EFFECTS OF SOME GROWTH REGULATORS ON FRUIT SET AND DEVELOPMENT IN GUAVA

A THESIS SUBMITTED TO THE GRADUATE DIVISION OF THE UNIVERSITY OF HAWAII IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN HORTICULTURE

JUNE 1968

By

Samuel A. Adenikinju

Thesis Committee:

Henry Y. Nakasone, Chairman
Richard T. Poole
Beatrice H. Krauss

We certify that we have read this thesis and that in our opinion it is satisfactory in scope and quality for the degree of Master of Science in Horticulture.

THESIS COMMITTEE

Henry Y. Nakasone
Chairman

R T Poole

Beatrice Krauss

ACKNOWLEDGEMENTS

The author expresses his deep gratitude to the USAID-IADS (United States Agency for International Development--Institute for Agricultural Development Service) for sponsoring the program and to the Hawaii Agricultural Experiment Station and the Department of Horticulture, University of Hawaii, for providing the necessary facilities for this research.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (CONT'D)

LIST OF FIGURES

INTRODUCTION

The guava has become an important commercial fruit in many tropical and semi-tropical areas of the world. It is a good source of vitamin C (8, 10, 32, 34) as well as vitamin A, and minerals such as iron, calcium and phosphorus (10). The fruit is utilised directly or indirectly in a variety of products which include jellies, pastes, preserved shells (8, 10) beverages and desserts (10).

In commercial fruit orchards the ultimate objective is to obtain maximum yields per unit area. All cultural practices are directed towards increasing flowering, fruit set and subsequent fruit development. In guava little data are available to show that maximum fruit set is being achieved under natural conditions or by the effects of growth regulators, not only upon fruit set but also upon fruit development and the production of seedless fruits.

This study was initiated to determine some of the effects of selected growth regulators upon fruit set, fruit-size, quality and seedlessness in the guava.

BOTANY OF THE GUAVA

The guava belongs to the family Myrtaceae and in the genus Psidium. The family contains approximately 3,000 species, all characterized by the presence of essential oils in various parts of the plant (10). Two other well-known genera in the family are Eugenia and Sygium. The genus Eugenia embraces about 600 species, most of which are native to the New World. The genus Sygium consists of about 75 species, all native to the

Old World (34). The genus Psidium alone contains approximately 150 species, all of which are native to Central America (10, 32).

There are wide variations in the fruit of the guava. They range from the wild uncultivated types with thin rinded seedy fruits to the highly improved clones which have large excellent fruits (34). Other commonly cultivated species in various parts of the tropical world are Psidium cattleianum Sabine, P. guineense Siv., P. polycarpum Lamb, P. molle Berthol, P. coriaceum Mart, P. friedrichsthalianum (Beng) Nied, P. arace Raddi and P. cuijavillus Burm f. (34). Other well-known relatives of the guava include the Feijoa, Feijoa sellowiana Berg, commonly called pineapple guava. It is grown extensively in California, the Northern part of Florida and in similarly cool subtropical areas (34). The Downy myrtle (Rhodomyrtus tomentosa Wight) has been described as another relative adapted to a subtropical climate, bearing good quality fruits (34). The Para guava (Britoa acida Beng) has been introduced to various parts of the tropics but it is not as popular as the foregoing species (34).

Floral anthesis in Psidium species occurs early in the day and is influenced by the minimum temperature (42). In P. molle and P. cattleianum anthesis occurs a little later in the day than in P. guajava, P. guineense and P. chinense. Balasubrahmanyam (4) reported that guava flowers open between 5 and 7 A.M. in the three cultivars: Allahabad, Chittidar and Lucknow and there were two flowering seasons, September-October and January-March. He also reported that bud development in the three cultivars took 30 days from initiation to flower opening. Pollen grains among Psidium species differ in shape as well as in size while

germinability ranges from 42.6 to 79.2 percent in surcose (42). P. molle showed optimum germination in 15 percent sucrose and other species in ten percent sucrose. Sehgal (39) also found that 15 percent sugar solution gave optimum germination in three cultivars of P. guajava L.

Stigma of P. cattleianum var. lucidum becomes receptive as the flower opens and remains so for up to 72 hours while other Psidium species become receptive one day before anthesis and remain receptive for 32 hours (42). In India, Balasubrahmanyam (4) found the stigma to be receptive from 2-3 hours after opening up to 48 hours and pollen remained viable for four hours in Allahabad Round, Chittidar and Lucknow (cultivars of P. guajava). However, in the three cultivars stigma was not receptive 24 hours before anthesis. In Hawaii, Hirano (22) was able to set fruit with pollen from P. guajava, 48 hours and 72 hours after anthesis.

Seth (42) in India found that during the rainy season initial fruit set is as high as 83.3 percent while in summer occasionally no fruits are set.

In all Psidium species the flower is epigynous with an inferior ovary. The sepals are united before anthesis, later slitting into 4-5 irregular parts. The petals are free and 4-5 in number. Stamens are numerous. The style is single end undivided while there are 4-5 carpels with numerous ovules arranged in axile placentation.

DESCRIPTION OF PSIDIUM GUAJAVA L. (Common Guava)

Psidium guajava L. has been variously described as a low tree or aborescent shrub, 3-10 meters tall with short crooked low branches or as a large shrub or small spreading tree growing to more than ten meters (32). While the common guava more closely fits the description of a

shrub, the nature of growth depends upon the environment and system of pruning. It has a trunk 10-30 cm thick with a dark greyish brown, smooth, flaky bark (32) and a thin irregular wide spreading crown. The bark has also been described as multi-colored, an appearance produced when the bark peels off, displaying a light brown color beneath. The young twigs bear narrow wings on four sides which later become tetragonous, yellowish green or often dark red and densely covered with pubescence. They are therefore square in cross-section. The bark of older branches are of a lighter color than that of young ones, dull and glabrous with scattered lenticels, peeling off in flaky pieces after a certain age. The smaller branches or twigs carry the almost sessile, opposite, light green simple leaves.

The leaves are distichous towards the apex of the branches, short-petioled, ovate or elliptic, oblong with a soft downy under surface and rounded or obtuse at the base. Each leaf has 10-25 pairs of veins which appear sunken above and prominent below and greenish yellow in color. The principal veins are prominent, ex-stipulate and pinnately arranged. The petiole is densely covered with pubsecence with a few rigid, subulate brown glands at the base (34).

The flowers are hermaphroditic, axillary in position, supported on short slender pedicels borne on young branches or current season's growth. They may be solitary or in two or three flowered cymes but rarely terminal. The pedicel is 2-4 cm long, terete, yellowish green in color and densely pubescent (34).

The bracts are subulate and pubscent. At an early stage the flower is completely subtended by the calyx tube which breaks open into 4-5 irregularly shaped lobes at anthesis. The sepals are turbinate or

sometimes obovoid, yellowish green, about 0.6-0.7 cm long with the calyx limb much longer than the tube and persistent in the fruit. The 4-5 white petals are free, obovate and covered with densely appressed pubescence on both surfaces. They are glabrous within and 1.5-2.0 cm long (34). They originate around the central disk of the flower, spreading out as the flower opens.

The numerous stamens are arranged in rows around the disk or sometimes in groups. Each stamen is 1.0-1.5 cm long with a longer filament and a short anther (34). The filaments are usually white while the anther is light yellow, ovoid-oblong and ellipsoid in shape.

The style is filiform, glabrous and yellow-green, 1.2-1.5 cm long and centrally located on the disk. It is smooth and hairy at the summit, longer and thicker than the stamen filaments and bends over the stamens at bud stage (32).

The ovary is inferior and syncarpous with 4-5 carpels each containing numerous ovules arranged in axile placentation. After fertilization, the ovary develops into a globular or pear-shaped berry, with numerous seeds embedded in a white or pink flesh originating from the ovary tissue and the fleshy placenta.

The seeds have been described as small, bony, reniform and compressed light yellowish or yellowish brown, 0.3-0.5 cm long, occupying the central portion of the berry (34).

The fruits are globose to globose-ovoid or pyriform, faintly or obtusely 5-8 sided or with 5-10 shallow longitudinal grooves, bearing vestiges of the calyx and the small round disk. They occur singly or sometimes in multiples of two or three on one peduncle and are green

externally when immature, becoming greenish-yellow or light-yellow at maturity. The fruit wall may be pebbled, rough, smooth or bumpy, depending on the variety and other factors. They vary in size from 5-12 cm long and 5-7 cm in diameter (34). The pulp is juicy with a distinct flavor and rich aroma. Pulp color, texture and flavor of the fruits depend upon the cultivar. The acidity is due to the citric acid content which declines with ripening. Yield records taken in Guyana showed variations from three to eight tons per acre per annum (32).

REVIEW OF LITERATURE

The first crop in which fruit was successfully improved with the application of auxins was the tomato where the need for pollination was completely replaced by auxins (25). Auxins were required specifically to improve set under conditions unfavorable for fruit set.

In 1934, Yasuda (25) first succeeded in producing fully parthenocarpic fruits in the cucumber by injecting pollen extracts into the ovary. Further work followed by Gustafson (25) who induced seedlessness in the fruits of tomato, pepper, crookneck-squash among other crops by applying a one percent solution of indoleacetic acid (IAA), 2-indole-3-butyric acid (IBA) and 2-indolepropionic acid (IPA) or phenylacetic acid to the stigma or cut surface of the style. But he failed to achieve the same in other species like watermelon, summer and winter squash and pumkin (3). Gustafson (19) defined the role of auxins in fruit setting as being made up of (a) setting of young fruits, i.e., initiating and prevention of abscission and (b) subsequent control of its expansion up to maturity. In 1939 Gustafson (25) examined the ovaries of seeded and non-seeded crops in an attempt to find a connecting link between auxin content and the natural inclination towards seedlessness. He found that among citrus fruits and grapes, the auxin contents were higher in seedless varieties.

Luckwill and Hatcher (29) located the source of auxin responsible for fruit set and development in the endosperm, the nutritive tissue surrounding the embryo. Stewart and Klotz (49) found that when they applied 2,4-dichlorophenoxyacetic acid (2,4-D) sprays to Valencia orange at full bloom, blossom drop was delayed 8-10 weeks but there was no increased

fruit set. Application in May likewise delayed the June drop of immature Washington Navel fruits 6-8 weeks but also did not increase yield. Young Navel fruits sprayed with 25-225 ppm 2,4-D developed seeds or seed-like structures in contrast to unsprayed fruits which were seedless. Some of the fruits sprayed with 225 ppm 2,4-D developed a thick rind and excessively large protruding navels while others became cylindrical in shape. Auxin treatment decreased pre-harvest drop of Valencia oranges by as much as 78 percent, even when applied two weeks after severe dropping began.

Livingston (28) studied abscission in the excised lamina in Valencia orange using various fractions of the blade tissue and immersing them in distilled water, sucrose, chloral hydrate, IAA, 2,4-D, ethylene and cynamid. All the treatments inhibited abscission except ethylene. Many of the treatments produced enlargement of tissues proximal to the abscission groove. This investigation demonstrated the value of studying abscission in the laboratory using excised tissue.

In 1947 and 1948, Stewart, working with Nield and Braunaman (50), used 17 different chemicals including 2,4-D and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) on Valencia orange. 2,4-D applied alone at 4-48 ppm water spray gave a reduction in fruit drop of approximately 35.0 percent. Among the 17 chemicals sprayed on trees at bloom, only 2,4,5-T and 2,4-D induced any significant increase in fruit size. They found a slight decrease in number of loose fruits but with only slight differences in quality. Fruits of young trees had greater increase in size than those of older trees. Observed growth responses which may have contributed to increase in fruit size are (1) thicker fruit stem (pedicel) in proportion to the fruit diameter, (2) a direct stimulation

of growth of certain fruit tissues, and (3) a reduction in number of fruits per tree.

Stewart and Hield (49) later tried 2,4-D, 2,4,5-T and chlorophenoxy-acetic acid (CIPA) on lemons in a randomised block experiment of seven treatments. They found that 5 ppm 2,4,5-T induced the greatest reduction in fruit drop and was highly significant at the five percent level as compared to the check. Their work showed that 2,4,5-T and 2,4-D were effective in reducing drop of mature lemons at concentrations as low as 5 ppm with the former being the more effective.

Mann and Minges in 1949 (30) conducted a fruit-setting experiment with growth regulating substances on field grown tomatoes in California. They applied beta-naphthoxyacetic acid (NOA), CIPA, its sodium salt form and 2,4-D, using three different methods of application, spray, aerosols and dust. All chemicals used were effective with CIPA and its salt form being most effective at 50 ppm. NOA applied in a water spray increased both fruit set and fruit size. Of the three concentrations of NOA: 50, 250, and 500 ppm, 250 ppm was the best, giving a result as satisfactory as 50 ppm CIPA. 2,4-D at 10-20 ppm gave a set as good as 50 ppm CIPA. Of the three methods of application used, water-spray was the most satisfactory.

Earlier, Singh and Kacker in India (44) investigated the effect of some hormones and three methods of application on tomatoes. With the application of IBA, IAA and NAA in lanolin paste they produced completely seedless tomatoes. Injecting 0.02 gm of the dry chemical into the base of the tomato stem, they produced fruits with less seeds than the check. They also compared two methods of application, injection and

paste but found no differences between them. The fruits produced parthenocarpically were smaller in diameter, weight and volume than those of the control.

Gustafson (19) tried gibberellic acid (GA) on tomato. He found that GA at 25 and 75 ppm water spray induced seedlessness in all fruits treated. Using flowers and flower buds of the first three clusters, setting was enhanced and total weight per cluster was increased. However, the response did not occur on subsequent clusters similarly treated. In 1962 Lam, Leopold and Johnson (24) conducted studies to concentrate tomato ripening by preventing late set through the use of sodium dichloroisobutyrate (DCIB) for mechanical harvesting. The percentage of ripe fruits produced at a single harvest was increased from about 50 to approximately 90 precent. There was marked reduction in fruit size and the actual amount of fruit harvested per single harvest and quality was unimpaired. Their experiment indicated that chemically imposed limitation of fruit set could simplify the mechanical harvesting of tomatoes.

Waddington and Teubuer (56) also tried to concentrate tomato yields for mechanical harvesting with n-m-tolyphthalamic acid. Using a spray concentration of 200 ppm on young seedlings during development of the first inflorescence, the number of flowers and subsequent yields in a single harvest were increased from 5 to 10 tons of marketable fruits per acre. They found the treatment particularly successful with the dwarf cultivar, Epoch, while the late maturing indeterminate cultivars failed to mature the increase crop of fruit before the frost.

Doughty (15) attempted to find a substance to supplement normal pollination and to insure good yields of cranberries (Vaccinium

macrocarpon). He applied the following chemicals and their mixtures in a factorial experiment: CIPA, 2,4,5-T, NAA, 2,4,5-trichloropropionic acid (2,4,5-TP) and NOA. None of the chemicals proved satisfactory in the season applied, but CIPA, when sprayed at 20 ppm during 40-45 and 80-95 percent bloom period showed its effects the following year by increasing the number of blossoms initiated and also induced a significant increase in yield. He found that NAA, 2,4,5-TP and NOA alone and in various combinations produced initial increase in fruit set but only the combination NAA-NOA gave a slight increase in yield and seed count.

McGlasson and Pratt (31) studied the fruit set patterns, growth and development of cantaloupe (Cucumis melo L.) cultivar Powdery Mildew Resistant No. 45. They found that the pattern of fruit development of individual fruits within a given population was very uniform. Chronological age recorded as days after anthesis provided a good basis for sampling fruits of different stages of development. The sigmoid curve of cantaloupe fruit growth resembled those described for other cucurbits. Regardless of fruit size, full volume was reached throughout the population after essentially the same growth period and half the final volume was achieved when 40 percent of the time had elapsed.

Crane (11) investigated fruit growth of four fig varieties: Mission, Adriatic, Kadota and Calimyrna. He recorded fruit diameter weekly and found the four varieties, though morphologically different from drupaceous fruits to exhibit a periodicity in growth similar to those reported for peaches, apricot and other stone fruits. On the basis of his studies he divided the growth period into three phases. For the first period of 36-53 days the average rate of growth was 0.48-0.62 mm per day.

For the second period of 35-43 days, growth was practically static, having an average increase of only 0.04-0.14 mm per day. The rate of growth for Adriatic was greater than for the other three varieties during this stage. In the final phase, lasting 13-17 days, the rate of growth was 0.22-0.74 mm per day.

Crane and Blondeau (14) studied the effects of synthetic hormone application on the growth of fig fruits. They found that 2,4,5-T or its isopropyl ester at 10, 25, 50, 75 and 100 ppm induced parthenocarpic development in unpollinated syconia of the Calimyrna fig. The fruit growth period was shortened 60 days from the normal 120 days. The fruits formed were comparable in size and color to the mature, pollinated fruits and though devoid of seeds, contained normal amount of sugar and were well filled with pulp. Chlorosis of the leaf was observed at concentrations greater than 10 ppm and increased in severity with increase in concentration. Death resulted in those branches sprayed with concentrations of 75 and 100 ppm one month after treatment.

Crane (13) studied preharvest fruit drop, size and maturity of apricots as affected by 2,4,5-T. He applied two concentrations of the chemical (25 and 50 ppm) on two dates and found that all concentrations and times of application were effective over the check in controlling drop. Spraying also increased fruit size and growth rate with fruits maturing over a period of one to two weeks. When he applied 2,4,5-T on Stewart apricot at concentrations of 25, 50 and 100 ppm at the initiation of pit hardening, fruit drop was reduced to 1.2, 0.8 and 0.6 percent, respectively as compared to 9 percent for the check. At harvest there was an increase in average fruit diameter and fresh weight by

as much as 9.3 and 33.8 percent respectively, at 100 ppm. Fruits matured over a period of 3.6 days.

Clore (9) investigated the responses of Delaware grapes to gibberellin. Using uniform clusters he found that dipping Delaware branches in 100 ppm GA before bloom and again after bloom resulted in an average of 88-96 percent seedless berries in 1963 and 1964 and advanced maturity by more than 28 days. The seedless grapes were almost of normal size. Those sprayed before and after bloom in 1964 produced 94.7 percent seedlessness. Dipping before bloom only induced seedlessness and advanced maturity but produced smaller berries. Dipping after bloom only produced 10 and 46 percent seedless berries in 1963 and 1964 respectively. The GA tended to lower sugar/acid ratio in seedless berries.

Yamane and Nakasone (58, 59) studied the effects of growth regulators on fruit set and growth in five clones of Acerola. The applied the compounds NAA, its sodium salt, NOA and its sodium salt, IAA, IBA and CIPA at 0, 10, 50, 100, 500, 1,000 and 5,000 ppm. Among the compounds applied, CIPA and IBA were effective in fruit setting with CIPA being effective over a wider range than IBA but exhibiting some phytotoxic affects. IBA at 100 ppm produced 60 percent fruit set with no apparent phytotoxic effects. CIPA produced 88 percent fruit set at 50 ppm. They also tried 100 and 500 ppm CIPA in another experiment at five stages of floral development: one and two days before anthesis, at anthesis and one and two days after anthesis. Flowers at anthesis were found to be significantly more receptive than at any other stage. Five hundred ppm CIPA was generally more effective than 100 ppm but was not recommended because of its detrimental effects.

Gardner, Hart and Batjer (18) inspired by the unusual persistence of petiole stubs on cuttings of apples treated with growth substances, attempted to control preharvest drop with chemicals. They sprayed the following chemicals on 20 varieties of apple: IAA, IPA, IBA, alpha-naphthalene acetamide (NAAd), NAA and its methyl, ethyl, sodium, potassium and calcium salts. They added supplementary materials such as citric acid (190 g/100 gals), bentomite (454 g/100 gals) and summer oil (0.125-0.2%). Their results showed that NAA and NAAd were particularly effective in controlling preharvest drop at concentrations of 250 and 500 ppm, respectively, with or without 0.125-0.2% summer oil.

Edgerton and Hoffmann (16) applied 2 chloro-4-fluorophenoxyacetic acid (2,4-F), 2,4,5-TP, NAA and 2,4,5-T to McIntosh apples in 1959 and they recorded a marked reduction in fruit set the following year with 2,4-F; a slight reduction with 2,4,5-TP and a slight increase with 2,4,5-T harvest spray. At low concentrations applied in the spring before bloom, 2,4,5-T increased fruit set under certain conditions. At high concentration, spring application of 2,4,5-T reduced fruit set similar to the thinning effect of NAA when applied before bloom. Adding Tween-20 as a wetting agent increased the effect of both 2,4,5-TP and 2,4,5-T in controlling harvest drop and generally accentuated the effect of auxin the following year.

Southwick, Weeks and Olamyk (47) in 1964 used a 50 percent wettable powder of 1-naphthyl-n-methyl carbamate (Sevin) and naphthalene acetic acid-type materials on apples. Treatments were applied at bloom as dilute sprays and data on return bloom were taken on the same limbs used for fruit set studies. They found that 50 percent wettable Sevin and

NAAd applied 12-24 days after petal fall on heavy flowering McIntosh trees had similar effects on fruit size and yield. Sevin did not thin McIntosh when applied 31 days after petal fall. Neither Sevin nor NAAd significantly affected the preharvest drop. Egerton, Hoffman and Forshey (16) tried eight benzoic acid derivatives on apple. None of the compounds was consistent in promoting flower formation on mature apple trees. Of the anti-auxins tried, maleic hydrazide (MH) increased flower buds in McIntosh and Delicious apples.

Chadha and Kirpal (6) investigated fruit drop of mango. They studied the intensity, periodicity and nature of shedding of immature fruits in three varieties: Lagra, Dueshri and Fajri. They found that unpollinated flowers dropped off after anthesis, and in some pollinated flowers the ovary swelled a little but disintegrated quickly. Percentage fruit set of 63.81, 57.25 and 54.62 were recorded for Dueshri, Larga and Fajri, respectively in 1957. High initial fruit set was recorded in the three varieties and a rapid rate of fruit drop followed due to competition between fruits. They also found that the size of fruit dropping varied from 4 to 35 mm in diameter in the three varieties. Finally, they classified the fruit drop into two phases: the pinhead drop, occurring when fruits are less than 4 mm; the post-setting drop when fruits are more than 4 mm in diameter.

In other studies on mango, Spencer and Kennard (48) enumerated the various factors affecting mango yield: high ratio of staminate to perfect flowers, diseases, insect pests, biennial bearing relationships and cultural practices, among others. They emasculated and bagged 674 flowers without pollination and excised the stigma of another 1,998

flowers. None of them matured. Eighteen of 460 hand-pollinated flowers produced fruits. They therefore concluded that pollination was necessary for carpel development.

Alvin (1) in 1961 investigated the effect of spraying GA on coffee (Coffea arabica L.). He found that with adequate water in the soil 60-70 percent of the flowers opened 10-90 days after spraying with 10-20 ppm GA and fruit set was increased 400-700 percent. When soil moisture was limiting and the flower buds were small, 50-100 ppm GA was necessary to produce the same results. GA (100 ppm) was more effective than immersion of the branches in water with the temperature ranging from 15-35°C. Double spraying with GA was generally more effective than a single application. On the other hand, no flowering occurred in defoliated branches.

Literature concerning fruit set of guavas is very scanty as compared to other crops such as apples, mangoes, citrus and tomatoes. However, Balasubramanyam and Rangaswami (5) succeeded in inducing seedlessness in Allahabad variety of guava by self-pollination and by applying aqueous extract of crushed pollen to the stigma of emasculated flowers.

In the following year, Rangaswami and Kaliaperumal (36) also produced parthenocarpic fruits in the same variety by treating the emasculated flowers with water and ether extracts of pollen, NAA, NOA and 2,4-D. They also found indole-like compounds in the pollen collected immediately after the opening of the flowers and in ovaries collected five days after selfing.

Aravindakshan (2) found that tipping of leaders of guava branches 4-5 inches hastened the production and increased the number of lateral

shoots, increased and advanced flowering and improved fruit set and size of fruit in various guava varieties. The variety Smooth Green reacted best to pruning. Sundarajan and Muthuswamy (53) conducted similar studies. Their studies revealed that pruning of the previous season leaders caused a general increase in number of laterals, flowers and fruits, compared with untipped shoots. The initiation of laterals was advanced 8-10 days and flowering also was advanced 3-28 days.

Tapota, Pandey and Mathur (54) applied GA in lanolin paste to emasculated guava flower buds at concentrations of 100, 500, 1,000 and 10,000 ppm. Buds treated with 100 and 500 ppm all dropped at the onset of the study while those treated with 1,000 ppm fell off after small fruitlets were formed. Of those treated with 10,000 ppm, 66.7 percent developed to full maturity and ripened earlier than normal fruits. They were parthenocarpic, oblong and ridged and the pulp was richer in ascorbic acid. Shammagarelu (43) also studied the induction of parthenocarpy in guava with GA. Applying the potassium salt of GA (8,000 ppm) mixed with lanolin paste to cut surface of the pistil, he produced seedless fruits in all varieties used. In the Allahabad variety there was 90 percent set with an increase in fruit size; in the Red Flower variety, the size of fruit was small with 80 percent set; Lucknow produced small fruits with 70 percent set, while in the seedless variety the fruits were normal with 80 percent set. The percentage seedless fruits therefore, varied from 70-90 percent and all such fruits had 6-8 prominent ridges on the surface and a swelling at the calyx end. On the other hand, Rao et al. (37) were unable to record any seedlessness when they applied the potassium salt of GA on some guava varieties, using

unemasculated flowers. However, the total number of seeds in some of the guava varieties was less than in the check.

MATERIALS AND METHODS

PLANT MATERIALS USED

Beaumont

This is a sour variety of Psidium guajava L. Four trees over 15 years old located in the Department of Horticulture Experimental plot were used. They are protected on one side by an over-grown hedge of mock-orange and on the winward side by garden hibiscus. The trees were given a 14-14-14 fertiliser mixture at the rate of 6 lb. per tree in April and May 1967. To accelerate flowering, the branches were all tipped. A different tree of Beaumont guava planted in the Mid-Pacific Farm in March 1965 was also used.

Clone 67-D

This is a sweet clone of P. guajava. This clone was established in March 1965 from cuttings and it is located in the Mid-Pacific Experimental Farm of the University of Hawaii. One tree from the clone was selected and given about 6 lb. of fertilizer in April and May 1967. The branches were also tipped as in the Beaumont variety to accelerate flowering.

P. cattleianum (Strawberry Guava)

The two trees of P. cattleianum used in this study was located in the same farm as Clone 67-D. This is a very hardy species and it is smaller and bushier than P. guajava L. The fruits are small, about the size of a plum and are known as the strawberry guava. The trees were also fertilized as for the other types.

Clone 14-9 and Elaine (P. guajava L.)

These are two sour clones of P. guajava L. which were planted in March 1965 in the Mid-Pacific Farm. One tree of each clone was fertilized in the same manner and time as in the other clones.

CHEMICALS USED

Four different growth regulators were used in the study: gibberellic acid (75% potassium salt), indolebutyric acid (IBA), para-chlorophenoxyacetic acid (CIPA) and sodium dichloroisobutyrate (DCIB).

METHOD

In a randomized block experiment of twelve treatments and four blocks the following treatments were applied to the Beaumont variety of guava:

1.	Gibberellic Acid (GA)	25 ppm
2.	" "	50 ppm
3.	" "	75 ppm
4.	Indolebutyric Acid (IBA)	25 ppm
5.	" "	50 ppm
6.	" "	75 ppm
7.	Para-chlorophenoxyacetic Acid (CIPA)	25 ppm
8.	" "	50 ppm
9.	" "	75 ppm
10.	Cross-pollination	
11.	Self-pollination	
12.	Check (open-pollination)	

Each block was made up of twelve branches from one tree.

Ten flowers were allocated for each replicate. All the flowers to be treated were tagged, emasculated and bagged one day before anthesis, except for the check. Emasculation was done by removing the stamens with a sharp scalpel. This was executed with care to minimize any mutilation of the flowers. For bagging the flowers, 3-3/4 x 5 in. 2-oz. Pak-Well glassine bags were used.

To reduce variability between the four trees, all the 12 treatments were replicated on each tree. The treatments were applied at around anthesis and each flower was sprayed to dripping with the growth regulator. Pollination of the flowers for treatment nos. 10 and 11 was done around 8:00 A.M. of the same day the growth regulators were applied. A mixture of pollen from different guava clones was used for cross-pollination while pollen from the same tree was used for self-pollination. Pollen was transferred to the stigma of each emasculated flower in treatment nos. 10 and 11 by shaking a vial full of pollen over the stigma. Four hundred and eighty flowers were used in all on the four trees of Beaumont variety guava.

The following treatments were applied to Clone 67-D in another part of the study:

1.	GA	50 ppm
2.	IBA	50 ppm
3.	CIPA	50 ppm
4.	Sodium Dichloroisobutyrate (DCIB)	1000 ppm
5.	Check	

The treatments were replicated twice and completely randomized on one tree of Clone 67-D. Ten flowers were allocated per treatment but

they were not emasculated before growth regulators were applied as was done in case of Beaumont.

The same five treatments with two replications were applied to two trees of Psidium cattleianum. This was a randomised block experiment and 20 flowers were allocated per treatment. As in Clone 67-D, the flowers were not emasculated. The growth regulators were sprayed on the flowers to the point of dripping in all cases. The treatments were applied to Beaumont guava, Clone 67-D and P. cattleianum in June 1967.

In December 1967, GA was applied at four concentrations to three sour clones of guava, Clone 14-9, Beaumont and Elaine to determine its effects upon fruit set. One tree from each type or variety was used as a block with all the treatments randomised on it. There were five treatments and three blocks in all.

1.	GA	100 ppm
2.	GA	500 ppm
3.	GA	1,000 ppm
4.	GA	2,000 ppm
5.	Check	

The same five treatments were also applied to non-flowering branches of the three sour clones for phytotoxicity tests.

Preparation of Solutions

All growth regulators were dissolved in a minimum amount of alcohol except GA (75% potassium salt) and DCIB (sodium salt) which were dissolved in distilled water. They were then made up to the required concentration. Twelve to 24 drops of Triton-B (1956) were added to a liter of each solution to act as a wetting agent. Application

of the growth regulators in the field was done by means of a small hand sprayer with a 50 ml capacity.

Collection of Data

Fruit set, drop, fruit diameter and phytotoxic effects were recorded on all guavas treated in June 1967. Only fruit set was recorded in Clone 14-9, Beaumont and Elaine which were treated in December 1967. Fruit length was measured but only on fruits of Clone 67-D and P. cattleianum while soluble solids, seed content and titratable acidity were recorded for Clone 67-D. Fruit length and diameter were measured in two week intervals. To find out how long any flower would remain on the tree without dropping in the absence of fruit set, ten flowers were emasculated and bagged without pollination on each of the guava trees used in the study. Since unpollinated and emasculated flowers dropped within 6-14 days after anthesis, initial fruit set was recorded in the treated flowers two weeks from anthesis. Final fruit set was recorded at maturity, fourteen weeks after anthesis. Fruit drop was recorded at weekly intervals up to the eighth week after anthesis and at two week intervals after that. Fruit drop was classified into three phases for the purposes of comparison among the various treatments:

Phase 1 - the floral drop, occurring within the first two weeks after anthesis;

Phase 2 - the post-set drop, occurring between the second and tenth weeks after anthesis; and

Phase 3 - pre-harvest drop, occurring between the end of the tenth week after anthesis and time of maturity.

Soluble solids, titratable acidity and seed content were recorded after the ripe fruits were harvested. Soluble solids were determined with a hand refractometer while titratable acidity was determined by AOAC's Method of Titratable Acidity using 0.1N NaOH and 0.1N HCl. Length and diameter were measured in centimeter with calipers. On the graphs, size of fruit (cm) is represented by a point above the age of fruit in weeks after anthesis, while the fruit growth between a certain period, 2-4 weeks from anthesis for example, is shown above 4 weeks from anthesis.

Statistics

Comparison among treatments was based on chronological age recorded as weeks after anthesis. Appropriate statistical analyses were carried out in each case. To determine any significant differences among the treatments, tables from Snedecor (45) were consulted.

RESULTS

EFFECTS OF LOW CONCENTRATION OF GROWTH REGULATORS ON FRUIT SET

In June 1967, parthenocarpic fruits were set by applying GA at 25, 50 and 75 ppm; IBA at 25 and 75 ppm; and CIPA at 25 and 50 ppm, to emasculated flowers of Beaumont guava (Psidium guajava L.). The results of these treatments are shown in Table I. Some of the fruits dropped in 14-21 days after anthesis and the rest in 28-35 days. All the fruits were seedless and deeply furrowed as compared to the untreated fruits.

The last parthenocarpic fruit to drop was set by CIPA at 50 ppm. It had six prominent furrows and was elongated in shape. IBA at 50 ppm and CIPA at 75 ppm failed to set any fruits at all. Percentage initial fruit set by GA at 25 ppm was significantly better than that set by IBA at 50 ppm or CIPA at 75 ppm ($P = 0.05$).

The difference between the percentage initial set by open-pollination (check) and cross-pollination was significant at $P = 0.05$, the former being more effective. The difference between the percentage initial fruit set by the check and self-pollination fell short of significance at the five percent level of probability. Difference between the percent initial fruit set by each of the three pollination regimes separately and the different concentrations of IBA and CIPA were also significantly different, with the pollination regimes being more effective in promoting initial set as shown in Table I.

Of the 12 treatments applied to the four trees of Beaumont, only fruits set by the three pollination regimes reached maturity. Fruits set by GA, IBA and CIPA dropped during advanced stages of development.

TABLE I. INITIAL AND FINAL FRUIT SET PERCENTAGES UNDER DIFFERENT TREATMENTS IN THE BEAUMONT VARIETY

Treatments	No. Flowers Treated[a]	Initial Fruit Set[b] %	Initial Fruit Set[b] 95 Percent Confidence Interval	Final Fruit Set[b] %	Final Fruit Set[b] 95 Percent Confidence Interval
GA 25 ppm	40	22.5	12 - 40.5	0	0 - 9.5
GA 50 ppm	40	12.5	4.5 - 28.5	0	0 - 9.5
GA 75 ppm	40	18	8.0 - 35.0	0	0 - 9.5
IBA 25 ppm	40	5	0.5 - 18.0	0	0 - 9.5
IBA 50 ppm	40	0	0 - 9.5	0	0 - 9.5
IBA 75 ppm	40	5	0.5 - 18.5	0	0 - 9.5
CIPA 25 ppm	40	2.5	0.0 - 14.0	0	0 - 9.5
CIPA 50 ppm	40	5	0.5 - 18.5	0	0 - 9.5
CIPA 75 ppm	40	0	0 - 9.5	0	0 - 9.5
Cross-pollination	40	40	27 - 59	25	13.5 - 43.5
Self-pollination	40	58	47.5 - 77.5	45	31.5 - 63.5
Check (open-pollination	40	87.5	71.5 - 95.5	40	27.0 - 59.0

[a] All the flowers treated with growth regulators were emasculated.

[b] Initial fruit set was recorded two weeks after anthesis. Final fruit set was recorded fourteen weeks after anthesis.

TABLE II. INITIAL AND FINAL FRUIT SET PERCENTAGES IMPOSED BY FOUR GROWTH REGULATORS ON CLONE 67-D

Treatments	No. Flowers Treated	Initial Fruit Set[a] %	Initial Fruit Set[a] 95 Percent Confidence Interval	Final Fruit Set[a] %	Final Fruit Set[a] 95 Percent Confidence Interval
GA 50 ppm	20	85	62 - 97	35	15 - 59
IBA 50 ppm	20	65	41 - 85	35	15 - 59
CIPA 50 ppm	20	75	51 - 91	15	3 - 38
DCIB 1,000 ppm	20	85	62 - 97	55	32 - 77
Check (open-pollination)	20	100	83 - 100	65	41 - 85

[a]Initial fruit set was recorded two weeks after anthesis and final fruit set at fourteen weeks after anthesis. Flowers were not emasculated.

TABLE III. INITIAL AND FINAL FRUIT SET PERCENTAGES IMPOSED BY FOUR GROWTH REGULATORS ON EMASCULATED FLOWERS OF PSIDIUM CATTLEIANUM

Treatments	No. Flowers Treated	Initial Fruit Set[a] %	Initial Fruit Set[a] 95 Percent Confidence Interval	Final Fruit Set[a] %	Final Fruit Set[a] 95 Percent Confidence Interval
GA 50 ppm	40	97.5	86 - 100	5.0	0.5 - 18.0
IBA 50 ppm	40	72.5	63 - 86	12.5	4.5 - 28.5
CIPA 50 ppm	40	90.0	75 - 97	7.5	1.5 - 22.0
DCIB 1,000 ppm	40	75.0	66.5 - 86.5	5.0	0.5 - 18.0
Check (open-pollination)	40	85.0	18.5 - 93.5	7.5	1.5 - 22.0

[a]Initial fruit set was recorded two weeks after anthesis and final fruit set at fourteen weeks after anthesis. Flowers were not emasculated before the application of growth regulators.

The differences between final percent fruit set by the three pollination regimes were not significant at the five percent level of probability, although the percentages of final fruit set by open-pollination and self-pollination were almost twice that of cross-pollination as shown in Table I.

Actual initial fruit set with four growth regulators applied to unemasculated flowers of Clone 67-D were lower than that of the check as shown in Table II. Although the differences in percent initial fruit set between the check and the growth regulators, GA, IBA, CIPA and DCIB were 15, 25 and 15 percent respectively, none of them was found to be significantly different.

As shown in Table II, the final percent fruit set of the check was significantly higher than that of CIPA. The other differences were not statistically significant although the differences between the final percent fruit set by DCIB and CIPA was as high as 40 percent.

Initial fruit set with four growth regulators applied to unemasculated flowers in Psidium cattleianum Sabine, were found to be high although the differences between the treatments as shown in Table III were not significant at the five percent level of probability.

In the final fruit set in P. cattleianum, however, IBA which was the least effective in initial fruit set, gave the highest final fruit set as shown in Table III. The final percent fruit set was generally low for all the treatments. There were no significant differences in final percent fruit set among the treatments although the set by IBA was more than twice that of GA or DCIB and a little less than twice that of the check (open-pollination) and CIPA.

TABLE IV. ACTUAL INITIAL AND FINAL FRUIT SET WITH HIGHER CONCENTRATIONS OF GIBBERELLIC ACID APPLIED TO EMASCULATED FLOWERS[a] OF GUAVA

Treatments	Initial Fruit Set			Final Fruit Set			Comments
	Clone 14-9	Elaine	Beaumont	Clone 14-9	Elaine	Beaumont	
GA 100 ppm	2	0	3	0	0	0	The fruits were seedless but dropped off 14-28 days after anthesis.
GA 500 ppm	6	6	0	0	0	0	The fruits were parthenocarpic but dropped off before maturity.
GA 1,000 ppm	0	4	5	0	1	0	Eight of the fruits dropped before maturity and one fruit matured. It was seedless and irregular in shape with a conspicuously enlarged calyx end.
GA 2,000 ppm	7	1	0	0	0	0	All the fruits dropped off within 28-42 days after anthesis.
Check (open-pollination)	9	6	9	7	5	0	The check fruits in Beaumont all dropped off before maturity. Some matured on Elaine and Clone 14-9.

[a]Although ten emasculated flowers were allocated per replicate, many of them were destroyed by unknown agents before they had the chance to set fruits.

TABLE V. FRUIT DIAMETER (cm) FOR DIFFERENT TREATMENTS AT VARIOUS STAGES OF DEVELOPMENT IN BEAUMONT GUAVA

Treatments[a]	WEEKS AFTER ANTHESIS						
	2	4	6	8	10	12	14
GA 25 ppm	0.722(9)[b]	1.750	---	---	---	---	---
50 ppm	0.710(5)	---	---	---	---	---	---
75 ppm	0.729(7)	1.700	---	---	---	---	---
IBA 25 ppm	0.925(2)	1.750	---	---	---	---	---
50 ppm	---	---	---	---	---	---	---
75 ppm	1.125(2)	1.825	---	---	---	---	---
CIPA 25 ppm	0.93 (1)	1.650	---	---	---	---	---
50 ppm	0.625(2)	0.900	---	---	---	---	---
75 ppm	---	---	---	---	---	---	---
Cross-pollination	1.069(16)	1.625	2.535	2.720	2.935	2.985	3.770(10)
Self-pollination	1.068(24)	1.622	2.318	2.632	2.753	2.882	3.808(18)
Check (open-pollination	1.326(35)	1.729	2.473	2.853	2.990	3.067	3.803(16)
Mean	0.978	1.652	2.378	2.727	2.882	2.979	3.821

[a]All the fruits produced from flowers treated with GA, IBA and CIPA dropped after the fourth week.

[b]Number of fruits measured per treatment is shown in parentheses.

EFFECTS OF HIGHER CONCENTRATIONS OF GIBBERELLIC ACID ON FRUIT SET IN BEAUMONT, ELAINE AND CLONE 14-9

In December 1967, concentrations of GA higher than those used earlier were applied to emasculated flowers of Beaumont, Elaine and Clone 14-9 (Psidium guajava L.). In this study GA at 100 ppm set fruits only on Clone 14-9 while at 500 ppm fruits were set on both Clone 14-9 and Elaine as shown in Table IV. GA at 1,000 ppm set fruits on Elaine and Beaumont variety while 2,000 ppm set fruits on Clone 14-9 and Elaine. Of all the fruits set, only one fruit which was set with 1,000 ppm GA reached maturity. All the set fruits were parthenocarpic. Of the ten flowers per replicate that were emasculated, some were damaged before they had a chance to set; consequently, no valid comparison among the treatments could be made.

EFFECTS OF GROWTH REGULATORS ON FRUIT SIZE

As shown in Table V measurements of fruit diameter were taken of fruits set by GA, IBA and CIPA on the Beaumont variety. By the end of four weeks after anthesis all the fruits set by the three growth regulators had dropped. Measurements of fruits set by the pollination regimes were continued to maturity.

Two weeks after anthesis, there were little differences in fruit size between the treatments, although the fruits in the check were the largest followed by IBA at 75 ppm. These differences could not be analysed statistically because some of the treatments did not set any fruit. Four weeks after anthesis, fruits set by GA at 25 ppm, and IBA at 25 and 75 ppm were slightly larger than the check fruits. The fruits in the check group were, however, slightly larger than those set by

FIG.1 THE EFFECTS OF 3 TYPES OF POLLINATION ON THE FRUIT DIAMETER IN BEAUMONT VARIETY

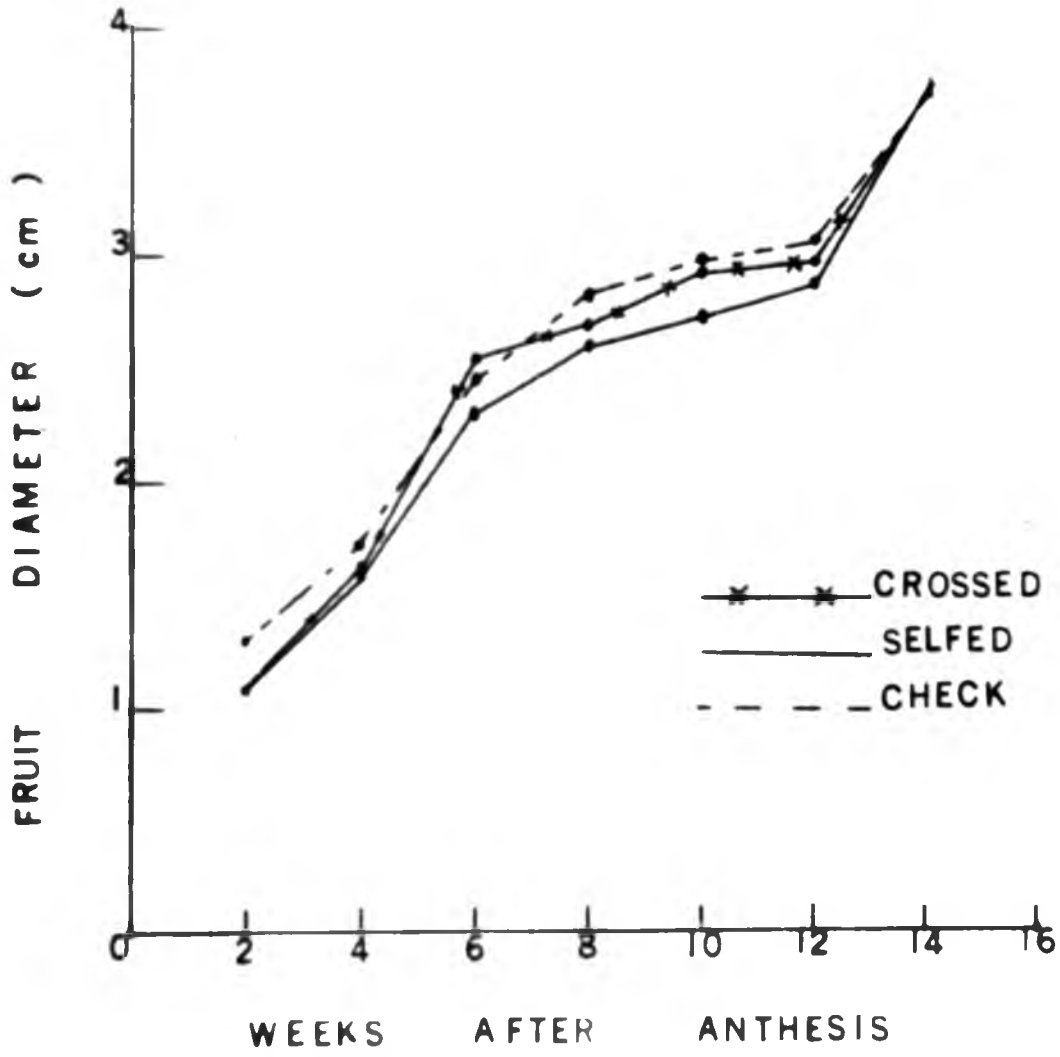


TABLE VI. RATE OF INCREASE IN FRUIT DIAMETER (cm per week) IN BEAUMONT VARIETY

Treatments	WEEKS AFTER ANTHESIS 2-4	4-6	6-8	8-10	10-12	12-14	Mean
GA 25 ppm	0.514(9)[a]	---	---	---	---	----	0.514
50 ppm	---	---	---	---	---	----	---
75 ppm	0.486(7)	---	---	---	---	----	0.486
IBA 25 ppm	0.413(2)	---	---	---	---	----	0.413
50 ppm	---	---	---	---	---	----	---
75 ppm	0.350(2)	---	---	---	---	----	0.350
CIPA 25 ppm	0.360(1)	---	---	---	---	----	0.360
50 ppm	0.138(2)	---	---	---	---	----	0.138
75 ppm	---	---	---	---	---	----	---
Cross-pollination	0.278(16)	0.455	0.093	0.108	0.020	0.393(10)	0.225
Self-pollination	0.277(24)	0.348	0.157	0.061	0.065	0.463(18)	0.229
Check (open-pollination)	0.202(35)	0.372	0.190	0.069	0.039	0.368(16)	0.207

[a]Number of fruits measured per treatment is shown in parentheses.

FIG.2 THE EFFECTS OF 3 TYPES OF POLLINATION ON THE RATE OF INCREASE IN FRUIT DIAMETER IN BEAUMONT VARIETY

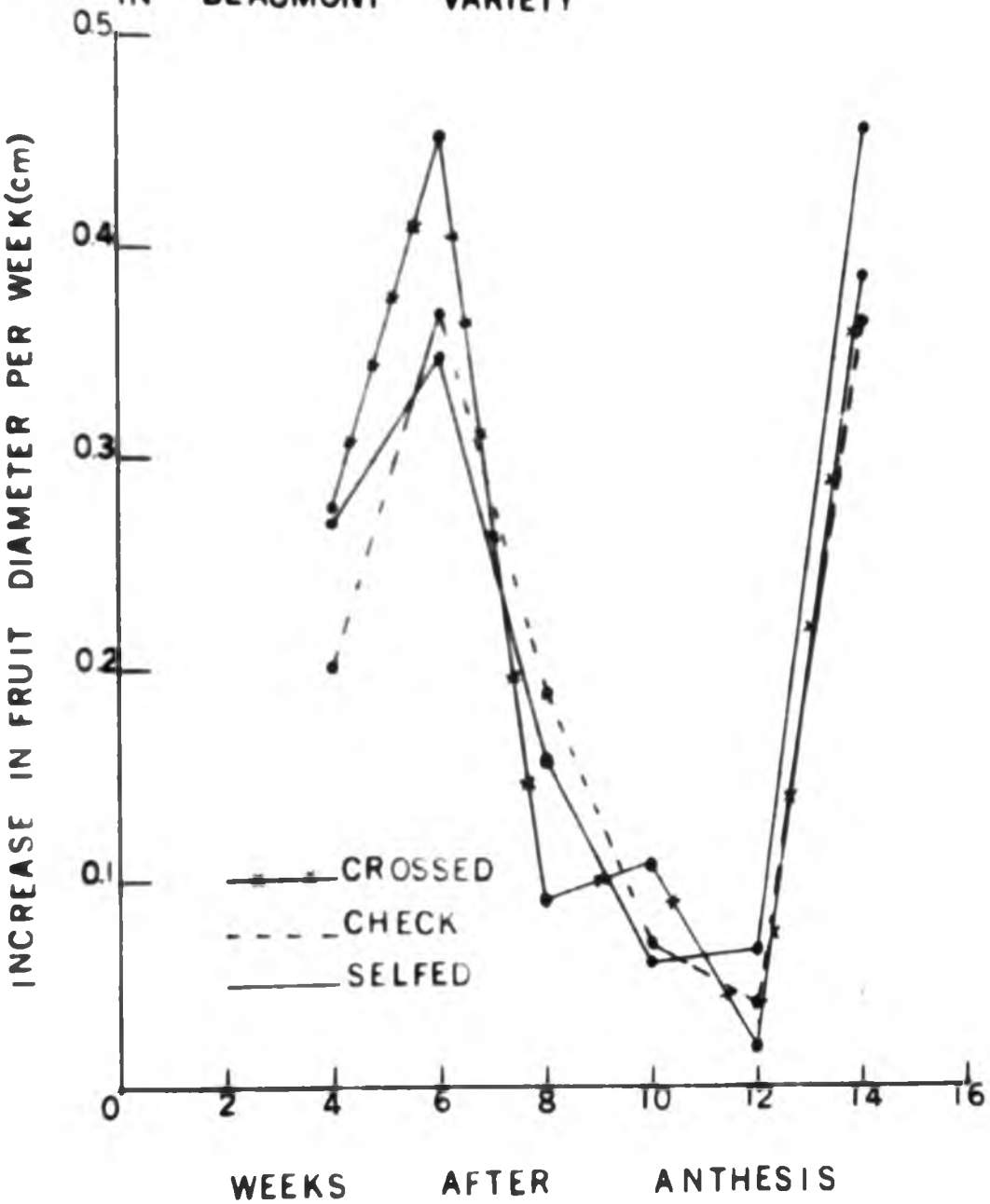


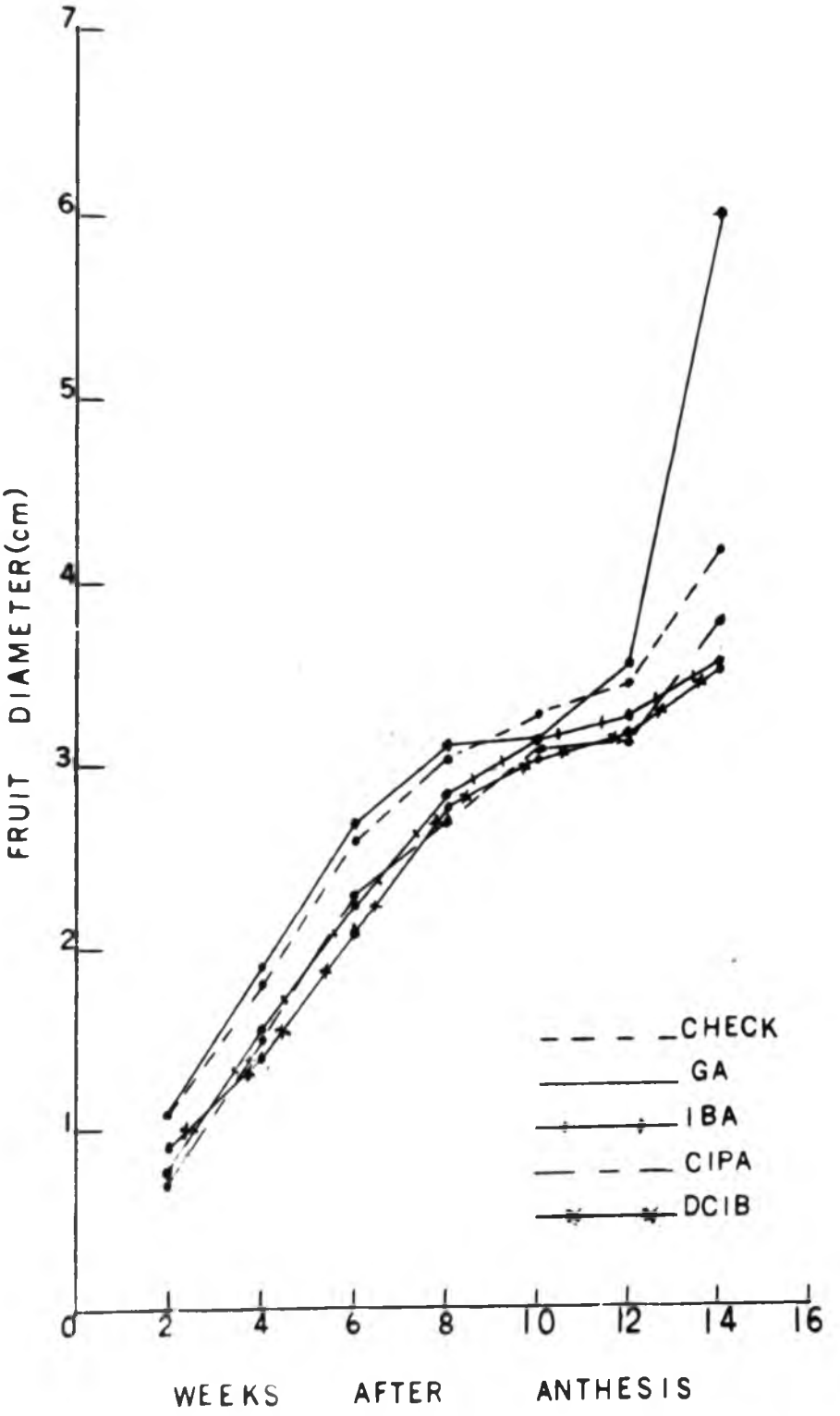
TABLE VII. MEAN FRUIT DIAMETER (cm per week) FOR DIFFERENT TREATMENTS AT STAGES OF DEVELOPMENT IN CLONE 67-D

Treatments	WEEKS AFTER ANTHESIS						
	2	4	6	8	10	12	14
GA 50 ppm	1.112(17)[a*]	1.910	2.700	3.107	3.157	3.587	6.064(7)*
IBA 50 ppm	0.892(13)	1.550	2.074	2.786	3.050	3.214	3.557(7)
CIPA 50 ppm	0.736(15)	1.400	2.300	2.717	3.100	3.167	3.767(3)
DCIB 1,000 ppm	0.774(17)	1.536	2.259	2.835	3.141	3.303	3.568(11)
Check (open-pollination)	1.068(20)	1.809	2.561	3.054	3.295	3.469	4.223(13)

[a]The number of fruits measured per treatment at any stage is shown in parentheses.

*Indicates significance at the 5 percent level.

FIG. 3 THE EFFECTS OF 4 GROWTH REGULATORS ON FRUIT DIAMETER IN CLONE 67—D



self- and cross-pollination as shown in Table V. These measurements are also shown graphically in Figure 1 for clarity.

At the end of six weeks after anthesis, only fruits set by the pollination regimes were left on the trees. At that stage, fruits set by cross-pollination were slightly larger than those set by the open-pollination (check) or self-pollination as shown in Table V and in Figure 1. At the end of eight weeks after anthesis, the trend changed and fruits in the check group were larger than those set by self- or cross-pollination. This trend continued until the time of maturity at fourteen weeks after anthesis as more clearly shown in Figure 1.

The rate of increase in diameter of the fruits of Beaumont guava is shown in Table VI and illustrated graphically in Figure 2. Two peaks of rapid growth can been seen for each of the treatments. Fruits set by the three pollination regimes showed relatively fast growth rates between 4-6 weeks after anthesis, followed by a decline in growth rate. Fruits of each pollination regime again showed rapid growth at the time of maturity, 12-14 weeks after anthesis as shown in Figure 2.

Fruits set by unemasculated flowers of Clone 67-D sprayed with 50 ppm GA were significantly larger ($P \leq 0.05$) in diameter than fruits in the check or of those set by other growth regulators, IBA, CIPA and DCIB as shown in Table VII. These same measurements are also shown in Figure 3. At the end of four weeks after anthesis, fruits set from flowers sprayed with GA at 50 ppm were still the largest in diameter. The same trend continued during the next four weeks of growth. However, at the end of ten weeks the check fruits were slightly larger than the fruits set with the aid of GA as shown clearly in Figure 3. At twelve weeks

TABLE VIII. RATE OF INCREASE IN FRUIT DIAMETER (cm per week) FOR DIFFERENT TREATMENTS IN CLONE 67-D

Treatments	WEEKS AFTER ANTHESIS						
	2-4	4-6	6-8	8-10	10-12	12-14	Mean
GA 50 ppm	0.399(17)[a]	0.395	0.204	0.025	0.215	1.237(7)	0.413
IBA 50 ppm	0.329(13)	0.262	0.354	0.132	0.082	0.172(7)	0.222
CIPA 50 ppm	0.332(15)	0.450	0.209	0.192	0.034	0.300(3)	0.233
DCIB 50 ppm	0.381(17)	0.362	0.288	0.153	0.081	0.133(11)	0.233
Check (open-pollination)	0.371(20)	0.376	0.247	0.121	0.087	0.377(13)	0.263

[a]The number of fruits measured per treatment is shown in parentheses. Flowers were not emasculated.

FIG.4 THE EFFECTS OF FOUR GROWTH REGULATORS ON THE RATE OF INCREASE IN FRUIT DIAMETER IN CLONE 67—D

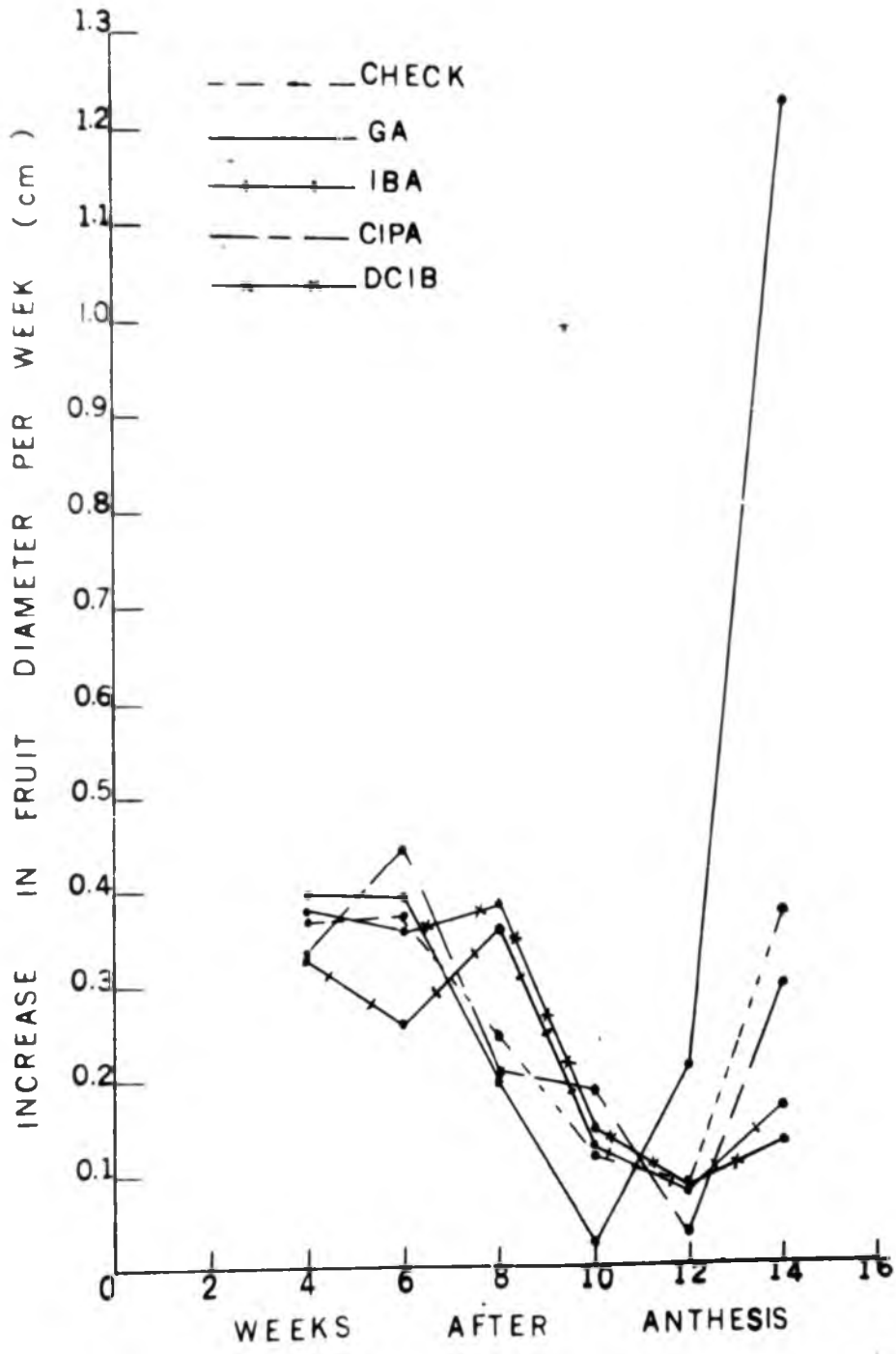


TABLE IX. MEAN FRUIT LENGTH (cm) FOR DIFFERENT TREATMENTS AT VARIOUS STAGES OF FRUIT DEVELOPMENT IN CLONE 67-D

Treatments	WEEKS AFTER ANTHESIS						
	2	4	6	8	10	12	14
GA 50 ppm	1.670(17)[a*]	3.275	3.936	4.050	4.586	5.253	6.929(7)*
IBA 50 ppm	1.246(13)	2.130	2.986	3.293	3.800	3.843	4.286(7)
CIPA 50 ppm	1,057(15)	2.000	3.067	3.533	3.850	3.967	4.617(11)
DCIB 1,000 ppm	1.126(17)	2.023	2.909	3.469	3.827	4.000	4.386(11)
Check (open-pollination)	1.443(20)	2.491	3.371	3.762	4.045	4.304	5.115(13)

[a]The number of fruits measured per treatment is shown in parentheses. Flowers were not emasculated before spraying.

*Indicates statistical significance at 5 percent level of probability.

after anthesis, fruits set with the aid of GA were again larger in diameter than the check or the other growth regulators, IBA, CIPA and DCIB. The same trend continued up to the time of maturity, fourteen weeks after anthesis, when fruits set with the aid of GA were significantly larger in diameter than the check or any of the other treatments ($P = 0.05$). Figure 3 clearly shows the differences between the fruits set with the aid of GA and those set with IBA, CIPA, DCIB and the check at that stage.

The growth rates of the fruits in terms of diameter increase per week is plotted in Table VIII and shown in Figure 4 for clarity. Figure 4 shows that there are two distinct peaks of rapid growth regardless of the treatment applied at floral anthesis. The check fruits and fruits set with the aid of CIPA and GA showed a high peak of growth between 4-6 weeks after anthesis while those set with the aid of IBA and DCIB showed the first peak between 6-8 weeks after anthesis. This was followed by a period of slow growth. Another rapid growth rate period occurred at the time of maturity in all treatments. For fruits set with the aid of GA this second peak of rapid growth far surpassed those of the other treatments.

Measurements of fruit length were taken simultaneously with the diameter and are shown in Table IX for Clone 67-D. Two weeks after anthesis, when the first measurements were taken, fruits set with the aid of GA showed the greatest mean length. This was significantly longer than the check fruits as well as those set with the aid of the other growth regulators, IBA, CIPA and DCIB. Differences among the other treatments other than GA were not significant.

FIG.5 THE EFFECTS OF FOUR GROWTH REGULATORS ON FRUIT LENGTH IN CLONE 67-D

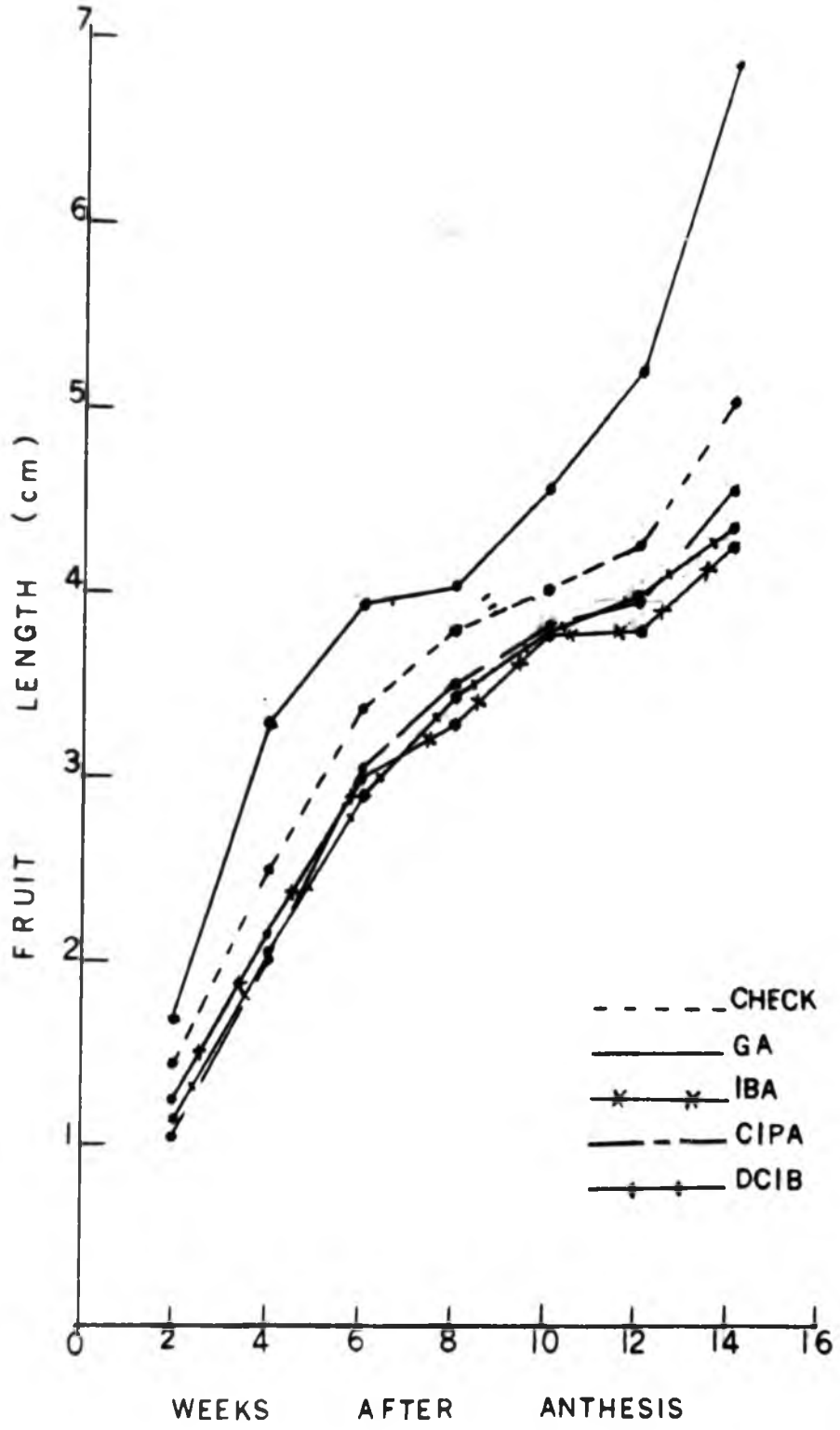


TABLE X. RATE OF INCREASE IN FRUIT LENGTH (cm per week) FOR DIFFERENT TREATMENTS IN CLONE 67-D

Treatments	WEEKS AFTER ANTHESIS						
	2-4	4-6	6-8	8-10	10-12	12-14	Mean
GA 50 ppm	0.803(17)[a]	0.331	0.057	0.268	0.334	0.838(7)	0.439
IBA 50 ppm	0.445(13)	0.428	0.154	0.254	0.022	0.222(7)	0.254
CIPA 50 ppm	0.472(15)	0.531	0.236	0.159	0.059	0.325(3)	0.297
DCIB 50 ppm	0.449(17)	0.443	0.280	0.179	0.087	0.193(11)	0.272
Check (open-pollination)	0.524(20)	0.440	0.196	0.142	0.130	0.306(13)	0.290

[a]Number of fruits measured per treatment is shown in parentheses. Flowers were not emasculated.

FIG 6 THE EFFECTS OF FOUR GROWTH REGULATORS ON THE RATE OF INCREASE IN FRUIT LENGTH IN CLONE 67—D

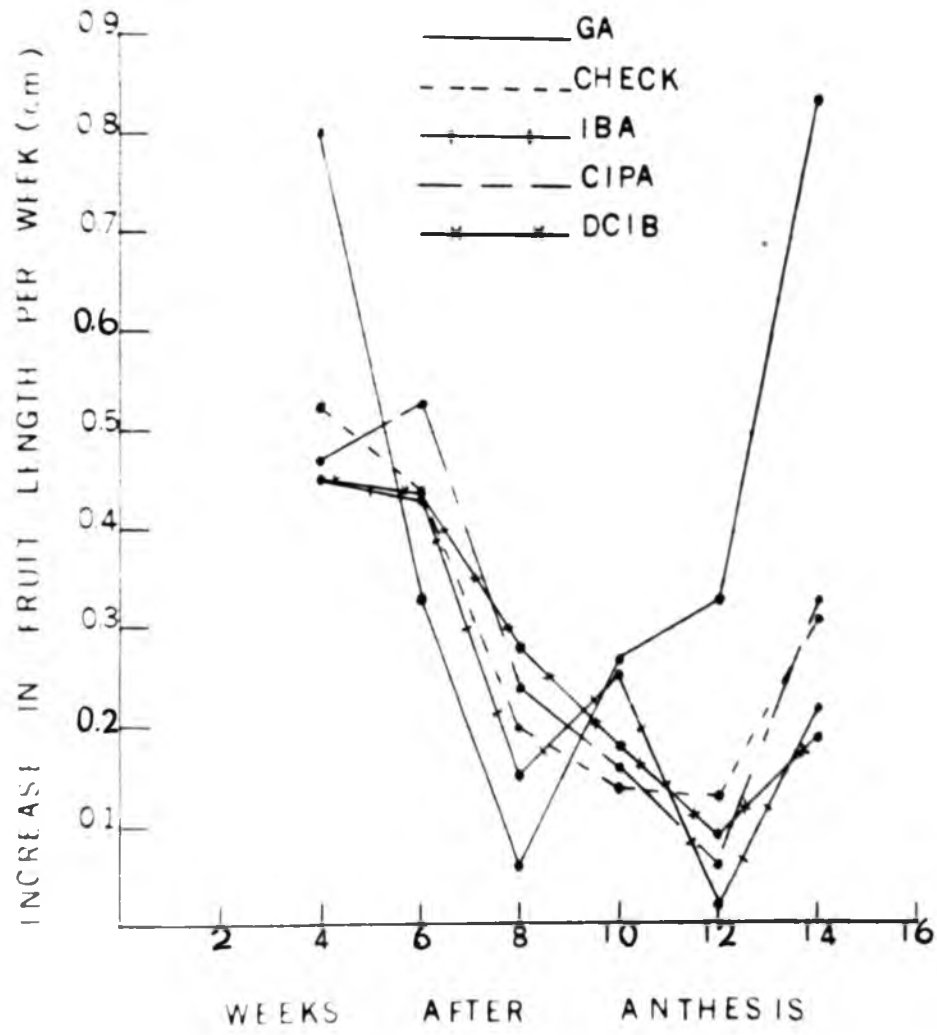


TABLE XI. MEAN FRUIT DIAMETER (cm) FOR DIFFERENT TREATMENTS AT VARIOUS STAGES OF DEVELOPMENT IN PSIDIUM CATTLEIANUM

Treatments	WEEKS AFTER ANTHESIS 6	8	10	12	14
GA 50 ppm	0.725(2)[a]	0.800	0.973	1.000	1.050(2)
IBA 50 ppm	0.771(7)	1.093	1.207	1.350	1.408(6)
CIPA 50 ppm	0.690(9)	1.053	1.108	1.188	1.433(3)
DCIB 1,000 ppm	0.600(4)	0.806	1.000	1.063	1.150(4)
Check (open-pollination)	0.913(4)	1.213	1.375	1.423	1.538(4)

[a]The number of fruits measured per treatment is shown in the parentheses. Flowers were not emasculated before treatment.

TABLE XII. RATE OF INCREASE IN FRUIT DIAMETER (cm per week) FOR DIFFERENT TREATMENTS IN PSIDIUM CATTLEIANUM

Treatments	WEEKS AFTER ANTHESIS 6-8	8-10	10-12	12-14	Mean
GA 50 ppm	0.038(2)[a]	0.087	0.014	0.025(2)	0.041
IBA 50 ppm	0.161(7)	0.057	0.072	0.029(6)	0.080
CIPA 50 ppm	0.184(9)	0.025	0.040	0.123(3)	0.093
DCIB 1,000 ppm	0.103(4)	0.087	0.032	0.044(4)	0.027
Check (open-pollination)	0.134(4)	0.049	0.075	0.058(4)	0.079

[a]Number of fruits measured per treatment is shown in parenthesis. Flowers treated were not emasculated before treatment.

Four weeks after anthesis, GA still caused a greater increase in length per week as compared to those of the check fruits and other growth regulator treatments as shown by the greater length of the GA stimulated fruits. These measurements are shown in Table IX. At the end of the sixth week after anthesis, mean fruit length for fruits set with the aid of GA was still greater than those of check fruits and other growth regulator treatments. This trend continued throughout the remaining period of fruit growth till the time of maturity, although the rate of increase in fruit length induced by GA was lass than for the check fruits and fruits in the other brouth regulator treatments as shown in Table X. The fruit length measurements shown in Table IX are also plotted on Figure 5 for clarity. The slow growth rates recorded by GA stimulated fruits mentioned above were not low enough to offset the high growth rates shown between 2-4 and 12-14 weeks after anthesis. On the averege, fruits that developed under the influence of GA had the highest rate of increase in fruit length over the entire period of growth followed by CIPA and the check as shown in Table X. As in the fruit diameter there were two periods of rapid growth at four and 14 weeks after anthesis, with a period of slow growth in between, as is clearly shown in Figure 6.

Fruits of Psidium cattleianum Sabine as mentioned earlier were too small to be measured until six weeks after anthesis. In fact, after six weeks of growth, the mean fruit diameter in all treatments was less than one centimeter as shown in Table XI. Fruits in the check group were larger than those produced with the aid of growth regulators at that stage. Eight weeks after anthesis the check fruits still maintained the

largest fruit diameter among the treatments. The trend was still the same at the end of the tenth week. This same trend in fruit size continued up to the time of maturity. Because of the number of fruits left at fourteen weeks after anthesis in some of the treatments, differences were not found to be significant at the five percent level of probability. However, the check fruits were about 1.5 times as large as those set with the aid of GA.

The rate of increase in fruit diameter between 6-8 weeks after anthesis in P. cattleianum shown in Table XII was fastest in fruits set with the aid of CIPA, followed by IBA, the check, DCIB and GA. Between 8-10 weeks after anthesis, however, the rate of increase in fruit diameter induced by GA, DCIB and IBA was greater than in the check fruits and that induced by CIPA was less. Between 10-12 weeks the check fruits had the highest growth rate compared with the growth regulator treatments, while between 12-14 weeks from anthesis CIPA again induced a higher rate of increase in fruit diameter than the check or the other growth regulators, GA, IBA and DCIB as shown in Table XII. For the period 6-14 weeks after anthesis when fruit diameter was taken, CIPA at 50 ppm induced the highest mean growth in the fruits, followed by IBA at 50 ppm, the check, GA at 50 ppm and DCIB at 1,000 ppm. These data for fruit diameter in P. cattleianum were not plotted graphically because it did not cover the entire fruit growth period.

Six weeks after antheais check fruits showed the largest fruit length followed by those set with the aid of CIPA, IBA, GA and DCIB, as shown in Table XIII. At the end of eight weeks after anthesis, the check fruits still maintained the largest fruit length over the growth

TABLE XIII. MEAN FRUIT LENGTH (cm) FOR DIFFERENT TREATMENTS AT VARIOUS STAGES OF DEVELOPMENT IN PSIDIUM CATTLEIANUM

Treatments	WEEKS AFTER ANTHESIS 6	8	10	12	14
GA 50 ppm	0.800(2)[a]	0.950	1.050	1.050	1.075(2)
IBA 50 ppm	0.821(7)	1.036	1.200	1.275	1.450(6)
CIPA 50 ppm	0.840(9)	1.067	1.192	1.313	1.533(3)
DCIB 1,000 ppm	0.680(4)	0.871	1.064	1.110	1.175(4)
Check (open-pollination)	1.075(4)	1.350	1.530	1.575	1.700(4)

[a]The number of fruits measured per treatment at any stage is shown in parenthesis. Flowers treated were not emasculated.

TABLE XIV. RATE OF INCREASE IN FRUIT LENGTH (cm per week) FOR DIFFERENT TREATMENTS IN PSIDIUM CATTLEIANUM

Treatments	WEEKS AFTER ANTHESIS 6-8	8-10	10-12	12-14	Mean
GA 50 ppm	0.078(2)[a]	0.050	0.000	0.035(2)	0.040
IBA 50 ppm	0.108(7)	0.082	0.038	0.083(6)	0.078
CIPA 50 ppm	0.114(9)	0.063	0.061	0.110(3)	0.087
DCIB 1,000 ppm	0.096(4)	0.097	0.023	0.033(4)	0.062
Check (open-pollination)	0.138(4)	0.090	0.023	0.063(4)	0.079

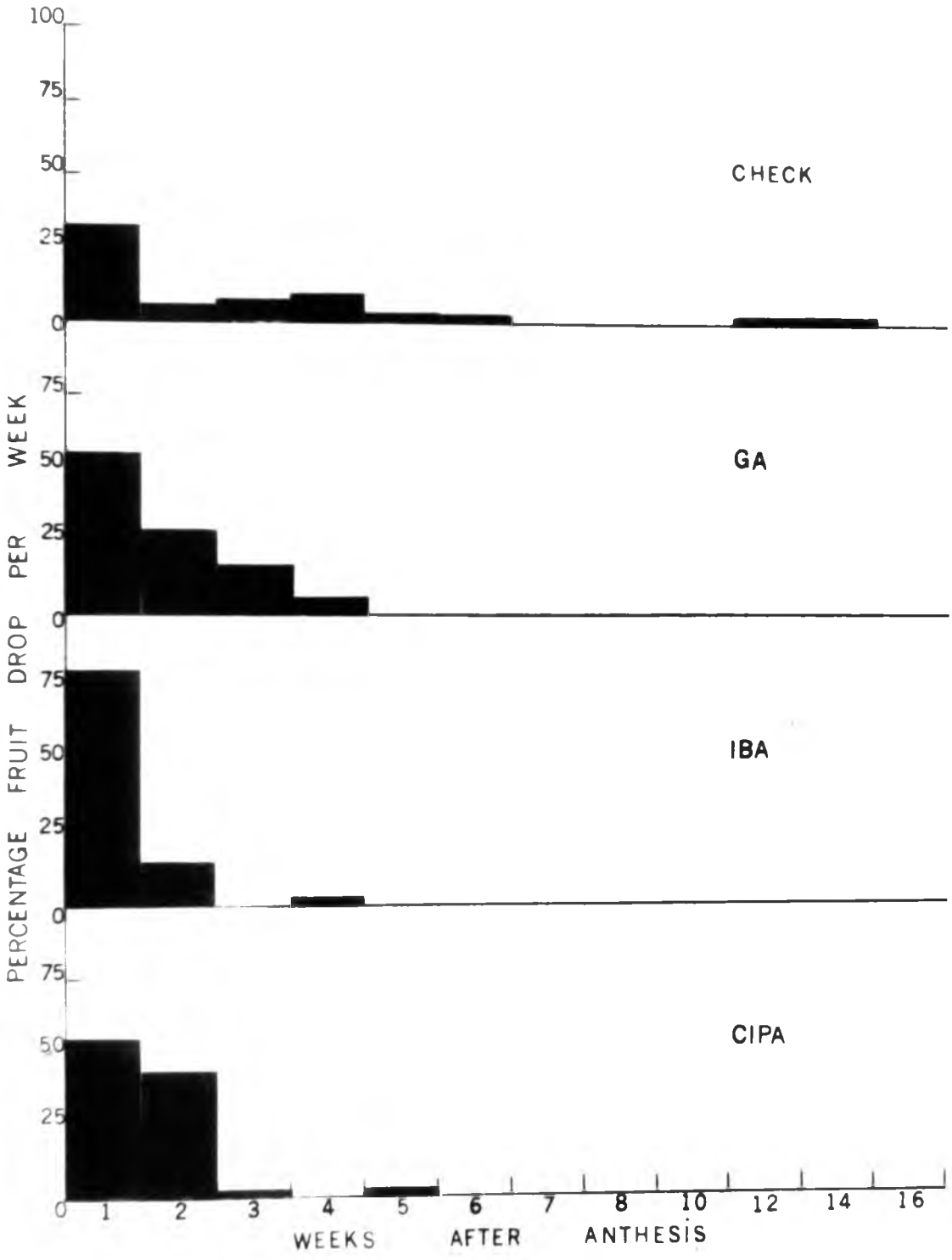
[a]Number of fruits measured for each treatment is shown in parenthesis. Flowers treated were not emasculated.

TABLE XV. WEEKLY AND PERCENTAGE FRUIT DROP FOR THE DIFFERENT TREATMENTS IN BEAUMONT GUAVA

Treatments[a]	WEEKS AFTER ANTHESIS															
	1	2	% Drop Phase 1	3	4	5	6	7	8	10	% Drop Phase 2	12	14	% Drop Phase 3	Total	% Total Drop
GA 25 ppm	23	9	80.0	4	3	1	-	-	-	-	20.0	-	-	0.0	40	100
50 ppm	24	11	87.5	3	2	-	-	-	-	-	12.5	-	-	0.0	40	100
75 ppm	20	14	85.0	5	-	1	-	-	-	-	15.0	-	-	0.0	40	100
Total	67	34	84.2	12	5	2	-	-	-	-	15.9	-	-	0.0	120	100
IBA 25 ppm	34	5	97.5	-	-	1	-	-	-	-	2.5	-	-	0.0	40	100
50 ppm	33	7	100.0	-	-	-	-	-	-	-	0.0	-	-	0.0	40	100
75 ppm	34	5	97.5	-	-	1	-	-	-	-	2.5	-	-	0.0	40	100
Total	101	17	98.3	-	-	2	-	-	-	-	1.7	-	-	0.0	120	100
CIPA 25 ppm	28	11	97.5	-	-	1	-	-	-	-	2.5	-	-	0.0	40	100
50 ppm	15	23	95.0	1	-	1	-	-	-	-	5.0	-	-	0.0	40	100
75 ppm	24	16	100.0	-	-	-	-	-	-	-	0.0	-	-	0.0	40	100
Total	67	51	97.5	1	-	2	-	-	-	-	2.5	-	-	0.0	120	100
Cross-pollination	23	1	60.0	3	-	1	1	-	-	-	12.5	-	-	0.0	29	72.5
Self-pollination	15	1	40.0	1	2	-	1	-	-	1	12.5	3	1	10.0	25	62.5
Open-pollination	2	3	12.5	6	10	1	1	-	-	1	47.5	-	-	0.0	24	60.0
Total	40	5	37.5	10	12	2	3	-	-	2	24.2	3	1	3.3	78	65.0

[a]There were 40 emasculated flowers per treatment.

FIG 7 THE EFFECTS OF THREE GROWTH REGULATORS ON FRUIT DROP IN BEAUMONT VARIETY



regulator treatments, and this trend continued up to the time of maturity.

The rate of increase in fruit length in P. cattleianum is shown in Table XIV. Between 6-8 weeks after anthesis the fastest rate of increase in fruit length was shown by the check fruits followed by fruits set with the aid of CIPA, IBA, DCIB and GA. Between 8-10 weeks after anthesis, however, DCIB induced a slightly faster growth rate in the fruits in the check group, followed by IBA, CIPA and GA. CIPA on the other hand, induced the fastest rate of fruit growth among the treatments between 10-12 and 12-14 weeks after anthesis. Over the entire period in which fruit growth was measured, CIPA induced the fastest growth rate followed by the check, IBA, DCIB and GA.

EFFECTS OF GROWTH REGULATORS ON FRUIT DROP

The fruit drop pattern in Beaumont is shown in Table XV. The percentage weekly drop is shown graphically in Figure 7 in the form of a histogram, with the three concentrations of GA, IBA and CIPA combined as well as the three pollination regimes combined and referred to as check. All the growth regulators induced a floral drop of more than 80 percent in phase 1 (the first two weeks after anthesis) as shown in Table XV. This is also clearly shown in Figure 7. In the pollination regimes, up to 60 percent of the flowers dropped during the same phase 1, with open-pollination (check) dropping the least as shown in Table XV. Comparing the three pollination regimes with the growth regulators, disregarding concentrations, IBA lost the largest percentage of the flowers in phase 1, followed by CIPA and GA. The pollination regimes lost the least percentage of their flowers during the same phase.

TABLE XVI. WEEKLY AND PERCENTAGE FRUIT DROP FOR THE DIFFERENT TREATMENTS IN CLONE 67-D

	WEEKS AFTER ANTHESIS														
Treatments[a]	1	2	% Drop Phase 1	3	4	5	6	7	8	10	% Drop Phase 2	12	14	% Drop Phase 3	Total	% Total Drop
GA 50 ppm	1	2	15.0	2	5	3	0	0	0	0	50.0	0	0	0.0	13	65.0
Percentage	5.0	10.0		10.0	25.0	15.0	0.0	0.0	0.0	0.0		0.0	0.0		65.0	
IBA 50 ppm	4	3	35.0	5	0	1	0	0	0	0	30.0	0	0	0.0	13	65.0
Percentage	20.0	15.0		25.0	0.0	5.0	0.0	0.0	0.0	0.0		0.0	0.0		65.0	
CIPA 50 ppm	1	4	25.0	8	3	1	0	0	0	0	60.0	0	0	0.0	17	85.0
Percentage	5.0	20.0		40.0	15.0	5.0	0.0	0.0	0.0	0.0		0.0	0.0		85.0	
DCIB 1,000 ppm	0	3	15.0	3	1	0	0	0	0	2	30.0	0	0	0.0	9	45.0
Percentage	0.0	15.0		15.0	5.0	0.0	0.0	0.0	0.0	10.0		0.0	0.0		45.0	
Check (open-pollination)	0	0	0.0	2	2	2	0	1	0	0	35.0	0	0	0.0	7	35.0
Percentage	0.0	0.0		10.0	10.0	10.0	0.0	5.0	0.0	0.0		0.0	0.0		35.0	

[a]There were 20 flowers per treatment at the onset.

In phase 2 (post-set drop) the remaining fruits on GA, IBA and CIPA treated branches dropped off as shown in Table XV, while the pollination regimes lost 24.2 percent of their fruits during the same phase 2.

During phase 3 (pre-harvest drop) only the pollination regimes still retained some of the fruits but they suffered 3.3 percent drop at this stage.

The percent drop per week is shown in Figure 7 and it shows that fruit drop was high in the first week after enthesis, followed by a decline in later weeks. IBA induced the highest percent drop of about 75 percent in the first weeks followed by CIPA, GA and the check. In the second week after anthesis, CIPA induced the highest rate of drop of about 40 percent, followed by GA, IBA and the check. In the third week, however, GA induced the highest drop as shown by the graph, followed by the check and CIPA while IBA induced no drop. In the fourth week after anthesis, the check dropped more fruits than GA or IBA. CIPA induced no fruit drop at this stage. By the end of the fifth week all the fruits treated with growth regulators had dropped while a few fruits were still dropping in the combined pollination regimes. This dwindling drop was experienced by the check in the sixth, twelfth and fourteenth weeks after anthesis.

In Clone 67-D, IBA at 50 ppm induced the highest percent drop in phase 1 (floral drop) while the check showed no drop as shown in Table XVI. IBA was followed by CIPA, GA and DCIB in order of magnitude.

During phase 2, CIPA and GA treatments showed more drop than the check, followed by IBA and DCIB which lost 30 percent each.

FIG 8 THE EFFECTS OF FOUR GROWTH REGULATORS ON FRUIT DROP IN CLONE 67–D

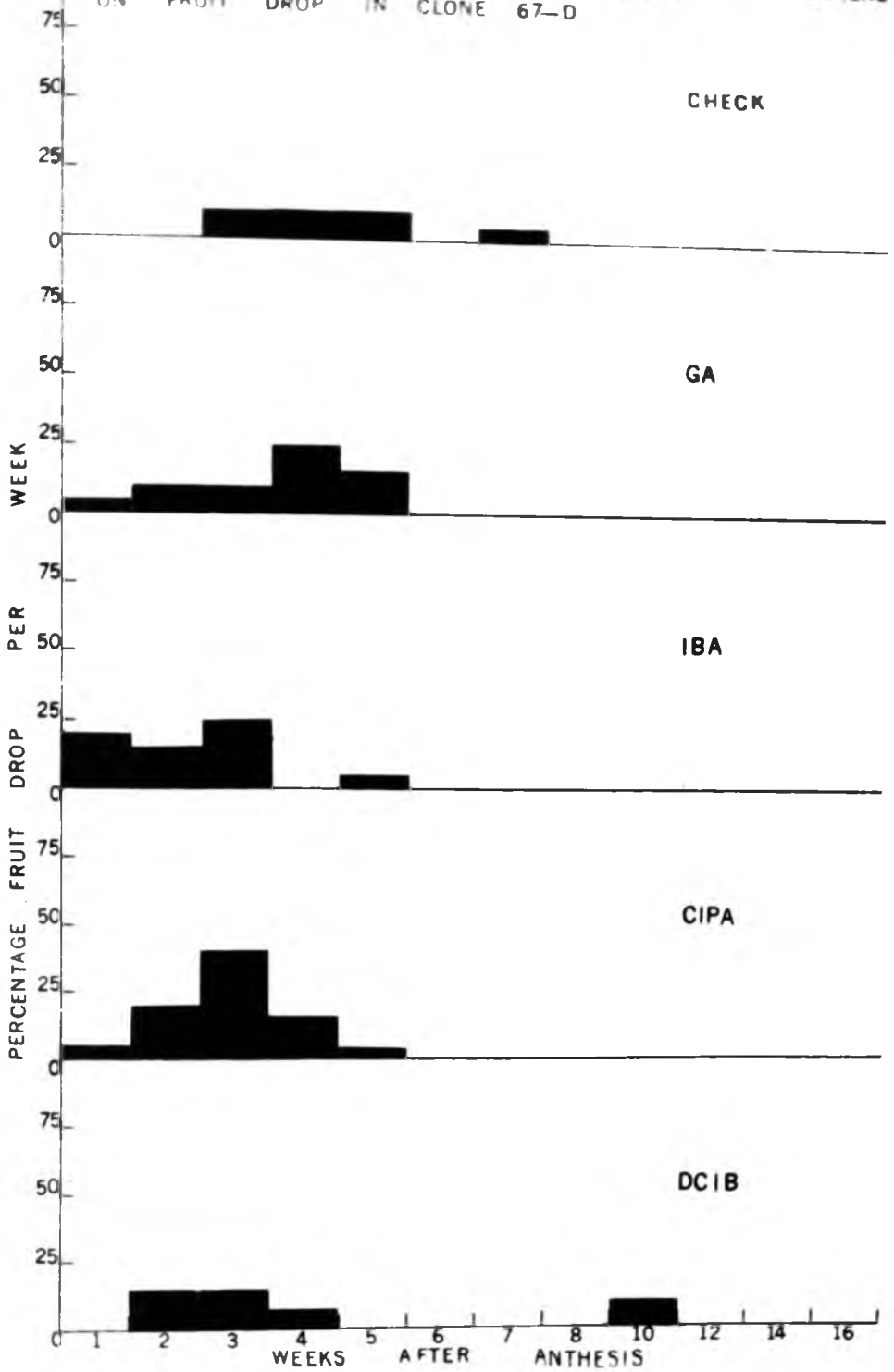


TABLE XVII. WEEKLY AND PERCENTAGE FRUIT DROP INDUCED BY FOUR GROWTH REGULATORS IN *PSIDIUM CATTLEIANUM*

	WEEKS AFTER ANTHESIS															
Treatments[a]	1	2	% Drop Phase 1	3	4	5	6	7	8	10	% Drop Phase 2	12	14	% Drop Phase 3	Total	% Total Drop
GA 50 ppm	0	1	2.5	14	19	5	1	0	0	0	92.5	0	0	0.0	38	95.0
Percentage	0.0	2.5		35.0	47.5	7.5	2.5	0.0	0.0	0.0		0.0	0.0		95.0	
IBA 50 ppm	0	11	27.5	10	9	3	0	0	0	0	55.0	1	0	2.5	34	85.0
Percentage	0.0	27.5		25.0	22.5	7.5	0.0	0.0	0.0	0.0		2.5	0.0		85.0	
CIPA 50 ppm	1	3	10.0	15	10	1	1	2	0	0	72.5	2	1	7.5	36	90.0
Percentage	2.5	7.5		37.5	25.0	2.5	2.5	5.0	0.0	0.0		5.0	2.5		90.0	
DCIB 1,000 ppm	0	10	25.0	12	9	1	1	0	0	0	57.5	3	0	7.5	36	90.0
Percentage	0.0	25.0		30.0	22.5	2.5	2.5	0.0	0.0	0.0		7.5	0.0		90.0	
Check (open-pollination)	3	3	15.0	20	6	1	4	0	0	0	77.5	0	0	0.0	37	92.5
Percentage	7.5	7.5		50.0	15.0	2.5	10.0	0.0	0.0	0.0		0.0	0.0		92.5	

[a]There were 40 unemasculated flowers per treatment.

None of the treatments, including the check, lost any fruits in phase 3 (pre-harvest drop).

The highest percent total drop was shown by CIPA, followed by GA, IBA and DCIB, and the check as shown on Table XVI. Only the percent total drop induced by CIPA was significantly higher than that of the check at the five percent level of probability. The other differences even though as high as 30 percent were not significantly different from those of the check.

The weekly fruit drop induced by each treatment is shown in Figure 8. IBA induced the highest percent fruit drop in the first week after anthesis followed by GA and CIPA. No drop was induced by DCIB and the check at this stage. In the second week, CIPA induced the highest percent drop followed by IBA, DCIB, the check and GA. The highest percent drop through the entire growth period of the fruits was recorded by CIPA in the third week after anthesis followed by IBA, DCIB, GA and the check. GA induced the highest drop in the fourth week, followed by CIPA, the check and DCIB, while IBA did not induce any drop. In the fifth week GA induced the highest percent drop followed by the check, IBA and CIPA. DCIB did not induce any drop. After the fifth week, however, until maturity, only DCIB and the check experienced any more drop. DCIB induced the last drop in the tenth week after anthesis while the check showed the last drop in the seventh week after anthesis.

Fruit drop in Psidium cattleianum is shown in Table XVII. During phase 1 (floral drop) the highest drop was recorded on branches treated with IBA. All the drop in this phase for all the growth regulator treatments occurred in the second week while floral drop for the check was the same in the first and second weeks after anthesis.

During phase 2 the highest percent fruit drop was found in the GA treatment followed by the check, CIPA, DCIB and IBA as shown in Table XVII. In all cases most of the phase 2 drop occurred in the third and fourth weeks after anthesis.

In phase 3 (pre-harvest drop), GA and the check did not show any fruit drop but CIPA and DCIB induced 7.5 percent drop each, while IBA lost 2.5 percent as shown in Table XVII.

On the whole GA treatments induced more percentage total drop than the check as well as the other growth regulators but these differences were not statistically significant.

The weekly fluctuation in drop are illustrated in Figure 9. DCIB, IBA and GA treatments did not experience any drop in the first week after anthesis but GA and the check lost some flowers. In the second week IBA and DCIB lost more flowers than any of the other treatments. In the third week after anthesis, the check lost the largest amount of fruits followed by CIPA, GA, DCIB and IBA. In the fourth week GA induced the highest drop after anthesis followed by CIPA, DCIB, GA and the check. In the fifth week, fruit drop was generally low as shown in Figure 9, but GA lost the most fruits followed by IBA. The check branches suffered the highest fruit drop among the treatments in the sixth week from anthesis while IBA and DCIB did not lose any fruits. After the sixth week till maturity, only IBA, CIPA and DCIB lost more fruits at intervals. IBA induced the last fruit drop in the twelfth week after anthesis, CIPA in the seventh and fourteenth weeks while DCIB experienced its last drop in the twelfth week after anthesis.

FIG. 9 THE EFFECTS OF FOUR GROWTH REGULATORS ON FRUIT DROP IN PSIDIUM CATTLEIANUM

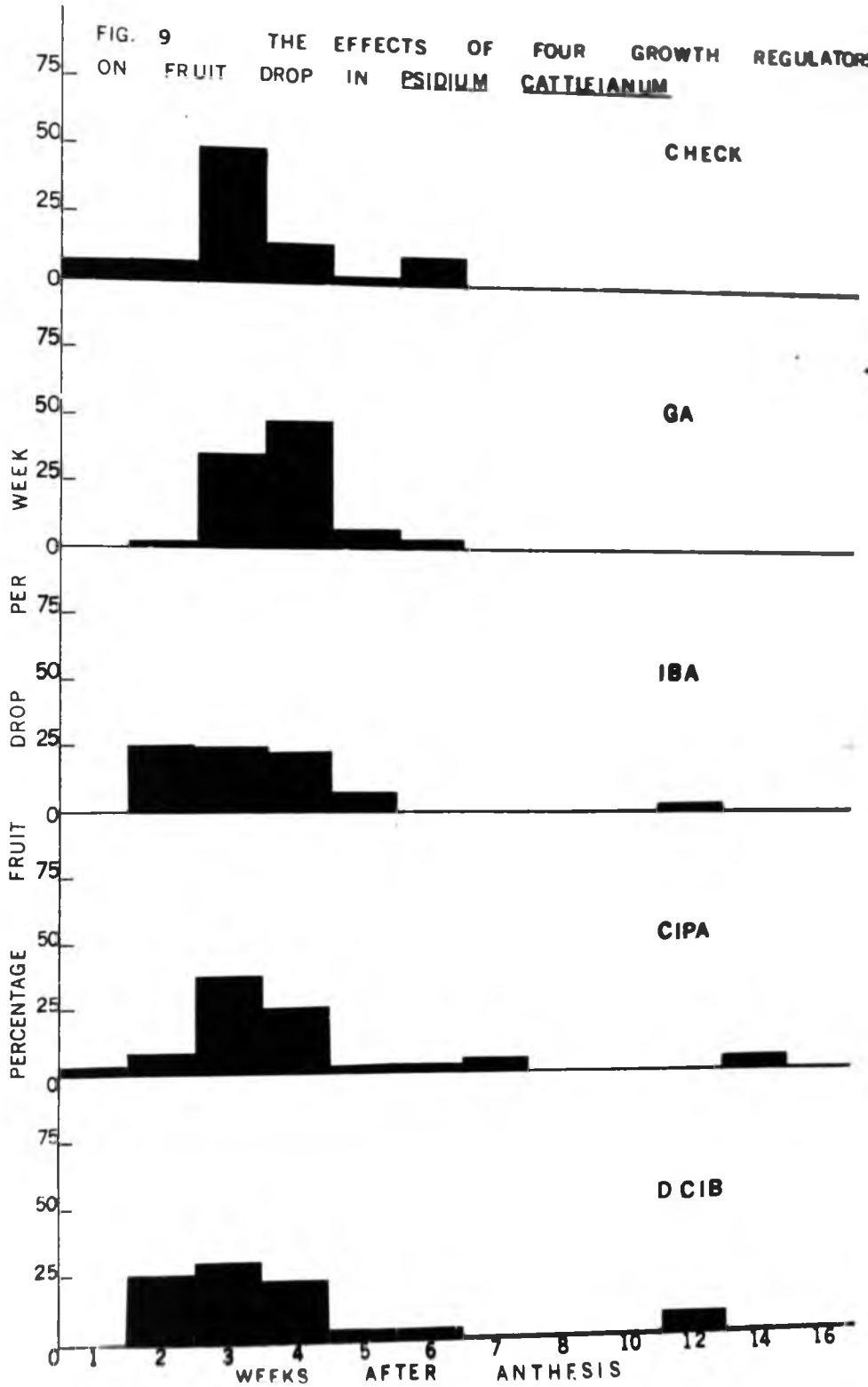


TABLE XVIII. AVERAGE SEED CONTENT, SOLUBLE SOLIDS AND TITRATABLE ACIDITY IN CLONE 67-D

Treatments	Seed No. Per Fruit	Range	Increase Over Check	% Sol. Solids	Mean % Titratable Acidity (Citric Acid)
GA 50 ppm	101.8(7)[a]	38 - 149	- 34.1	11.22	0.834
IBA 50 ppm	288.7(7)	281 - 296	87.0	13.52	0.467
CIPA 50 ppm	169.5(3)	99 - 240	9.8	11.00	0.423
DCIB 1,000 ppm	194.8(11)	114 - 270	26.2	13.00	0.607
Check (open-pollination)	154.4(13)	50 - 238	---	11.78	0.482

[a]Number of fruits used per treatment are shown in parentheses.

EFFECT OF GROWTH REGULATORS ON SEED CONTENT IN GUAVA FRUITS (Clone 67-D, Psidium guajava L.)

Seed counts in fruits produced by spraying growth regulators on unemasculated flowers of Clone 67-D were made after harvest and the results are shown in Table XVIII. Seed count data showed that GA at 50 ppm set fruits with 34.1 percent less seeds than in the check fruits. Fruits set with the aid of the other growth regulators, IBA and CIPA at 50 ppm and DCIB at 1,000 ppm contained more seeds per fruit than the check. The amount of seeds in guava is, however, a variable factor as shown by the range in seed count. The results were not analyzed statistically.

EFFECTS OF GROWTH REGULATORS ON TITRATABLE ACIDITY

Fruits set with the aid of GA in Clone 67-D were higher in titratable acidity than the check by about 0.35 percent but the difference was not statistically significant. The other differences were also not significant. The values of percent titratable acidity are shown in Table XVIII. Clone 67-D is a sweet clone naturally low in acidity.

EFFECT OF GROWTH REGULATORS ON SOLUBLE SOLID CONTENT

There were no significant differences in the soluble solid content of Clone 67-D fruits harvested from the different treatments. Differences as high as 2.5 percent were recorded between fruits set with the aid of IBA and CIPA as shown in Table XVIII. Such differences could occur naturally.

EFFECT OF GROWTH REGULATORS ON TIME OF RIPENING AND MATURITY

In Beaumont guava there was no difference in ripening time of fruits set by the three pollination regimes. They all matured in 14-16 weeks after anthesis, ripening in seven days from the first alteration in the green color.

IBA tended to induce fruits in Clone 67-D to commence ripening as early as the twelfth week after anthesis. IBA, therefore, seems to hasten onset of ripening. The other fruits treated with GA, CIPA and DCIB started ripening 14 weeks after anthesis. All the fruits were fully ripened within 14-16 weeks after anthesis.

Fruits of Psidium cattleianum ripened one to two weeks later than those of P. guajava L. (Beaumont and Clone 67-D), whether or not treated with growth regulators. In fact, all fruits set with the aid of growth regulators in P. cattleianum failed to show the normal red color which is indicative of ripeness.

All fruits of Clone 67-D and Beaumont showed the normal color at ripening. A cross-section of fruits harvested from P. cattleianum, however, showed the presence of an external coating of wax-like material which obscured the normal red color at ripening. This made it difficult to know when the fruits were fully ripe.

EFFECTS OF GROWTH REGULATORS ON THE FLAVOR OF GUAVA FRUIT

Application of the four growth regulators did not have any detectable effect on the fruit flavor. Consequently, no unusual flavors were detected in fruits of Clone 67-D that were used for the test.

OBSERVATIONS ON PHYTOTOXICITY AND OTHER SIDE EFFECTS

Effects of the Growth Regulators on Fruits

IBA at 50 ppm and 75 ppm caused lopsidedness in some of the fruits of *P. cattleianum* while GA at 50 ppm and IBA at the same concentration caused enlargement of the calyx end of Clone 67-D and Elaine fruits. The swellings caused by GA were far more conspicuous than those due to IBA sprays. IBA at 50 ppm, CIPA at 50 ppm and DCIB at 1,000 ppm caused fruits to be disfigured at maturity. Cracking of fruits was caused by CIPA, IBA and DCIB in *P. cattleianum* and Clone 67-D but the effects were more serious in the former where the fruits split half-across.

Effects on the Vegetative Parts of the Guava Tree

Chlorosis of the leaves was caused by sprays of CIPA at 50 ppm and 75 ppm while lecerations of the leaf surface were due to CIPA at 50 ppm. IBA at 50 ppm, CIPA at 50 ppm and DCIB at 1,000 ppm caused die-back of the shoot apex in *P. cattleianum* and Clone 67-D. However, the incidence of shoot die-back was most serious in *P. cattleianum* and Beaumont when it was sprayed with IBA at 50 and 75 ppm and CIPA at 50 and 75 ppm.

DISCUSSION AND CONCLUSION

This study indicated that initial fruit set can be induced in the guava with low concentrations of GA, IBA and CIPA. The main problem lies in the failure of the growth regulators to prevent abscission. The fruits were all parthenocarpic but dropped off in less than 35 days from anthesis. In some work by Tagota et al. (54) 100 and 500 ppm GA failed to set any fruit while a concentration of 1,000 ppm GA set fruits that later dropped when they were still small. Only a concentration as high as 10,000 ppm of GA produced mature parthenocarpic fruits. Shanmgarelu (43) was unable to set mature parthenocarpic guava fruits with 8,000 ppm GA applied as a paste to the encised stigma in Allahabad variety.

In the study reported here concentrations as high as 2,000 ppm GA were applied to emasculated flowers of Elaine, Clone 14-9 and Beaumont. Initial fruits set by GA at 100, 500 and 2,000 ppm all dropped at early stages of development. GA at 1,000 ppm produced one mature parthenocarpic fruit while a higher concentration failed to set any mature fruits. This inconsistency in the effects suggests that other factors besides the growth regulators may also be involved in fruit set and in preventing the formation of the abscission. Weather conditions were mostly bad with frequent rains and wind during the December test period. The one mature parthenocarpic fruit set by 1,000 ppm GA on Clone Elaine was conspicuously swollen at the calyx end, had seven prominent ridges and an irregular surface. This irregularity on the outside may be due to the absence of seeds or differential tissue growth.

From the fruit set results and work done elsewhere using emasculated flowers, apparently the concentrations of growth regulators used in the

Beaumont variety in June 1967 were too low to produce mature seedless fruits in the absence of pollination. As shown by the December study, higher concentrations of growth regulators would be required to produce mature parthenocarpic fruits under the prevailing conditions. Seedlessness in many fleshy crops like the guava is a desirable feature. If combined with productivity, it outweighs other pomological features, as mentioned by Raman (35) in his studies of seedlessness.

Using unemasculated guava flowers in Psidium cattleianum and Clone 67-D, none of the three growth regulators, GA, IBA or CIPA induced any seedlessness in the presence of pollination. This shows the failure of the growth regulators used to induce embryo abortion or prevent fertilization and ovule development once pollination has occurred. Fruits set were seedy showing that there was adequate pollination in the flowers treated. Fruits that were set with the aid of 50 ppm GA developed far less seeds per fruit than the check fruits while those set with the aid of IBA, CIPA and DCIB had more seeds than the check. Rao et al. (37) recorded less seeds in fruits set by treating unemasculated flowers with GA. Using emasculated flowers, however, Balasubramanyam and Rangaswami (5) as well as Rangaswami and Kaliaperumal (36) induced complete seedlessness with aqueous extracts of pollen. Lower seed content or complete seedlessness combined with larger fruits leads to a large pulp recovery, much desired in the guava industry.

In the Beaumont variety, there were no differences between self, cross and open-pollination in effecting fruit set. This indicates that there are factors other than the types of pollination affecting fruit

set and according to Seth (41) the fruit set could vary from zero in one season to over 80 percent in the same season.

Fruits set with the aid of GA and IBA were swollen at the calyx end. In this respect GA was more effective in inducing enlargement of the calyx end of the fruits than IBA. These swellings gave the fruit an ugly appearance especially in the completely seedless fruits. The swelling caused by GA and IBA in the seedy fruits were not as severe as those in the seedless fruits. Similar swellings at the calyx end were observed by Shanmgarelu (43) but not by Tagota (54) in separate studies on the guava.

Fruits produced from unemasculated flowers of Clone 67-D sprayed with 50 ppm GA were superior in size to those treated with the other growth regulators in both fruit diameter and length. Larger fruit sizes are desirable from the standpoint of tonnage yields. The increase in fruit size appeared to be due to (1) a faster longitudinal and lateral development of the fruits and (2) an enlargement of the calyx end of the fruits. Shanmgarelu (43) and Aravindakshan (2) have previously recorded an increase in fruit size of guavas. In P. cattleianum none of the growth regulators was effective in improving fruit size. The reasons for the ineffectiveness of the growth regulators could be due to the fact that fruits of P. cattleianum are genetically uniformly round, small and slow-growing. In Psidium guajava on the other hand, fruit size is very variable at maturity.

The growth curves for fruits of Clone 67-D, Beaumont and P. cattleianum were shown in Figures 1-6. According to Leopold (25) there are two general patterns of growth common to many fruits: the sigmoid and the

double sigmoid curves. The growth curves produced by the fruit length and diameter of guava did not exactly follow any of the two suggested curve models. However, the growth curves in all the three cases followed an inverted sigmoid pattern in the check fruits as well as fruits set with the aid of growth regulators. The growth curves appeared more complicated than the normal sigmoid curve because they were composed of rapid growth periods with a slow or static growth period in between. The general pattern of two periods of rapid growth increase and one of slow or static growth increase corresponds with that for the double sigmoid curve as described for fruits like figs, grape and currents (25). The growth rates plotted in Figures 2, 4 and 6 follow a bimodal curve like many other fruits because of the similar rapid-slow-rapid growth rythm. The growth curves in berries, pomes and other types are not distinctive because of the wide variation in fruits within each type (25).

Unpollinated and unsprayed flowers all dropped within phase 1 which covers the first two weeks after anthesis.

None of the growth regulators used in this study succeeded in reducing total fruit drop. This showed that the growth regulators were ineffective in prevention of abscission. Concentrations of 25-75 ppm GA, IBA and CIPA, in fact, increased abscission of emasculated flowers. Floral drop was much more intensive when emasculated flowers were sprayed with growth regulators as shown in Figure 7 while post-setting drop was light. When unemasculated flowers were used, the drop was lighter in the initial set than in the post-set drop. Pre-harvest drop was either light or absent in either of the two situations.

Percentage titratable acidity was not significantly higher in GA

treated fruits than the check. Apart from GA only DCIB increased the citric acid content of guava fruits.

None of the growth regulators used had any effect on the soluble solid content although a difference of 2.5 percent occurred between IBA treated fruits and CIPA treated ones. Such differences do occur naturally among untreated fruits.

A number of undesirable phytotoxic effects were noted but only a few were definitely caused by the growth regulators. Chlorosis of the leaf and cracking of fruits are known to occur naturally. Chlorosis could be due to a soil deficiency in certain nutrients and according to Mortensen and Bullard (33) prolonged and excessive rainfall could cause cracking of fruits in guava. These effects, however, could have been aggravated by the application of IBA, CIPA and DCIB. IBA at 50 ppm also caused lopsidedness in fruits of Psidium cattleianum. This lopsidedness in the fruits was probably due to failure of some ovules to develop into seeds in some sections of the fruit. And the ovule has been identified as a source of hormones (3, 25, 29). Shoot die-back caused by CIPA, IBA and DCIB is also very undesirable because it prevents or reduces the formation of new growth in the next season, upon which new flowers are normally formed. The serious disfiguring of fruits of P. cattleianum caused by IBA, CIPA and DCIB lowers the quality of such fruits except for processing of guava juice.

SUMMARY

Treatments that were applied to emasculated flowers, GA at 25, 50 and 75 ppm; IBA at 25 and 75 ppm; and CIPA at 25 and 50 ppm, initially set parthenocarpic fruits. However, all dropped within 35 days from anthesis. GA, IBA and CIPA at 50 ppm and DCIB at 1,000 ppm failed to set parthenocarpic fruits when applied to unemasculated flowers. Ga, however, set fruits with less seeds than the check fruits while IBA set fruits with about twice as many seeds as the check. Other treatments also induced more seed content. Application of growth regulators did not hamper natural pollination.

GA at 1,000 ppm successfully set one mature parthenocarpic fruit in Elaine but not in Beaumont and Clone 14-9. Two thousand ppm GA failed to set any mature parthenocarpic fruits.

Fruit drop was classified into three phases for all treatments: floral drop, post-set drop and pre-harvest drop. Growth regulators, GA, IBA and CIPA when applied to emasculated guava flowers, produced intensive floral drop in all cases followed by lighter post-set drop and no pre-harvest drop. When the same chemicals, including DCIB, were applied to unemasculated flowers, there was light floral drop with a larger percentage post-set drop but only IBA, CIPA and DCIB induced some pre-harvest drop.

Growth curves of guava fruits followed a pattern quite dissimilar to the two common growth curves. An inverted sigmoid curve was formed by plotting the fruit length and fruit diameter in all varieties and treatments except IBA. The growth rate curves were bimodal, however.

GA at 50 ppm produced significantly larger fruits than the check and other growth regulators.

GA, IBA and CIPA each at 50 ppm and DCIB at 1,000 ppm had no effect on the titratable acidity and soluble solids.

IBA, CIPA and DCIB caused die-back of shoot apex and a delay in the production of new flushes. The same chemicals could have aggravated the natural occurrence of chlorosis and cracking of fruits.

IBA, CIPA and DCIB caused fruits of P. cattleianum to be disfigured. GA caused conspicuous swelling of the calyx end of the fruits and IBA caused very slight but similar swellings, which tend to increase fruit length.

LITERATURE CITED

1. Alvim, P. de T. 1968. Use of Growth Regulators to Induce Fruit Set in Coffee (Coffea arabica L). Turialba 8:64-72.

2. Aravindakshan, M. 1963. Effect of Pruning on Growth, Flowering and Fruit Set in Guava (P. guajava L.) Madras Agric. Journal 50:87-88.

3. Andus, L. J. 1965. Plant Growth Substances. Interscience Publishers, New York. 170-175.

4. Balasubrahmanyam, V. R. 1959. Studies on Blossom Biology of Guava (Psidium guajava L.) Ind. Jour. Hort. 16(2):69-76.

5. _____ and G. Rangaswami. 1959. Parthenocarpy in Guava Induced by Pollen Hormone. Curr. Sc. 28:413-415.

6. Chadhe, K. L. and Kirpal Singh. 1963. Effects of NAA, 2,4-D and 2,4,5-T on Fruit Drop, Size and Quality of Lagra Mango. Ind. J. Hort. 2(1) 30-33.

7. _____. 1964. Fruit Drop in Mango. IV. Fruit Drop and Its Relation to Fruit Growth. Ind. J. Hort. 21:197-200.

8. Chandler, W. H. 1958. Evergreen Orchards. 2nd Ed. Lea and Febiger, Philadelphia, 326-327.

9. Clore, W. J. 1965. Responses of Delaware Grapes to Gibberellin. Proc. Am. Soc. Hort. Sc. 87:259-263.

10. Cobley, Leslie S. 1965. An Introduction to the Botany of Tropical Crops. 5th Ed. Longmans, Great Britain. 285-287.

11. Crane, J. C. 1952. Ovary Wall Development as Influenced by Growth Regulators Inducing Parthenocarpy in Calimyrna Fig. Bot. Gaz. 114:102-107.

12. _____. 1948. Fruit Growth of Four Fig Varieties as Measured by Diameter and Fresh Weight. Proc. Am. Soc. Hort Sc. 52:337-344.

13. _____. 1952. Preharvest Drop, Size and Maturity of Apricots as Affected by 2,4,5-Trichlorophenoxyacetic Acid. Proc. Am. Soc. Hort. Sc. 65:75-84.

14. _____ and Rene Blondeau. 1949. Control Growth of Fig Fruits by Synthetic Hormone Application. Proc. Am. Soc. Hort. Sc. 54:102-108.

15. Doughty, Charles C. 1962. The Effects of Certain Growth Regulators on Fruiting of Cranberries, Vaccinium macrocarpon. Proc. Am. Soc. Hort. Sc. 80:340-349.

16. Edgerton, L. J. and M. B. Hoffman. 1963. The Effects of Certain Growth Regulators on Fruit Set in the McIntosh Apple. Proc. Am. Soc. Hort. Sc. 83:63-67.

17. _____, _____ and C. G. Forshey. 1964. The Effects of Some Growth Regulators on Flowering and Fruit Set of Apple Trees. Proc. Am. Soc. Hort. Sc. 84:1-6.

18. Gardner, F. E., Paul C. Marth and L. P. Batjer. 1939. Spraying with Plant Growth Substances for Control of Preharvest Drop of Apples. Proc. Am. Soc. Hort. Sc. 37:415-428.

19. Gustafson, F. C. 1960. Influence of GA on Setting and Development of Fruits in Tomato. Pl. Phys. 35:521-523.

20. Hamilton, R. A. and H. Seagrave-Smith. 1954. Growing Guava for Processing. Extension Bulletin 63, University of Hawaii, p. 6.

21. Hartmann, H. T. 1950. Tests with Growth Regulating Chemicals for Increasing Fruit Set in Olives. Proc. Am. Soc. Hort. Sc. 55:818-189.

22. Hirano, Robert T. 1967. Chromosomal and Pollination Studies as Related to Intraspecific and Interspecific Compatibility in the Genus Psidium. M. S. Thesis, Graduate School, University of Hawaii.

23. Jones, C. M. 1965. Effects of Benzyladenine on Fruit Set in Muskmelon. Proc. Am. Soc. Hort. Sc. 87:335-340.

24. Lam, Shue-Lock, A. C. Leopold and K. W. Johnson. 1962. A Chemical Treatment to Concentrate Tomato Ripening for Mechanical Harvesting. Proc. Am. Soc. Hort. Sc. 80:530-534.

25. Leopold, Carl A. 1964. Plant Growth and Development. McGill Publications, New York, 259-269.

26. _____. 1958. Auxin Uses in Control of Flowering and Fruiting. Ann. Rev. Pl. Phys. 281-310.

27. _____. 1963. Auxins and Plant Growth. Univ. of California Press, Berkeley and Los Angeles.

28. Livingston, George A. 1950. In Vitro Tests of Abscission Agents. Pl. Phys. 25:771-721.

29. Luckwill, L. C. 1953. Studies of Fruit Development in Relation to Plant Hormones. II. The Effects of NAA on Fruit Set and Fruit Development in Apples. J. Hort. Sc. 28:25-40.

30. Mann, Louis K. and P. A. Minges. 1949. Experiments on Setting Fruit with Growth Regulating Substances on Field Grown Tomatoes in California. Hilgardia 19(10):309-337.

31. McGlasson, W. B. and Harlan K. Pratt. 1963. Fruit Set Patterns and Fruit Growth in Cantaloupe (Cucumis melo L. var. reticulatis Nand). Proc. Am. Soc. Hort. Sc. 83:495-505.

32. McIlroy, R. J. 1963. An Introduction to Tropical Cash Crops. Ibadan University Press, Nigeria, 95-96.

33. Mortensen, E. and Ervin T. Bullard. 1965. Handbook of Tropical and Subtropical Horticulture. A.I.D. Communication and Resources Div. Publication and Technical Services Bureau, Washington D. C. 44-46.

34. Ochse, J. J., M. J. Soule, M. J. Djickman and C. Wehlburg. 1961. Tropical and Subtropical Agriculture. McMillan and Co., New York, 686-688.

35. Raman, K. R. 1949. Methods of Inducing Seedlessness in Fruits. Ind. J. Hort. 6(3):11-27.

36. Rangaswami, G. and T. T. Kaliaperunal. 1960. The Presence of Indole-like Compounds in Parthenocarpic Guava. Curr. Sc. 29: 485-486.

37. Rao, S. N., P. Bhaskarna Rao and Ch. Subba Rao. 1960. The Effect of GA on Fruit Set, Weight, Size, Seed Content and Soluble Solids in Guava (P. guajava L.). Andhra Agric. J. 7:82-90.

38. LaRue, Carl. D. 1936. The Effects of Auxin on Debladed Petioles. Proc. Nat. Acad. Sc. 23:254-259.

39. Sehgal, O. P. 1961. Studies on Morphology and Blossom Biology in Guava (P. guajava L.). M. S. Post-Grad. School, Div. of Hort. Ind. Agric. Res. Inst., New Delhi.

40. Seth, J. N. 1959. Causes of Seedlessness in P. guajava L. Hort. Adv. 3:82-88.

41. _____. 1960. Varietal Cross-incompatibility in Guava (P. guajava L.) Hort. Adv. 4:161-164.

42. _____. 1962. Floral Biology Studies in Psidium. Hort. Adv. 4:110-136.

43. Shanmugarelu, K. C. 1952. A Preliminary Study on the Induction of Parthenocarpic Guava by GA. Ind. J. Hort. 19:128-129.

44. Singh, S. M. and P. N. Kacker. 1952. Effects of Some Hormones and Methods of Application on Parthenocarpy in Tomato Fruits. Ind. J. Hort. 9(4):23-29.

45. Snedecor, G. W. 1956. Statistical Methods. 5th Ed. Iowa State Univ. Press, Ames, Iowa.

46. Soubihe, J. (Sobrunho) and J. R. A. Gurgel. 1962. The Extent of Natural Cross-pollination in Guavas (P. guajava L.). Brangantia 21:15-20.

47. Southwick, F. W., W. D. Weeks and G. W. Olanyk. 1967. The Effects of Naphthaleneacetic Acid Type Materials and 1-Naphthyl-N-Methyl Carbanate (Sevin) on the Fruiting, Flowering and Keeping Quality of Apples. Proc. Am. Soc. Hort. Sc. 84:14-23.

48. Spencer, J. L. and W. C. Kennard. 1955. Studies on Mango (Mangifera indica L.) Fruit Set in Puerto Rico. Trop. Agric. 32:323-330.

49. Stewart, Wm. S. and H. Z. Hield. 1950. Effects of 2,4-D and 2,4,5-T on Fruit Drop, Fruit Production and Leaf Drop in Lemons. Proc. Am. Soc. Hort. Sc. 55:163-171.

50. _____, _____ and B. L. Braunnaman. 1952. Effects of 2,4-D and Related Substances on Fruit Drop, Yield, Size and Quality of Valencia Oranges. Hilgardia. 21(11):301-329.

51. _____ and L. K. Klotz. 1947. Some Effects of 2,4-D on Fruit Drop and Morphology of Oranges. Bot. Gz. 109:150-162.

52. Stuart, Neil W. and Henry M. Cathey. 1961. Applied Aspects of Gibberellins. Ann. Rev. Pl. Phys. 12:369-394.

53. Sundararajan, R. and Methuswamy. 1964. Preliminary Studies on the Effect of Pruning in Certain Varieties of Guava (P. guajava L.). Madras Agric. J. 51:81.

54. Tagota, S. S., P. C. Pandey and R. S. Mathus. 1961. Gibberellin Induced Parthenocarpy in Guava (P. guajava L.). Curr. Sc. 30:312.

55. Tukey, H. B. Plant Regulators in Agriculture

56. Waddington, J. T. and F. C. Teubner. 1963. The Concentration of Tomato Yields for Mechanical Harvesting with N-m-tolyphthalamic Acid. Proc. Am. Soc. Hort. Sc. 83:700-704.

57. Weaver, R. J. 1952. Response of Black Corinth Grapes to Applications of 4-Chlorophenoxyacetic Acid. Bot. Gaz. 114:107-113.

58. Yamane, G. M. and H. Y. Nakasone. 1961. Effects of Growth Regulators on Fruit Set and Growth of Acerola. Haw. Agric. Expt. St. Tech. Bull. No. 43.

59. _____ and _____. 1961. Pollination and Fruit Set Studies of Acerola Malphigia Glabra L. in Hawaii. Proc. Am. Soc. Hort. Sc. 78:141-147.