Studies on the Effect of Growth Regulators on Fruit Setting in Cardamom

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Introduction

Elettaria cardamomum Mat. belongs to the natural order Scitamineae and the family Zingiberaceae. It is a tall, herbaceous perennial, with branching subterranean root stock, from which arise a number of upright leafy shoots, 5-14 ft high, bearing alternate elliptical or lanceolate sheathing leaves, 1-3 ft long. Flowers are borne in panicles, 2-4 ft long, arising from the base of vegetative shoots, panicles upright throughout their length or upright at first and ultimately pendent or prostrate; flowers about 1 • 5 ft long, white or pale green in colour with a central lip streaked with violet, borne in a close series on the rachis; they are bisexual, but self-sterile, and open in succession from the base towards the tip. Fruits trilocular capsules, fusiform to ovoid, pale green to yellow in colour, containing 15-20 hard, brownish black, angled and rugose seeds, covered by a thin mucilaginous membrane. (The Wealth of India, 1952).

The most important cardamom growing region in India is Kerala. In this State the crop is grown in the High Ranges and is largely distributed in the regions known as the Cardamom Hills. This is grown largely as a single crop on a plantation basis, the size of which often ranging from 50-200 acres. Bulk of the cardamom of commerce is produced in this region. The next most important cardamom growing area is in Mysore State, particularly in the Munzerabad taluka of the Hasan District. Certain portions of Nilgiris and Madura District of the Madras State and North Kanara District in the Bombay State also grow cardamom, but the production from these sources is comparatively small and is often collected as minor forest produce. (Report of the Spices Enquiry Committee, 1953).

Cardamom grows well above an altitude of 2500 and below 5000 ft with a warm, humid atmosphere with an annual rainfall of 60-230 inches and a temperature range of 50-95°F. These appear to be about the limits for its cultivation. In the few areas where cardamoms were seen above 4500 ft their growth was slow and crops were small. Apart from the exceptional area in North Kanara there was no cardamom below 3000 ft and at lower elevations, although vegetative growth was satisfactory,

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Fig. 1. Cobalt 60′ irradiated cardamom plant with, flowers

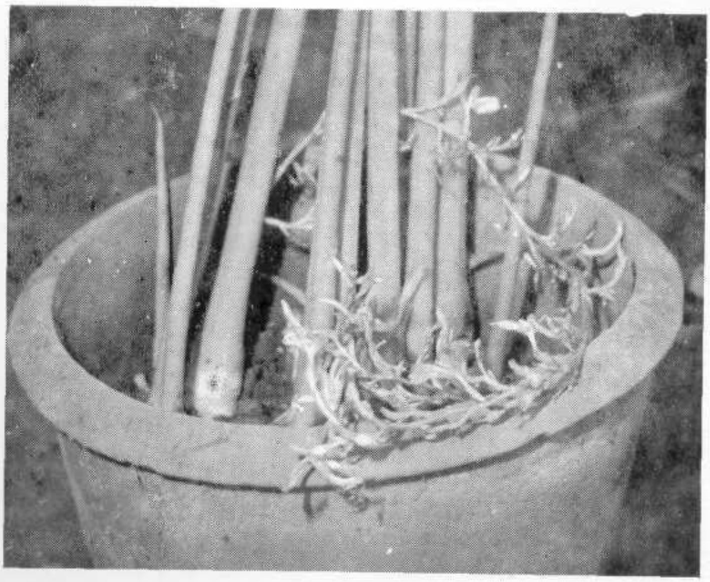

Fig 2. Irradiated cardamom plant sprayed with Gibberellic acid has induced swelling of ovaries

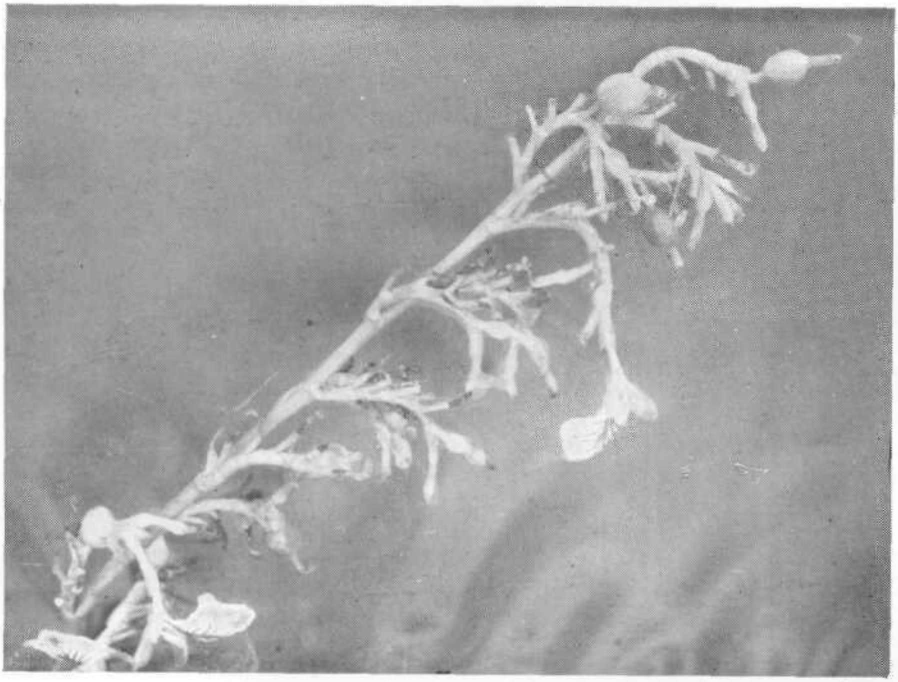

Fig. 3. Gibberellic acid sprayed panicle with mature fruits

Fig. 4. Cardamom seedlings raised from seeds of G. A. treated plant.

cropping was extremely poor. In North Kanara plants grow at sea level, where they give no crop. The upper limits are probably largely determined by temperature but also depend on the maximum elevations in the locality. (Mayne, 1942).

Elevations and rainfall are the two important factors for successful cultivation of cardamoms. The elevations best suited for the Malabar variety is between 2000 and 3500 ft above sea level and for the Mysore variety between 3000 and 4500 ft. with a well distributed rainfall between 120-150 inches per year. It would be a venturesome proposition to grow cardamoms for commerce at lower or higher elevations than these. (Extracts from Tropical Agriculturist, 1938).

The use of growth regulating substances for inducing and also improving fruit set and yield in fruit crops has been investigated by many research workers. Failure of fruit set on many crops is frequently caused by pollen sterility, incomptiability or by adverse weather conditions during flowering, which may hinder pollen production, pollination, pollen germination, pollen-tube growth and fertilisation. The natural fruit setting hormones are then not produced. In such cases certain growth regulators applied to the flowers are useful in supplementing normal pollination and in the normal and parthenocarpic setting of fruits. In cases where the fruit set is good but the development is poor due to heavy dropping or some other causes, the application of growth hormones is of great utility.

The present investigation was carried out to study the effect of floral application of Gibberellic acid and 2, 4–Dichlorophenoxy acetic acid on fruit set in cardamom on the plains of Kerala.

Review of Literature

Massarat (1902) first established the existence of the stimulus of hormones in fruit set. He demonstrated that dead pollen grains could stimulate the swelling of ovaries. Gustafson (1936) succeeded in the chemical induction of fruit set on several crops. Tukey (1952) demonstrated that in the absence of stimulus of fertilisation only a few plants are able to form parthenocarpic fruits.

Rappaport (1957) while studying the effect of gibberellin on germination, flower and fruit of tomato observed that setting of normal and parthenocarpic fruit was increased by repeated floral sprays at 1-500 mg/ml, eventhough the ovule size and development was unaffected. Wittwer and Bukovac (1957) while reviewing the effect of GA for crop production observed that gibberellin proved to be very effective in setting tomato fruits without pollination.

Arnulf Persson and Rappaport (1958) found that the floral sprays containing 500 mg of gibberellin per milliliter resulted in characteristic parthenocarpic fruit development in a male sterile tomato. Weaver and McCune (1958) observed specific responses to gibberellin sprays in grapes as shown by fruit set, berry size and elongation of cluster parts. Krimbas, Davidas and Michailidis (1959) found that spray application of GA at 10, 20 or 30 ppm to Black corinth grapes three days after full bloom increased fruit size and approximately doubled the yield of fresh fruit as compared with control vines. But in Sultania vines spray application of 20, 30 or 50 ppm GA solutions gave no clear positive response, but the raisins produced from their fruit were tougher and darker coloured than those of the controls.

Krishnamurthy, Randhawa and Singh (1959) studied the effect of GA sprays as 10, 25 and 50 ppm to the flower clusters of Pusa seedlings variety of grapes. At the lower concentrations of 10 and 25 ppm the fruit set was increased by 76 . 50 and 59 . 11 % respectively, but at the highest concentration re ulted in thinning of flowers and reduction of fruit set by 15-41 %, but produced highest average weights. Luckwill 1959) studied the effect of GA on fruit set in apples and pears. Aqueous solutions of the potassium salt of gibberellic acid at 50 ppm sprayed at petal fall on apples and pears after preventing the pollination by cutting off the styles resulted in early swelling of the fruitlets and increased the initial set. GA applied at petal fall to open pollinated trees usually resulted in some diminution of fruit set in apples. Parthenocarpic pears produced by GA treatment were slightly smaller than seeded fruits and are of abnormal shape. Randhawa, Singh and Khana (1959) found that GA sprays in Phalsa at a concentration of 10 ppm markedly increased fruit set. size and total yield and quality of fruits over all other treatments. Randhawa, Singh and Dhuria (1959) found that in sweet lime application of GA at 10 ppm and 2, 4—D at 10 and 15 ppm improved fruit set, size and total yield over control. Rives and Pooget (1959) studied the effect of gibberellin on the compactness of bunches of the two vine varieties. Application of GA at 10, 50 and 100 mg increased the bunch length to 10-15 cms compared with 7 cms in the control. Singh and Randhawa (1959) studied the effect of GA and Parachlorophenoxy acetic acid on growth and fruitfulness in strawberry. GA sprays at 5 and 10 ppm increased the length of peduncle and fruit and total yield was also increased by 46 and 62% respectively over control. Weaver and McCune (1959) found that spray application of GA at 1 to 100 ppm concentration to clusters of Black corinth grapes progressively increased berry size and length to width ratio. In Thompson seedless vines spray application of G A at 10, 25 or 50 ppm to flower clusters resulted in an increased length of cluster. Kukovac, Larsoen and Bell (1960) found that in Concord grapes fresh, dry weight and number of berries per cluster were not affected by spray application of GA after full bloom. Davison (1960) observed that in apples GA applied as 1% lanolin paste to the receptacles during flowering induced parthenocarpic fruit development. Gustafson (1960) studied the influence of GA on setting and development of fruits in tomato· GA application of 35 and 700 ppm sprays on flower clusters enhanced setting, but the total weight of fruits was lower in first three clusters. Kononov (1960) observed that by immersing vine inflorescences at the beginning of flowering for 20-30 seconds in 0.0025% GA improved fruit set and in functionally female varieties induced parthenocarpy and raised the sugar content of fruits. Laree (1960) studied the effect of GA on seeded grapes. Bunches of Queen vine yard grapes were sprayed after full bloom with 20 ppm GA and NAA separately. GA increased fruit size but NAA had no effect.

Muromcev and others (1960) found that GA application 10-100 mg/l to seedlings and/or inflorescences of mature plants accelerated ripening of the fruit and increased yield by 23 to 66 %. Spina (1960) reported that spraying of GA at 5, 20 and 50 ppm on the foliage and inflorescences of grapes 3 days after flower opening gave no significant effect on yield. Weaver (1960) found that GA application to Black corinth grapes increased fruit set. Venkataratnam (1961) studied the effect of GA on Anab-e-shahi grape. The inflorescences of the grape dipped in GA at concentrations ranging from 40, 60, 80 and 100 ppm before anthesis increased fruit set.

Stewart and Parker (1954) reported the effect of 2, 4-D and related substances on fruit drop, yield, size and quality of grape fruit. Krishamurthy and Subramaniyan (1954) found that application of 2, 4-D as a paste at 0 . 0025 to 0. 01% or as water sprays at 0 . 0005 % increased fruit set as a whole to 50 to 60%. Taguchi and Nishiri (1955) found that concentrations of 0 .0007 to 0 . 005% of 2, 4-D was effective in improving seed set of varietal crosses in potato varieties. Muthukrishnan (1957) reported the influence of *2,* 4-D in decreasing blossom drop and increasing fruit set in a Summer crop of brinjal. He found the application of 2, 4-D at 5 ppm as water spray to individual flowers, reduced the blossom drop to 66 . 4 % and increased fruit set by 37%.

Materials and Methods

The investigation reported in this paper was conducted at the Agricultural Botany Division, Agricultural College and Research Institute, Vellayani, Trivandrum, Kerala.

Fresh cardamom seeds of variety "Singampetty", obtained from the Superintendent, Cardamom Research Station. Pampadampara, Kerala were got irradiated, using Cobalt 60, at various doses at the American Pavilion of the World Agricultural Fair held at New Delhi on February 13, 1960. The treated seeds were sown in pots on March 3, 1960 and kept under artificial shade. The seeds germinated on July 28, 1960. Non-irradiated seeds (control) were also sown in pots simultaneously and kept under shade. When the seedlings attained about one foot height, they were transplanted in bigger pots of 18 x 18" and kept under artificial shade. In February 1962, some of the plants raised from irradiated seeds, bloomed under the Agro-climatic conditions of Vellayani, which is situated about 100 ft above sea level with an annual rainfall of 40-60 inches and temperature ranging from 75-95°F. Out of 22 plants raised from treated seeds, 9 produced normal panicles about 1–1½ ft long with normal flowers of about one inch length. Control plants did not produce any panicle. Eventhough the irradiated plants produced panicles and normal flowers no fruit set was noticed. (Fig; 1.)

In order to induce fruit setting in cardamom on the plains of Kerala, an experiment, using growth regulators, was conducted in 1963 on the irradiated plants which bloomed profusely during the year also. Growth regulators, GA and 2, 4–D, of various concentrations were sprayed on the panicles before anthesis of flowers.

The following concentrations of GA and 2, 4–D were selected for the trial.

GA : 25, 50, 100, 200, 250 and 300 ppm

2, 4-D: 2, 5 & 10 ppm.

The number of plants under each irradiated group and the various doses of growth regulators used are given below :–

5000 r—	1. 25 ppm		2000 r—	4. 200 ppm		10,000 r—	8. 5 ppm
	2. 50 ppm			5. 250 ppm			9. 10 ppm
	3. 100 ppm			6. 300 ppm			10. Control
				7. 2 ppm			

Before spraying all panicles present in the 9 groups were labelled, measured and their length recorded. The first spray, using an atomizer, was given at 10 A. M. on 1-4-1963. After a fortnight the second spray was given after recording the length of the labelled panicles. Similarly the third and fourth sprays were given at intervals of 14 days. At each time the length of all the labelled panicles was recorded before spraying. (Table 1.). Control plants, which received distilled water sprays, were kept away from the plants treated with growth regulators. After third spraying some of the plants reacted very favourably to the treatment by producing swollen ovaries which later developed into normal capsules containing normal and aromatic seeds (Figs. 2 & 3). Seedlings raised from these seeds are under observation (Fig. 4).

TABLE 1.

Effect of growth regulators on length of panicle and fruit-setting

S No	Treatments	No. of Panicles	Date of spraying and length in cm 1-4-63	16-4-63	1-5-63	15-5-63	29-5-63	No of fruits
1.	GA. 25 ppm	1	17.0	20 0	26.0	29.0	30.0	
		2	13.0	22.0	30.0	31.0	34 0	
		3	32.0	40.0	51.0	54.0	54.0	
		4	40.0	34.0	39.0	39.0	39.0	
		5	32.0	35.0	41.0	42.0	42.0	
		6	31.0	40.0	47.0	47.0	49.0	
		7	33.0	41.0	49.0	49.0	53.0	Nil
2.	GA. 50 ppm	1	27.0	33.0	41.0	50.0	51.0	Nil
3.	GA. 100 ppm	1	20.0	24.0	27.0	28.0	32.0	
		2	10.0	15.0	17.0	17.0	19.0	5
4.	GA. 200 ppm	1	28.0	32.0	40.0	43.0	44.0	
		2	25.0	30.0	36.0	40.0	42.0	
		3	27.0	31.0	41.0	43.0	44.0	
		4	14.0	20.0	24.0	25.0	25.0	
		5	9.0	12.0	17.0	19.0	20.0	
		6	10.0	13.0	16.0	18 0	19.0	
		7	11.0	18.0	22.0	23.0	23.0	
		8	12.0	16.0	20.0	22.0	22.0	74
5.	GA. 250 ppm	1	24.0	30.0	34.0	35.0	35.0	
		2	11.0	14.0	20.0	21.0	21.0	
		3	30.0	34.0	39.0	42.0	42 0	
		4	29.0	32.0	37.0	37.0	37.7	
		5	12.0	17.0	21.0	24.0	24.0	

Table I- Continued

		6	27.0	30.0	36.0	36.0	36.0	
		7	14.0	20.0	25.0	25.0	26.0	
		8	10.0	14.0	17.0	18.0	18.0	33
6.	GA 300 ppm	l	21.0	27.0	31.0	35.0	44.0	
		2	8.0	10.0	15.0	17.0	18,0	
		3	7.0	12.0	16.0	19.0	23 0	
		4	5.0	11.0	18.0	190	25.0	Nil
7.	2, 4-D 2 ppm	1	23.0	30.0	34.0	36.0	36.0	
		2	6.0	8.0	12.0	17.0	21.0	
		3	13.0	17.0	23.0	24.0	27.0	
		4	8.0	11.0	16.0	19.0	22.0	58
8.	2,4–D 5 ppm	1	31.0	36.0	40.0	40.0	44.0	
		2	9.0	12.0	16.0	18.0	19.0	
		3	14.0	17.0	23.0	24.0	28.0	
		4	10.0	13.0	17.0	19.0	19.0	Nil
9.	2, 4-D 10 ppm	1	23.0	27.0	31.0	31.0	32.0	
		2	20.0	22.0	26.0	27.0	30.0	
		3	17.0	21.0	25.0	25.0	29.0	
		4	12.0	14.0	17.0	18.0	22.0	Nil
10.	Control	l	150	18 0	20.0	22.0	22.0	
		2	18.0	21.0	23.0	24.0	25.0	
		3	13.0	16.0	17.0	21.0	22.0	
		4	24.0	28.0	30.0	30.0	30.0	Nil

Results and Discussion

Cardamom, which does not set fruit on the plains of Kerala, was first treated with Cobalt 60. This treatment has induced the plants to bloom profusely but has not induced fruit-setting. In order to induce fruit-setting, different doses of GA and 2, 4-D were sprayed on the panicles before anthesis. Certain doses of these growth regulators have induced panicle length and also fruit-set.

In has been found that repeated floral applications of GA at 25 and 50 ppm increased the length of panicle to 16 and 24 cm respectively compared with 7.25 cm in the control. All other doses of GA (I00, 200, 250 and 300 ppm) and 2, 4-D (2, 5 and 10, ppm) also induced panicle length compared with the control. This confirms the findings of Rives and Pooget (1959) and Singh and Randhawa (1959) who have reported that GA and 2, 4-D could induce bunch length in grapes and strawberry.

TABLE II.

Average length of panicles and number of fruits for different treatments

Treatments.	No.of Pani-cle.	Av. length of panicles before spraying (cm.)	Average length of panicles (cm) after				No. of Fruits
			1st Spray.	2nd Spray.	3rd Spray.	4th Spray	
GA 25 ppm	7	26.85	32.72	40.42	41.28	43.00	Nil
,, 50 ppm	1	27.00	33.00	41.28	60.00	51.00	Nil
,, 100 ppm	2	15.00	19.50	22.00	22.50	25.50	5
,, 200 ppm	8	17.00	21.50	27.00	29.12	29.87	74
,, 250 ppm	8	19.62	23.87	28.62	29.75	29.87	33
,, 300 ppm	4	10.25	15.00	20.00	22.50	27.50	Nil
2,4D. 2 ppm	4	12.50	16.50	21.25	24.00	26.50	58
,, 5 ppm	4	16.00	19.50	24.00	25.25	27.50	Nil
,, 10 ppm	4	18.00	21.00	24.75	25.25	28.25	Nil
Control	4	17.50	20.75	22.50	24.25	24.75	Nil

GA and 2, 4-D induced fruit setting also in cardamom. The highest number of fruits was obtained from plants treated with 200 ppm GA (74 fruits) followed by plants treated with 12 ppm 2, 4-D (58 fruits). Although 25 and 50 ppm GA induced the maximum length of panicle, they did not induce fruit setting in cardamom. Inhibition of fruit setting was also observed in plants treated with 300 ppm GA and 5 and 10 ppm 2, 4-D. 100 and 250 ppm GA also induced fruit set, but to a much lesser extent. Control plants, sprayed with distilled water, did not produce any fruit.

Summary and Conclusions

Floral spray of GA at 50 ppm induced the maximum length of panicle over the control. But it did not induce fruit setting.

All concentrations of GA and 2, 4-D also induced panicle length over the control.

The highest number of fruit-set was obtained from plants sprayed with 200 ppm GA followed by plants treated with 2 ppm 2, 4-D. GA at 25, 50 and 300 ppm and 2, 4-D at 5 and 10 ppm did not induce fruit-setting.

From the above results it may be assumed that 25 and 50 ppm GA are insufficient to induce fruit-set and that at 300 ppm GA fruit inhibition results. Similarly doses of 2, 4-D beyond 2 ppm inhibits fruit induction.

200 ppm GA and 2 ppm 2. 4-D appear to be the optimum doses required for inducing satisfactory fruit-set in cardomom on the plains of Kerala.

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