# EFFECT OF GROWTH REGULATORS ON THE GROWTH, YIELD AND QUALITY OF SWEET POTATO

*(Ipomoea batatas* (L.) *Lam)*



BY

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THESIS

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# DECLARATION

I hereby declare that this thesis entitled "Effect of growth regulators on the growth, yield and quality of sweet potato (*Ipomoea batatas* (L.) Lam.)" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Vellayani,
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# CERTIFICATE

Certified that this thesis, entitled "Effect of growth regulators on the growth, yield and quality of sweet potato (Ipomoea batatas (L.) Lam.)" is a record of research work done independently by Shri.M. Abdul Vahab under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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# INTRODUCTION

# INTRODUCTION

The tropical root crops play a very important role in world nutrition. One or more of the tropical tuber crops feature as major food items in the diet of the people of several developing countries. Recently published figures of F.A.O. indicate that the global production of root crops is of the order of 170 million tonnes per annum which, expressed nutritionally represents something of the order of 250 terra calories. That is, the tropical root crops provide food of a quarter of the total population of the tropical developing countries (Coursey, 1975). The tuber crops such as cassava, sweet potato, yams and aroids are the most important subsistance crops for the world's small farmers. These crops are important because they possess high potentiality for yielding large amounts of food per unit area and are biologically efficient producers of calories.

Most of these root crops grown to provide food locally within the tropical world have been greatly under-researched during the recent decades compared with the plantation crops or other export cash crops. Partly because of this lack of research activity, the tropical root crops are greatly misunderstood as inefficient food producers. It is also erroneously believed that they contain little protein and their consumption leads to the occurrence of protein deficiency diseases. But this generalization cannot be justified because of the enormous yield that can be achieved with many of the tropical root crops, compared with the better known grain crops even in their present virtually unimproved state. Under the humid tropical ecosystem to which most of the tropical root crops are particularly well adapted their high yielding capacity may often mean that they can out-produce grain crops in terms of protein per hectare per year. More over, those parts of the world where tropical root crops are important in the diet are precisely the parts where population growth is highest, the threat of large scale starvation is ever present (Onhuemo, 1979). It has therefore become important to improve the quantity and quality of these crops.

Sweet potato (Ipomoea batatas (L.) Lam) belonging to the family of convolvulaceae is an important tuber crop in the tropical and subtropical regions of the world, being grown in Africa, India, China, Japan, South-East Asian countries, Latin America, Southern U.S.A., etc. In India, sweet potato ranks third in importance as a tuber crop next only to potato and tapioca. It occupies an area of 1,91,500 hectares with an annual production of 1,312,000 tonnes (Choudhry, 1977). The area and production in Kerala State are 5400 hectares and 26836 tonnes, respectively.

The chief use of sweet potato tubers is for human consumption and for the manufacture of starch and alcohol. It contains on an average 16% starch and 4% sugar, that is 20% alcohol producing materials. The fresh tubers have 50% more calories than potato. They are also rich source of carotene. The fresh leaves are richer in minerals and vitamins and are used as cattle feed and in some parts as leafy vegetables.

The increasing demand of sweet potato as an edible starchy tuber, forming a substitute for cereals is now well understood and hence it is included in many of the cropping patterns. The importance of this crop will increase in the years to come: the future prospects look good. The reason for this lie in the fact that this crop yields more edible material in a relatively short time and that it requires very little care. The ability of sweet potato to come up in marginal soils and its adaptability to a wide range of climatic conditions have facilitated its profitable cultivation throughout the State.

At present, the average yield in Kerala is only 4500 kg per hectare. Though a lot of work has been carried out towards the date of planting and optimum dose of fertilizers and manures in different parts of the world, the yield of tubers could be increased only to a certain limit. The yield of sweet potato tubers is often controlled by its foliage growth. The tuber crops in general are noted for their luxuriant vegetative growth. They possess a very wide shoot/tuber ratio resulting in the low production of tubers with poor quality. The excessive vegetative growth is often at the expense of tuber growth. The scope of improving the tuber crops in the direction of limiting foliage growth and increasing tuber yield with acceptable quality by using plant growth regulators have been examined by many workers. Among the growth regulators, Ethrel (2-Chloroethyl phosphonic acid) and CCC (2-Chloroethyl trimethyl ammonium chloride) have been successfully used for controlling excessive vegetative growth, increasing yield and improving quality in potato (Dyson, 1965; El-Fouly and Caras, 1974; Radwan et al., 1971; Choudhury et al., 1976), Sweet potato (Tompkins and Bowers, 1970, Nambiar, 1975 and Muthukrishnan et al., 1976), Cassava (Gupta, 1976; Muthukrishnan et al., 1976), Coleus (Rajmohan, 1978) and other horticultural crops (Dyson, 1972; Linser et al., 1974). These two growth regulators have been selected for the present study with the objective of finding out the best concentrations for obtaining maximum yield and quality. Finding out the economics of growing sweet potato with and without the application of growth regulators was another objective of the present investigation.

# REVIEW OF LITERATURE

# REVIEW OF LITERATURE

Growth regulators have been found to be influencing the growth, yield and quality of many horticultural crops. In recent years many growth regulators have been employed for different purposes in crop plants. Among the different growth regulators, Ethrel (2-Chloroethyl phosphonic acid) and CCC (2-Chloroethyl trimethyl ammonium chloride) have been successfully used in controlling the vegetative growth, increasing the yield and improving the quality in many root crops. A brief review of the investigations on the effects of Ethrel and CCC on the morphological characters, growth, yield and quality of different horticultural crops is presented below, with particular stress on root crops.

## ETHREL.

The ability of ethylene gas on the growth and development of plants is well known (Pratt and Goeschl, 1969). However, its insolubility in water prevents its practical use as a growth regulator. This difficulty has been overcome by using a freely soluble derivative, 2-Chloroethyl phosphonic acid (Ethephon) which yields ethylene and phosphonic acid after entry into the plant tissue by a base-catalysed reaction which takes place at pH above 3.5 (Cooke and Randall, 1968; Yang, 1969). 'Ethrel' is the brand name for the chemical under which it is marketed by

Amchem Products Inc. of United States of America.

Biological tests indicate that Ethrel is absorbed through the leaves and the roots. It is translocated intact readily throughout the plant and accumulates in rapidly growing sinks, with portions breaking down to produce ethylene along the translocation path due to the tissue-mediated increase in pH (Kwong and Lagerstedt, 1977). A variety of responses like epinasty, root initiation, auxillary bud stimulation, defoliation, stimulation of underground rhizome buds, earlier flower bud formation, earlier fruit maturity, increased yield, inhibition of vegetative growth, increased tillering, etc. have been attributed to Ethrel (Anon., 1969). These effects are seen manifested in many horticultural plants. The inhibition of growth is mainly through its retarding effects on shoot growth. Evidences in this regard are reviewed below.

Effect of Ethrel on shoot growth

Ethrel has been shown to inhibit shoot growth and internodal elongation. Catchpole and Hillman (1969) reported that Ethrel treatment inhibited stem elongation process in potatoes. Ethrel caused shortening of stem in potato cv. King Edward (Edward et al., 1969). The growth was markedly inhibited by Ethrel when applied to potatoes as foliar spray at 100, 500 and 1000 ppm (Singh, 1970). Tompkins and Bowers (1970) found that Ethrel treated sweet potato plants were shorter and with shorter internodes.

Bryan (1975) reported decreased shoot length with increasing concentration of Ethrel application in Dioscorea alata cv. Blanco.

In Coleus parviflorus, Ethrel caused a significant reduction in the internodal length and fresh weight of shoot (Rajmohan, 1978). Ethrel at 200 ppm recorded a reduction in internodal length of 52.2% over the control.

In pea reduction in the length of the main stem as well as retardation of the general seedling growth has been observed. Anderson (1970) reported a reduction in the height in Alaska pea plants due to Ethrel treatment. Saimbi et al. (1975) observed retarded seedling growth and reduced fresh and dry weights in pea plants.

Ethrel at 350 ppm applied at seedling stage of both monoecious and gynoecious cucumber plants reduced the internodal length and inhibited the growth of the main stem (Benoit, 1972; Lee et al., 1973).

Several fruit plants have also shown inhibition reaction to Ethrel application. Cooke and Randall (1968) reported that in pineapple, Ethrel caused a retardation of vegetative growth. In peach trees, Ethrel treatment caused inhibition of vegetative growth (Edgerton and Green halgh, 1969). According to Valenzuela and Kender (1970), the aerial shoot growth of low bush blue berry was stimulated by foliar application of Ethrel at 50 or 100 ppm, but increasing concentration of 500 or 5000 ppm resulted in a corresponding greater growth inhibition. In CO.1 papaya plants, Ethrel at 250 and 500 ppm reduced the internodal length (Alagianmanavalan, 1971). Selvaraj (1972) observed that Ethrel at 500, 1000 or 2000 ppm exhibited a marked retarding effect of 74.45 to 81.25 per cent in CO.1 papaya. Ethrel treatment suppressed terminal growth and internodal elongation in apple cultivars (Williams, 1973; Agafnov and Ivanushkin, 1974).

The effects of Ethrel on various ornamental plants have been investigated by several workers. Ethrel at 1000 ppm reduced the height of geranium plants (Carpenter and Carlson, 1970; Semeniuk and Taylor, 1970). In rose, Dean (1972) reported that Ethrel sprays produced most compact and bushy plants with reduced shoot length. Ethrel treatment caused reduction in length of the terminal shoots in hibiscus cultivars (Shanks, 1972). Kher (1973) observed that 1000 ppm Ethrel spray shortened the internodal length, giving shorter plants in chrysanthemum. In an experiment with Ethrel on potted chrysanthemum plants, Pergola (1973) observed a reduction in vegetative growth. Loeser (1975) observed reduction in the extension growth of shoot in narcissi plants. Bodlaender and Vander (1975) reported temporary inhibition of growth in height due to Ethrel treatment on flax.

Besides reducing the length of main stem, Ethrel has been shown to have promotive effects on production of laterals and increasing stem girth. Muthukrishnan et al. (1974) reported that in sweet potato foliar application of Ethrel 50, 100, 200, 500 and 1000 ppm promoted the production of laterals and their increase was found to be linear with increase in concentrations. They obtained 104.5 per cent increase in the number of laterals over the control by the application of 250 ppm of Ethrel as foliar spray. Rajmohan (1978) in his study with Ethrel on coleus found that 200 ppm foliar spray recorded an increase in stem girth of 30.5 per cent over the control. He also observed a significant increase in the number of branches when treated with 100 and 200 ppm of Ethrel.

Application of Ethrel to the epicotyl apex in *Phaseolus vulgaris* resulted in loss of apical dominance of epicotyl and in the growth of lateral buds (Hradilik, 1974). Poovaih (1974) reported that foliar application of Ethrel to the two week old *Phaseolus vulgaris* plants induced radical enlargement of stems. Bussell (1975) reported that pot grown plants of pea cvs. Dark-skinned Perfection and Puget treated with 625 and 1250 ppm Ethrel at nine-node stage had significantly more branches than the controls. In *Cyamopsis tetragonaloba* also, Ethrel treatment increased the number of branches (Verma and Sankhla, 1976). Kwong and Lagerstedt (1977) observed that in two-week old bean plants

(*Phaseolus vulgaris* L. cv. Black Valentine) Ethrel application caused promotion of lateral bud growth and stem enlargement.

In young pear trees, Ethrel treatment resulted in the vigorous development of the dormant buds on the main trunk and side branches (Lenseen, 1970). Ethrel treatment significantly increased the stem circumference in CO.1 papaya (Alagiamanavalan, 1971). In apple plants, Ethrel application stimulated increase in diameter (Robitaille and Leopold, 1974).

Ethrel spray at 1000 ppm stimulated branching in geranium plants (Carpenter and Carlson, 1970), Semeniuk and Taylor (1970) also observed similar response in geranium plants.

Effect of Ethrel on the leaf area and number of leaves

Ethrel at high concentrations affects the leaf growth of many plants. Muthukrishnan *et al*. (1974) found that in sweet potato, Ethrel treatment at 500 ppm recorded a significant reduction in leaf growth (47.1 and 66.4 per cent through foliar and soil application, respectively). The leaf area of treated plants were also reduced by the application of Ethrel. Shanmughan and Sreenivasan (1974) reported a reduction in the weight of sweet potato leaves.

Rajmohan (1978) obtained a significant reduction in the leaf area of *Coleus parviflorus* by foliar application of Ethrel at 100 and 200 ppm. The greatest reduction of 46% over the control was obtained by application of Ethrel at

200 ppm.

Ethrel at 5000 to 10000 ppm caused retardation of leaf size in onion and leek plants (Levy and Kedar, 1970). Lipe (1975) observed that Ethrel at 1000-3000 ppm applied as sprays to short, medium and long day onions reduced the number of leaves. Adedipe and Ormrod (1977) observed that all concentrations of Ethrel upto 100 mg $1^{-1}$ decreased leaf weight in cow pea (Vigna unguiculata L. cv. Adzuki).

Number of leaves and leaf expansion were reduced due to Ethrel treatment in young apple trees (Dozier and Barden, 1973a).

Unlike in other vegetable crops and fruit plants Ethrel does not seem to have severe inhibitory effects in papaya. Selvaraj (1972) reported that there was about 80-100 per cent reduction in leaf number within 10 days after Ethrel spraying in CO.1 papaya plants; but such an inhibiting effect was not observed during the later stages. It is interesting that in one of the earlier studies with CO.1 papaya plants, Alagiamanavalan (1971) observed no appreciable difference in leaf production due to Ethrel treatment.

The review has yielded only one report where promoting effect on leaf development was observed on Ethrel application. Benoit (1972) observed accelerated leaf development in cucumber plants treated with Ethrel at 240 ppm.

Effect of Ethrel on yield and quality

Hildebond et al. (1969) reported in their preliminary observation that Ethrel treatment increased the development of tubers of Russet Burbank and Kennebec varieties of potato. Edward et al. (1970) reported that in potato cv. King Edward treated with Ethrel at 0.3 per cent or 1 lb/acre, the tuber number was increased and the tuber weight was reduced. Ethrel treatment considerably promoted tuberization of etiolated potato sprouts in vitro and increased tuber number (Torres and Campo, 1973).

In sweet potato also similar effects were observed by several workers. In the variety Centennial, Ethrel treatment caused increased tuber production (Tompkins and Bowers, 1970). Muthukrishnan et al. (1974) observed that in sweet potato variety I.B.2, Ethrel treatment at 50, 100, 200, 500 and 1000 ppm both as foliar spray and soil treatment, caused significant increase in yield; Ethrel at 250 ppm as foliar spray recorded maximum yield over all other treatments. Ethrel applied at 250 ppm to the foliage of sweet potato 15, 30 and 45 days after planting increased the number and yield of tubers (Shanmugam and Srinivasan, 1974). Muthukrishnan et al. (1976) reported in sweet potato that foliar sprayings of Ethrel at 250 ppm at fortnightly intervals commencing after 45 days of planting recorded higher yields accounting for a significant increase of 49 per cent over the control. They further observed that Ethrel treatment at 250 ppm reduced the shoot/tuber ratio to an optimum 0.59:1. Contrary to the findings reported above, Menon (1971) had earlier observed that Ethrel reduced the number and yield of tubers in sweet potato.

In Dioscorea alata cv. Blanco, Bryan et al. (1975) obtained higher yield when tuber sections were treated with Ethrel prior to planting.

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

Kuhn et al. (1978) obtained increased root weight in sugar beet by Ethrel application. The roots became egg-shaped due to elongation of the crown and decrease in diameter.

In Coleus parviflorus, Rajmohan (1978) obtained earlier tuber initiation and increased yield of tuber by Ethrel treatment. Ethrel at 200 ppm caused significant increase, accounting for 49.7 per cent over the control. But he did not observe a significant change in the number of tubers per plant by Ethrel treatment. The shoot/tuber ratio was also reduced by the treatment.

Yield increases as a result of Ethrel application has been reported in vegetable crops as well. In Trichosanthus anguina, Ethrel treatment at 50 and 100 ppm significantly increased the yield of fruits per vine both in terms of number and weight of fruits (Shanmugavelu and Thamburaj, 1973). Ethrel treatment greatly increased yields in tomatoes (Burgis *et al.*, 1974). However, Postglione (1974) reported that total production was not significantly affected by Ethrel treatment in tomato plants; but there was a marked reduction in the average weight of ripe fruits. Churata-Masca et al. (1974) reported that Ethrel treatment at 5400 ppm increased the number of fruits per plant in cucumber cv. Adai.

Several research workers have critically examined the role of Ethrel in influencing the quality of vegetables. Menon (1971) reported that in sweet potato, Ethrel at 1000 ppm significantly increased the nitrogen content of tubers. At a lower level, that is, at 250 ppm, Ethrel increased the nitrogen content of the haulms and the ascorbic acid content of tubers. The carbohydrate content was not significantly affected by the treatment.

In cassava cv. Malavelle, Muthukrishnan *et al.* (1976) reported that Ethrel sprays at 1000 ppm caused the tuber starch content to increase two fold over the control and at 2000 ppm caused the ascorbic acid content of tubers to decrease by 38.8 per cent of the control.

There was an increase in the dry matter percentage and calcium content of shoots of *Coleus parviflorus* treated with Ethrel at 200 ppm (Rajmohan, 1978). Further, Ethrel significantly increased the contents of starch, ascorbic acid and calcium and significantly reduced the percentage of protein in the tubers.

An increase in the ascorbic acid content and a decrease in the sugar content in Trichosanthus anguina with increasing concentrations of Ethrel (50-100 ppm) was noticed by Shanmugavelu and Thamburaj (1973). In tomatoes, however, Postglione (1974) did not find any significant change in quality on treatment with Ethrel.

CCC

2-Chloroethyl trimethyl ammonium chloride, also known as chloro choline chloride (CCC), chlormequat and cycocel is one of the most extensively used plant growth retardant to control the growth and thereby to increase the production of a number of agricultural and horticultural crops. CCC is the most active member of the new group of quarternary ammonium compounds reported in 1960 by Tolbert. Normally CCC produces an effect opposite to that of gibberellins. This growth retardant is characterised by its range of activity, its primary effect being shortening and strengthening of the stem and thereby the treated plants are generally compact and sturdy and have shortened internodes, shortened petioles and darker green leaves. Such plants usually remain dwarfed even under optimum watering and fertilization (Anon., 1966). This compound is highly specific in its effects and sometimes even different varieties of species show different responses (Cathey, 1964; Mohmoud and Steponkus, 1970). CCC retards the growth of plants whatever be their photo period. The growth of long-day plants is retarded by weak solutions of the retardant, that of neutral and short day plants by strong solutions (Chailakhyan and Kochankov, 1967).

Effect of CCC on shoot growth

Application of CCC retards shoot growth and reduces the internodal length in many tuber crops. Ota et al. (1961) observed a reduction of internodal length in potato plants. Gifford and Moorby (1967) reported compact plants in potato cv. Majestic due to CCC application. Hruska and Popper (1970) observed a retardation of growth in potato cvs. Saskia, Meise and Blanite. A decrease in the growth of stem in the potato cv. Marie Peer, by way of shortening the upper internodes was reported by Digby and Dyson (1973). However, the rate of internode production was not affected by CCC application. Fisher (1974) reported reduced growth of potato plants due to CCC application. Volkova et al. (1975) reported retarded stem growth of potato plants of cv. Berlochinger by the application of CCC as foliar spray at the rate of 0.37 to 1.49 kg CCC ai/ha. He found that foliar application of 0.74 kg CCC ai/ha produced long term inhibition in growth of above ground parts in mid-early maturing cv. Fatenskii. Melikyan and Azarian (1975) reported reduced apical growth in potatoes. Foliar sprayings of potato seedlings with $10^{-2}$M CCC temporarily inhibited stem growth (Sycheva et al., 1975). A reduction in the height of potato plants was reported by Choudhuri et al. (1976) due to CCC treatment.

Nambiar (1975) reported a significant reduction in the length of vine in sweet potato by the application of CCC at 150 ppm. He also observed a reduction in the wet and dry weight of vine per plant with increasing levels of CCC.

In Coleus parviflorus, Rajmohan (1978) obtained a significant reduction in the internodal length and fresh weight of shoot, due to CCC application.

Dyson (1972) found reduction in the growth of tops in carrots.

Contrary to the findings reported above, Menon (1971) reported a slight increase in the vegetative growth of sweet potato plant due to CCC treatment.

Growth retarding effect has been reported by Wittwer and Tolbert (1960) and Marisidhaiah et al. (1977) in tomatoes. Similar results have been reported by Lockhart (1962) and Dobrev et al. (1970) in cucumber, Humphries (1963) in Mustard, Klapwijk (1967a) in runner beans, Thomas (1968) in lettuce, Will (1968a) in peas, Cockshull and Van Emden (1969) in brussels sprouts, Felippe (1969) and Wheeler (1969) in French beans, Raman (1969) in CO.1 lab-lab. Kaukoivirta (1970) in beans and Shukla and Tewari (1973) in okra.

The effect of CCC to reduce the shoot growth and shorten the internodes have been reported in fruit crops also. Bomeke (1966) observed shortened internodes in apple due to CCC treatment. A reduction in the internodal length and shoot elongation in apples was reported by Crabbe (1970). Arumugam and Madhava Rao (1972) reported reduction in shoot growth and internodal length in *Vitis vinifera*. Singh and Sharma (1973) observed in young pear trees that CCC at 1500, 3000 and 4500 ppm reduced shoot growth and internodal length; but did not affect internode number. Frydman and Wareing (1974) reported that CCC had a marked dwarfing effect in juvenile rooted cuttings of ivy due to the suppression of internode elongation.

In ornamental plants such as chrysanthemums, carnations, hibiscus and poinsettias soil application of CCC caused profound retardation of growth (Cathey and Stuart, 1961). Cathey (1964) reported reduction in vegetative growth in chrysanthemums, azaleas, carnations and holly. Lemper (1964) observed that CCC treatment caused growth reduction in chrysanthemum. Bose and Hore (1967) and Bhattacharjee (1972) observed growth reduction in bougainvilleas. Reduction of vegetative growth was also reported by Leinfelder (1968) in *Acalypha hispida*. CCC reduced length of individual internodes in balsam plants (Nanda *et al*., 1968). Jasa *et al*. (1971) in *Salvia splendens*, Bhattacharjee and Bose (1972) in dahlia and Sen and Maharana (1972) in carnation seedlings also reported growth reduction due to CCC treatment. However Bose (1972) observed that in dahlia plants foliar spray with CCC resulted in stem elongation. Enhanced shoot growth due to the application of CCC at 5000, 10000 and 15000 ppm was reported in Chrysanthemums also (Shanmugam *et al*., 1973).

Application of CCC registered less weight, the reduction in weight arising primarily as a result of reduction in stem length. Cockshull and Van Emden (1969) obtained significant reduction in stem weight of brussels sprout plants, treated with 2 per cent CCC. In tomato, CCC treated plants recorded a reduction of 4 per cent in fresh and dry weight (Irulappan and Muthukrishnan, 1973). In okra plants, Shukla and Tewari (1973) recorded a reduction in shoot weight of 20 to 45 per cent due to CCC treatment. Nambiar (1975) reported significant decrease in the fresh and dry weight of vine in sweet potato with increasing levels of CCC.

Rajmohan (1978) obtained 46.5 per cent reduction in the fresh weight of shoot in Coleus parviflorus due to CCC treatment at 500 ppm.

However, Adedipe and Ormrod (1977) observed no effect for CCC in stem weight in cowpea (var.Mala).

CCC increased the production of lateral branches in many plants. Dobrov et al.(1973) observed increased number of laterals in cucumber plants. Irulappan (1972) and Marisidhaiah and Muddappa Gowda (1977) reported increased number of laterals in tomato plants. Melikyan and Azarian (1975) observed increased number of laterals in potato plants. Rajmohan (1978) obtained increased number of branches in Coleus parviflorus with increasing levels of CCC. CCC at 1000 ppm produced 25 per cent increase over the control.

Increase in stem diameter due to CCC treatment have been reported by Cockshull and Van Emden (1969) in brussels sprouts, Irulappan et al. (1973) and Marisidhaiah and Muddappa Gouda (1977) in tomatoes and Rajmohan (1978) in Coleus parviflorus.

Effect of CCC on the leaf area and number of leaves

Reduction in leaf number and leaf area has been reported due to CCC application in several plants. Humphries and Dyson (1967) reported reduction in leaf area of CCC treated potato cultivars. CCC reduced leaf area in potato var. Craigs Royal (Gunasena and Harris, 1969). In carrot the leaves were smaller and greener and the petioles were shorter due to CCC treatment (Dyson, 1972). El-Mansoy et al. (1972) observed that 1000 ppm CCC spray at 75 and 90 days after sowing reduced leaf number in carrots. Rajmohan (1978) reported a significant reduction in leaf number in Coleus parviflorus due to the application of CCC at 500 ppm. He also noted a significant reduction in leaf area due to the application of CCC at 1000 ppm.

In contrary to the above results, Hruska and Popper (1970) reported increased leaf area in potato cvs. Saskia, Moise and Blanito due to CCC application. Increased number of compound leaves was observed by Chaudri et al. (1976) in potato. Popravko (1976) also found increased leaf area and increased leaf number in potatoes. CCC at 250 ppm gave increased leaf number in Coleus parviflorus (Rajmohan, 1978).

In cucumber the leaf area and number of leaves were significantly reduced by CCC application (Laboric, 1963).

Similar results have been reported by Morgan and Hennerty (1967) and Singh and Young (1971) in tomatoes, Sanders *et al*. (1969) in snap beans and Wheeler (1969) in french beans. However Lingaraj and Srinivasan (1967) reported that CCC treatment resulted in larger leaves in French beans. Irulappan (1972) also observed a significant increase in leaf area in tomato plants.

Boetz (1970) reported a reduction of 7 to 10 per cent leaf area in grapes by foliar application of 0.1 per cent CCC. Coombe (1970) found that in grapes CCC at 100 mg/litre applied to shoots reduced leaf expansion and the rate of leaf emergence. Ivanushkin (1973) observed that CCC applied to apple cultivars decreased leaf size but increased the number of leaves per unit length of shoot.

Jasa *et al*. (1971) found retarded leaf development in *Salvia splendens*. According to Sen and Maharana (1972) leaf production in carnation was decreased by CCC treatment. Hildrum (1974) observed reduced leaf size in pelargonium by CCC application. However, Lindstorm and Tolbert (1960) did not observe any change in number of leaves of chrysanthemums due to CCC treatment.

Effect of CCC on yield and quality

CCC affects the yield and quality of a number of crop plants. Dyson (1965) working with potato reported that CCC solutions of 790 and 3150 ppm caused earlier formation of more uniform tubers. Gifford and Moorby (1967) reported that CCC treatment at 3160 ppm led to tuber initiation one week earlier in potato cv. Majestic. Tizio (1969) found that CCC treatment promoted tuberization in potato cv. Bintji. Tuber initiation was accelerated in potato cv. Seskia, Meise and Blanito (Hruska and Popper, 1970). Listowski and Lis (1973) reported that soaking seed tubers of potato cv. Pierwiosnek in 0.2 per cent CCC solution accelerated initiation of tuber formation by 16 days. In potato cv. Alpha CCC treatment caused earlier tuber formation and higher yield of tubers (El-Fouly and Caras, 1974). CCC treatment accelerated tuberization and increased tuber yield by 19.8 to 20.1 per cent in potato plants.(Ficher and Pyshataleva, 1974). Bisaria and Sharma (1975) obtained increased tuber yield and tuber size in potato plants. Parrot (1975) observed in potato plants that tuber growth was stimulated by CCC. Choudhri et al. (1976) and Popravko (1976) reported increased tuber yield in potato plants.

Nambiar (1975) reported increased tuber yield with increasing levels of CCC in sweet potato.

Gupta (1976) reported that in cassava plants CCC treatment increased yield of fresh tuber by 25 to 31 per cent.

Rajmohan (1978) observed earlier tuberization and increased tuber yield in *Coleus parviflorus* by foliar application of CCC at 250 ppm and 1000 ppm.

In carrot the cv. Autumnking gave 20 to 25 per cent greater yield (Dyson, 1972).

Results opposite to the above findings were also reported by some workers. Gunasena and Harris (1969) reported reduction in tuber yield due to CCC treatment in potato var. Craigs Royal. Hrucka and Popper (1970) concluded that CCC application had no practical value in potato growing. In sweet potato, Menon (1971) reported a reduction in number of tubers as well as yield per plant. Reust (1976) found that tuber yields at maturity, tuber number per plant and tuber size were not affected by CCC treatment.

The role of CCC in influencing the quality constituents were also studied by some workers in vegetables. In radish leaves CCC caused increased protein content (Vlasjuk et al., 1969). In potato application of CCC increased the starch and protein content of tubers (Fisher and Pyshtaleva, 1974). CCC induced a slight temporary increase in root dry weight and slightly promoted protein storage in radish (Linser et al., 1974). Bisaria and Sharma (1975) reported reduction in tuber dry matter content and increase in tuber starch content in potatoes. Nambiar (1975) obtained a significant increase in the percentage of starch in sweet potato tubers due to the application of incremental doses of CCC. Carbohydrate percentage and nitrogen content were increased in potato plants (Choudhri et al., 1976). In cassava cv. cocoa, CCC treatment resulted in increased dry matter content of tubers (Gupta, 1976). In sugarbeet, increased root sugar content and plant sugar content were reported (Pochinok et al., 1976). Popravko (1976) reported increase in tuber dry matter content in potatoes treated with CCC. In *Coleus parviflorus*, Rajmohan (1978) observed a significant increase in the dry matter, calcium and nitrogen content of shoot by CCC application. In tubers he observed a considerable increase in the dry matter percentage, starch, calcium and iron contents and a reduction in protein percentage. Reust (1976) found that starch content was not affected due to CCC treatment in potato cv. Bintje and Maritta. However in sweet potato, carbohydrate content and protein content was decreased (Menon, 1971). In tuber yield he observed a considerable increase in the dry matter percentage, starch, calcium and iron contents. Nambiar (1975) reported that 150 ppm and 100 ppm of CCC gave significantly lower nitrogen content of sweet potato vine. The nitrogen content of tuber was also decreased with increasing levels of CCC.

Dobrov *et al*. (1970) reported increased yield and earliness in CCC treated cucumber plants. Irulappan (1972) and Mariloidhaiah and Muddappa Gowda (1977) reported that CCC treatment in tomato plants resulted in increased yields. However, Adedipe *et al*. (1969) observed that CCC treatment at 100 ppm had no effect on pea yields. He also observed that one ppm treatment resulted in yield reduction. Shukla and Tewari (1973) noted delay in fruit maturity in CCC treated okra plants.

In peas CCC treatment resulted in increased content of nitrogen and reduced content of calcium (Adedipe *et al*., 1969). Sutti (1969) observed in ash-gourd that the N content of the CCC treated plants was increased whereas Ca content was decreased. CCC treated tomato plants contained more N and Ca (Knavel, 1969). Abdulla and Verkork(1970) observed considerably increased N content in CCC treated tomato plants. Kannan and Mathew (1970) observed in *Phaseolus vulgaris* that the absorption of Fe by root and transport to other parts were increased by pre-treatment of the roots with CCC for three days. Blaium *et al*. (1971) found that the stalks of the CCC treated tomato plants contained approximately 10 per cent more bound Ca over the control plants. However, Irulappan and Muthukrishnan (1972) observed a reduction in the content of N and Ca in CCC treated tomato plants.

# MATERIALS AND METHODS

# MATERIALS AND METHODS

The present investigations were carried out with the following objectives:

1. To study the effect of Ethrel (2-Chloroethyl phosphonic acid) and CCC (2-Chloroethyl trimethyl ammonium chloride) on the morphological characters and on the growth of sweet potato.

2. To assess the comparative efficacy of Ethrel and CCC on the yield, size and quality of sweet potato tubers.

3. To assess the best concentration of these growth regulators for obtaining higher yield and better quality.

4. To study the economics of crop production with and without the application of growth regulators.

## 1. Experimental site.

The experiment was laid out in the Instructional Farm, College of Agriculture, Vellayani during the year 1978-79. Before laying out the experiment, soil samples were collected and the chemical analysis done as per standard procedures (Table 1). The meteorological observations during the entire period of the experiment are given in Table 15 as weekly averages.

Table 1. Chemical analysis of the soil collected from experimental field.

| Particulars | Content |
|---|---|
| pH | 5.00 |
| Total nitrogen | 0.061% |
| Total $P_2O_5$ | 0.116% |
| Total $K_2O$ | 0.654% |
| CaO | 0.163 |

2. Lay out of the experiment.

The experiment was laid out in a Randomised Block Design. The following are the details of the experimental lay out.

| | |
|---|---|
| Number of blocks: | 3 |
| Number of plots/block: | 8 |
| Plot size | 4.5 x 5 = 22.5 $m^2$ |
| Method of planting: | Ridges and furrow system |

3. Treatments.

The growth regulators used for the experiment were Ethrel and CCC. The details of these growth regulators are given in Table 2.

Table 2.

| Growth regulators | Active ingredient | Source |
|---|---|---|
| 1. Ethrel | 2-Chloroethyl phosphonic acid - 39.56% | Agromore Limited, Bangalore |
| 2. CCC | 2-Chloroethyl trimethyl ammonium chloride - 50% | Bharat Pulverising Mills (P) Limited, Madras |

The treatments included three levels of two growth regulators, one water spray and one control. Hence, there were eight treatments with three replications. The details of the treatments are as follows:-

1. O: Control with no growth regulator and no water spray
2. W: Control with water spray
3. E-1: Ethrel 150 ppm as foliar spray
4. E-2: Ethrel 300 ppm as foliar spray
5. E-3: Ethrel 450 ppm as foliar spray
6. C-1: CCC 250 ppm as foliar spray
7. C-2: CCC 500 ppm as foliar spray
8. C-3: CCC 1000 ppm as foliar spray

Stock solutions of growth regulators were first prepared. The required concentrations were prepared by diluting the stock solution with distilled water. Three sprays of the growth regulators were given as foliar spray at an interval of 15 days starting from the 30th day after planting. In the case of water spray distilled water alone was used. The spraying was done with an ordinary stainless steel hand sprayer till run off started on the foliage. 'Teepol' was used as spreader.

4. Cultivation.

The cultivation practices were followed as per the package of practices of Kerala Agricultural University (1978). Vine cuttings of the variety Bhadrakalichola were collected from the Instructional Farm and multiplied in the nursery to obtain sufficient planting materials. The crop was planted on 1-8-1978 and harvested on 15-11-1978, 105 days after planting.

5. Sampling technique

Out of the seven rows, the second row was used for periodical up-rooting to make observations on the fresh and dry weight of shoots and tubers as well as the various biometric aspects (length of main vine, number of branches, number of leaves, etc.). Two plants were up-rooted from the second row of each plot at intervals of 15 days, starting from the 45th day after planting.

For chemical analysis of shoot, the samples were washed with distilled water, air dried for two days and then oven dried at 60°C for eight hours. The dried shoot was powdered and used for chemical analysis.

For chemical analysis of the tubers, all tubers from the observation plants were used. The tubers were thoroughly washed with distilled water, chipped into pieces and sun dried for two days. The sun dried chips were then oven dried at 60°C for eight hours, powdered and used for chemical analysis.

6. Observations recorded.

The following observations were recorded at an interval of 15 days starting from the 45th day of planting.

(a) Length of vine

The length of the vine of the observational plants was measured from the base to the top of the longest vine in centimetres.

(b) Number of branches

The total number of branches in the observational plants were counted and the average number of branches per plant worked out.

(c) Number of leaves

The total number of leaves in the observational plants were counted and the average number per plant recorded.

(d) Length of internode

The length of the 5th internode from the terminal end of the branches of the observational plants were measured in cm and the average recorded.

(e) Girth of internode

The girth of the 5th internode from the terminal end of the branches of the observation plants were measured in cm using the conventional method and the average girth per plant worked out.

(f) Length of the petiole

The length of petiole of the 5th leaf from the top of each branches of the observational plants was measured and average worked out.

(g) Fresh weight of shoot per plant.

Out of the seven rows, the second row was used for periodical uprooting of plants. At 15 days intervals commencing from the 45th day after planting two plants each were uprooted. After separating the roots and tubers the fresh weight of the shoot was recorded.

(h) Individual leaf area

On 75th day of planting, the area of the 5th leaf from the terminal end of the branches of the observational plants were calculated graphically and the average leaf area recorded.

The observations listed below were recorded after harvest.

(i) Fresh weight of tubers per plant

From the plants uprooted each time, the tubers were separated, washed and found out the fresh weight of tubers.

(j) Yield of tubers per plot

The total weight of tubers (kg) per net plot area was recorded as yield of tubers per plot.

(k) Number of tubers per plant

The total number of tubers from the observational plants was counted and the average recorded as the number of tubers per plant.

(l) Shoot/tuber ratio

The ratio between the fresh weight of shoots and the fresh weight tubers of the two observational plants was calculated, averaged and expressed as shoot/tuber ratio.

(m) Length of marketable tubers

After the harvest from the observational plants, the length of each marketable tuber was measured. The average length of such tubers was then calculated and recorded.

(n) Girth of marketable tubers

The average girth of marketable tubers was found out by taking the girth measurements at three different portions, one in the middle and the others, a quarter distance from both ends of the tubers. The average of these figures of all the marketable tubers of the observational plants was designated as mean girth.

(o) Dry weight of shoot

After recording the initial weight, the shoot from the observational plants was chopped, sun dried for two days and oven dried for 8 hours at 60°C till two consecutive weights coincided. The final weight was then expressed as dry matter percentage.

(p) Dry weight of tubers

The tubers from the observational plants were weighed, chipped into pieces and sun dried for two days. The sun dried chips were then oven dried for 8 hours at 60°C till two consecutive weights coincided and the final weight was taken. From this, the percentage of dry matter of the tubers was calculated and recorded.

(q) Nitrogen content of shoot

The total nitrogen content of the oven dried shoot samples from the observational plants was estimated colorimetrically, using the method of Le-Poldevin and Robinson (1965).

(r) Calcium content of shoot

The calcium content of shoot was estimated according to Jackson (1962) and expressed as percentage of dry matter of the shoot.

(s) Iron content of shoot

Iron content of shoot was estimated colorimetrically using orthophenanthroline in 95% ethanol and 10% hydroxylamine hydrochloride with 2,4 dinitro phenol as indicator (Jackson, 1962). The values were expressed as percentage.

(t) Starch content of tubers

The percentage of starch present in the oven dried sample of tubers from the observational plants was estimated using potassium ferricyanide method (Ward and Pigman, 1970). The values are expressed as percentage of fresh weight of tubers.

(u) Protein content of tubers

The total nitrogen content of the oven dried sample from the observational plants was estimated colorimetrically by using the method of Le-Poidevin and Robinson (1965). The nitrogen values were multiplied by the factor 6.25 to get the protein content of the tuber (A.O.A.C., 1975). The values were converted into the protein percentage of fresh weight of tuber.

(v) Calcium content of tubers

The calcium content of tubers was estimated according to Jackson (1962) and expressed as percentage of dry matter of tuber.

(w) Sugar content of tubers

The sugar content of tubers were estimated according to A.O.A.C. (1975) and expressed as percentage of fresh weight of tubers.

(x) Iron content of tubers

Iron content of tubers were estimated colorimetrically using orthophenanthroline in 95% ethanol and 10% hydroxylamine hydrochloride with 2,4 dinitro phenol as indicator (Jackson, 1962). The values were expressed as percentage.

Statistical analysis

The data from the field experiments and chemical determinations were subjected to statistical analysis wherever necessary as per Panse and Sukatme (1961).

# RESULTS

# RESULTS

The data obtained from field experimentation and laboratory determination were subjected to statistical analysis and the results are presented in Appendices 1 to XI . For the purpose of lucid discussion, the mean tables and relevant figures have also been prepared and presented.

## A. Field experimentation.

### (a) Length of vine

Length of the main vine was estimated at 45th, 60th, 75th, 90th and 105th day of planting. The results are presented in Table 3 and Fig.1.

A significant reduction in the length of the main vine was observed on application of Ethrel as well as CCC in the later stages of growth. In the earlier stages of growth, that is, upto the 60th day of planting the reduction in length of vine was not significant. At harvest stage, the length of vine of the treated plants were significantly reduced by Ethrel and CCC in all concentrations when compared with the control and water spray. The reduction was more in the case of CCC than in Ethrel and the trend was in an increasing manner with increase in the concentration of both growth regulators. The maximum reduction (18.2 per cent) was obtained in the highest level (1000 ppm) of CCC. Highly significant difference was observed between the different

Table 3. Effect of Ethrel and CCC on the length of vine in sweet potato

| Treatments | Length of vine in cm (Mean) | | | | |
|---|---|---|---|---|---|
| | On 45th day | On 60th day | On 75th day | On 90th day | On 105th day |
| Control | 60.91 | 80.50 | 90.05 | 105.38 | 111.06 |
| Water spray | 60.40 | 80.66 | 95.10 | 105.20 | 111.27 |
| Ethrel 150 ppm | 58.56 | 77.11 | 93.00 | 102.91 | 106.58 |
| Ethrel 300 ppm | 59.16 | 78.91 | 89.93 | 102.08 | 105.00 |
| Ethrel 450 ppm | 58.21 | 77.50 | 87.25 | 99.30 | 101.33 |
| CCC 250 ppm | 58.83 | 75.66 | 81.60 | 87.16 | 95.93 |
| CCC 500 ppm | 58.76 | 76.18 | 79.83 | 85.30 | 91.46 |
| CCC 1000 ppm | 59.50 | 70.16 | 79.54 | 86.10 | 90.83 |
| C.D.(P = 0.05) | 3.06 | 6.68 | 3.46 | 2.67 | 2.49 |

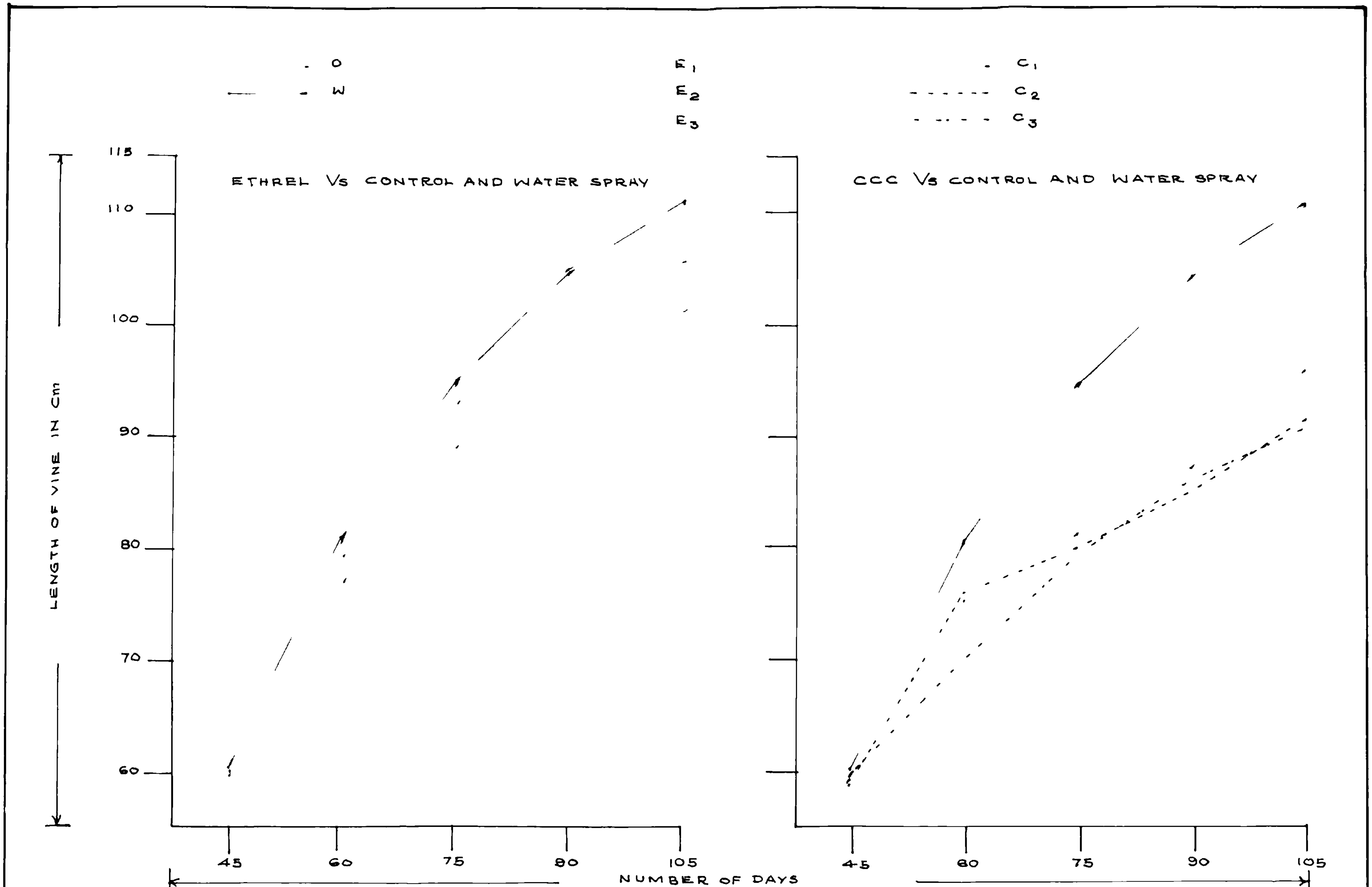


FIG 1 EFFECT OF ETHREL AND CCC ON THE LENGTH OF VINE RECORDED AT 15 DAY INTERVALS

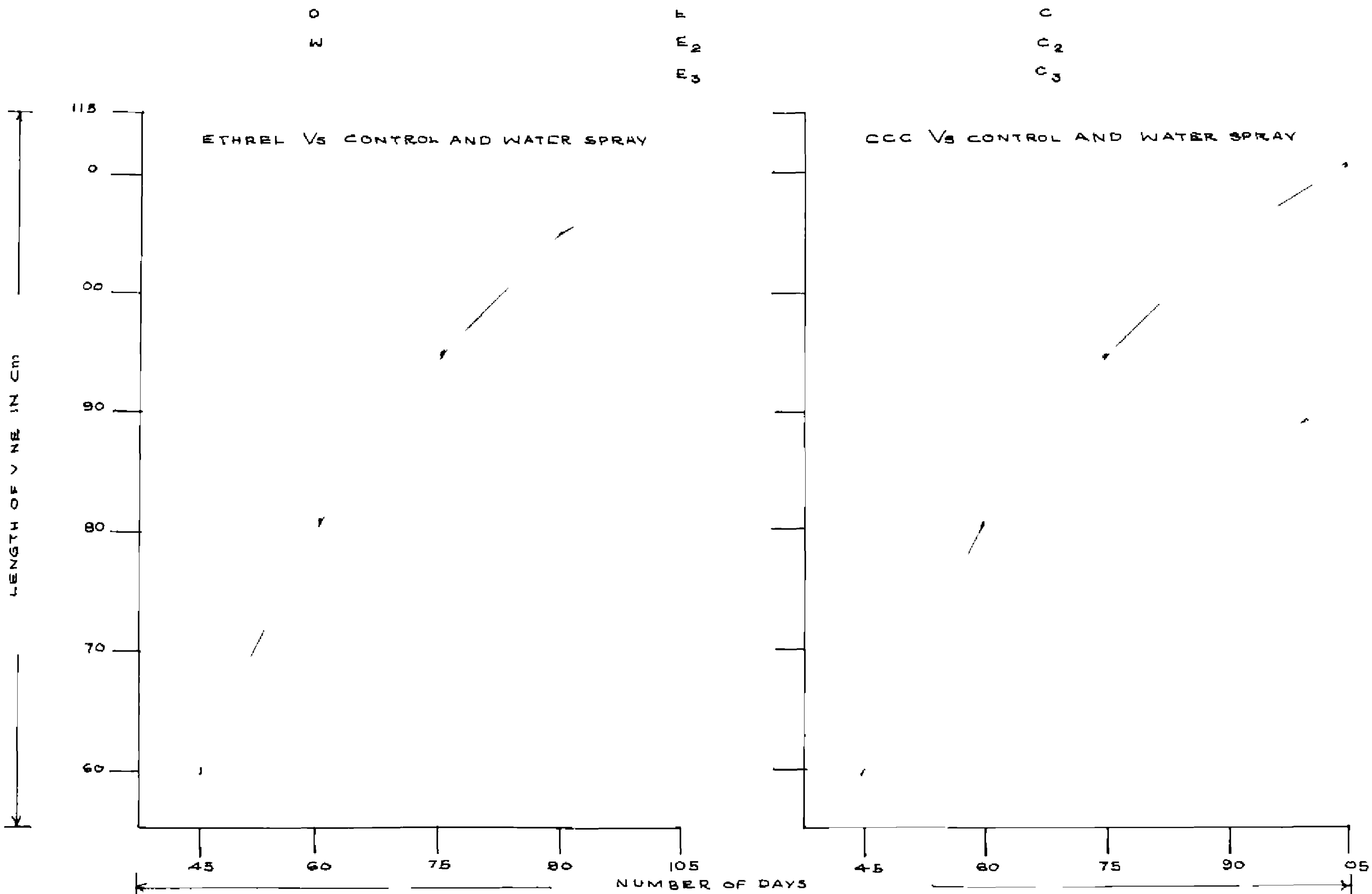


FIG 1 EFFECT OF ETHREL AND CCC ON THE LENGTH OF VINE RECORDED AT 15 DAY INTERVALS

levels of CCC as well as those of Ethrel. CCC 1000 ppm, which caused maximum reduction, was superior to CCC 500 ppm and 250 ppm. Ethrel 150 ppm caused the least reduction in the length of the main vine over the control and was on par with Ethrel 300 ppm.

(b) Number of branches

The data on the number of branches are presented in Table 4 and Fig.2.

The number of branches of treated plants were significantly increased by the two higher levels of CCC and Ethrel. Maximum number of branches, 8.03 was obtained in Ethrel 450 ppm as against 5.08 and 5.50 in the case of the control and the water spray, respectively. Significant difference was observed between the various levels of Ethrel, the highest level being superior to the lower two levels. Among the various levels of CCC also significant difference was observed, CCC 1000 ppm being superior to 500 ppm and 250 ppm.

It can be seen from the figures that in the earlier stages of growth (around 45th day) only the higher levels of CCC were found to be effective in increasing the number of branches. Around 60th day of planting the highest level of Ethrel also was found to be effective in increasing the number of branches. As the days passed, the effects of both growth regulators in higher levels possessed superiority in producing branches.

Table 4. Effect of Ethrel and CCC on the number of branches in sweet potato

| Treatments | Number of branches (Mean) | | | | |
|---|---|---|---|---|---|
| | On 45th day | On 60th day | On 75th day | On 90th day | On 10th day |
| Control | 3.28 | 4.33 | 4.66 | 5.25 | 5.08 |
| Water spray | 3.33 | 4.00 | 5.33 | 5.25 | 5.50 |
| Ethrel 150 ppm | 3.33 | 3.98 | 5.18 | 5.41 | 5.91 |
| Ethrel 300 ppm | 3.33 | 5.66 | 6.50 | 6.23 | 7.00 |
| Ethrel 450 ppm | 3.25 | 6.16 | 6.80 | 8.00 | 8.03 |
| CCC 250 ppm | 3.31 | 4.23 | 4.75 | 5.16 | 5.33 |
| CCC 500 ppm | 3.83 | 6.08 | 7.16 | 7.26 | 7.66 |
| CCC 1000 ppm | 4.33 | 6.33 | 7.00 | 7.66 | 8.00 |
| C.D.(P=0.05) | 0.60 | 0.70 | 0.70 | 0.75 | 0.54 |

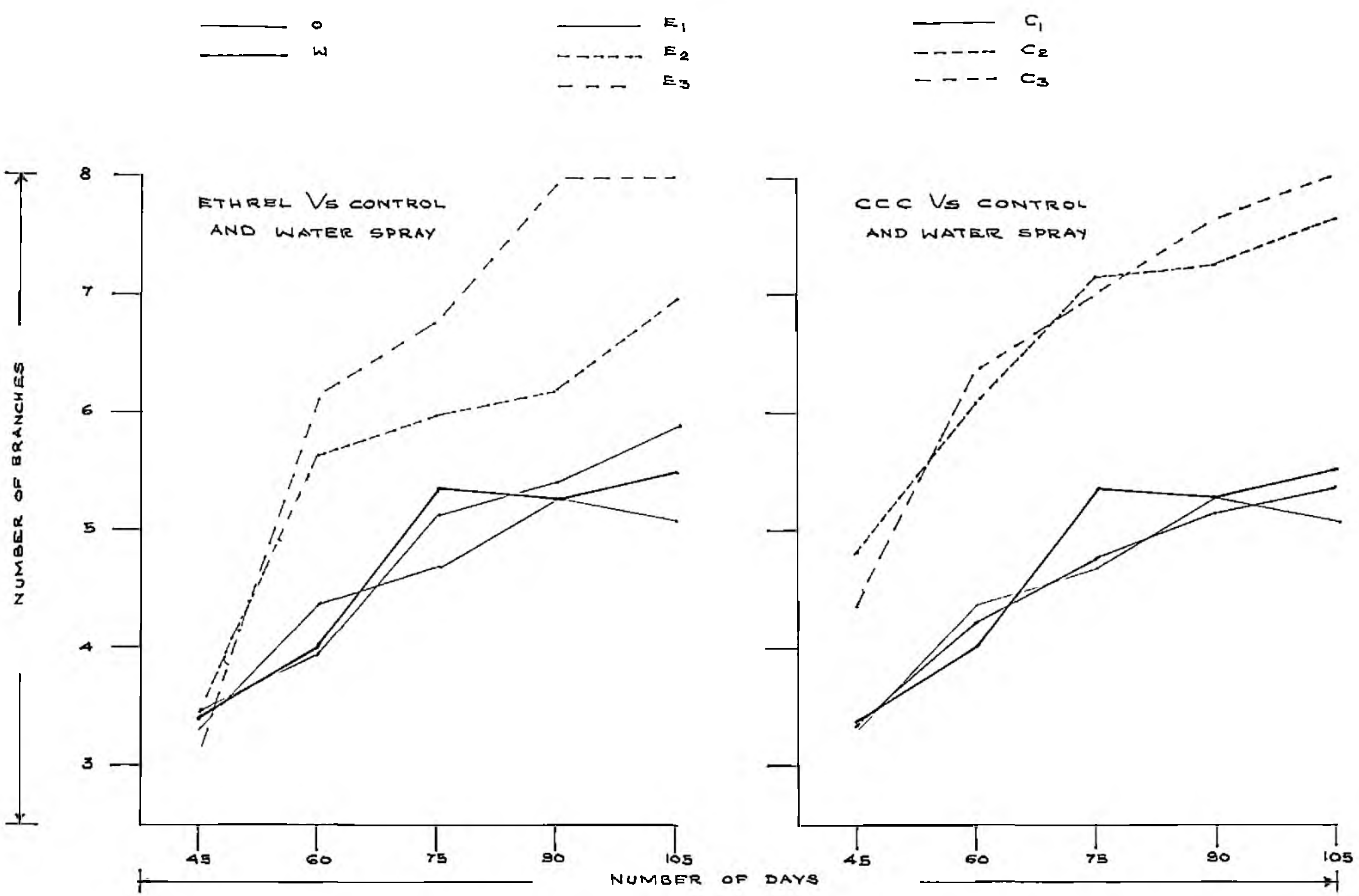


FIG 2 EFFECT OF GROWTH REGULATORS ON THE NUMBER OF BRANCHES

(c) Number of leaves

The observations made on the number of leaves at various stages are presented in Table 5 and Fig.3a and 3b

The number of leaves of the treated plants was found to be significantly reduced by the higher two levels of Ethrel (300 ppm and 450 ppm) and increased by the lowest level of (CCC 250 ppm). At 75th day of planting the maximum reduction (12.5%) in the number of leaves over the control was obtained by Ethrel 300 ppm followed by Ethrel 450 ppm. CCC 250 ppm produced the highest number. There was no significant difference between the control, water spray, Ethrel 150 ppm, CCC 500 ppm and CCC 1000 ppm. Similarly Ethrel 450 ppm and 300 ppm were on par but significantly lower to CCC 500 ppm and 1000 ppm in reducing the number of leaves.

From the figures it is clear that there is no significant difference in the number of leaves in the earlier stages (upto 45th day). CCC 250 ppm was found to produce maximum number of leaves through out the growth period and the behaviour of Ethrel 300 ppm and 450 ppm was found to have the same trend in reducing the number of leaves throughout the growth period.

(d) Length of internode

For the different observational stages, the length of the internode was measured and the results are presented in Table 6 and Fig.4.

There was a significant difference in the length of

Table 5. Effect of Ethrel and CCC on the number of leaves in sweet potato

| Treatments | Number of leaves (Mean) | | | | |
|---|---|---|---|---|---|
| | On 45th day | On 60th day | On 75th day | On 90th day | On 105th day |
| Control | 59.51 | 80.88 | 120.73 | 150.53 | 100.76 |
| Water spray | 57.15 | 80.98 | 120.70 | 149.86 | 100.45 |
| Ethrel 150 ppm | 60.30 | 81.08 | 121.35 | 150.39 | 100.65 |
| Ethrel 300 ppm | 62.01 | 78.81 | 109.62 | 132.15 | 80.85 |
| Ethrel 450 ppm | 61.53 | 76.82 | 106.98 | 132.81 | 77.98 |
| CCC 250 ppm | 60.20 | 90.58 | 131.29 | 171.55 | 119.91 |
| CCC 500 ppm | 61.26 | 81.44 | 121.73 | 150.86 | 99.31 |
| CCC 1000 ppm | 61.56 | 82.43 | 122.93 | 153.43 | 101.90 |
| C.D.(P=0.05) | 6.60 | 6.76 | 8.04 | 6.27 | 7.33 |

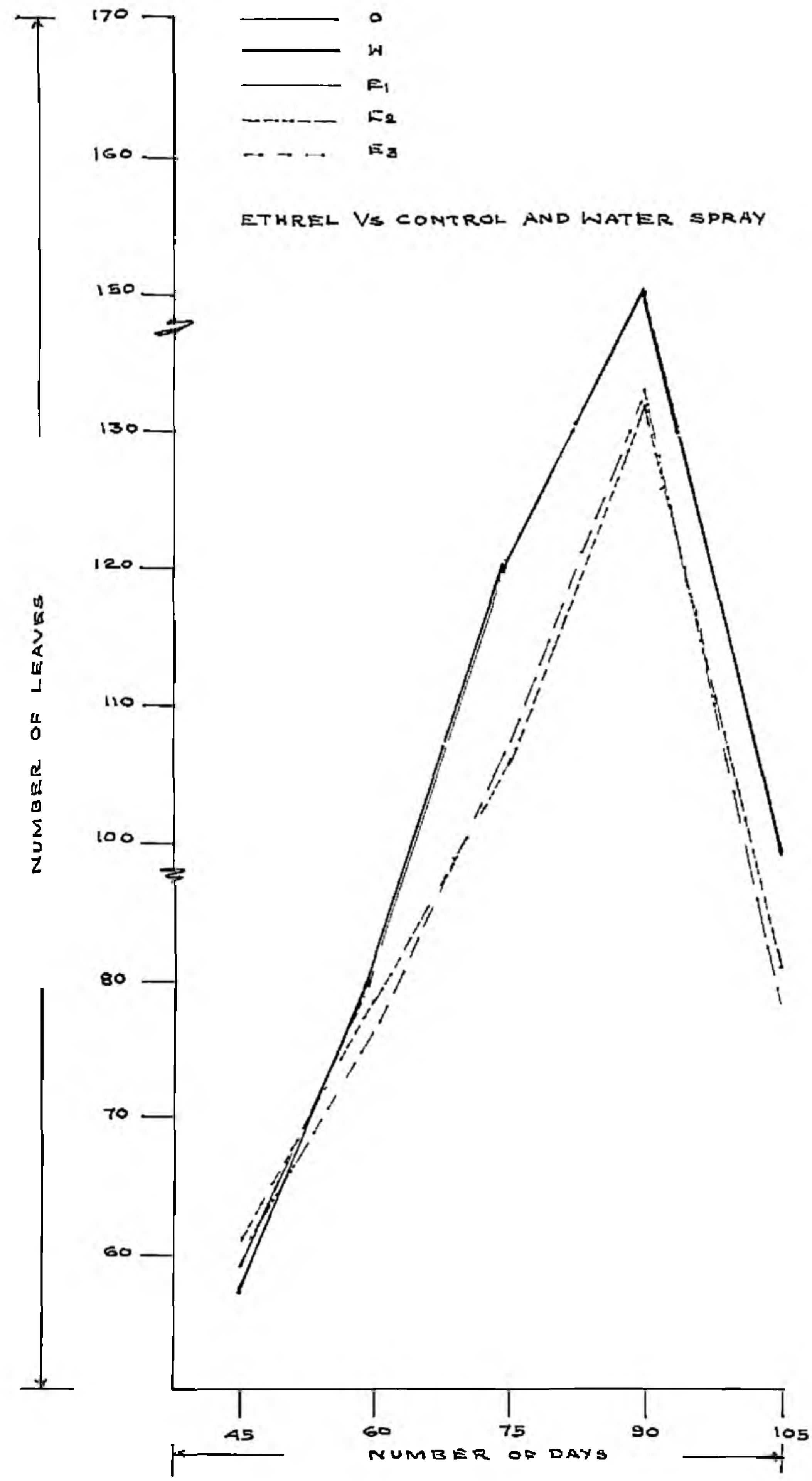


FIG 3a EFFECT OF ETHREL AND CCC ON THE NUMBER OF LEAVES

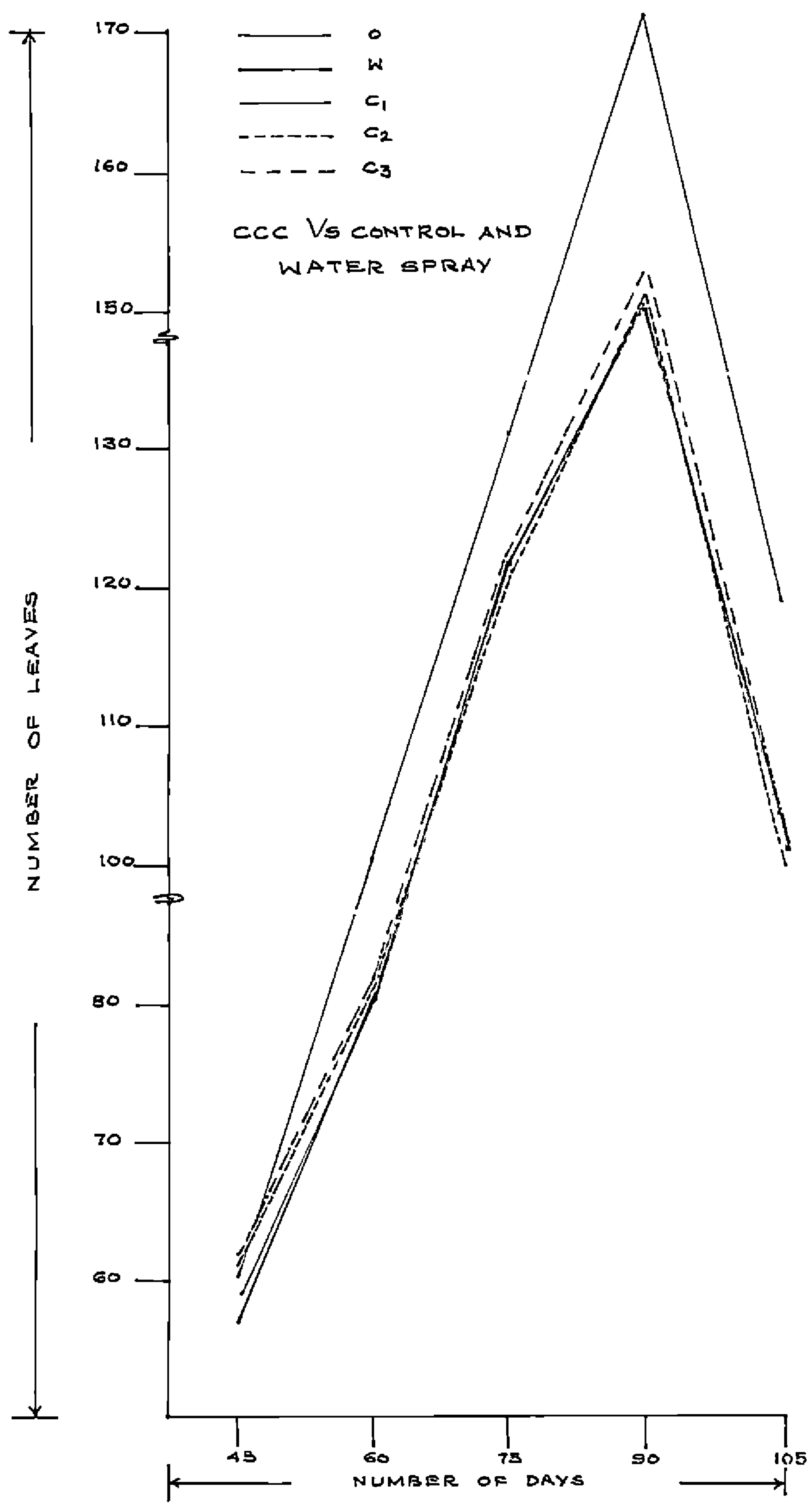


FIG 3b EFFECT OF ETHREL AND CCC ON THE NUMBER OF LEAVES

Table 6. Effect of Ethrel and CCC on the length of internode in sweet potato

| Treatments | Length of internode in cm (Mean) | | | | |
|---|---|---|---|---|---|
| | On 45th day | On 60th day | On 75th day | On 90th day | On 105th day |
| Control | 5.88 | 6.03 | 5.08 | 3.62 | 2.90 |
| Water spray | 5.73 | 6.01 | 4.90 | 3.49 | 2.95 |
| Ethrel 150 ppm | 4.71 | 4.96 | 5.03 | 3.28 | 2.93 |
| Ethrel 300 ppm | 3.93 | 4.00 | 3.64 | 3.00 | 1.85 |
| Ethrel 450 ppm | 3.63 | 4.07 | 3.71 | 2.56 | 1.94 |
| CCC 250 ppm | 4.91 | 4.91 | 4.33 | 3.03 | 3.00 |
| CCC 500 ppm | 2.95 | 2.25 | 2.36 | 2.26 | 1.90 |
| CCC 1000 ppm | 2.50 | 2.64 | 2.50 | 2.09 | 1.80 |
| C.D.(P=0.05) | 0.50 | 0.68 | 0.50 | 0.50 | 0.40 |

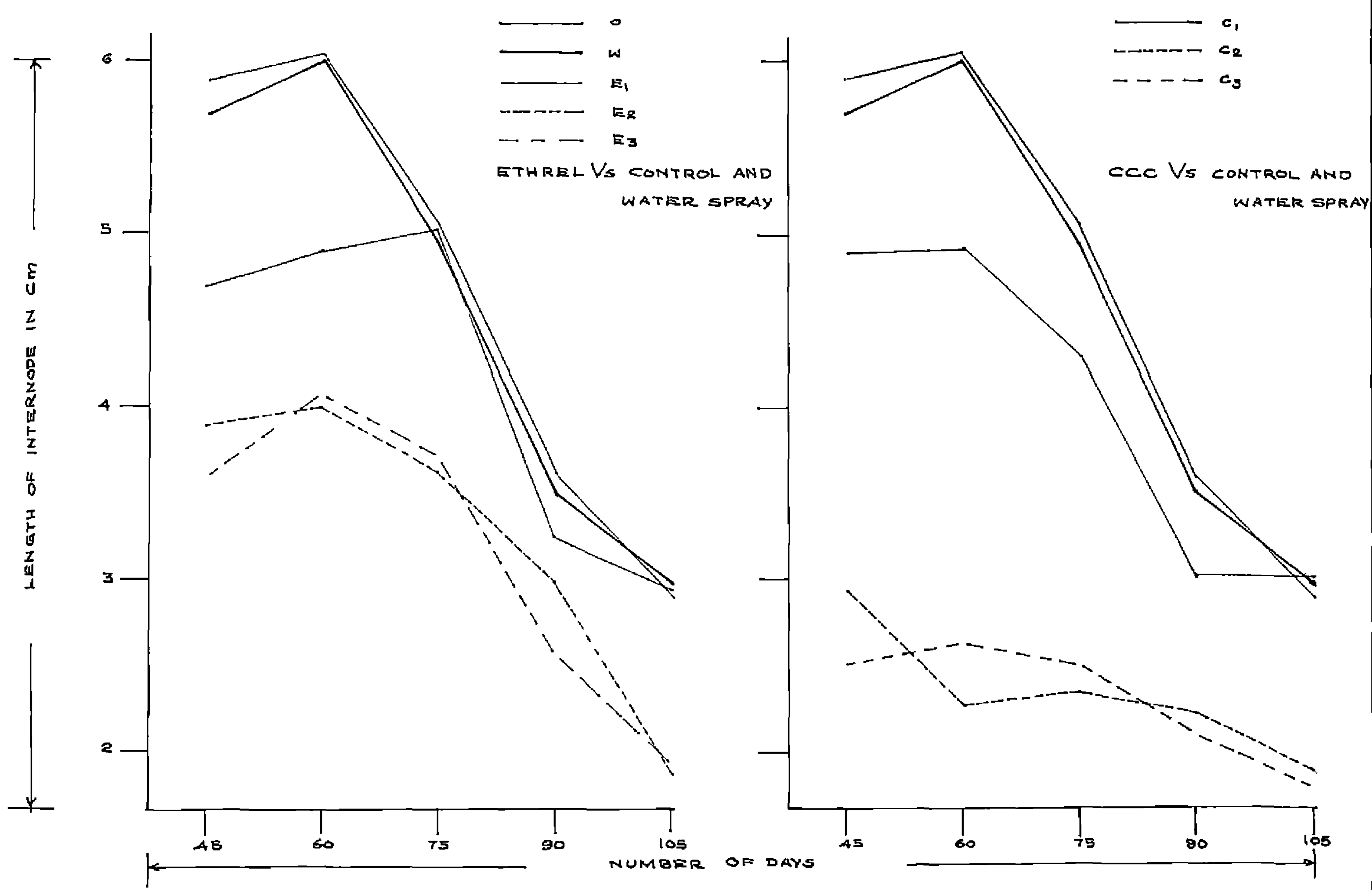


FIG 4 EFFECT OF ETHREL AND CCC ON THE LENGTH OF INTERNODE

the internode throughout the growth period in the plants treated with Ethrel and CCC. At harvest stage, a significant reduction in the length of the internode was observed in the two higher levels of CCC and Ethrel, when compared with the control and water spray. Maximum reduction (37.9 per cent) was obtained in CCC 1000 ppm followed by in Ethrel 300 ppm (36.3 per cent). There was an increase in the length of the internode in the case of the lowest level of CCC (250 ppm), water spray and the lowest level of Ethrel (150 ppm).

(c) Girth of internode

A perusal of the data on girth of internode is presented in Table 7 and Fig.5 revealed that both Ethrel and CCC brought about a significant increase in the girth of the vine throughout the growth period. In general, Ethrel was found to be superior in increasing the stem girth. At harvest stage, the maximum stem girth of 2.016 cm was obtained in 300 ppm Ethrel, followed by in Ethrel 450 ppm was against 1.05 cm for the control. There was significant difference between the various levels of Ethrel, 300 ppm being superior. The two higher levels of CCC (1000 ppm and 500 ppm) were found to be significantly superior to the control and the water spray. A significant difference was also observed between the various levels of CCC 1000 ppm being superior. The lowest level of CCC had no significant effect over the control and the water spray.

Table 7. Effect of Ethrel and CCC on the girth of internode in sweet potato

| Treatments | Girth of internode in cm (Mean) | | | | |
|---|---|---|---|---|---|
| | On 45th day | On 60th day | On 75th day | On 90th day | On 105th day |
| Control | 1.16 | 1.20 | 1.25 | 1.15 | 1.05 |
| Water spray | 1.04 | 1.05 | 1.21 | 1.16 | 1.00 |
| Ethrel 150 ppm | 1.54 | 1.48 | 1.30 | 1.70 | 1.35 |
| Ethrel 300 ppm | 2.14 | 2.23 | 2.16 | 2.06 | 2.01 |
| Ethrel 450 ppm | 2.11 | 2.01 | 2.06 | 2.08 | 1.99 |
| CCC 250 ppm | 1.24 | 1.47 | 1.25 | 1.21 | 1.10 |
| CCC 500 ppm | 1.50 | 1.55 | 1.71 | 1.53 | 1.39 |
| CCC 1000 ppm | 1.81 | 1.83 | 1.83 | 1.77 | 1.70 |
| C.D.(P=0.05) | 0.19 | 0.37 | 0.20 | 0.29 | 0.15 |

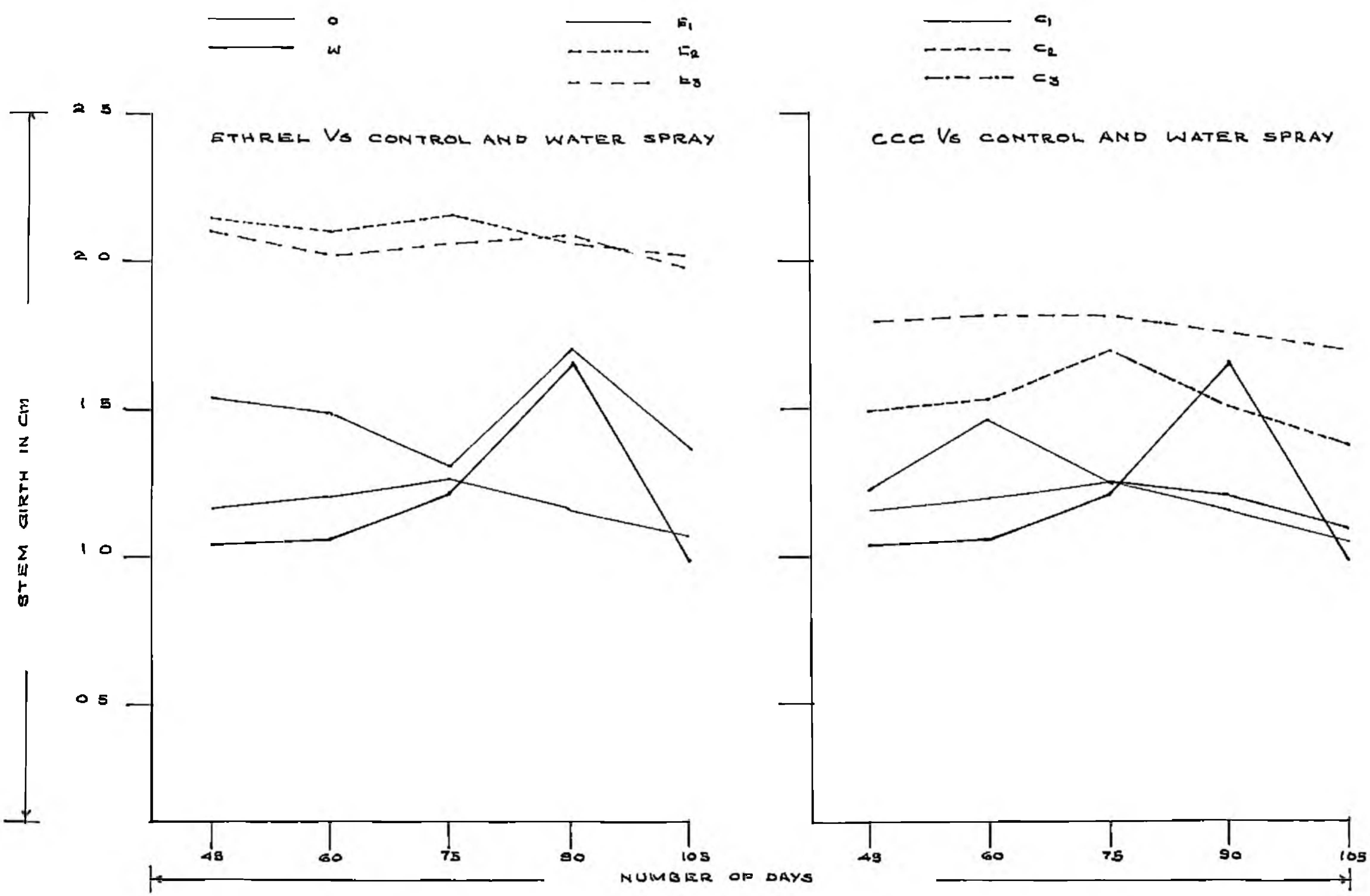


FIG 5 EFFECT OF ETHREL AND CCC ON THE GIRTH OF INTERNODE

(f) Length of petiole

The length of petiole of the 5th leaf from the tip recorded at various stages is presented in Table 8 and Fig.6.

Length of petiole of the treated plants were not significantly affected by the growth regulators except in one stage (around 90th day). At 90th day of planting the length of petiole of the treated plants were significantly increased by Ethrel and CCC at the higher two levels. There was no significant difference between the higher two levels of these two growth regulators.

(g) Fresh weight of shoot per plant

The Table 9 and Fig.7 illustrates the details of the weight of tops recorded at various stages of growth.

There was a significant reduction in the fresh weight of tops by Ethrel in all concentrations when compared to the control and water spray. But CCC did not affect the weight of tops significantly although there was a slight increase by the lowest level (250 ppm) at the time of harvest. The maximum reduction was obtained by the highest level of Ethrel (450 ppm) followed by the lower two levels. The water spray and all levels of CCC were on par with each other in the fresh weight of tops. In general Ethrel was superior in reducing the fresh weight of tops.

From the figures it is evident that Ethrel was found to be more effective to reduce the fresh weight of tops than CCC throughout the growth period. In the earlier stages

Table 8. Effect of Ethrel and CCC on the length of petiole in sweet potato

| Treatments | Length of petiole in cm (Mean) | | | | |
|---|---|---|---|---|---|
| | On 45th day | On 60th day | On 75th day | On 90th day | On 105th day |
| Control | 7.97 | 9.20 | 10.01 | 7.50 | 4.60 |
| Water spray | 8.24 | 9.08 | 10.04 | 7.74 | 4.75 |
| Ethrel 150 ppm | 7.98 | 9.98 | 11.04 | 9.49 | 5.43 |
| Ethrel 300 ppm | 8.23 | 10.00 | 10.88 | 9.08 | 5.38 |
| Ethrel 450 ppm | 8.28 | 8.93 | 10.36 | 8.15 | 5.05 |
| CCC 250 ppm | 7.71 | 9.43 | 10.09 | 8.59 | 4.86 |
| CCC 500 ppm | 8.03 | 9.00 | 10.44 | 9.45 | 5.15 |
| CCC 1000 ppm | 7.93 | 9.40 | 10.66 | 9.45 | 5.81 |
| C.D.(P=0.05) | 0.93 | 1.22 | 1.20 | 0.94 | 1.03 |

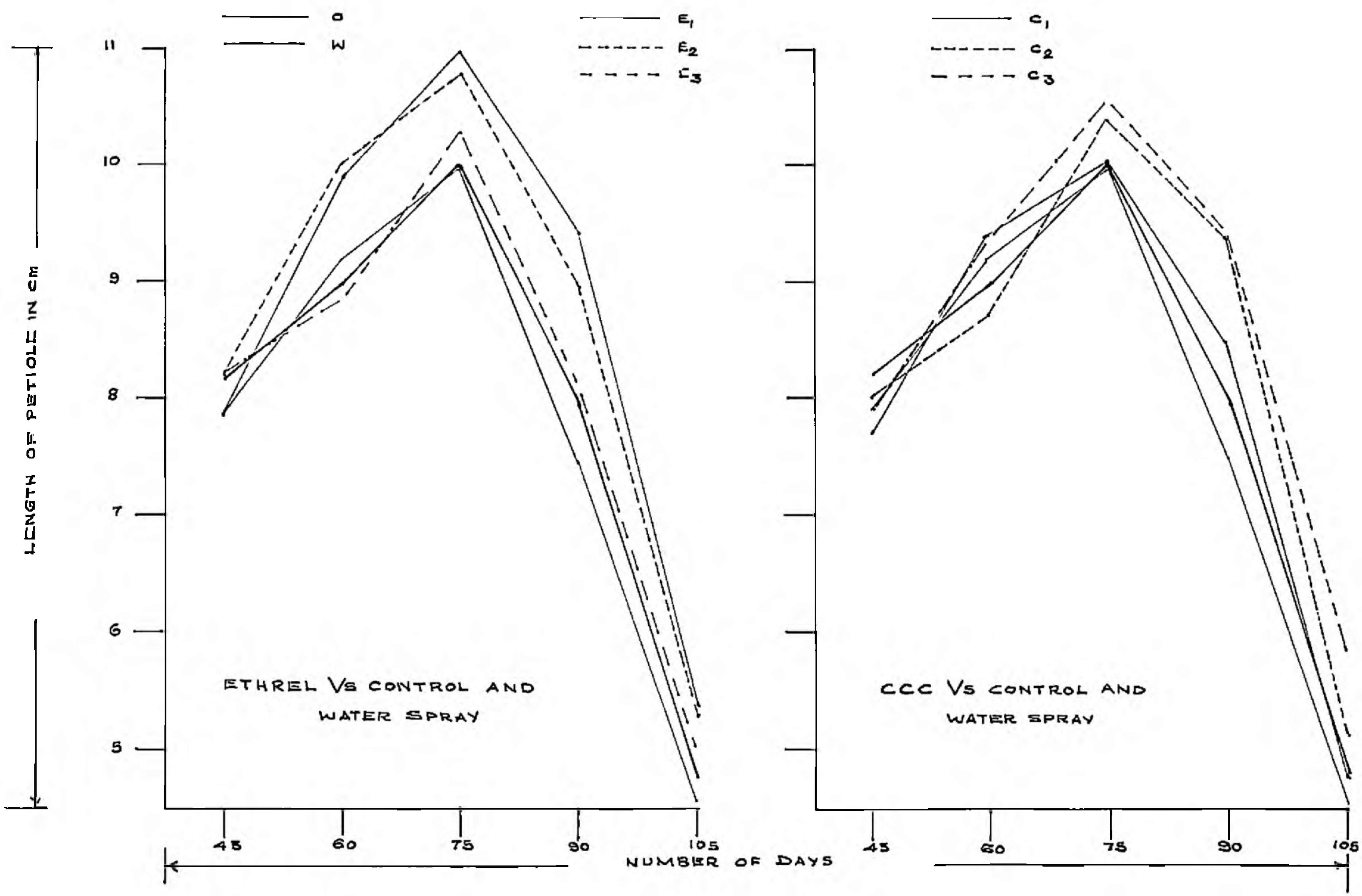


FIG 6 EFFECT OF ETHREL AND CCC ON THE LENGTH OF PETIOLE

Table 9. Effect of Ethrel and CCC on the fresh weight of shoot in sweet potato

| Treatments | Fresh weight of shoot in g (Mean) | | | | |
|---|---|---|---|---|---|
| | On 45th day | On 60th day | On 75th day | On 90th day | On 105th day |
| Control | 75.24 | 101.61 | 149.17 | 140.46 | 99.67 |
| Water spray | 76.17 | 102.99 | 154.65 | 140.74 | 104.77 |
| Ethrel 150 ppm | 73.77 | 99.30 | 141.58 | 131.08 | 90.94 |
| Ethrel 300 ppm | 72.10 | 96.12 | 143.23 | 124.50 | 78.61 |
| Ethrel 450 ppm | 72.71 | 93.62 | 134.60 | 121.08 | 72.50 |
| CCC 250 ppm | 77.73 | 111.53 | 165.61 | 158.75 | 107.89 |
| CCC 500 ppm | 76.86 | 115.60 | 160.50 | 141.65 | 103.86 |
| CCC 1000 ppm | 75.53 | 100.65 | 149.75 | 139.90 | 105.58 |
| C.D. (P=0.05) | 2.49 | 3.27 | 3.61 | 3.43 | 6.53 |

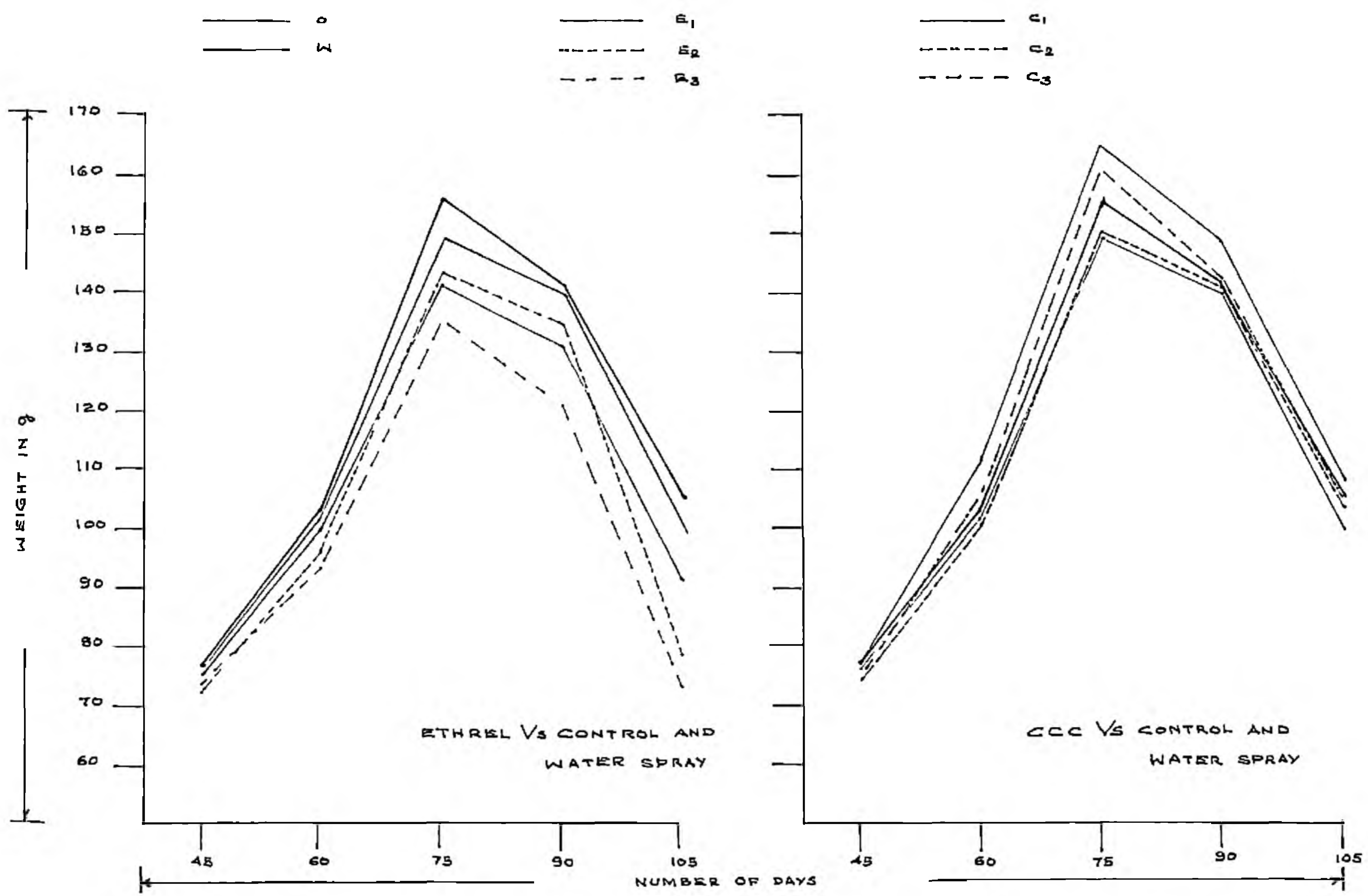


FIG 7 EFFECT OF ETHREL AND CCC ON THE FRESH WEIGHT OF SHOOT

(60th day of planting) the lower two levels of CCC significantly increased the fresh weight of tops and the highest level was on par with the control, the water spray and the lowest level of Ethrel. Around 75th day of planting the same trend was followed, except that the lower level of Ethrel also reduced the tops considerably when compared to the control, water spray and the highest level of CCC. Around 90 days and 105 days of planting the trend was as described earlier.

(h) Individual leaf area

The area of the 5th leaf from the tip of each vine of the observational plants was recorded on 75th day after planting and presented in Table 12 and Fig.9.

The individual leaf area of the treated plants was found to be significantly reduced by both Ethrel and CCC in all concentrations when compared with the control and water spray. The least area was obtained by Ethrel 450 ppm and CCC 1000 ppm followed by Ethrel 300 ppm. There was no significant difference between the three levels of Ethrel and CCC 1000 ppm. However, CCC 250 ppm and 500 ppm were on par with each other and significantly lower than 1000 ppm of CCC.

(i) Fresh weight of tubers per plant

The weight of tubers per plant was estimated at 45th, 60th, 75th, 90th and 105th day after planting. The results are presented in Table 10 and Fig.8.

Table 10. Effect of Ethrel and CCC on the fresh weight of tubers in sweet potato

| Treatments | Fresh weight of tubers in g (Mean) | | | | |
|---|---|---|---|---|---|
| | On 45th day | On 60th day | On 75th day | On 90th day | On 105th day |
| Control | 51.13 | 86.00 | 154.81 | 179.76 | 204.33 |
| Water spray | 62.33 | 84.36 | 152.32 | 180.00 | 202.13 |
| Ethrel 150 ppm | 50.00 | 100.81 | 205.35 | 266.30 | 280.25 |
| Ethrel 300 ppm | 50.65 | 105.16 | 216.51 | 281.56 | 301.98 |
| Ethrel 450 ppm | 54.00 | 105.45 | 178.48 | 278.83 | 302.65 |
| CCC 250 ppm | 48.11 | 93.96 | 182.83 | 321.25 | 250.80 |
| CCC 500 ppm | 51.11 | 93.08 | 184.38 | 240.26 | 263.13 |
| CCC 1000 ppm | 47.73 | 85.85 | 192.65 | 259.71 | 277.70 |
| C.D.(P=0.05) | 17.92 | 14.60 | 40.54 | 9.01 | 16.98 |

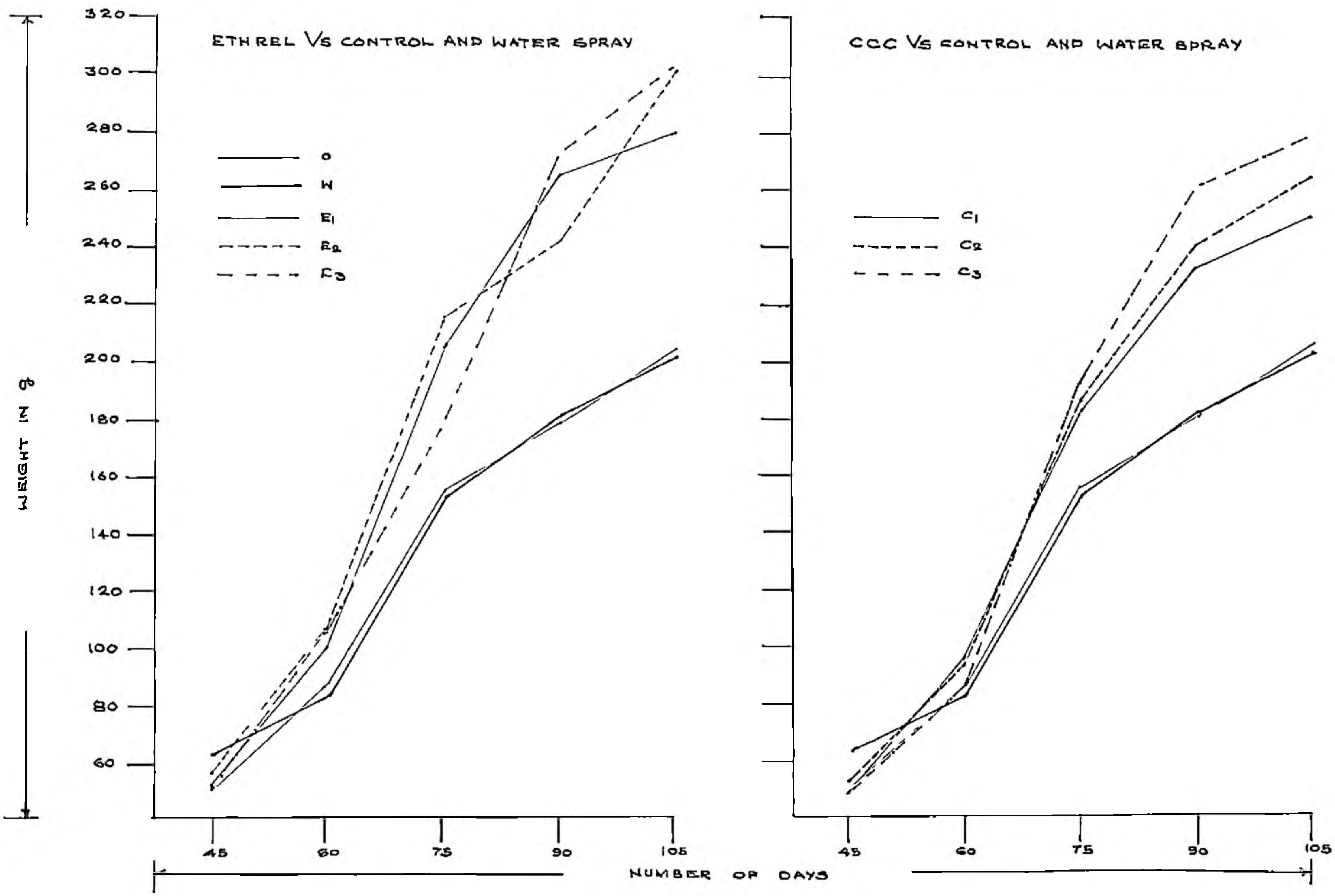


FIG 8 EFFECT OF ETHREL AND CCC ON THE FRESH WEIGHT OF TUBERS PER PLANT

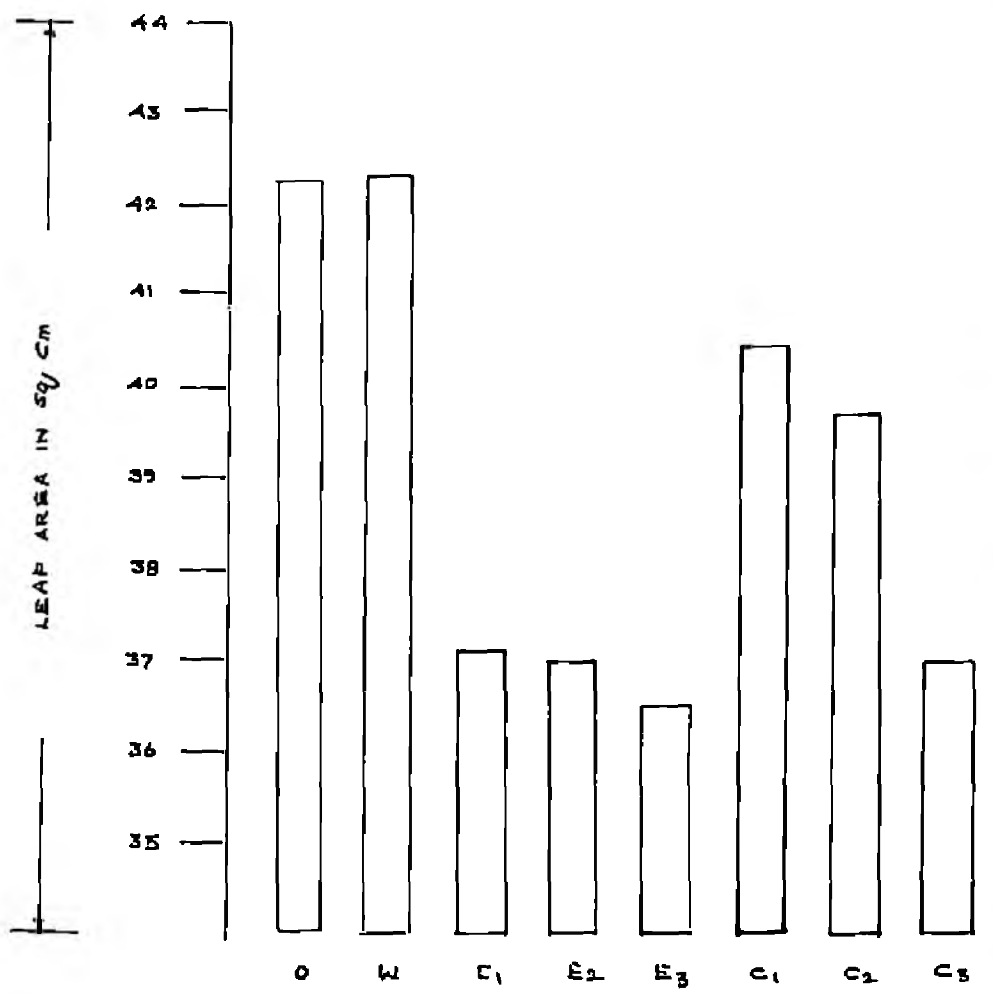


FIG 9 EFFECT OF GROWTH REGULATORS ON LEAF AREA

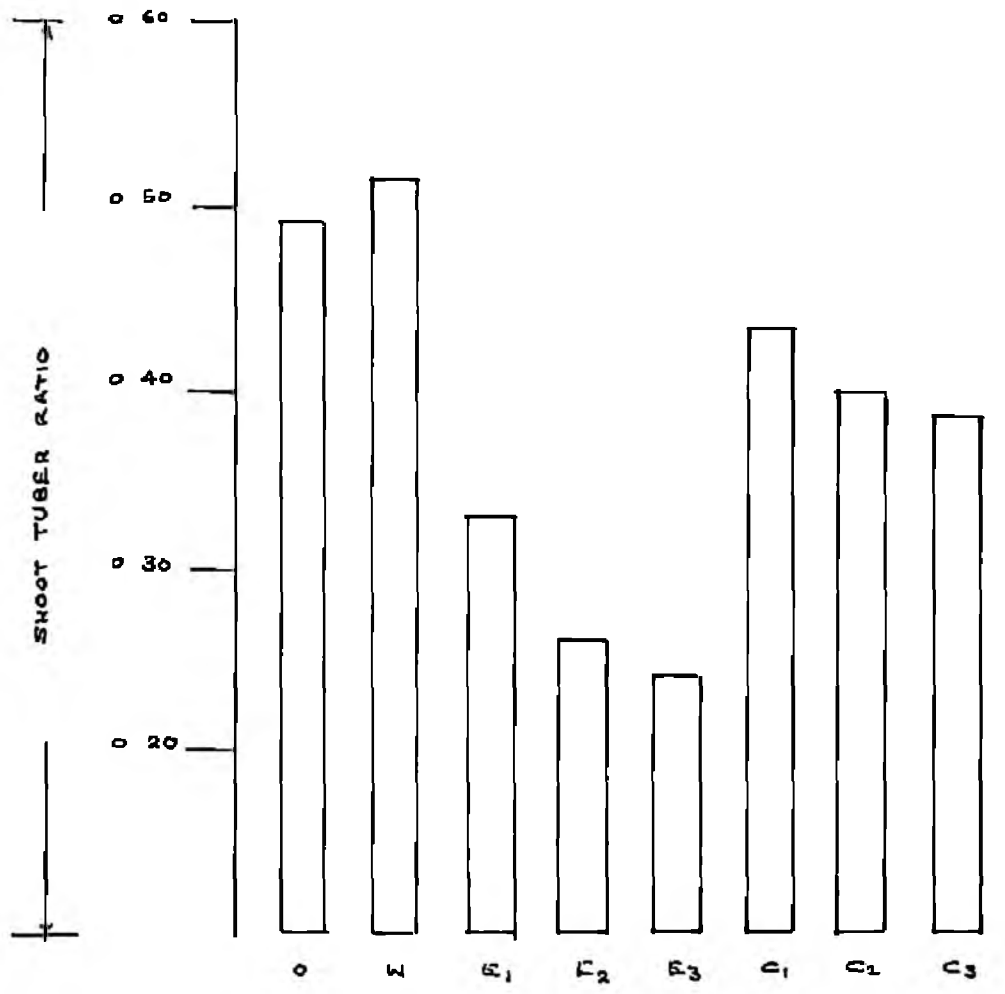


FIG 10 EFFECT OF GROWTH REGULATORS ON SHOOT PER TUBER RATIO

The weight of tubers of sweet potato plants treated with Ethrel and CCC were found to be significantly increased when compared to the control and water spray. The highest yield of tubers per plant was obtained by Ethrel 300 ppm and 450 ppm followed by 150 ppm. Ethrel 450 ppm yielded 302.65 g of tubers per plant as against 204.33 g of the control. There was no significant difference between Ethrel 450 ppm and 300 ppm which are superior to Ethrel 150 ppm. Among the different levels of CCC, the highest level (1000 ppm) gave the highest yield of 277.70 g per plant followed by the lower levels. CCC 1000 ppm was on par with CCC 500 ppm but superior to CCC 250 ppm. Ethrel in general was superior to CCC. Ethrel 450 ppm was significantly superior to all levels of CCC.

In the earlier stages of growth (up to 45th day) the growth regulators did not produce any significant increase in tuber yield. Around 60th day only Ethrel could cause an increase in tuber yield. By about 75th day of planting all levels of Ethrel and the highest level of CCC increased the yield considerably. By about 90th day, both Ethrel and CCC in all levels caused a significant increase in yield.

(j) Yield of tuber per plot

Table 11 and Fig.12 gives a perusal of the data on the weight of tuber per plot recorded at harvest.

There was a significant increase in yield of tubers per plot by Ethrel and CCC in all concentrations when compared

Table 11. Effect of Ethrel and CCC on the yield of tubers per plot, number of tubers per plant, length and girth of marketable tubers in sweet potato.

| | Mean | | | |
|---|---|---|---|---|
| | Yield of tuber per plot in kg | Number of marketable tubers per plant | Length of tubers in cm | Girth of tubers in cm |
| Control | 12.32 | 2.66 | 16.45 | 11.26 |
| Water spray | 12.26 | 2.91 | 16.07 | 11.11 |
| Ethrel 150 ppm | 17.52 | 2.33 | 16.09 | 10.27 |
| Ethrel 300 ppm | 19.06 | 4.25 | 18.14 | 10.14 |
| Ethrel 450 ppm | 17.85 | 4.20 | 20.04 | 9.10 |
| CCC 250 ppm | 14.56 | 3.30 | 16.39 | 10.06 |
| CCC 500 ppm | 16.10 | 3.50 | 16.25 | 12.70 |
| CCC 1000 ppm | 16.94 | 3.75 | 17.00 | 12.71 |
| C.D.($P_2$ = 0.05) | 1.20 | 0.56 | 1.51 | 0.92 |

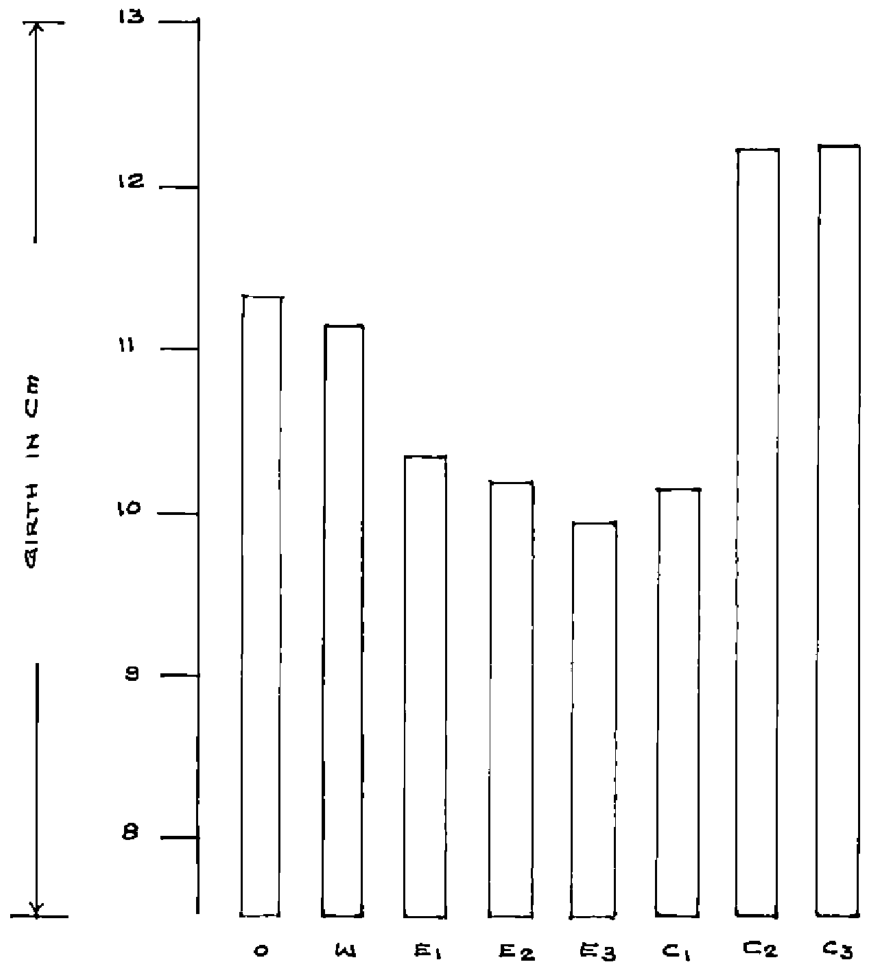


FIG 11 EFFECT OF GROWTH REGULATORS ON THE GIRTH OF TUBERS

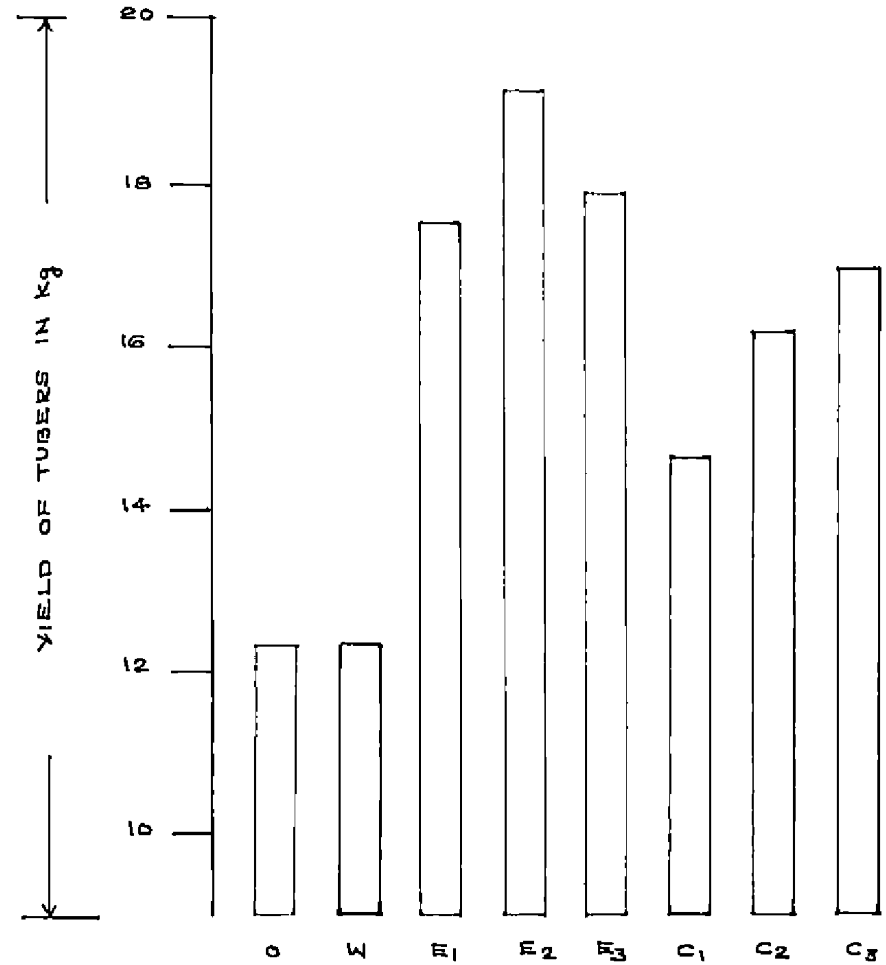


FIG 12 EFFECT OF GROWTH REGULATORS ON THE YIELD OF MARKETABLE TUBERS

to control and water spray. The highest yield of 19.06 kg per plot was recorded by Ethrel 300 ppm as against 12.32 kg and 12.26 kg for control and water spray respectively. A significant difference was observed by the different levels of Ethrel. Ethrel 150 ppm was inferior to Ethrel 300 ppm and 450 ppm. An increase in yield of tubers per plot was observed with increasing concentrations of CCC. Among the different levels of CCC, 1000 ppm produced the highest yield of 16.94 kg per plot which is superior to CCC 250 ppm, and was on par with CCC 500 ppm. Ethrel in general was found to be superior to CCC in increasing tuber yield.

(k) Number of marketable tubers

The results of the data presented in Table 11 and Fig.13 revealed that the number of marketable tubers per plant was found to be significantly increased by the treatment with both Ethrel and CCC in all concentrations. The highest number of tubers (4.25) was obtained by Ethrel 300 ppm. Ethrel 300 ppm was on par with Ethrel 450 ppm and superior to 150 ppm. Among the different levels of CCC, 1000 ppm gave the highest number (3.75) which is on par with CCC 500 ppm.

(l) Shoot/tuber ratio

The results of the data on the shoot/tuber ratio is presented in Table 12 and Fig.10.

There was a significant reduction in shoot/tuber ratio due to the application of both growth regulators in all concentrations when compared with the control and water spray.

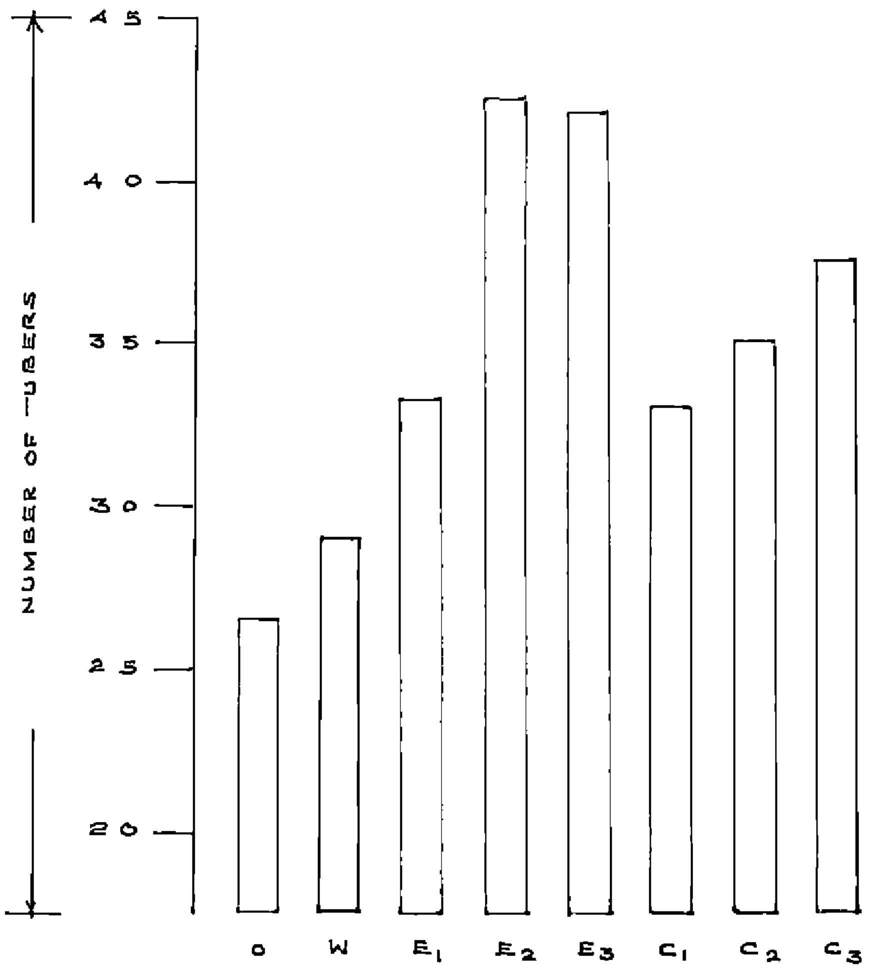


FIG 13 EFFECT OF GROWTH REGULATORS ON THE NUMBER OF TUBERS AT HARVEST

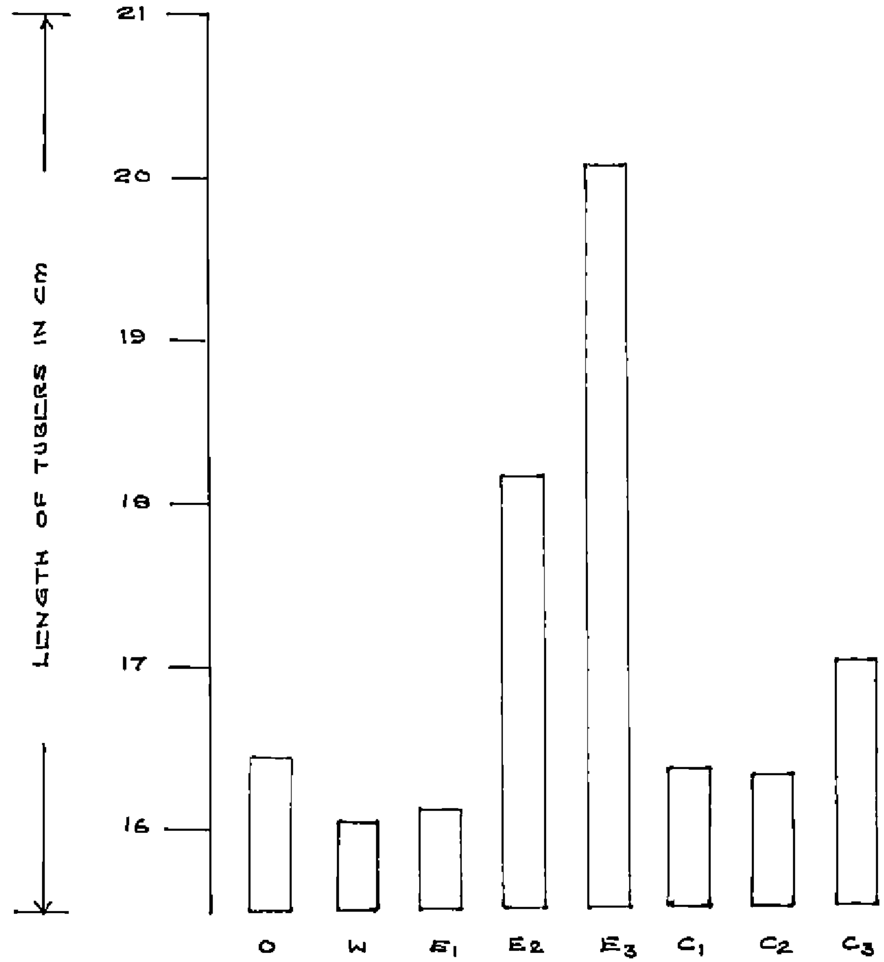


FIG 14 EFFECT OF GROWTH REGULATORS ON THE LENGTH OF MARKETABLE TUBERS

The shoot/tuber ratio was reduced by increasing the level of both Ethrel and CCC. There was a significant difference among the various levels of Ethrel. The maximum reduction was obtained by the highest level of Ethrel followed by the lower levels. Ethrel 450 ppm gave a shoot/tuber ratio of 0.2395 as against 0.4914 of control. Ethrel in general was more effective in reducing the shoot/tuber ratio than CCC. Among the various levels of CCC the highest level (1000 ppm) was superior in reducing the shoot/tuber ratio which is on par with CCC 500 ppm and significantly superior to 250 ppm. CCC 1000 ppm produced a shoot/tuber ratio of 0.3804 as against 0.4914 of the control. The difference between the control and water spray was not significant.

(m) Length of marketable tubers

The length of marketable tubers recorded at the harvest stage is presented in Table 11 and Fig.14.

The results showed that the two higher levels of Ethrel were found to have significantly increased the length of marketable tubers. 450 ppm of Ethrel produced the longest tubers of 20.04 cm followed by Ethrel 300 ppm which produced tubers of 18.14 cm in length. There was no significant difference in length of tubers on CCC application. All the levels of CCC and the lowest level of Ethrel were found to be on par with the control and water spray, though there is a slight increase due to the highest level of CCC.

(n) Girth of marketable tubers

From the Table 11 and Fig.11 it is clear that the girth of marketable tubers were found to have significantly increased by the two highest levels of CCC. All the levels of Ethrel and the lowest level of CCC have significantly reduced the girth of tubers when compared to control or water spray. The maximum reduction in girth was observed due to the highest level of Ethrel followed by the lowest levels of CCC. The lower two levels of Ethrel were on par with the lowest level of CCC and were inferior to the highest level of Ethrel in reducing the length of tubers.

## B. Laboratory determination

### (a) Dry matter percentage of shoot

The dry matter percentage of the shoot was calculated and results are presented in Table 12 and Fig.15.

All the levels of Ethrel and the two higher concentrations of CCC brought about a significant increase in the dry matter per cent of the shoot when compared to the control and water spray. Ethrel at 450 ppm recorded the maximum increase and was superior to all other concentrations of Ethrel and CCC. Highly significant difference was observed between the effects of the varying levels of Ethrel. Ethrel 450 ppm recorded the dry matter per cent of 23.25 as against 18.51 of the control. Among the varying levels of CCC the two highest levels were on par with each other but significantly higher to the lowest level. There was no significant difference between the control water spray and the lowest level of CCC.

(p) Dry matter percentage of tuber

From Table 13 and Fig.19 it is evident that the highest two levels of CCC and all levels of Ethrel brought about a significant increase in the dry matter content of tubers. Ethrel 450 ppm recorded the maximum content (34.96%) of dry matter. There was significant difference between the varying levels of Ethrel. Among the varying levels of CCC, the highest level was superior to the lower two levels. Ethrel in general was superior in increasing the dry matter content.

(q) Nitrogen content of shoot

The results of the data on the nitrogen content of shoot presented in Table 12 and Fig.16 revealed that only the highest two levels of CCC brought about a significant increase in the nitrogen content of shoot when compared to the control. The maximum nitrogen content of 0.9250 per cent was recorded by CCC 500 ppm and minimum by water spray. There was no significant difference between the highest levels of CCC. The higher two levels of Ethrel were on par with the lowest level of CCC and the control, but superior to water spray.

(r) Calcium content of shoot

The Table 12 and Fig.18 gives the results of the data on the calcium content of shoot of the observational plants. The lowest level of Ethrel brought about a significant increase in the calcium content of shoot. However two higher levels of Ethrel brought about a significant reduction in the

Table 12. Effect of Ethrel and CCC on the leaf area, shoot/tuber ratio, and the contents of dry matter, nitrogen, iron and calcium in shoots in sweet potato.

| Treatments | Mean | | | | | |
|---|---|---|---|---|---|---|
| | Leaf area in $cm^2$ | Shoot/tuber ratio | Dry matter content of shoot in percentage | Nitrogen content of shoot in percentage | Iron content of shoot in percentage | Calcium content of shoot in percentage |
| Control | 42.20 | 0.49 | 18.51 | 0.80 | 0.052 | 0.6100 |
| Water spray | 42.33 | 0.51 | 18.40 | 0.76 | 0.051 | 0.6400 |
| Ethrel 150 ppm | 37.11 | 0.32 | 19.60 | 0.81 | 0.049 | 0.6700 |
| Ethrel 300 ppm | 36.95 | 0.26 | 21.60 | 0.85 | 0.050 | 0.5000 |
| Ethrel 450 ppm | 36.56 | 0.23 | 23.25 | 0.84 | 0.051 | 0.4300 |
| CCC 250 ppm | 40.43 | 0.43 | 18.65 | 0.80 | 0.059 | 0.5633 |
| CCC 500 ppm | 39.71 | 0.39 | 21.26 | 0.92 | 0.065 | 0.5800 |
| CCC 1000 ppm | 36.95 | 0.38 | 21.96 | 0.91 | 0.062 | 0.5700 |
| C.D.($P_2$ = 0.05) | 1.29 | 0.04 | 0.82 | 0.06 | 0.008 | 0.0644 |

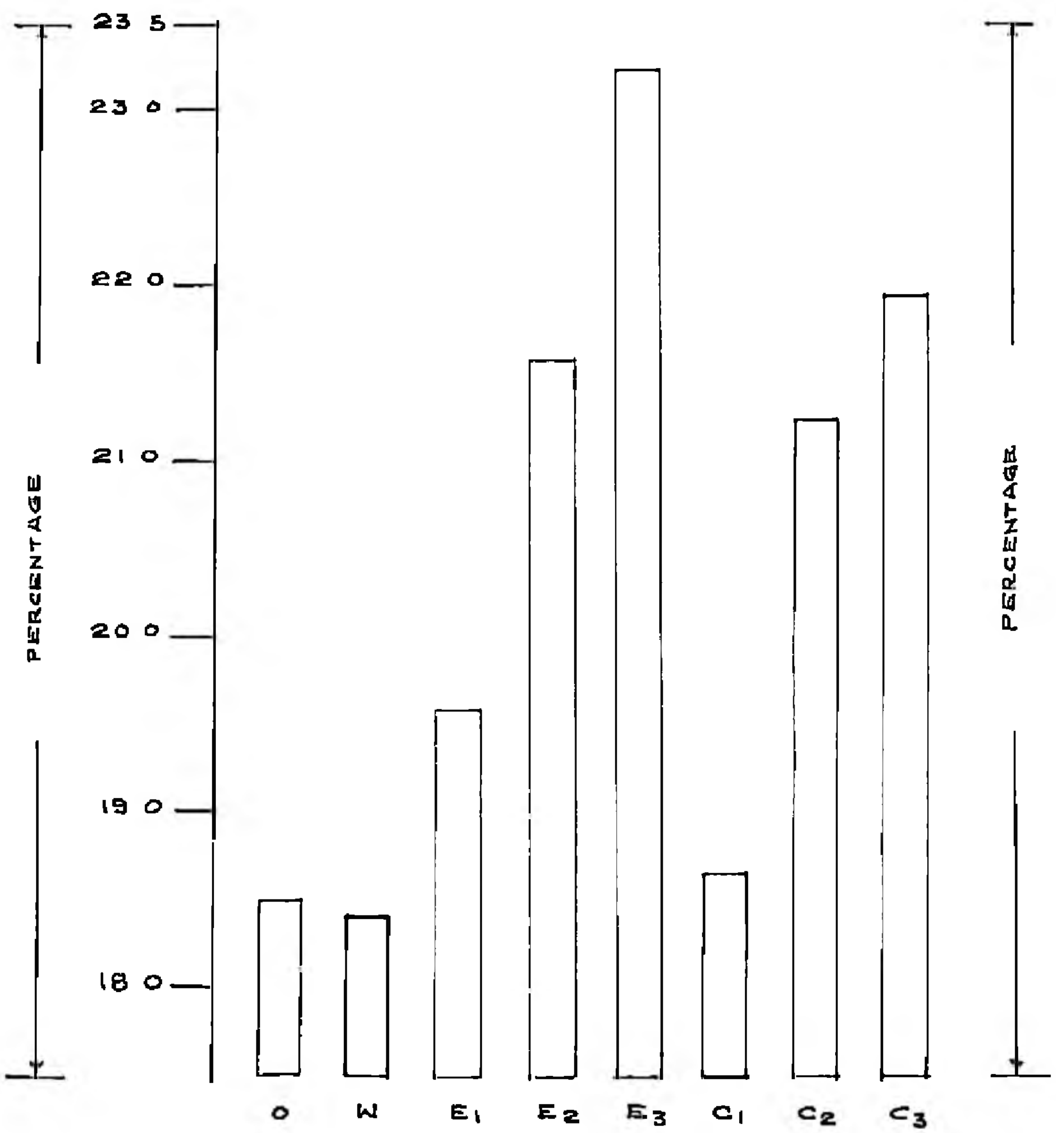


FIG 15 EFFECT OF GROWTH REGULATORS ON THE DRY MATTER PERCENTAGE OF SHOOT

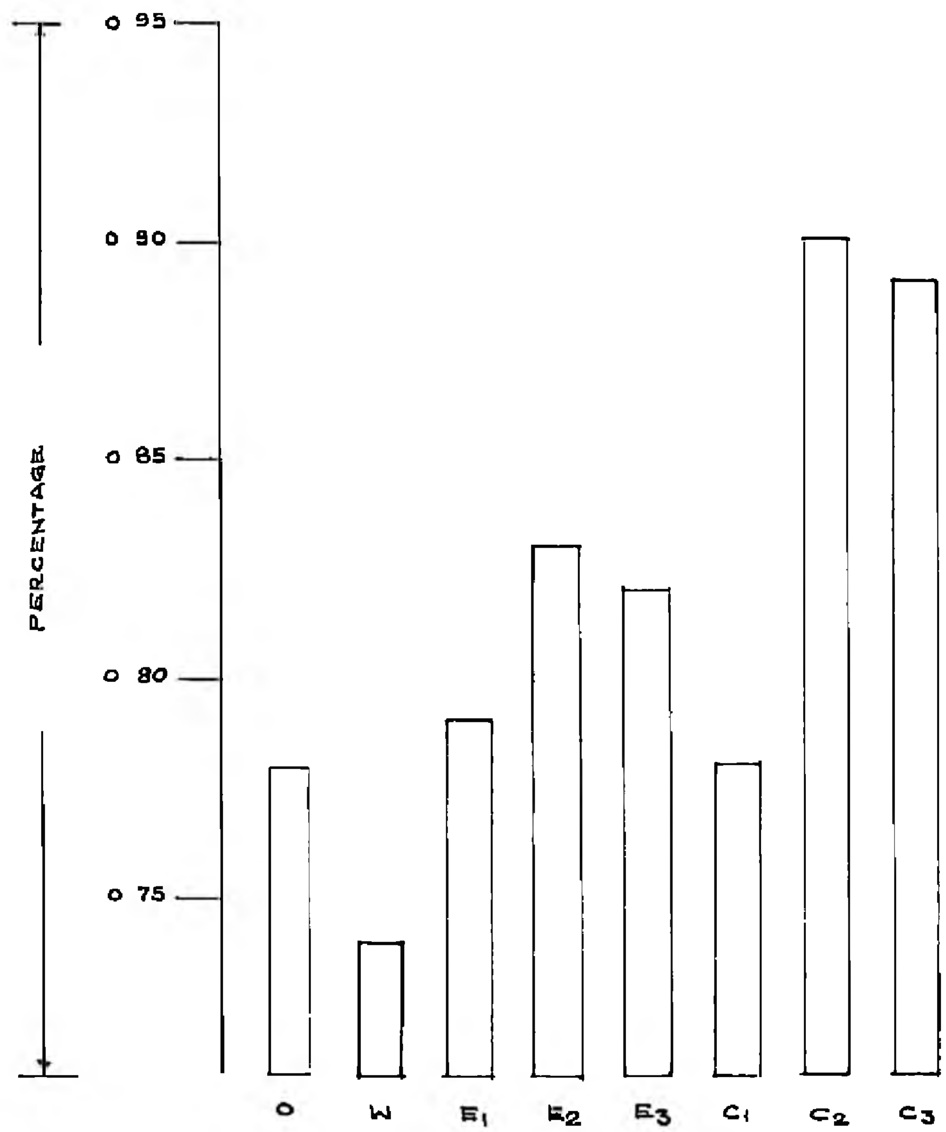


FIG 16 EFFECT OF GROWTH REGULATORS ON THE NITROGEN PERCENT OF SHOOT

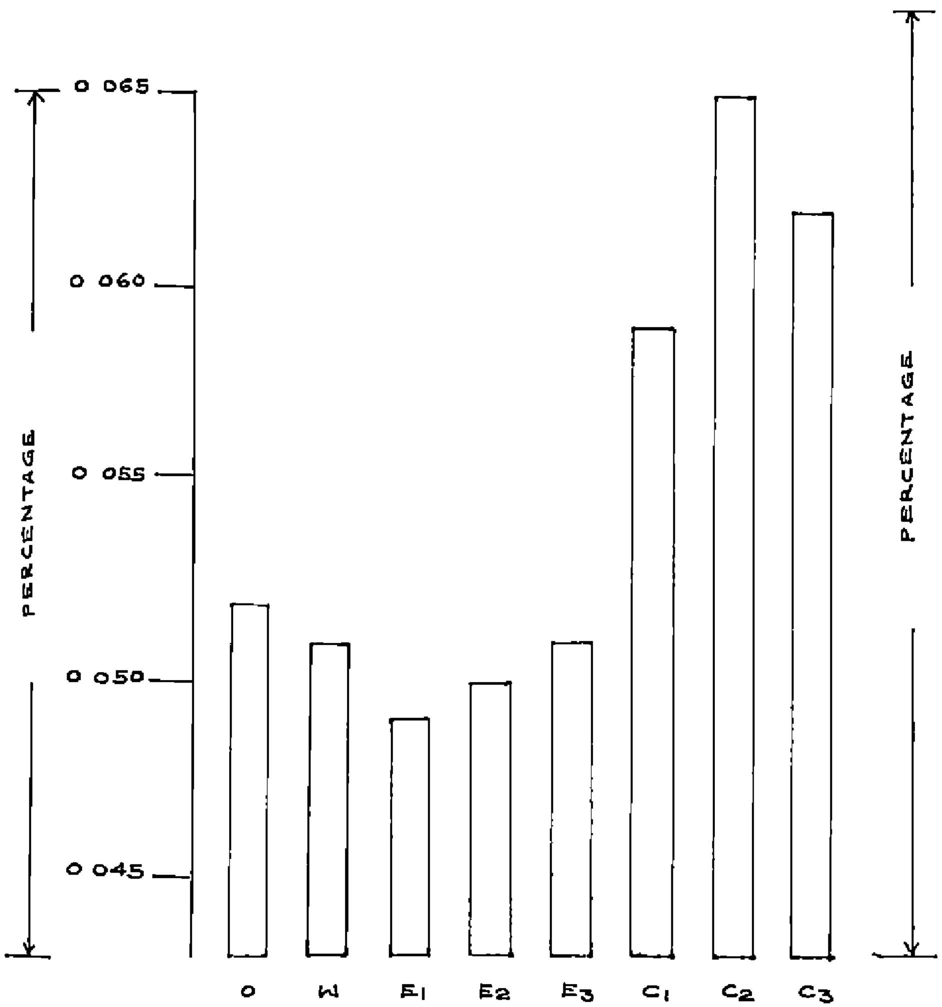


FIG 17 EFFECT OF GROWTH REGULATORS ON THE IRON CONTENT OF SHOOT

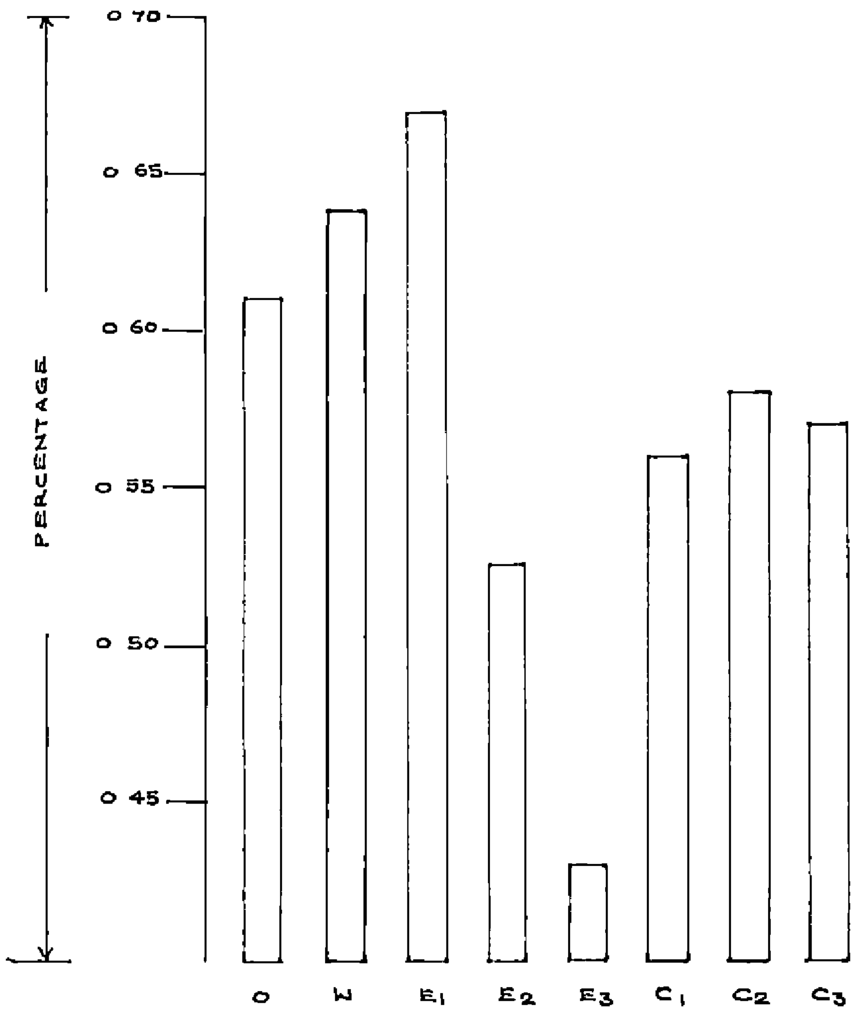


FIG 18 EFFECT OF GROWTH REGULATORS ON THE CALCIUM CONTENT OF SHOOT

calcium content of shoot. Ethrel 450 ppm gave the lowest calcium content of 0.43 per cent as against 0.61 per cent of the control. The CCC treatments did not bring about any significant change in this regard.

(s) Iron content of shoot

The iron content of shoot is presented in Table 12 and Fig.17. It revealed that the iron content was significantly increased by all levels of CCC and decreased by all levels of Ethrel. The least iron content was recorded by the lowest level of Ethrel. CCC 500 ppm gave the highest iron content of 0.0653 per cent as against 0.0523 per cent of the control.

(t) Starch content of tubers

The starch content of tubers was estimated and the results are presented in Table 13 and Fig. 21.

The two higher levels of CCC and all levels of Ethrel brought about a significant increase in the starch content of tubers when compared to the control. The highest starch content (23.75%) was observed by Ethrel 300 ppm followed by Ethrel 450 ppm. Ethrel 450 ppm is on par with Ethrel 300 ppm and superior to Ethrel 150 ppm. Among the different levels of CCC, the higher two levels are superior to the lowest level which is on par with the control and water spray.

(u) Protein content of tuber

The protein content of tubers of the various observational plants is presented in Table 12 and Fig.20.

Table 13. Effect of Ethrel and CCC on the content of dry matter, protein, starch, sugar, iron and calcium in tubers of sweet potato.

| Treatments | Mean | | | | | |
|---|---|---|---|---|---|---|
| | Dry matter content of tubers in percentage | Protein content of tubers in percentage | Starch content of tubers in percentage | Sugar content of tubers in percentage | Iron content of tubers in percentage | Calcium content of tubers in percentage |
| Control | 29.35 | 2.83 | 19.65 | 2.77 | 0.019 | 0.2166 |
| Water spray | 30.18 | 2.82 | 20.66 | 2.90 | 0.019 | 0.2400 |
| Ethrel 150 ppm | 31.91 | 2.52 | 21.35 | 3.17 | 0.017 | 0.2600 |
| Ethrel 300 ppm | 33.66 | 2.48 | 23.73 | 3.88 | 0.020 | 0.2500 |
| Ethrel 450 ppm | 34.96 | 2.43 | 23.46 | 3.70 | 0.018 | 0.2233 |
| CCC 250 ppm | 30.51 | 2.49 | 19.86 | 2.78 | 0.018 | 0.2400 |
| CCC 500 ppm | 31.41 | 2.55 | 22.58 | 3.25 | 0.019 | 0.2800 |
| CCC 1000 ppm | 33.70 | 2.37 | 22.98 | 3.58 | 0.019 | 0.2733 |
| C.D.(P = 0.05) | 1.20 | 0.11 | 1.27 | 0.30 | 0.002 | 0.0155 |

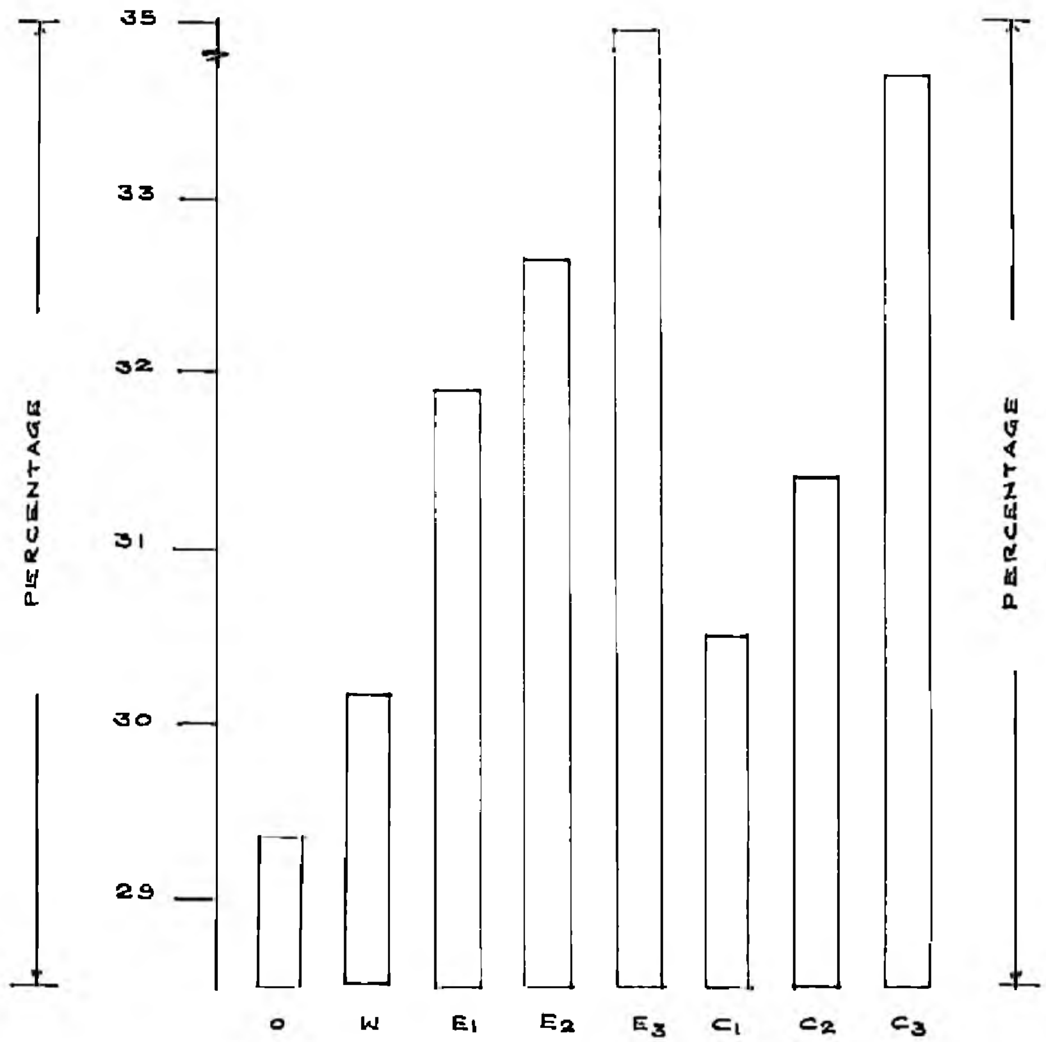


FIG 19 EFFECT OF GROWTH REGULATORS ON THE DRY MATTER PERCENTAGE OF TUBERS

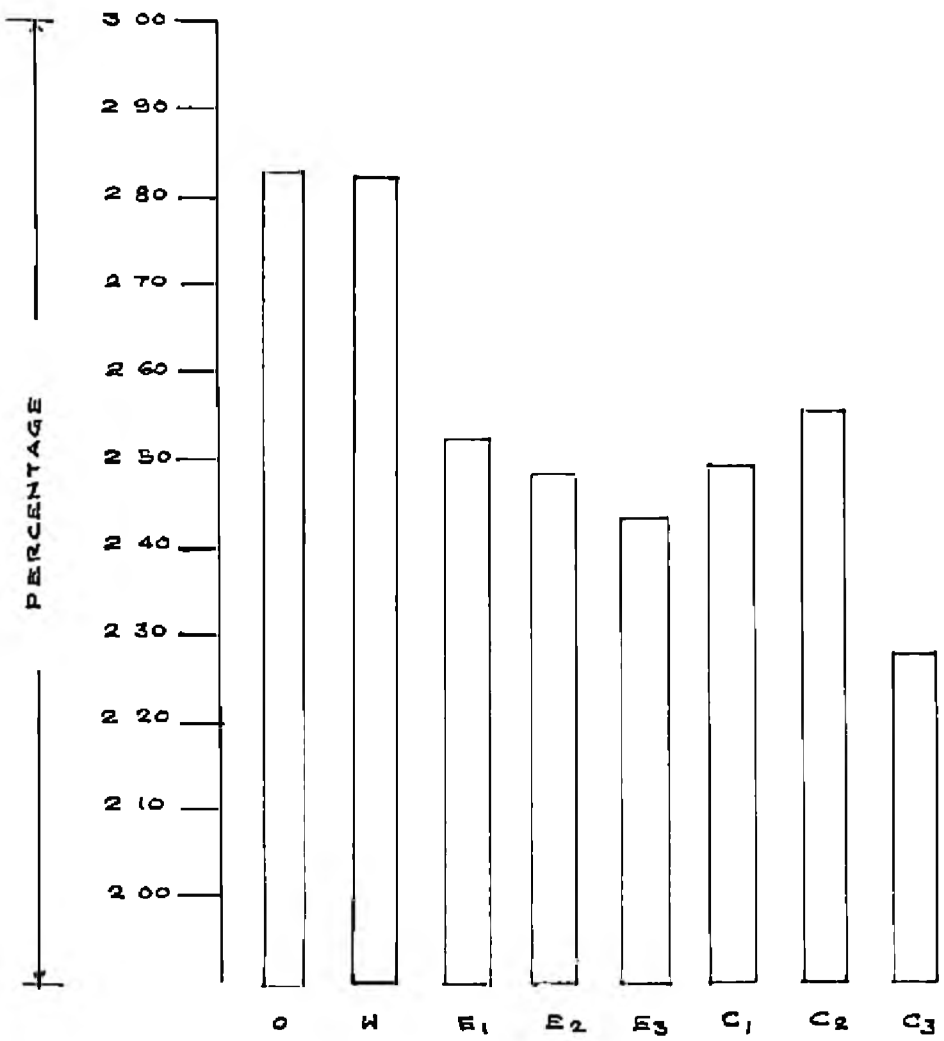


FIG 20 EFFECT OF GROWTH REGULATORS ON THE PROTEIN CONTENT OF TUBERS

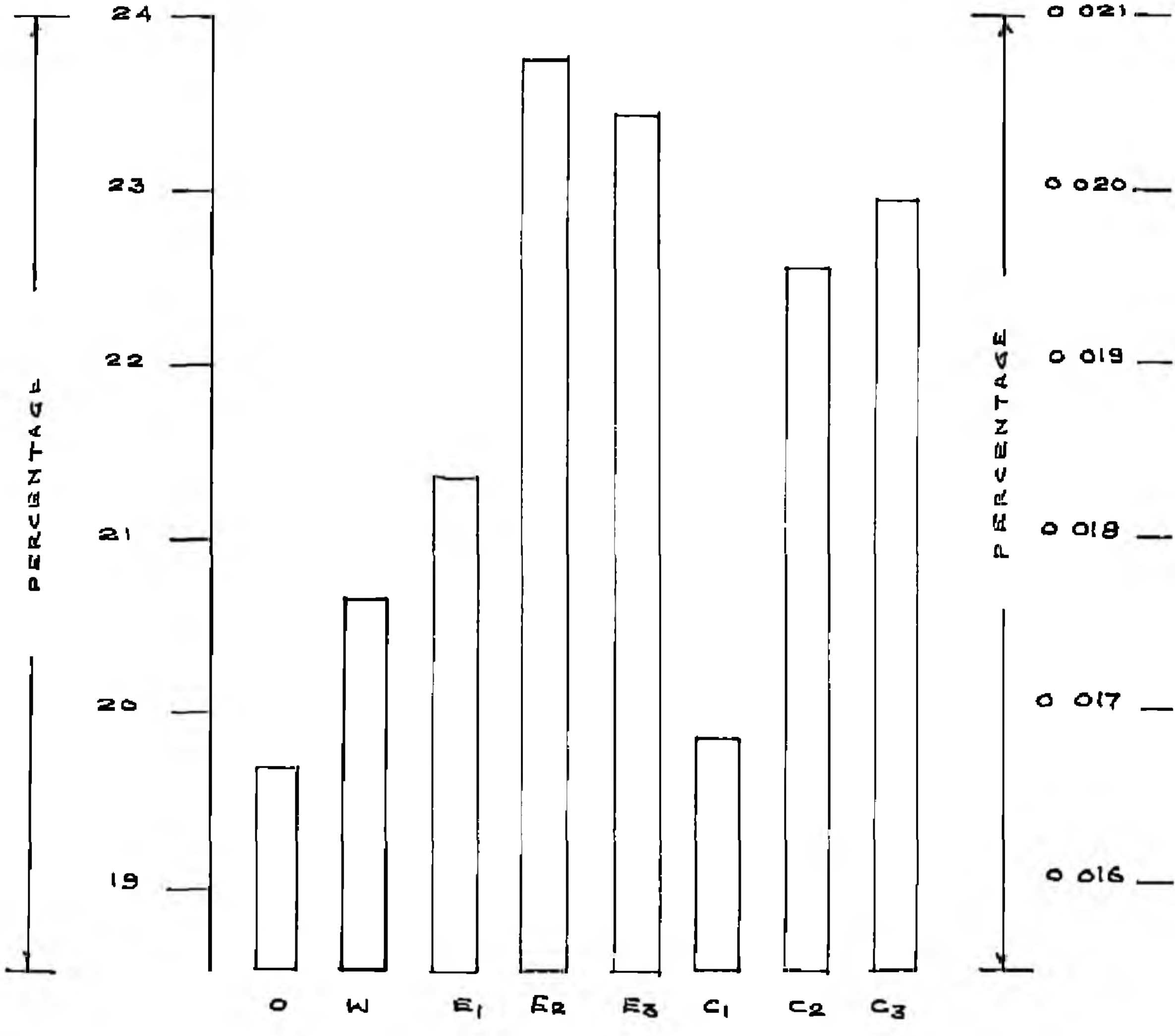


FIG 21 EFFECT OF GROWTH REGULATORS ON THE STARCH CONTENT OF TUBERS

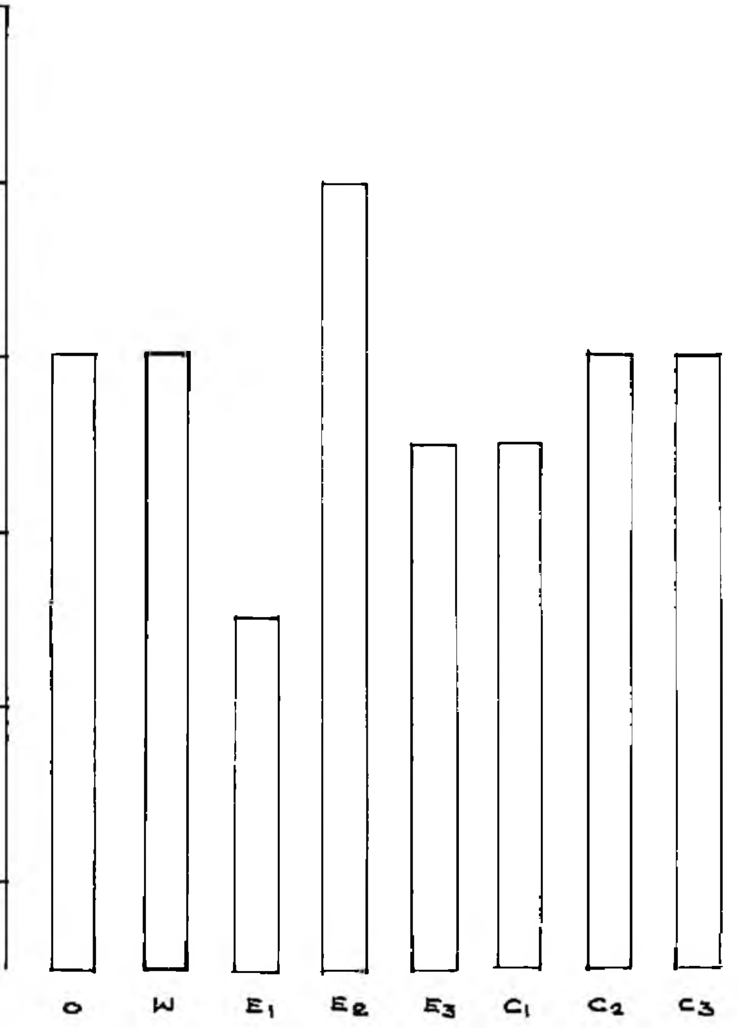


FIG.22 EFFECT OF GROWTH REGULATORS ON THE IRON CONTENT OF TUBERS

There was a significant reduction in the protein content of tubers due to the application of both growth regulators when compared to the control and water spray. The maximum reduction was obtained by the highest level of CCC. Among the various levels of Ethrel, there was no significant difference in the protein content of tubers. Among the various levels of CCC, significant difference was observed, CCC 500 ppm being superior in the protein content to CCC 250 ppm and 1500 ppm. The highest protein content (2.83%) was observed in the case of control.

(v) Calcium content of tubers

The results of the data in the calcium content of tubers presented in Table 13 and Fig.23 revealed that all levels of Ethrel and the two higher levels of CCC brought about a significant increase in the calcium content of tubers. The highest calcium content (0.280%) was recorded by CCC 500 ppm and the lowest by the control (0.216%). There was significant difference between the different levels of Ethrel and CCC in the content of calcium. Among the various levels of Ethrel, the lowest level recorded the highest calcium content and among the different levels of CCC, 500 ppm gave the highest content of calcium in tubers.

(w) Sugar content of tuber

The details of the data on the sugar content of tubers presented in Table 13 and Fig.24 revealed that there was a significant increase in the sugar content by all levels of

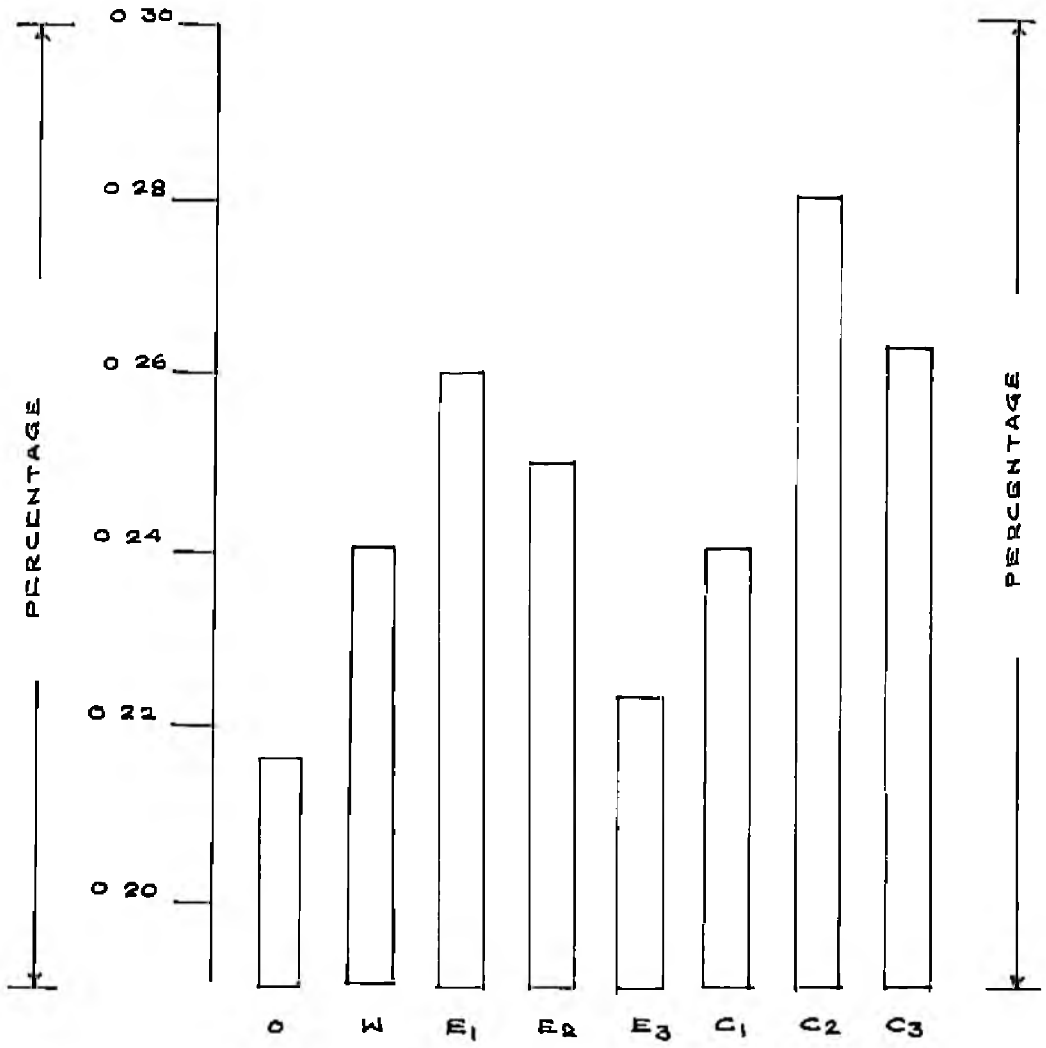


FIG 23 EFFECT OF GROWTH REGULATORS ON THE CALCIUM CONTENT OF TUBERS

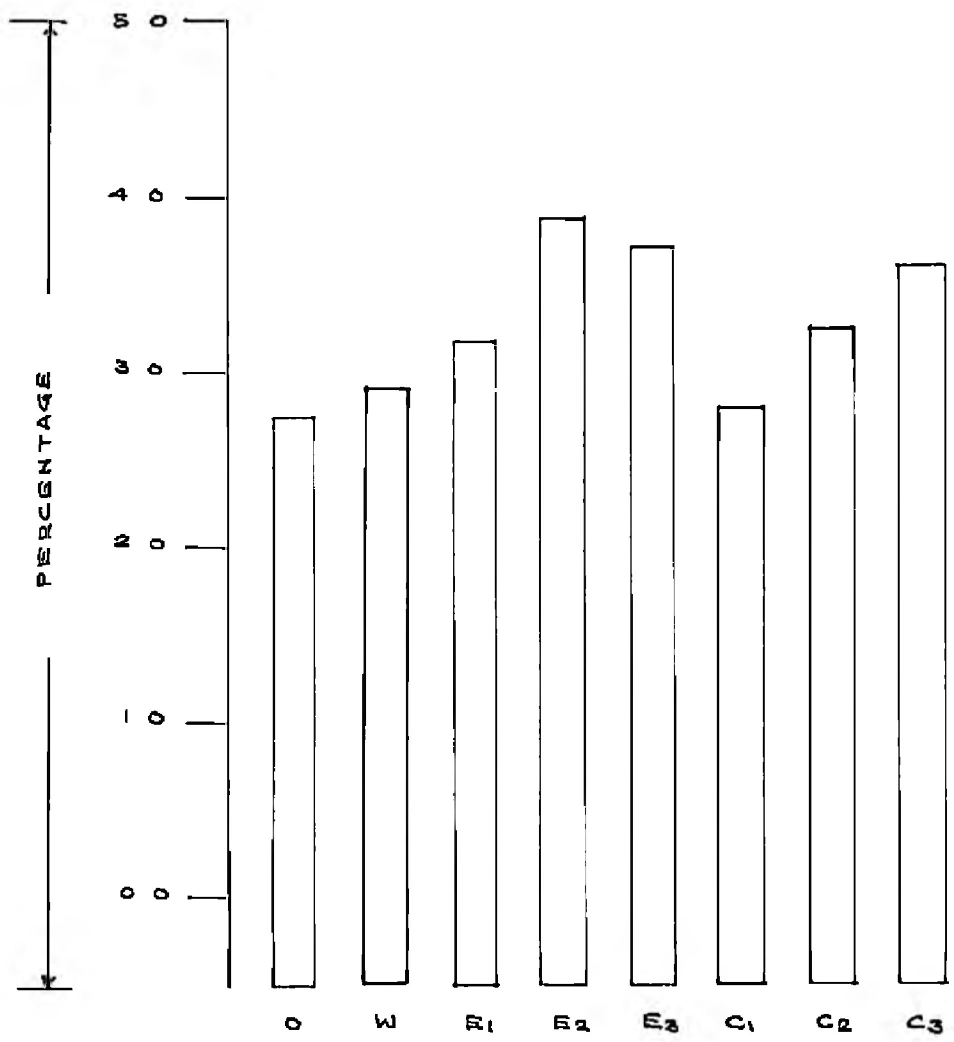


FIG 24 EFFECT OF GROWTH REGULATORS ON THE SUGAR CONTENT OF TUBERS

Ethrel and the two highest level of CCC when compared to the control. The maximum content of sugar (3.88%) was observed in the case of Ethrel 300 ppm. Significant difference was observed between the varying levels of Ethrel. The higher two levels of Ethrel were on par with each other and superior to the lowest level. Among the different level of CCC also significant difference was observed. The sugar content was found to be increased with increasing concentration of CCC. CCC 1000 ppm recorded a sugar content of 3.58 per cent as against 2.77 per cent for the control.

(x) Iron content of tubers

The results of data presented in Table 13 and Fig.22 revealed that there was no significant difference in the iron content of tubers due to the application of growth regulators.

Economics of crop production with the application of growth regulators.

The economics of crop production with the application of growth regulators is presented in Table 14 and Fig.25. It can be seen that the cost of cultivation per hectare increased with the application of both Ethrel and CCC. The cost of cultivation by using Ethrel 300 ppm, which gave the maximum profit was found to be Rs.4900/- as against Rs.3500/- for the control. Among the different level of CCC, 1000 ppm gave the maximum profit, the cost of cultivation being Rs.4700/-. Ethrel 300 ppm gave an increase of 75.52 per cent over the

Table 14. Economics of crop production with the application of growth regulators

| Treatments | Cost of cultivation/hectare (Rs) | Yield per hectare (kg) | Income (Rs) | Net profit (Rs) | Percentage increase over control |
|---|---|---|---|---|---|
| Control | 3500 | 11740 | 5870 | 2370 | - |
| Water spray | 3700 | 11670 | 5835 | 2135 | -9.91 |
| Ethrel 150 ppm | 4500 | 16680 | 8340 | 3840 | 62.44 |
| Ethrel 300 ppm | 4900 | 18120 | 9060 | 4160 | 75.52 |
| Ethrel 450 ppm | 5100 | 17000 | 8500 | 3400 | 43.45 |
| CCC 250 ppm | 4300 | 13870 | 6935 | 2635 | 11.18 |
| CCC 500 ppm | 4500 | 15330 | 7665 | 3165 | 33.54 |
| CCC 1000 ppm | 4700 | 16130 | 8065 | 3365 | 46.20 |

Cost of 1 kg sweet potato tubers: Rs.0.50

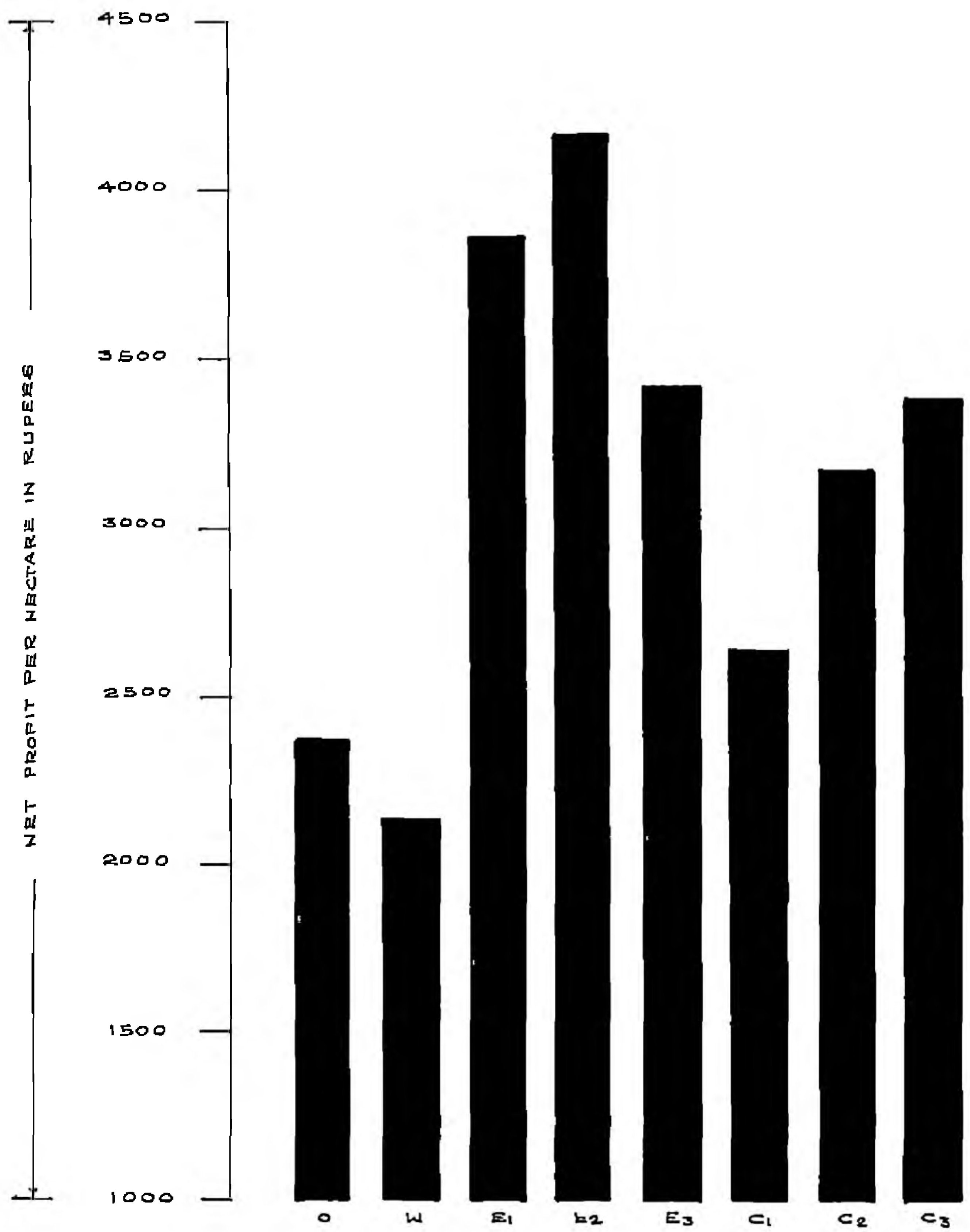


FIG 25 ECONOMICS OF CROP PRODUCTION WITH THE APPLICATION OF GROWTH REGULATORS

control in the net profit, followed by Ethrel 150 ppm (62.44 per cent) and CCC 1000 ppm (46.20 per cent). In general application of Ethrel was found to be more economic in sweet potato cultivation.

Table 15. Meteorological data for the period from 1-8-1978 to 15-11-1978 (weekly averages) recorded at Vellayani (Source: College of Agriculture, Vellayani).

| Period | Rain-fall (cm) | Temperature (°C) Maximum | Minimum | Relative humidity (%) |
|---|---|---|---|---|
| Aug.1. - Aug. 7 | 0 | 30.0 | 24.0 | 85 |
| Aug.8 - Aug.14 | 0 | 30.0 | 23.5 | 84 |
| Aug.15 - Aug.21 | 0 | 30.5 | 23.0 | 82 |
| Aug.22 - Aug.28 | 0 | 30.0 | 23.0 | 87 |
| Aug.29 - Sept.4 | 0 | 30.5 | 23.5 | 86 |
| Sept.5 - Sept.11 | 0 | 30.0 | 23.1 | 92 |
| Sept.12- Sept.18 | 0 | 30.5 | 23.5 | 92 |
| Sept.18- Sept.25 | 0 | 30.0 | 23.0 | 91 |
| Sept.26- Oct. 2 | 0 | 30.0 | 23.2 | 92 |
| Oct. 3 - Oct. 9 | 0 | 28.2 | 23.8 | 92 |
| Oct.10 - Oct. 16 | 0 | 28.0 | 23.6 | 90 |
| Oct.17 - Oct. 23 | 2.5 | 28.0 | 23.4 | 91 |
| Oct.24 - Oct. 30 | 2.3 | 29.0 | 23.0 | 91 |
| Oct.31 - Nov. 6 | 46.4 | 29.8 | 22.1 | 92 |
| Nov. 7 - Nov.13 | 48.5 | 20.9 | 22.0 | 92 |
| Nov.14 - Nov.20 | 1.4 | 30.0 | 23.3 | 91 |

# DISCUSSION

# DISCUSSION

The growth and differentiation in plants are controlled by a number of factors. Though the growth is a dynamic and complex process, it can be controlled to a great extent by factors which affect the physiological activities of the plant. A number of growth regulators are being employed now-a-days to increase the yield and quality in many crop plants by controlling their growth.

Tuber crops in general are noted for their luxuriant vegetative growth resulting in low production of tubers of poor quality. It is also known that growth regulators are effective in controlling the vegetative growth, mobilizing the food materials and other enzymes from other parts to the tubers, thereby increasing the tuber growth. Hence, in the present investigations the feasibility of limiting the vegetative growth and increasing the yield and quality of sweet potato tubers by application of growth regulators was examined. The results of the experiment which was carried out to study the effect of growth regulators on the growth, yield and quality of sweet potato are discussed below.

A. Field experimentation

Ethrel and CCC were found to reduce the length of the main internode and the main vine. It was also observed that the reduction in length of vine increased with increasing concentrations of both the growth regulators.

The maximum reduction of 18.2 per cent in the length of vine was observed in CCC 1000 ppm. These results are in agreement with the findings of Choudhri et al. (1976) in potatoes treated with CCC, of Tompkins and Bowers (1970) in sweet potato plants treated Ethrel and of Rajmohan (1978) in Coleus parviflorus treated with Ethrel and CCC. One of the possible reason for the reduction in length of the internode and main vine may be the release of ethylene by Ethrel which inhibited auxin transport (Morgan and Gansman, 1966). Ethylene could have interfered with auxin synthesis (Leopold and Kriedmann, 1975) or may have inhibited bud growth by interfering with cell division (Apelbaum and Burg, 1972). The reduction in the length of vine and internode by CCC could be attributed to the shifling of balance of endogenous gibberellins and inhibitors towards the inhibitor (Krishnamoorthy, 1975) as a result of the possible blockage of synthesis of gibberellins (Anderson and Moore, 1967) or synthesis of a gibberellin antagonist (Halevy et al., 1966; Considine, 1970) by CCC. Briston and Simmonds (1968) believed that the reason for retarded growth of CCC treated plants is the disappearance of the functional form of GA and a concomitant increase in the bound GA to a supra optimal level.

Both Ethrel and CCC brought about a significant increase in the stem girth. Ethrel was found to be superior in increasing the stem girth and at 500 ppm, it produced the maximum stem girth. Similar findings were reported by

Kwong and Lagerstedt (1977) in bean plants (*Phaseolus vulgaris* L. cv. Black Valentine) by the application of Ethrel and by Irulappan and Muthukrishnan (1973b) in tomato by the application of CCC. Rajmohan (1978) reported increased stem girth in *Coleus parviflorus* also on Ethrel application. Ethrel releases ethylene which causes enhanced isodiametric cell expansion as a result of the preferential interference of ethylene with longitudinal auxin transport than lateral transport. This could be the possible reason for the increased stem girth.

The two higher levels of both CCC and Ethrel increased the number of branches and Ethrel at 450 ppm gave the maximum number of branches. Increased number of branches due to the application of Ethrel in the present investigation was similar to the findings of Muthukrishnan *et al.* (1974) in sweet potato plants, of Kwong and Lagerstedt (1977) in bean plants and of Rajmohan (1978) in *Coleus parviflorus*. The behaviour of CCC in increasing the number of branches was similar to the observations of Melikyan and Azariah (1975) and Choudhri *et al.* (1976) in potato plant. The probable reason for the increase in the number of branches could be the loss of apical dominance due to Ethrel treatment (Hradilik, 1974 and Muthukrishnan *et al.*, 1974). Luckwill (1966) in apple and Arumugam and Rao (1972) in grape var. Anabe-e-shahi obtained increased number of branches by CCC treatment. This could be due to the reducing; but not arresting effect of apical dominance by CCC application.

The number of leaves of the treated plants was significantly reduced by Ethrel 300 ppm and 450 ppm. Though CCC 250 ppm increased the number of leaves, the higher two levels were not much effective in altering the number of leaves. Similar reduction in number of leaves was observed by Selvaraj (1972) in CO.1 papaya plants, 10 days after the application of Ethrel. Results on the same lines were reported by the Kuong and Lagerstedt (1977) in bean plants and by Rajmohan (1978) in Coleus parviflorus. Arumugam and Rao (1972) observed in grape var. Anabe-e-shahi that CCC did not alter the number of nodes which was related to the number of leaves. Similar results were obtained by Rajmohan (1978) in Chinese potato.

In the present study, both Ethrel and CCC in all concentrations reduced the individual leaf area of the plants. Reduction in leaf area due to CCC treatment was reported by Humphries and Dyson (1967) in potato and by Rajmohan (1978) in Coleus parviflorus. A reduction in leaf area by the application of Ethrel was reported in sweet potato by Muthukrishnan et al.(1974) and in Coleus parviflorus by Rajmohan (1978). These observations are in agreement with the present results.

Ethrel in all concentrations brought about a significant reduction in the fresh weight of shoot. This could be due to the shortening of internodal length, and/or reduction in the length of the main vine and the leaf area.

This result was similar to the results obtained by Muthukrishnan *et al*. (1976) in sweet potato and by Rajmohan (1978) in *Coleus parviflorus*. CCC did not affect the fresh weight of shoot, inspite of the reduction in the length of the main vine and that of the internode. This may be due to the increased number of branches which compensated for the reduction in length of main vine.

The weight of tubers of sweet potato plants treated with Ethrel and CCC were found to be significantly higher when compared to the control and water spray. Ethrel 300 ppm recorded the highest yield. The results of many previous experiments support the present instance. Increased tuber yield was reported by Hildebond *et al*. (1969) and by Edward *et al*. (1970) in potatoes; Tompkins and Bowers (1970) and Muthukrishnan *et al*. (1974) in sweet potato, Bryan (1975) in *Dioscorea alata*, Kuhn (1975) in sugar beet and Rajmohan (1978) in *Coleus parviflorus*. The increased tuber yield could be attributed to the earlier tuberization, increased photosynthetic activities and enhanced translocation of the photosynthates to the roots.

Ethrel and CCC in all concentrations brought about a significant increase in the yield of tubers per plot as well. Ethrel 500 ppm recorded the highest yield of 19.06 kg per pot as against 12.32 kg for control. Nambiar (1975) obtained higher yield with increasing levels of CCC in sweet potato. Increased yield of tubers due to the application of Ethrel and CCC was reported in other tuber crops also. In potato, CCC treatment produced increased tuber yield (Choudhri et al., 1976 and Popravko, 1976). In sweet potato, Ethrel treatment gave higher yield (Muthukrishnan et al., 1976). All these observations support the present results. The increased tuber yield may be due to the restriction of excessive vegetative growth. Further, CCC and Ethrel may enhance earlier tuberization thus increasing the tuber yield as is evident from the findings of Milthrope and Morbey (1966). Under conditions of enhanced tuberization, the tubers act as active physiological sinks and more carbohydrates are transported to them under conditions of late tuberization. It hasalso been reported that stored carbohydrates in the leaves led to decreased photosynthesis (Milthrope and Moorby, 1966) and as soon asthe physiological sink began to act in transporting carbohydrates from leaves and stem to tuber, higher photosynthetic activities could be recorded (Milthrope and Moorby, 1966; Humphries, 1967). The observed yield increase could also be due to the fact that CCC application increased the photosynthetic pigments in plants causing increased photosynthetic activity (Laborie, 1963).

The number of marketable tubers per plant was found to be significantly increased with both Ethrel and CCC in all concentrations, Ethrel at 300 ppm giving the highest number. This increase in number of marketable tubers per plant might have also contributed to the increased yield of tubers per plot. The result is in agreement with the findings of Shanmugam and Srinivasan (1974) in sweet potato that Ethrel application resulted in increased number of tubers.

The length of marketable tubers was significantly increased by the application of Ethrel. However, all levels of Ethrel significantly reduced the girth of tubers. On the other hand the length of tuber was not affected by CCC, though the girth of tubers was significantly increased by the highest level of CCC. The observation that the length of tubers increased due to Ethrel application is in agreement with the findings of Kuhn (1978) in sugarbeet. He believed that Ethrel caused elongation of the crown which increased the length of tuber.

The shoot/tuber ratio was significantly reduced by Ethrel and CCC application. This may be due to the suppression of vegetative growth and promotion of tuber growth as was evident from the present study. Muthukrishnan et al. (1976) in sweet potato and Rajmohan (1978) in *Coleus parviflorus* also observed similar suppression of vegetative growth on the application of Ethrel.

B. Laboratory determinations

A significant increase in the dry matter percentage of shoot by all levelsof Ethrel and the two higher levels of CCC was observed in the present studies. The possible reason for this may be the increased photosynthesis on the application of growth regulators. The findings of Rajmohan (1978) in Coleus parviflorus support the present instance of increase in dry matter content of shoot.

Only the higher two levels of CCC brought about a significant increase in the nitrogen content of shoot, when compared to the control. Ethrel did not alter the nitrogen content of shoot. Knavel (1969) in tomatoes, Vlasjuk (1969) in radish and Rajmohan (1978) in Coleus parviflorus observed similar increase in nitrogen levels on CCC application.

In the present investigations, the two higher levels of CCC and all levels of Ethrel brought about a significant increase in the dry matter per cent of tubers. Ethrel 450 ppm recorded the maximum dry matter content. Similar results were reported by Popravko (1976) in CCC treated potato plants, Gupta (1976) in CCC treated cassava cv. Cocoa and Rajmohan (1978) in CCC treated Coleus parviflorus. This increased dry matter content can be attributed to the higher photosynthetic activities and increased mobilization of photosynthates to the tubers.

The protein content of tubers was significantly reduced by the application of growth regulators. The maximum reduction was obtained by the highest level of CCC. This result is in line with the findings of Menon (1971) in sweet potato.

In the case of starch content of tubers, the two higher levels of CCC and all levels of Ethrel brought about a significant increase when compared to the control and water spray. The highest starch content (23.73 per cent) was recorded by Ethrel 300 ppm which was on par with Ethrel 450 ppm. Increased starch content of tubers was also reported by Nambiar (1975) in sweet potato and Bisaria and Sharma (1975) in potatoes due to CCC treatment and Muthukrishnan et al. (1976) in cassava due to Ethrel. The reason for this may be the increased translocation of carbohydrates to the tubers and higher photosynthetic activities (Milthrope and Moorly, 1966; Humphries, 1967). Key (1969) reported that Ethrel treatment caused metabolic rearrangement as a result of induction of certain enzymes at the level of meristematic metabolism. This also might have contributed to the increased starch content of tubers.

There was a significant increase in the sugar content of tubers by all levels of Ethrel and the two higher levels of CCC. Ethrel 300 ppm recorded the maximum sugar content (3.88%) which did not significantly differ from Ethrel 450 ppm. The sugar content was found to be increasing with increasing levels of CCC. 1000 ppm CCC recorded 3.58 per cent of sugar in the tubers. Increase in sugar content due to Ethrel application was also reported by Muthukrishnan <u>et al</u>. (1976) in sweet potato.

Only the lowest level of Ethrel brought about a slight increase in the calcium content of shoot. Increase in calcium content of shoot due to Ethrel application was also reported in <u>Coleus parviflorus</u> (Rajmohan, 1978) which given support to the present investigation.

With regard to the iron content of shoot, a significant increase was observed by all levels of CCC. This may be due to the increased absorption of iron by the roots and transport to other parts of the plant (Kannan and Mathew, 1970).

The calcium content of tubers was increased by all levels of Ethrel and the two higher levels of CCC. This may be due to the enhanced uptake of calcium by the plant as suggested by Ashour (1974). Similar result was also observed by Rajmohan (1978) in <u>Coleus parviflorus.</u>

In the present investigation, the iron content of tubers was not significantly affected by the treatments, though the iron content in the shoot was increased by the application of CCC. This may be due to the transport of iron absorbed by the roots to the shoots as is suggested by Kannan and Mathew (1970).

Ethrel at 300 ppm gave the highest net profit followed by Ethrel 150 ppm and CCC 1000 ppm. Though there was an increase in the total cost of cultivation by the application of both Ethrel and CCC, the net profit was found to be greater when calculated on a per hectare basis. The reason for this was the increased tuber yield due to the application of growth regulators. The net profit did not increase with the increase in the level of Ethrel beyond 300 ppm. This can be due to the suppression of vegetative growth by the highest concentration of Ethrel beyond the optimum level necessary for the formation and growth of tubers.

Summing up, the investigations reported herein proved beyond doubt that the growth regulators Ethrel and CCC had general suppressing effect on the vegetative growth of sweet potato. This turned to be an advantage in realising higher yields and better proportion of marketable tubers. These effects were probably brought about by the restriction of excessive vegetative growth, earlier tuberization, increased photosynthetic activities and enhanced translocation of photosynthates to the roots.

It can be safely concluded from the present investigation that application of Ethrel at 300 ppm three times commencing from the 30th day of planting as foliar spray to sweet potato plants can bring in increased income to the growers.

# SUMMARY

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An experiment was laid out in Randomised Block Design with three concentrations of Ethrel (150, 300 and 450 ppm) and three concentrations of CCC (250, 500 and 1000 ppm) during 1978 at the Instructional Farm, College of Agriculture, Vellayani to study the effect of the two growth regulators on the growth, yield and quality of sweet potato variety Bhadrakalichola. A summary of the results of the experiment is given below.

1. There was a significant reduction in the length of vine by the application of both Ethrel and CCC. The maximum reduction of 18.20 per cent was brought about by CCC 1000 ppm.

2. The two higher levels of Ethrel and CCC brought about a significant increase in the number of branches and Ethrel at 450 ppm produced the maximum mean number of 5.08 as against 5.05 for the control.

3. The number of leaves was significantly reduced by the two levels of Ethrel. Ethrel at 300 ppm caused the maximum reduction of 12.50 per cent over the control.

4. There was a significant reduction in the length of internode by the two higher levels of Ethrel and CCC. Maximum reduction of 37.90 per cent over the control was observed in CCC 1000 ppm followed by Ethrel 300 ppm (36.30 per cent).

5. Ethrel and CCC brought about a significant increase in the girth of internode. The maximum stem girth of 2.016 cm was obtained in 300 ppm Ethrel.

6. The length of petiole was not significantly affected by the growth regulators.

7. There was a significant reduction in the fresh weight of shoot by Ethrel in all concentrations and the maximum reduction was obtained by the highest level. The weight of tops was not significantly affected by CCC.

8. The individual leaf area of the treated plants were significantly reduced by both Ethrel and CCC in all concentrations. Ethrel 450 ppm caused the maximum reduction in the leaf area.

9. The weight of tubers of the treated plants by Ethrel and CCC were found to be significantly increased. The highest yield of tubers were obtained by Ethrel at 300 ppm.

10. The yield of tubers per plot was found to be significantly increased by both Ethrel and CCC in all concentrations. The highest yield of 19.06 kg per plot was recorded by Ethrel at 300 ppm as against 12.32 kg by the control.

11. Both Ethrel and CCC in all levels brought about a significant increase in the number of marketable tubers per plant. Ethrel 300 ppm recorded the highest number of marketable tubers.

12. The shoot/tuber ratio was significantly reduced by both growth regulators in all concentrations. Ethrel at 300 ppm gave the optimum shoot/tuber ratio of 0.26:1.

13. The two higher levels of Ethrel increased the length of tubers considerably. CCC failed to cause any significant change in the length of tubers.

14. The girth of tubers were found to have significantly increased by the two higher levels of CCC. All the levels of Ethrel and the lowest level of CCC significantly reduced the girth of tubers.

15. There was a significant increase in the dry matter content of shoot by all levels of Ethrel and the two higher levels of CCC. Ethrel at 450 ppm recorded the maximum dry matter content of 23.25 per cent in shoots as against 18.51 per cent of the control.

16. The dry matter content in tubers was found to be significantly increased by all levels of Ethrel and the two higher levels of CCC. Ethrel 450 ppm recorded the maximum dry matter content of 34.96 per cent.

17. Only the two higher levels of CCC brought about a significant increase in the nitrogen content of shoot and at 500 ppm CCC recorded the highest nitrogen content of 0.925 per cent.

18. The two higher levels of Ethrel brought about a significant reduction in the calcium content of shoots. However the lowest level of Ethrel gave a slight increase in the calcium content. CCC failed to cause any significant change in the calcium content of shoot.

19. The iron content of shoot was significantly increased by all levels of CCC and decreased by all levels of Ethrel. The least iron content was recorded by Ethrel 150 ppm and the highest by CCC 500 ppm.

20. The two higher levels of CCC and all levels of Ethrel brought about a significant increase in the starch content of tubers. The highest starch content (23.75%) was recorded by Ethrel 300 ppm followed by Ethrel 450 ppm.

21. There was a significant reduction in the protein content of tubers due to the application of both growth regulators. The maximum reduction was recorded by the highest level of CCC.

22. All levels of Ethrel and the two higher levels of CCC brought about a significant increase in the calcium content of tubers. CCC 500 ppm recorded the highest calcium content.

23. There was a significant increase in the sugar content of tubers by all levels of Ethrel and the two higher levels of CCC. The maximum content of sugar (3.88%) was observed in the case of Ethrel at 300 ppm.

24. The iron content in the tubers was not significantly affected by the application of growth regulators.

25. Both Ethrel as well as CCC appreciably increased the net profit per hectare. Ethrel at 300 ppm gave the maximum net profit accounting for an increase of 75.52 per cent over the control.

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*Originals not seen.

# APPENDICES

Appendix I

Abstracts of ANOVA

Length of vine

| | | MS | | | | |
|---|---|---|---|---|---|---|
| Source | df | 45th day | 60th day | 75th day | 90th day | 105th day |
| Replications | 2 | 0.3570 | 9.6702 | 1.3790 | 0.9715 | 10.9304* |
| Treatments | 7 | 2.6120 | 33.7280 | 131.5380** | 237.9590** | 201.508** |
| Error | 14 | 3.0602 | 14.5520 | 3.9169 | 2.3281 | 2.0247 |

*Significant at 0.05 level

**Significant at 0.01 level

Appendix II

Abstracts of ANOVA

Number of branches

| Source | df | MS | | | | |
|---|---|---|---|---|---|---|
| | | 45th day | 60th day | 75th day | 90th day | 105th day |
| Replications | 2 | 0.0107 | 0.0787 | 0.1415 | 0.0534 | 0.0613 |
| Treatments | 7 | 0.4422* | 3.3183* | 3.2819** | 4.2701** | 4.6650** |
| Error | 14 | 0.1593 | 0.1967 | 0.1902 | 0.1843 | 0.0982 |

*Significant at 0.05 level

**Significant at 0.01 level

Appendix III

Abstracts of ANOVA

Number of leaves

| Source | df | MS 45th day | 60th day | 75th day | 90th day | 105th day |
|---|---|---|---|---|---|---|
| Replications | 2 | 36.9066 | 20.9844 | 17.3466 | 5.4258 | 8.4076 |
| Treatments | 7 | 7.4241 | 48.5067* | 218.154** | 463.9278** | 519.4997 |
| Error | 14 | 14.2084 | 14.9421 | 21.0889 | 12.8257 | 17.5168 |

*Significant at 0.05 level

**Significant at 0.01 level

## Appendix IV

Abstracts of ANOVA

Length of internode

| Source | df | MS | | | | |
|---|---|---|---|---|---|---|
| | | 45th day | 60th day | 75th day | 90th day | 105th day |
| Replications | 2 | 0.1394 | 0.0257 | 0.0005 | 0.8380 | 0.3420 |
| Treatments | 7 | 4.6090** | 5.9334** | 3.5422 | 0.9470** | 0.9931** |
| Error | 14 | 0.1025 | 0.1529 | 0.0930 | 0.1005 | 0.0722 |

*Significant at 0.05 level

**Significant at 0.01 level

Appendix V

Abstracts of ANOVA
Girth of internode

| | | MS | | | | |
|---|---|---|---|---|---|---|
| Source | df | 45th day | 60th day | 75th day | 90th day | 105th day |
| Replications | 2 | 0.0494 | 0.1131 | 0.0028 | 0.0437 | 0.0458* |
| Treatments | 7 | 0;5265** | 0.4798** | 0.4630** | 0.4422** | 0.5003** |
| Error | 14 | 0.0121 | 0.0456 | 0.0014 | 0.02276 | 0.0081 |

*Significant at 0.05 level

**Significant at 0.01 level

Appendix VI

Abstracts of ANOVA

Length of petiole

| Source | df | MS | | | | |
|---|---|---|---|---|---|---|
| | | 45th day | 60th day | 75th day | 90th day | 105th day |
| Replications | 2 | 0.0715 | 0.4075 | 0.1500 | 0.0266 | 0.0708 |
| Treatments | 7 | 0.1117 | 0.5199 | 0.4601 | 1.9626** | 0.4525 |
| Error | 14 | 0.2376 | 0.4867 | 0.4722 | 0.2923 | 0.3514 |

**Significant at 0.01 level

Appendix VII

Abstracts of ANOVA

Fresh weight of shoot/plant

| | | MS | | | | |
|---|---|---|---|---|---|---|
| Source | df | 45th day | 60th day | 75th day | 90th day | 105th day |
| Replications | 2 | 0.8156 | 11.0215 | 1.5352 | 10.8232 | 2.6296 |
| Treatments | 7 | 11.9332** | 165.9351** | 312.9155** | 417.0657** | 541.5840** |
| Error | 14 | 2.0291 | 3.4961 | 4.2679 | 3.8405 | 13.9257 |

**Significant at 0.01 level

Appendix VIII

Abstracts of ANOVA

weight of tubers per plant

| Source | df | MS | | | | |
|---|---|---|---|---|---|---|
| | | 45th day | 60th day | 75th day | 90th day | 105th day |
| Replications | 2 | 56.9974 | 49.0246 | 382.3785 | 114.9600* | 1331.0920** |
| Treatments | 7 | 68.8477 | 225.2074* | 1491.1900* | 4980.1190** | 4648.1300** |
| Error | 14 | 104.7980 | 69.5484 | 235.8700 | 26.4792 | 94.0790 |

*Significant at 0.05 level

**Significant at 0.01 level

Appendix IX

Abstracts of ANOVA

| Source | df | MS | | | |
| --- | --- | --- | --- | --- | --- |
| | | Yield of tubers per plant | Number of marketable tubers per plant | Length of tubers | Girth of tubers |
| Replications | 2 | 0.0718 | 0.0038 | 0.2280 | 0.0192 |
| Treatments | 7 | 19.4190** | 0.9499** | 5.7362** | 3.9691** |
| Error | 14 | 4.7404 | 1.0357 | 0.7515 | 0.2788 |

*Significant at 0.05 level

**Significant at 0.01 level

Appendix X

Abstracts of ANOVA

| Source | df | MS | | | | | |
|---|---|---|---|---|---|---|---|
| | | Area of leaf | Shoot/tuber ratio | Dry matter content of shoot | Nitrogen content of shoot | Iron content of shoot | Calcium content of shoot |
| Replications | 2 | 0.9301 | 0.0029* | 0.0272 | 0.0019 | 0.0000220 | 0.00065 |
| Treatments | 7 | 17.9071** | 0.0305** | 10.2838** | 0.0094** | 0.0001122** | 0.01760** |
| Error | 14 | 0.5470 | 0.0007 | 2.2450 | 1.3244 | 0.0000210 | 0.00135 |

*Significant at 0.05 level

**Significant at 0.01 level

Appendix XI

Abstracts of ANOVA

| Source | df | MS | | | | | |
|---|---|---|---|---|---|---|---|
| | | Dry matter content of tubers | Protein content of tubers | Starch content of tubers | Sugar content of tubers | Iron content of tubers | Calcium content of tubers |
| Replications | 2 | 0.5424 | 0.0315 | 0.0809 | 0.0300 | 0.0000037 | 0.00065* |
| Treatments | 7 | 11.6967** | 0.0812** | 7.8751** | 0.5500** | 0.0000014 | 0.00150** |
| Error | 14 | 0.4760 | 0.0042 | 0.5266 | 0.0300 | 0.0000015 | 0.000077 |

*Significant at 0.05 level

**Significant at 0.01 level

# EFFECT OF GROWTH REGULATORS ON THE GROWTH, YIELD AND QUALITY OF SWEET POTATO

*(Ipomoea batatas* (L.) *Lam)*


BY

M. ABDUL VAHAB, B. Sc. (Hort.)


**ABSTRACT OF THE THESIS**

SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENT FOR THE DEGREE

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# ABSTRACT


An experiment was conducted with three concentrations of Ethrel (150, 300 and 450 ppm) and three concentrations of CCC (250, 500 and 1000 ppm) to study the effect of the two growth regulators on the growth, yield and quality of a sweet potato variety, Bhadrakalichola. Three foliar sprayings were given at an interval of 15 days starting from the 30th day after planting.

Ethrel as well as CCC showed similarity in influencing the length of vine, number of branches, length of internode, girth of internode and leaf area. While the length of vine, length of internode and individual leaf area were significantly decreased the number of branches and girth of internode were significantly increased by the application of the growth regulators. Ethrel significantly reduced the fresh weight of top and the number of leaves. The weight of tops was not significantly affected by CCC.

Both Ethrel and CCC brought about a significant increase in the yield of tubers per plot. Ethrel 300 ppm recorded the highest yield accounting for an increase of 54.59 per cent over the control. The number of marketable tubers were also increased by both Ethrel and CCC. A significant reduction in the shoot/tuber ratio was caused by Ethrel as well as CCC.

The two higher levels of Ethrel considerably increased the length of tubers. While the girth of tubers were significantly increased by the two higher levels of CCC, all the levels of Ethrel significantly reduced the tuber girth.

There was a significant increase in the dry matter content of shoot by both Ethrel and CCC. The two higher levels of CCC brought about a significant increase in the contents of nitrogen and iron in shoot.

In tubers, the percentage of dry matter, starch, sugar and calcium were found to be significantly increased by both the growth regulators. However the protein content was significantly reduced by both Ethrel and CCC.

Application of Ethrel as well as CCC in sweet potato appreciably increased the net profit per hectare. Ethrel 300 ppm gave the highest net profit accounting for an increase of 75.32 per cent over the control.