EFFECT OF GROWTH SUBSTANCES ON THE GROWTH, RHIZOME YIELD AND DIOSGENIN CONTENT IN *Costus speciosus*

BY

SATHEESHAN, K. N.

THESIS

Submitted in partial fulfilment of the
requirement for the degree of

Master of Science in Horticulture

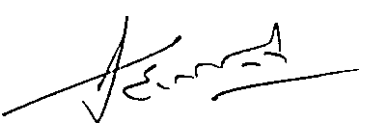
Faculty of Agriculture
Kerala Agricultural University

Department of Plantation Crops & Spices,
COLLEGE OF HORTICULTURE
Vellanikkara - Trichur

1984

DECLARATION

I hereby declare that this thesis entitled "Effect of growth substances on the growth, rhizome yield and diosgenin content in *Costus speciosus*" is a bona fide 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,
30 -4-1984.

SATHEESHAN, K.N.

CERTIFICATE

Certified that this thesis entitled "Effect of growth substances on the growth, rhizome yield and diosgenin content in Costus speciosus" is a record of research work done independently by Shri. Satheeshan, K.N. 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.

30/4/84

Dr. N. MOHANAKUMARAN,
Associate Director,
NARP (Southern Region),
College of Agriculture,
Vellayani, Trivandrum.

Vellayani,
30-4-1984.

CERTIFICATE

We, the undersigned members of the Advisory Committee of Shri. Satheeshan, K.N. a candidate for the degree of Master of Science in Horticulture, agree that the thesis entitled "Effect of growth substances on the growth, rhizome yield and diosgenin content in Costus speciosus" may be submitted by Shri. Satheeshan, K.N. in partial fulfilment of the requirement for the degree.

Dr. N. MOHANAKUMARAN,
Advisor and Chairman

Dr. M. ARAVINDAKSHAN,
Member.

Dr. S. RAMACHANDRAN NAIR,
Member

Dr. K.M.N. NAMBOODIRI,
Member.

ACKNOWLEDGEMENTS

I wish to express my heartfelt gratitude and indebtness to Dr. N. Mohanakumaran, Associate Director, NARP (Southern Region), College of Agriculture, Vellayani and the chairman of my Advisory Committee, for his valuable guidance, constructive criticism and constant encouragement during the course of investigations as well as during the preparation of the thesis.

I am deeply indebted to Dr. M. Aravindakshan, Professor and Head, Department of Pomology and Floriculture and a member of my advisory committee for his sincere help, inspiring suggestions and encouragement throughout the course of this investigation.

I would like to record my sincere appreciation to Dr. S. Ramachandran Nair, Professor and Head, Department of Plantation Crops & Spices and a member of my advisory committee for his valuable help and astute advice throughout the study.

I express my humble thanks to Dr. K.M.N. Namboodiri, Professor and Head, Department of Agricultural Botany and a member of my advisory committee for his immense help and advice during the course of this investigation.

I am very much indebted to Shri. P.V. Prabhakaran, Associate Professor, Department of Agricultural Statistics and Shri. V.K. Gopinathan Unnithan, Associate Professor,

Department of Agricultural Statistics for their sincere help and suggestions during the course of study and analysis of the data.

I acknowledge my gratitude to the Indian Council of Agricultural Research for the Junior fellowship awarded to me during the tenure of this study.

I express my heartful thanks to Shri. K. Rajmohan, Shri. M. Abdul Vahab and Shri. K. Vasanthakumar for their tireless help.

It is with great pleasure that I record my sincere thanks to the staff members of the Department of Plantation Crops and Spices and to all my friends and colleagues for the valuable help and wholehearted co-operation rendered by them.

SATHEESHAN, K.N.

Vellanikkara,
30-4-1984.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

Introduction

INTRODUCTION

India, with her mammoth population of over 700 million, has been trying to check the birth rate by various means. Of the various methods adopted, the use of oral contraceptives in birth control holds a prominent role.

Diosgenin, a sapogenin, is the principal raw material required for the synthesis of a large number of steroidal drugs which include cortico-steroids, sex hormones, anti-fertility compounds, oral contraceptive pills and several other steroid products. About 50 per cent of the steroid drug production in the world relies on diosgenin as the base material. The total world requirements of steroid drugs and diosgenin by 1985 have been estimated to be around 320 tonnes and 2607 tonnes, respectively (Asolkar and Chadha, 1979).

In India, the pharmaceutical industry has been meeting the requirements of diosgenin from the tubers of Dioscorea deltoidea. The demand for steroidal drugs, especially those used as oral contraceptives, has increased very much in recent years. There is thus, a necessity to find out other sources of diosgenin than Dioscorea deltoidea. For this, two major approaches have been resorted to. One is the introduction of exotic species such as Dioscorea floribunda and Dioscorea composita, which have been found to be promising. The other approach is to search for the presence of

this glyco-alkaloid in the locally available plant species.

Steroid hunters were able to locate many plants which are sources of diosgenin. They include Dioscorea spp., Solanum khasianum, Tribulus terrestris, Costus speciosus etc. Among these, Costus speciosus has the advantage that it has a very wide geographical distribution extending from the Sub-Himalayan tracts in the North to the hilly regions of central India and the Western Ghats.

Costus speciosus (Koening) Smith is a perennial herb with tuberous rhizomes. It belongs to the family Zingiberaceae. The presence of diosgenin in the rhizomes of Costus speciosus was first reported by Dasgupta and Pandey (1970). They reported the diosgenin content as 2.12 per cent in the alcoholic extract of the rhizome samples. However, chemical evaluation of a number of samples from different parts of the country revealed the existence of a definite clonal variation in respect of diosgenin content (Gupta et al., 1980). Apart from it's wide adaptability, the production of higher biomass in a shorter period and the comparative ease in the extraction are the added advantages of Costus speciosus. Further, the diosgenin from Costus speciosus has been found to be purer than that obtained from other sources.

Realising the possibilities of costus as a commercial source of diosgenin, a series of research projects were programmed by the Kerala Agricultural University, which aimed

at formulating the package of practices. One study conducted at the College of Horticulture, Vellanikkara during 1979-81 indicated that the application of 45 kg N along with 30 kg each of P_2O_5 and K_2O per hectare resulted in maximum yield of diosgenin (Sudhadevi, 1981). Studies by Joseph (1983) revealed that planting of 100 g rhizome pieces at 50 x 50 cm spacing and harvesting the crop at nine months after planting gave maximum yield of diosgenin.

In recent years, several growth substances have been employed for obtaining beneficial effects on yield, quality and other aspects in horticultural crops. Growth substances have been reported to be useful in increasing production and improving quality in ginger, turmeric, potato, sweet potato, dioscorea and many other crops. Trials with growth substances in costus to increase the rhizome yield and diosgenin content are yet to be taken up in a systematic way. Hence, the present study was undertaken with the following objectives:

i) To study the effect of three growth substances, namely, ethrel (2-chloroethyl phosphonic acid), 2,4-D (2,4-dichlorophenoxy acetic acid) and MH (Maleic hydrazide) on the morphological characters and growth of costus,

ii) To assess the comparative efficacy of ethrel, 2,4-D and MH on rhizome yield and diosgenin content in costus,

iii) To identify the best concentration of these growth substances for obtaining higher yield of rhizome and diosgenin, and

iv) To study the economics of crop production with and without the application of growth substances.

The present study, the third in the series, along with the previous two, will help make firm recommendations and to evolve a package of practices for the commercial cultivation of Costus speciosus.

2. REVIEW OF LITERATURE

Among the plant growth substances, ethrel, 2,4-D and MH have shown promise for regulating the vegetative growth, enhancing the yield and improving the quality in many crops. Studies on the effect of these growth substances are scarce in Costus speciosus. Hence, the available literature has been reviewed to obtain information on the effects of these growth substances on root, tuber, bulb and rhizomatous crops as well as on medicinal plants.

Ethrel

Ethrel and ethephon are the common names for 2-chloro ethyl phosphonic acid which releases ethylene and phosphonic acid after entry into the plant tissue. Ethylene has long been known to influence a number of plant physiological processes. However, it was only in 1962 that Burg recognized its properties as a growth hormone. Since then, this chemical aroused a great deal of interest among the Horticulturists and Plant Physiologists. Ethylene has a very wide range of effects from strongly stimulatory to powerfully inhibitory. A variety of responses like elongation of stem, stimulation of axillary buds, production of laterals, increase or decrease in leaf area and leaf number, induction of defoliation, stimulation of underground rhizome buds, increase in yield and

improvement of quality have been well established (Pratt and Geoschel, 1969). A review of these aspects follow:

Effect of ethrel on plant height and number of tillers

Ethrel has been shown to inhibit shoot and internodal elongation. Catchpole and Hillman (1969) reported that ethrel treatment inhibited stem elongation process in potatoes. Ethrel caused shortening of the stem in the potato cv. King Edward (Edward et al., 1970). Growth was markedly inhibited by ethrel when applied to potatoes as foliar spray at 100, 500 and 1000 ppm (Singh, 1970). Murti and Banerjee (1978) reported that ethephon decreased the plant height and induced epinastic bending of the leaf petioles in the potato varieties, Kufri Sindhuri and Kufri Jyoti, when foliar sprays of 50-800 mg/l were applied at four-day intervals, beginning fifty days after emergence. Postinikov et al. (1978) observed that ethrel slowed down the growth rate in potato plants (grown in pots).

In sweet potato, Tompkins and Bowers (1970) found that ethrel treated plants were shorter with shorter internodes. Ethrel significantly reduced the length of the vines, the fresh weight of the tops and the length of the internodes in sweet potato (Vahab, 1980). A maximum reduction of 36.3 per cent over the control was observed with ethrel 300 ppm.

In Dioscorea alata, Bryan and McMillan (1975) reported reduced shoot length with increasing concentrations of ethrel applied to the cv. Blanco. Extension growth of the stem was suppressed at concentrations above 200 microgram/ml when tuber pieces of Dioscorea sp. were pre-treated with ethrel (Nandi and Chatterjee, 1975).

In onion, a reduction in the plant height was observed when ethrel was applied at concentrations of 2000 or 3000 ppm or when repeated application of 1000 ppm ethrel was made in the cvs. New Mexico White Grano and Yellow Sweet Spanish Colorado (Lipe, 1976).

Exposure of ginger rhizome seed pieces to ethrel at less than 250 ppm for 15 minutes caused substantial increase in shoot growth (Islam et al., 1978). Jayachandran (1978) found that ethrel 200 ppm induced a temporary inhibitory effect on the height of ginger plants. This effect was pronounced immediately following the application; but was not sustained during the later stages.

In coleus, Khosh-kui et al. (1978) reported that ethrel treatment resulted in dwarfing. Rajmohan (1978) obtained significant reduction in the internodal length and fresh weight of shoot when ethrel was applied to Coleus parviflorus. Ethrel 200 ppm recorded a reduction in the internodal length by 52.2 per cent over the control.

Effect of ethrel on various medicinal and aromatic plants also have been investigated by several workers. Bosela and Smik (1977) reported that application of ethrel increased the plant height in Mentha sp. In senna (Cassia angustifolia), ethrel at 50 to 100 ppm increased the growth and dry weight of the plants (Bhatia et al., 1978). Ethrel increased the vegetative growth, plant height and dry weight of the foliage in Adonis autumnalis (Shoushan et al., 1981). In poppy (Papaver somniferum), ethephon (10^{-2}M) retarded the vegetative growth when applied during stem elongation (Hsu and Forman, 1982).

Besides reducing the length of the main stem, ethrel exhibited promotive effects on the production of laterals and on the stem girth. Torres and Campo (1973) reported that ethrel application resulted in shorter and thicker stolons in sweet potato. Foliar application of ethrel at 50, 100, 200, 500 and 1000 ppm promoted the production of laterals in sweet potato. The response was found to be linear with increase in concentrations (Muthukrishnan et al., 1974). They obtained 104.5 per cent increase in the number of laterals over the control by the application of 250 ppm ethrel as foliar spray. Similar results of increasing the number of laterals in sweet potato were reported by Shanmugam and Srinivasan (1974). Vahab (1980) reported that ethrel at

300 and 450 ppm brought about a significant increase in the number of branches and girth of internodes in sweet potato.

In potato, var. Kufri Sindhuri exposed to long days, ethephon increased the number of stolons and the swelling of their sub-apical regions, especially at concentrations of 400-800 mg/l (Murti and Banerjee, 1978).

In coleus, Khosh-kui et al. (1978) observed increased number of branches with ethrel at 300 to 900 ppm. Rajmohan (1978) in his study with ethrel on coleus found that 200 ppm foliar spray produced an increase in the stem girth by 30.5 per cent over the control. He also observed a significant increase in the number of branches in the plants treated with 100 and 200 ppm ethrel.

In ginger, Jayachandran (1978) reported significantly higher production of tillers with the use of ethrel 50 to 200 ppm. Tillering was observed to increase with increasing concentrations.

In Mentha piperita and Mentha crispa, ethrel application increased the shoot number (Bosela and Smik, 1977). Shoushan et al. (1981) reported that ethrel at 125 to 1500 ppm tended to increase the number of branches in Adonis autumnalis.

Effect of ethrel on leaf area and number of leaves

Ethrel at high concentrations affect the leaf growth of many plants. In sweet potato, Muthukrishnan et al. (1974)

found that the plants treated with 500 ppm ethrel recorded a significant reduction in the leaf growth (47.1 per cent and 66.4 per cent through foliar and soil application, respectively). Shanmugam and Srinivasan (1974) reported a reduction in the total leaf area and the fresh weight of leaves in sweet potato by treatment with ethrel. Significant reduction in the number of leaves in sweet potato was reported by Vahab (1980) as a result of treatment with ethrel at 300 to 450 ppm. Maximum reduction of 12.5 per cent over the control was obtained by ethrel 300 ppm.

In coleus, reduction in leaf size was observed as a result of ethrel application (Khosh-kui et al., 1978). Rajmohan (1978) obtained a significant reduction in the leaf area of Coleus parviflorus by foliar application of 100 to 200 ppm ethrel. The greatest reduction of 46 per cent over the control was obtained with 200 ppm ethrel. In the case of leaf number, he obtained a significant increase as a result of ethrel application.

In ginger, Jayachandran (1978) reported that ethrel induced leaf production and 200 ppm concentration showed marked increase in the total leaf area per clump over the control.

In onion and leek, application of 5000 to 10000 ppm ethrel caused a reduction in the leaf size (Levy and Kedar, 1970). Lipe (1975) observed a reduction in the number of

leaves in short, medium and long day onion plants when treated with 1000 to 3000 ppm ethrel as foliar spray.

Bosela and Smik (1977) reported an increase in the number of leaves in Mentha piperita and M. crispa when sprayed with ethrel. In Adonis autumnalis, ethrel at 125 to 1500 ppm concentrations increased the number of leaves and foliage dry weight (Shoushan et al., 1981).

Effect of ethrel on yield and yield components

In potato, Hildeband and Deen (1969) reported that ethrel treatment increased the development of tubers in the varieties Russet Burbank and Kennebec. Increased tuber number and decreased tuber weight was observed in the potato cv. King Edward when the plants were sprayed with 0.3 per cent or one lb ethrel per acre (Edward et al., 1970). Torres and Campo (1973) reported that ethrel treatment considerably promoted tuberization and increased the tuber number in etiolated potato sprouts in vitro. Murti et al. (1977) reported that foliar sprays of 100 to 400 mg of ethephon per litre increased the number and yield of tuber per plant in the potato cv. Kufri Jyothi under long day conditions. Marked reduction in the size of tubers was observed with 400 to 800 mg ethephon per litre. At these concentrations, malformation of tubers was also observed. An increase in the tuber/top ratio was observed in the summer crop treated with

ethephon. Postinikov et al. (1978) reported that ethephon considerably increased the tuber number; but decreased their weight and size causing a reduction of total yield in potato. Reduction in the number of large tubers and an increase in the number of small tubers was reported in the potato cv. Desiree and Katela by ethrel application. The best results in yield were obtained with 60 ppm ethrel (Kusumo et al., 1979). Bavilov et al. (1980) reported 1.6 to 1.8 fold increase in the yield of potato seed tubers with 0.2 per cent ethephon.

Similar effects were observed in sweet potato by several workers. In the variety Centennial, ethrel treatment caused increased production of tubers (Tompkinsand Bowers, 1970). Muthukrishnan et al. (1974) observed a significant increase in the tuber yield when IB2 variety of sweet potato was treated with 50, 100, 250, 500 and 1000 ppm of ethrel both as foliar spray and soil application. Among these levels, ethrel at 250 ppm as foliar spray recorded the maximum yield over all the other treatments. Shanmugam and Srinivasan (1974) reported that ethrel 250 ppm applied to the foliage of sweet potato plants at 15, 30 and 45 days after planting increased the number and yield of tubers. Increased tuber yield was also reported in the sweet potato cvs. Julian and Centennial with 500 to 1000 ppm ethephon (Tompkins and Horton, 1974). Muthukrishnan et al. (1976) recorded a significant increase (49 per cent) in tuber yield of sweet potato with 250 ppm ethrel

sprayed at fortnightly intervals commencing from 45 days after planting. The treatment also reduced the shoot:tuber ratio to an optimum of 0.59:1.00. Mustaffa et al. (1980) reported a 66 per cent increase in the yield of sweet potato tubers with three foliar sprays of 250 ppm ethrel. Vahab (1980) in his studies found that application of 300 ppm ethrel gave the highest yield and more number of marketable tubers per plant in sweet potato. He observed an increase in the length; but a decrease in the girth of tubers. An optimum shoot:tuber ratio of 0.26:1.00 was observed with 300 ppm ethrel.

In Dioscorea alata cv. Blanco, Bryan and McMillan (1975) obtained higher marketable yield when tuber sections were soaked in low concentrations of ethrel prior to planting.

In cassava cv. Malavella, treatment with 250 and 500 ppm ethrel increased the tuber yield by 18 and 20 per cent, respectively over the control (Muthukrishnan et al., 1976).

In sugar beet, Malik and Shakara (1977) reported that ethrel application reduced yield in all the varieties tried. However, Kuhn et al. (1978) obtained increased root weight in sugar beet by ethrel application.

In Coleus parviflorus, Rajmohan (1978) obtained earlier tuber initiation and increased tuber yield by ethrel treatment. Ethrel at 200 ppm resulted in significant increase in the tuber yield, 49.1 per cent over the control. However, a

significant change in the number of tubers per plant was not observed by ethrel treatment. The shoot/tuber ratio was also reduced by the treatment.

In ginger, Jayachandran (1978) observed that 200 ppm ethrel induced higher shoot/rhizome ratio over the control and significantly suppressed the rhizome development.

Ethrel application had exhibited pronounced effects on bulb induction and bulb growth. Bulb growth was induced in the onion cv. Zittan Vellow when the plants were grown hydroponically in Hoagland solution or in one per cent sucrose solution, along with 200 ppm ethephon under day lengths non-inductive for bulbing (Lercari and Ceccarelli, 1975). Lipe (1976) reported that application of 3000 ppm ethephon during the early stages accelerated the growth rate of bulbs in onion 18 to 22 days after initial application. This enhancement in bulb growth continued for about 20 days resulting in advanced maturity. Thereafter the relative growth of bulbs declined and the final bulb size and yields were lesser than those of untreated control. Cantliffe and Wood (1978) observed that a single or multiple application with varying concentrations of ethephon to seven cultivars of onion planted on five different dates resulted in reduced marketable yields in the early plantings. However, a single spray of 3000 ppm promoted higher yields in the cvs. Red Granex and Red Grano. In the late plantings, 500 ppm ethephon

increased the bulb index (bulb/stem diameter ratio) and yield of six cultivars. Thomas and Raukin (1982) reported that application of 1000 or 3000 mg ethephon per litre during early August, either once or thrice at weekly intervals, reduced the average bulb weight and the total yield (by 14 to 17 per cent.) in onion.

Influence of ethrel on yield has been reported in several medicinal plants. Nandi and Chatterjee (1978) reported increased yam yield in Dioscorea spp. by the application of 25 to 50 ppm ethrel. Gupta et al. (1982) reported that treatment with 250 to 500 ppm ethrel did not affect the tuber yield in Dioscorea composita.

In opium poppy, increased opium yield resulted when the plants were treated with 1000 to 2000 ppm ethrel (Ramanathan, 1978). Opium yield was highest in the plants sprayed twice with ethrel 2000 ppm. Hsu and Forman (1982) reported that 10^{-2} molar concentrations of ethrel applied during stem elongation inhibited capsule formation in Papaver somniferum. Ethrel significantly reduced the capsule size when applied during the flowering period; but did not alter capsule development if applied during capsule formation stage. At 10^{-3} and 10^{-4} molar concentrations of ethrel, capsule size was reduced when applied during stem elongation. However, capsule development was not affected when applied during flower bud formation. Increased capsule size was observed when ethrel was applied during capsule formation stage.

In Adonis autumnalis, application of 125, 250, 500 and 1000 ppm of ethrel at triweekly intervals to two month old seedlings increased the number of fruits and roots (Shoushan et al., 1981).

Effect of ethrel on quality

Several workers have critically examined the role of ethrel in influencing the quality of tuber crops. In sweet potato, Muthukrishnan et al. (1976) reported that 500 ppm ethephon increased the total soluble sugar content of tubers by 16.3 per cent. At 250 ppm, acidity was reduced by 33.4 per cent. Mustaffa et al. (1980) reported an increase in the carotene, ascorbic acid and protein content of sweet potato tubers when the plants were applied with three foliar sprays of 250 ppm ethrel and the crop harvested 110 to 120 days after planting. Vahab (1980) reported that application of three foliar sprays of 150 to 450 ppm ethrel significantly increased the starch, sugar, calcium content and dry matter percentage. The protein content of sweet potato tubers was found to be reduced. The highest starch content (23.73 per cent) was recorded by ethrel 300 ppm, followed by ethrel 450 ppm (23.46 per cent).

In cassava cv. Malavella, Muthukrishnan et al. (1976) reported that ethrel sprays at 1000 ppm resulted in a two-fold increase in the starch content of the tubers over the

control. Ethrel at 2000 ppm reduced the ascorbic acid content of tubers by 38.8 per cent over the control.

In potato, ethrel application reduced the drymatter, starch, nitrogen, protein and aminoacid content whereas it increased the physical strength of tubers (Poppr, 1977).

In ginger, maximum recovery of volatile oil was obtained with 50 ppm ethrel and an increase in the starch content with 200 ppm ethrel (Jayachandran, 1978).

In Coleus parviflorus, Rajmohan (1978) reported significant increase in the content of starch, ascorbic acid and calcium and a significant reduction in the content of protein in the tubers on treatment of the plant with ethrel.

Influence on quality due to ethrel application has been reported in a few medicinal plants. In Cassia angustifolia, the sennoside content in the leaves was increased by ethrel at 10 ppm (Bhatia et al., 1978). Nandi and Chatterjee (1978) reported that diosgenin synthesis in Dioscorea composita, D. pentaphylla and D. bulbifera var. Pultehella was enhanced when the tuber pieces were treated with ethrel 25 ppm for 24 hours before planting (in pots).

In a two year trial with poppies (cv. Dhawla Bada and Telia), ethrel applied at 250 to 1000 ppm gave increased morphine content of opium (Ramanathan, 1978). In the poppy cv. Dhawla Chotta, Ramanathan (1981) observed that yields of morphine were highest in the plants sprayed twice with ethrel

at the rate of 2000 ppm. Hsu and Forman (1982) reported that ethephon applied at 10^{-3} and 10^{-4} molar concentrations to poppy plants during stem elongation reduced the accumulation of morphinan alkaloids (thebaine, codeine and morphine) by 21 per cent. However, an increased alkaloid content was obtained when ethrel was applied during capsule formation stage.

In Adonis autumnalis, ethrel treatment generally decreased the glycosidal content in the foliage and raised it in flowers, fruits and roots (Shoushan et al., 1981). In Solanum laciniatum, solasodine production was inhibited by CEPA (ethephon) in the callus and suspension cultures (Chandler and Dodds, 1983).

2,4-D

2,4-dichlorophenoxy acetic acid is a purely synthetic auxin generally used as a weedicide. But at lower concentrations, 2,4-D exhibits growth stimulatory properties. Effect of this growth substance on certain root crops and medicinal plants are reviewed here:

Effect of 2,4-D on vegetative growth

In sweet potato, Michael and Smith (1951) reported that treatment with 2,4-D reduced or completely destroyed the proximal dominance in the sprouting tubers with resultant increase in the number of sprouts per tuber. Potato plants

grown in pots when sprayed with 30 per cent double superphosphate solution containing 0.05 per cent 2,4-D inhibited growth of the tops (Al'Tergot et al., 1976). In Crocus sativus, Kabdal and Joshi (1978) noted marked acceleration in vegetative growth as well as multiplication of corms with 2,4-D application. In the sugar beet cv., Monohy D2, the greatest reduction in top growth occurred when 0.07 kg of 2,4-D per ha was applied to the oldest plants at 12-leaf stage (Scweizer, 1978). 2,4-D application resulted in the growth inhibition of young leaves in fodder beet (Arkhangelskii et al., 1982).

Haleem (1978) reported that 5 ppm 2,4-D plus foliar application of 45 kg N/ha produced the greatest plant height in Solanum khasianum. 2,4-D sprayed on aerial parts of Solanum khasianum plants over two consecutive years retarded the growth (Barua and Hazarika, 1982).

In Dioscorea floribunda, Vasanthakumar et al. (1980) reported that spray application of 2,4-D did not markedly improve plant growth.

Effect of 2,4-D on yield and yield components

Potato plants sprayed with 30 per cent double superphosphate solution containing 0.05 per cent 2,4-D showed increased translocation of assimilates to the stolons and tubers during 12 to 15 days after spraying which finally

resulted in increased yield (Al'Tergot et al., 1976). Foliar application of 0.1 per cent 2,4-D amine salt to potatoes at bud formation stage increased diurnal growth rate and yield of tubers and accelerated tuber maturation (Bobrov and Kapustin, 1976). Skrinskaya and Lin'kov (1976) found that potato seed tubers treated with a solution containing 0.002 per cent 2,4-D, 0.005 per cent $KMnO_4$, 0.05 per cent $CuSO_4$ and 1.00 per cent boric acid solution produced eight fold increase in the yield of tubers. Mukhametova (1979) reported that application of 20 per cent double superphosphate plus 0.01 per cent 2,4-D amine during peak flowering stage increased the potato tuber yield by 1.43 to 1.78 tonnes per ha.

Sugar beet yield was increased by 21.7, 16.7 and 12.9 per cent when 10^{-5} per cent 2,4-D was added to Mn, B or Mo respectively and sprayed to sugar beet plants (Brysov, 1974). Arkhangelskii et al. (1978) reported increased root yield by the application of 0.0002 per cent 2,4-D at seven-leaf stage in fodder beet. Application of 2,4-D esters to two fodder beet cultivars at the beginning of intensive carbohydrate accumulation stage significantly increased root yields (Arkhangelskii et al., 1982).

A few reports on the influence of 2,4-D on the yield of medicinal plants are available. Haleem (1978) reported that application of 5 ppm 2,4-D plus 45 kg N/ha resulted in

increased fruitset, yield of berries per plant and yield per hectare in Solanum khasianum. On the contrary, Barua and Hazarika (1982) reported a yield reduction in Solanum khasianum as a result of 2,4-D treatment.

Effect of 2,4-D on quality

2,4-D has been reported to have improved the quality of many tuber crops. In potatoes, 2,4-D applied annually at the rate of 3 kg/ha increased tuber nitrogen content in the cv. Kaszubski. In the cv. Epoka, 2,4-D applied twice annually increased both tuber nitrogen and protein contents (Rycerka and Mezykowska, 1975). Al'Tergot et al. (1976) observed that spraying potato plants with 30 per cent double superphosphate solution containing 0.05 per cent 2,4-D increased the tuber starch content from 12.6 to 15.3 per cent and the ascorbic acid content from 17.6 to 20.9 mg/100 mg. Keeping and marketable qualities of potato tubers were improved by foliar application of 0.1 per cent 2,4-D amine during early bud formation stage (Bobrov and Kapustin, 1976). Mukhametova (1979) reported an increase by 2.2 per cent in the starch content of potato tubers when the plants were sprayed with 20 per cent double superphosphate along with 0.01 per cent 2,4-D amine during peak flowering stage.

In sugar beet, Scweizer (1978) reported that the yield of recoverable sucrose was reduced by 6.8, 7.8 and 13.2 per cent on application of 2,4-D at 0.017, 0.035 and 0.07 kg/ha,

respectively. Application of 2,4-D ester to two fodder beet cultivars increased the protein and essential amino acid content in the roots (Arkhangelskii et al., 1982).

In carrot suspension cultures synthesis of carotenoids and steroids was stimulated by 2,4-D (Shimizu et al., 1979).

Several medicinal plants also have shown improvement in quality as a result of 2,4-D application. On analysis of tissue cultures of Solanum xanthocarpum, Heble et al. (1971) observed that growth substances like 2,4-D at one ppm concentration caused changes in the steroidal contents, thus suggesting hormonal regulation of steroidal synthesis. Eid et al. (1974) found that treatment with 50 ppm 2,4-D raised the alkaloid content in the berries of Solanum laciniatum. Haleem (1978) investigated the effect of nitrogen application and use of growth regulators on the growth and yield of Solanum khasianum. He found that solasodine percentage in the berries was not significantly affected by 2,4-D treatment. But on account of the differential yield of berries per plant, the yield of solasodine per hectare varied considerably. Hosoda et al. (1979) reported that accumulation of solasodine in the callus tissues of Solanum laciniatum was highest when the medium contained 1-2 ppm of 2,4-D.

In Origanum majorana treated with 50 ppm 2,4-D, El-Antably (1975) reported higher yields of volatile oil in the flowers.

The best growth and diosgenin production in Dioscorea deltoidea suspension cultures was obtained with 0.1 mg/l 2,4-D in the medium (Marshall and Staba, 1975). Vasanthakumar et al. (1980) reported that 2,4-D treatments generally improved the diosgenin content in the tubers of Dioscorea floribunda, the best result being obtained with the application of 2 ppm 2,4-D.

In Rauvolfia serpentina, 2,4-D at 1 mg/l inhibited the alkaloid synthesis in the suspension cultures of stem tissues (Nikolueva and Vollosovich, 1977). Ohta and Yatazawa (1979) reported that 2,4-D, when present in the basal nutrient medium of callus tissues stimulated the growth of the callus as well as the synthesis of ajmaline and certain phytosterols in Rauvolfia serpentina. In Trigonella foenum-graecum, yield of stigma sterol was greater when 2,4-D at 0.01, 0.1 or 1.0 mg/l was added to the static culture media (Hardman and Stevens, 1978).

The diosgenin content increased from 1.3 per cent to 5.0 per cent when Costus speciosus tubers were incubated in 2,4-D at 1 to 100 ppm (Shah et al., 1978). Seth et al. (1979) observed an increase in the diosgenin content upto 270 per cent on incubation of costus rhizome slices with 100 ppm 2,4-D. Ramawat and Arya (1979) obtained relatively less ephedrin in Ephedra gerardiana callus cultures when treated

with 5 mg/l 2,4-D as compared to the control. The ephedrin contents were 0.13 per cent and 0.17 per cent for treated and untreated plants, respectively.

MH

Maleic hydrazide is the first synthetic growth suppressor to be described. Growth regulating properties of MH were first reported by Schoene and Hoffman (1949). They observed that MH caused cessation of stem elongation and apical dominance, as well as induced growth of lateral buds in plants. Crafts (1959) found the water soluble form of maleic hydrazide to be more effective. High humidity promoted absorption of the chemical by plants. Some of the regulatory effects of maleic hydrazide on root crops, medicinal plants and other important crops are reviewed here:

Effect of MH on vegetative growth

In potato, Zukel (1950) observed inhibition of shoot growth with concentrations of MH above 0.3 per cent, applied seven weeks after planting. Friesen and Howat (1950) found that foliar application of 0.25 and 0.50 per cent MH to potato plants after two weeks of emergence, stunted their growth. Wittwer (1963) observed that sprouting in potato tubers can be controlled by MH. Kaul et al. (1977) obtained a significant delay in the sprouting of potato tubers when the plants were sprayed with 0.3 per cent MH, six weeks

before the harvest. MH at 2000, 2500 and 3000 ppm had no significant effect on sprouting of potato tubers when the plants were sprayed 30 days before the harvest (Hegazy et al., 1978).

Choudhury and Bhatnagar (1954) sprayed MH to six-week old radish plants. They observed one week after the spraying that MH at 1.0 per cent concentration reduced the fresh weight and increased the dry weight of tops. Backa (1961) observed stimulated growth of radish plants with 0.01 per cent MH. However, 0.25 per cent concentration was found to be inhibitory. Application of 200 ppm MH in the early stages of the radish crop yielded more number of leaves, but reduced the leaf area. In the later stages, this reduction in leaf area was found to be beneficial in retarding the weight of the foliage (Ananthanarayanan, 1968). Guzman (1971) observed inhibition of top growth in radish by the application of 5000 ppm MH.

In sugar beet, Vajna and Vajna (1954) reported that application of 0.1 to 0.3 per cent MH resulted in the wilting of leaves. Sugar beet leaves showed signs of necrosis with 0.5 per cent MH, if sprayed in the early growth stages. In the later stages, MH caused reversible wilting and loss of vigour (Fergusen and Fiuezek, 1958).

In turnip sprayed with 1.0 per cent MH, Choudhury and Bhatnagar (1955) observed a reduction in the fresh weight

of tops and the number of mature leaves. The number of immature leaves, however, increased.

In sweet potato, Ananthanarayanan (1968) reported that application of 500 ppm MH at all stages, and 1000 ppm and 2000 ppm at 105th day had been beneficial for increased foliage.

In turmeric, Sabina George (1981) observed the effect of MH on the plants at five stages, at monthly intervals starting from three months after planting (upto 240th day). Two foliar sprays of the growth substances was given at 15 days interval starting from 90th day after planting. Plant height was significantly increased by 75 ppm MH on 210th day after planting. MH at 50 ppm increased the number of tillers on the 150th day. MH at 25, 50 and 75 ppm reduced the number of leaves during the initial stages. Significant increase in the leaf area was observed with 25 ppm MH at 120th day and 75 ppm MH at 240th day. On the 150th day, a significant reduction in the leaf area was observed in plants treated with 50 ppm MH. MH at 50 ppm and 75 ppm significantly increased the number of leaves per tiller on the 120th day and 180th day, respectively.

Wittwer (1963) succeeded in controlling the sprouting of onion bulbs with MH. However, El-Oksh *et al.* (1971) was unable to obtain similar results in garlic. Foliar application of 2000 ppm MH from 175 days after planting until

harvest retarded leaf growth in garlic plants (Chung et al., 1974). Maltob (1979) found that MH at 4000 and 6000 ppm levels were most effective in controlling sprouting in the bulbs of onion cv. Loval.

Effect of MH on yield and yield components

Maleic hydrazide has been observed to influence the yield and quality of many tuber crops and medicinal plants. Zukel (1950) observed a reduction in the yield of potatoes with concentration of MH over 0.3 per cent when applied seven weeks after planting. Bernard and Warden (1950) reported that 0.1 and 0.5 per cent MH applied two weeks after emergence of potato plants increased the tuber set. Higher concentrations resulted in secondary growth and formation of aerial tubers. Kennedy and Smith (1951) recorded an increase in the tuber number when potato plants were sprayed with 0.1 per cent MH after initial tuber set. Marked increase in the number of tubers per plant was also observed with increased dosage of the compound and as application was made later in the season. Denison (1953) observed that MH application during full bloom stage resulted in reduced yields; but application during blossom drop stage did not affect the yield. Fults and Payne (1955) found that early application of MH showed a reduction in yield of potatoes. Tamki (1958) stated that the development of potato tubers was inhibited when MH was applied three weeks before flowering. On the

other hand, Harmey et al. (1966) from their studies using potato cuttings found that MH promoted tuberization. MH at 5000 ppm levels gave rise to slightly higher yields in Royal Kidney and Up-to-date varieties of potato (Choudhury, 1967). In pot trials with potatoes, the treatment of cut seed tubers with MH caused a reduction in tuber yield per plant and tuber size. The reduction effect increased with increasing concentration of MH from 1 to 100 ppm (Bisaria and Sharma, 1975). Kaul et al. (1977) reported that 0.3 per cent MH sprayed on potato plants tended to decrease yields by 7.7 to 26.0 per cent. Hegazy et al. (1978) reported that MH at 2000, 2500 and 3000 ppm applied 30 days before the harvest had no significant effect on the yield of potatoes. According to Davis and Groskopp (1981) foliar application of 3.4 kg MH ai/ha caused a reduction in the total yield of tubers by 4.9 to 5.7 per cent; but did not affect the yield of Grade 1 tubers.

In radish, Rumyantseva and Krotova (1972) reported an increase in the marketable yield, when young plants were sprayed with sodium salt of MH at 0.1 per cent concentration.

In sugar beet, application of MH at 1.2 to 2.0 kg/ha 30 to 35 days before the harvest gave increased root yields (Borbro, 1976). Application of 250 ppm MH resulted in increased yield of sugar beet variety KWs. Monobela (Malik and Shakara, 1977).

In Dioscorea oposita, bulbil formation was inhibited when the tubers were cultured in vitro in media containing MH (Ashira and Yazawa, 1979).

Sabina George (1981) reported that the number of primary fingers at the time of harvest was significantly increased by 25 and 50 ppm MH; but the treatments significantly reduced the internodal length of the primary fingers in turmeric.

In garlic, Chung et al. (1974) found that foliar application of 2000 ppm MH at different growth stages from 175 days after planting until harvest retarded bulb development and seed stalk elongation and completely inhibited bulbil formation. In onion, pre-harvest spray of 4000 ppm or 6000 ppm MH controlled the weight loss during storage at room temperature in the cv. Loval (Maltob, 1979).

Effect of MH on quality

Reports on the influence of MH on the quality of tuber crops and medicinal plants are also available. In radish, Rumyantseva and Krotova (1972) reported an increase in the dry matter, sugar and ascorbic acid content of roots of young plants by the application of 0.1 per cent sodium salt of MH. In sugar beet, the reduction in betaine content as a result of parasitation of dodder (Cuscuta campestris) was restored by MH triethanol amine and MH potassium at a concentration of 1.5 per cent, almost to the level of non-parasatized

plants (Evtushenko and Shapanova, 1973). Borbro (1976) recorded increase in the sugar content of sugar beet with 1.2 to 2.0 kg MH per hectare applied 30 to 35 days before harvesting.

In a pot culture trial, cut seed tubers of potato treated with 1, 10 and 100 ppm solution of MH showed reduction in the drymatter and increase in the starch content of tubers (Bisaria and Sharma, 1975).

In turmeric, Sabina George (1981) found that 50 and 75 ppm MH significantly increased the curcumin content and curing percentage respectively.

Misra and Panda (1979) recorded the highest content of reducing sugars and TSS in onions with a pre-harvest spray of 1000 or 2000 ppm MH. The moisture content of the bulbs recorded a month after spraying was the highest with 100 ppm MH.

In Origanum majorana, El-Antably (1975) reported highest essential oil content from the leaves and flowers of plants treated with 100 mg/l MH. In Cassia angustifolia, Bhatia et al. (1978) observed increased content of sennoside in the leaves as a result of application of 25 to 50 ppm MH.

Materials & Methods

3. MATERIALS AND METHODS

A field experiment was carried out at the College of Horticulture, Vellanikkara from May 1982 to February 1983 to investigate the effect of growth substances namely, ethrel, 2,4-D and maleic hydrazide on the growth, rhizom... yield and diosgenin content in Costus speciosus.

The soil at the experimental plot had sandy loam texture, moderate fertility and good drainage. The meteorological data during the cropping season have been presented in Table 1 and Fig.1.

3.1. Land preparation

The soil was dug upto a depth of 30 cm and the clods were broken so as to obtain a medium-fine tilth. The area was then levelled. Raised beds (plots) of size 3 m x 3 m and height of 45 cm were formed giving a spacing of 60 cm between the beds. Farm yard manure was applied at the rate of 10 kg per bed (@ 10 t/ha) and incorporated to the soil prior to planting.

3.2. Planting material and planting

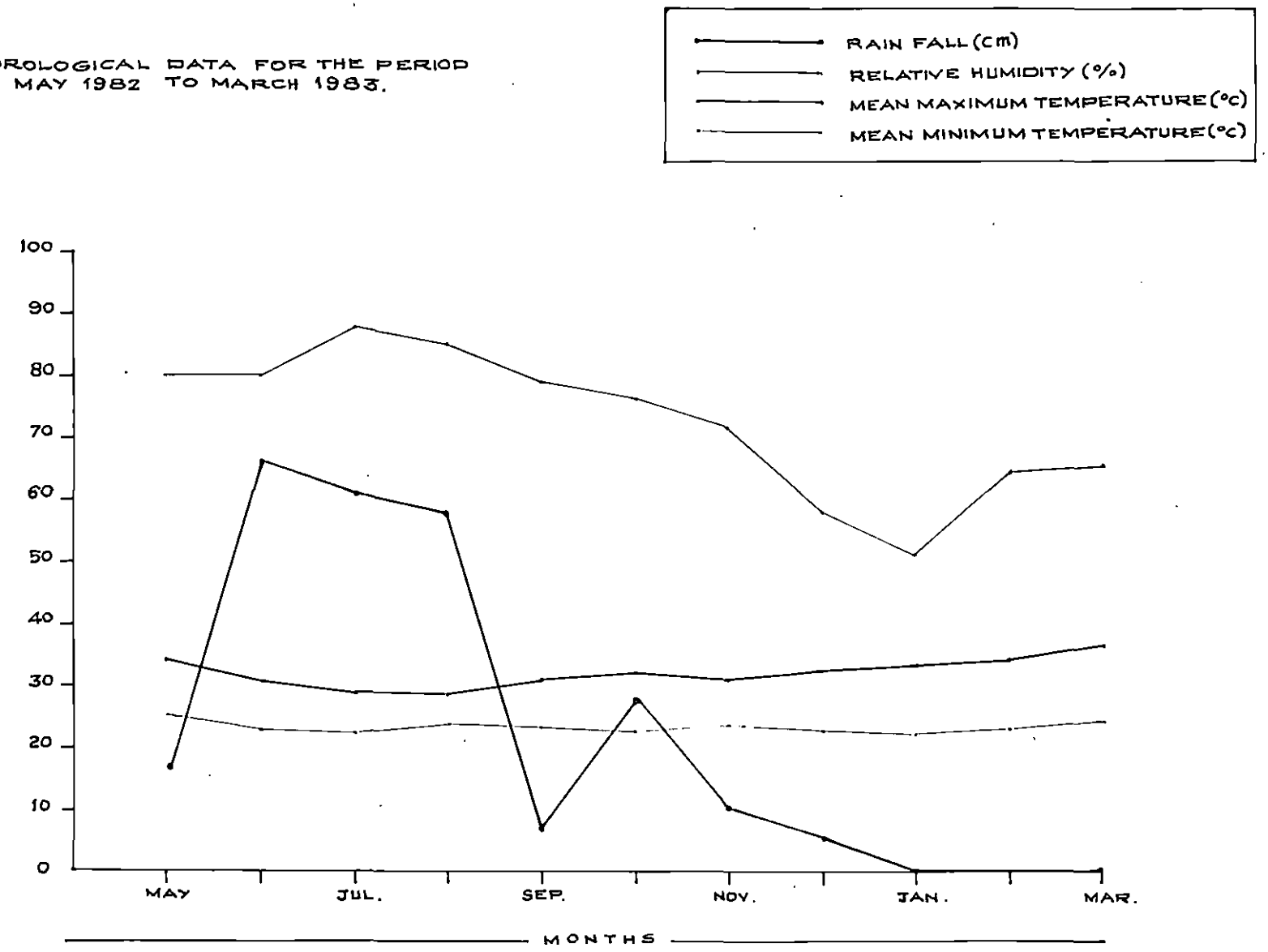
Rhizomes collected from the border plants of a previous experiment conducted at the College of Horticulture were used as the planting material. The rhizomes were cut into 10 cm (weighing approximately 75 g) pieces. They were planted

Table 1.- Meteorological data (monthly averages) from May 1982 to March 1983*

Month	Temperature (°C)		Relative humidity (%)	Rainfall (mm)
	Maximum	Minimum		
May 1982	33.80	24.50	79.90	173.6
June 1982	30.60	23.10	79.80	657.6
July 1982	29.10	22.92	87.50	600.9
August 1982	28.90	24.30	85.00	575.4
September 1982	30.98	24.00	78.88	67.4
October 1982	32.04	23.13	77.00	277.8
November 1982	31.40	23.93	71.88	98.4
December 1982	31.93	23.19	58.40	5.2
January 1983	33.25	21.64	51.31	Nil
February 1983	34.46	22.70	64.00	Nil
March 1983	36.15	23.76	65.00	Nil

* Source: 'B'Class observatory, College of Horticulture, Vellanikkara.

FIG. 1. METEOROLOGICAL DATA FOR THE PERIOD FROM MAY 1982 TO MARCH 1983.



horizontally at a depth of about ten cm with a spacing of 60 cm x 60 cm, giving a total population of 25 plants per plot. Planting was done on 27-5-1982. After planting, the soil surface was mulched with green leaves.

3.3. Lay out and treatment details

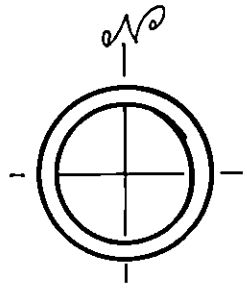
The experiment was laid out in Randomised Block Design with three replications (Fig.2). The treatments were:

Ethrel 100 ppm	- T_1
Ethrel 200 ppm	- T_2
Ethrel 300 ppm	- T_3
2,4-D 10 ppm	- T_4
2,4-D 20 ppm	- T_5
2,4-D 30 ppm	- T_6
MH 50 ppm	- T_7
MH 100 ppm	- T_8
MH 150 ppm	- T_9
Water spray	- T_{10}
Absolute control	- T_{11}

3.4. Fertilizer application

Nitrogen, phosphorus and potassium were applied at the rate of 45, 30, 30 kg/ha of N, P_2O_5 and K_2O respectively as recommended by Sudhadevi (1981). Nitrogen in the form of urea was applied in two split doses, two-third 20 days after planting and the remaining 60 days after planting. P_2O_5 in the form of superphosphate and K_2O in the form of muriate of

FIG. 2. LAY OUT PLAN OF THE EXPERIMENT.



REPLICATION 1

T_8	T_1	T_9	T_7	T_6	T_{11}	T_3	T_5	T_4	T_2	T_{10}

REPLICATION 2

T_4	T_3	T_1	T_{10}	T_8	T_7	T_{11}	T_6	T_5	T_9	T_2

REPLICATION 3

T_2	T_6	T_4	T_9	T_{11}	T_5	T_3	T_8	T_{10}	T_1	T_7

potash were applied in two equal splits, half as basal and the remaining 60 days after planting.

3.5. Application of growth substances

Stock solutions of the growth substances were first prepared. The concentrations required for spraying were prepared by diluting the stock solution with distilled water. Three foliar sprays of the growth substances were given, starting from 60 days after planting at intervals of one month. The third application coincided with flowering. Distilled water alone was sprayed in T_{10}. The spraying was done with an ordinary stainless steel hand sprayer, till run off started on the foliage. 'Teepol' was used as the spreader.

3.6. Intercultivation

Earthing up was done 60 days after planting. The beds (plots) were weeded thrice during the cropping season at bimonthly intervals.

3.7. Observation on growth parameters

From each plot, four observational plants were selected at random after leaving the border plants. The following observations were recorded:

3.7.1. Plant height

Measurement was taken from the base of the stem to tip of the topmost leaf of the longest tiller in each observational plant. The average of the four observations was worked out to get the mean height of the plants.

3.7.2. Number of tillers per plant

The number of aerial shoots that had arisen from the rhizome was counted. Mean number of tillers per plant was then calculated.

3.7.3. Number of leaves per tiller

The number of leaves on each tiller was recorded and the mean number of leaves per tiller was then computed.

3.7.4. Number of leaves per plant

The number of leaves of all tillers in a plant was added up to get the number of leaves per plant. The mean number of leaves per plant in a plot was then worked out.

3.7.5. Length and width of leaf

The length and width of two leaves from each tiller of the four observational plants were recorded. The distance between the point of attachment of the leaf blade to the pseudostem and the tip of the blade was taken as the length. Width was measured at three points, viz., one at the widest portion and the others on either side of the widest portions corresponding to the points of inclination of the lamina towards the tip and base of the leaf. From these, the mean width of leaf was calculated. Average length and width of the leaves were then arrived at.

3.7.6. Total leaf area per plant

The methodology suggested by Sudhadevi (1981) was employed for estimation of leaf area. The mathematical equation $y = 0.6341 x + 4.008$ (where y = the leaf area and x = the product of length and breadth) was made use of. The total leaf area per plant was then arrived at by multiplying the average leaf area with number of leaves per plant.

The observation on the growth characters (from 3.7.1 to 3.7.6) were taken four times at monthly intervals, starting from ten days prior to the first spraying.

3.8. Harvest

Harvest was done on 18-2-1983 at nine months after planting. The rhizomes were dug out, the roots were pruned and cleaned with tap water to remove the adhering dirt. Finally, the cleaned rhizomes were rinsed with distilled water.

3.9. Post-harvest observations

3.9.1. Internodal length of the shoot

The mean internodal length of the shoots was obtained by dividing the total shoot length by the number of nodes present in the observational plants.

3.9.2. Number of main rhizomes per plant

The number of main rhizomes produced by the observational

plants in the plots was recorded separately and their mean calculated.

3.9.3. Length and girth of the main rhizomes

The length of the rhizome was measured separately for each observational plant and the mean worked out for each plot. Their girth at proximal, middle and distal portions was also measured to work out the average girth of the main rhizomes.

3.9.4. Internodal length of the main rhizomes

The length of intermode was worked out by dividing the length of the rhizomes with the number of nodes separately for each observational plant and then the mean internodal length was found out

3.9.5. Number of primary and secondary fingers

The primary fingers are those originating from the main rhizomes and the secondary fingers are those originating from the primary fingers. The number of primary and secondary fingers were counted separately for the four observational plants and the mean per plot was then calculated.

3.9.6. Length and girth of primary and secondary fingers

Ten primary and ten secondary fingers were taken at random from each plot for the observations. Length of the primary and secondary fingers was recorded separately and the means computed for each type. Their girth was measured as in

the case of the main rhizomes to work out the mean girth for each type of finger.

3.9.7. Shoot/rhizome ratio

The ratio between the fresh weight of shoot and the fresh weight of rhizome per clump of the observational plants in each plot was calculated and the mean expressed as shoot/rhizome ratio.

3.9.8. Total yield of rhizomes

The rhizomes of all the plants in the plots were weighed and the mean worked out. The total yield of green rhizomes per hectare was worked out taking into consideration the net area of the plots.

3.9.9. Dry weight of shoot

After recording their initial fresh weight, the shoots from the observational plants were chopped, sun dried for two days and oven dried for 24 hours at 60°C till two consecutive weights coincided. Based on the final weight, the dry matter percentage was calculated.

3.9.10. Dry weight of rhizomes

One kg of green rhizomes from each plot were chopped and dried in sun for one day. The samples were later transferred to a hot air oven kept at 60 to 70°C and were dried to constant weight on test weighing. On completion of the drying, the samples were weighed separately. The dry matter percentage

was calculated on the basis of the fresh weight and the dry weight. The total dry rhizome yield per plot was then computed.

3.10. Soil sampling

Soil samples were taken before and after the experiment. Samples were taken from 0 to 30 cm depth at five random spots in each block and these were pooled to get a representative sample for each block. The samples were air dried, ground to pass through a 2 mm sieve and stored in polyethylene bags for chemical analysis.

3.11. Sampling of rhizomes

Rhizome samples collected for the estimation of dry matter were powdered and used for the extraction of diosgenin.

3.12. Chemical analysis

3.12.1. Soils

Total nitrogen in the samples was determined by Kjeldahl digestion-distillation method. Available phosphorus extracted by Bray No.1 reagent (0.03 N NH_4F in 0.025 N HCl) was estimated by chlorostannous reduced molybdophosphoric blue colour method. Available potassium extracted by 1 N neutral ammonium acetate was estimated using a flame photometer (Jackson, 1958). The soil pH was determined in 1.0:2.5 soil:water suspension using a pH meter.

3.12.2. Estimation of diosgenin in the rhizomes

For the extraction of diosgenin, the method of Selvaraj (1971) was adopted.

The powdered rhizome samples were used for analysis. The material (10.0 g) was blended thoroughly in a mixer with 50 ml of water for five minutes. The slurry was transferred to a 500 ml flask containing 100 ml of water and a calculated amount of 11.45 N HCl added to maintain the required acid concentration of 2.5 N. The flask fitted with a condensor was placed on boiling water bath for two hours to complete the hydrolysis. The slurry after hydrolysis was cooled to room temperature and filtered through a Buchner funnel under vacuum. The residue was then washed with distilled water until the filterate became free of acid. The residue along with the filter paper was then transferred to a petri dish and dried in an oven at 100°C for six hours. The residue was then extracted with petroleum ether (b.p. 40-60°C) in a Soxhlet apparatus for eight hours. The extract containing diosgenin was concentrated to 25 ml, chilled in ice and filtered. The mother liquor obtained after the first filteration was again concentrated, chilled in a deep freezer to get a second crop of diosgenin, if any. The entire quantity of diosgenin was weighed after drying in an oven at 100°C for two hours and expressed as percentage to the dry weight of the rhizomes.

3.13. Statistical analysis

The data obtained from the field experiment and the chemical determinations were statistically analysed in a microcomputer (Micro 2200) using standard procedures (Snedecor and Cochran, 1967).

3.14. Economics of the application of growth substances

The economics of crop production with and without the application of growth substances was calculated and recorded.

Results

4. RESULTS

The effects of ethrel, 2,4-D and MH on the growth, yield and quality constituents in Costus speciosus were investigated upon in a field trial (RBD experiment with three replications) conducted at the College of Horticulture, Vellanikkara during 1982-83. The results of the studies are presented in this chapter.

4.1. Growth characters

4.1.1. Height of the plant

The data on plant height recorded at monthly intervals starting from the 50th day of planting have been presented in Table 2 and Fig. 3. The Anova (Appendix I) showed that the differences in the height of the plants due to the treatments were not statistically significant at the 50th day of planting. The plant height, however, showed significant differences from the 80th day onwards.

On the 80th day after planting, ethrel at the levels tried, showed inhibitory effect on the plant height. The height was found to be reduced by 25.04, 27.40 and 24.80 per cent in plants treated with 100, 200 and 300 ppm ethrel, respectively. MH 150 ppm also reduced the height of the plants significantly on the 80th day. The reduction in plant height caused by the three levels of ethrel and by MH at 150 ppm was statistically on par. The height was maximum in plants sprayed with water. However, this height was statistically

Table 2.- Height of plants under different levels of ethrel, 2,4-D and MH

Treatments	Mean height (cm)			
	50th day	80th day	110th day	140th day
T_1 - Ethrel 100 ppm	32.10	39.36	48.46	50.31
T_2 - Ethrel 200 ppm	30.99	38.12	47.60	47.50
T_3 - Ethrel 300 ppm	32.18	39.49	46.64	47.85
T_4 - 2,4-D 10 ppm	37.37	52.91	66.04	66.04
T_5 - 2,4-D 20 ppm	40.50	53.72	72.84	71.40
T_6 - 2,4-D 30 ppm	35.74	52.02	69.67	67.38
T_7 - MH 50 ppm	36.37	46.70	57.73	57.67
T_8 - MH 100 ppm	39.05	46.86	54.21	57.93
T_9 - MH 150 ppm	34.83	44.09	52.20	55.20
T_{10}- Water spray	39.14	53.73	67.75	66.56
T_{11}- Absolute control	35.25	52.51	69.90	70.18
C.D. (0.05)	7.74	8.08	10.20	9.49

on par with those of the absolute control, the three levels of 2,4-D (10, 20 and 30 ppm) and the two lower levels of MH (50 and 100 ppm).

On the 110th day and 140th day also, the plant height was significantly reduced by ethrel treatments. The reductions in the plant height when compared to the absolute control were 30.67, 30.90 and 33.21 per cent on the 110th day and 28.31, 32.16 and 31.81 per cent on the 140th day in 100, 200 and 300 ppm ethrel, respectively. The plant height was reduced significantly by the three levels of MH also, on the 110th and 140th day; but not to the extent that was being brought about by ethrel treatments. The corresponding reductions in plant height were 17.41, 22.45 and 25.32 per cent on the 110th day and 17.83, 17.46 and 21.35 per cent on the 140th day in 50, 100 and 150 ppm MH, respectively. The height was maximum in plants treated with 2,4-D 20 ppm, but this was not significantly different from the height of plants in the other two levels of 2,4-D (10 and 30 ppm), in the absolute control and in the water spray on the 110th and 140th day.

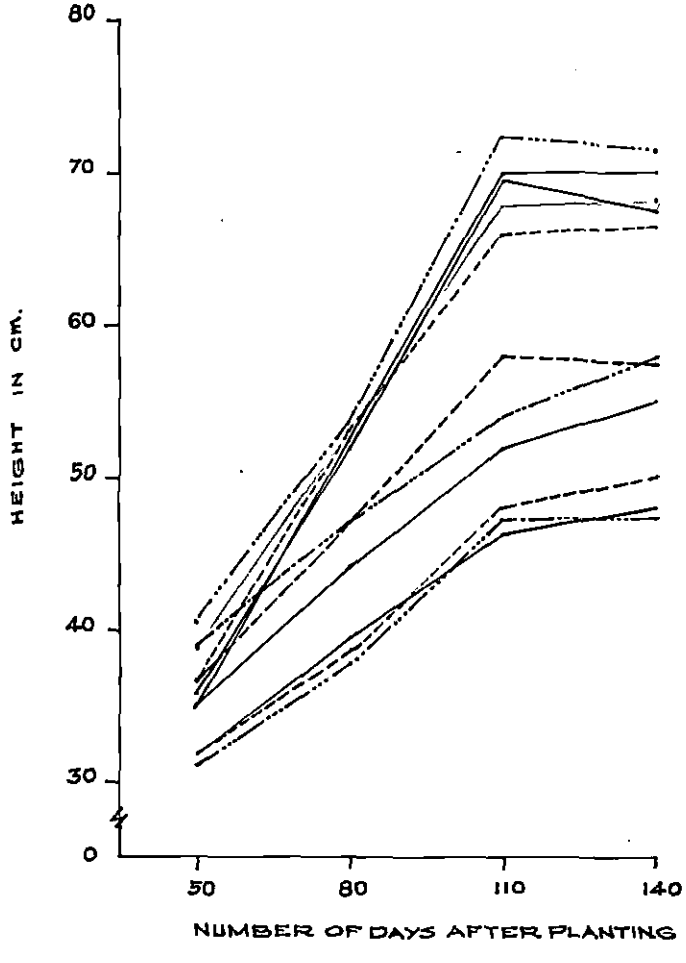
4.1.2. Number of tillers

The data on the number of tillers have been presented in Table 3 and Fig.4. The treatments did not show any significant difference on the 50th day (Appendix II). The differences in the number of tillers due to the treatments were

Table 3.- Tiller production under different levels of ethrel, 2,4-D and MH

Treatments	Mean number of tillers			
	50th day	80th day	110th day	140th day
T_1 - Ethrel 100 ppm	3.17	5.16	7.16	7.75
T_2 - Ethrel 200 ppm	4.08	6.08	8.08	8.08
T_3 - Ethrel 300 ppm	3.41	4.50	5.42	5.58
T_4 - 2,4-D 10 ppm	2.83	4.00	5.08	5.58
T_5 - 2,4-D 20 ppm	3.41	4.17	4.75	4.75
T_6 - 2,4-D 30 ppm	3.25	4.25	4.67	4.75
T_7 - MH 50 ppm	3.50	5.41	6.50	6.42
T_8 - MH 100 ppm	3.33	4.60	5.50	5.67
T_9 - MH 150 ppm	3.25	5.00	5.50	5.50
T_{10}- Water spray	3.17	3.91	4.42	4.42
T_{11}- Absolute control	3.08	4.59	5.17	5.25
C.D. (0.05)	1.04	0.84	0.99	1.00

FIG. 3. PLANT HEIGHT (CM)



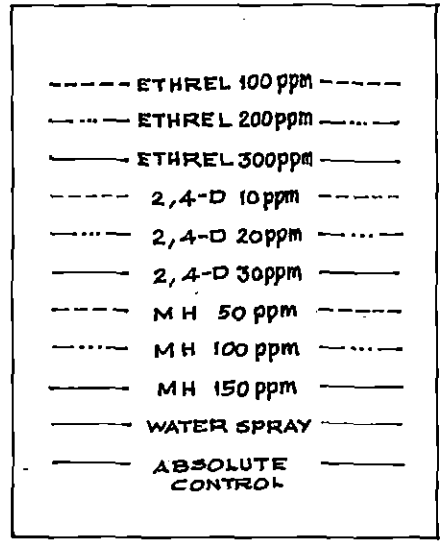
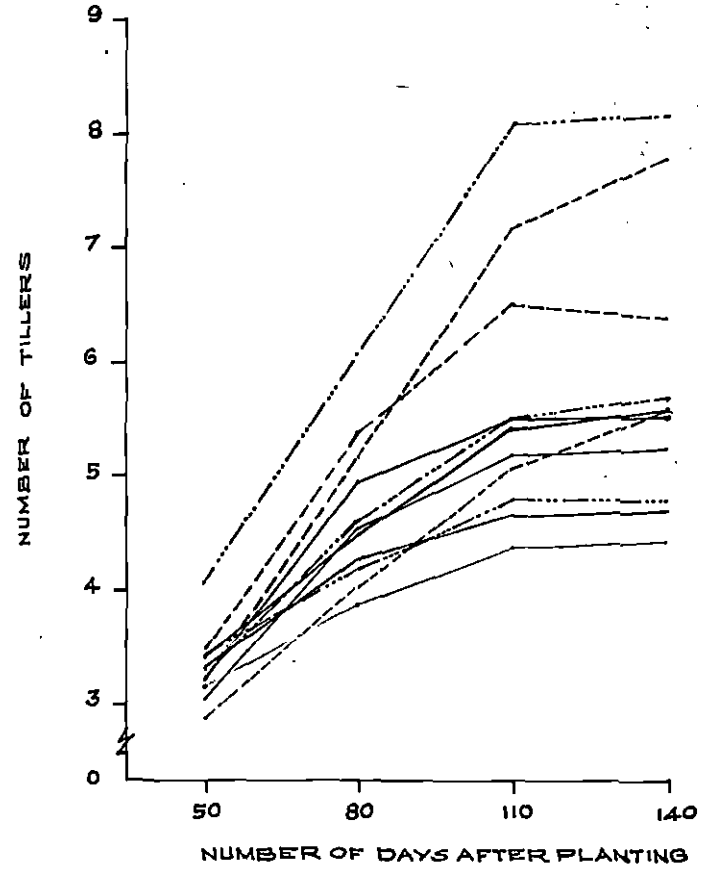


FIG. 4. NUMBER OF TILLERS PER PLANT



highly significant on the 80th, 110th and 140th day after planting.

A perusal of the data revealed that on the 80th day, the maximum number of tillers was produced by the plants treated with ethrel 200 ppm. The treatment was found to be on par with MH 50 ppm, but was superior to the control, the water spray and all the other treatments. Ethrel 200 ppm recorded a significant increase in the number of tillers by 32.46 per cent over that of the control at this stage. The number of tillers found in the plants treated with the other two levels of ethrel (100 and 300 ppm), all the levels of 2,4-D and MH and in the water spray were not significantly different from that of the absolute control.

On the 110th day, ethrel, at 100 and 200 ppm concentrations, was found to be significantly superior in increasing the number of tillers per plant when compared to the control. The number of tillers were also increased by MH 50 ppm. The increase in the number of tillers over that of the control was 38.49, 56.29 and 25.72 per cent by ethrel at 100 and 200 ppm and MH at 50 ppm, respectively. However, the differences in the number of tillers were not significant between ethrel 100 and 200 ppm and between ethrel 100 ppm and MH 50 ppm treatments. The rest of the treatments including water spray did not differ significantly from the absolute control in their ability to influence the production of tillers.

At 140th day of the observation, ethrel at 100 and 200 ppm concentration, was significantly superior to the absolute control, the water spray and all the other treatments in increasing the number of tillers per plant. The number of tillers increased by 47.62 and 53.90 per cent over that of the control with ethrel at 100 and 200 ppm, respectively. MH 50 ppm also increased the number of tillers significantly at this stage by 22.29 per cent over the control. The rest of the treatments were statistically on par with the absolute control on the 140th day.

4.1.3. Number of leaves per plant

The data on the number of leaves per plant recorded at monthly intervals are presented in Table 4 and Fig.5. The Anova presented in Appendix III showed that the three growth substances at the levels tried exhibited significant effect on the number of leaves per plant from 80th day onwards. However, the comparison of each levels of the growth substances to the control did not reveal any significant difference.

4.1.4. Number of leaves per tiller

The data on the number of leaves per tiller have been presented in Table 5 and Fig.6. The Anova presented in Appendix IV showed that differences due to the treatments were statistically significant at the 80th, 110th and 140th day after planting.

Table 4.- Leaf production in the plants treated with different levels of ethrel, 2,4-D and MH

Treatments	Mean number of leaves per plant			
	50th day	80th day	110th day	140th day
T_1 - Ethrel 100 ppm	39.16	63.58	76.75	37.83
T_2 - Ethrel 200 ppm	38.60	62.92	73.41	47.83
T_3 - Ethrel 300 ppm	35.58	54.58	67.33	42.00
T_4 - 2,4-D 10 ppm	32.08	61.25	73.08	65.58
T_5 - 2,4-D 20 ppm	34.08	55.67	65.00	52.58
T_6 - 2,4-D 30 ppm	24.81	40.66	49.58	37.50
T_7 - MH 50 ppm	37.50	59.17	72.75	57.50
T_8 - MH 100 ppm	29.91	45.00	54.00	43.83
T_9 - MH 150 ppm	30.91	44.58	53.83	37.50
T_{10} - Water spray	37.58	53.66	62.75	52.25
T_{11} - Absolute control	34.92	52.91	60.83	51.83
C.D. (0.05)	8.96	14.20	16.17	17.13

On the 80th day, the number of leaves per tiller was maximum in the plants treated with 2,4-D 10 ppm and 2,4-D 10 ppm was significantly superior to absolute control, but was on par with the water spray treatment. The number of leaves per tiller in 2,4-D 10 ppm was 32.45 per cent more than that of the control. With respect to the number of leaves per tiller, all the other treatments were on par with the control.

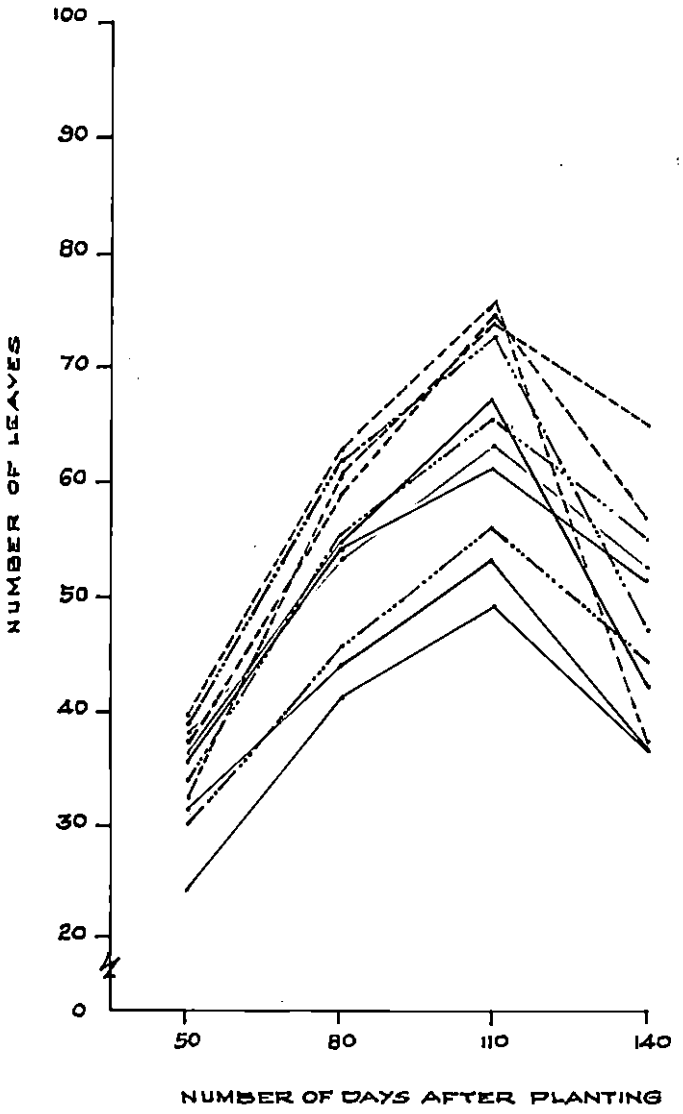
On the 110th day, higher leaf production per tiller was recorded by ethrel 300 ppm, 2,4-D 10 ppm and 2,4-D 20 ppm, but these treatments were on par with the absolute control and water spray treatment at this stage. In general, the per tiller leaf production as a result of application of growth substances did not show significant difference with that of the control.

On the 140th day, the number of leaves per tiller was significantly reduced by ethrel at 100 and 200 ppm. The reduction was 50.96 and 40.20 per cent, respectively at the two concentrations. The highest level of MH (150 ppm) also reduced the number of leaves per tiller significantly (by 30.86 per cent of the control). The maximum mean for the number of leaves per tiller was recorded by water spray treatment. However, the response was statistically on par with that of 2,4-D 10 ppm, 2,4-D 20 ppm and the control. The number of leaves per tiller recorded by the plants treated

Table 5.- Leaf production per tiller under different levels of ethrel, 2,4-D and MH.

Treatments	Mean number of leaves per tiller			
	50th day	80th day	110th day	140th day
T_1 - Ethrel 100 ppm	12.47	12.40	10.75	4.83
T_2 - Ethrel 200 ppm	9.07	10.37	9.11	5.89
T_3 - Ethrel 300 ppm	10.40	12.35	12.43	7.71
T_4 - 2,4-D 10 ppm	11.34	15.39	14.96	11.92
T_5 - 2,4-D 20 ppm	10.02	13.34	13.61	11.29
T_6 - 2,4-D 30 ppm	9.13	9.58	10.93	7.99
T_7 - MH 50 ppm	11.09	10.98	11.18	8.95
T_8 - MH 100 ppm	9.07	9.81	9.97	7.72
T_9 - MH 150 ppm	9.53	8.92	11.40	6.81
T_{10}- Water spray	12.02	13.91	14.42	11.96
T_{11}- Absolute control	11.22	11.62	11.82	9.85
C.D. (0.05)	3.09	3.51	3.28	2.87

FIG. 5. NUMBER OF LEAVES PER PLANT



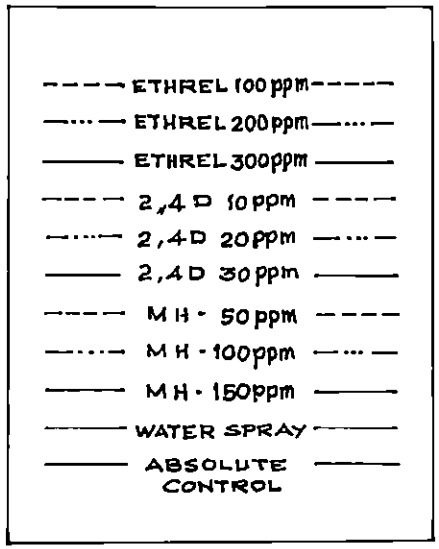
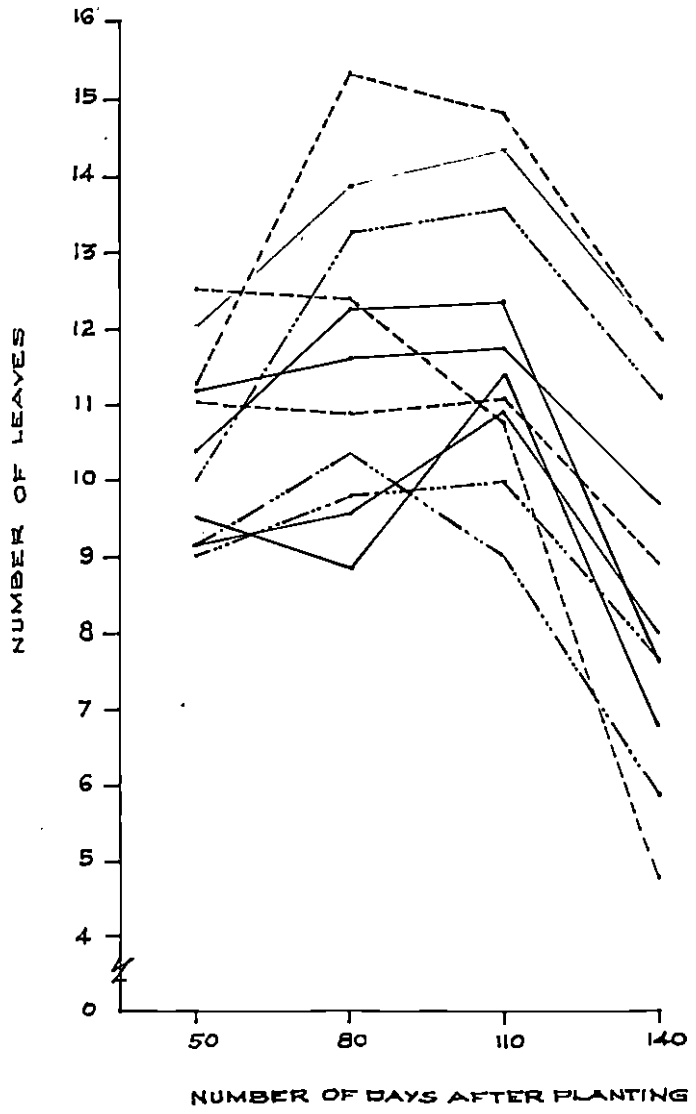


FIG. 6. NUMBER OF LEAVES PER TILLER.



171099

KERALA AGRICULTURAL UNIVERSITY LIBRARY THRISSUR 680 654

with 2,4-D at the three levels (10, 20 and 30 ppm), MH at the two lower levels (50 and 100 ppm) and ethrel at the highest level (300 ppm) were not significantly different from that of the absolute control.

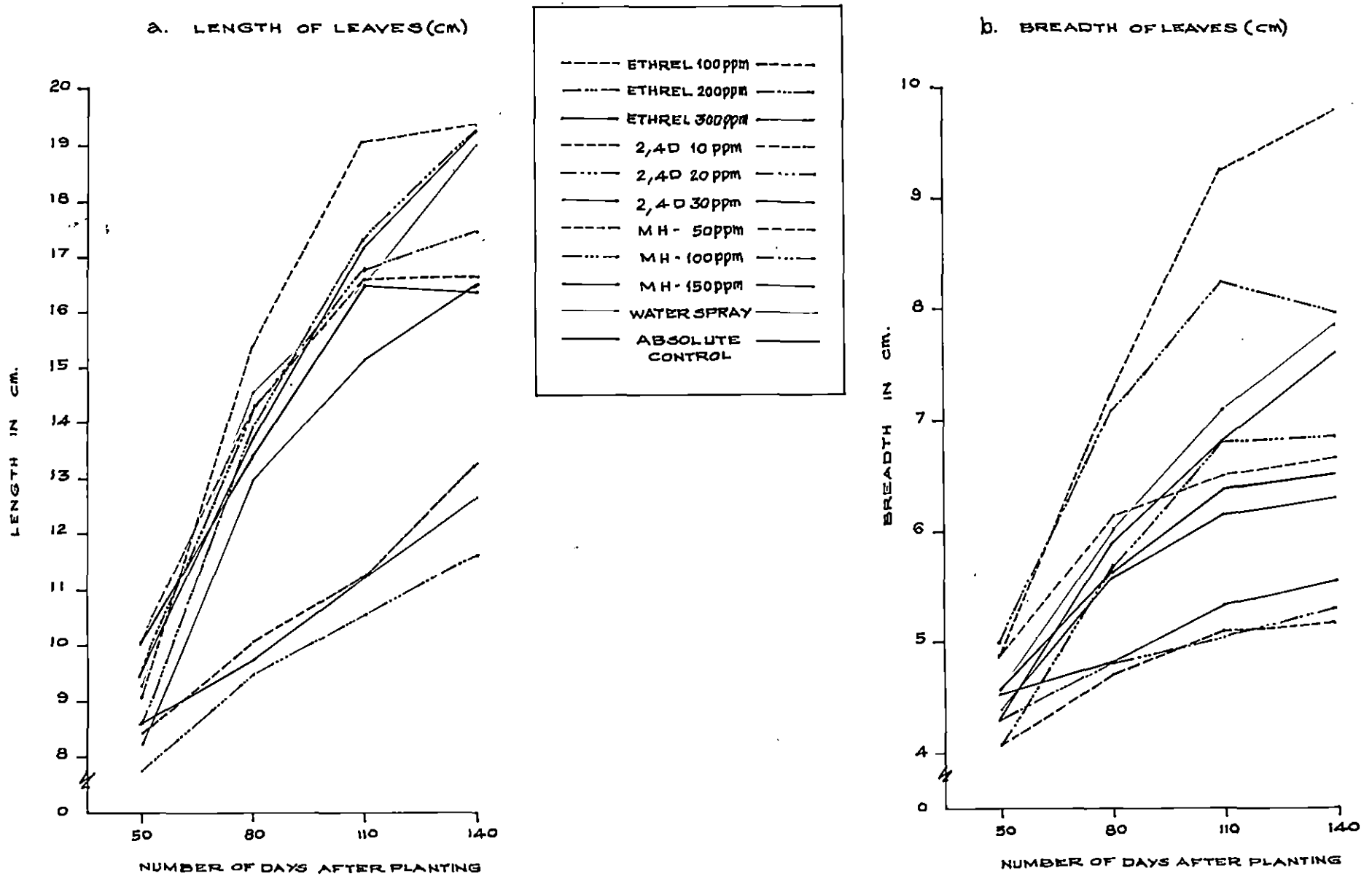
4.1.5. Length and width of leaves

The data on the length and width of the leaves have been presented in Table 6 and Fig.7 and the Anova, in Appendix V. The perusal of the data revealed that effect of the treatments on the length and width of leaves was highly significant from the 80th day onwards. Ethrel exhibited an inhibitory effect on the leaf length and width at all the levels tried. On the 80th, 110th and 140th day, the leaf length was significantly reduced by the ethrel treatments. On the 140th day, ethrel at 100, 200 and 300 ppm brought about 30.93, 38.96 and 34.20 per cent reduction in leaf length when compared to the control. With respect to the length of leaves, the ethrel treatments were significantly inferior to the absolute control, water spray and all the other treatments on the three stages observed. However, the differences in the response between the three levels of ethrel were not statistically significant. On the 80th and 110th day, the treatments including the water spray, except the three levels of ethrel, did not show any significant difference in the leaf length as compared to the control. On the 140th day, along with the three levels of ethrel, the highest levels of

Table 6.- Size of leaves under different levels of ethrel, 2,4-D and MH

Treatments	50th day		80th day		110th day		140th day	
	Length (cm)	Width (cm)	Length (cm)	Width (cm)	Length (cm)	Width (cm)	Length (cm)	Width (cm)
T_1 - Ethrel 100 ppm	8.41	4.08	10.09	4.69	11.25	5.07	13.33	5.17
T_2 - Ethrel 200 ppm	7.77	4.33	9.51	4.82	10.61	5.04	11.78	5.28
T_3 - Ethrel 300 ppm	8.48	4.50	9.83	4.82	10.57	5.35	12.70	5.53
T_4 - 2,4-D 10 ppm	9.07	4.90	15.52	7.27	19.07	9.29	19.51	9.79
T_5 - 2,4-D 20 ppm	8.56	4.98	14.04	7.15	17.40	8.26	19.38	7.98
T_6 - 2,4-D 30 ppm	10.01	4.42	13.46	5.63	16.51	6.17	16.47	6.28
T_7 - MH 50 ppm	9.97	4.41	14.56	6.17	16.71	6.51	16.81	6.72
T_8 - MH 100 ppm	9.53	4.11	14.42	5.68	16.78	6.79	17.52	6.86
T_9 - MH 150 ppm	8.33	4.56	13.02	5.68	15.15	6.42	16.53	6.55
T_{10}- Water spray	9.34	4.62	14.56	6.00	16.53	7.08	19.15	7.86
T_{11}- Absolute control	9.48	4.36	13.79	5.91	17.18	6.80	19.30	7.63
C.D. (0.05)	1.83	0.77	2.04	0.92	2.28	1.26	2.75	1.43

FIG. 7. LENGTH AND BREADTH OF LEAVES (CM)



2,4-D (30 ppm) and MH (150 ppm) also significantly reduced the length of leaves by 14.66 and 14.35 per cent, respectively. The other levels of 2,4-D and MH and the water spray recorded leaf length which were statistically on par with that of the control.

Ethrel reduced the leaf width significantly on the 80th, 110th and 140th day. On the 140th day, the reductions in leaf width were 32.24, 30.80 and 27.52 per cent at 100, 200 and 300 ppm of ethrel, respectively over the control. However, the reduction in leaf width brought about by the three levels of ethrel was on par at all the stages of observation. Leaf width was significantly increased by 2,4-D 10 and 20 ppm over the control on the 80th and 110th day. The effects of the highest level of 2,4-D (30 ppm), the three levels of MH (50, 100 and 150 ppm) and the water spray were not significantly different from that of the control at these stages. On the 140th day, 2,4-D 10 ppm alone was effective in increasing the leaf width significantly. All the other treatments, except the levels of ethrel, recorded leaf width on par with that of the control at the 140th day.

4.1.6. Individual leaf area and leaf area per plant

The data on the leaf area presented in Table 7 and Fig.8, and the Anova presented in Appendix VI showed that individual leaf area and leaf area per plant were significantly

influenced by the application of growth substances from the 80th day onwards.

On the 80th day, the maximum individual leaf area was recorded by 2,4-D 20 ppm. This treatment recorded significantly higher leaf area than the absolute control. But the effect was on par with that of the water spray treatment. At this stage, MH at the three levels, 2,4-D at 10 and 30 ppm and the water spray treatment recorded the individual leaf area which was on par with that of the control. On the 110th day and 140th day 2,4-D at 10 and 20 ppm increased the individual leaf area significantly, being superior to all the other treatments and the control. 2,4-D was more effective in increasing the individual leaf area at 10 ppm than at 20 ppm. 2,4-D at 10 and 20 ppm registered an increase in the individual leaf area by 79.73 and 45.18 per cent, respectively over the control on the 140th day. All the three levels of ethrel significantly reduced the leaf area on the 80th, 110th and 140th day. On the 140th day, individual leaf area was reduced by 32.78, 38.66 and 32.69 per cent of the control in the plants treated with ethrel at 100, 200 and 300 ppm, respectively. The three levels of ethrel were on par with each other on the 80th, 110th and 140th day. However, the individual leaf area in the ethrel treated plants was significantly lower than that of all the other treatments and the absolute control on the 80th and 110th day.

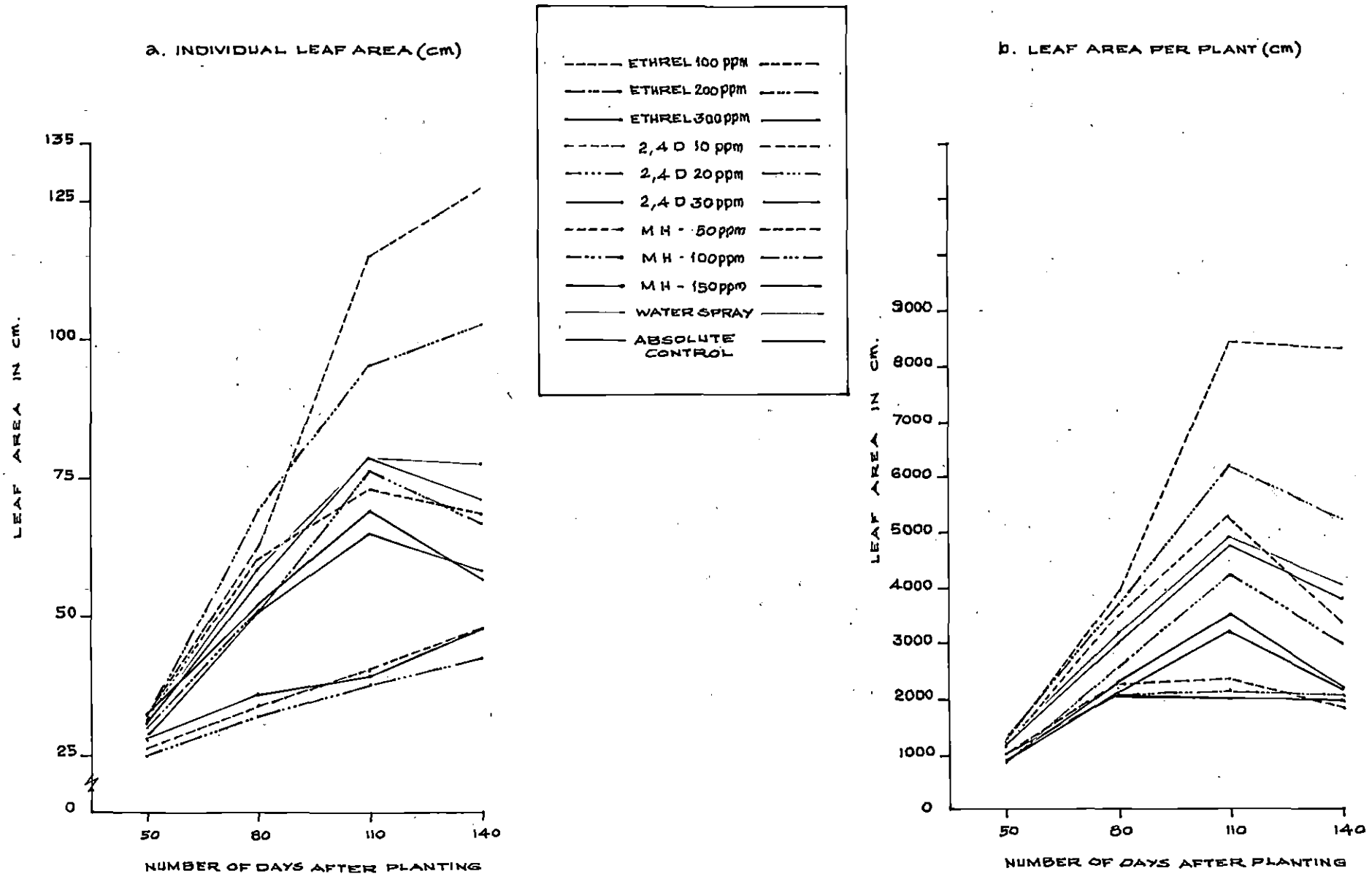
MH at the three levels and 2,4-D at 30 ppm recorded individual leaf area statistically on par with that of the control and water spray treatments on the 110th and 140th day.

The data showed that the growth substances did not exhibit any significant effect on the total leaf area per plant when compared to the control on the 80th day. 2,4-D at 10 and 20 ppm and MH 50 ppm which recorded maximum leaf area per plant were on par with the control. Ethrel at the three levels which recorded the minimum leaf area per plant was also on par with the control. On the 110th day, the maximum leaf area was recorded by the plants treated with 2,4-D 10 ppm. The treatment was significantly superior to all the other treatments and the control. At this stage, a significant reduction in the total leaf area was observed with ethrel at the three levels tried and with 2,4-D at 30 ppm. On the 140th day the total leaf area was maximum in the plants treated with 2,4-D 10 ppm. This treatment was superior to all other treatments and the control. The next best treatment which significantly increased the leaf area against the control was 2,4-D 20 ppm. However, the treatment was on par with the water spray. The increase in the leaf area per plant brought about by 2,4-D 10 and 20 ppm was 124.82 and 40.81 per cent, respectively against the control. 2,4-D exhibited a tendency to reduce the leaf area with increase in concentration on all the stages of observation.

Table 7.- Leaf area (cm) as influenced by the different levels of ethrel, 2,4-D and MH.

Treatments	Mean leaf area (cm)							
	50th day		80th day		110th day		140th day	
	Individual leaf area	Leaf area per plant	Individual leaf area	Leaf area per plant	Individual leaf area	Leaf area per plant	Individual leaf area	Leaf area per plant
T_1 - Ethrel 100 ppm	25.76	1013.24	34.16	2168.45	40.43	2313.59	47.66	1774.66
T_2 - Ethrel 200 ppm	25.15	970.69	33.05	2066.03	38.00	2103.53	43.40	2075.75
T_3 - Ethrel 300 ppm	28.14	1001.21	36.03	2000.36	39.55	2015.67	47.73	1994.83
T_4 - 2,4-D 10 ppm	32.07	1028.78	63.41	3902.43	115.89	8463.46	127.44	8371.90
T_5 - 2,4-D 20 ppm	30.92	1039.18	69.39	3760.75	95.42	6092.65	102.95	5243.78
T_6 - 2,4-D 30 ppm	32.11	915.67	52.25	2124.89	69.04	3289.99	57.84	2170.68
T_7 - MH 50 ppm	32.13	1233.82	60.83	3604.06	73.01	5300.67	67.50	3794.04
T_8 - MH 100 ppm	29.72	871.92	55.92	2557.50	76.23	4190.31	66.73	2950.93
T_9 - MH 150 ppm	28.07	867.79	51.11	2267.89	65.33	3483.91	58.49	2188.27
T_{10}- Water spray	31.03	1176.64	59.33	3188.24	78.32	4903.33	76.52	3982.73
T_{11}- Absolute control	30.48	1088.99	55.81	2997.69	78.20	4800.61	70.91	3723.76
C.D. (0.05)	7.28	424.20	12.93	1126.16	16.87	1479.75	21.91	1347.97

FIG. 8. INDIVIDUAL LEAF AREA AND LEAF AREA PER PLANT (cm)



Ethrel at the three levels (100, 200 and 300 ppm) reduced the leaf area per plant on the 140th day as well. The reduction in leaf area was 52.30, 44.26 and 46.42 per cent at 100, 200 and 300 ppm of ethrel, respectively. Similarly, the highest levels of 2,4-D (30 ppm) and MH (150 ppm) also reduced the leaf area significantly by 41.7 and 41.23 per cent respectively at this stage. However, the reduction in leaf area recorded by the three levels of ethrel and the highest levels of 2,4-D and MH did not differ significantly.

4.1.7. Internodal length of shoots

The data on internodal length of shoots at harvest presented in Table 8 and the Anova presented in Appendix VII indicated that there was significant difference in the internodal length of shoots as a result of application of growth substances. The internodal length of shoots was significantly reduced by ethrel at all the levels tried. Ethrel 300 ppm was significantly different from the other levels of ethrel and all the other treatments, the water spray and the control. A 55.66 per cent reduction in the internodal length, against the control, was recorded by the plants treated with ethrel 300 ppm. The reductions were 20.44 and 34.27 per cent for ethrel at 100 and 200 ppm, respectively. The internodal length recorded in 100 ppm ethrel was statistically on par with that of the water spray treatment. 2,4-D and MH, at the

levels tried, did not influence the internodal length of shoots.

4.1.8. Shoot dry matter content

The data on the shoot dry matter content were analysed and the results have been presented in Table 8, Fig.9 and Appendix VII. The results indicated that there was significant difference in the shoot dry matter content by the application of growth substances. Ethrel, at the three levels tried, significantly increased the dry matter content of shoots and was superior to all the levels of 2,4-D and MH, the absolute control and the water spray treatment. Plants treated with ethrel 100 ppm recorded the maximum dry matter content (25.16 per cent as against 14.67 per cent in the control). However, the different levels of ethrel were statistically on par with respect to dry matter content. There was no significant difference between the control, the water spray and the levels of 2,4-D and MH on their influence on the dry matter content of shoots.

4.1.9. Shoot/rhizome ratio

The data on the shoot/rhizome ratio have been presented in Table 8, Fig.10 and the Anova in Appendix VII. The results indicated that there was a significant reduction in the shoot/rhizome ratio in plants sprayed with the different levels of ethrel and MH, as compared to those of the controls. The maximum reduction in the shoot/rhizome ratio was obtained

Table 8.- Internodal length (of shoot), dry matter percentage (of shoot) and shoot/rhizome ratio in plants treated with ethrel, 2,4-D and MH.

Treatments	Average internodal length of shoot (cm)	Average dry matter percentage of shoot (cm)	Average shoot/rhizome ratio
T_1 - Ethrel 100 ppm	2.53	25.16	0.21
T_2 - Ethrel 200 ppm	2.09	21.59	0.23
T_3 - Ethrel 300 ppm	1.41	22.02	0.19
T_4 - 2,4-D 10 ppm	2.78	14.57	0.36
T_5 - 2,4-D 20 ppm	3.20	16.23	0.32
T_6 - 2,4-D 30 ppm	2.87	13.32	0.42
T_7 - MH 50 ppm	3.06	14.20	0.26
T_8 - MH 100 ppm	2.96	16.38	0.25
T_9 - MH 150 ppm	2.83	13.41	0.24
T_{10}- Water spray	3.00	13.10	0.41
T_{11}- Absolute control	3.18	14.67	0.40
C.D. (0.05)	0.57	4.31	0.12

FIG. 9. DRY MATTER PERCENTAGE OF SHOOT

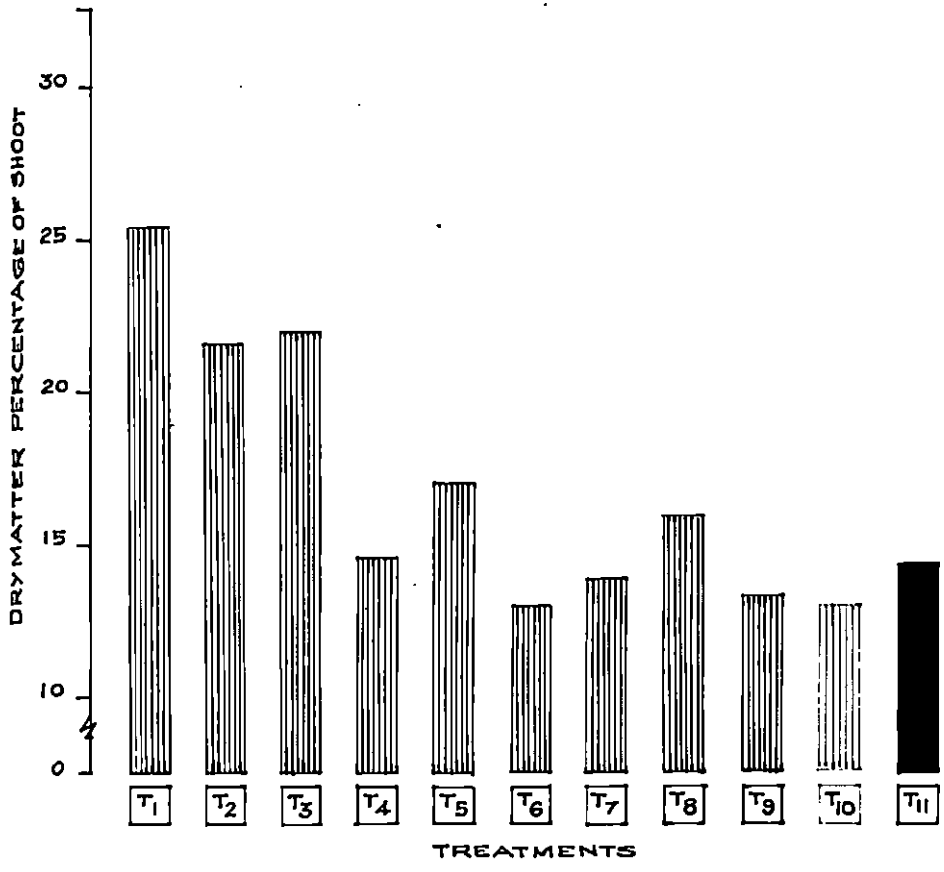
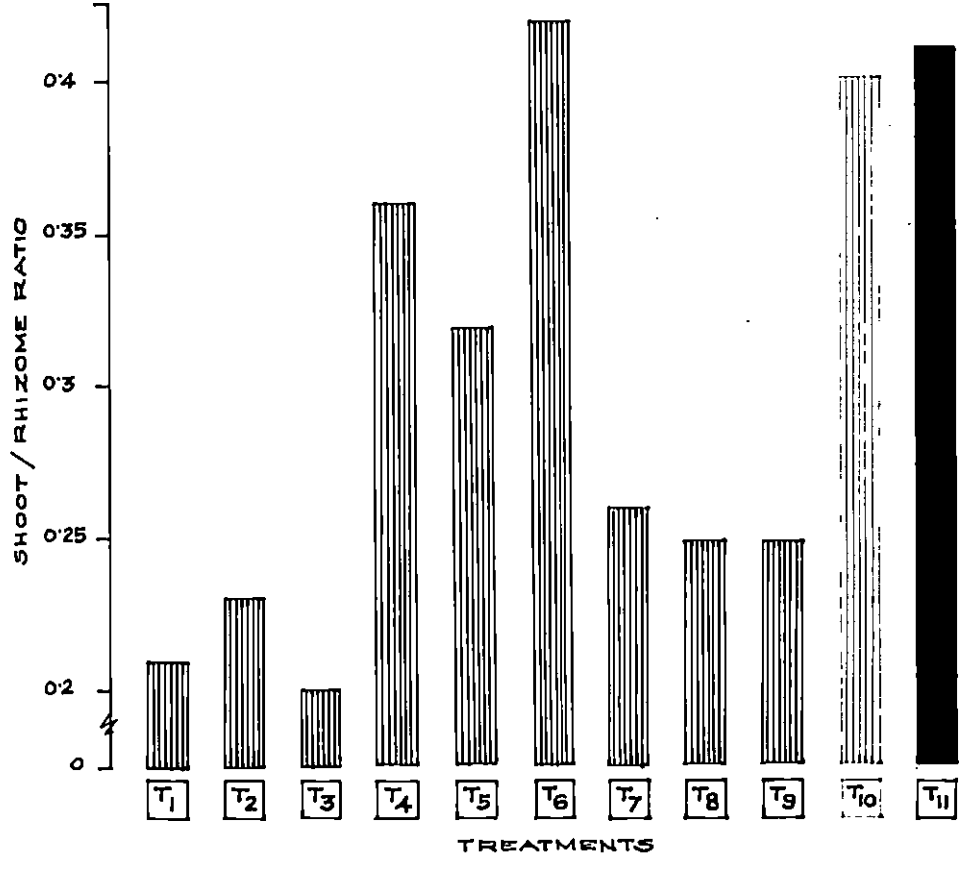


FIG.10. SHOOT/RHIZOME RATIO



with 300 ppm ethrel which gave a shoot/rhizome ratio of 0.19, as against 0.40 of the control. The different levels of ethrel and MH were statistically on par in their ability to reduce the shoot/rhizome ratio. 2,4-D 30 ppm showed slightly higher ratio than the control and the water spray treatments. However, the differences in the shoot/rhizome ratio were not significant between the three levels of 2,4-D, control and water spray.

4.2. Rhizome characters

4.2.1. Character of main rhizomes

The data on the characters of the main rhizome are presented in Table 9, Fig.11 and the Anova in Appendix VIII. A perusal of the data revealed that the number and the length of the main rhizome were not influenced by the application of the growth substances. However, there was significant difference in the internodal length of main rhizomes caused by the application of growth substances. 2,4-D at 10 ppm significantly increased the internodal length of main rhizomes by 31.62 per cent over the control. However, the response was on par with that of the water spray treatment. Other levels of 2,4-D, the three levels of ethrel and the three levels of MH did not influence the internodal length of rhizomes significantly.

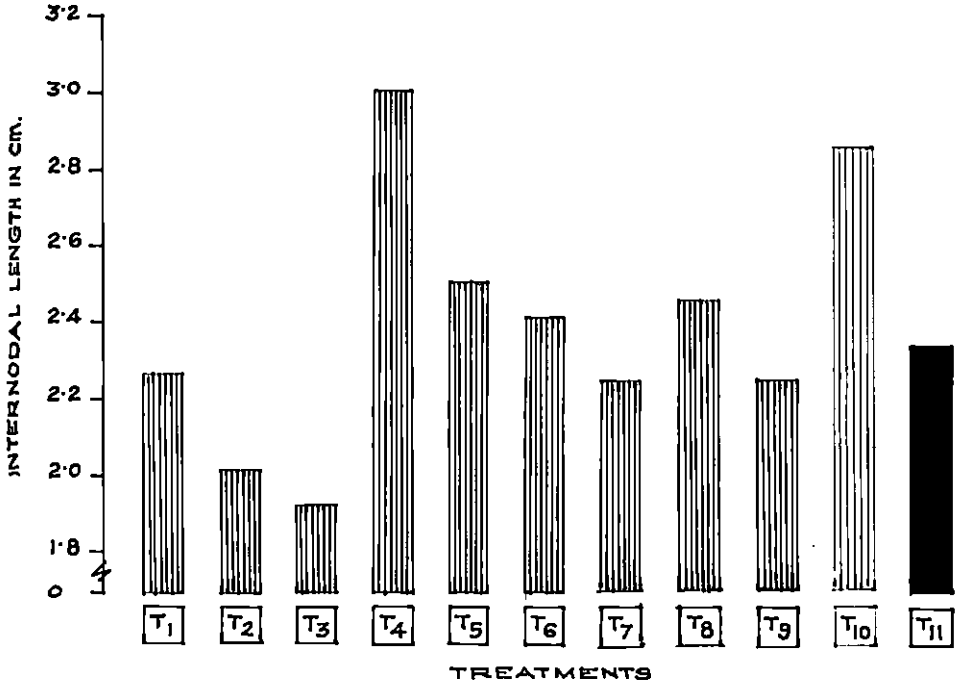
The girth of the main rhizome also was significantly influenced by the treatments. Ethrel at 100 and 200 ppm

Table 9.- Character of main rhizome in plants under different levels of ethrel, 2,4-D and MH.

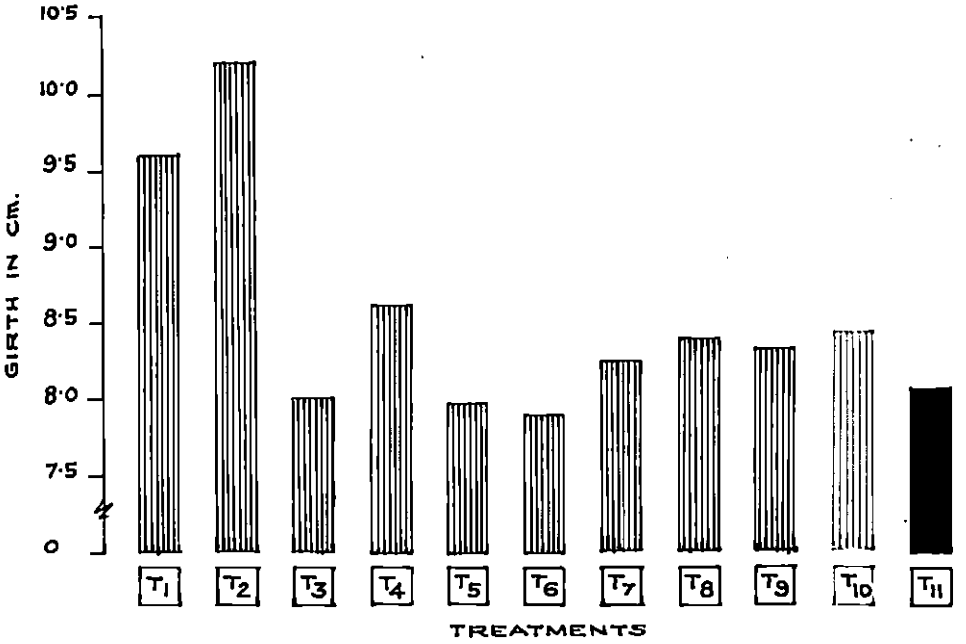
Treatments	Main rhizome			
	Number	Length (cm)	Internodal length (cm)	Girth (cm)
T_1 - Ethrel 100 ppm	1.67	31.75	2.27	9.62
T_2 - Ethrel 200 ppm	1.90	32.50	2.07	10.29
T_3 - Ethrel 300 ppm	1.67	25.38	1.93	8.02
T_4 - 2,4-D 10 ppm	1.67	40.09	3.08	8.63
T_5 - 2,4-D 20 ppm	1.75	29.97	2.51	7.96
T_6 - 2,4-D 30 ppm	1.67	27.75	2.42	7.88
T_7 - MH 50 ppm	2.33	27.64	2.26	8.24
T_8 - MH 100 ppm	2.00	43.37	2.47	8.38
T_9 - MH 150 ppm	1.99	27.03	2.26	8.35
T_{10}- Water spray	1.67	35.21	2.86	8.44
T_{11}- Absolute control	1.58	30.16	2.34	8.08
C.D. (0.05)	0.70	12.89	0.52	1.17

FIG. 11. CHARACTER OF MAIN RHIZOME

a. MAIN RHIZOME - INTERNODAL LENGTH



b. GIRTH OF MAIN RHIZOME



brought about a significant increase in the girth of main rhizomes. The increase in girth was 19.06 and 26.48 per cent (over control) for ethrel 100 and 200 ppm, respectively. 2,4-D 10 ppm recorded higher girth than the water spray and the absolute control; but the difference was not statistically significant. Other levels of 2,4-D (20 and 30 ppm), the highest level of ethrel (300 ppm) and the three levels of MH (50, 100 and 150 ppm) were ineffective in increasing the girth of the main rhizome.

4.2.2. Character of primary fingers

The data on the character of primary fingers have been presented in Table 10, Fig.12 and the Anova in Appendix IX. Observations revealed that the internodal length and girth of primary fingers were not significantly influenced by the application of growth substances. However, ethrel at 100 and 200 ppm increased the girth by 29.42 and 31.54 per cent, respectively, over the control, though the differences were statistically not significant.

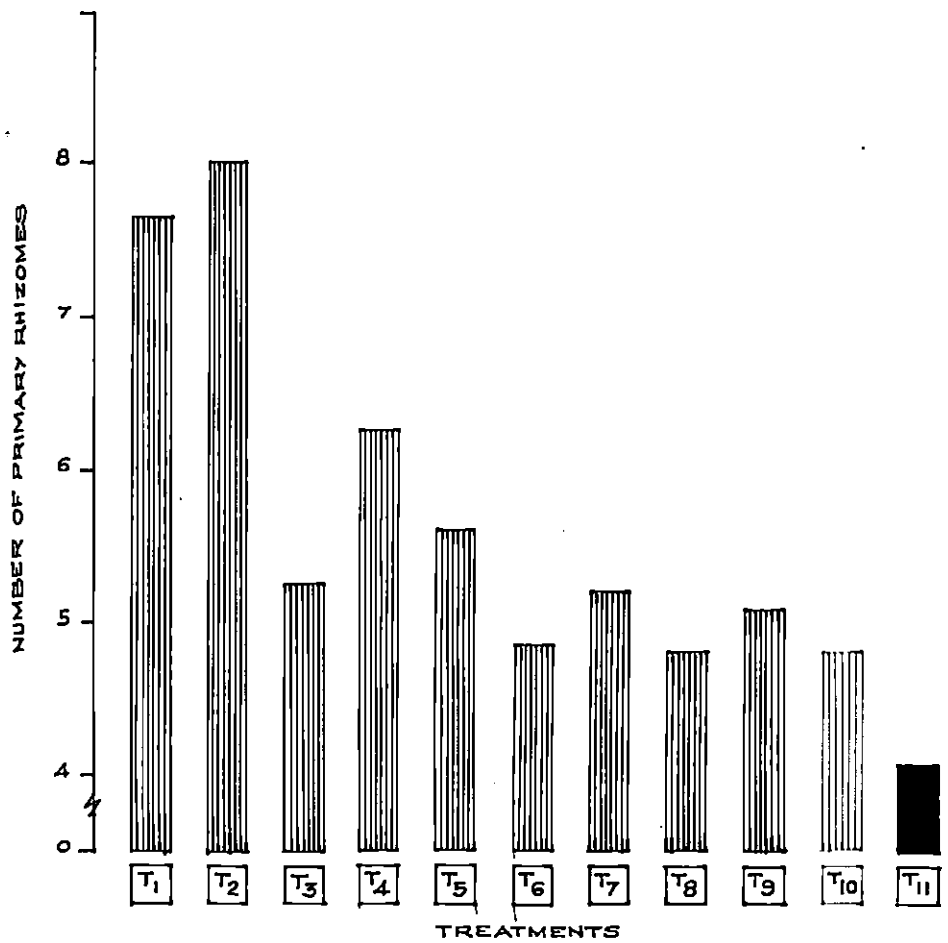
The two lower concentrations of ethrel (100 and 200 ppm) had significant effects on the number of primary fingers. The mean number of primary fingers was the maximum (8.00) in the plants treated with ethrel 200 ppm, followed by ethrel 100 ppm (7.66), as against the control (4.03). 2,4-D 10 and 20 ppm also increased the number of primary fingers significantly when compared to the absolute control, but the effect was on

Table 10.- Character of primary rhizomes in plants under different levels of ethrel, 2,4-D and MH

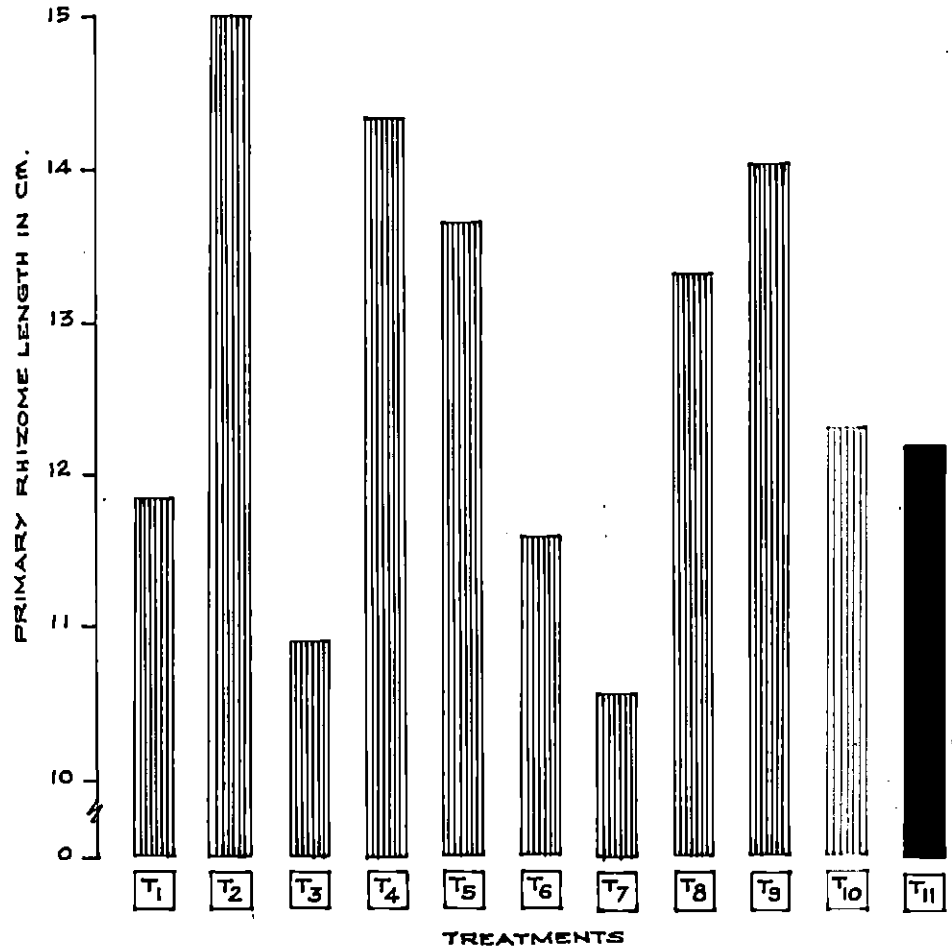
Treatments	Primary rhizome (fingers)			
	Number	Length (cm)	Internodal length (cm)	Girth (cm)
T_1 - Ethrel 100 ppm	7.66	11.85	1.54	7.92
T_2 - Ethrel 200 ppm	8.00	15.07	1.65	8.05
T_3 - Ethrel 300 ppm	5.25	10.90	1.53	6.50
T_4 - 2,4-D 10 ppm	6.25	14.37	1.77	6.89
T_5 - 2,4-D 20 ppm	5.58	13.67	1.71	6.97
T_6 - 2,4-D 30 ppm	4.83	11.59	1.60	7.07
T_7 - MH 50 ppm	5.18	10.56	1.75	6.76
T_8 - MH 100 ppm	4.83	13.31	1.68	6.95
T_9 - MH 150 ppm	5.08	14.03	1.62	7.26
T_{10}- Water spray	4.83	12.30	1.72	6.25
T_{11}- Absolute control	4.03	12.22	1.71	6.12
C.D. (0.05)	1.43	2.45	0.21	1.41

FIG.12. CHARACTER OF PRIMARY RHIZOME

a. NUMBER OF PRIMARY RHIZOME



b. LENGTH OF PRIMARY RHIZOME



par with that of the water spray treatment. The highest levels of ethrel (300 ppm) and 2,4-D (30 ppm) and all the levels of MH were statistically on par with the control with respect to the number of primary fingers.

The length of primary fingers also differed significantly with the application of the growth substances. Ethrel 200 ppm was significantly superior to all the other treatments. The treatment recorded a 23.32 per cent increase in the length of primary fingers over the control. Longer primary rhizomes were also produced in plants treated with 2,4-D at 10 and 20 ppm and MH at 100 and 150 ppm. However, the length of the primary fingers in these treatments was on par with that of the control and the water spray.

4.2.3. Characters of secondary fingers

The data on the characters of secondary fingers have been presented in Table 11 and the Anova, in Appendix X. The number of secondary fingers was significantly increased by ethrel 100 ppm, followed by 200 ppm. MH 150 ppm also significantly increased the number of secondary fingers compared to the control; but the effect was on par with that of water spray treatment. The three levels of 2,4-D (10, 20 and 30 ppm), the two higher levels of MH (100 and 150 ppm) and the highest level of ethrel (300 ppm) produced secondary fingers statistically on par with that of the absolute control and the water spray.

Table 11.- Character of secondary rhizomes in plants under different levels of ethrel, 2,4-D and MH

Treatments	Secondary rhizome (fingers)			
	Number	Length (cm)	Internodal length (cm)	Girth (cm)
T_1 - Ethrel 100 ppm	4.18	3.07	1.07	5.37
T_2 - Ethrel 200 ppm	3.42	3.19	1.06	4.89
T_3 - Ethrel 300 ppm	2.08	2.62	0.90	4.56
T_4 - 2,4-D 10 ppm	1.92	2.35	1.11	3.87
T_5 - 2,4-D 20 ppm	2.33	3.05	0.99	5.01
T_6 - 2,4-D 30 ppm	1.92	3.68	1.14	4.48
T_7 - MH 50 ppm	1.17	3.67	1.16	4.67
T_8 - MH 100 ppm	1.83	2.39	1.07	4.88
T_9 - MH 150 ppm	2.67	2.45	0.98	5.08
T_{10}- Water spray	1.91	2.47	0.10	4.75
T_{11}- Absolute control	1.33	3.30	1.26	4.78
C.D. (0.05)	1.28	1.72	0.40	0.98

The three growth substances at the concentrations tried had no significant effect on the length, internodal length and girth of the secondary fingers.

4.3. Yield and quality

4.3.1. Yield of green rhizomes

The data on the yield of green rhizomes have been presented in Table 12 and Fig.13. The Anova presented in Appendix XI indicated that there was highly significant variation in yield due to the application of growth substances. Ethrel 200 ppm which registered the highest yield was significantly superior to all the other treatments and the controls. The increase in the yield of green rhizomes brought about by 200 ppm ethrel was 60.51 per cent over the control. 2,4-D 10 ppm, ethrel 100 ppm and 2,4-D at 20 ppm also, significantly increased the yield of green rhizomes. The increase in yield was 34.78 per cent, 31.97 per cent and 30.75 per cent respectively. MH 50 and 100 ppm recorded yields on par with the control. The highest levels of all the three growth substances yielded less rhizomes than the control and the water spray. However, the differences in the yield recorded by these treatments were not significant when compared to the control.

4.3.2. Dry matter content and dry rhizome yield

The data on the dry matter content and dry rhizome yield of plants have been presented in Table 12, Fig.14 and the

Anova in Appendix XI. With respect to the dry matter content of the rhizomes the treatment differences were statistically significant. The dry matter content was the highest in the rhizomes of plants treated with 200 ppm ethrel which recorded a dry matter content of 28.30 per cent as against 20.93 per cent in the control. Ethrel 100 and 300 ppm, and MH 50 and 100 ppm also recorded higher dry matter content than the control and the water spray; but the differences were statistically not significant when these treatments were compared to the control. 2,4-D at the levels tried, recorded lesser dry matter content than the control. The dry matter content of the rhizomes was the least in plants subjected to water spray. However, the three levels of 2,4-D and the water spray were on par with the control.

Maximum yield of dry rhizome was given by ethrel 200 ppm which was significantly superior to all the other treatments and the controls. This was followed by ethrel 100 ppm. The yield of dry rhizome was 12.15 t/ha and 9.06 t/ha for 200 and 100 ppm ethrel, respectively, as against 6.05 t/ha for the absolute control. MH 50 and 100 ppm and 2,4-D 10 and 20 ppm also increased the dry rhizome yield; but was on par with that of the absolute control. The highest concentrations of the three growth substances and the water spray recorded less dry rhizome yield than the control. However, these were statistically on par.

Table 12.- Green and dry rhizome yields, dry matter and diosgenin content, and yield of diosgenin under different levels of ethrel, 2,4-D and MH

Treatments	Yield of green rhizomes (t/ha)	Dry matter content (%)	Yield of dry rhizomes (t/ha)	Diosgenin content (%)	Yield of diosgenin (kg/ha)
T_1 - Ethrel 100 ppm	34.76	26.20	9.06	1.52	138.50
T_2 - Ethrel 200 ppm	42.28	28.30	12.15	1.64	197.43
T_3 - Ethrel 300 ppm	23.54	25.33	5.79	1.17	68.85
T_4 - 2,4-D 10 ppm	35.50	19.23	6.89	1.83	126.30
T_5 - 2,4-D 20 ppm	34.44	18.13	6.24	1.57	99.01
T_6 - 2,4-D 30 ppm	23.81	19.00	4.53	1.14	51.30
T_7 - MH 50 ppm	29.74	25.00	7.32	1.59	116.28
T_8 - MH 100 ppm	32.01	21.16	6.79	1.64	112.48
T_9 - MH 150 ppm	23.91	18.60	4.48	1.26	55.62
T_{10}- Water spray	25.23	18.03	4.57	1.14	51.74
T_{11}- Absolute control	26.34	20.93	6.05	1.16	70.56
C.D. (0.05)	6.35	5.91	2.67	0.21	44.04

FIG.13. YIELD OF GREEN RHIZOMES

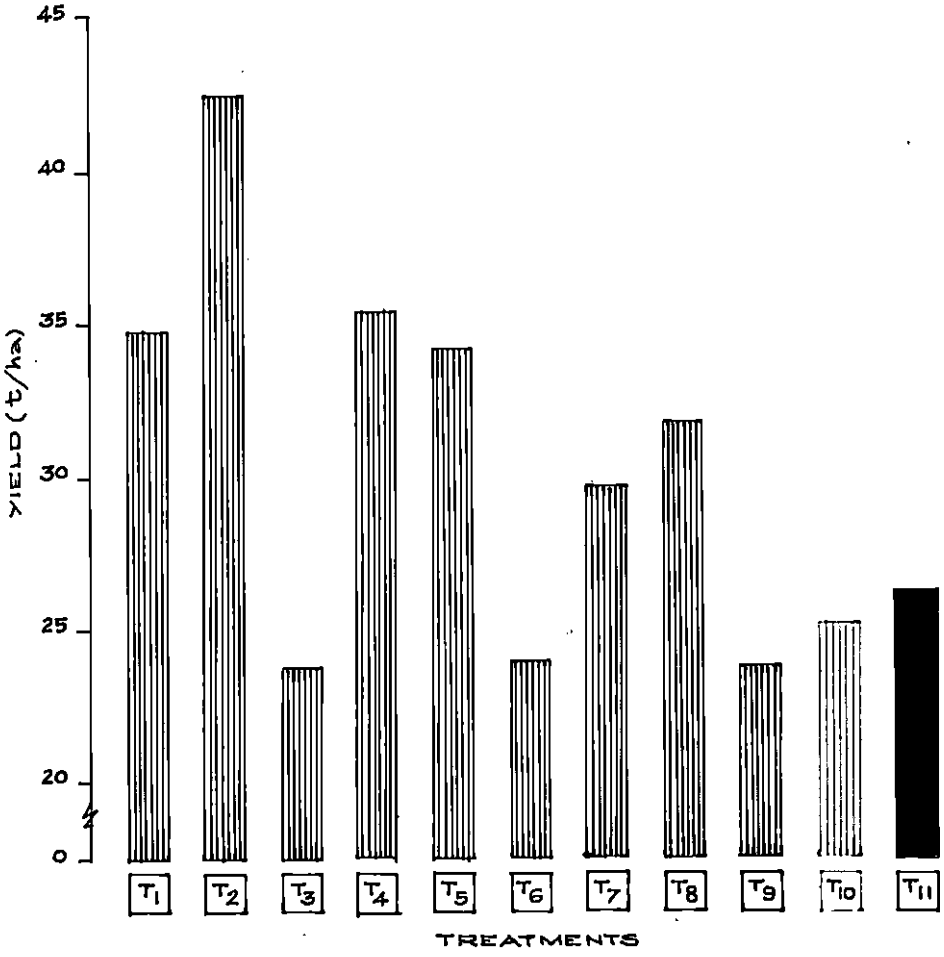
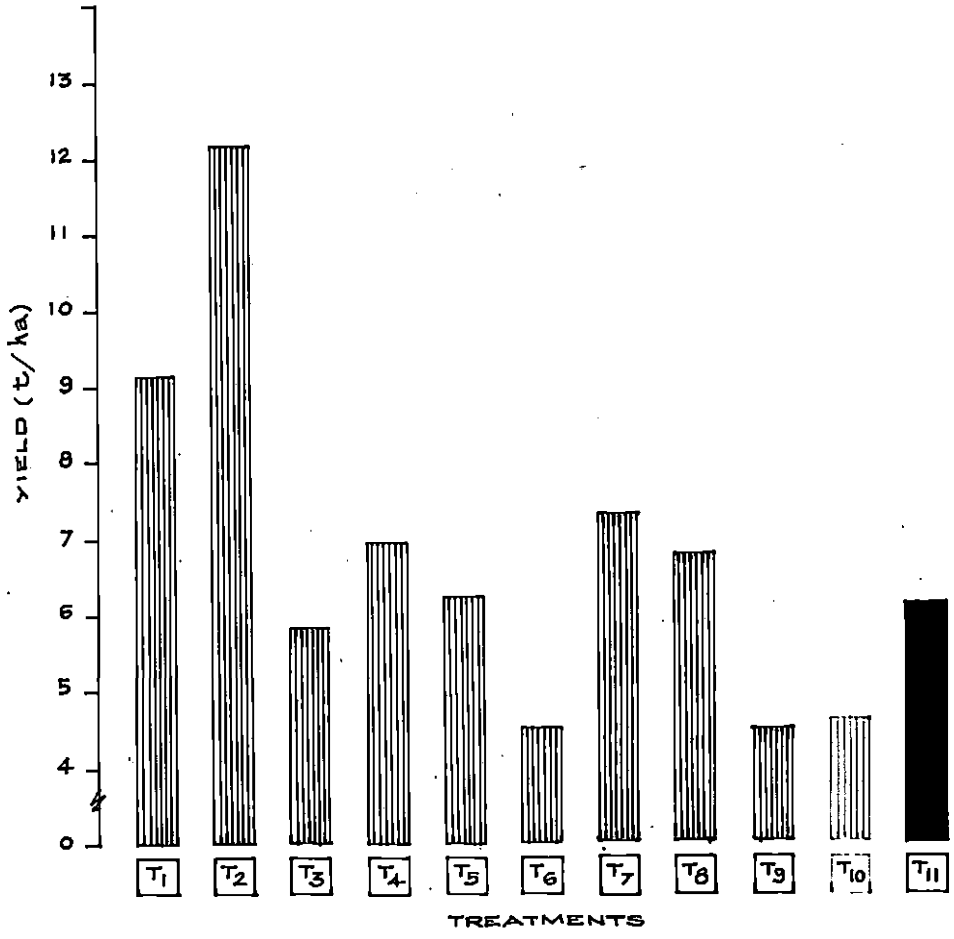


FIG.14. YIELD OF DRY RHIZOMES



4.3.3. Diosgenin content and yield of diosgenin

The data on the diosgenin content and diosgenin yield have been presented in Table 12, Fig.15 and the Anova, in Appendix XI. The data revealed that there was significant differences in the content of diosgenin as a result of the application of the growth substances. The diosgenin content of the rhizomes was the highest in plants treated with 2,4-D 10 ppm, followed by ethrel 200 ppm and MH 100 ppm. 2,4-D 10 ppm registered a diosgenin content of 1.83 per cent, compared to 1.64 for ethrel 200 ppm and MH 100 ppm, and 1.16 for the control. Significant increase in the diosgenin content of rhizome was also recorded in MH 50 ppm, 2,4-D 20 ppm and ethrel 100 ppm. The highest levels of the three growth substances recorded diosgenin content, statistically on par with that of the control and the water spray. The diosgenin content decreased with increase in the concentration of 2,4-D applic...

Ethrel 200 ppm was significantly superior to all the other treatments and the controls in increasing the yield of diosgenin per ha. This treatment recorded 179.8 per cent increase in diosgenin yield per ha, compared to the absolute control. Significant increase in diosgenin yield was also given by the lowest levels of ethrel, 2,4-D and MH. The diosgenin yield per ha recorded by the two higher levels of 2,4-D (20 and 30 ppm) and MH (100 and 150 ppm) and the highest

FIG.15a. DIOSGENIN CONTENT OF RHIZOMES.

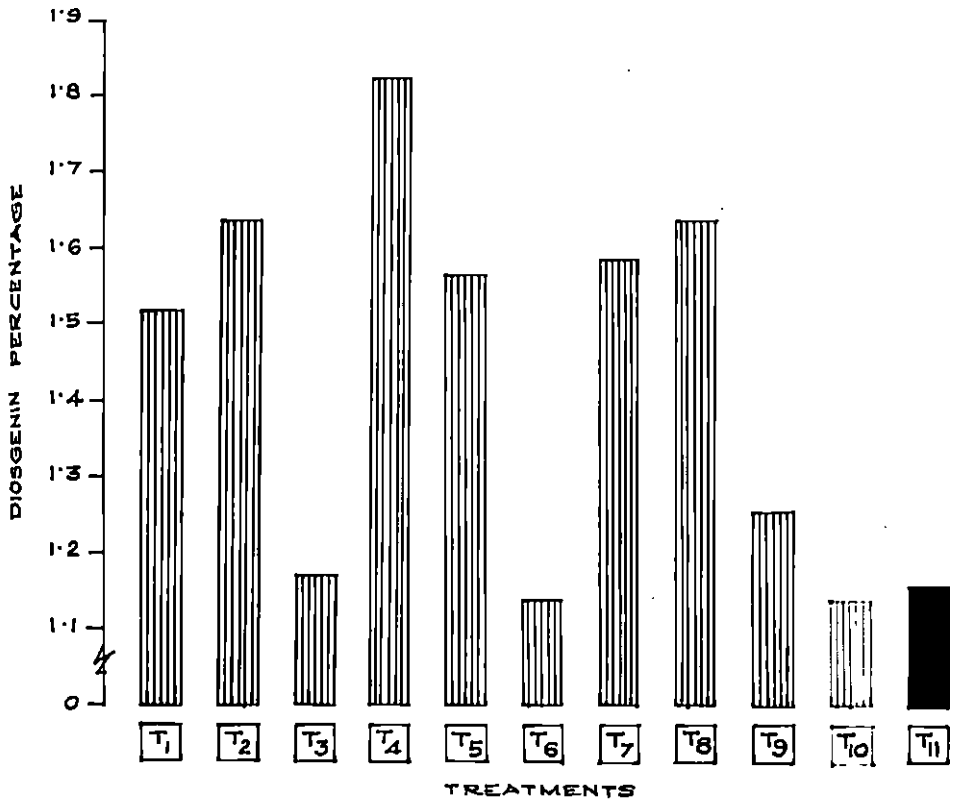
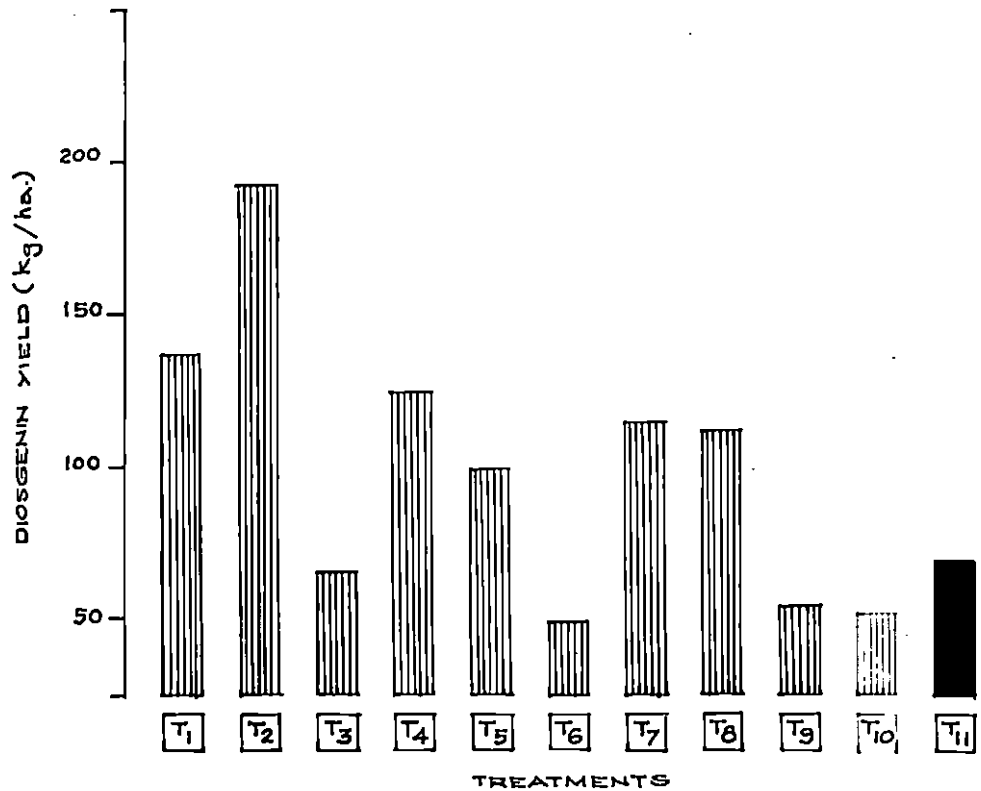


FIG.15b. YIELD OF DIOSGENIN.



level of ethrel (300 ppm) was not significantly different from that of the control.

4.4. Correlation studies

Correlation between the morphological characters of the plant, the rhizome characters and the yield on the one hand and the diosgenin yield per plant on the other, were worked out. The correlation coefficients have been presented in Table 13.

The number of tillers per plant, the number of primary rhizomes, the girth of primary rhizomes, the dry matter content of the rhizomes and the diosgenin content of rhizomes showed highly significant positive correlation with the yield of diosgenin per plant. Positive correlation significant at five per cent level was observed between the number of secondary fingers and diosgenin yield per plant. The plant height and leaf area per plant showed negative correlation with yield of diosgenin, though the correlation was not significant. Positive correlations were observed between characters such as the number of main rhizomes per plant, the number of leaves, the length and girth of the main rhizome, length of primary fingers, the girth of secondary fingers and shoot/rhizome ratio, and the yield of diosgenin per plant. However, there were not statistically significant.

Table 13.- Correlation between the growth and yield parameters, and the yield of diosgenin per plant

y	x	Correlation coefficients (r)
Yield of diosgenin per plant	Height of the plant	- 0.166
"	Number of tillers per plant	+ 0.667**
"	Number of leaves per plant	+ 0.272
"	Leaf area per plant	- 0.089
"	Number of main rhizomes per plant	+ 0.280
"	Length of main rhizome	+ 0.192
"	Girth of main rhizome	+ 0.277
"	Number of primary rhizomes	+ 0.667**
"	Length of primary finger	+ 0.300
"	Girth of primary finger	+ 0.451**
"	Number of secondary fingers	+ 0.371*
"	Length of secondary rhizomes	+ 0.038
"	Girth of secondary finger	+ 0.076
"	Yield of green rhizomes per plant	+ 0.675**
"	Dry matter content of rhizomes (%)	+ 0.631**
"	Diosgenin content (%)	+ 0.613**
"	Shoot/rhizome ratio	+ 0.205

n = 33 df = 31

* = Significant at five per cent level

** = Significant at one per cent level

Table 14.- Economics of the application of different levels of ethrel, 2,4-D and MH

Treatments	Cost of production per ha in rupees	Yield of crude diosgenin (60%) (kg per ha)	Yield of pure diosgenin (kg per ha)	Income per ha in rupees	Profit/loss per ha in rupees
Ethrel 100 ppm	33755.00	138.50	83.10	45705.00	+11950.00
Ethrel 200 ppm	44522.00	197.43	118.45	65147.50	+20625.50
Ethrel 300 ppm	21542.00	68.85	41.31	22720.50	+ 1178.50
2,4-D 10 ppm	31447.00	126.30	75.78	41679.00	+10232.00
2,4-D 20 ppm	26586.00	99.01	59.41	32675.50	+ 6089.50
2,4-D 30 ppm	18137.00	51.30	30.78	16929.00	- 1208.00
MH 50 ppm	29699.00	116.28	69.77	38373.50	+ 8674.50
MH 100 ppm	29120.00	112.48	67.49	37119.50	+ 8079.50
MH 150 ppm	18989.00	55.62	33.37	18353.50	- 635.50
Control	21087.50	70.56	42.34	23287.00	+ 2199.50

Table 15.- Chemical characteristics of the soil in the experimental plot

Constituent	Content in soil		*Rating	Method used for estimation
	Before the experiment	After the experiment		
Total nitrogen (%)	0.042	0.040	low	Microkjeldahl (Jackson, 1958)
Available P_2O_5 (ppm)	4.83	5.02	low	In Bray I extract, Chlorostannous reduced Molybdophosphoric blue colour method (Jackson, 1958)
Available K_2O (ppm)	160.91	146.30	medium	In neutral ammonium acetate extract - flame photometric method (Jackson, 1958)
pH	5.2	5.4	acidic	1:2.5 soil:water suspension using pH meter

* Muhr et al. (1965)

4.5. Economics of cultivation

The cost of cultivation of the crop and the net profit that could be expected from adopting the various growth regulator treatments was computed, based on the yield of crude diosgenin (of 60 per cent purity) per ha and have been presented in Table 14. The price of diosgenin was taken as Rs.550/- per kg (Anon., 1982) for the calculation of net profit. Ethrel at 200 ppm gave the greatest return per hectare. The treatment recorded a profit of Rs.20,625.5 against Rs.2,199.5 of the control. The next highest profit was recorded by ethrel 100 ppm followed by 2,4-D 10 ppm. 2,4-D 30 ppm and MH 150 ppm was found to be unprofitable recording a loss of over Rs.1208/- and Rs.635.5 respectively. 2,4-D 20 ppm, MH 50 ppm and MH 100 ppm recorded a nominal profit.

4.6. Chemical characteristics of soil

The soil at the experimental site was acidic, low in N and P and medium with respect to K, based on the conventional soil test rating. The results of soil chemical analysis have been presented in Table 15.

5. DISCUSSION

The investigations reported in this thesis were undertaken at the College of Horticulture, Vellanikkara during 1982-'83 to study the effects of ethrel, 2,4-D and MH on the growth, rhizome yield and diosgenin content in Costus speciosus. The results of the investigations are discussed here.

5.1. Growth characters

The growth parameters studied, namely, the height of plants, the internodal length of shoots, the number of tillers, the number of leaves, and the leaf area per plant were found to be significantly influenced by the application of the growth substances.

At the levels tried, ethrel exhibited an inhibitory effect on the plant height and produced plants shorter than in the other treatments. The plant height was significantly reduced by the three levels of MH also, especially on the 110th and 140th days after planting. Such inhibitory effect was not observed in 2,4-D treatments in which the plant height was on par with that of the control. In general, there was not much difference in the height of plants between 110th and 140th days which suggested that the plants attained their maximum height by about 110 days after planting. This may be due to the fact that, flowering in costus coincided with the

third and final application of the growth substances (on 120th day) and because in costus, the height of the plants does not increase after flowering due to the production of terminal inflorescence.

The inhibitory effect of ethrel on the height of plants (or on the parameters such as the length of vine, length of internode, etc.) as observed in the present study is evident in the reports of several investigators in root and rhizomatous crops. Tompkins and Bowers (1970) observed reduction in the length of vines, while Biswas et al. (1980) and Vahab (1980) recorded suppression of elongation of the vines in sweet potato treated with ethrel. Bryan and McMillan (1975) reported a reduction in shoot length with increasing concentrations of ethrel in Dioscorea alata cv. Blanco. Extension growth of stem was suppressed by ethrel at concentrations above 200 microgram/ml in Dioscorea sp. (Nandi and Chatterjee, 1975). Plant height was reduced in onion (Lipe, 1976) and coleus (Khosh-kui et al., 1978) when they were sprayed with ethrel. Jayachandran (1978) observed significant reduction in plant height at 120 days after planting in ginger, by ethrel application.

In the present study, the plant height was reduced by the application of MH also. Reports on the inhibitory effect of MH on plant height are scarce in root and rhizomatous crops.

As such, the results of the present investigation in this respect are to be viewed in the light of the findings of Bose and Hamner (1960) in tomato, Chauhan and Singh (1972) in chilli, Guzman (1971) in radish, and Sen and Maharana (1972) and Shanmugam and Muthuswamy (1973) in chrysanthemum. These workers have observed reduced plant height due to the application of MH. However, Tosh et al. (1978) and Sabina George (1981) recorded increases in plant height on application of 2000 to 5000 ppm MH to bhindi (cv. Pusa sawani) and 75 ppm MH to turmeric, respectively. MH is known to inhibit meristematic activities in shoot tip (Krishnamoorthy, 1981) and as such the reduction in plant height can be expected.

Plant height is a function of the number of nodes (internodes) and the length of the internodes. Any treatment that influences one or both of the above will influence the plant height also. In the present studies, the internodal length of shoots was found to be drastically reduced by the application of ethrel at the levels tried. The reduction in the internodal length increased with increasing concentrations of ethrel. Although MH, at the three levels tried, produced shorter internodes than the absolute control, the results were not conclusive in as much as the MH treatments were on par with the controls.

Tompkins and Bowers (1970) and Vahab (1980) recorded

shorter internodes in ethrel treated sweet potato plants and Rajmohan (1978), in ethrel treated Coleus parviflorus.

The reduction in the length of internodes and the suppression in the height of plants and length of vines caused by ethrel could be attributed to the release of ethylene by the chemical which inhibits auxin transport (Morgan and Gausman, 1966) and interferes with IAA synthesis (Leopold and Kriedemann, 1975). Ethylene may also inhibit bud growth by interfering with cell division (Apelbaum and Burg, 1972). The height reduction observed in the ethrel treated plants in the present study may be due to the shorter internodes observed. Number of nodes (internodes) was not included in the present study, which could have yielded further evidence in this regard. With regard to MH treatments, eventhough shorter internodes were produced, they were on par with those of the controls. However it may be recalled that the MH treated plants were significantly shorter than the controls on the 110th and 140th days.

One of the important growth parameters with decisive influence on the final yield is the number of tillers. Tiller production was significantly higher in the plants treated with ethrel at the two lower levels (100 and 200 ppm) and MH at the lowest level (50 ppm) on the 110th and 140th days. The rest of the treatments including the three levels of 2,4-D and waterspray were on par with the control.

Enchancement of tiller production as a result of application

of ethrel has been reported by Muthukrishnan *et al.* (1974), Shanmugam and Srinivasan (1974) and Vahab (1980) in sweet potato, by Jayachandran (1978) in ginger, by Rajmohan (1978) in *Coleus parviflorus* and by Shoushan *et al.* (1981) in *Adonis autumnalis*. The promotion of tillering and lateral growth by ethrel may be a result of the suppression of apical dominance, as suggested by Hradilik (1974) and Muthukrishnan *et al.* (1974).

Increased tiller production was also obtained by the application of MH. Briefhof (1959) and Patel and Srivastava (1971) reported increased tiller production in pea plants by MH application. Sabina George (1981) obtained a significant increase in the number of tillers in turmeric (var. Armoor) by treatment with 50 and 75 ppm MH. The increased tiller production by MH may be due to the inhibition of meristematic activity at the shoot tip and subsequent stimulation of lateral buds which emerge out into tillers (Krishnamoorthy, 1981).

The number of functional leaves and their length and width determine the total leaf area per plant. The total photosynthesis and ultimate yield would depend on the leaf area. In the present studies, the production of leaves was found to be significantly influenced by the application of growth substances (ethrel, 2,4-D and MH). However, the individual treatments did not differ significantly from the control in this respect.

There was a general reduction in the number of leaves towards the later stages of growth in all the treatments including the control and the water spray. In all the stages, ethrel failed to show any significant influence in the production of leaves per plant as compared to the control. Though a slight increase was observed between the 80th and 110th day in ethrel 100 and 200 ppm, the leaf production in these treatments was seen reduced by 140th day. The increased number of tillers observed in the ethrel treated plants at the two lower levels (100 and 200 ppm) during the earlier stages (80th and 110th day) might have contributed to the increased leaf number. The sharp reduction in the number of leaves observed in ethrel treated plants after the 110th day may be due to the high incidence of defoliation observed during the later stages. Such incidence of leaf abscission has been reported in Valencia oranges sprayed with ethrel 120 ppm (Hutton, 1978). In Ficus benjamina, ethrel application induced heavy leaf drop when plants were grown under full sun (Johnson et al., 1982). Reduction in the number of leaves as a result of application of ethrel was reported by Selvaraj (1972) in ethrel treated (during the early stages of growth) Co-1 papaya plants, by Kwong and Lagerstedt (1977) in bean plants, by Rajmohan (1978) in Coleus parviflorus and by Vahab (1980) in sweet potato. Another trend observed in the present studies was the increase in number of leaves in 2,4-D

treated plants (at lower levels). This may be due to the growth stimulatory property of 2,4-D at lower concentrations. At the highest level (30 ppm), 2,4-D may have exhibited inhibitory effect through inducing ethylene production (Yang et al., 1979). MH at the highest level (150 ppm) has also exhibited an inhibitory effect on the leaf production in costus.

The data on the leaf production per tiller revealed that 2,4-D 10 and 20 ppm and the water spray treatment produced maximum number of leaves per tiller. However, these except 2,4-D 10 ppm on 80th day, did not exhibit significant difference from the control. The data also revealed that three of the treatments (the two lower levels of ethrel and the highest level of MH) produced significantly lesser number of leaves per tiller than the controls on the 140th day.

The significantly higher number of leaves per tiller recorded in the 2,4-D 10 ppm treatment (on 80th day) may be due to the higher number of leaves per plant and the lesser number of tillers produced. Similarly, the significant reduction in the number of leaves per tiller observed on the 140th day in the ethrel 100 and 200 ppm and MH 150 ppm treatments may be due to the higher number of tillers present and due to the severe abscission of leaves which occurred towards the later stages of the growth.

The width of leaves, the individual leaf area and the leaf area per plant were significantly increased by the two

lower levels of 2,4-D (10 and 20 ppm). Though these two treatments produced the longest leaves on 110th and 140th days, there was no statistically significant difference between the two treatments and the control. The three levels of ethrel (100, 200 and 300 ppm) exhibited significant reduction in the length and width of leaves, individual leaf area and leaf area per plant at all stages of observation. The highest levels of 2,4-D (30 ppm) and MH (150 ppm) also reduced the length of leaves and the leaf area of the plants significantly; but not to the extent brought about by ethrel.

The increase in leaf area by 2,4-D application at the lower levels observed in the present investigation is seen supported by the findings of Ashour (1973) in tomato and Kabdal and Joshi (1978) in Crocus sativus. However, Arkhangel'skii et al. (1982) observed contradictory results in fodder beet. The increase in leaf area by the application of 2,4-D at lower levels in comparison to the other treatments may be due to the stimulatory effect of 2,4-D on the leaf growth at lower concentrations and due to the reduction in defoliation observed during the later stages of growth. The increased leaf size as a result of increases in length and breadth may also have contributed to the larger leaf area. The reduction in the leaf area observed at the highest concentration of 2,4-D (30 ppm) may be due to its inhibitory effect in the leaf production and leaf size at the growth stages.

Humphries and Dyson (1967), Muthukrishnan *et al.* (1974) and Vahab (1980) in sweet potato and Rajmohan (1978) in *Coleus parviflorus* reported similar inhibitory effect of ethrel on leaf area. The reduction in leaf size and consequent reduction in the individual leaf area in ethrel treated plants might have resulted in lesser leaf area per plant. The severe defoliation observed in the later stages also might have contributed to this.

MH (150 ppm) significantly reduced the total leaf area at 140th day after planting. The reduced leaf size and individual leaf area observed at the highest level of MH (150 ppm) may be the reason for the reduced leaf area per plant under this treatment. Ananthanarayanan (1968) reported that application of 200 ppm MH to radish plants decreased the leaf area in the later stages of growth. In turmeric, Sabina George (1981) reported reduction in leaf area by 50 ppm MH on 180th day. However, at lower concentration (25 ppm), she observed a significant increase in the leaf area on the 120th day.

In the present study, ethrel treatments were found to be significantly superior to 2,4-D, MH, water spray and control in increasing the dry matter content of shoots. The results are in conformity with those obtained by Bhatia *et al.* (1978) in senna (*Cassia angustifolia*) and Shoushan *et al.* (1981) in *Adonis autumnalis*. However, Saimbhi *et al.* (1975) observed

that ethrel treatments reduced the shoot dry matter content in pea plants.

5.2. Rhizome characters

Apart from the growth parameters, the rhizome characters also exhibit decisive influence on the final yield. Observations in this regard were made on the characters of the main rhizomes and primary and secondary fingers. The length and number of the main rhizomes, the girth and internodal length of the primary fingers and the length, internodal length and girth of the secondary fingers were not influenced by the application of growth substances. However, the internodal length and girth of the main rhizomes, the number and length of the primary fingers and the number of the secondary fingers were significantly influenced by ethrel, 2,4-D and MH treatments.

The internodal length of the main rhizome was increased by 2,4-D 10 ppm. The length of the primary fingers was significantly increased by ethrel 200 ppm. The number of primary fingers was significantly increased by the two lower concentrations of ethrel (100 and 200 ppm) and 2,4-D (10 and 20 ppm). The number of secondary fingers was significantly higher in ethrel 100 and 200 ppm and MH 150 ppm treatments. The two lower concentrations of ethrel (100 and 200 ppm) significantly increased the girth of the main rhizomes.

Increase in the length of tubers due to ethrel application has also been reported by Kuhn *et al.* (1978) in sugar beet and Vahab (1980) in sweet potato.

Increase in the number of tubers as a result of application of ethrel has been reported by Torres and Campo (1973), Murti *et al.* (1977) and Postinikov *et al.* (1978) in potato and Shanmugam and Srinivasan (1974) and Vahab (1980) in sweet potato. The results obtained by the application of ethrel in the present study are in agreement with the above findings. However, Rajmohan (1978) did not observe a significant change in the number of tubers per plant by treatment with ethrel in *Coleus parviflorus*.

Enhancement of the multiplication of corms by the application of 2,4-D has been reported by Kabdal and Joshi (1978) in *Crocus sativus*. The increase in the number of primary fingers obtained with 2,4-D 10 and 20 ppm corroborate this finding. Increased number of fingers may be the result of destruction of proximal dominance (of the seed tubers) by the growth substance, as suggested by Michael and Smith (1951). A similar action could have given rise to the increased number of primary fingers observed in the present studies.

MH at 150 ppm induced the production of secondary fingers. Sabina George (1981) also observed a tendency of MH to increase the number of fingers in turmeric.

The increase in the girth of the main rhizomes brought about by ethrel in the present investigations may be due to the ethylene induced lateral swelling of cells and the isodiametrical expansion of tubers as reported by Krishnamoorthy (1981).

5.3. Yield and quality

As observed, the application of the three growth substances significantly influenced the important growth parameters and rhizome characters. Hence, it is logical to assume that these would influence the final yield also.

In the present study, it was observed that ethrel 200 ppm recorded the highest yield of green rhizomes, significantly superior to all the other treatments. The yield was also significantly increased by ethrel 100 ppm and 2,4-D at the two lower levels (10 and 20 ppm). MH at the three levels recorded green rhizome yields on par with the control. The highest levels of the three growth substances produced lesser yield than the controls; but without statistical significance.

Yield increase due to ethrel application has been reported in several crops. Tompkins and Bowers (1970), Muthukrishnan et al. (1974), Shanmugam and Srinivasan (1974), Tompkins and Horton (1974), Mustaffa et al. (1980) and Vahab (1980) reported increased yield of tubers in sweet potato as a result of ethrel application. In potato, Murti et al. (1977) and Bavilov et al. (1980) reported higher yield when treated with ethrel. In

cassava cv. Malavella, Muthukrishnan et al. (1976) reported that ethrel at 250 and 500 ppm increased the tuber yield by 18 and 20 per cent, respectively over the control. Significant increase in yield was observed in Coleus parviflorus by Rajmohan (1978) as a result of ethrel application. Nandi and Chatterjee (1978) reported increased yam yield in ethrel treated Dioscorea sp. However, there are a few reports in which either no influence (Gupta et al., 1982 in Dioscorea composita) or negative influence (Malik and Shakara, 1977 in sugar beet, Jayachandran, 1978 in ginger) was observed.

Ethrel has been reported to promote earlier tuberization (Catchpole and Hillman, 1969; Torres and Campo, 1973). Under conditions of earlier and enhanced tuberization, the tubers act as active physiological sinks and more carbohydrates are translocated to them than under conditions of late tuberization. It has also been reported that stored carbohydrates in the leaves lead to decreased photosynthesis (Milthrope and Moorby, 1966) and as soon as the physiological sink begin to act in transporting carbohydrate from leaves and stems to tuber, higher photosynthetic activities could be recorded (Milthrope and Moorby, 1966; Humphries, 1967). These views can explain the higher yield recorded by the ethrel treatments, in the present study. The increased girth of the main rhizomes, the higher number of the primary fingers and the longer primary fingers obtained in ethrel 200 ppm treatment also may have contributed to the highest yield obtained. It may be seen

that the girth of the main rhizomes and the number of the primary fingers were significantly higher in ethrel 100 ppm also, which was found as the second best treatment with respect to green rhizome yield.

The increase in green rhizome yield obtained by the two lower levels of 2,4-D (10 and 20 ppm) in the present instance can be substantiated in the light of the findings of several investigators. Yield increase has been reported in potato when 0.05 per cent 2,4-D was sprayed along with 30 per cent superphosphate (Al'Tergot et al., 1976), when 0.10 per cent 2,4-D amine salt was sprayed at bud formation stage (Bobrov and Kapustin, 1976) or when 20 per cent double superphosphate and 0.01 per cent 2,4-D amine was sprayed at peak flowering stage (Mukhametova, 1979). Increased root yields were obtained in fodder beet when treated with 2,4-D at 0.0002 per cent at seven-leaf stage (Arkhangelskii et al., 1978). According to Al'Tergot et al. (1976), the increased yield of potato tubers obtained when applied with 2,4-D might have resulted due to increased translocation of assimilates to the stolons and tubers, at a faster rate. Increased and faster translocation of assimilates may have occurred in the present studies also. Increased production of primary fingers, higher girth of main rhizome and longer primary rhizomes observed in the treatments may also have contributed to the increased yield.

MH application had no significant effect on the yield of green rhizomes, in the present study.

The dry matter percentage is an important parameter which finally decides the yield of total diosgenin. The dry matter percentage was increased in general by ethrel treatments; but was unaffected by 2,4-D and MH treatments. Significant increase in dry matter content of rhizome has been brought about by 200 ppm ethrel. Rajmohan (1978) in ethrel treated Coleus parviflorus and Vahab (1980) in ethrel treated sweet potato observed increased dry matter content. The increase in the dry matter content (of tubers/rhizomes) can be attributed to the higher photosynthetic activity and increased mobilization of photosynthates (to the tubers/ rhizomes) as reported by Jerie and Chalmers (1976).

The yield of dry rhizomes was maximum in ethrel 200 ppm, followed by in ethrel 100 ppm. This was due to the fact that the yield of green rhizomes and the dry matter content were highest in ethrel 200 ppm. It may be recalled in this context that with reference to the yield of green rhizomes and the dry matter content, ethrel 100 ppm was the third best and the second best treatment, respectively.

Another main parameter under study was the diosgenin content of rhizomes which was found to be influenced by the application of the growth substances. Maximum content of diosgenin in the rhizomes was found in plants treated with 2,4-D 10 ppm, ethrel 200 ppm and MH 100 ppm, as the treatments were on par. Significant increase in diosgenin content was

also given by ethrel 100 ppm, 2,4-D 20 ppm and MH 50 ppm. However, significant increase in diosgenin yield per hectare was recorded only by ethrel 200 and 100 ppm, 2,4-D 10 ppm and MH 50 ppm. Of these, ethrel 200 ppm produced the maximum diosgenin yield per ha, significantly different than the others. Ethrel 100 ppm, 2,4-D 10 ppm and MH 50 ppm were on par. It may be recalled that ethrel 200 ppm produced the maximum green rhizome yield and dry matter content also. It is interesting to note that the highest concentrations of the three growth substances were ineffective in improving the diosgenin content and diosgenin yield.

Application of ethrel has been reported to enhance the content of sennoside in leaves of Cassia angustifolia (Bhatia et al., 1978), volatile oil content in ginger (Jayachandran, 1978), morphine content of opium (Ramanathan, 1978) and glycosidal content in the flowers, fruits and roots of Adonis autumnalis (Shoushan et al., 1981). The results obtained in the present investigations indicated that ethrel has favourable influence in increasing the diosgenin yield in Costus speciosus. The lowest level of MH (50 ppm) also exhibited favourable influence on the diosgenin content and its yield. El-Antably et al. (1975) reported increased volatile oil content in sweet majoram (Origanum majorana) leaves with 100 ppm MH. Bhatia et al. (1978) reported that MH 100 ppm improved the sennoside content in Cassia angustifolia.

Sabina George (1981) reported significant increase in the curcumin percentage in turmeric when applied with 50 ppm MH.

Improvement in the content and yield of diosgenin and related compounds as a result of application of 2,4-D has been observed by various workers. 2,4-D treatment generally improved the diosgenin content in the tubers of Dioscorea floribunda, the best result being obtained with 2,4-D at 2 ppm (Vasanthakumar et al., 1980). Eid et al. (1974) found that treatment with 50 ppm 2,4-D raised the glyco-alkaloid content in Solanum laciniatum. Haleem (1978) observed that the solasodine yield per hectare varied considerably as a result of 2,4-D application in Solanum khasianum. In costus, the effect of 2,4-D on the diosgenin content has been studied only in in vitro incubation experiments. Shah et al. (1978) found that Costus speciosus tubers incubated in 2,4-D at 1 to 100 ppm raised the diosgenin content from 1.3 per cent 5.0 per cent at the higher concentrations. Seth et al. (1979) also observed increase in diosgenin content upto 270 per cent after incubation of rhizome slices with 2,4-D. He observed that 2,4-D at 100 ppm gave the best results in Costus speciosus. On analysis of tissue cultures of Solanum xanthocarpum, Heble et al. (1971) observed that growth substances like 2,4-D caused changes in the steroidal contents, thus suggesting hormonal regulation of steroidal synthesis. This may probably explain why 2,4-D at the two lower levels

influenced the diosgenin content in the present investigations.

The reduction in diosgenin content observed at the highest levels of the three growth substances may be due to the inhibition of synthesis of diosgenin at the higher concentrations.

The shoot/rhizome ratio was found to be significantly reduced by the three levels of ethrel and MH. 2,4-D treatments did not exhibit any influence in this regard. The reduction in shoot/rhizome ratio was more pronounced in the case of ethrel than in MH. Muthukrishnan et al. (1976) and Vahab (1980) in sweet potato and Rajmohan (1978) in Coleus parviflorus also observed reduced shoot/tuber ratios with ethrel application. Contrary observation on increased shoot/rhizome ratio has been recorded by Jayachandran (1978). The reduced shoot growth as well as the increased rhizome yield observed due to the application of ethrel may have contributed towards the reduced shoot/rhizome ratio.

Sabina George (1981) reported that MH did not significantly influence the shoot/rhizome ratio in turmeric. But in the present study, a reduction in shoot/rhizome ratio was observed by MH application. This contradiction may be explained as due to the differential response of the crops.

5.4. Correlation studies

In order to assess the nature and degree of association of the plant morphological characters and rhizome characters

with the yield of diosgenin per plant, correlations were worked out with reference to 17 characters selected from among 28 included in the studies. Out of these, highly significant or significant positive correlations were observed between seven characters and diosgenin yield per plant. The studies thus indicated that these characters, (namely, number of tillers per plant, number of primary fingers, number of secondary fingers, girth of primary fingers, rhizome yield per plant and dry matter content and diosgenin content of the rhizomes) could be useful in selecting the material which would give higher diosgenin yield.

5.5. Economics of cultivation

Ethrel 200 ppm gave the highest net profit followed by ethrel 100 ppm and 2,4-D 10 ppm. MH 50 and 100 ppm and 2,4-D 20 ppm also gave increased profits when compared to the control. Though the total expenditure for cultivation, extraction and purification of diosgenin was the highest in ethrel 200 ppm, the net profit calculated on per hectare basis was also high because of the highest yield of rhizomes and diosgenin obtained in the treatment. 2,4-D 30 ppm and MH 150 ppm recorded losses. This was due to higher cost of production and less increase in yield as compared to the other concentrations of these growth substances.

The present investigations, therefore indicated that application of ethrel 200 ppm, three times at monthly intervals commencing from the 60th day of planting as foliar spray to costus plants can bring increased income to the growers.

Summary

6. SUMMARY

An experiment in RBD was conducted at the College of Horticulture, Vellanikkara during 1982-83 to study the effect of ethrel (100, 200 and 300 ppm), 2,4-D (10, 20 and 30 ppm) and MH (50, 100 and 150 ppm) on the growth, rhizome yield and diosgenin content of Costus speciosus. The salient results are summarised below:

6.1. Height of the plants was significantly reduced by ethrel and MH throughout the growth period, the greatest reduction being evident at 110th and 140th day after planting. 2,4-D treatments did not significantly influence the plant height.

6.2. The internodal length of shoot was significantly reduced by ethrel at the levels tried, the minimum internodal length being recorded by ethrel 300 ppm treatment. 2,4-D and MH did not significantly influence the internodal length of shoot at the levels tried.

6.3. The number of tillers per plant was significantly increased by ethrel 200 ppm on the 80th day and by ethrel 100 and 200 ppm and MH 50 ppm on the 110th and 140th days. 2,4-D at the levels tried, did not significantly influence the number of tillers.

6.4. The three growth substances at the levels tried, exhibited significant effect on the number of leaves per plant

at the stages observed. Leaf production per tiller was increased significantly by 2,4-D 10 ppm on the 80th day and reduced significantly by ethrel 100 and 200 ppm, and MH 150 ppm on the 140th day.

6.5. The leaf area in general was reduced in the plants treated with ethrel. Individual leaf area was significantly higher in plants treated with 2,4-D 20 ppm on the 80th day and 2,4-D 10 and 20 ppm on the 110th and 140th days. Maximum leaf area per plant was recorded by 2,4-D 10 ppm on the 110th day while 2,4-D 30 ppm significantly reduced the total leaf area at this stage. On 140th day, the total leaf area was increased significantly by 2,4-D 10 and 20 ppm treatments. The highest levels of 2,4-D (30 ppm) and MH (150 ppm) significantly reduced the leaf area on the 140th day.

6.6. The three levels of ethrel brought about a significant increase in the dry matter content of shoot when compared to the control and water spray, the maximum being found in plants sprayed with 100 ppm ethrel. The dry matter content was not significantly influenced by the levels of 2,4-D and MH.

6.7. The shoot/rhizome ratio (fresh) was significantly reduced by ethrel and MH at the levels tried and the maximum reduction was recorded in ethrel 300 ppm. There was no significant difference in the shoot/rhizome ratio between 2,4-D treatments and absolute control.

6.8. The internodal length of main rhizomes was increased significantly by 2,4-D 10 ppm. The two lower concentrations of ethrel (100 and 200 ppm) significantly increased the girth of main rhizomes. The number of primary fingers was significantly increased by the two lower concentrations of ethrel (100 and 200 ppm). The length of primary finger was significantly increased only by ethrel 200 ppm. The number of secondary fingers was significantly higher in ethrel 100 and 200 ppm and MH 150 ppm treatments.

6.9. Ethrel 200 ppm recorded 60.51 per cent increase in the yield of green rhizomes over the control which was significantly superior to all the other treatments. Significant increase in the yield was also given by plants treated with ethrel at 100 ppm and 2,4-D at 10 and 20 ppm. MH application did not significantly increase the yield of green rhizomes.

6.10. The dry matter content of rhizome was significantly increased by ethrel 200 ppm. Maximum yield of dry rhizomes was also given by ethrel 200 ppm, followed by ethrel 100 ppm. The other levels of ethrel and all the levels of 2,4-D and MH were ineffective in increasing the dry matter content and yield of dry rhizomes.

6.11. The diosgenin content of rhizome was found to be the highest in the plants treated with 2,4-D 10 ppm

(1.83 per cent) followed by ethrel 200 ppm (1.64 per cent) and MH 100 ppm (1.64 per cent) as against the control (1.16 per cent). Significant increase in diosgenin content was also observed in plants treated with ethrel at 100 ppm, 2,4-D at 20 ppm and MH at 50 ppm. The yield of diosgenin per ha was found to be significantly more in 200 ppm ethrel than in the other treatments. Significant increase in diosgenin yield was also obtained in the case of ethrel 100 ppm, 2,4-D 10 ppm and MH 50 ppm.

6.12. The characters such as number of tillers per plant, primary and secondary rhizomes, girth of primary rhizomes, rhizome yield, dry matter content and diosgenin content of the rhizomes exhibited positive correlation with the yield of diosgenin per plant.

6.13. Ethrel 200 ppm gave the greatest return per hectare, followed by ethrel 100 ppm and 2,4-D 10 ppm. MH 50 and 100 ppm also gave an increased profit when compared to control.

References

REFERENCES

Ananthanarayanan, K.K. 1968. Studies on the effect of maleic hydrazide on root, tuber and bulb crops. M.Sc. (Ag) Diss., University of Madras, pp. 33-53.

Anonymous, 1982. Market trends in production, price, export, import etc. CROMAP, Central Institute of Medicinal and Aromatic Plants, Lucknow, 4(2): 101-104.

El-Antably, H.M.M., Ahmed, S.S. and Eid, M.N.A. 1975. Effect of some growth hormones on plant vigour and volatile oil of Origanum majorana L. Pharmazie, 30(6): 400-401. Horticultural Abstracts, 46(4): 3668.

Apelbaum, A. and Burg, S.P. 1972. Effect of ethylene on cell division and deoxyribonucleic acid synthesis in Pisum sativum. Plant Physiology, 50: 117-24.

*Arkhangelskii, N.S., Kostrikin, V.M. and Zaidel, K.L. 1978. Effect of treatment with physiologically active compounds on root yield and quality of fodder beet. Izvestiya Timiryazevskoi sel'sko-khozyaistvennoi akademii, 5: 49-58. Plant Growth Regulator Abstracts, 6(10): 2210.

*Arkhangelskii, N.S., Kostrikin, V.M., Gruzdev, L.G. and Luzik, L.V. 1982. Yielding capacity of different fodder beet cultivars and protein and amino acid contents in the roots after using 2,4-D as growth regulator. Izvestiya Timryazevskoi sel'sko-khozyaistvennoi akademii, 2: 40-47. Plant Growth Regulator Abstracts, 9(6): 1004.

*Ashira, T. and Yazawa, S. 1979. Bulbil formation of Dioscorea oposita cultured in vitro. Memoirs of the College of Agriculture, Kyoto University, 113: 39-51. Plant Growth Regulator Abstracts, 6(3): 581.

*Ashour, N.I. 1973. The effect of leaf sprays of 2,4-D and ZnSO4 on the growth and yield of tomatoes. Archiv fur Gartenbau, 21(5): 411-17. Plant Growth Regulator Abstracts, 1(2): 281.

Asolkar, L.V. and Chadha, Y.R. 1979. Diosgenin and other steroid drug precursors. 1st Ed., Publications and Information Directorate, CSIR, New Delhi, pp. 170.

*Backa, P. 1961. The effect of maleic hydrazide on the growth and development of tomatoes and radishes. Biologia, 16: 150-55. Chemical Abstracts, 55: 21448.

Barua, A. and Hazarika, J.N. 1982. Effect of certain growth substances on the yield of berries and solasodine content of Solanum khasianum. Indian Drugs, 19(6): 219-23.

*Bavilov, P.P., Postinikov, A.N. and Stepenev, V. 1980. Potato yield, out turn of seed tubers and their quality in relation to plant density and growth retardants. Izvestiya Timiryazevskoi sel'sko-khozyaistvennoi akademii, 2: 3-10. Plant Growth Regulator Abstracts, 9(1): 202.

*Bernard, E.E. and Warden, R.L. 1950. The effect of herbicides on weed control, stands and yield of Netter Gem potato. Research Report. Seventh Annual North Central Weed Control Conference, Milwankee, Wisconsin, 145.

Bhatia, R.K., Lohar, D.R., Chawan, D.D. and Garg, S.P. 1978. Chemical control of yield of sennosides in senna leaves. Planta Medica, 34(4): 437-41.

Bisaria, A.K. and Sharma, J.K. 1975. Influence of morphactin, MH and cycocel on yield and post harvest qualities of potato (Solanum tuberosum L.). Current Science, 44(24): 899-900.

Biswas, J., Sen, H. and Bose, T.K. 1980. Effect of growth substances on tuber development in sweet potato. National Seminar on Tuber Crops Production Technology, Tamil Nadu Agricultural University, Coimbatore, 128-30.

*Bobrov, L. and Kapustin, V. 1976. Effect of 2,4-D sodium sprays on yield and maturation of potatoes. Referativnyi zhurnal, 10: 127. Plant Growth Regulator Abstracts, 4(3): 343.

*Borbro, M. 1976. Increasing the productivity of sugar beet with maleic hydrazide. Trudy Khar'kovskii sel'skokhozyaistvennyi instituta, 206: 46-63. Plant Growth Regulator Abstracts, 4(3): 397.

Bose, P.C. and Hamner, C.I. 1960. Growth, development and mineral uptake in tomato plants as affected by MH. Indian Journal of Agricultural Science, 30: 170-75.

*Bosela, K.H.A. and Smik, G.K. 1977. Biomorphological changes in Mentha piperita and M. crispa caused by growth regulators. Ukrayins'kyi botanichnyi zhurnal, 34(1): 95-99.

*Briefhof, N. 1959. Influence of some growth substances on peanut shoots. Agriculture (Lourain), 7: 207-28. Chemical Abstracts, 53: 22698.

Bryan, H.H. and McMillan, R.T. 1975. Effect of growth regulator on dormancy, shoot growth and yield of Dioscorea alata L. Proceedings of the tropical region, American Society for Horticultural Science, 19: 239-46.

*Brysov, N.S. 1974. The effect of combining minor nutrients with 2,4-D on the yield of root crops. Biologicheskii Activnye veshchestva zhizni Rastenii i Zhivotnykh, pp. 52-60. Plant Growth Regulator Abstracts, 1(7): 960.

Burg, S.P. 1962. Physiology of ethylene formation. Annual Review of Plant Physiology, 13: 265-302.

Cantliffe, D.J. and Wood, F.E. 1978. Use of ethephon to induce early bulbing in onion. Hort Science, 13(3&4): 354.

Catchpole, A.H. and Hillman, J. 1969. Effect of ethylene on tuber initiation in Solanum tuberosum L. Nature, 223: 1387.

Chandler, S. and Dodds, J. 1983. Solasodine production in rapidly proliferating tissue cultures of Solanum laciniatum. Plant Cell Reports, 2(2): 69-72.

Chauhan, S.V.S. and Singh, S.P. 1972. Effect of MH, FW-450 and dalapon on growth, flowering and pollen viability of Capsicum annum L. and Datura alba L. Indian Journal of Plant Physiology, 15(1&2): 138-47.

Choudhuri, B. and Bhatnagar, V.B. 1954. Effects of MH on growth, bolting behaviour and keeping quality of Indian radish. Proceedings of Indian Academy of Sciences, 39: 112-15.

Choudhuri, B. and Bhatnagar, V.B. 1955. Effect of MH on the keeping quality of turnips. Indian Journal of Horticulture, 12: 88-96.

Choudhury, H.C. 1967. Effect of MH on yield and storage of potato in West Bengal. American Potato Journal, 44(1-3): 128.

Chung, H., Kim, J. and Lee, J. 1974. The effect of the time of maleic hydrazide application on the growth and chemical constituents in garlic plants. Journal of the Korean Society for Horticultural Science, 15(1): 14-19.

*Crafts, A.S. 1959. Further studies on comparative mobility of labelled herbicides. Plant Physiology, 34: 613-20. Hilgardia, 20: 58-60.

Dasgupta, B. and Pandey, B.V. 1970. A new Indian source of diosgenin - Costus speciosus. Experientia, 26: 475-76.

Davis, J.R. and Groskopp, M.D. 1981. Yield and quality of Russet Burbank potato as influenced by interaction of rhizoctonia, MH and PCNB. American Potato Journal, 58(5): 227-37.

Denison, E.L. 1953. Response of Kennebec potatoes to MH. Proceedings of the American Society for Horticultural Science, 62: 411-421.

*Edward, P.D., Bond, W. and Humphries, E.C. 1970. Effects of growth regulators on potato. Rothamsted Experiment Station Report, pp. 117-18. Field Crop Abstracts, 44: (14&15):4323.

Eid, M.N.A., Ahmed, S.S. and El-Antably, H.M.M. 1974. Preliminary studies on the effect of some growth regulators on the growth and glyco-alkaloid content of Solanum laciniatum. Egyptian Journal of Horticulture, 1(1): 3-16.

*Evtushenko, G.A. and Shapanova, L.G. 1973. The effect of MH on the betaine content of sugar beet parasatized by dodder. In: Vliyanie Fiziologicheski aktivnykh Soedinenii na obmen Veshchestv i produktivnost rastenii. Ed. Evtushenko, G.A. pp. 36-39. Plant Growth Regulator Abstracts, 1(11): 1730.

*Fergusen, W. and Fiuezek, M. 1958. Effect of MH on development of sugar beet. Morphological changes and respiration. Gazette Culcrowieza, 60: 90-92. Chemical Abstracts, 53: 12304.

*Friesen, H.A. and Howat, M.G. 1950. Effect of maleic hydrazide on vegetables. Research Report, Seventh Annual North Central Weed Control Conference, Milwankee, Wisconsin, 148-49.

Fults, J.L. and Payne, M.G. 1955. The effect of 2,4-D and MH on sprouting, yield and colour in red Mc-Clure potatoes. American Potato Journal, 32: 451-59.

Gupta, M.M., Misra, L.N., Lal, R.N., Srivastava, G.N. and Singh, P. 1980. Variation in diosgenin content in the rhizomes of Costus speciosus. Indian Drugs, 17(8): 232-34.

Gupta, S., Sobti, S.N. and Kumar, A. 1982. Effect of growth regulator (ethrel) and micronutrients on yield parameters of Dioscorea composita Hemsl. Proceedings of National Seminar on Medicinal and Aromatic Plants, 94-95.

*Guzman, V.L. 1971. Top growth inhibition of topped film packaged radishes by growth retardants and mechanical means. Proceedings of the Florida State Horticultural Society, 84: 147-52. Horticultural Abstracts, 43(9): 5942.

Haleem, S.A. 1978. Studies on the effect of different methods of application of nitrogen and use of growth regulators on growth and yield of Solanum khasianum Clarke. M.Sc.(Hort.) thesis, University of Agricultural Sciences, Bangalore. Thesis Abstracts, 4: 305-306.

Hardman, R. and Stevens, R.G. 1978. The influence of NAA and 2,4-D on steroidal fractions of Trigonella foenumgraecum static cultures. Planta Medica, 34(4): 414-19.

Harmey, M.A., Crowby, M.P. and Clinch, P.E.M. 1966. The effect of growth regulators on tuberization of cultured stem pieces of Solanum tuberosum. European Potato Journal, 9: 146-57.

Heble, M.R., Narayanaswamy, S. and Chadha, M.S. 1971. Hormonal control of steroid synthesis in Solanum xanthocarpum tissue cultures. Phytochemistry, 10(10): 2393-2394.

*Hegazy, A.T., Radwan, A., El-Fouly, M.M. and Garas, N.I. 1978. Effect of 2,4-D, maleic hydrazide (MH) and methyl ester of alpha-naphthalene acetic acid (MENA) on potato yield and tuber sprouting under Egyptian conditions. Agrochimica, 22(3): 88-97. Field Crop Abstracts, 32(8): 5566.

Hildeband, E.J. and Deen, B.B. 1969. Effect of ethrel on growth responses of 'Russet Burbank' and 'Kennebec' potatoes. Hort Science, 4: 401.

Hosoda, N., Ito, N. and Yatazawa, M. 1979. Some accounts on culture conditions of callus tissues of Solanum laciniatum for producing solasodine. Biological Chemistry, 43(8): 1745-1748.

*Hradilik, J. 1974. Reversal of auxin induced inhibition by ethrel. Biologia Plantarum, 16(4): 255-61. Field Crop Abstracts, 48: 2284.

Hsu, A.F.C. and Forman, H.I. 1982. Effect of 2-chloroethyl phosphonic acid on capsule formation and alkaloid content in Papaver somniferum. Physiologia Plantarum, 54(2): 142-46.

*Humphries, E.C. 1967. The dependence of photosynthesis on carbohydrate sinks - current concepts. Proceedings of the 1st International Symposium on Tropical Root Crops (St. Augustine, Trinidad), 11: 34-35.

Humphries, E.C. and Dyson, P.W. 1967. Effect of growth regulators, CCC and BS on some potato varieties. Annals of Applied Biology, 60(2): 333-41.

*Hutton, R.J. 1978. Abscission chemicals for late Valencia oranges in the Murrumbidgee irrigation areas of New South Wales. Proceedings of the International Society for Citriculture, Agricultural Research Centre, Yanco, Australlia. Horticultural Abstracts, 51(7): 5795.

Islam, A.K.M.S., Asher, C.J., Edwards, D.G. and Evenson, J.P. 1978. Germination and early growth of ginger (Zingiber officinale Roscoe.) II. Effects of 2-chloroethyl phosphonic acid or elevated temperature pre-treatments. Tropical Agriculture, 55(2): 127-34.

Jackson, M.L. 1958. Soil Chemical Analysis, 1st Ed., Prentice-Hall of India, New Delhi, pp. 498.

Jayachandran, B.K. 1978. Studies on the effect of growth regulators on growth, yield and quality of ginger (Zingiber officinale Roscoe.). M.Sc.(Hort.) Thesis, Kerala Agricultural University, pp. 35-60.

Jerie, P.A. and Chalmers, D.J. 1976. Ethylene as a growth hormone in peach fruit. Australian Journal of Plant Physiology, 3: 429-34.

Johnson, C.R., McConnell, D.B. and Joiner, J.N. 1982. Influence of ethephon and light intensity on growth and acclimatization of Ficus benjamina. Hort Science, 17(4): 614-15.

Joseph, E.J. 1983. Effect of spacing, rhizome weight and time of harvest on yield and quality constituents in Costus speciosus. M.Sc. (Hort.) Thesis, Kerala Agricultural University, pp. 29-49.

Kabdal, P.B. and Joshi, P. 1978. Effects of 2,4-D (2,4-dichlorophenoxy acetic acid) on the development and corm formation in Crocus sativus. Indian Journal of Pharmaceutical Science, 40(5): 165-66.

*Kaul, H.N., Perumal, W.L. and Sukumaran, N.P. 1977. Chemical control of over sprouting in stored potatoes under room temperature. CPRI Annual Scientific Report, Simla. Field Crop Abstracts, 32(7): 4975.

Kennedy, E.J. and Smith, O. 1951. Response of potato to field application of MH. American Potato Journal, 28: 701-12.

*Khosh-kui, M., Roubani, I. and Shaybany, B. 1978. Axillary shoot stimulation and development of coleus treated with certain plant growth regulators. Canadian Journal of Plant Science, 58(4): 971-76. Horticultural Abstracts, 49(5): 3627.

Krishnamoorthy, H.N. 1981. Plant growth substances including applications in agriculture. Tata McGraw Hill Publishing Co. Ltd., New Delhi, pp. 130-169.

*Kuhn, H., Linser, H. and Sadeghian, E. 1978. Effect of ethrel on shape and sugar content of sugar beet. Bodenkunde, 140(2): 229-31. Field Crop Abstracts, 31: 2617.

*Kusumo, S., Sulaeman, H. and Sukemi, I. 1979. Effect of 2-chloroethyl phosphonic acid spray on tuber size of potatoes. Bulletin Penelitian Hortikultura, 7(6): 3-11. Plant Growth Regulator Abstracts, 8(4): 688.

Kwong, F.Y. and Lagerstedt, H.B. 1977. Translocation of ethephon in beans and peas. Journal of the American Society for Horticultural Science, 102(4): 437-40.

Leopold, A.C. and Kriedemann, P.E. 1975. Plant Growth and development. 2nd Ed., Tata-McGrawhill Publishing Co. Ltd., New Delhi. pp. 545.

*Lercari, B. and Ceccarelli, N. 1975. The effect of various growth regulators on bulb induction in Allium cepa. Rivista della Ortoflorofrutticoltura italiana, 59(4):262-72. Plant Growth Regulator Abstracts, 2(11): 1608.

Levy, D. and Kedar, N. 1970. Effect of ethrel on growth and bulb initiation in onion, Hort Science, 5: 80-82.

Lipe, W.N. 1976. Effect of ethephon on the rate of bulb enlargement, maturity and yield in onions. Hort Science, 11(4): 424-25.

*Malik, B.K. and Shakara, S.A. 1977. Effect of growth regulators on seed development and intermediate type of growth in sugar beet. Agriculture Pakistan, 28(1): 65-75. Plant Growth Regulator Abstracts, 6(2): 354.

*Maltob, A.N. 1979. The effect of pre-harvest sprays of maleic hydrazide on the sprouting of onion bulbs during storage. Mesopotamia Journal of Agriculture, 14(1): 145-51. Horticultural Abstracts, 50(6): 4171.

*Marshall, J.G. and Staba, E.J. 1975. Plant hormone effects on the production of diosgenin by Dioscorea deltoidea tissue cultures. Lloydia, 38(6): 541-42. Plant Growth Regulator Abstracts, 2(12): 1801.

Michael, R. and Smith, P.G. 1951. Stimulation of sweet potato sprout production. Proceedings of the American Society for Horticultural Science, 59: 414-20.

*Milthrope, F.L. and Moorby, J. 1966. The growth of the potato. Proceedings of the Third Triennial Conference of the European Association of Potato Research, 51-70.

Misra, R.S. and Panda, S.C. 1979. Biochemical changes in onion bulbs during storage. Punjab Horticultural Journal, 19: 86-88.

Morgan, P.W. and Gausman, H.W. 1966. Effect of ethylene on auxin transport. Plant Physiology, 41: 45-52.

Muhr, G.R., Dutta, N.P., Sankarasubramony, H., Leley, V.K. and Donah, R.C. 1965. Soil testing in India. USAID, New Delhi pp. 73.

*Mukhametova, A.S. 1979. Effects of pre-harvesting management of potatoes on yield, structure and keeping quality of tubers. Sibirskii Vestnik sel'sko-khozyaistvennoi Nauki, 3: 89-91. Plant Growth Regulator Abstracts, 6(12): 2512.

Murti, G.S.R., and Banerjee, V.N. 1978. Effect of ethrel on tuberization and development of potato. International Seminar on approaches towards increasing the potato production in developing countries. Indian Potato Association, Simla, 38.

Murti, G.S.R., Banerjee, V.N., Kaul, H.N. and Perumal, N.K. 1977. Studies on the effect of growth regulators on potato. Annual Scientific Report, Central Potato Research Institute, Simla, 80-84.

Mustaffa, M.M., Muthukrishnan, C.R. and Ramaswamy, N. 1980. Effect of ethrel on maturity and quality of sweet potato clones. National Seminar on Tuber Crops Production Technology, Tamil Nadu Agricultural University, Coimbatore, 142-44.

Muthukrishnan, C.R., Shanmugam, A. and Thamburaj, S. 1974. Effect of soil and foliar application of ethrel on sweet potato (Ipomoea batatas Lamb.). South Indian Horticulture, 22(1&2): 1-5.

Muthukrishnan, C.R., Thamburaj, S., Shanmugam, A. and Shanmugavelu, K.G. 1976. Effect of certain regulators on tapioca (Manihot esculenta Crantz.) and sweet potato (Ipomoea batatas L.). Journal of Root Crops, 2(1): 52-56.

Nandi, R.P. and Chatterjee, S.K. 1975. Modification of growth and development of Dioscorea sp. by chemical and fertilizer treatments. Science and Culture, 41(11): 537-39.

Nandi, R.P. and Chatterjee, S.K. 1978. Effect of ethrel, GA and potassium thiocyanate on growth, development and diosgenin formation in different species of dioscorea. Indian Journal of Experimental Biology, 16(4): 523-25.

*Nikolueva, L.A. and Vollosovich, A.G. 1977. The effect of growth stimulants on biomass and alkaloid accumulation in suspension culture of Rauvolfia serpentina tissues. Rastitel'nye Resursy, 13(3): 450-55. Plant Growth Regulator Abstracts, 4(4): 494.

Ohta, S. and Yatazawa, M. 1979. Growth and alkaloid production in callus tissues of Rauvolfia serpentina. Agricultural and Botanical Chemistry, 43(11): 2297-2303.

El-Oksh, I., Abdulkader, A.S., Wally, Y.A. and El-Kholly, A.H. 1971. Comparative effects of gamma irradiation and MH on the storage of garlic. Journal of the American Society for Horticultural Science, 96: 637-40.

Patel, R.A. and Srivastava, V.K. 1971. Growth and yield of pea as affected by concentration of sprays of maleic hydrazide and gibberellic acid on plants of different ages. University of Udaipur Research Journal, 9: 89-90.

*Poppr, J. 1977. Effect of ethrel and kinetin on the chemical composition and physical properties of potato. Vedecke prace Vyzkumneho a Slechtitelskeho Ustavu Bram borar Skehov Haulickove Brode, 6: 93-101.

*Postinikov, A.N., Stepenev, V.I. and Blinovskii, I.K. 1978. The response of potato plants to treatment with retardant 2-chloroethyl phosphonic acid. Izvestiya Timiryazevskoi sel'sko-khozyaistvennoi akademii, 3: 43-49. Plant Growth Regulator Abstracts, 5(3): 312.

Pratt, H.K. and Goeschel, J.D. 1969. Physiological role of ethylene in plants. Annual Review of Plant Physiology, 20: 541-84.

Rajmohan, K. 1978. Studies on the comparative efficacy of two growth regulators on the growth, productivity and quality of coleus (Coleus parviflorus Benth.). M.Sc. (Hort.) Thesis, Kerala Agricultural University, pp. 37-69.

Ramanathan, V.S. 1978. Effect of plant growth regulators on the yield of opium and its morphine content in opium poppy. Indian Journal of Agricultural Research, 12(4): 246-50.

Ramanathan, V.S. 1981. Effect of ethrel on the yield of opium and its morphine content in opium poppy. Indian Journal of Agricultural Science, 15(4): 223-26.

Ramawat, K.G. and Arya, H.C. 1979. Effect of some growth regulators on ephidrine production in Ephedra gerardiana callus cultures. Indian Journal of Experimental Biology, 17(2): 227-28.

*Rumyantseva, V.I. and Krotova, O.A. 1972. The effect of maleic hydrazide in the markettability of radish. Khimiya v Sel'skom Khozyaistve, 10(11): 53-4. Horticultural Abstracts, 43(9): 5941.

*Rycerska, B.K. and Mezykowska, B. 1975. Influence of prometryn and 2,4-D on total and protein nitrogen content in tubers of Epoka and Kaszubski potatoes. Biuletyn Instytutu Ziemniaka, 16: 135-144. Plant Growth Regulator Abstracts, 3(9): 959.

Sabina George, T. 1981. Effect of growth regulators on the growth, yield and quality of turmeric (Curcuma longa Linn.). M.Sc. (Hort.) Thesis, Kerala Agricultural University, pp. 30-45.

Saimbhi, M.S., Arora, S.K. and Chhibha, I.M. 1975. Influence of seed treatment with 2-chloroethyl phosphonic acid, gibberellic acid, ascorbic acid and simazine on growth and nutrient composition of pea (Pisum sativum L.) seedlings. Plant and Soil, 43(3): 697-99.

*Schoene, D.L. and Hoffman, O.L. 1949. Maleic hydrazide, a unique growth regulant. Science, 109: 588-90.

Scweizer, E.E. 1978. Response of sugar beet (Beta vulgaris) to sub lethal rates of 2,4-D. Weed Science, 26(6): 629-31.

Selvaraj, Y. 1971. Dioscorea improvement II. Studies on the standardisation of diosgenin assay procedure. Indian Journal of Horticulture, 28(2): 135-38.

Selvaraj, S. 1972. Effect of some growth regulants on CO-1 papaya (Carica papaya Linn.). M.Sc. (Ag) Diss., Tamil Nadu Agricultural University, Coimbatore, pp. 35-61.

Sen, S.K. and Maharana, T. 1972. Growth and flowering response of chrysanthemum to growth regulator treatment. Punjab Horticultural Journal, 11: 274-77.

Seth, A., Jethi, K.B., Bhavsar, G.C. and Shah, C.S. 1979. Effect of growth regulators on the post-harvest diosgenin content of Costus speciosus. Indian Journal of Pharmaceutical Science, 41(6): 252.

Shah, C.S., Bhavsar, G.C. and Seth, A. 1978. Post-harvest induced changes of diosgenin in Costus speciosus. Current Science, 47(8): 270-71.

Shanmugam, A. and Muthuswamy, S. 1973. A study on the effect of growth substances on chrysanthemums. Madras Agricultural Journal, 60(1): 1-5.

Shanmugam, A. and Srinivasan, C. 1974. Influence of ethephon on growth and yield of sweet potato (Ipomoea batatas L.). Horticultural Research, 13(2&3): 143-45.

Shimizu, K., Kikuchi, T., Sugano, N. and Nishi, A. 1979. Carotenoid and steroid synthesis by carrot cells in suspension culture. Physiologia Plantarum, 46(2): 127-32.

*Shoushan, A.M., Abdalla, N.M., El-Gengaihi, S.E. and El-Badway, A.A. 1981. Growth and cardiac glycoside content of Adonis autumnalis L. as affected by growth retardants and ethrel. Gartenbauwissenschaft, 46(3): 101-105. Plant Growth Regulator Abstracts, 8(1): 84.

Singh, G. 1970. Influence of ethrel on the growth and yield of potatoes. Research in the Life Sciences, 18(1): 38-43.

*Skrinskaya, E. and Lin'kov, A. 1976. Dependence of yield of early potatoes on methods of pre-planting treatment of seed tubers. Referativnyi Zhurnal, 10: 261. Plant Growth Regulator Abstracts, 4(3): 342.

Snedecor, G.W. and Cochran, W.G. 1967. Statistical methods. 6th Ed., Oxford & IBH Publishing Co., New Delhi, pp. 359-75.

Sudhadevi, P.K. 1981. Yield and quality constituents in Costus speciosus under varying levels of N, P and K. M.Sc.(Hort.) Thesis, Kerala Agricultural University, pp. 63-78.

*Tamki, K. 1958. Effect of early foliage sprays of MH on growth behaviour and various chemical components of potato plants. Kagawa Diagaku Nogakubu Gakuzatu Hokku, 9: 119-25. Chemical Abstracts, 53: 12414.

Al'Tergot, V.F., Mordkovich, S.S. and Kuzmenko, V.A. 1976. Regulation of tuber formation in early potatoes. Sibirskii Vestnik sel'sko-khozyaistvennoi nauki, 4: 45-49. Plant Growth Regulator Abstracts, 3(9): 958.

Thomas, T.H. and Raukin, W.E.F. 1982. The effect of ethephon on bulbing, bulb necking, yield and sprouting during storage of 2 cultivars of onion (Allium cepa L.). Journal of Horticultural Science, 57(4): 465-67.

Tompkins, D.R. and Bowers, J.K. 1970. Sweet potato production as influenced by gibberellin and 2-chloroethyl phosphonic acid. Hort Science, 5(2): 84-86.

Tompkins, D.R. and Horton, R.D. 1974. Sprouting of sweet potatoes from root pieces as influenced by gibberellic acid or ethephon. Hort Science, 9(4): 392-93.

Torres, G.L. and Campo, G.C. 1973. In vitro tuberization of potato sprouts as affected by ethrel and gibberellic acid. Potato Research, 16(1): 73-79.

Tosh, S., Choudhuri, M.A. and Chatterjee, S.K. 1978. Effect of growth regulators on growth, development and yield of Abelmoschus esculentus (L) Moench. Science and Culture, 44(12): 544-47.

Vahab, M.A. 1980. Effect of growth regulators on the growth, yield and quality of sweet potato (Ipomoea batatas Lam.). M.Sc. (Hort.) thesis, Kerala Agricultural University, pp. 35-63.

*Vajna, P.M. and Vajna, S. 1954. Effects of MH in the living processes of the beet. Cukoripar, 1: 59-63.

Vasanthakumar, K., Chacko, E.K. and Chandra, M.S. 1980. Effect of growth substances on Dioscorea floribunda Mart. and Gal. Indian Journal of Pharmaceutical Science, 42(2): 65-66.

Wittwer, S.H. 1963. Chemical regulators in horticulture. Hort Science, 3: 163-167.

Yang, S.F., Adams, D.O., Lizada, C., Yu, Y., Bradford, K.J., Cameron, A.C. and Hoffman, N.E. 1979. Mechamism and Regulation of ethylene biosynthesis. In: Plant Growth substances. Ed. Skoog, P.F. Springer-Verlag, New York, pp. 219-38.

*Zukel, J.W. 1950. Use of maleic hydrazide as a plant growth inhibitor. Agricultural Chemicals, 5: 35-36.

* Originals not seen

Appendices

APPENDIX I

Abstract of ANOVA

Plant height

Source	df	Mean square			
		50th day	80th day	110th day	140th day
Replication	2	0.36	24.04	144.00	121.10
Treatment	10	29.33	114.76**	304.01**	239.20**
Error	20	20.73	21.41	35.87	31.01

** Significant at 0.01 level

APPENDIX II

Abstract of ANOVA

Number of tillers

Source	df	Mean square			
		50th day	80th day	110th day	140th day
Replication	2	0.16	0.38	3.01	2.05
Treatment	10	0.30	1.31**	3.86**	4.21**
Error	20	0.38	0.25	0.34	0.35

** Significant at 0.01 level

APPENDIX III

Abstract of ANOVA

Number of leaves per plant

Source	df	Mean square			
		50th day	80th day	110th day	140th day
Replication	2	23.47	71.84	94.10	120.43
Treatment	10	40.58	180.74*	252.79*	249.05*
Error	20	27.70	69.49	90.10	101.19

* Significant at 0.05 level

APPENDIX IV

Abstract of ANOVA

Number of leaves per tiller

Source	df	Mean square			
		50th day	80th day	110th day	140th day
Replication	2	0.76	2.38	12.39	5.69
Treatment	10	4.47	12.05*	10.03*	17.37**
Error	20	3.29	4.24	3.72	2.83

* Significant at 0.05 level

** Significant at 0.01 level

APPENDIX V

Abstract of ANOVA

Length and width of leaves

Source	df	Mean square							
		50th day		80th day		110th day		140th day	
		Length	Width	Length	Width	Length	Width	Length	Width
Replication	2	1.12	0.05	1.34	1.02	1.49	0.80	0.05	0.73
Treatment	10	1.61	0.24	13.76**	2.04**	26.99**	5.07**	24.01**	5.71**
Error	20	1.16	0.20	1.43	0.29	1.79	0.54	2.60	0.70

** Significant at 0.01 level

APPENDIX VI

Abstract of ANOVA

Individual leaf area and leaf area per plant

Source	df	Mean square							
		50th day		80th day		110th day		140th day	
		Individual leaf area	Leaf area per plant	Individual leaf area	Leaf area per plant	Individual leaf area	Leaf area per plant	Individual leaf area	Leaf area per plant
Replication	2	8.24	34056.98	231.28	444195.20	146.72	1396378.55	183.97	1682931.47
Treatment	10	18.92	40276.17	458.30**	1604111.71**	1735.66**	11351981.60**	1928.39**	11460365.00**
Error	20	18.25	62058.81	57.66	437181.03	98.14	754811.41	165.44	626367.34

** Significant at 0.01 level

APPENDIX VII

Abstract of ANOVA

Shoot internodal length, dry matter percentage and shoot/rhizome ratio

Source	df	Mean square		
		Shoot internodal length	Shoot dry matter percentage	Shoot/rhizome ratio
Replication	2	0.094	1.39	0.005
Treatment	10	0.861**	52.58**	0.021**
Error	20	0.113	6.39	0.005

** Significant at 0.01 level

APPENDIX VIII

Abstract of ANOVA

Character of main rhizome

Source	df	Mean square			
		Main rhizome			
		Leaf number	Length (cm)	Internodal length (cm)	Girth (cm)
Replication	2	0.03	28.17	0.15	1.52
Treatment	10	0.15	92.48	0.32*	1.70**
Error	20	0.17	57.21	0.14	0.47

* Significant at 0.05 level

** Significant at 0.01 level

APPENDIX IX

Abstract of ANOVA

Character of primary rhizome

Source	df	Mean square			
		Primary rhizome			
		Number	Length (cm)	Internodal length (cm)	Girth (cm)
Replication	2	0.86	2.81	0.022	0.54
Treatment	10	4.57**	6.48*	0.020	1.10
Error	20	0.71	2.08	0.016	0.69

* Significant at 0.05 level

** Significant at 0.01 level

APPENDIX X

Abstract of ANOVA

Character of secondary rhizome

Source	df	Mean square			
		Secondary rhizome			
		Number	Length (cm)	Internodal length (cm)	Girth (cm)
Replication	2	1.39	1.40	0.26	0.87
Treatment	10	2.35**	0.75	0.03	0.45
Error	20	0.57	1.02	0.06	0.33

** Significant at 0.01 level

APPENDIX XI

Abstract of ANOVA

Yield of green and dry rhizomes, dry matter and diosgenin percentage and yield of diosgenin

Source	df	Mean square				
		Yield of green rhizomes (t/ha)	Dry matter percentage	Yield of dry rhizome (t/ha)	Diosgenin percentage	Yield of diosgenin (kg/ha)
Replication	2	56.92	16.97	0.78	0.08	592.08
Treatment	10	114.24**	41.34**	15.41**	0.19*	6177.24**
Error	20	13.91	12.08	2.46	0.02	668.47

* Significant at 0.05 level

** Significant at 0.01 level

EFFECT OF GROWTH SUBSTANCES ON THE GROWTH, RHIZOME YIELD AND DIOSGENIN CONTENT IN *Costus speciosus*

BY

SATHEESHAN, K. N.

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Horticulture

Faculty of Agriculture
Kerala Agricultural University

Department of Plantation Crops & Spices,
COLLEGE OF HORTICULTURE
Vellanikkara - Trichur

1984

ABSTRACT

An experiment was conducted at the College of Horticulture, Vellanikkara to study the influence of ethrel (100, 200 and 300 ppm), 2,4-D (10, 20 and 30 ppm) and MH (50, 100 and 150 ppm) on the growth, rhizome yield and diosgenin content in Costus speciosus.

Plant height was significantly reduced by the three levels of ethrel (100, 200 and 300 ppm) and MH (50, 100 and 150 ppm) more evidently on the 110th and 140th day after planting. Ethrel 100 and 200 ppm and MH 50 ppm significantly increased the number of tillers per plant on the 110th and 140th day. Leaf production per tiller was significantly increased by 2,4-D 10 ppm on the 80th day and was significantly reduced by ethrel 100 and 200 ppm on the 140th day after planting. The length, width and area of the leaves and the internodal length of shoot was significantly reduced by ethrel treatments. Individual and total leaf area in general was significantly higher in plants treated with the two lower levels of 2,4-D (10 and 20 ppm), on the stages observed. Ethrel, at the three levels tried, significantly increased the dry matter content of shoots. The shoot/rhizome ratio was reduced significantly by ethrel and MH.

The girth of main rhizome was increased significantly by ethrel 100 and 200 ppm. The number of primary fingers

was significantly increased by ethrel 100 and 200 ppm and 2,4-D 10 and 20 ppm and its length was significantly increased by ethrel 200 ppm. The number of secondary finger was significantly higher in ethrel 100 and 200 ppm and MH 150 ppm treatments.

Ethrel 200 ppm recorded the maximum yield of green and dry rhizomes. Significant increase in the yield of green rhizome was also given by ethrel 100 ppm and 2,4-D 10 and 20 ppm. The diosgenin content of the rhizomes was maximum in 2,4-D 10 ppm (1.83 per cent), but the yield of diosgenin per ha was maximum in ethrel 200 ppm. Significant increase in diosgenin yield was also obtained in ethrel 100 ppm, 2,4-D 20 ppm and MH 50 ppm. The greatest return per ha was given by ethrel 200 ppm, followed by ethrel 100 ppm and 2,4-D 10 ppm.