EFFECT OF GROWTH REGULATORS ON FRUIT SET AND YIELD OF PUMPKIN (*Cucurbita moschata.* Poir)

By
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THESIS
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1984

DECLARATION

I hereby declare that this thesis entitled "Effect of growth regulators on fruit set and yield of pumpkin" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

Vellanikkara,
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CERTIFICATE

Certified that this thesis entitled "Effect of growth regulators on fruit set and yield of pumpkin" is a record of research work done independently by Shri. MOHAN KUMAR, S. under my guidance and supervision and that it has not previously formed the basis for award of any degree, fellowship or associateship to him.

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INTRODUCTION

INTRODUCTION

Plant growth regulators are used in agriculture and horticulture to alter the relative proportions of component parts of crop plants. Research on plant growth substances like auxins, gibberellins, cytokinins, ethylene, morphactins, inhibitors and retardants has gathered a steady momentum, and it is now known that these chemicals regulate many aspects of growth and development in plants. In many crop plants, the different alterations, modifications and regulations taking place during the course of growth periods are well utilized for the benefit of men.

The plant growth regulators are extensively used to increase and improve seed germination, to induce plant vigour, earliness in flowering and fruiting, to increase yield and also to alter the sex expression in crop plants.

The application of growth active compounds for the regulation of sex expression in monoecious species of cucurbits has emphasized the need for more detailed information about new chemicals, especially as to optimum concentrations. Ethylene as a natural growth regulator has been implicated in several developmental processes in plants. Since the ethylene releasing property of ethrel (2-chloro ethyl phosphonic acid) has been reported in 1969, much evidence has demonstrated its ability to alter sex-expression in a number of species.

Plant growth retardants are now being commonly used to retard the vegetative phase and to boost the reproductive phase of crop plants. Cycocel and alar are found to be very much effective in changing the growth pattern and distribution of dry matter. Several modifications of CCC/ cycocel/chlormequat (2-chloroethyl trimethyl ammonium chloride) have been used to study the effect on growth, flowering, fruit set and yield of cucumber plants. Alar (N, N-dimethyl aminosuccinamic acid) has undergone extensive testing in horticultural crops since its introduction in 1962. It is found to retard the vegetative growth and promote flower bud initiation, flowering, fruit set and yield.

Pumpkin is a highly nutritive vegetable cultivated commonly in the northern parts of Kerala State. Profuse and luxuriant vegetative growth, male dominated sex-ratio and poor source-sink relationship has made the crop less productive. Poor fruit set, fruit drop and a subsequent decline in the early and total yield are found to be the other reasons for its low productivity. The modification of floral morphology, which causes sex reversion to a favourable female:male ratio as a result of growth regulator treatments is being tried in a number of crop plants. In spite of the extensive use of ethylene, alar and cycocel on horticultural crops especially vegetables,

there is only limited information on its application to alter sex-expression and to improve fruit set and yield in pumpkin. The present trial was initiated and planned to study the effects of CCC, ethrel and alar on pumpkin with special reference to the following objectives.

(1) to increase the number of female flowers by using growth substances (alar, CCC and ethrel) and regulating the growth.

(2) to study the effect of growth substances on the percentage of fruit set.

(3) to study the effect of growth substances in increasing the yield and quality of pumpkin.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Endogenous plant growth substances play a major role in plant growth and development. Research on naturally occurring growth substances is gradually revealing the hormonal control mechanism of plant growth and development. Both experimental studies and basic research have led to the use of synthetic growth substances in agriculture where they have assumed an importance equal to that of pesticides and fungicides.

The increasing consumption of plant growth regulators in India, has been encouraged by the benefit of higher crop yields of better quality combined with a reduction in labour costs. The most prolific plant growth regulators used however had been the herbicides. The plant growth regulators now include not only herbicides that destroy the living plants at higher concentrations, but those materials that increase and improve seed germination (Choudhary and Singh, 1960), induce plant vigour (Choudhary and Singh, 1960), induce earliness in flowering and fruiting (Zimmerman and Hitchcock, 1944 and Lepold and Scott, 1952) and increase yield (Singh and Choudhary, 1966) and Verma and Choudhary, 1980) in many crop plants when applied at very minute concentrations.

The sex expression in monoecious plants of the family cucurbitaceae, in particular cucumber and pumpkin has been of great interest to a number of investigators in different parts of the world. Several plant growth regulators of different physiological properties have been successfully utilised not only to increase the number of female flowers but also the fruit set and ultimate yield. This includes the plant growth promoters as well as plant growth retardants which retard the vegetative growth of the plant and enhance the reproductive phase.

Ethephon, an ethylene releasing plant growth promoter has been explored for its ability to regulate sex-expression in cucurbits. Foliar applications of this compound has been demonstrated to inhibit staminate flower development and to promote pistillate flowers in cucumbers and squashes (Robinson et al., 1970 and Rudich and Lovell, 1983). This effect is similar to, but more dramatic than that reported for auxin promotion of pistillate flowering in cucurbits. The influence of ethrel on stem elongation, production of laterals, flowering, yield and quality of different cucurbits has been reviewed.

Growth retardants are a diverse group of chemicals which have the common physiological property of reducing stem growth by inhibiting cell division of the apical

meristem. These new synthetic organic chemicals retard stem elongation, increase green colour of leaves and indirectly effect flowering without causing any malformations. It was introduced in 1949, and has proved to be valuable for the control of plant size. Tolbert (1960) reported the existence of a series of quaternary ammonium compounds. The most active form of these was designated as CCC and was found to retard the growth of more species of plants than any of the previously reported compounds. Riddell et al. (1962) reported SADH (Alar) to be another active plant growth retardant. The growth retardant effects obtained with SADH (Alar) was similar in many aspects to those with CCC (Chlormequat). Both these compounds effectively reduce vegetative growth and promote flower bud initiation.

Eventhough the information on the effects of these plant growth regulators in different cucurbits are abundant, the amount of work done in pumpkin is very limited and scanty. So the available literature on the effect of alar, CCC and ethrel on different cucurbits are reviewed. The changes in morphological and reproductive characteristics of different cucurbits due to the application of various growth regulators are represented in a tabular form (Table 2.1 to table 2.3).

Table 2.1. Effect of alar on vegetative and reproductive growth of cucurbits.

a. Length of main vine.

Crop	Concentration	Stage of application	Effect	Reported by
Musk melon	5000 ppm	First true leaf stage	Decreased	Rudich et al. (1970)
Musk melon	4000-5000 ppm	One leaf and three leaf stage	Decreased	Loy (1971)
Cucumber	1250-5000 ppm	Two leaf and four leaf stage	Decreased	Ghosh and Bose (1972)
Long melon	1250-5000 ppm	Two leaf and four leaf stage	Decreased	Ghosh and Bose (1972)
Pumpkin	100-200 ppm	3-4 leaf stage and 5-6 leaf stage	Decreased	Das and Swain (1973)
Summer squash	2500-7500 ppm	Two leaf stage and two days after	Decreased	Singh et al. (1975)
Cucumber (Long green)	2000 ppm	4-5 leaf stage	Decreased	Mishra et al. (1976)

In parenthesis variety used is given

Table 2.1. (Concluded)

b. Female:male ratio

Crop	Concentration	Stage of application	Effect	Reported by
Cucumber	1250-5000 ppm	Two leaf and four leaf stage	Increased	Ghosh and Bose (1972)
Bitter gourd	1250-5000 ppm	Two leaf and four leaf stage	Increased	Ghosh and Bose (1972)
Tinda	250 ppm	-	Increased	Bhandari and Sen (1973)
Summer squash	2500-7500 ppm	Two leaf stage and repeated two days after	Increased	Singh et al. (1975)
Ridge gourd	250-1000 ppm	-	Increased	Krishnamoorthy et al. (1976)
Cucumber (Long green)	500 ppm	2-3 leaf and 4-5 leaf stage	Increased	Mishra et al. (1976)

c. Fruit set, fruit number and yield

Summer squash	2500-7500 ppm	Two leaf stage and two days after	No effect	Singh et al. (1975)
Cucumber	1000 ppm	2-3 leaf and 4-5 leaf stage	Increased	Mishra et al. (1976)

In parenthesis variety used is given

Table 2.3. Effect of CCC on vegetative and reproductive growth of cucurbits.

a. Length of main vine

Crop	Concentration	Stage of application	Effect	Reported by
Cucumber	1000 ppm	-	Decreased	Tanaka and Konochi (1969)
Cucumber (Poinsett)	50 cc/10 l	Start of secondary shoot growth	Decreased	Anon (1970)
Tinda	250-1000 ppm	2-3 leaf stage	No effect	Saimbhi and Thakur (1973)
Bottle gourd	250-1000 ppm	-	No effect	Saimbhi and Thakur (1974)
Ridge gourd	1000 ppm	Two leaf, four leaf and eight leaf stage	Decreased	Mishra (1975)
Water melon	1000 ppm	Two leaf, four leaf and eight leaf stage	Decreased	Mishra (1975)
Cucumber (Long green)	1000 ppm	2-3 leaf and 4-5 leaf stage	Decreased	Mishra et al. (1976)
Bottle gourd	40-60 ppm	2-4 leaf stage	Decreased	Randhawa and Daljit Singh (1975)

In parenthesis variety used is given

Table 2.2. (Continued)

b. Primary branches

Crop	Concentration	Stage of application	Effect	Reported by
Tinda	250-1000 ppm	2-3 leaf stage	No effect	Saimbhi and Thakur (1973)
Bottle gourd	40-60 ppm	Two and four leaf stage	Increased	Randhawa and Daljit Singh (1976)

c. Female:Male flower ratio

Cucumber	500-2000 ppm	2-3 leaf and 4-5 leaf stage	Increased	Mishra and Pradhan (1970)
Tinda	250-1000 ppm	2-3 leaf stage	Increased	Saimbhi and Thakur (1973)
Cucumber	2000 ppm	2-3 leaf stage	No effect	Chirata-Kasca and Awai (1974)
Ridge gourd	1000 ppm	-	Increased	Patnaik et al. (1974)
Bottle gourd	250-1000 ppm	-	Increased	Saimbhi and Thakur (1974)
Summer squash	250-750 ppm	Two leaf stage and two days after	Increased	Singh et al. (1975)

Table 2.2. (Concluded)

Crop	Concentration	Stage of application	Effect	Reported by
Water melon	1000 ppm	Two leaf, four leaf and eight leaf stage	Increased	Mishra (1975)
Musk melon	1000 ppm	Two leaf, four leaf and eight leaf stage	Increased	Mishra (1975)
Bottle gourd	40-60 ppm	Two leaf and four leaf stage	Increased	Randhawa and Daljit Singh (1976)
Ridge gourd	250-1000 ppm	-	Increased	Krishnamoorthy et al. (1976)
Cucumber	1000 ppm	2-3 leaf and 4-5 leaf stage	Increased	Mishra et al. (1976)
	d. Fruit set, fruit number and yield			
Tinda	500 ppm	2-3 leaf stage	Increased	Saimbhi and Thakur (1973)
Ridge gourd	1000 ppm	-	Increased	Patnaik et al. (1974)
Bottle gourd	250-1000 ppm	-	No effect	Saimbhi and Thakur (1974)
Summer squash	250-750 ppm	Two leaf stage and two days after	Increased	Singh et al. (1975)
Bottle gourd	40-60 ppm	Two leaf and four leaf stage	Increased	Singh et al. (1975)
Cucumber	1000 ppm	2-3 leaf and 4-5 leaf stage	Increased	Mishra et al. (1976)

Table 2.3. Effect of ethrel on vegetative and reproductive growth of cucurbits.

a. Length of main vine

Crop	Concentration	Stage of application	Effect	Reported by
Cucumber (Monoecious)	240 ppm	First true leaf stage	Decreased	McMurray and Miller (1969)
Musk melon (Charentais melon)	150-600 ppm	1-2 leaf and 3-4 leaf stage	Decreased	Treccani et al. (1971)
Musk melon	240-480 ppm	One leaf and three leaf stage	Decreased	Loy (1971)
Cucumber	100 ppm	-	Decreased	Rodriquez and Lambeth (1972)
Cucumber (Monastyrski)	240 ppm	Two leaf stage	Decreased	Borowski (1972)
Pumpkin	100-1000 ppm	Seedling stage	Decreased	Shanmugavelu et al. (1973)
Cucumber	300 ppm	Seedling stage	Decreased	Sumpoundlek and Abella (1974)
Bottle gourd	250-1000 ppm	-	No effect	Saimbhi and Thakur (1974)
Ridge gourd	480 mg/l	2-3 leaf stage and repeated at weekly intervals for six weeks	Decreased	Saimbhi (1974)
Summer squash	120-240 ppm	Two leaf stage and two days after	Decreased	Singh et al. (1975)

In parenthesis variety used is given

Table 2.3. (Continued)

b. Primary branches

Crop	Concentration	Stage of application	Effect	Reported by
Musk melon (Charentais melon)	150-600 ppm	1-2 leaf and 3-4 leaf stage	Increased	Treccani et al. (1971)
Cucumber (Monastyski)	240 ppm	Two leaf stage	Increased	Borowski (1972)
Cucumber	150 ppm	Pre flowering stage	Increased	Kurchi and Govers (1972)

c. Female:Male flower ratio

Summer squash	100 ppm	Four leaf stage	Increased	Kim and Pyo (1970)
Cucumber (Improved long green)	50 ppm	One and three leaf stage	Increased	Iwahori et al. (1970)
Musk melon	250 ppm	First true leaf stage	Increased	Sulikeri and Dhandary (1973)
Pumpkin	100-1000 ppm	Seedling stage	Increased	Shanmugavelu et al. (1973)
Bottle gourd	500 ppm	-	Increased	Saimbhi and Thakur (1974)
Cucumber (Aoday)	100-500 ppm	Seedling stage	Increased	Churata-Masca and Awad (1974)
Cucumber	500 ppm	First true leaf stage	Increased	Bhandary and Shetty (1974)

In parenthesis name of variety used is given

Table 2.3. (Continued)

Crop	Concentration	Stage of application	Effect	Reported by
Summer squash	500 ppm	Two leaf stage and one week later	Increased	Saimbhi (1974)
Pumpkin	100-250 ppm	First true leaf stage to first flower bud stage	Increased	Shanmugavelu et al. (1975)
Summer squash	150 ppm	Three leaf stage	Increased	Sens and Krueger (1977)
Pumpkin (Crown)	100 ppm	Four leaf stage	Increased	Hopping and Hawthorne (1979)
Cucumber (Poona Khira)	50-200 ppm	2-4 leaf stage	Increased	Verma and Choudhary (1980)
Summer squash	250-1000 ppm	-	Increased	Krishnamoorthy and Sandooja (1981)
Summer squash (Hissar selection-1)	100-250 ppm	-	Increased	Arora et al. (1982)
Musk melon (Hara Madhu)	500 ppm	-	Increased	Sindhu et al. (1982)

In parenthesis name of variety used is given

Table 2.3. (Concluded)

d. Fruit set, fruit number and yield

Crop	Concentration	Stage of application	Effect	Reported by
Pumpkin	100-400 ppm	First true leaf stage	Increased	Kim and Pyo (1970)
Bottle gourd	500 ppm	Seedling stage	Increased	Saimbhi and Thakur (1974)
Pumpkin	100-250 ppm	First true leaf to first flower bud stage	Increased	Shanmugavelu et al. (1975)
Winter squash (Golden delicious)	150 ppm	Two leaf and four leaf stage	Increased	Baker and Bradley (1976)
Summer squash	150 ppm	Three leaf stage	Increased	Sams and Krueger (1977)
Pumpkin	100 ppm	Four leaf stage	No effect	Hopping and Rawthrone (1979)
Cucumber (Poona Khira)	50-200 ppm	2-4 true leaf stage	Increased	Verma and Choudhary (1980)
Summer squash	100-250 ppm	Four leaf stage	Increased	Arora et al. (1982)
Musk melon	500 ppm	Two leaf and six leaf stage	Increased	Sidhu et al. (1982)

In parenthesis name of variety used is given

MATERIALS AND METHODS

MATERIALS AND METHODS

The present investigation was conducted during December-April 1983-84, at the College of Horticulture, Kerala Agricultural University, Vellanikkara, Trichur. This station is located at an altitude of 23 M above MSL and in between 10° 23' N latitude and 76° 16' E longitude, with a warm humid tropical climate.

3.1. Experimental materials

The experimental materials consisted of two local pumpkin genotypes collected from Palghat district of Kerala State. The genotypes are diverse in their genetic make up. Type T_1 is characterised by medium sized fruits with average TSS and carotene content. The female flowers produced as well as the percentage fruit set is very low. Type T_2 bears small sized fruits with very high TSS and carotene content. This makes it very ideal for culinary purposes. But the female flower production as well as the percentage fruit set in this genotype too, is considerably low. The source and morphological description of the genotypes are presented in Table 3.1.

3.2. Experimental methods

2.1. Design and lay out

The experiment was conducted in split-plot design, with three replications. Four combinations of two pumpkin

Table 3.1. Morphological description of the genotypes used for the experiment.

	Type T_1	Type T_2
Place of collection	Appalam (Palghat district)	Chattamangalam (Palghat district)
Morphological characters		
Vigour of the plant	Very vigorous	Moderately vigorous
Leaf size	Large	Small
Presence of white spots on the leaves	Present; large and prominent	Present, slight and not prominent
Fruit characters		
Shape	Flat/round	Round
Size	Medium (Average weight 3.5 kg)	Small (Average weight - 1 kg)
Colour of the immature fruit	Green	Green
Nature of furrows present on the fruits surface	Shallow	Shallow
Flesh colour on maturity	Orange	Deep orange

genotypes and two stages of application (four leaf and six leaf stage) were taken in the main plots. The growth regulator treatments were taken in the sub-plots. The seven sub-plot treatments were alar 100 and 200 ppm, CCC 500 and 1000 ppm, ethrel 100 and 200 ppm and a control.

There were two pits per sub-plot per main plot. The spacing adopted was 7 x 3 M. Four seeds were sown in each pit and two plants were retained after thinning. During the cropping period various cultural operations and prophylatic plant protection measures were adopted as per the Package of Practice recommendations of the Kerala Agricultural University.

2.2. Preparation of growth regulator solutions

Alar (extra pure A.R., 99 per cent minimum assay), ethrel (40 per cent aqueous solution) (SISCO) and cycocel (99 per cent minimum assay) (BDH) were used in the experiment. The growth regulator solutions at desired concentrations were prepared taking into consideration the concentration of the available growth regulators and the quantity required for the treatment.

2.3. Observations recorded

Four plants per sub-plot were considered for taking the observations. The quantitative and qualitative characters studied were as follows:

A. Vegetative characters

a. Length of main vine (m)

b. Number of branches per plant

c. Number of leaves per plant

d. Leaf area per plant (square meters). Seven leaves were taken at random from each plant and the mean leaf area was calculated. This multiplied with the total number of leaves per plant gave the total leaf area of a plant.

e. Number of nodes on the main vine

f. Girth of vine at collar region (cm)

g. Length of internode (cm). Length of 6th, 7th, 8th, 9th and 10th internode were measured and the average was worked out.

B. Reproductive characters

a. Days to first male flower anthesis

b. Days to first female flower anthesis

c. Number of male flowers

d. Number of female flowers

e. Node at which first female flower appeared

f. Days to first fruit set

g. Days to first fruit harvest

h. Days from flowering to maturity of fruit

i. Node at which the first fruit is matured

C. Fruit characters

a. Fruit yield per plant (kg)

b. Number of fruits per plant

c. Length of the fruit (cm)

d. Weight of the first matured fruit (kg)

e. Flesh thickness (cm)

f. Number of seeds per fruit

g. Average weight of the fruit (kg)

D. Chemical constituents

a. Acidity:- It is measured in terms of ml of N/10 NaOH required to neutralise the acidity.

b. TSS:- It is recorded in terms of degree Brix using a refractometer.

c. Carotene:- The carotene content of dried sample was estimated using spectrophotometer after extracting the carotene with methanol and expressed as percentage of dry weight.

The fruit characters and the qualitative characters were recorded/estimated from the first matured fruit.

2.4. Statistical analysis of data

The data was statistically analysed by using the analysis of variance technique for split-plot design and significant treatment effects were compared by calculating the critical difference as suggested by Cotle (1954).

RESULTS

RESULTS

The data collected from the present study was analysed and the results are presented below.

4.1. General analysis of variance and estimation of the effect of different growth regulators on the pumpkin genotypes.

Four combinations involving two pumpkin genotypes (T_1 and T_2) and two stages of application (four leaf and six leaf stage) taken in main plots, and seven sub-plot levels (three growth regulators at two concentrations each, with a control) constituted each of the three replications of the split-plot design used in conducting the trial. The use of different growth regulator treatments such as alar 100 and 200 ppm, ethrel 100 and 200 ppm and CCC 500 and 1000 ppm had a significant difference from each other in all the vegetative characters studied, which were the length of the main vine, number of nodes on the main vine, girth of vine, length of internode, number of branches, number of leaves and leaf area per plant. The two genotypes differed significantly in all the vegetative characters studied, except for the length of the internode. The genotype x growth regulator interaction was also significant in all the above cases (Table 4.1).

Table 4.1. General analysis of variance for morphological characters.

Source of variation	df	MS						
		Length of main vine	No. of nodes main vine	Girth of vine	Length of inter-node	No. of branches	No. of leaves	Leaf area
1	2	3	4	5	6	7	8	9
Replication	2	0.5090	6.53	0.2600	0.850	0.283	0.25	0.0100
Genotype	1	8.3600**	63.35**	11.5100**	4.860	166.320**	132044.00**	106.7600**
Stage of application	1	0.0964	5.52	0.0260	0.724	0.458	122.65*	0.1290
Genotype x Stage	1	0.0525	4.56	0.0098	0.600	0.172	15.38	0.0039
Error (a)	6	0.0114	4.78	0.1900	1.490	0.726	17.91	0.0240
Growth regulator	6	15.7700**	252.03**	19.9100**	135.070**	87.820**	16276.71**	6.3500**
Genotype x Growth regulator	6	1.3500**	225.30**	0.6930**	6.340**	3.310**	3756.85**	3.4000**
Stage x Growth regulator	6	0.0377	4.75	0.1680	0.345	0.320	32.34	0.0226
Genotype x Stage x Growth regulator	6	0.0755	12.72	0.5160	0.456	4.120	72.91	0.1030
Error (b)	48	0.0277	6.15	0.1060	0.441	0.589	48.96	0.0201

* P = 0.05

** P = 0.01

Table 4.2. General analysis of variance for reproductive characters.

Source of variation	df	MS									
		Days to first male flower anthesis	Days to first female flower anthesis	No. of male flowers	No.of female flowers	Sex ratio (Male: Female)	Node at which first female flower is formed	Days to first fruit set	Days to first harvest	Days from flowering to maturity	Node at which the first fruit is retained
1	2	3	4	5	6	7	8	9	10	11	12
Replication	2	102.51	98.68	141.14	3.567	0.015	1.890	92.51	140.62	4.09	1.30
Genotype	1	190.10	545.19**	3693.44**	370.860**	38.410**	390.010**	17.19	21.00	236.68**	352.19**
Stage of application	1	2.68	29.76	2.33	1.869	0.172	0.107	1.71	105.19	12.96	3.86
Genotype x Stage	1	0.11	48.76	10.01	5.509	0.458	0.581	19.05	15.43	2.69	4.76
Error (a)	6	66.89	63.96	236.25	2.656	0.178	7.695	71.55	164.92	3.18	6.85
Growth regulator	6	46.31**	597.15**	5813.81**	465.580**	202.030**	210.360**	656.02**	1220.80**	41.22**	244.48**
Genotype x Growth regulator	6	41.47**	12.47	362.89**	19.650	3.153**	11.920*	44.24	57.75*	1.37	7.96*
Stage x Growth regulator	6	13.87	3.98	50.00	0.658	0.560	5.005	5.44	5.61	0.55	8.19
Genotype x Stage x Growth regulator	6	28.79	15.95	83.99	2.342	0.0183	3.935	1.69	19.35	1.37	7.49
Error (b)	48	14.42	23.17	45.25	20.000	0.2550	5.150	23.36	19.01	10.66	3.47

* P = 0.05
** P = 0.01

Table 4.3. General analysis of variance for fruit characters and chemical constituents.

Source of variation	df	MS								
		Yield per plant	No. of fruits per plant	Length of the fruit	Weight of first matured fruit	Flesh thickness	No. of seeds per fruit	Average weight of fruit	Acidity	Carotene
1	2	3	4	5	6	7	8	9	10	11
Replication	2	142.10	16.79	5.00	0.370	0.0959	35.22	1.19	0.0500	0.00014165
Genotype	1	748.50**	29.16**	6642.96**	313.200**	18.0100**	573.57**	14.80**	0.0094	1.76842070**
Stage of application	1	6.56	0.074	6.30	1.440	0.3600	6.57	0.020	0.9630	0.00022019
Genotype x Stage	1	11.35	1.080	16.31	2.129	0.0900	1113.20	0.270	0.0054	0.00035260
Error (a)	6	10.00	1.020	4.73	1.280	0.0550	84.21	0.248	0.1810	0.00013707
Growth regulator	6	35.08**	3.440	6.54**	5.195**	0.2170	121.75	0.283	0.1708	0.00086527**
Genotype x Growth regulator	6	4.42**	0.358	4.74	0.850	0.0220	42.95	0.089	0.1998	0.00006078
Stage x Growth regulator	6	1.47	0.079	3.55	0.630	0.0043	108.52	0.096	0.0612	0.00011467
Genotype x Stage x Growth regulator	6	3.39	0.192	5.63	0.156	0.0123	149.28	0.932	0.0732	0.00001062
Error (b)	48	1.75	1.000	2.14	0.790	0.1230	105.57	0.903	1.6360	0.00003573

* P = 0.05
** P = 0.01

The different levels of growth regulators used also differed significantly in case of the reproductive characters studied. Except for the days required for the first female flower anthesis and the number of female flowers produced, the genotype x growth regulator interaction was also significant (Table 4.2).

Data on yield and other fruit characters analysed, revealed that the growth regulator treatments did not affect the number of fruits produced per plant, the average weight of the fruit, flesh thickness and the number of seeds produced per fruit. The yield per plant, weight of the first matured fruit and the length of the fruit was however found to be affected by the different growth regulator treatments. Except for the yield per plant, the genotype x growth regulator interaction was not significant in any other fruit character studied (Table 4.3).

The chemical constituents viz., the TSS and acidity was not affected by the growth regulator treatments. The carotene percentage was found to be altered by the growth regulator treatments. However the genotype x growth regulator interaction in this case too was not found to be significant (Table 4.3).

1.1. Length of main vine

The length of main vine was found to be decreasing

with the application of growth regulators. All growth regulators varied significantly in their retarding effect, higher concentrations of which were found to be superior than the lower concentrations, tried in each case. Vine length varied from 4.92 m (CCC 1000 ppm) to 7.0 m (Control). CCC 500 (5.45 m) and CCC 1000 ppm were found to be the most effective in retarding the vine length, followed by alar and ethrel. Both pumpkin genotypes varied in their response to the application of growth regulators. The percentage reduction in vine length was found to be higher in type T_2 (43.67) with the application of CCC than in type T_1, which showed only 29.53 per cent reduction (Table 4.7). Both concentrations of ethrel varied significantly in reducing the vine length in type T_1 while they were on par in the case of type T_2 (Fig. 1).

1.2. Length of internode

The length of internodes was found to reduce with the application of growth regulators. In general CCC 1000 ppm (9.93 cm) was found to be the most effective in reducing the internodal length. This treatment caused 53.79 per cent reduction in type T_1 and 42.48 per cent reduction in type T_2. In both genotypes CCC was found to be effective in reducing the internodal length, both concentrations of which varied significantly. The two concentrations of alar and ethrel showed no significant

difference in reducing the vine length in type T_2, while all the four treatments varied significantly in type T_1. The percentage reduction in the internodal length influenced by all growth regulators was more in type T_1 than in type T_2 (Table 4.7).

1.3. Number of nodes on main vine

The number of nodes on the main vine increased with a decrease in the internodal length. Alar 200 ppm caused a higher percentage increase in the number of nodes in type T_2 (54.58 nodes per vine) while CCC 1000 ppm (59.7 nodes per vine) was more effective in type T_1. Both concentrations of ethrel and CCC were on par with the control in type T_2 while ethrel 100 ppm was found to be on par with the control in type T_1.

1.4. Girth of vine

There was significant positive response to CCC sprays resulting in an increase in the girth of the vine. Girth of the vine varied from 8.65 cm (CCC 1000 ppm) to 5.12 (Control). The ethrel treatments did not show any significant increase in girth, when compared to the control, in both the genotypes. The two concentrations of alar did not show any significant difference with each other in type T_1. A similar result with CCC was found in the type T_2.

1.5. Number of primary branches

The two pumpkin genotypes differed significantly in the number of primary branches produced per plant. Both genotypes showed a significant decrease in the number of primary branches produced with the application of growth regulators. Both genotypes showed a similar response in the percentage decrease in production of primary branches. CCC was found to be the most effective in both cases, the two concentrations of which was significantly different. CCC 1000 ppm treated plants produced on an average of 7.6 branches per vine when compared to the untreated plants which had the highest number of 14 branches per vine. The two concentrations of ethrel did not vary significantly and ethrel 100 ppm was found to be on par with the control in both cases.

1.6. Number of leaves per plant

The two genotypes did not vary in the number of leaves produced per plant. But there was a drastic reduction in the leaf number with the application of growth regulators. In general the number of leaves produced varied from 239.80 (CCC 1000 ppm) to 357.42 (Control). Both the genotypes differed in their response to various growth regulator sprays. The two concentrations of ethrel did not differ significantly and CCC 1000 ppm was found to

be most effective in both cases. Alar concentrations were highly significant in type T_1 while they were not in type T_2. The percentage reduction in the number of leaves influenced by alar (33.6) and CCC (44.10) were higher in type T_1 than in type T_2.

1.7. Leaf area per plant

The leaf size of the two pumpkin genotypes were significantly different with type T_1 having a larger leaf size than type T_2. Hence the two genotypes varied in the leaf area per plant, eventhough the number of leaves produced per plant were the same. CCC 1000 ppm induced the maximum reduction in leaf area per plant. The leaf area per plant varied from 4.32 square meters (CCC 1000 ppm) to 8.13 square meters (Control) in type T_1 and 3.03 square meters (CCC 1000 ppm) to 3.68 square meters (Control) in type T_2. In type T_1 the ethrel concentrations were not significantly different but they showed significant difference when compared to the control. The ethrel treatments were on par with the control in the case of type T_2. The percentage reduction in leaf area influenced by CCC was more in type T_1 than in type T_2 (Table 4.7) (Fig. 2).

1.8. Days to first male flower anthesis

The different growth regulator treatments did not

FIG.1. EFFECT OF GROWTH REGULATORS ON THE LENGTH OF MAIN VINE.

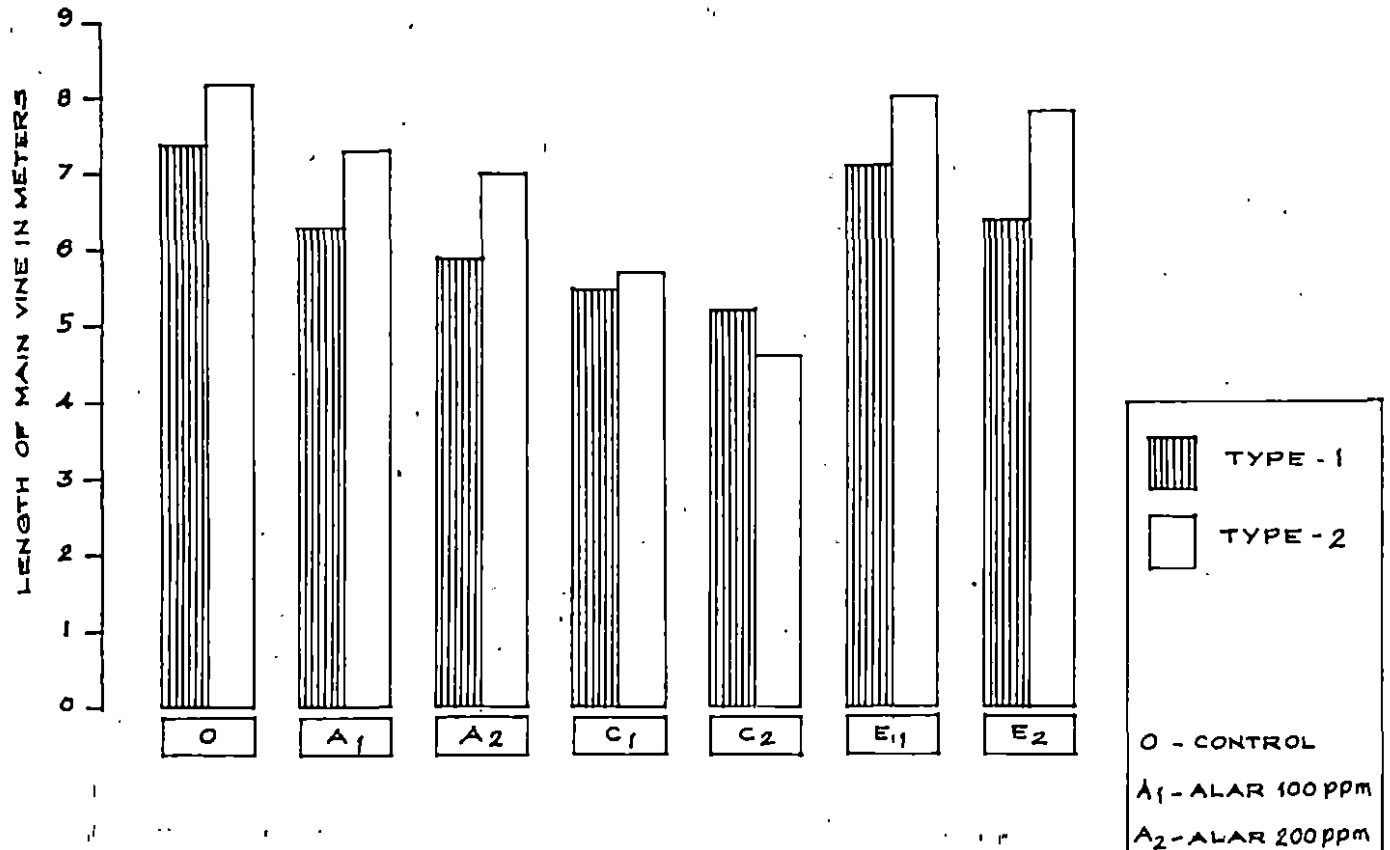
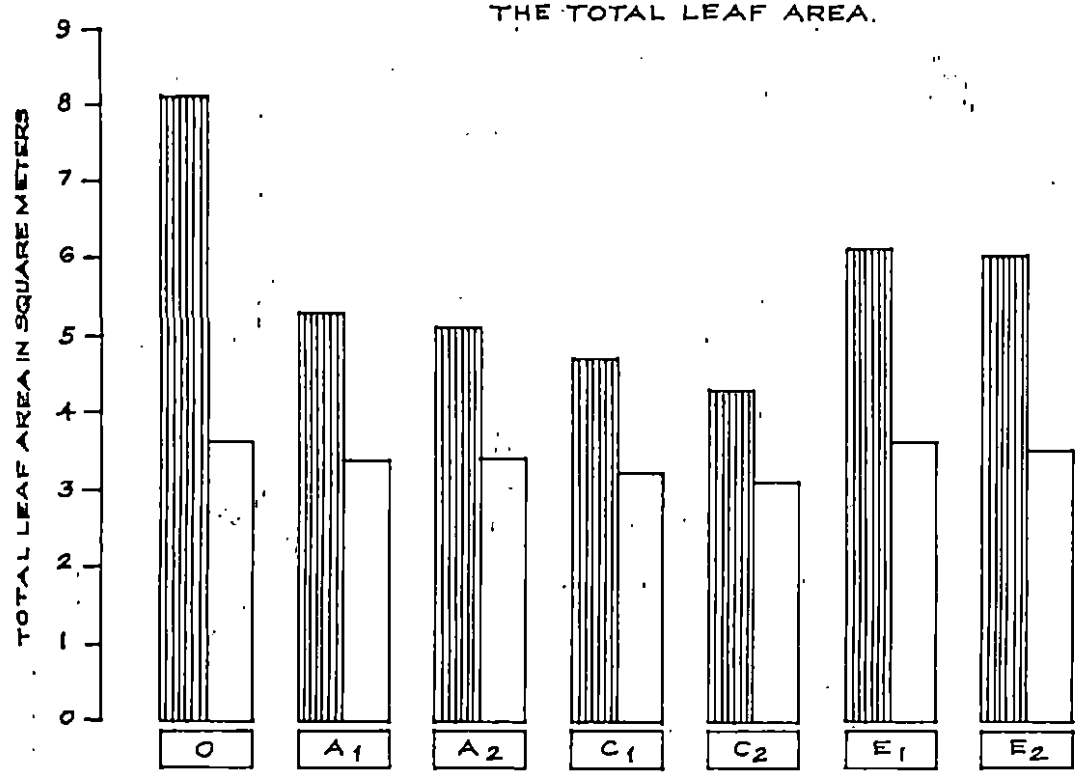


FIG.2. EFFECT OF GROWTH REGULATORS ON THE TOTAL LEAF AREA.



differ significantly in altering the number of days taken for the first male flower anthesis. But all the treatments were significantly different from the control. The two genotypes did not differ significantly but differed in their response to growth regulator sprays. The percentage reduction in the number of days to first male flower anthesis was maximum with CCC 1000 ppm in type T_1 (-17.09) while this treatment was found to be in par with the control in type T_2. The other treatments on type T_2 did not show any significant difference from each other though they differed from the control. The two ethrel concentrations and alar 100 ppm was found to be on par with the control in type T_1.

1.9. Days to first female flower anthesis

The two genotypes were found to be significantly different in the number of days taken for first female flower anthesis. Type T_1 produces the first female flower 60 days after planting while type T_2 takes 72 days. The different growth regulator treatments did not show any significant difference from each other though they differed significantly from the control. The growth regulator treated type T_1 plants produced the first female flower in 46 days while the treated type T_2 plants caused the first female flower anthesis in 51 days after planting. The genotype x growth regulator interaction was also not

found to be significant.

1.10. Number of male flowers

The two genotypes varied significantly in the number of male flowers produced with type T_1 producing a higher number (181 flowers per plant) than type T_2 (159 flowers per plant). Significant interaction between the genotypes and levels of growth regulator was noticed. CCC 1000 ppm caused the maximum reduction in the number of male flowers in both cases. The treatment was on par with the treatment CCC 500 ppm and both alar concentrations, but was significantly different from the ethrel treatments in type T_1. Both concentrations of CCC, alar and ethrel were not significantly different from each other in type T_2. But the three growth regulators showed significant difference from each other in the effect to reduce the number of male flowers produced. The percentage reduction caused by CCC was more in type T_1 (36.36) than in type T_2 (27.09).

1.11. Number of female flowers

There was significant positive response to growth regulator sprays in increasing the percentage of female flowers produced in the two genotypes. The two genotypes differed in the number of female flowers produced. On an average type T_1 produces 12 flowers per vine while type T_2

produced only 9 flowers. The genotype x growth regulator interaction was not found to be significant. In both cases CCC 1000 ppm and alar 200 ppm were the most effective in increasing the number of female flower. CCC 1000 ppm treated plants produced 26 female flower per vine in type T_1 and an average of about 24 flowers per vine in type T_2. The ethrel 100 ppm and CCC 500 ppm were not significantly different from the control.

1.12. Sex-ratio

The sex-ratio was found to decrease with the application of growth regulators. The genotype x growth regulator interaction was found to be significant. In both the genotypes CCC 1000 ppm and alar 200 ppm which were on par, was found to be superior than all other treatments in reducing the sex-ratio. The male:female sex-ratio was reduced from 14.8 (Control) to 4.6 (CCC 1000 ppm) in type T_1 and from 18.1 (Control) to 4.7 (CCC 1000 ppm) in type T_2. In type T_1 all other treatments were significantly different from each other while in type T_2 alar 100 ppm and CCC 500 ppm were on par. The percentage reduction in sex ratio was found to be similar in both the varieties (Fig.3).

1.13. Node at which the first female flower is formed

A significant difference was noticed between the two

genotypes as far as the node at which the first female flower formed was concerned. Type T_1 produced the first female flower at the 18th node while type T_2 produced at still higher, on an average of about 24th node. The genotype x growth regulator interaction was also significant. The two genotypes differed slightly in their response to the growth regulator treatments. But in both cases CCC concentrations were the most effective in producing female flowers at lower nodes. CCC 1000 ppm treated plants of type T_1 produced the first female flowers at the 7th node while type T_2 plants under the same treatment gave the first female flower at the 11th node. The percentage reduction caused by the three growth regulators was similar in both genotypes (Table 4.7).

1.14. Days to first fruit set

The two genotypes were not found to be significantly different in the number of days taken for first fruit set. The first fruit set was observed in about 79 days after planting in both the genotypes. CCC 1000 ppm was found to be the most effective in both varieties. CCC 1000 ppm treated plants caused the first fruit set in about 55 days after planting. This treatment is followed by CCC 500 ppm (66 days) and alar 200 ppm (62 days). The other treatments were found to be on par but significantly different from the control.

FIG.3. EFFECT OF GROWTH REGULATORS ON SEX-RATIO.

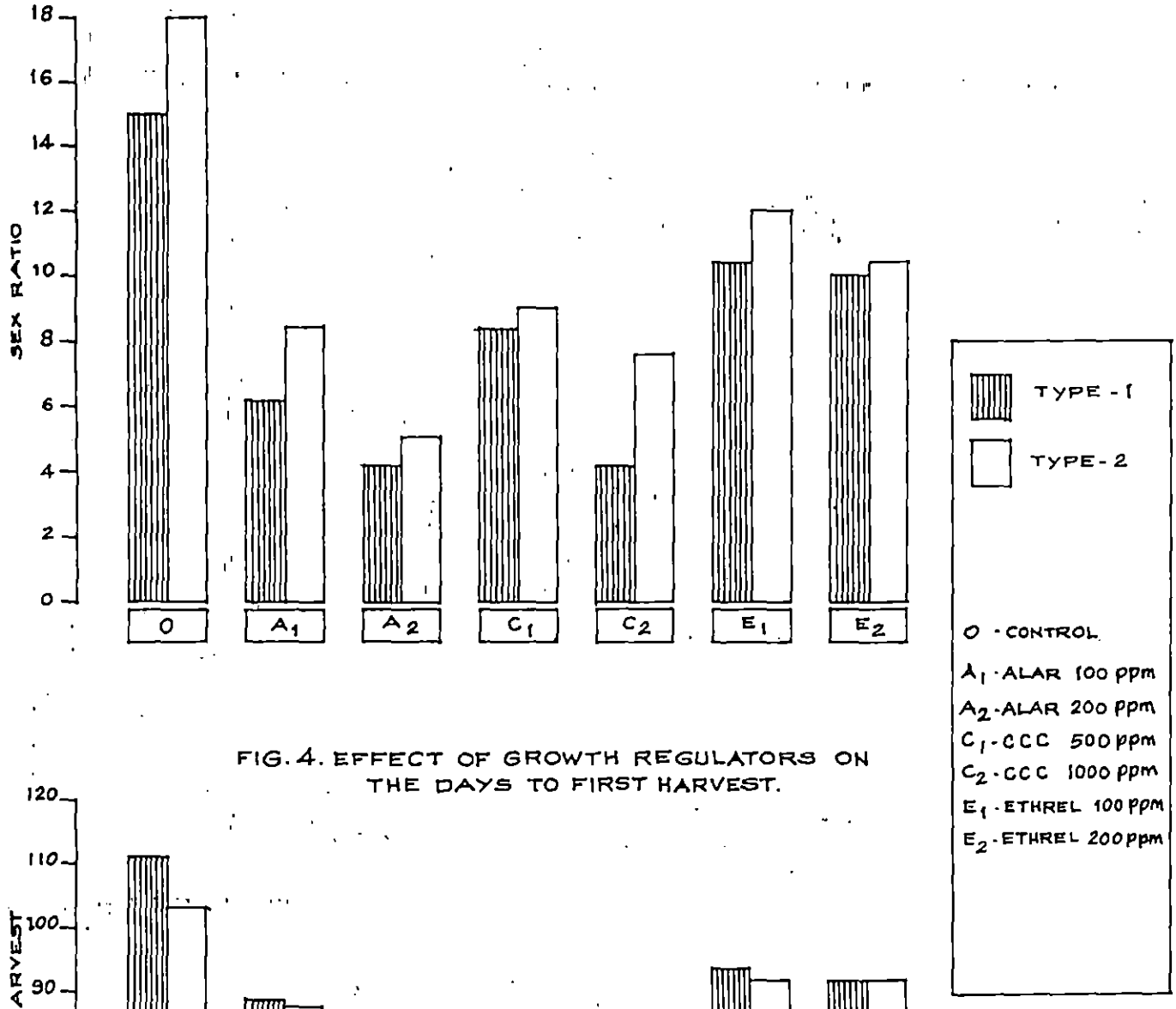
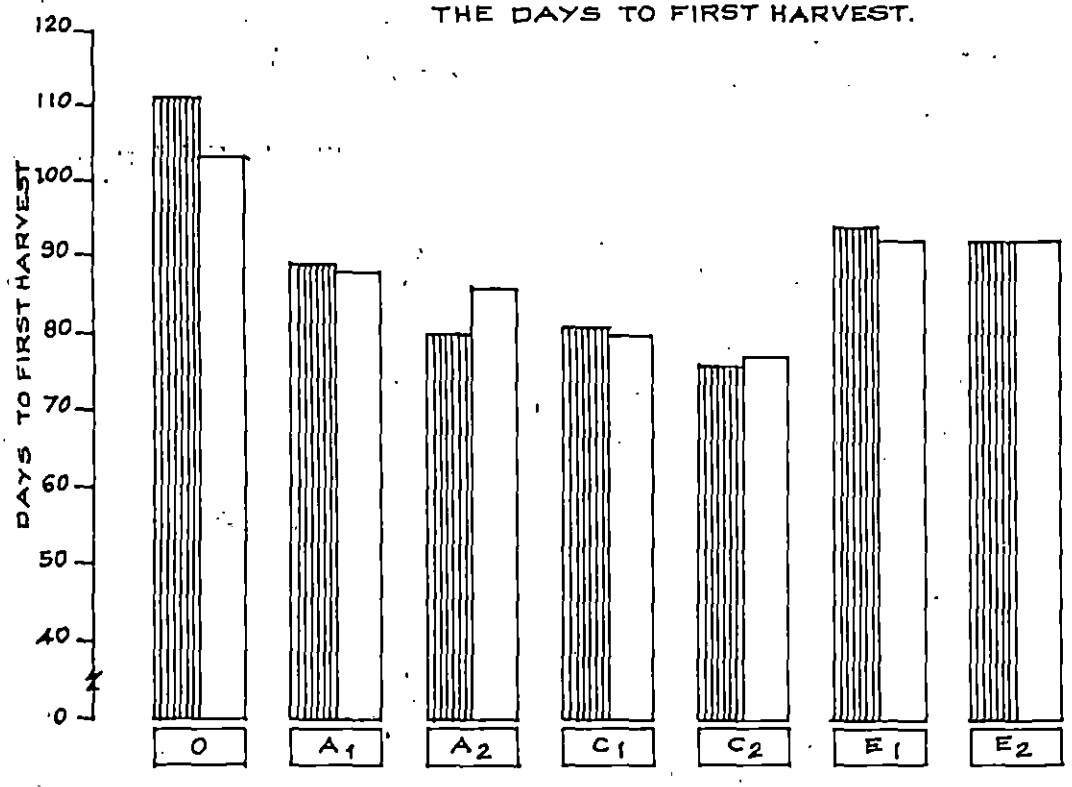


FIG. 4. EFFECT OF GROWTH REGULATORS ON THE DAYS TO FIRST HARVEST.



1.15. Days to first fruit harvest

The growth regulators showed significant difference in their response to the number of days required for fruit maturity (Fig. 4). CCC concentrations were found to be the most effective in both the genotypes, and this treatment was found to be on par with alar 200 ppm in case of genotype T_2. The number of days taken for the first fruit harvest varied from 76 days (CCC 1000 ppm) to 107 days (Control). The percentage reduction in the number of days required for first harvest, caused by CCC and alar was more in type T_1 (31.48) than in T_2 (25.28).

1.16. Days from flowering to maturity

The two genotypes differed significantly in the number of days required from flowering to maturity. Type T_1 took 29 days from flowering to fruit maturity while type T_2 took only 24 days. The growth regulator x genotype interaction was found to be significant. Alar and CCC treatments showed no significant difference though they were found to be superior to the control. These treatments reduced the number of days from 29 to 22 in type T_1 and from 24 to 19 in type T_2. The ethrel concentrations were found to be on par with the control.

1.17. Node at which the first fruit is retained

The two genotypes varied significantly, with type T_1

producing the first fruit at lower nodes (21st node) than type T_2 (25th node). The growth regulator sprays caused the fruits to be formed at still lower nodes. The genotype x growth regulator interaction was also found to be significant. In both the genotypes, the CCC treatments which were on par was found to superior than others. CCC 1000 ppm and CCC 500 ppm caused the fruits to be formed at the basal nodes ranging from 8 to 11. In type T_1 CCC 1000 ppm caused a higher percentage reduction (-65.96) than in type T_2 (-53.63).

1.18. Yield per plant

There was significant response to growth regulator sprays in increasing the yield per plant. Both varieties differed significantly in their yield. Type T_1 produces an average of about 10 kg fruits per vine while type T_2 yields 5 kg fruits per vine. This was found to be significantly increased by the growth regulator treatments. The two genotypes differed in their response to the different growth regulator treatments. CCC treatments were found to be the most effective in increasing the yield in both genotypes. In type T_1 the alar and ethrel concentration were on par though significantly different from the control. In type T_2 the ethrel and alar treatments showed no significant difference. The ethrel treatments and alar 100 ppm were found to be on par with the control. The percentage increase in yield caused by CCC was more in type T_2 than

in type T_1. CCC 1000 ppm and CCC 500 ppm recorded 50.6 per cent and 39.27 per cent increase respectively in yield in type T_1. In type T_2 CCC 500 ppm caused the maximum percentage increase in yield (07.6 per cent) while CCC 1000 ppm treatment marked a slight decrease in yield. The increase in yield caused by this treatment was only 82.6 per cent (Fig. 6).

1.19. Number of fruits per plant

The two genotypes differed significantly in the number of fruits produced per plant. There was no significant positive response to growth regulator sprays in increasing the number of fruits per plant.

1.20. Length of fruits

The different treatments did not show any significant difference from each other. The ethrel treatments and alar 100 ppm were found to be on par with the control. The genotypes differed significantly from each other as far as the fruit length is concerned.

1.21. Weight of the first matured fruit

The genotypes differed significantly in the weight of the first matured fruits. The genotype x growth regulator interaction was not found to be significant. The different growth regulator treatments did not show any

FIG. 5. EFFECT OF GROWTH REGULATORS ON WEIGHT OF THE FIRST MATURED FRUIT.

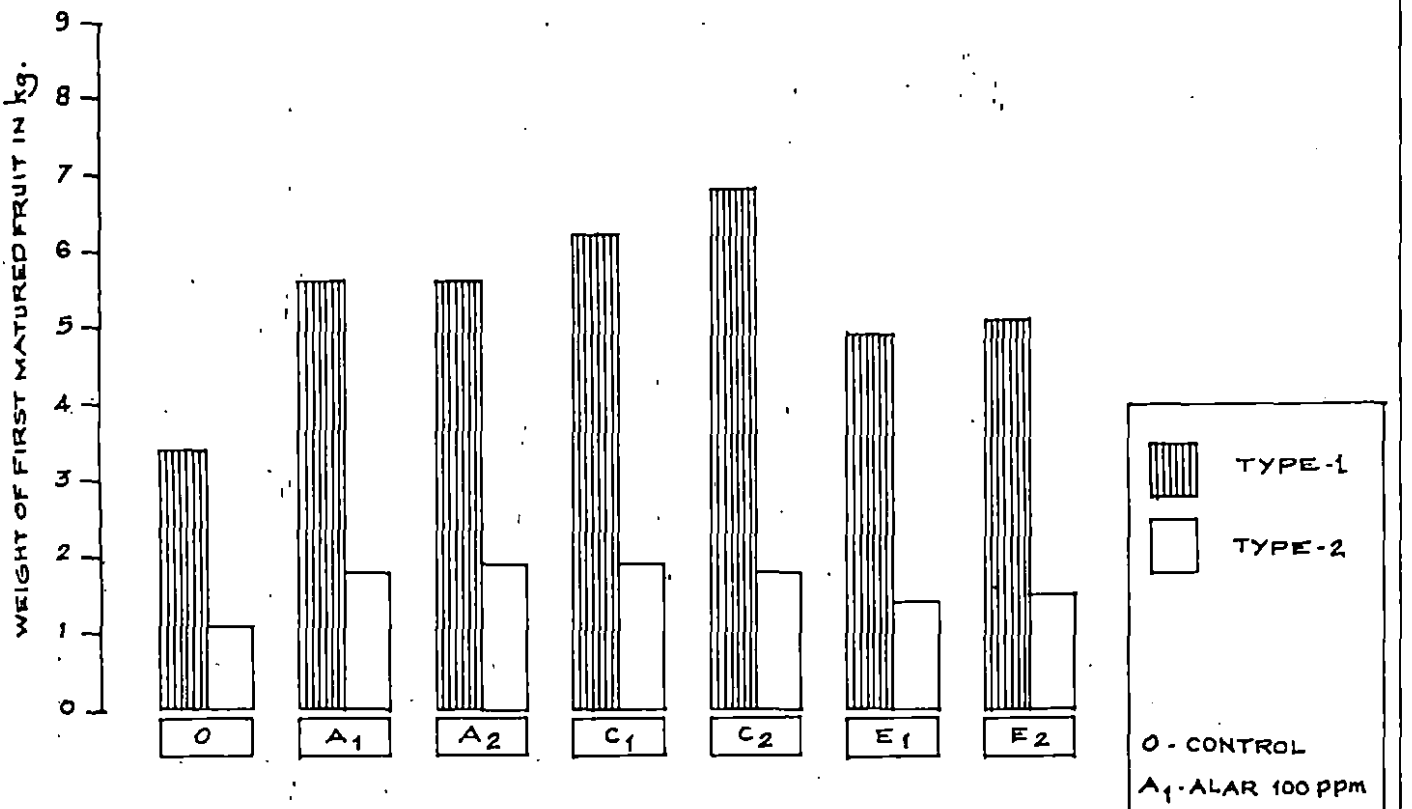
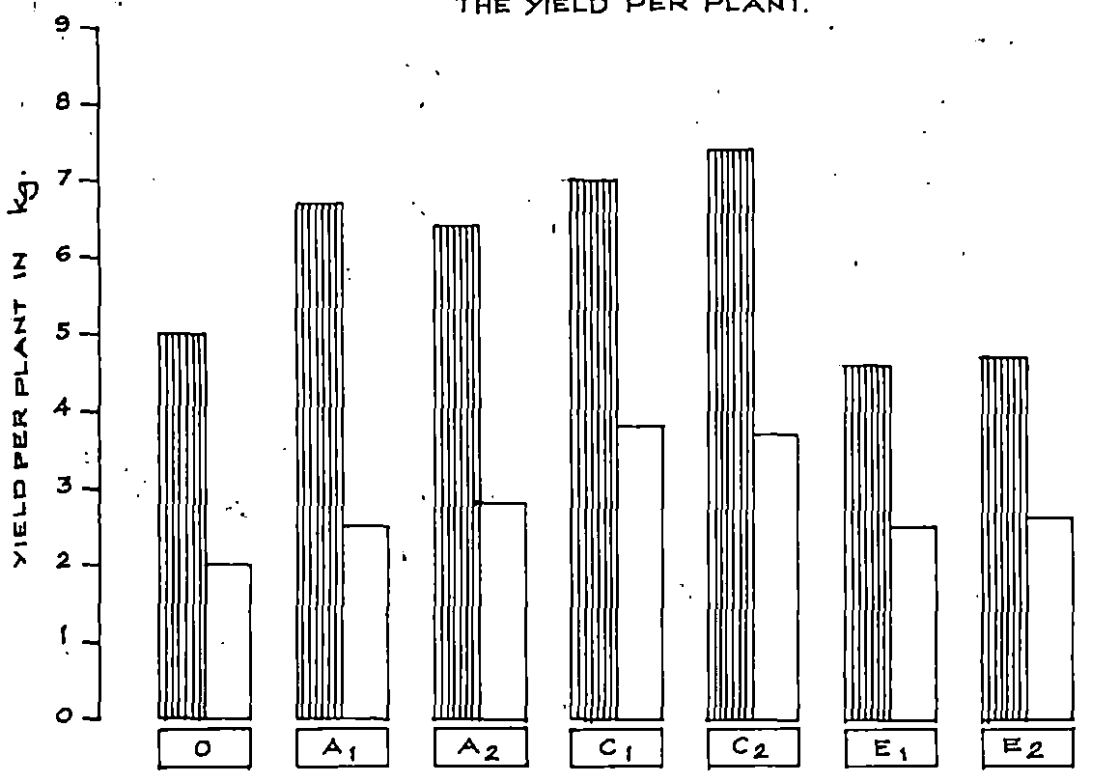


FIG. 6. EFFECT OF GROWTH REGULATORS ON THE YIELD PER PLANT.



significant difference from each other though they varied significantly from the control (Fig. 5).

1.22. Flesh thickness

There was no significant positive response to growth regulator sprays in increasing the flesh thickness. The genotypes differed significantly, with type T_1 producing fruits with a thicker flesh (3.5 cm) than type T_2 (2.6 cm). The flesh thickness was found to be influenced by the size of the fruits. Larger sized fruits had thicker flesh than smaller ones.

1.23. Number of seeds per fruit

The genotypes differed significantly in the number of seeds produced per fruit with type T_2 producing more seeds than type T_1. The growth regulator sprays had no effect in altering the number of seeds produced per fruit.

1.24. Average weight of the fruit

There was no significant effect to growth regulator sprays in increasing the average weight of the fruits. The genotypes however varied significantly with type T_1 producing fruits weighing more (3.9 kg) than type T_2 (1.2 kg).

1.25. Acidity

The two genotypes did not differ significantly as far as the acidity of the fruits are concerned. The growth

Table 4.4. Effect of growth regulators and stages of application, on different vegetative characters of the two pumpkin genotypes.

Sources of variation		Mean						
		Length of main vine	Number of nodes	Girth of vine	Length of inter-node	Number of branches	Number of leaves	Leaf area
1	2	3	4	5	6	7	8	9
Genotypes	T_1	6.29	45.38	6.24	14.54	10.54	248.75	5.66
	T_2	6.91	47.12	5.50	15.03	13.36	328.29	3.76
	C.D.	0.0670	1.167	0.233	NS	0.455	2.260	0.0827
Stages of application	S_1	6.60	46.51	5.85	14.70	14.70	287.31	4.49
	S_2	6.58	45.99	5.88	14.88	14.88	284.73	4.92
	C.D.	NS	NS	NS	NS	NS	2.260	NS
Levels of growth regulators	C	7.80	40.55	4.68	19.26	15.29	357.42	5.91
	G_1	7.55	42.38	4.79	17.68	14.44	306.25	4.79
	G_2	7.18	43.55	4.78	16.96	13.50	303.75	4.77
	G_3	6.79	46.29	5.92	14.45	12.00	282.04	4.28
	G_4	6.46	49.42	5.73	13.38	11.17	278.08	4.25
	G_5	5.45	49.96	7.20	11.82	8.71	252.58	3.96
	G_6	4.92	53.77	7.97	9.93	7.92	239.80	3.68
	C.D.	0.0137	2.035	0.267	0.544	0.630	5.741	0.368

Table 4.4. (Continued)

		Mean						
1	2	3	4	5	6	7	8	9
Genotype x Growth regulator	T_1G_1	7.13	37.75	5.30	18.15	12.55	264.16	6.01
	T_2G_1	7.97	47.00	4.28	17.22	16.33	348.33	3.57
	T_1G_2	6.55	41.60	5.13	16.57	12.00	264.33	6.00
	T_2G_2	7.80	45.50	4.42	17.35	15.00	343.17	3.53
	T_1G_3	6.30	43.58	6.27	13.87	10.00	233.58	5.30
	T_2G_3	7.28	49.00	5.67	15.03	14.00	330.50	3.40
	T_1G_4	5.90	50.00	6.17	12.33	9.50	224.50	5.10
	T_2G_4	7.02	54.58	5.28	14.42	12.83	331.66	3.40
	T_1G_5	5.47	54.58	7.12	11.20	8.00	207.83	4.73
	T_2G_5	5.43	47.00	7.28	12.45	10.66	297.33	3.18
	T_1G_6	5.20	59.71	8.65	9.38	8.00	190.50	4.32
	T_2G_6	4.63	47.83	7.28	10.48	8.83	288.50	3.05
	T_1G_0	7.38	35.95	5.12	20.30	13.08	356.33	8.13
	T_2G_0	8.22	45.17	4.25	18.22	15.83	358.50	3.68
	C.D.	0.193	2.678	0.378	0.771	0.891	8.119	0.165

Table 4.4. (Concluded)

		Mean						
1	2	3	4	5	6	7	8	9
Stage x Growth regulator	S_1G_1	7.60	42.33	4.66	17.73	14.66	303.83	6.02
	S_2G_1	7.50	42.42	4.92	17.63	14.22	308.66	3.57
	S_1G_2	7.12	43.22	4.68	17.03	13.75	300.66	6.00
	S_2G_2	7.23	43.83	4.87	16.83	15.25	306.83	3.53
	S_1G_3	6.77	47.25	6.15	14.27	12.08	284.08	5.30
	S_2G_3	6.82	45.33	5.68	14.13	11.92	280.00	3.40
	S_1G_4	6.52	47.08	5.70	13.37	11.25	277.00	5.10
	S_2G_4	6.40	47.42	5.75	13.38	11.08	279.16	3.40
	S_1G_5	5.53	49.83	7.13	11.70	9.42	250.75	4.73
	S_2G_5	5.37	50.08	7.27	11.95	8.25	254.42	3.18
	S_1G_6	4.87	55.08	7.97	9.52	7.67	238.75	4.32
	S_2G_6	4.97	52.45	7.97	10.35	8.17	240.25	3.22
	S_1G	7.82	40.75	4.63	19.22	15.33	356.08	8.13
	S_2G	7.78	40.37	4.73	19.30	15.25	358.75	3.68
	C.D.	NS	NS	NS	NS	NS	NS	NS
Genotype x Stage	T_1S_1	6.26	45.87	6.22	14.35	10.57	247.14	5.62
	T_2S_2	6.29	44.89	6.24	14.73	10.51	250.36	5.69
	T_2S_1	6.94	47.14	5.47	15.06	13.48	327.48	3.36
	T_2S_2	6.87	47.10	5.52	15.02	13.24	329.10	3.42
	C.D.	NS	NS	NS	NS	NS	NS	NS

Table 4.5. Effect of growth regulators and stages of application on different reproductive characters of the two pumpkin genotypes.

Sources of variation		Mean								
		Days to first male flower anthesis	Days to first female flower anthesis	Number of male flowers	Number of female flowers	Sex ratio	Node at which first female flower is formed	Days to first fruit set	Days to first harvest	Days from flowering to maturity
1	2	3	4	5	6	7	8	9	10	11
Genotypes	T_1	54.62	55.02	143.04	19.76	8.27	10.90	66.00	89.16	24.95
	T_2	57.69	60.12	129.77	15.56	9.62	15.33	66.90	88.17	21.60
	CD	NS	4.27	8.20	0.870	0.225	1.481	NS	NS	0.952
Stages	S_1	56.33	56.98	136.57	17.51	8.99	13.09	66.31	87.55	22.88
	S_2	55.98	58.17	136.24	17.81	8.90	13.14	66.60	89.79	23.66
	CD	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of growth regulators	C	60.08	69.92	168.54	10.30	16.38	20.67	81.75	107.25	25.58
	G_1	56.08	61.17	152.95	13.96	11.08	13.50	69.08	92.58	25.00
	G_2	56.50	60.33	155.25	15.67	9.99	15.38	69.75	92.17	24.83
	G_3	57.08	57.42	123.33	17.83	7.36	13.08	66.50	89.92	22.75
	G_4	54.42	53.42	125.79	26.08	4.73	12.13	62.50	85.25	22.33
	G_5	55.17	51.92	114.50	13.33	8.60	8.75	60.33	81.08	21.67
	G_6	54.00	48.83	114.95	25.42	4.50	8.33	55.42	76.42	20.83
	CD	3.115	3.949	3.396	3.676	0.414	1.062	3.966	3.652	2.679

Table 4.5. (Continued)

1	2	Mean 3	4	5	6	7	8	9	10	11
Genotype x growth regulator	T_1G_1	56.33	59.50	166.17	16.00	10.38	12.00	68.83	93.67	27.17
	T_2G_1	55.83	62.83	139.75	11.92	11.77	15.00	69.33	91.50	22.83
	T_1G_2	56.50	58.00	164.58	17.42	9.47	12.58	69.83	92.33	26.83
	T_2G_2	56.50	62.67	145.92	13.92	10.52	18.17	69.67	92.00	22.83
	T_1G_3	56.50	55.33	129.25	21.92	6.22	11.33	66.33	88.50	24.50
	T_2G_3	57.66	59.50	114.72	13.83	8.50	14.83	65.67	87.33	21.00
	T_1G_4	51.33	48.33	130.58	30.33	4.30	8.58	58.83	80.17	23.50
	T_2G_4	57.50	58.00	121.00	23.42	5.15	15.67	65.83	86.33	21.00
	T_1G_5	52.83	49.17	113.67	13.58	8.42	7.33	59.50	81.33	23.17
	T_2G_5	57.50	54.67	115.33	13.08	8.82	10.17	61.17	80.83	20.17
	T_1G_6	49.33	46.00	115.50	26.75	4.30	6.66	54.00	76.50	22.17
	T_2G_6	57.67	51.67	113.42	24.08	4.67	10.00	56.83	76.83	19.50
	T_1C	59.50	68.33	181.50	12.33	14.82	17.83	84.67	111.67	27.33
	T_2C	60.17	71.67	155.58	8.67	17.95	23.50	78.83	102.83	23.83
	CD	4.406	NS	7.631	NS	0.586	2.633	NS	5.164	NS

Table 4.5. (Concluded)

		Mean								
1	2	3	4	5	6	7	8	9	10	11
Stage x growth regulator	S_1G_1	56.00	60.17	150.75	13.83	11.00	13.33	69.83	92.00	24.66
	S_2G_1	56.17	62.17	155.17	14.08	11.15	13.67	68.33	93.17	25.33
	S_1G_2	55.67	59.67	154.58	15.75	9.88	14.50	70.00	91.33	24.17
	S_2G_2	57.33	61.00	155.92	15.58	10.10	16.25	69.50	93.00	25.50
	S_1G_3	56.50	55.93	126.42	17.58	7.37	14.00	65.67	86.67	22.33
	S_2G_3	57.67	59.00	120.25	18.17	7.35	12.17	67.33	90.17	23.17
	S_1G_4	53.50	52.83	127.82	27.00	4.78	11.50	62.00	81.50	21.83
	S_2G_4	55.33	54.00	123.67	26.76	4.66	8.67	62.67	86.00	22.66
	S_1G_5	55.67	51.50	115.83	13.33	8.57	6.83	59.83	80.00	21.67
	S_2G_5	54.67	52.33	115.17	13.33	8.63	8.60	60.83	82.17	21.17
	S_1G_6	55.50	48.83	115.83	24.92	4.65	8.17	46.17	75.33	20.50
	S_2G_6	52.50	48.33	113.08	25.92	4.35	8.50	56.33	77.50	21.17
	S_1G_C	61.50	70.00	116.67	10.17	16.70	21.33	82.33	107.00	25.00
	S_2G_C	58.17	69.83	170.42	10.83	16.07	20.00	81.17	107.50	26.17
	C.D.	NS	NS	NS	NS	NS	NS	NS	NS	NS
Genotype x Stage	T_1S_1	54.76	55.19	14.55	19.36	8.39	10.90	66.55	87.62	24.30
	T_1S_2	54.48	54.86	142.52	20.17	8.15	10.90	65.67	90.71	25.52
	T_2S_1	57.90	58.76	129.60	15.67	9.60	15.29	66.29	87.48	21.38
	T_2S_2	57.48	61.48	129.95	15.45	9.69	15.38	67.52	88.86	21.80
	C.D.	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4.6. Effect of growth regulators and stages of application on different fruit characters and chemical constituents of the two pumpkin genotypes.

Sources of variation		Node at which first fruit is retained	Yield per plant	No. of fruits per plant	Length of fruit	Mean weight of first matured	Flesh thickness	No. of seeds per fruit	Average weight of fruit	Acidity	T.S.S.
1	2	3	4	5	6	7	8	9	10	11	12
Genotype	T_1	12.21	13.65	2.83	42.24	5.38	3.75	232.27	4.05	1.01	0.212
	T_2	16.31	5.67	4.01	24.45	1.56	3.31	239.38	9.98	1.04	0.503
	C.D.	1.165	1.689	0.539	1.161	0.604	0.125	4.900	0.266	NS	0.00625
Stage	S_1	14.05	8.36	3.39	33.07	3.36	3.21	236.99	2.74	1.99	0.356
	S_2	14.48	8.94	3.45	33.62	3.58	3.35	237.55	2.71	2.10	0.359
	C.D.	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of growth regulators	C	22.75	6.95	3.42	32.17	2.26	3.13	233.92	2.55	1.07	0.353
	G_1	15.17	7.05	3.08	35.33	3.13	3.13	239.25	2.56	1.03	0.352
	G_2	16.08	7.35	3.04	32.75	3.29	3.19	231.75	2.59	1.06	0.330
	G_3	14.00	8.27	3.17	33.33	3.62	3.36	238.25	2.79	1.08	0.350
	G_4	12.58	9.31	3.42	33.42	3.63	3.37	237.71	2.85	0.92	0.364
	G_5	9.92	10.62	4.04	34.33	4.01	3.34	239.03	2.67	0.95	0.366
	G_6	9.58	11.07	4.29	34.08	4.31	3.48	240.92	2.88	0.93	0.369
	C.D.	1.528	1.005	0.539	1.2003	0.729	0.099	NS	NS	NS	0.0048

Table 4.6. (Continued)

		Mean									
1	2	3	4	5	6	7	8	9	10	11	12
Genotype x Levels of growth regulator	T_1G_1	14.00	9.25	2.41	41.83	4.88	3.50	237.67	3.81	1.05	0.207
	T_2G_2	16.33	4.85	3.75	24.83	1.38	2.68	240.83	1.30	1.02	0.498
	T_1G_2	13.83	9.43	2.42	41.50	5.10	3.00	227.00	3.77	0.97	0.204
	T_2G_2	18.33	5.27	3.58	24.33	1.48	2.75	236.50	1.42	1.17	0.491
	T_1G_3	12.33	11.50	2.75	42.17	5.63	3.85	231.66	4.18	1.07	0.207
	T_2G_3	15.67	5.03	3.58	24.50	1.75	2.87	239.17	1.40	1.08	0.493
	T_1G_4	9.17	12.78	3.00	42.17	5.55	3.85	234.25	4.20	0.97	0.221
	T_2G_4	16.00	5.83	3.83	24.67	1.60	2.83	241.17	1.50	1.00	0.506
	T_1G_5	8.83	13.76	3.25	43.67	6.22	3.73	233.83	4.20	1.00	0.218
	T_2G_5	11.00	7.47	5.08	25.00	1.85	2.93	244.33	1.53	1.00	0.814
	T_1G_6	7.00	14.88	3.50	44.17	6.82	4.00	240.50	4.32	1.03	0.222
	T_2G_6	11.67	7.27	5.08	24.00	1.80	2.95	241.33	1.45	0.97	0.516
	T_1G_c	20.33	9.88	2.50	40.50	3.43	3.60	232.00	3.90	1.02	0.207
	T_2G_c	25.17	3.98	3.33	23.83	1.08	2.67	235.83	1.20	1.12	0.501
	C.D.	2.162	1.535	NS	NS	NS	NS	NS	NS	NS	NS

Table 4.6. (Continued)

		Mean									
1	2	3	4	5	6	7	8	9	10	11	12
Stage x Levels of growth regulator	S_1G_1	14.67	7.15	3.25	32.83	2.92	3.10	239.33	2.65	6.98	0.350
	S_2G_1	15.33	6.95	3.08	33.83	3.35	3.20	236.16	2.46	1.08	0.355
	S_1G_2	15.33	7.50	3.08	32.50	2.80	3.08	232.66	2.77	1.05	0.344
	S_2G_2	16.83	7.20	3.00	33.00	3.78	3.13	229.17	2.42	1.08	0.349
	S_1G_3	15.00	8.25	3.17	32.50	3.43	3.30	236.83	2.73	1.05	0.348
	S_2G_3	13.00	8.28	3.17	34.17	3.90	3.42	239.67	2.85	1.12	0.353
	S_1G_4	12.33	8.85	3.42	34.17	3.56	3.30	236.58	2.80	0.92	0.362
	S_2G_4	12.83	9.77	3.42	32.67	3.68	3.43	238.83	2.90	1.05	0.365
	S_1G_5	9.00	9.90	3.92	33.50	4.12	3.25	239.50	2.88	0.92	0.364
	S_2G_5	10.83	11.33	4.17	36.82	3.90	3.42	238.67	2.85	0.98	0.368
	S_1G_6	8.17	10.43	4.33	34.00	4.38	3.42	241.33	2.82	1.00	0.370
	S_2G_6	16.50	11.71	4.25	34.17	4.23	3.53	240.50	2.95	1.00	0.369
	S_1G_C	23.50	6.54	2.75	32.00	2.28	3.07	228.00	2.55	1.08	0.353
	S_2G_C	22.00	7.22	3.08	32.33	2.23	3.20	239.83	2.53	1.05	0.355
	C.D.	2.162	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4.6. (Concluded)

		Mean									
1	2	3	4	4	6	7	8	9	10	11	12
Genotype x Stage	T_1S_1	12.24	10.99	2.69	41.52	5.13	3.65	233.21	4.09	0.98	0.213
	T_1S_2	12.19	12.29	3.93	42.95	5.62	3.84	236.09	4.02	1.05	0.212
	T_2S_1	15.86	5.76	4.10	24.62	1.58	2.79	240.76	1.40	1.01	0.498
	T_2S_2	16.76	5.59	3.93	24.29	1.55	2.85	239.00	1.40	1.06	0.506
	C.D.	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

T_1 and T_2 = Indicates the two pumpkin genotypes
S_1 = Growth regulator application at 4 leaf stage
S_2 = Growth regulator application at 6 leaf stage
G_1 = Ethrel 100 ppm
G_2 = Ethrel 200 ppm
G_3 = Alar 100 ppm
G_4 = Alar 200 ppm
G_5 = CCC 500 ppm
G_6 = CCC 1000 ppm
C = Control

Table 4.7. Estimated percentage change over control for different characters on the application of various treatments in pumpkin.

Character	Geno-types	Control	Ethrel 100 ppm	Ethrel 200 ppm	Alar 100 ppm	Alar 200 ppm	CCC 500 ppm	CCC 1000 ppm
1	2	3	4	5	6	7	8	9
Length of main vine	T_1	7.38	7.13 (-3.38)	6.55 (-11.24)	6.30 (-14.63)	5.90 (-20.03)	5.47 (-25.88)	5.20 (-29.53)
	T_2	8.22	7.97 (-3.04)	7.80 (-5.10)	7.28 (-11.43)	7.02 (-14.59)	5.43 (-33.94)	4.63 (-43.67)
Nodes on main vine	T_1	35.95	37.75 (+5.00)	41.60 (+15.71)	43.58 (+21.22)	50.00 (+39.08)	54.58 (+51.82)	59.71 (+5.86)
	T_2	45.17	47.00 (+4.05)	45.50 (+0.73)	49.00 (+8.47)	54.58 (+20.53)	47.00 (+4.05)	47.83 (+5.88)
Girth of vine	T_1	5.12	5.30 (+3.51)	5.13 (+0.19)	6.17 (+20.50)	6.17 (+20.50)	7.12 (+39.06)	8.65 (+68.94)
	T_2	4.29	4.28 (+0.70)	4.42 (+4.00)	5.67 (+33.41)	5.28 (+24.33)	7.28 (+71.29)	7.28 (+71.29)
Length of internode	T_1	20.30	18.15 (-10.59)	16.57 (-18.37)	13.67 (-37.67)	12.33 (-39.26)	11.20 (-44.82)	9.38 (-53.79)
	T_2	18.22	17.22 (-5.48)	17.35 (-4.77)	15.03 (-17.50)	14.42 (-21.95)	12.45 (-31.66)	10.48 (-42.48)
Number of branches	T_1	13.08	12.55 (-4.05)	12.00 (8.25)	10.00 (-23.54)	9.50 (-27.37)	8.00 (-38.83)	7.00 (-46.48)
	T_2	15.83	16.33 (+3.15)	15.00 (-5.82)	14.00 (-11.56)	12.83 (-18.95)	10.66 (-32.65)	8.83 (-44.21)
Number of leaves per plant	T_1	356.30	264.16 (-25.86)	264.16 (-25.81)	233.58 (-34.44)	224.50 (-36.99)	207.83 (-41.67)	190.53 (-46.53)
	T_2	358.90	348.33 (-2.83)	343.17 (-4.27)	330.50 (-7.81)	331.66 (-7.48)	297.33 (-17.06)	288.50 (-19.52)
Leaf area	T_1	8.13	6.01 (-26.07)	6.00 (-26.19)	5.30 (-34.80)	5.10 (-37.26)	4.73 (-41.82)	4.32 (-46.86)
	T_2	3.68	3.57 (-2.98)	3.53 (-4.07)	3.40 (-7.60	3.40 (-7.60	3.18 (-13.51)	3.05 (-17.11)

Data in parenthesis indicate percentage increase or decrease

Table 4.7. (Concluded)

1	2	3	4	5	6	7	8	9
Days to male flower anthesis	T_1	59.50	56.33 (-5.32)	56.50 (-5.04)	56.50 (-5.04)	51.33 (-13.73)	52.83 (-11.21)	49.33 (-17.09)
	T_2	60.17	55.83 (-7.21)	56.50 (-6.09)	57.66 (-4.17)	57.50 (-4.43)	57.50 (-4.43)	58.67 (-2.49)
Number of male flowers	T_1	181.50	166.27 (8.44)	164.58 (-9.32)	129.25 (-28.78)	130.54 (-28.01)	113.67 (-37.37)	115.50 (-36.36)
	T_2	155.50	139.75 (-10.17)	145.92 (-6.20)	117.42 (-24.52)	121.00 (-22.22)	115.33 (-25.87)	113.42 (-27.09)
Sex ratio	T_1	14.82	10.38 (-29.95)	9.47 (-36.09)	6.22 (-58.02)	4.30 (-70.92)	8.42 (-43.18)	4.30 (-70.98)
	T_2	17.95	11.77 (-34.42)	10.52 (-41.39)	8.50 (-52.64)	5.15 (-71.30)	8.82 (-50.86)	4.67 (-73.98)
Node at which first female flower is formed	T_1	17.83	12.00 (-32.69)	12.58 (-29.44)	11.33 (-36.45)	8.58 (-51.87)	7.33 (-58.88)	6.66 (-62.64)
	T_2	23.50	15.00 (-36.17)	18.17 (-22.68)	14.83 (-36.89)	15.67 (-33.31)	10.17 (-56.72)	10.00 (-57.44)
Days to first harvest	T_1	111.67	93.67 (-16.11)	92.33 (-17.31)	88.50 (-20.74)	80.17 (-28.20)	81.33 (-27.16)	76.50 (-31.49)
	T_2	102.83	91.50 (-11.01)	92.00 (-10.53)	87.33 (-15.14)	86.33 (15.63)	80.83 (-21.39)	76.83 (-25.28)
Node at which first fruit is retained	T_1	20.33	14.00 (-31.35)	13.83 (-31.97)	12.33 (-39.35)	9.17 (-54.89)	8.83 (-56.56)	7.00 (-65.56)
	T_2	25.17	16.33 (-35.12)	18.33 (-27.17)	15.67 (-39.72)	16.00 (-36.43)	11.00 (-56.29)	11.67 (-53.63)
Yield	T_1	9.88	9.25 (-6.37)	9.43 (-4.55)	11.50 (+11.78)	12.78 (+29.35)	13.76 (+39.27)	14.88 (+50.61)
	T_2	3.88	4.85 (+21.05)	5.27 (+32.41)	5.03 (+26.31)	5.38 (+46.48)	7.47 (87.68)	7.27 (+82.66)

Data in parenthesis indicate percentage increase or decrease

regulator effect was also not found to be significant.

1.26. Carotene

The carotene content of the two genotypes were significantly different, with type T_2 showing a higher percentage of carotene (0.5 per cent) when compared to type T_1 (0.2 per cent). This was marked by a deeper flesh colour in type T_2. The flesh colour was found to be related to the carotene percentage of the fruits. The higher the carotene percentage, the deeper would be the flesh colour. Ethrel 200 ppm caused a decrease in the carotene content. Alar 100 ppm and ethrel 100 ppm treatments were found to be on par with the control. CCC 1000 ppm caused a slight increase in the carotene content of both the genotypes.

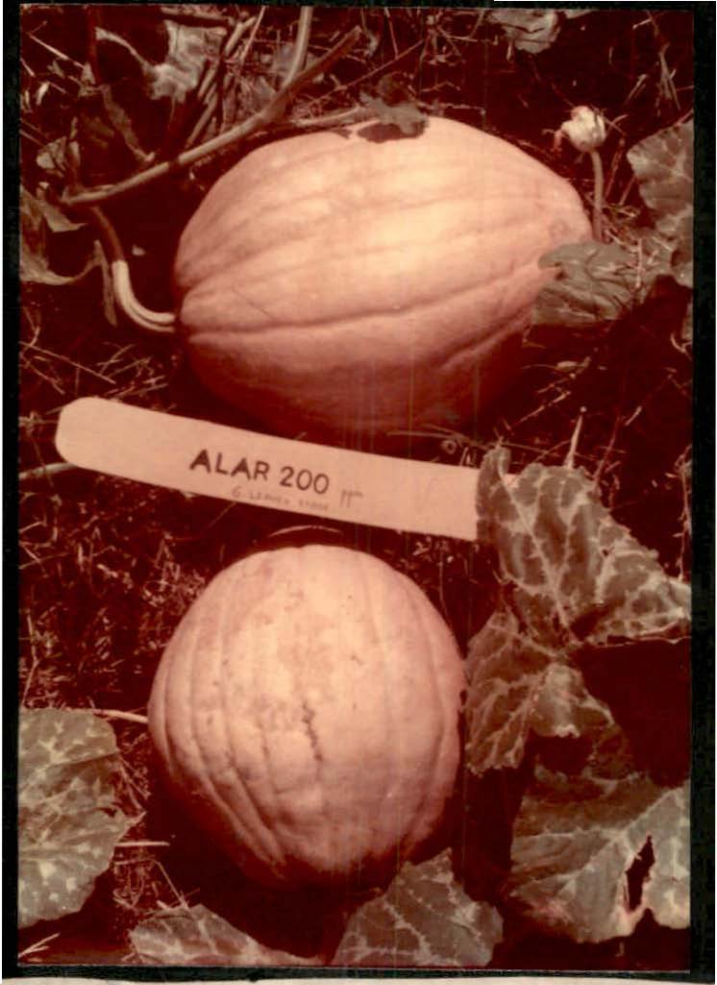
1.27. TSS

The growth regulator treatments did not show any significant effect in altering the TSS content of the fruits. However the two genotypes differed significantly with type T_2 having a higher TSS content (7° brix) than type T_1 (5° brix).

Plate 1. Field performance of type T_1 treated with CCC 1000 ppm

Length - 48 cms. Girth - 86 cms.

Plate 2. Field performance of type T_1 treated with alar 200 ppm



Length - 58 cms. Girth - 71 cms.

Plate 3. Field performance of type T_1 treated with alar 100 ppm

Length - 53 cms. Girth - 76 cms.

Plate 4. Field performance of type T_2 treated with CCC 500 ppm

Length - 36 cms. Girth - 57 cms.

DISCUSSION

DISCUSSION

The results obtained in the present investigation are discussed and presented below.

In the present study two pumpkin genotypes were selected, taking into consideration its popularity in Palghat district and also its superior qualities like size, carotene and TSS content of the mature fruits. The growth regulators namely alar (100 and 200 ppm), CCC (500 and 1000 ppm) and ethrel (100 and 200 ppm) were used in this study.

5.1. Vegetative characters

The length of main vine an important growth parameter directly correlated with yield showed significant retardation with all the growth regulator treatments tried. A concentration, 1000 ppm CCC caused the maximum retardation in vine length (4.91 m), followed by CCC 500 ppm and alar 200 ppm. Mishra (1975) got a similar result in water melon, when treated with CCC at two leaf, four leaf and six leaf stages. Mishra et al. (1976) noticed reduction in vine length of cucumber variety 'Long Green'. In contrast, Saimbhi and Thakur (1973) recorded no reduction in vine length in tinda. Saimbhi and Thakur (1974) also noticed no effect on vine length with CCC applications in bottle gourd. Cathey (1964), Mahmoud and Stephonkus (1970)

suggested that CCC is highly specific to its action and they found that even different varieties of the same species behaved differently in altering the growth habits. Ariston and Simmonds (1968) suggested that in CCC treated plants, the functional form of gibberellic acid disappears and an increase in the bound form is seen, which is the possible reason for retardation of growth. Effect of CCC on growth retardation has also been reported on other crops like potato, ginger, tomato and sweet potato.

Ethrel treatments (100 and 200 ppm) caused a significant reduction in vine length of both genotypes tried. Shanmugavelu et al. (1973) got similar results in pumpkin. Vine length reduction was also noticed in other cucurbits like cucumber (McMurray and Miller, 1969 and Borowski, 1972), muskmelon (Treccani et al., 1971 and Roy, 1971) and summer squash (Singh et al., 1975). Inhibition of auxin transport (Morgan and Gausman, 1966) and further interference with the auxin synthesis by ethylene released by ethrel externally applied (Leopold and Kriedemann, 1975) is found to be the reason for retardation of vine length.

Alar treated plants showed a significant difference in vine length, the higher concentrations of which (200 ppm) was more effective. The result is in full agreement with the report of Das and Swain (1973) who also reported reduction of vine length of pumpkin. Rudich et al. (1972)

reported that endogenous level of gibberellin decreased on alar application and this causes the retardation of vine length. Similar results were obtained in muskmelon (Loy, 1971) summersquash (Singh et al., 1978) and cucumber (Mishra et al., 1976).

Cycocel treated plants (500 and 1000 ppm) showed a significant reduction in the number of primary branches per plant. Cycocel at 1000 ppm had significantly reduced the number of primary branches (7.91) compared to control (14.45). But Randhawa and Daljit Singh (1976) working on bottle gourd found that the number of primary shoots were found to increase with CCC application. Saimbhi and Thakur (1975) reported that CCC had no effect in altering the primary branch number in tinda even at concentrations higher than those tried in this study. This could be possibly due to the highly specific mode of action of CCC. The different varieties of the same species may respond differently to the same chemical (Cathey, 1964 and Mahmoud and Stephenkus, 1970).

Ethrel applications at 200 ppm had significantly decreased the number of primary branches. Trecconi et al. (1971) in musk melon and Borowski (1972) and Kurchi and Covers (1972) in cucumber had shown that ethrel applications caused an increase in the number of primary branches.

Saimbhi and Thakur (1973) reported no change in the number of primary branches on ethrel application. No reports supporting nor contradicting this is found in pumpkin. However differential response to ethrel even to different varieties of the same crop (cucumber) has been reported by George (1971).

Alar treatments also showed a decrease in the number of primary branches. The higher concentration of alar (200 ppm) was found to be more effective than the lower concentration (100 ppm). This may be due to the reduction in the total vine length as a result of a decrease in the endogenous gibberellin content by the application of alar (Rudich et al., 1972). The growth retardation effect in turn has suppressed the lateral shoot production.

Treatment with 1000 ppm CCC recorded a maximum reduction in the number of leaves and subsequently the total leaf area per plant. However, Irulappan (1972) and Choudhari et al. (1975) observed an increase in the leaf number in CCC treated potato and tomato plants respectively. The decrease in the number of primary branches with growth regulator treatments might have contributed to a decrease in the leaf number and subsequently to the total leaf area per plant.

Ethrel (100 and 200 ppm) caused a significant reduction in the leaf number per plant and the total leaf

area. The result fully agrees with the reports of Dozier and Braden (1973) in apple and Muthukrishnan et al. (1974) in sweet potato.

A decrease in the internodal length and an increase in the number of nodes on the main vine was noticed on application of all the three growth regulators tried. CCC 1000 ppm was found to be the most effective. Anon (1970) reported similar results with CCC treated cucumber plants which is supporting the present finding.

Alar treatments (100 and 200 ppm) caused a significant reduction in the internodal length and an increase in the number of nodes on the main vine. This shortening could be due to the low gibberellin production as a result of an external application of alar as reported by Rudich et al. (1972).

Ejsmond (1974) reported shortening of the internodes in cucumber by application of ethrel. Sodhu and Das (1978) also reported on similar lines in ridge gourd and bitter gourd. Ethrel (100 and 200 ppm) caused an effective reduction in the internodal length in both the genotypes used in this study.

Kwong and Lagerstedt (1977) observed stem enlargement in Phaseolus vulgaris and Alagiamanavalan (1971) got increased girth of stem in CO-2 papaya treated with ethrel. However ethrel treatments (100 and 200 ppm) did not cause

any significant increase in girth of both the genotypes tried. Alar (100 and 200 ppm) and CCC (500 and 1000 ppm) showed a significant increase in girth, of which CCC 1000 ppm was found to be the most effective. Such an increase in girth of stem noticed in tomato plants was reported by Harisidhaiah and Huddappa Gowda (1977).

5.2. Reproductive characters

All the three growth regulators tried showed a significant effect on flowering and in altering the sex expression and subsequently the sex-ratio of the two pumpkin genotypes. Ethrel (100 and 200 ppm) treated plants caused early female flower production and late male flower anthesis. The number of female flowers were increased, and the number of male flowers decreased thereby increasing the female:male sex ratio. Similar results are reported by Rudich et al. (1969) in cucumbers and squashes, Lippert et al. (1972) in muskmelon, Shanmugavelu et al. (1973) in pumpkin and Verma and Choudhary (1980) in Poona Khira, a common variety of cucumber.

Mishra and Pradhan (1969), Arun (1970) and Mishra and Pradhan (1970) observed early and increased female flower production, and a reduction in the number of male flowers, subsequently increasing the female:male sex ratio in CCC treated cucumber plants. CCC 500 and 1000 ppm

treatments in this present study had shown results which are agreeable with the above finding. However, CCC 1000 ppm was found to be the most effective in both the genotypes. Alar (100 and 200 ppm) treated plants also showed early female flower production, more number of female flowers and an altered sex-ratio. This is supported by similar observations in musk melon (Rudich et al., 1970) and also in long melon, bottle gourd, and wax gourd (Ghosh and Bose, 1972).

The node at which the first female flower is formed was drastically reduced as a result of ethrel (100 and 200 ppm) treatments. Rudich et al. (1969) got similar results in cucumbers while Shanmugavelu et al. (1973) and Swamy et al. (1977) got identical results in pumpkins. The ethrel (100 and 200 ppm) treated plants gave early fruit set and harvest in both the pumpkin genotypes used for this study. This is further supported by studies of Cantliffe and Robinson (1973) and Sunpoundlek and Abella (1974) working on cucumber.

Tanaka et al. (1970) reported a decrease in the number of pistillate flowers at lower nodes of the main stem and also a decrease in the early fruit yield when a cucumber variety 'Natsunomidori' was treated with plant retardants - CCC and alar. In contrast, the present

investigation recorded pistillate flower production at lower nodes and early fruit set in both alar (100 and 200 ppm) and CCC (500 and 1000 ppm) treatments. This could be substantiated by the reports of Tanaka and Kamochi (1969) stating that the sensitivity of CCC varies with genotype and season of cultivation of the crop.

5.3. Fruiting characters and quality

The effect of growth regulators on the yield per plant was studied in detail. CCC 1000 ppm in type T_1 and CCC 500 ppm in type T_2 recorded the maximum yield per plant. Mishra and Pradhan (1969) reported that CCC treatments on cucumber doubled the number of fruits per plant and increased the yield more than three fold. Saimbhi and Thakur (1973) observed increase in the fruit number per plant and yield in CCC treated squash melon. Similar result was noticed by Patnaik et al. (1974) wherein an increased total yield and fruit number per plant was got in ridge gourd when they were treated with high concentrations of CCC. Bottle gourd genotypes, both direct sown and transplanted responded well to CCC applications. Higher and early yields were noted in treated plants when compared to the control. But Anon (1970) reported that in cucumber there was no significant difference in yield between CCC treated and untreated plants. This could

possibly be due to the highly specific mode of action of CCC. Even different varieties of the same species responds differently to it (Cathey, 1964). The response of the two genotypes tried was different to CCC treatments. Type T_1 recorded 50.61 per cent increase in yield with CCC 1000 ppm, while type T_2 recorded a maximum of 87.68 per cent increase in yield with CCC-500 ppm treatment. A decrease in yield was noticed in type T_2 as the concentration was increased from 500 to 1000 ppm. Type T_1 responded well to increasing concentrations of CCC and so concentrations higher than those used in the present experiment could be tried. In contrast to the reports by Saimbhi and Thakur (1973) in squash melon and Patnaik et al. (1974) in ridge gourd, there was no significant increase in the number of fruits per plant with CCC (500 and 1000 ppm) treatments. But CCC caused a significant increase in the weight of the first matured fruit as well as the length of the fruits. This is in full agreement with the findings of Saimbhi and Thakur (1974) in bottle gourd. Quality analysis of the first matured fruit revealed no significant change in the TSS and acidity content with CCC treatments. However a slight increase in the carotene content was noticed. This was marked by the deeper colour of the flesh.

Lee et al. (1973) observed marked varietal differences to ethrel sprays in cucumber when applied at the two leaf stage. Sustikova and Gintarova (1973) also observed similar results on varietal response to ethrel sprays. In the present trial the two genotypes responded differently to both concentrations of ethrel (100 and 200 ppm), as far as the yield per plant is concerned. In both the genotypes, the fruits were formed at the lower nodes, when compared to the control. Hopping and Heathcote (1979) got similar results in pumpkin. Type T_2 responded well to ethrel treatments, both concentrations (100 and 200 ppm) had a significant effect on yield per plant. The total yield per plant and also the weight of the first matured fruit was increased. This was supported by the findings of Shanmugavelu et al. (1973) in pumpkin, Sumpowdlak and Abella (1974) in cucumber, Sama and Krueger (1977) in summer squash and Verma and Choudhary (1980) in cucumber cv. Poona Khira. The number of fruits per plant did not show any significant difference. Type T_1 on the other hand showed a significant reduction in yield due to ethrel treatment, when compared to the control. There was also no significant difference in the number of fruits produced per plant due to poor fruit set, in spite of early and increased production of female flowers. Similar reduction in yield due to poor fruit set was

noticed in cucumber (Churata-Masca and Awad, 1974) musk melon (Lippert et al., 1972) and in pumpkin cv. Arka Suryamukhi (Swamy et al., 1977). Though ethrel 200 ppm treatments did not show any significant difference statistically, it was found to be slightly better than ethrel 100 ppm concentration in increasing the fruit set. This reveals that the genotype might respond favourably to concentrations higher than those tried in this experiment. Ethrel (100 and 200 ppm) did not produce any significant effect on the seed number of the matured fruits. But Shanmugavelu et al. (1973) working on pumpkin found that the seed number was found to increase with ethrel applications. Churata-Masca and Awad (1974) on the other hand observed a decline in the seed number when cucumber plants were treated with ethrel. This again reveals the differential response of ethrel to different genotypes of the same crop as reported by Lee et al. (1973). The flesh thickness of the fruits also did not show any significant difference. This observation is in contradiction to the report by Shanmugavelu et al. (1973) who observed an increase in flesh thickness of pumpkin with ethrel treatments. Except for the carotene content there was no significant change in the quality attributes studied. Shanmugavelu et al. (1973) in pumpkin and Sindhu et al. (1982) in musk melon reported as increase in the TSS content with ethrel application.

However no significant difference was noticed in the TSS content of both the genotypes with ethrel application. Acidity of the matured fruits was also found to be unaffected. The carotene content was slightly decreased which was marked by a change (to light orange) in the flesh colour of the fruits.

Alar 200 ppm was found to be more effective in increasing the yield of both genotypes than 100 ppm. Alar 200 ppm recorded 21.05 per cent increase in yield in type T_1 while 46.48 per cent increase was seen in type T_2. The average weight of the fruit showed no significant difference while the weight of the first matured fruit was increased. The fruit number per plant was however not affected in both the genotypes. This result was similar to that of the reports of Singh et al. (1975) in summer squash. But Mishra et al. (1976) observed highest average number of fruits per plant in cucumber cv. 'Long green' treated with alar 1000 ppm. This indicates that higher concentrations of alar might prove favourable in increasing the number of fruits per plant. So concentrations higher than those used in this study could be tried as a future line of work. The carotene, content, acidity and TSS of the matured fruits were not however affected by alar treatments in both the genotypes.

SUMMARY

SUMMARY

The present study "The effect of growth regulators on fruit set and yield of pumpkin" was conducted at the College of Horticulture, Vellanikkara to explore the effects of growth regulators namely alar, CCC and ethrel applied at two different stages of the crop. The experimental materials consisted of two pumpkin genotypes collected from Palghat district of Kerala State. The effects were evaluated by studying various growth, reproductive, yield and quality attributes of the crop. The salient features are summarised below:

1. The two genotypes used for the experiment differed significantly in all the vegetative characters under study, except for the length of the internode. Reproductive characters like the days to first male flower anthesis, fruit set and harvest showed no significant difference. All fruit characters and the yielding pattern were significantly different in both the genotypes. The two genotypes did not vary in the acidity of the matured fruits.

2. The different levels of growth regulators tried had a significant effect in suppressing the excessive vegetative growth of the crop. CCC 1000 ppm followed by CCC 500 ppm and alar 200 ppm were the most effective in

reducing the vine length, total leaf area, internodal length, number of primary branches, and in increasing the girth and the number of nodes on the main vine.

3. CCC 1000 ppm caused early female flower production and late male flower anthesis. The number of female flowers were increased and male flowers reduced, thereby altering the sex-ratio of the crop. CCC 1000 ppm followed by CCC 500 ppm and alar 200 ppm were found to be the most effective in inducing early maturity and harvest of the crop.

4. The growth regulators tried produced no significant effect on the average weight of the fruit, fruit number per plant, flesh thickness and the number of seeds per fruit.

5. CCC treatments followed by alar 200 ppm was found to be the most effective in increasing the yield. Type T_1 produced the maximum yield in CCC 1000 ppm treated plants while Type T_2 responded best to CCC 500 ppm concentration. However a slight decrease in yield was noted in this genotype with CCC 1000 ppm treatment. Type T_1 recorded a decrease in yield with both ethrel 100 and 200 ppm treatments. The genotype (Type T_1) had responded well to higher levels of all the growth regulators. Hence it is possible to think for a still higher concentration of growth regulators for future line of work.

6. The genotype x growth regulator interaction was significant for the length of main vine, nodes on main vine, girth of vine, length of internode, number of branches, number of leaves per plant, leaf area, days to male flower anthesis, number of male flowers, sex ratio, node at which first female flower is formed, days to first fruit harvest, node at which first fruit is retained and the fruit yield.

7. No significant difference was noticed when growth regulators were sprayed at two different stages (four leaf and six leaf) of the crop. The genotype x stage interaction was significant only for the node at which the first fruit is retained.

8. The carotene content of the two genotypes was slightly increased by CCC treatments (500 and 1000 ppm).

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EFFECT OF GROWTH REGULATORS ON FRUIT SET AND YIELD OF PUMPKIN (*Cucurbita moschata.* Poir)

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ABSTRACT OF THE THESIS
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ABSTRACT

An experiment was conducted at the College of Horticulture, Kerala Agricultural University, Vellanikkara during December-April 1983-'84 to study the effect of six levels of growth regulators viz., alar (100 and 200 ppm), CCC (500 and 1000 ppm) and ethrel (100 and 200 ppm) and of the two different stages of application (four leaf and six leaf stage) on growth, sex-expression, fruit set, yield and quality of two distinct pumpkin genotypes (Cucurbita moschata Poir.) collected from Palghat district of Kerala State. The experiment was laid out in split-plot design with three replications.

The effect of plant growth retardants to suppress the luxuriant growth of the crop is further confirmed by the results of the present study. All treatments caused a significant reduction in the length of the main vine and all other vegetative characters under study. There was a drastic reduction in the number of male flowers and an increase in the female flower number, altering an otherwise male dominated sex-ratio of the crop. CCC 1000 ppm was found to be effective in promoting early fruit set and harvest of both the genotypes tried. However there was no significant increase in the number of fruits per plant, average weight of the fruit, flesh thickness

and the number of seeds per fruit. CCC treatments followed by alar 200 ppm was found to be the most effective in increasing the yield. Type T_1 gave maximum yield with CCC 1000 ppm whereas type T_2 responded well to CCC 500 ppm concentration. CCC 1000 ppm however caused a slight reduction in the yield of this genotype. There was also a slight increase in the carotene content with CCC treatments. Type T_1 recorded a slight decrease in yield with both ethrel (100 and 200 ppm) treatments.

No significant difference was noticed when growth regulator sprays were given at two different stages (four leaf and six leaf) of the crop. The study thus also proved that the response of pumpkin to growth regulators sprays is governed by the genotype and the concentration of the growth regulators used.