44	105.78	362.22
T7	NAA 40 ppm	259.78	107.00	366.78
T8	NAA 50 ppm	264.44	109.33	372.78
T9	'Navras' 0.25%	249.56	103.22	352.78
T10	'Navras' 0.50%	245.89	101.22	347.00
T11	'Navras' 0.75%	249.11	103.00	352.11
T12	'Navras' 1.00%	250.78	100.45	351.23
T13	Control	252.89	104.89	357.78
C.D. (5%)		10.11	N.S.	13.44
SEm±		385.97	31.97	63.63

FIG. 3 - EFFECT OF 2,4-D, NAA AND 'NAVRAS BANANA SPECIAL' ON NUMBER OF DAYS FOR SHOOTING.

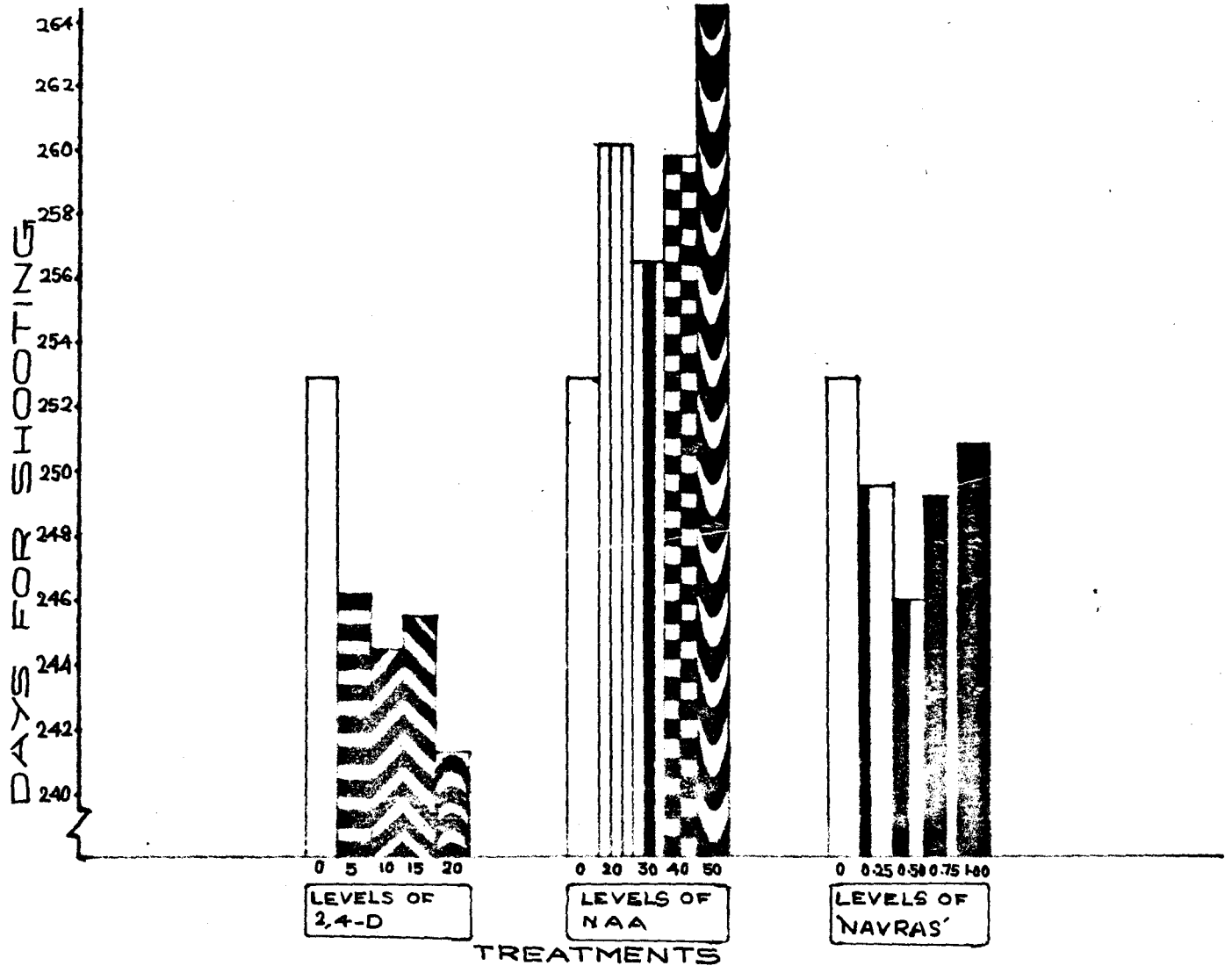
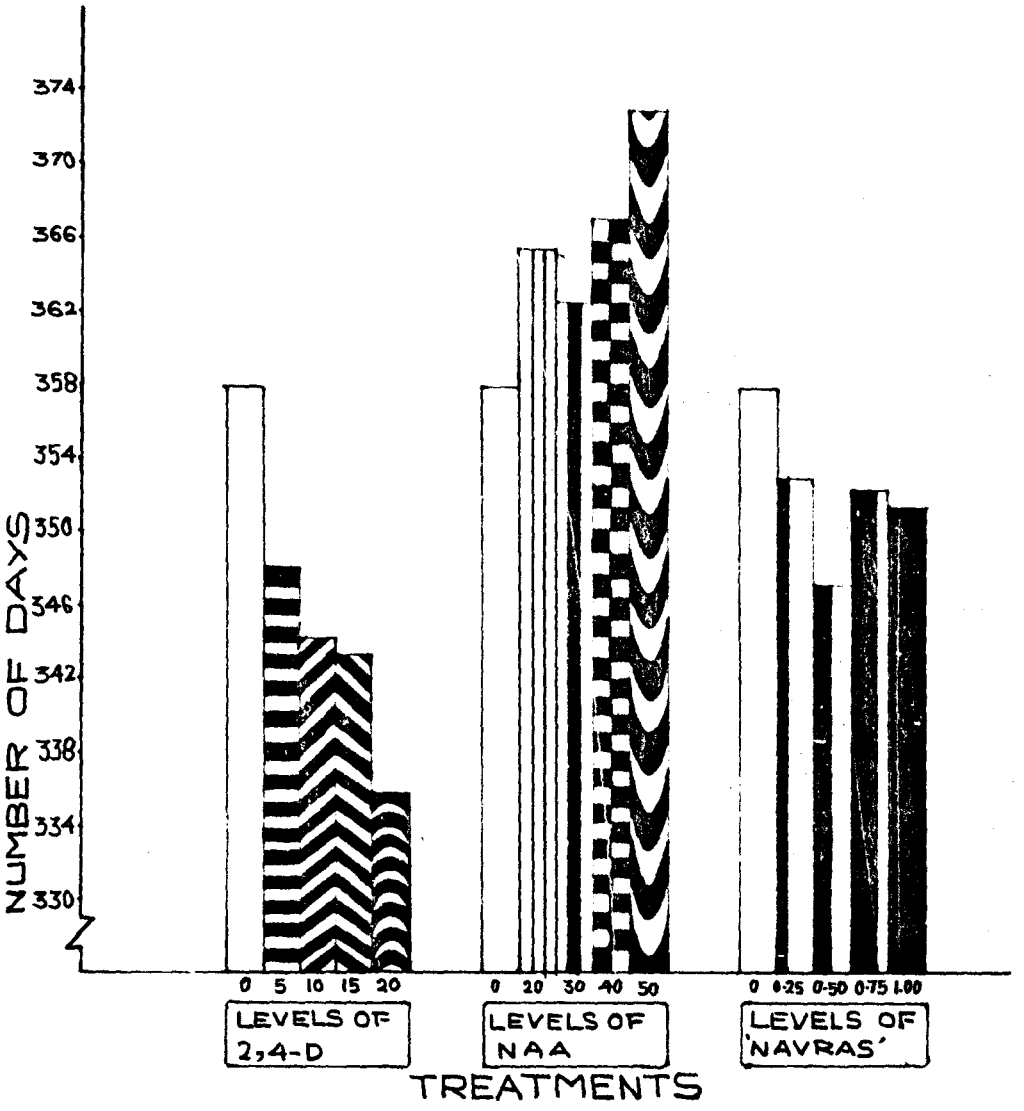


FIG. 4 - EFFECT OF 2,4-D, NAA AND 'NAVRAS BANANA SPECIAL' ON NUMBER OF DAYS FROM PLANTING TO HARVEST.



of 'Navras' tried did not show significant difference from control with respect to the number of days from planting to harvest.

3. Bunch characters

Data pertaining to various bunch characters as influenced by different levels of 2,4-D, NAA and 'Navras' are furnished in Table 8 to 10.

3.1. Bunch weight

The treatments, 'Navras' at 0.5 per cent, 2,4-D at 20 ppm 'Navras' at 0.75 per cent, NAA at 50 ppm, 'Navras' at 0.25 per cent and 2,4-D at 15 ppm recorded significantly higher bunch weight compared to control (Table 8). Maximum bunch weight of 13.53 kg was recorded in the treatment with 'Navras' at 0.5 per cent and the minimum in control (6.89 kg).

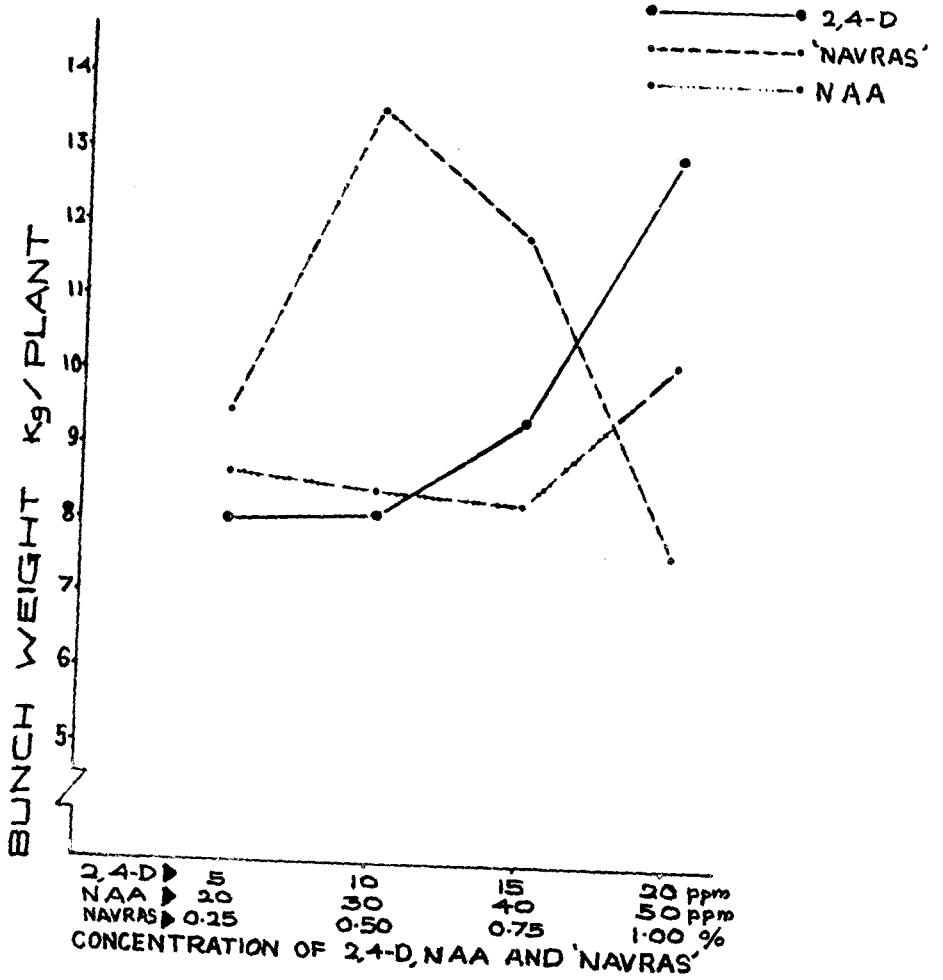
3.2. Length of bunch

The length of bunch also differed significantly between different treatments. Maximum length of bunch (53.44 cm) was recorded in the treatment with 2,4-D at 20 ppm followed by 'Navras' at 0.75 per cent (51.39 cm), 'Navras' 0.5 pef cent and NAA at 50 ppm (49.19 cm) which were significantly superior to control. The minimum length of bunch was recorded in control (41.98 cm).

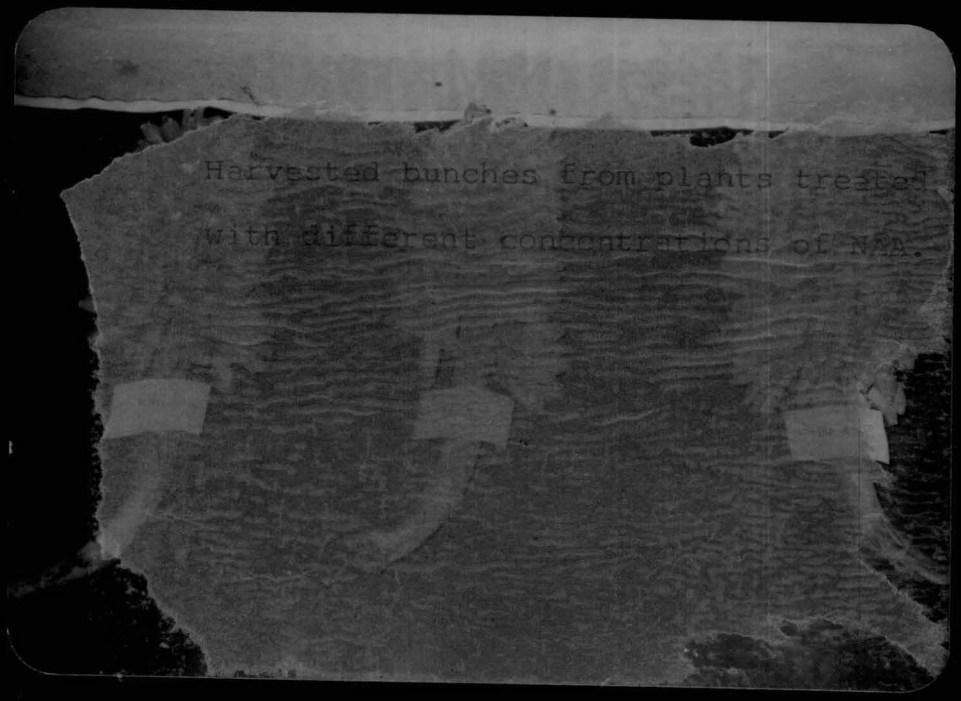
Table 8. Effect of different treatments on bunch characters.

Treatments	Mean weight of bunch (kg)	Mean length of bunch (cm)	Mean number of hands per bunch	Mean number of fingers per bunch
T1 2,4-D 5 ppm	8.00	42.71	10.44	168.44
T2 2,4-D 10 ppm	8.10	45.27	11.22	167.89
T3 2,4-D 15 ppm	9.38	45.94	11.00	162.55
T4 2,4-D 20 ppm	12.94	53.44	13.11	189.33
T5 NAA 20 ppm	8.67	45.33	10.78	165.44
T6 NAA 30 ppm	8.45	43.06	10.56	166.55
T7 NAA 40 ppm	8.28	44.22	11.22	150.89
T8 NAA 50 ppm	10.18	49.19	11.67	171.00
T9 'Navras' 0.25%	9.48	44.56	11.33	156.78
T10 'Navras' 0.50%	13.53	49.80	12.89	173.22
T11 'Navras' 0.75%	11.83	51.39	11.92	169.55
T12 'Navras' 1.00%	7.60	42.86	10.22	148.44
T13 Control	6.89	41.98	9.67	149.44
C.D. (5%)	1.94	5.40	0.965	16.18
SEm^{+}	1.32	10.27	0.328	92.22

FIG. 5 - EFFECT OF 2,4-D, NAA AND 'NAVRAS BANANA SPECIAL' ON BUNCH WEIGHT.




24.0.F
24.9.20



Harvested bunches from plants treated with different concentrations of NAA.

PLATE -3

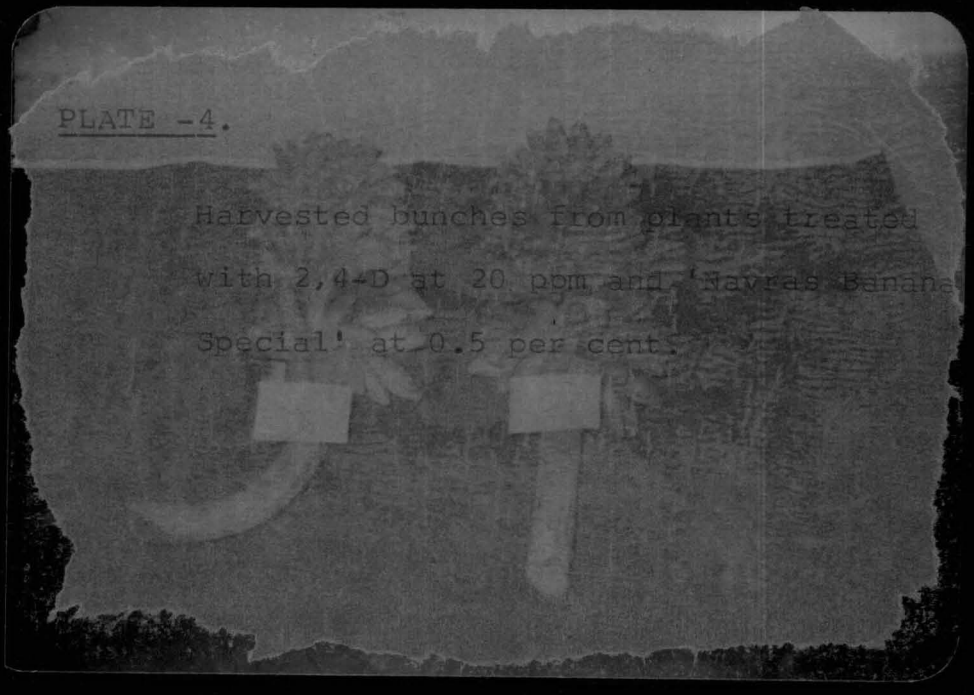


PLATE -4.

Harvested bunches from plants treated with 2,4-D at 20 ppm and 'Navras Banana Special' at 0.5 per cent.

3.3. Number of hands per bunch

The mean number of hands per bunch as influenced by the different treatments are presented in Table 8. The treatments, 2,4-D at 20 ppm, 'Navras' at 0.5 per cent, 'Navras' at 0.75 per cent, NAA at 50 ppm, 'Navras' at 0.25 per cent, 2,4-D at 10 ppm and NAA at 40 ppm showed significantly higher number of hands per bunch compared to control. Application of 2,4-D at 20 ppm and 'Navras' at 0.50 per cent were superior to all other treatments. The maximum number of hands per bunch (13.11) was recorded in the treatment with 2,4-D at 20 ppm and the minimum in control (9.67).

3.4. Number of fingers per bunch

The data on the number of fingers per bunch (vide Table 8) showed that the differences among the treatments were significant. All concentrations of 2,4-D (except 15 ppm), NAA at 50 ppm and 'Navras' at 0.5 per cent and 0.75 per cent recorded significant difference in the number of fingers per bunch compared to control. Maximum number of fingers per bunch (189.33) was found when 2,4-D was applied at 20 ppm and the minimum was recorded in treatment with 'Navras' 1.00 per cent (148.44).

3.5. Weight of hand

The mean weight of hands showed significant variation due to treatments (Table 9). 2,4-D at 20 ppm, NAA at 50 ppm and all levels of 'Navras' except 1.00 per cent recorded substantial increase in weight of hand over control. Treatment with 2,4-D at 20 ppm resulted in the maximum weight of hands (1.38 kg) and the minimum was recorded in control (0.82 kg).

3.6. Number of fingers per hand

With respect to the mean number of fingers per hand, application of 2,4-D at 20 ppm, 'Navras' at 0.5 per cent and NAA at 50 ppm resulted in significantly higher values over control. The highest number of fingers per hand was recorded with 2,4-D at 20 ppm (18.78) and it was significantly superior to all other treatments.

3.7. Length of finger

The different treatments also had a significant influence on the mean length of fingers. 2,4-D at 20 ppm and 'Navras' at 0.25 per cent, 0.5 per cent and 0.75 per cent significantly increased the length of finger over control. Maximum increase in finger length was seen with 'Navras' at 0.5 per cent (12.90 cm) while control recorded the minimum length (9.79 cm).

Table 9. Effect of different treatments on hand characters.

	Treatments	Mean weight of hand (kg)	Mean number of fingers per hand
T1	2,4-D 5 ppm	0.88	15.78
T2	2,4-D 10 ppm	0.97	16.11
T3	2,4-D 15 ppm	1.02	16.56
T4	2,4-D 20 ppm	1.38	18.78
T5	NAA 20 ppm	1.02	15.67
T6	NAA 30 ppm	0.96	16.00
T7	NAA 40 ppm	0.94	16.44
T8	NAA 50 ppm	1.04	17.33
T9	'Navras' 0.25%	1.11	16.67
T10	'Navras' 0.50%	1.37	17.56
T11	'Navras' 0.75%	1.23	16.56
T12	'Navras' 1.00%	0.87	15.89
T13	Control	0.82	15.78
C.D. (5%)		0.214	1.084
SEm$\pm$		0.016	0.414

3.8. Girth of finger

Data on the mean girth of fingers (vide Table 10) showed significant variation due to treatments. Compared to control, significant difference in girth of finger was r recorded in the treatments, 'Navras' at 0.5 per cent, 2,4-D at 20 ppm, 'Navras' at 0.75 per cent and 0.25 per cent and NAA at 50 ppm and 20 ppm. The highest value for girth of finger was noted with the application of 'Navras' at 0.5 per cent (11.32 cm) which was closely followed by 2,4-D at 20 ppm (10.76 cm) and 'Navras' at 0.75 per cent (10.43 cm). The control recorded minimum value for girth of finger (8.88 cm).

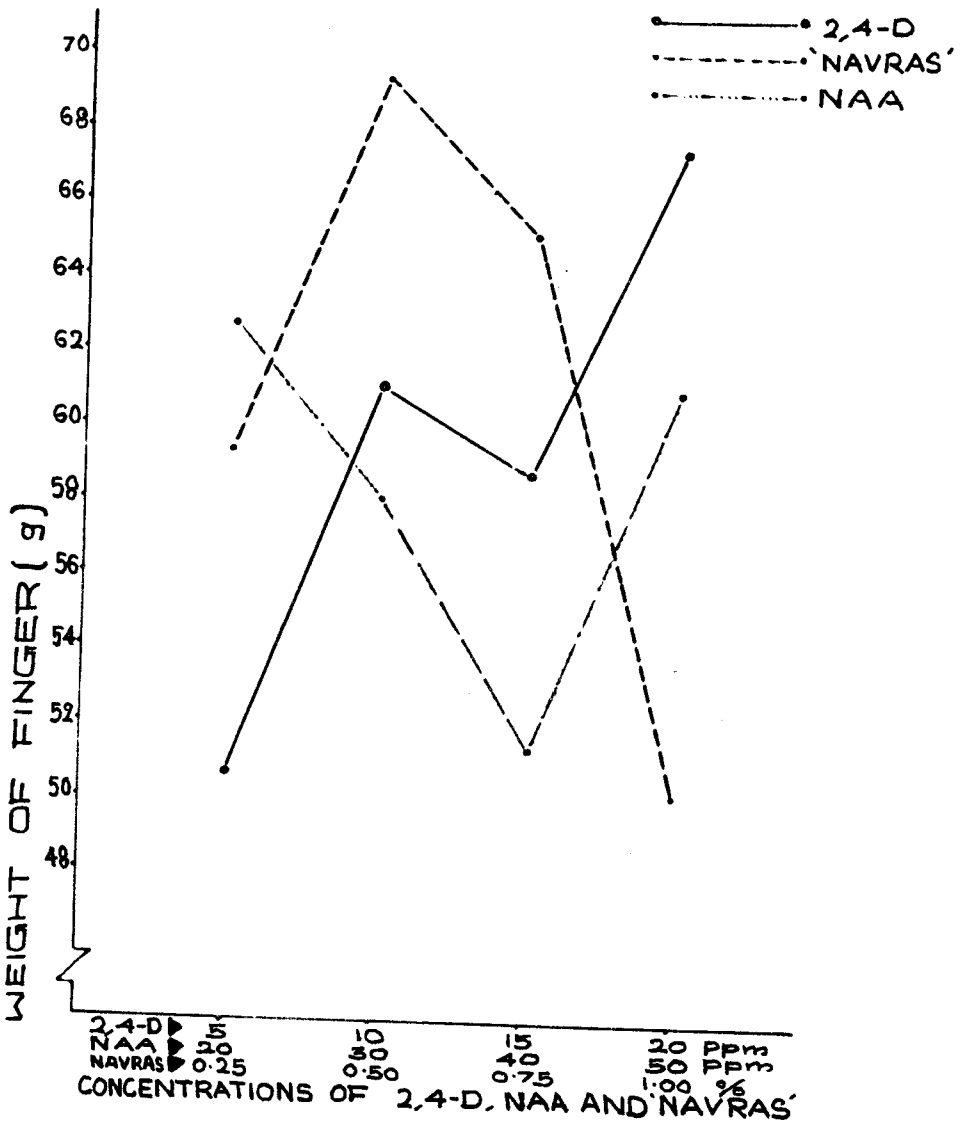
3.9. Weight of finger

Significant difference was observed between treatments with respect to the weight of finger. Application of 'Navras' at 0.5 per cent, 2,4-D at 20 ppm, 'Navras' at 0.75 per cent, NAA at 20 ppm, 2,4-D at 10 ppm, NAA at 50 ppm, 'Navras' at 0.25 per cent and 2,4-D at 15 ppm resulted in significantly higher finger weight compared to control. The maximum weight of finger was recorded in treatment with 'Navras' at 0.5 per cent (69.34 g), followed by 2,4-D at 20 ppm (67.41 g) and the least in control (47.66 g).

Table 10. Effect of different treatments on finger characters.

Treatments	Mean length of finger (cm)	Mean girth of finger (cm)	Mean weight of finger (g)	Mean dry weight of finger (%)
T1 2,4-D 5 ppm	10.33	9.36	50.62	59.56
T2 2,4-D 10 ppm	10.84	9.73	61.10	57.30
T3 2,4-D 15 ppm	10.88	9.49	58.78	54.44
T4 2,4-D 20 ppm	12.46	10.76	67.41	54.29
T5 NAA 20 ppm	10.96	9.89	62.72	48.40
T6 NAA 30 ppm	10.40	9.16	58.01	49.02
T7 NAA 40 ppm	11.12	9.65	51.32	51.40
T8 NAA 50 ppm	10.96	9.97	60.97	52.25
T9 'Navras' 0.25%	11.47	10.06	59.26	57.32
T10 'Navras' 0.50%	12.90	11.32	69.34	54.28
T11 'Navras' 0.75%	11.59	10.43	65.08	52.62
T12 'Navras' 1.00%	10.77	9.16	50.15	54.33
T13 Control	9.79	8.88	47.66	51.51
C.D. (5%)	1.342	0.957	10.523	6.074
SEm±	0.634	0.322	38.993	12.992

FIG. 6 - EFFECT OF 2,4-D, NAA AND 'NAVRAS BANANA SPECIAL' ON WEIGHT OF FINGER.



3.10. Percentage dry weight of fingers

Table 10 presents the data on percentage dry weight of fingers as influenced by different treatments tried. Lower concentration of 2,4-D (5 ppm) only recorded significantly higher percentage of dry weight (59.56 per cent) compared to control. All the other treatments were on par with control. However, 2,4-D treatment at 5 ppm was statistically on par with 2,4-D at 10, 15 and 20 ppm and 'Navras' at 0.50 per cent and 1.00 per cent concentrations.

4. Fruit characters

Data on the physical characteristics of fruits as influenced by the treatments are furnished in Tables 11 and 12.

4.1. Days to full ripeness

Analysis of the data on the number of days taken by the fruits for ripening revealed that there was significant difference between treatments. All levels of 2,4-D, 40 and 50 ppm NAA and 1.00 per cent 'Navras' applied on the crop, hastened the ripening of fruits compared to control. Further, among these treatments, 2,4-D at all concentrations and 'Navras' at 1.00 per cent were significantly superior to NAA treatments. There was no significant difference in the effect of different concentrations of 2,4-D tried.

Table 11. Effect of different treatments on mean number of days to full ripeness.

	Treatments	Days to full ripeness
T1	2,4-D 5 ppm	2.56
T2	2,4-D 10 ppm	2.67
T3	2,4-D 15 ppm	2.67
T4	2,4-D 20 ppm	2.89
T5	NAA 20 ppm	4.33
T6	NAA 30 ppm	4.67
T7	NAA 40 ppm	4.00
T8	NAA 50 ppm	4.00
T9	'Navras' 0.25%	4.67
T10	'Navras' 0.50%	4.11
T11	'Navras' 0.75%	4.11
T12	'Navras' 1.00%	3.11
T13	Control	4.55
C.D. (5%)		0.517
SEm^{+}		0.094

4.2. Fruit weight

The data presented in Table 12 showed that the treatments had significant effects on the weight of ripe fruits. The maximum fruit weight was recorded due to the application of 'Navras' at 0.5 per cent (64.66 g) followed by 2,4-D at 20 ppm (63.19 g) and 'Navras' at 0.75 per cent (59.32 g) and the least in control (43.67 g). NAA at 20 ppm and 50 ppm also proved superior with respect to weight of ripe fruits over control.

4.3. Weight of pulp

Maximum increase in pulp weight was observed when 2,4-D was applied at 20 ppm followed by 'Navras' at 0.5 per cent and 0.75 per cent, NAA at 20 ppm and 50 ppm and 2,4-D at 15 ppm. The minimum value (33.22 g) was recorded by control.

4.4. Peel weight

Treatments with 'Navras' at 0.5 per cent and 0.75 per cent and NAA at all concentrations except 40 ppm significantly increased the peel weight over control. All other treatments were on par with control. The lowest peel weight was observed with 'Navras' at 1.00 per cent (9.46 g) followed by 2,4-D at 5 ppm (10.06 g) and the maximum with 'Navras' at 0.5 per cent (14.15 g).

Table 12. Effect of different treatments on fruit characters.

Treatments	Mean fruit weight (g)	Mean pulp weight (g)	Mean peel weight (g)	Pulp/peel ratio
T1 2,4-D 5 ppm	44.89	34.83	10.06	3.45
T2 2,4-D 10 ppm	53.11	42.92	10.19	4.22
T3 2,4-D 15 ppm	54.53	44.05	10.48	4.20
T4 2,4-D 20 ppm	63.19	50.82	12.37	4.14
T5 NAA 20 ppm	57.80	45.28	12.52	3.64
T6 NAA 30 ppm	53.69	41.16	12.53	3.32
T7 NAA 40 ppm	46.60	34.54	12.06	2.87
T8 NAA 50 ppm	57.01	44.34	12.68	3.51
T9 'Navras' 0.25%	52.51	40.38	12.14	3.29
T10 'Navras' 0.50%	64.66	50.51	14.15	3.58
T11 'Navras' 0.75%	59.32	46.31	13.01	3.57
T12 'Navras' 1.00%	43.97	34.51	9.46	3.73
T13 Control	43.67	33.22	10.45	3.18
C.D. (5%)	11.41	10.52	2.01	N.S.
SE_m^+	45.85	38.98	1.43	0.326

4.5. Pulp/peel ratio

The treatments did not significantly influence the pulp/peel ratio. The mean values ranged from 2.87 for NAA at 40 ppm to 4.22 for 2,4-D at 10 ppm.

5. Fruit quality

The data in respect of fruit quality, as influenced by different treatments are presented in Table 13 and 14.

5.1. Total soluble solids

TSS of fruits were significantly influenced by various treatments. Treatments with 2,4-D at 20 ppm and 'Navras' at 1.00 per cent and 0.5 per cent which were on par, recorded significantly higher TSS over control. However, betweeen 'Navras' treatments ranging from 0.25 per cent to 1.00 per cent there was no significant difference in their effects.

5.2. Acidity

The acidity was not significantly influenced by any of the treatments. A tendency towards lower acidity with the application of growth regulators and 'Navras' was noteworthy. The acidity of fruits ranged from 0.44 per cent in 2,4-D at 20 ppm to 0.53 per cent in control.

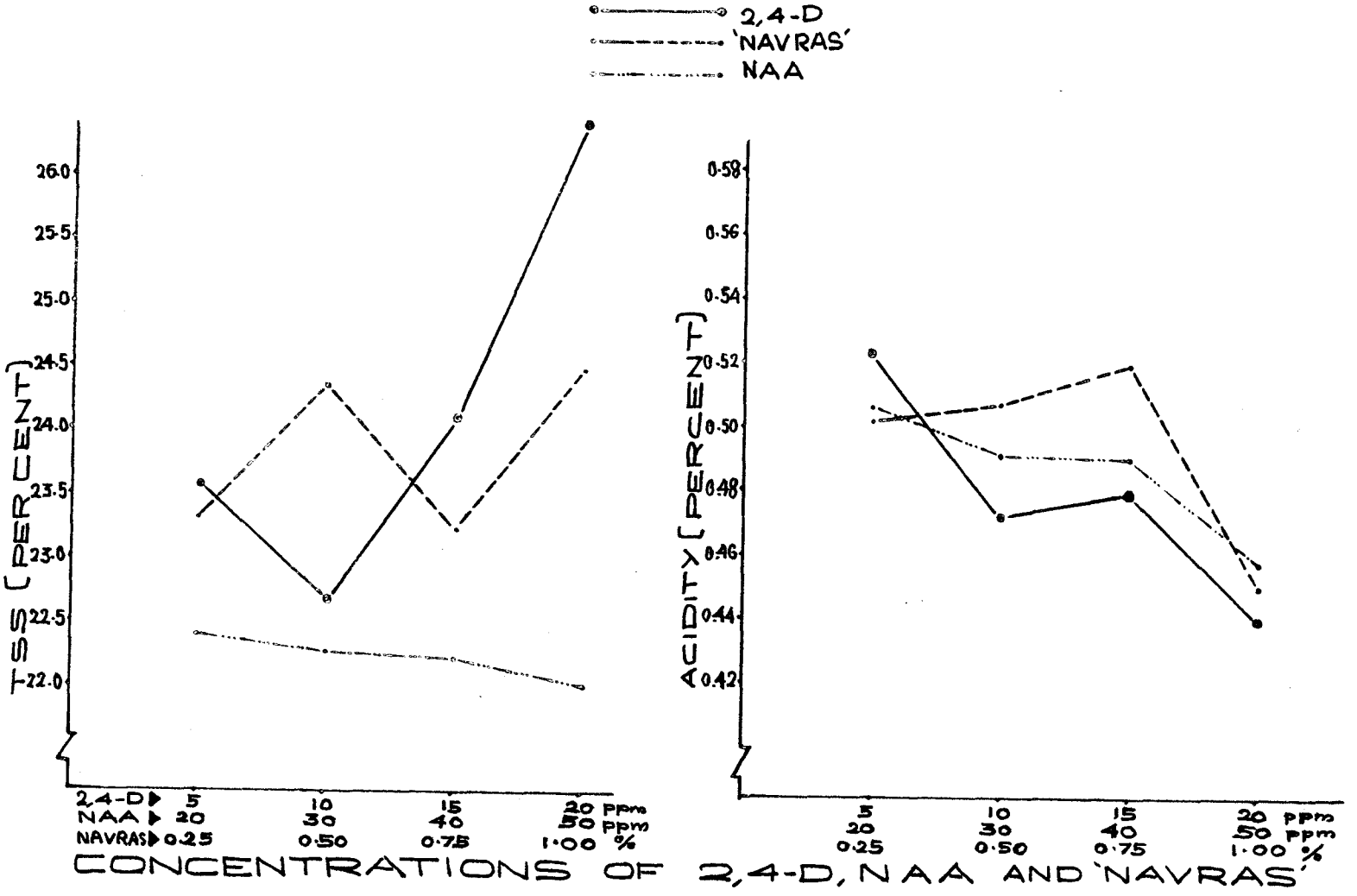
5.3. TSS/acid ratio

Data on TSS/acid ratio as influenced by various treatments is presented in Table 13. 2,4-D at 20 ppm, 'Navras' at

Table 13. Effect of different treatments on TSS and acidity of fruits.

Treatments	Total soluble solids (%)	Acidity (%)	TSS/acid ratio
T1 2,4-D 5 ppm	23.59	0.52	45.14
T2 2,4-D 10 ppm	22.69	0.47	48.33
T3 2,4-D 15 ppm	24.13	0.48	50.41
T4 2,4-D 20 ppm	26.45	0.44	60.34
T5 NAA 20 ppm	22.40	0.51	44.46
T6 NAA 30 ppm	22.28	0.49	45.65
T7 NAA 40 ppm	22.22	0.49	45.38
T8 NAA 50 ppm	22.02	0.46	48.35
T9 'Navras' 0.25%	23.33	0.50	47.15
T10 'Navras' 0.50%	24.35	0.51	48.27
T11 'Navras' 0.75%	23.24	0.52	44.88
T12 'Navras' 1.00%	24.49	0.45	54.73
T13 Control	22.08	0.53	41.91
C.D. (5%)	2.14	N.S.	8.17
SEm±	1.61	0.0015	23.49

FIG. 7 - EFFECT OF 2,4-D, NAA AND 'NAVRAS BANANA SPECIAL' ON QUALITY OF FRUITS (TSS & ACIDITY).



1.00 per cent and 2,4-D at 15 ppm recorded significantly higher TSS/acid ratio compared to control. Maximum TSS/acid ratio was recorded with 2,4-D at 20 ppm (6034) while it was the least in control (41.91).

5.4. Total sugars

There was significant difference between treatments with respect to the percentage of total sugars in the fruits. Application of 2,4-D at 20 ppm gave the highest percentage of total sugars (17.07) and it was significantly superior to all other treatments except 2,4-D at 10 ppm and NAA at 50 ppm. However, the effects due to 2,4-D at 10 ppm and NAA at 50 ppm were not significantly different from that of the remaining treatments except 'Navras' at 0.5 per cent which recorded the least value (15.17 per cent).

5.5. Reducing sugars

None of the treatments showed significant influence on the reducing sugar content of fruits (Table 14). The mean values ranged from 14.37 per cent in control to 15.87 per cent with 2,4-D at 20 ppm.

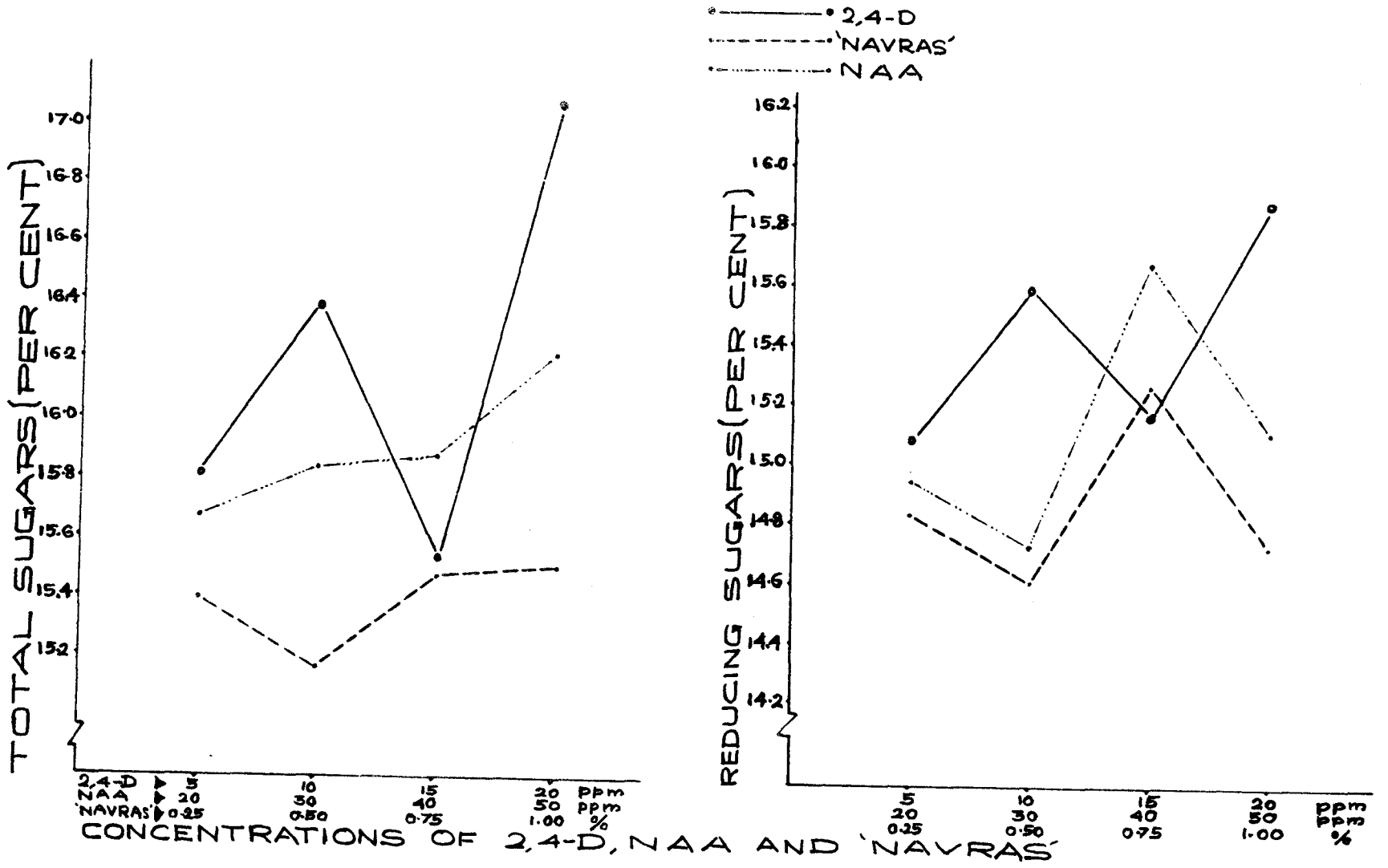
5.6. Non reducing sugars

There was no significant difference between treatments with respect to the content of non reducing sugars in fruits.

Table 14. Effect of different treatments on sugar content of fruits.

Treatments	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)	Sugar/ acid ratio
T1 2,4-D 5 ppm	15.82	15.07	0.77	30.27
T2 2,4-D 10 ppm	16.39	15.58	0.81	34.99
T3 2,4-D 15 ppm	15.55	15.15	0.40	31.17
T4 2,4-D 20 ppm	17.07	15.87	1.20	38.98
T5 NAA 20 ppm	15.68	14.93	0.75	32.21
T6 NAA 30 ppm	15.85	14.71	1.14	32.47
T7 NAA 40 ppm	15.88	15.66	2.20	32.43
T8 NAA 50 ppm	16.22	15.10	1.12	35.60
T9 'Navras' 0.25%	15.41	14.82	0.59	30.87
T10 'Navras' 0.50%	15.17	14.59	0.58	30.18
T11 'Navras' 0.75%	15.48	15.25	0.23	30.19
T12 'Navras' 1.00%	15.52	14.71	0.80	34.60
T13 Control	15.50	14.37	1.13	29.26
C.D. (5%)	0.978	N.S.	N.S.	4.69
SEm^{+}	0.337	0.861	0.328	7.75

FIG. 8 - EFFECT OF 2,4-D, NAA AND 'NAVRAS BANANA SPECIAL' ON QUALITY OF FRUITS (SUGARS).



5.7. Sugar/acid ratio

Data on sugar/acid ratio presented in Table 14 showed that the differences in the effects due to various treatments were significant. The treatments, 2,4-D at 20 ppm, NAA at 50 ppm, 2,4-D at 10 ppm and 'Navras' at 1.00 per cent which were on par showed higher sugar/acid ratio than in control. The highest sugar/acid ratio was recorded with 2,4-D at 20 ppm (38.98 per cent) and the least in control (29.26 per cent).

6. Nutrient content in leaves

Data on the percentage of nitrogen, phosphorus and potash in leaves at late vegetative phase as influenced by the various treatments are presented in Table 15.

6.1. Nitrogen

The application of 2,4-D, NAA and 'Navras' at early vegetative phase caused significant variation in nitrogen content of leaves at maximum vegetative phase. All concentrations of 'Navras', all levels of 2,4-D and NAA at 30, 40 and 50 ppm recorded significantly higher nitrogen content over control. Maximum nitrogen content in leaves was recorded with 'Navras' application at 1.00 per cent (2.57 per cent) and the minimum in control (1.81 per cent).

Table 15. Mean nutrient content in leaves at late vegetative phase for different treatments.

Treatments	N (%)	P_2O_5 (%)	K_2O (%)
T1 2,4-D 5 ppm	2.05	0.26	3.66
T2 2,4-D 10 ppm	2.09	0.28	3.81
T3 2,4-D 15 ppm	2.24	0.29	4.07
T4 2,4-D 20 ppm	2.29	0.32	4.20
T5 NAA 20 ppm	1.96	0.24	3.15
T6 NAA 30 ppm	2.02	0.25	3.27
T7 NAA 40 ppm	2.22	0.29	3.65
T8 NAA 50 ppm	2.23	0.26	3.67
T9 'Navras' 0.25%	2.23	0.32	3.99
T10 'Navras' 0.50%	2.32	0.34	4.25
T11 'Navras' 0.75%	2.41	0.37	4.17
T12 'Navras' 1.00%	2.57	0.35	4.26
T13 Control	1.81	0.19	3.08
C.D. (5%)	0.160	0.0239	0.124
SEm$^{\pm}$	0.009	0.0002	0.006

FIG. 9 - EFFECT OF 2,4-D, NAA AND 'NAVRAS BANANA SPECIAL' ON NUTRIENT CONTENT IN LEAVES (NITROGEN & PHOSPHORUS).

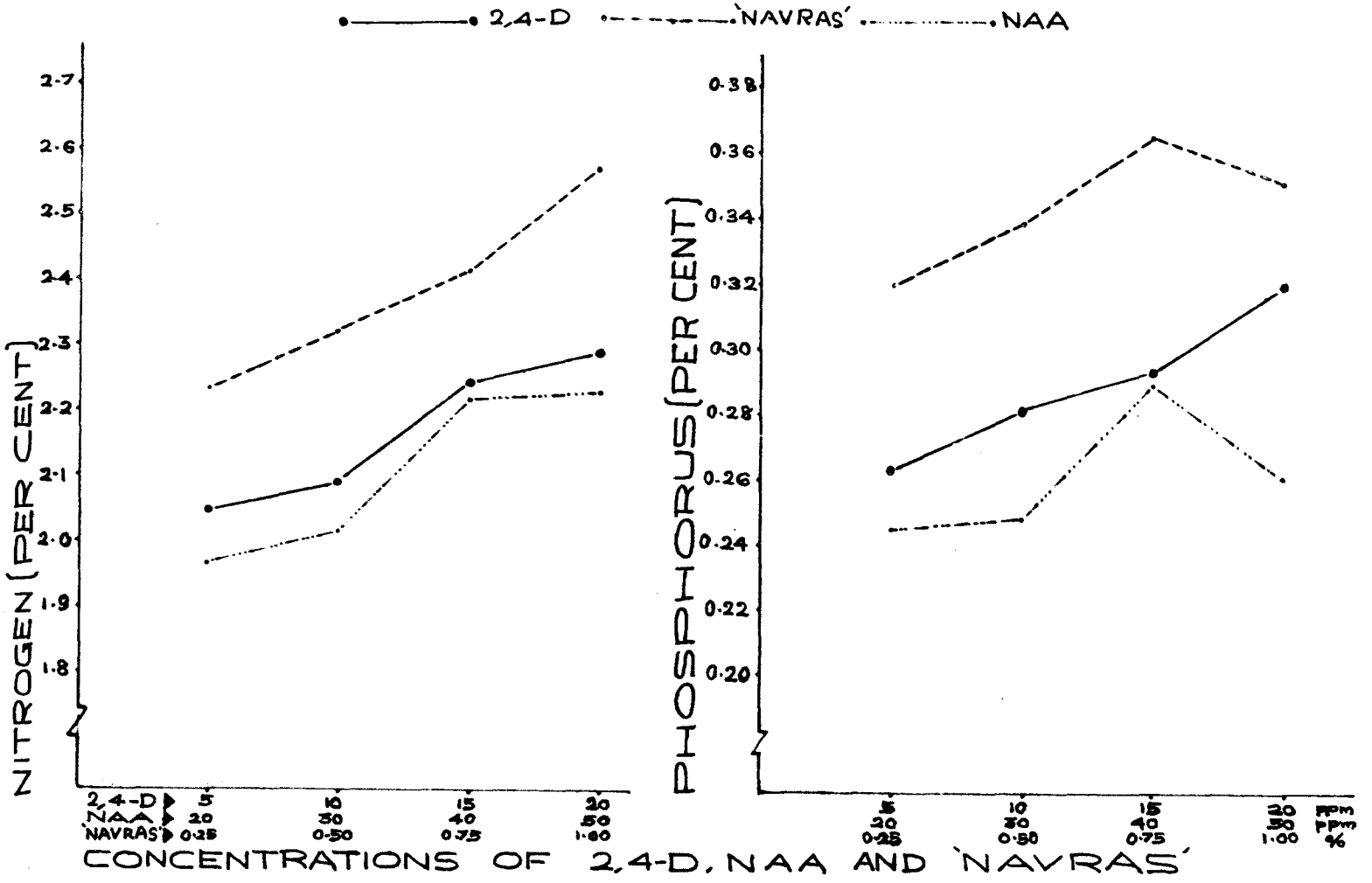
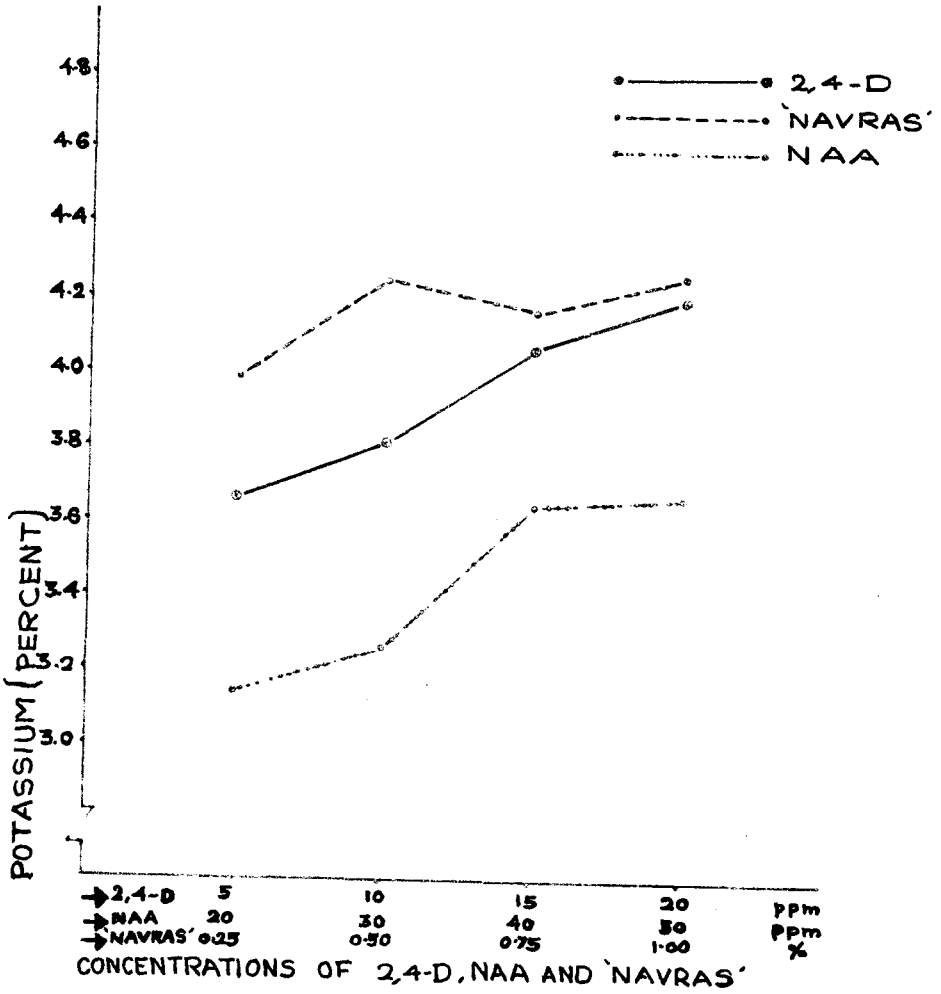


FIG. 10 - EFFECT OF 2,4-D, NAA AND 'NAVRAS BANANA SPECIAL' ON NUTRIENT CONTENT IN LEAVES (POTASSIUM).



6.2. Phosphorus

Phosphorus content of the leaves was also influenced by the treatments, all the treatments being significantly superior to control. 'Navras Banana Special' at all levels and 2,4-D at 20 ppm were significantly superior to other treatments. Maximum percentage of phosphorus was seen with 'Navras' at 0.75 per cent (0.37 per cent) which was closely followed by 'Navras' at 1.00 per cent (0.35 per cent) and the minimum in control (0.19 per cent).

6.3. Potassium

All treatments except NAA at 20 ppm resulted in significantly higher pottasium content in leaves compared to control. However, NAA at 20 ppm was on par with NAA at 30 ppm. Maximum potash content was observed with 'Navras' at 1.00 per cent (4.26 per cent) and the minimum in control (3.08 per cent).

7. Optimum level of 'Navras Banana Special'

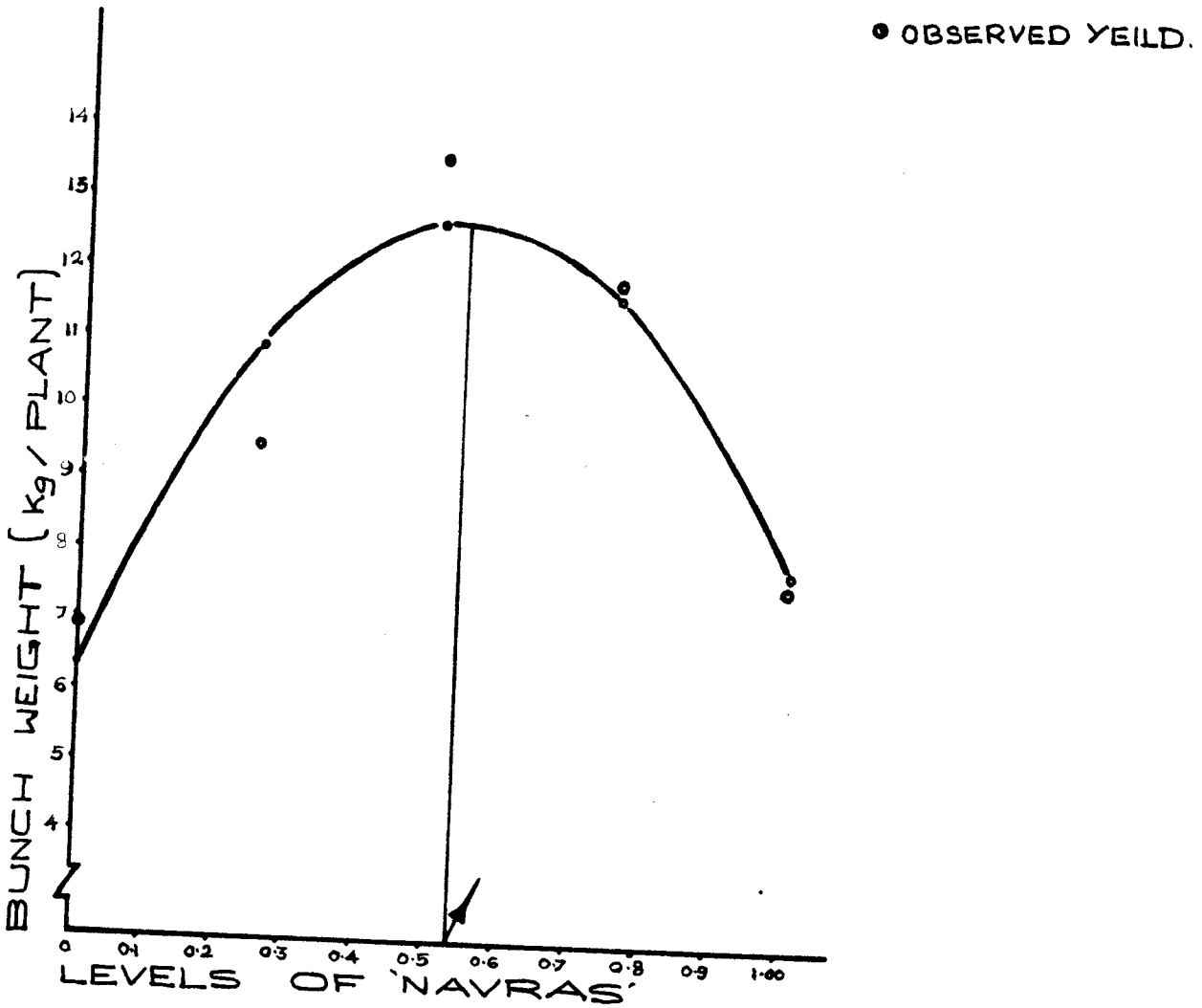
The yield response to the different concentrations of 'Navras Banana Special' was estimated by the quadratic model $Y = 12.63978 + 0.37723 \left(\frac{X-0.5}{0.25}\right) - 1.386 \left(\frac{X-0.5}{0.25}\right)^2$, the R^2 value being 0.90 (Table 16).

Table 16. Observed and expected bunch weight per plant for different concentrations of Navras Banana Special.

Treatments	Observed yield (kg)	Expected yield (kg)
1. Control 0 per cent	6.89	6.34
2. 'Navras' 0.25 per cent	9.48	10.88
3. *'Navras' 0.50 per cent	13.53	12.64
4. 'Navras' 0.75 per cent	11.83	11.63
5. 'Navras' 1.00 per cent	7.60	7.85

*Concentration of Navras Banana Special which gave the maximum bunch weight per plant.

FIG. 11 - YIELD RESPONSE TO LEVELS OF 'NAVRAS BANANA SPECIAL'



The optimum dose of 'Navras' was observed as 0.534 per cent from which the maximum yield per plant 12.70 kg could be expected.

8. Correlation studies

Correlation of yield with various characters that showed significant difference among the treatments were worked out and are presented in Table 17.

All important plant morphological characters such as girth of psuedostem, number of functional leaves per plant, total leaf area per plant and mean length of leaf showed highly significant positive correlations with bunch weight. Among the bunch characters length of bunch, number of hands per bunch, number of fingers per bunch, number of fingers per hand, weight of hand and weight of finger also showed highly positive significant correlation with bunch weight. Positive correlations significant at five per cent level were observed in case of total soluble sbbids content of fruits and potassium content in leaves at late vegetative phase. Characters like total sugars, sugar/acid ratio, nitrogen and phosphorus content in leaves did not show significant correlation with bunch weight.

Table 17. Correlation coefficients of various c with yield.

Yield (y)	Character (x)	Correlation coefficient (r)
	1. Vegetative parameters	
Bunch weight (kg) per plant	1 Psuedostem girth	0.8068**
"	2 Number of functional leaves	0.8420**
"	3 Total leaf area	0.9048**
"	4 Length of leaf	0.7477**
	2. Duration of crop	
"	1 Days for shooting	-0.3452NS
"	2 Days from planting to harvest	-0.3632NS
	3. Bunch characters	
"	1 LLength of bunch	0.9194**
"	2 Number of hands per bunch	0.9460**
"	3 Number of fingers per bunch	0.7462**
"	4 Weight of hand	0.9785**
"	5 Number of fingers per hand	0.8433**
"	6 Length of finger	0.9220**
"	7 Girth of finger	0.9416**
"	8 Weight of finger	0.8670**
	4. Fruit wuality	
"	1 TSS	0.5769*
"	2 Total sugars	0.1458NS
"	3 Sugar acid ratio	0.2100NS
	5. Nutrient content in leaves	
"	1 Nitrogen	0.1611NS
"	2 Phosphorus	0.1375NS
"	3 Potassium	0.6109*

NS Not significant
* Significant at 5 per cent level
** Significant at 1 per cent level

Table 18. Economics of cultivation of 'Palayankodan' banana, using 2,4-D (20 ppm) and 'Navras Banana Special' (0.5 per cent).

Items		Control	2,4-D (20 ppm)	'Navras' (0.5 per cent)
I a.	Cost of cultivation (excluding cost of chemical and application charges) (Rs)	17,200.00	17,200.00	17,200.00
b.	Cost of chemical + application charges (Rs)	Nil	1,125.00	2,150.00
c.	Total cost of cultivation (Rs)	17,200.00	18.325.00	19.350.00
II	Bunch yield in kg	14813.5	27821	29089.5
III	Total income (Rs) @ Rs.1.40/kg	20,738.90	38.949.40	40,725.30
IV	Net profit (Rs)	3,538.90	20,624.40	21,375.30
V	Benefit/Cost ratio	1.21	2.13	2.11

9. Economics of cultivation

Economics of cultivation and the net profit per hectare were worked out for the two treatments (2,4-D 20 ppm and 'Navras' 0.5 per cent) that gave the maximum bunch weight and were compared with control (Table 18). The yield observed in the experiment due to application of 0.5 per cent 'Navras Banana Special' accounted 29089.5 kg per hectare. The yield due to 2,4-D at 20 ppm was 27821 kg and that in control was 14813.5 kg per hectare. The net profit obtained from the control, 2,4-D (20 ppm) and 'Navras' (0.5 per cent) treated crops were Rs.3538.90, Rs.20624.40 and Rs.21375.30 per hectare respectively.

Discussion

DISCUSSION

Although the state of Kerala ranks first in the country with respect to the area under banana, production is comparatively low. The average bunch weight works out to about 6 kg (Aravindakshan, 1978) which is far below standard. This pointed out the necessity for detailed studies for increasing the bunch weight in banana in our state.

Although factors like the large number of varieties grown, cultivation ranging from rainfed to irrigated conditions, backyard semeperennial system of growing, inadequate cultural and manurial practices adopted and the incidence of pests and diseases could be generally attributed to the poor yield, remedial measures in more specific terms are yet to be worked out.

Earlier investigations on bananas conducted elsewhere (Annadurai, 1976; Annadurai and Shanmughavelu, 1977) and in the Department of Pomology, College of Horticulture (Valsamma Mathew, 1980; Sheela 1982) have pointed out that the functional leaves present on the plant at the various stages of growth and development have a definite role on the bunch weight. The classic studies conducted by Summerville (1944) on the developmental physiology of banana in relation to inflorescence and bunch development is of particular interest.

The present investigations reported in the thesis were aimed at to explore the possibility of increasing the efficiency of functional leaves at the different stages of plant growth through the use of certain growth regulators and commercially available preparation viz., 'Navras Banana Special', with the ultimate purpose of increasing the yield. The application of these growth regulators and the formulation on the developing bunch was also tried for supplementary effects.

The effect of the various treatments on vegetative growth, bunch production, crop duration and fruit quality are discussed hereunder.

1. Vegetative growth

The vegetative parameters studied in the experiment consisted of height and girth of psuedostem, number of functional leaves, total leaf area per plant, length and breadth of leaves, length of petiole and production of suckers.

None of the treatments had significant effect on the height of psuedostem except for the fact that there was a general tendency for increased psuedostem height with the application of NAA. More noticeable effect of the applied growth regulators and 'Navras' was on the girth of the psuedostem. The maximum girth of psuedostem was observed with 2,4-D at 20 ppm and 'Navras' at 0.50 per cent. Increased cell size due to application of growth regulators and

nutrients have been reported by several workers (Puttaswamy et al.,1975; Thimmegowda et al.,1976; Kamruddin et al.,1978; Krishnamoorthy, 1981; Dubey, 1983).

The correlation between girth of the psuedostem and yield has been established by previous studies in the Department of Pomology, College of Horticulture also (Valsamma Mathew, 1980, Sheela, 1981). The consequential increase in the girth of psuedostem due to the application of 2,4-D, NAA and 'Navras Banana Special' thus appears to be one of the contributing factors for the increased yield noticed in the present study.

Significant increase in the number of functional leaves was noticed at shooting when the plants were treated with 2,4-D at 20 ppm and 'Navras Banana Special' at all concentrations except 1.00 per cent. Plants treated with 'Navras' at 0.25 per cent produced 11.44 leaves and those treated with 2,4-D at 20 ppm produced 12.89 leaves at shooting while in control, the number of leaves at this stage was only 9.89.

While a similar trend was observed with respect to leaf length, the breadth of leaf was not significantly affected by any of the treatments. Increased length of lamina was noticed in many crop plants when growth regulators alone or in combination with nutrients were applied (El-saod et al.,1976; Das and Swain, 1977; Kamruddin et al., 1978; Nagarajan, 1982).

The increase in the dimensions of lamina consequent to exogenous application of auxins has been reported by Krishnamurthy (1981) also explained that cell elongation caused by auxin application was more along the longitudinal direction than towards lateral direction.

The increase in the total leaf area noticed in the present study due to the application of 2,4-D and 'Navras' (Table 4, Fig.2) was the overall effect of the increase in leaf number as well as the increased length of lamina. Maximum increase in leaf area was observed in the treatment with 2,4-D at 20 ppm (13.73 m^2) at shooting which was on par with 'Navras Banana Special' at 0.5 per cent concentration. Interestingly, the highest yields were also recorded in the above treatments, thus indicating the positive correlation between total leaf area and yield. Similar results due to application of 2,4-D either alone or in combination with nutrients have been reported by Rathore and Wort (1971) in beans and by Nagarajan (1982) in banana.

The lack of response to NAA treatments with respect to vegetative characters, observed in the present study, might be due to the lower concentrations tried. Hence further investigations may be necessary with higher concentrations of NAA to decide the suitability of NAA for better growth in bananas.

Sucker production was not significantly influenced by any of the treatments (Table 6) thus indicating that the effect of the auxins and formulations tried was confined to the mother plants, with little translocatory effects on 'daughters'.

2. Influence on crop duration

The duration of the crop, both in terms of the number of days taken from planting to shooting and planting to harvest, was greatly influenced by the application of 2,4-D and NAA at higher concentrations while 'Navras' had no such effects. Early flowering in bananas reported by Nagarajan (1982) due to 'Navras' application was not observed in the present studies.

While 2,4-D caused considerable earliness in flowering (by about 12 days) at the highest concentration (20 ppm), NAA treatments in fact, showed a tendency to delay shooting (Table 7; Fig.3). With the application of 50 ppm NAA flowering was delayed by 12 days. Presumably, application of 2,4-D might have induced earlier completion of vegetative phase by enhanced growth rate, whereas NAA would have extended the vegetative growth.

The total duration of the crop was also greately influenced by the application of 2,4-D and NAA at higher levels. While 'Navras' had no such effect at any of the

concentrations tried, 2,4-D at 20 ppm resulted in hastening of the crop duration by about 22 days in contrast to NAA at 50 ppm which extended the duration by 15 days (Table 7; Fig.4).

Depending upon the crop, earliness or delay in crop duration have been previously reported by the application of growth regulators. Earliness in flowering and total duration of tomato crop has been reported by Kamruddin et al.(1978) and of Kagzi lime by Singh (1979) and Haribabu and Rajput (1982). The delay in the crop duration noticed in the present study due to NAA application has been observed by earlier workers in other crops (James et al., 1965; Rylski, 1972).

The effect of treatments on fruit maturity was not significant. However, 2,4-D and 'Navras' treatments slightly advanced the maturity of bunches whereas NAA delayed it.

The earliness or delay in the crop duration caused by the application of 2,4-D or NAA noticed in the present study was mainly due to their effect during vegetative phase with little or no effect on the reproductive phase. The effect of auxins is thus evident, the more critical phase in banana for hastening or delaying crop duration being the vegetative phase. Summerville (1944) noticed that the effect of nutrients and soil moisture during the vegetative phase decided the ultimate bunch production in banana. The present study also emphasised that between vegetative and reproductive phases, the most vulnerable phase for manipulation of the crop like banana is during its vegetative phase.

3. Influence on bunch characteristics and yield

The various yield parameters studied under the present investigation included bunch weight, length of bunch, number of hands per bunch, number of fingers per bunch, number of fingers per hand, weight of hand and finger characters. All characters except the pulp/peel ratio were found to be markedly influenced by the various treatments.

The parameters that generally contribute to bunch weight in banana are number of hands and fingers per bunch, number of fingers per hand, length of finger, girth of finger and weight of finger (Geetha and Rajeevan, 1983). Correlations worked out making use of data in the present study also confirmed the above findings. Increase in bunch weight noticed by the application of growth regulators and 'Navras Banana Special' in the present study was found to be through the parameters as indicated above.

Amongst the different treatments, application of 'Navras' at 0.5 per cent and 2,4-D at 20 ppm were the most effective to produce bunches with maximum weight (13.53 kg and 12.94 kg respectively) which was on par with 'Navras' at 0.75 per cent. Thus about 100 per cent increase in bunch weight was observed with the above treatments. At concentrations above 0.5 per cent 'Navras Banana Special' had a deleterious effect, bringing down the bunch weight to 7.6 kg

at 1.00 per cent which was comparable to control (Table 8, Fig.5).

Concentrations of 'Navras' above optimum level thus appears to be toxic. Since the formulation contains 2,4-D, such adverse effects would be expected at higher concentrations. Deleterious effects of 2,4-D on various crops at higher concentrations have been reported by several previous workers (Van Overbeek, 1952; Blackman et al., 1959; Krishnamoorthy, 1981).

While the effectiveness of increasing the bunch weight by the application of the 2,4-D treatments was more through the increase in number of hands and finger per bunch, the effectiveness of 'Navras Banana Special' was more through the increase in size and weight of individual fingers (Table 8 and 10; Fig.6; Plate 4). Anbazhagan (1978) and Aravindakshan (1981) also reported increased bunch weight in banana due to 2,4-D treatments, especially at higher concentrations upto 25 ppm. The results reported in the present study on the effect of 'Navras' are in conformity with those reported by Nagarajan (1982).

NAA at 50 ppm also had a marked effect on bunch weight and was the next best to 2,4-D at 20 ppm and 'Navras' at 0.5 and 0.75 per cent (Table 8; Fig.5). The results agree with the findings of Aravindakshan (1981) who reported significant

increase in bunch weight due to NAA treatments at higher concentrations from 50 to 100 ppm. He also reported that NAA at concentrations below 50 ppm were not effective.

The possibility of applied auxins increasing the number of hands and fingers through a mechanism by which male structures are transformed into female clusters cannot be ruled out. The increased number of hands and fingers per bunch observed on the study due to the treatments could perhaps be better explained on the hypothesis put forth by Summerville (1944). He explained that an upper limit to fruit number is set at the early stage of inflorescence development, but the actual number achieved may be dependent on the conditions during fruit differentiation. Application of 2,4-D, NAA or 'Navras' might have thus provided a beneficial environment for the developing bunches.

'Navras' treatments upto the concentration of 0.75 per cent and particularly at 0.5 per cent resulted in increased length, girth and weight of fingers, pulp weight and peel weight (vide Table 10 and 12), the results being in agreement with those of Nagarajan (1982). Increased weight, length and girth of individual fingers, pulp weight and pulp/peel ratio due to the application of 2,4-D was also reported by Anbashagan (1978) and Aravindakshan (1981). The results on the effect of NAA on the above parameters are also

in conformity with that of Aravindakshan (1981) who reported increased length, girth and weight of 'Nendran' banana fruits as a result of application of NAA at or above 50 ppm.

The effect of auxins on the formation of edible pulp in seeded and parthenocarpic bananas have been explained by Simmonds (1960). From the time of set and especially during growth, the fruit becomes an active metabolic sink (Crane, 1952; Leopold, 1958; Biale, 1978) into which the nutrients and photosynthates flow, curtailing the vegetative growth. This translocation is under hormonal control, auxins being greately involved, the extend of mobilisation being dependent on the site of action and concentration of auxins applied (Crane, 1974; Rahman and Siddique, 1983). The increased finger and fruit weight due to 'Navras Banana Special', 2,4-D and NAA at higher concentrations observed in the present study (vide Table 10; Fig.6) could thus be explained on the above hypothesis.

The comparatively better performance of 'Navras' at 0.5 per cent over the growth regulators alone might be attributed to better availability and/or supply of nutrients through the foliage. Increased photosynthetic efficiency consequent to the application of 'Navras' or 2,4-D cannot also be ruled out.

4. Effect on ripening and quality of fruits

The time taken for ripening of fruits was significantly hastened by the 2,4-D treatments at all concentrations (Table 11). Effect of other treatments was not significant. The residual effect of 2,4-D is thus evident. Early ripening due to the application of growth regulators, especially 2,4-D and NAA was reported by Blake and Stevenson (1956), Evans (1959); Dedolph and Goto (1960); Lakshminarayana et al. (1967); Aziz and Wahab (1970); Vendrell (1970); Saha (1971) and Sadasivam and Muthuswamy (1972) in several fruits.

The fruit qualities studied consisted of TSS, acidity total sugars, reducing sugars, nonreducing sugars and sugar/acid ratio.

The effects of 2,4-D at 20 ppm and 'Navras' at 0.5 per cent and 1.00 per cent on TSS were significant, recording an increase of TSS (Table 13; Fig.7). Increased TSS in fruits due to growth regulator application have been reported by Shanmughavelu et al.(1969); Tomi et al.(1970); Srivastava et al. (1971); Veera and Das (1971); Kumar et al (1975); Das and Mahapatra (1976); Singh and Singh (1976) and Sinha et al.(1977).

All the treatments although increased the TSS/acid ratio, the effect was significant only with 2,4-D at 15 and 20 ppm and 'Navras' at 1.00 per cent. Increased TSS/acid

ratio due to 2,4-D application have been reported by several workers (Randhawa and Dhuria, 1965; Bajwa and Mishra, 1969; Shanmughavelu et al., 1969; Mayura et al., 1973; Das and Mahapatra, 1976; Sinha et al., 1977; Snbazhagan, 1978).

Increase in total sugar content due to 2,4-D at 20 ppm was significant whereas the reducing sugars and nonreducing sugars in fruits were not significantly affected by any of the treatments (Table 14, Fig.8). The growth regulators were found to be more effective in increasing the total and reducing sugar content of fruits compared to 'Navras' treatments. This might be because of the comparatively slower rate of biochemical conversion of solids, mainly starch, into sugars in the 'Navras' treatments; the concentration of auxin (2,4-D) in it being proportionally lesser.

The acidity of fruits was a factor not influenced by any of the treatments (Fig.7). The results thus indicated that the growth regulators at higher concentrations appreciably improved the quality of fruits by way of increased TSS, total sugars and TSS/acid ratio. Reducing and nonreducing fraction of sugars and acidity were not markedly influenced by the treatments. The studies have shown the suitability of 2,4-D application at 20 ppm over 'Navras' (0.5 per cent) in the production of fruits of better quality.

5. Nutrient content in leaves

The increased leaf nitrogen, phosphorus and potassium content noticed by the application of the growth regulators and 'Navras Banana Special' (vide Table 15; Fig.9 and 10) is of interest. The highest bunch weight was generally observed in those treatments in which the leaf nutrient content was maximum.

Significantly positive correlation was observed between potash content and bunch yield. The increased uptake of nutrients consequent of application of 2,4-D and 'Navras' might have had a beneficial effect on plant growth and on developing bunches. The results are in conformity with several previous trials (Annadurai, 1976; Anbazhagan, 1978).

On an overall analysis of the results, it was found that the application of 2,4-D at 20 ppm and 'Navras' at 0.5 per cent as two sprays at 3 months and 5 months after planting and one bunch sprays at the cessation of female phase of bunch development was beneficial in terms of vegetative growth and yield. The above treatments increased the yields to the tune of 88 per cent and 96 per cent respectively. Based on the benefit/cost ratio, the above treatments were found to be equally profitable for increasing yields in 'Palayankodan' bananas.

Summary

SUMMARY

The results of the investigations conducted in the Department of Pomology, College of Horticulture to study the effect of growth regulators and commercially available formulations on growth and yield of the banana variety, 'Palayankodan' are summarised below.

1. The growth regulators and chemicals tried in the present studies were 2,4-D (5, 10, 15 and 20 ppm), NAA (20, 30, 40 and 50 ppm) and 'Navras Banana Special' (0.25, 0.50, 0.75 and 1.00 per cent). These were applied at three stages viz., foliar sprays at three months after planting, four months after planting and a bunch spray immediately after the completion of female phase.

2. The vegetative characters in terms of psuedostem girth, number of functional leaves, individual leaf length and total leaf area were increased by the application of 2,4-D at 10 to 20 ppm and by 'Navras' application at 0.25 to 0.5 per cent. In general, NAA treatments could not exert marked influence on the vegetative growth of the plants.

3. Plant characters like height of psuedostem, breadth of leaves and sucker production were not influenced by the various treatments.

4. Application of 2,4-D at 20 ppm induced early shooting of plants by about 12 days whereas at lower concentrations it did not affect shooting. On the contrary, NAA at 50 ppm significantly delayed the time of shooting 'Navras' treatments did not alter the time of flowering compared to control.

5. None of the treatments was found to be effective in influencing the maturity of bunches; that is, the duration from flowering to maturity.

6. 2,4-D at concentrations from 10 to 20 ppm significantly hastened the total crop duration by 15 to 22 days. NAA at 50 ppm significantly delayed the crop duration. In general, 'Navras Banana Special' was not effective in influencing the crop duration.

7. 2,4-D at 20 ppm and 'Navras Banana Special' at 0.50 and 0.75 per cent were equally effective in increasing the bunch weight. The number of hands and fingers per bunch, number of fingers per hand, weight of hand and size and weight of individual fingers were increased by the above treatments.

8. All levels of 2,4-D, NAA at 40 and 50 ppm and highest concentrations of 'Navras' (1.00 per cent) induced early ripening of fruits.

9. Fruit quality except TSS and total sugars were not markedly influenced by any of the treatments. The TSS of fruits increased consequent to the application of 2,4-D at 20 ppm and 'Navras' at 0.50 and 1.00 per cent. Application of 2,4-D at 10 and 20 ppm and NAA at 50 ppm was found to be effective in increasing the total sugar content of fruits.

10. The optimum concentration of 'Navras Banana Special' for obtaining maximum bunch weight worked out to 0.534 per cent.

11. The characters such as psuedostem girth, number of functional leaves, leaf length, total leaf area per plant, bunch length, number of hands and fingers per bunch, number of fingers per hand, weight of hand, weight, length and girth of individual fingers and pulp and peel weight showed highly significant positive correlation with bunch weight.

12. The computed yield per hectare with the application of 'Navras Banana Special' at 0.5 per cent was 29089.5 kg and with 2,4-D at 20 ppm it was 27821 kg. The resultant net profit per hectare worked out to Rs.21375.30 and Rs.20624.40 per hectare respectively. The benefit/cost ratio worked out for 2,4-D at 20 ppm and 'Navras' at 0.5 per cent did not differ between the treatments.

From the results, it could be inferred that 2,4-D at 20 ppm and 'Navras' at 0.50 per cent were the best for better overall performance of plants and for getting substantially higher yields in the banana var. 'Palayankodan'.

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* Originals not seen

Appendices

APPENDIX - 1

Analyses of variance for the effect of 2,4-D, NAA and 'Navras Banana Special' on the height of psuedostem at various stages of growth.

Source	Degrees of freedom	Mean sum of squares		
		Early vegetative phase	Late vegetative phase	Shooting
Blocks	2	115.145	935.258**	78.513
Treatments	12	26.738	295.870	176.940
Error	24	60.212	163.677	116.163

** Significant at 1 per cent level.

APPENDIX - 2

Analyses of variance for the effect of 2,4-D, NAA and 'Navras' on girth of psuedostem at various stages of growth.

Source	Degrees of freedom	Mean sum of squares		
		Early vegetative phase	Late vegetative phase	Shooting
Blocks	2	7.328	55.290*	54.162**
Treatments	12	3.263	14.474	16.877*
Error	24	3.803	14.399	6.233

* Significant at 5 per cent level
** Significant at 1 per cent level

APPENDIX - 3

Analyses of variance for the effect of 2,4-D, NAA and 'Navras' on number of functional leaves at various stages of growth.

Source	Degrees of freedom	Mean sum of squares		
		Early vegetative phase	Late vegetative phase	Shooting
Blocks	2	0.379	0.174	1.507
Treatments	12	0.205	0.338	3.065**
Error	24	0.216	0.465	0.800

** Significant at 1 per cent level

APPENDIX - 4

Analyses of variance for the effect of 2,4-D, NAA and 'Navras' on total leaf area at various stages of growth.

Source	Degrees of freedom	Mean sum of squares		
		Early vegetative phase	Late vegetative phase	Shooting
Blocks	2	0.267	1.300	0.729
Treatments	12	0.121	1.860**	6.953**
Error	24	0.179	0.587	0.817

** Significant at 5 per cent level

APPENDIX - 5

Analyses of variance for the effect of 2,4-D, NAA and Navras on leaf length, leaf breadth and length of petiole.

Source	Degrees of freedom	Mean sum of squares		
		Leaf length	Leaf breadth	Petiole length
Blocks	2	65.025**	35.136*	18.730*
Treatments	12	30.300*	8.257	2.868
Error	24	10.562	7.057	5.352

* Significant at 5 per cent level
** Significant at 1 per cent level

APPENDIX - 6

Analyses of variance for the effect of 2,4-D, NAA and Navras on number of days from planting to shooting, shooting to harvest and planting to harvest.

Source	Degrees of freedom	Mean sum of squares		
		Planting to shooting	Shooting to harvest	Planting to harvest
Blocks	2	3.306	39.812	34.420
Treatments	12	130.159**	48.035	341.965**
Error	24	35.966	31.972	63.629

** Significant at 1 per cent level

APPENDIX - 7

Analysis of variance for the effect of 2,4-D, NAA and Navras on production of suckers.

Source	Degrees of freedom	Mean sum of squares
Blocks	2	0.112
Treatments	12	0.527
Error	24	0.506

APPENDIX - 8

Analyses of variance for the effect of 2,4-D, NAA and 'Navras' on bunch and hand characters.

Source	Degrees of freedom	Mean sum of squares					
		Mean weight of bunch	Mean length of bunch	Mean number of hands per bunch	Mean number of fingers per bunch	Mean weight of hand	Mean number of fingers per hand
Blocks	2	0.465	19.871	0.156	101.800	0.0007	0.148
Treatments	12	12.994**	40.155**	2.940**	381.436**	0.0989**	2.379**
Error	24	1.322	10.274	0.328	92.216	0.0161	0.414

** Significant at 1 per cent level

APPENDIX - 9

Analyses of variance for the effect of 2,4-D, NAA and 'Navras' on finger characters

Source	Degrees of freedom	Mean sum of squares			
		Mean length of finger	Mean girth of finger	Mean weight of finger	Percentage dry weight
Blocks	2	1.163	0.612	4.211	15.250
Treatments	12	2.133**	1.425**	143.095**	31.376*
Error	24	0.634	0.322	38.995	12.992

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX - 10

Analysis of variance for the effect of 2,4-D, NAA and Navras on number of days to full ripeness.

Source	Degrees of freedom	Mean sum of squares
Blocks	2	0.3165
Treatments	12	1.9911**
Error	24	0.0940

** Significant at 1% level

APPENDIX - 11

Analyses of variance for the effect of 2,4-D, NAA and 'Navras' on fruit characters

Source	Degrees of freedom	Mean sum of squares			
		Mean fruit weight	Mean pulp weight	Mean peel weight	Pulp/peel ratio
Blocks	2	7.353	2.377	1.404	0.0779
Treatments	12	148.592**	108.219*	5.949**	0.4943
Error	24	45.853	38.984	1.429	0.3259

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX - 12

Analyses of variance for the effect of 2,4-D, NAA and 'Navras' on fruit quality

Source	Degrees of freedom	Mean sum of squares						
		TSS	Acidity	TSS/acid ratio	Total sugars	Reducing sugars	Non-reducing sugars	Sugar/acid ratio
Blocks	2	0.1248	0.0022	18.737	0.1763	0.0708	0.0913	0.2875
Treatments	12	4.9244**	0.0025	71.087	0.7633*	0.5848	0.3414	23.1990*
Error	24	1.6055	0.0015	23.488	0.3371	0.8610	0.3276	7.7504

* Significant at 5 per cent level

** Significant at 1 per cent level

APPENDIX - 13

Analyses of variance for the effect of 2,4-D, NAA and 'Navras' on nutrient content in leaves.

Source	Degrees of freedom	Mean sum of squares		
		Nitrogen	Phosphorus	Potassium
Blocks	2	0.0014	0.0008*	0.0049
Treatments	12	0.1212**	0.0074**	0.5198**
Error	24	0.0090	0.0002	0.0054

* Significant at 5 per cent level

** Significant at 1 per cent level

EFFECT OF GROWTH REGULATORS AND CERTAIN FORMULATIONS ON BUNCH DEVELOPMENT IN BANANA VAR. PALAYANKODAN

By

RAJENDRAN, P.

ABSTRACT OF A THESIS

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ABSTRACT

The yield of banana in Kerala remains very low inspite of the adoption of proper manuring and other management practices. Investigations have indicated that the main barrier to the increased production in banana is the lack of sufficient leaf area at the active phase of growth of the plants.

The present experiment was conducted with the banana cultivar 'Palayankodan' under sparsely irrigated conditions with a view to increase the plant growth and ultimate yield by the use of growth regulators and commercially available formulations.

The growth regulators viz., 2-4-D and NAA and the commercially available formulation namely 'Navras Banana Special' were tried at four different concentrations as given below:-

2,4-D	-	5, 10, 15 and 20 ppm
NAA	-	20, 30, 40 and 50 ppm
'Navras'	-	0.25, 0.50, 0.75 and 1.00 per cent

The various chemicals at different concentrations were applied as two foliar sprays at three and four months after planting. A third spray was also given on the bunches immediately after the female phase of flower opening.

On an overall analysis, 2,4-D at 20 ppm and 'Navras' at 0.50 per cent were found to be more effective in promoting the vegetative growth of plants.

With respect to flowering and duration of the crop, the growth regulators alone had significant effects when compared to the commercial preparation 'Navras'. The effectiveness also depended on the concentrations of the growth regulators. Thus 2,4-D at 20 ppm induced early shooting of plants by about 12 days whereas NAA at 50 ppm caused substantial delay in shooting.

The chemicals at their various concentrations were not effective in influencing the bunch maturity, thus indicating that the applied chemicals caused the earliness or delay observed, through their influencedon the vegetative growth only. Consequent to the application of 2,4-D at 20 ppm the crop duration was advanced by 22 days. Contrary to this, NAA at 50 ppm delayed the duration of the crop.

The treatments with 2,4-D at 5 to 20 ppm, NAA at 40 and 50 ppm and 'Navras' at 1.00 per cent were found to advance the ripening of fruits.

The best quality fruits in terms of TSS and total sugars were obtained by the application of 2,4-D at 20 ppm.

Among the concentrations of 'Navras Banana Special', 0.5 per cent gave the best results with respect to the growth

and yield of plants. When the concentration was increased further, there was a decrease in the performance of the plants. The optimum dose of 'Navras Banana Special' was worked out to 0.534 per cent.

The correlations worked out from the data collected revealed that the vegetative and bunch characters such as girth of psuedostem, number of functional leaves, total leaf area, length of bunch, number of hands and fingers per bunch, number of fingers per hand and weight of hand, length, girth and weight of fingers amply contributed to the overall yield in the form of bunch weight.

The yield increase observed in the present study due to the application of 2,4-D at 20 ppm was by 88 per cent and that for 'Navras' at 0.5 per cent was by 96 per cent. The benefit/cost ratio worked out for these treatments did not differ and hence application of 2,4-D (20 ppm) and 'Navras Banana Special' (0.5 per cent) were equally good for increasing the yield.

The present investigations were conducted under sparsely irrigated conditions where, irrigation was given just for the maintenance of the crop. Further investigations with rainfed and irrigated 'Palayankodan' bananas may be of particular interest.