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EFFECTS OF GROWTH REGULATORS ON FRUIT SET AND GROWTH OF THE ACEROLA (*MALPIGHIA GLABRA* L.)

G. M. YAMANE
and
H. Y. NAKASONE

Hawaii Agricultural Experiment Station, University of Hawaii

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THE AUTHORS

G. M. YAMANE was Assistant in Horticulture at the Hawaii Agricultural Experiment Station, and is presently Assistant Supervisor, Dole Corporation, Lanai City, Lanai.

DR. H. Y. NAKASONE is Assistant Horticulturist at the Hawaii Agricultural Experiment Station and Assistant Professor of Agriculture, University of Hawaii.

EFFECTS OF GROWTH REGULATORS ON FRUIT SET AND GROWTH OF THE ACEROLA (*MALPIGHIA GLABRA* L.)

G. M. Yamane and *H. Y. Nakasone*

INTRODUCTION

Previous studies (manuscript in press)[1] on pollination and fruit set of acerola showed that flowers are produced in great abundance, but actual fruit set is low, the percentage of fruit set ranging from 1.3 to 11.5 percent. The commonly known causes of low fruit set such as dichogamy, inviable pollen, and peculiarities in floral structures such as heterostyly were ruled out in the previous study. Incompatibility, another common cause of low fruit set, was found to be present to some degree. Hand pollination was shown to increase yields, with cross pollination effecting significantly greater yields than self-pollination, indicating a higher degree of self-incompatibility. The ineffectiveness of pollen-disseminating agents such as wind and insects was found to be the major cause of low fruit set of the acerola in Hawaii. Ledin's report (*15*) indicates that in Florida large populations of bees are found working among the acerola flowers and natural fruit set is relatively high.

The above factors suggested the need to induce fruit set by some artificial means. This study was initiated to determine some chemical means of achieving higher fruit set and to study the effects of such chemicals on the fruiting and flowering behavior of the acerola plant.

REVIEW OF LITERATURE

Prevention of floral abscission and induction of ovary swelling with water extracts of pollen by Fitting (*9*) was the first indication that specific substances were involved in parthenocarpic fruit set. Yasuda (*36*) produced parthenocarpic eggplant fruits with pollen extracts. Thimann (*32*) found that auxins were involved and Gustafson (*11, 12*) induced fruit set and development in tomato, pepper, petunia, and salpiglossis by the application of synthetic growth regulators. The increase in auxin content in the ovaries of *Nicotiana tabacum* immediately after pollination as reported by Muir (*19*) and the findings of Gustafson have shown that it is possible to induce fruit set artificially by application of additional auxins.

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[1] Manuscript entitled *Pollination and Fruit Set of Acerola* submitted to Proc. Amer. Soc. Hort. Sci.

One of the first crops in which growth regulators were used to set fruits when conditions of pollination and fertilization were unfavorable was tomatoes. Under certain environmental conditions, such as low light intensity (*26, 33, 35*) and high day temperatures (*28*), elongation of the pistils takes place and extends beyond the stamens. In these cases, growth regulators were effective and resulted in increased yield and increased fruit size. Others (*13, 14, 21, 22, 27*) have also reported these beneficial results by using growth regulators in fruit setting of tomatoes.

In addition to increased fruit set and production of seedless tomatoes, plant growth regulator sprays have had these effects on vegetable crops such as snapbeans (*23, 34*), on fruit crops such as certain varieties of pears (*2, 10, 24*), Calmyra figs (*5*), and avocado (*30*), and on ornamental crops such as American holly (*3*).

MATERIALS AND METHODS

Materials

Acerola plants used in this study were drawn from various sources. Seedlings from Acc. No. 6663 (sour type) were derived from seeds acquired from the University of Florida in June, 1955. Clone Maunawili (sour type) was obtained from the Hawaiian Sugar Planters' Association Experiment Station. Clone 269-2 (sour type) is a selection from 10 seedlings (P.I. 209269) received from the United States Plant Introduction Garden, Glendale, Maryland. Clones H-5 (sweet type) and 13½ (sour type) are designations of the Hawaiian Acerola Company.

Growth regulators utilized were in crystalline forms. Where the acid forms were used, 95 percent ethyl alcohol was used as the bridging solvent. A small amount of commercial wetting agent (Tween 20) was added to the distilled water solution.

Methods

All preliminary field and laboratory experiments were conducted on the Manoa campus of the Hawaii Agricultural Experiment Station, University of Hawaii. Experiments requiring large numbers of clonal plants were conducted at the Puna orchard of the Hawaiian Acerola Company at Puna, Hawaii.

The following organic compounds were utilized to determine their efficacy in promoting fruit set: 1-naphthaleneacetic acid (NAA) and its sodium salt (NaNAA), 2-naphthoxyacetic acid (NOAA) and its sodium salt (NaNOAA), 3-indoleacetic acid (IAA), 3-indolebutyric acid (IBA), and 4-chlorophenoxyacetic acid (para-chlorophenoxyacetic acid, PCA).

Aqueous growth regulator solutions were applied to branch treatments with a small hand atomizer, and a 4½-gallon knapsack sprayer was used for whole-tree treatments. Where necessary, a plastic screen, 6x12 feet, was employed to minimize drift to adjacent trees.

Fruit set was determined 6 days after application of treatments, fruits at this age being approximately 3/16 inch in diameter.

After it was ascertained chromatographically following methods outlined by Strohecker, *et al.* (*31*) that there were no interfering substances, the iodate titration method after Ballantine (*1*) was used for ascorbic acid determination.

For analysis of data following a binomial distribution, confidence interval tables from Snedecor (*29*) were used. Yield data were summarized by analysis of variance as outlined by Snedecor. The Duncan's multiple range test (*6*) was used to delimit differences between means. Mean weights of fruits were estimated from random samples drawn from each treatment at each harvest.

RESULTS AND DISCUSSION

Selection of growth regulators

Data presented in table 1 show that PCA and IBA were effective in promoting fruit set, the former over a wide range of concentrations and IBA only at 100 ppm. NAA, NOAA, and NaNOAA were ineffective, although NaNOAA was slightly effective at 5000 ppm. Although increase in fruit set was obtained with high concentrations, the fruits were deformed and reduced in size. Fruits set with PCA at 500 and 1000 ppm were highly ridged and small. At lower concentrations, the fruits were less ridged and larger in size, though smaller than those of the controls.

TABLE 1. Mean percent fruit set of acerola treated with five acid and two sodium salt forms of growth regulators (summary of different experiments)

TREATMENTS (PPM)	GROWTH REGULATORS						
	NAA	IBA	IAA	NaNAA	PCA	NaNOAA	NOAA
0	0	.5	19.5	4.8	4.8	0	4.3
10	2.4	.6	16.0	7.3	33.8	3.8	0
50	2.1	2.7	15.8	6.2	88.2	0	0
100	0	61.5	15.2	13.1	89.0	0	0
500	–	–	–	9.0	86.7	–	–
1000	0	–	–	–	82.4	–	–
5000	0	4.0	12.8	22.0	–	13.7	–

Although tremendous increase in fruit set was realized with PCA, undesirable effects in the form of leaf curling and yellowing of vegetative terminals resulted. Figures 1 and 2 show the curling effect of PCA on the terminal leaves. Mature leaves sprayed with PCA showed no effects. Only young leaves and leaves which appeared after application of the chemical were affected (fig. 2). In severe cases the terminals turned yellow and ultimately died. The severity of these conditions was related to the concentration used. At 10 and 50 ppm, leaf curling was less pronounced and less time was required for leaves to return to normal.

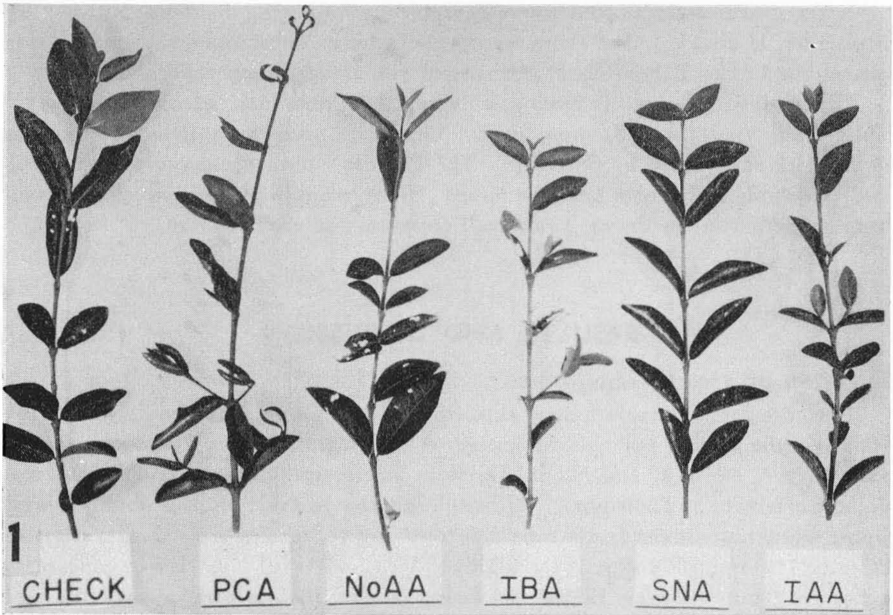


FIG. 1. Leaf curling effects of five growth regulators. Only PCA caused leaf curling.

FIG. 2. Check group of branches on the left. Severe effects from 100 ppm PCA on young expanding shoots.

In the case of IBA, no leaf curling or yellowing of terminals was present. Fruits, on the other hand, showed ridging and slight deformity. The other growth regulators tested did not produce any visible phytotoxic effects as in the case of PCA.

Growth regulator treatments appeared to improve the firmness of the fruits. Fruits set by treatments were solid and did not bruise as easily as those from natural set. This may be an important consideration from the standpoint of post-harvest handling of fruits when acerola is grown for ascorbic acid production. Ponting and Joslyn (25) have reported that ascorbic acid is more readily oxidized when the exocarp of apples is bruised or broken.

As has been demonstrated with tomatoes (26), the use of growth regulator sprays did not alter the ascorbic acid content of the acerola fruit. This is clearly shown in table 2. There was no real difference in the ascorbic acid content between open-pollinated fruits and PCA-treated fruits.

TABLE 2. Ascorbic acid content (mg. per 100 gm.) of acerola fruits from open pollination and PCA treatment (100 ppm)

PLANT	OPEN POLLINATION (MG. PER 100 GM.)	PARA-CHLOROPHENOXYACETIC ACID (MG. PER 100 GM.)
R3-T1	1998	1795
R4-T2	2038	1961
R4-T4	1989	2073
R4-T6	1936	1980
R4-T8	2193	2138
4-14	2156	2046
8-11	1894	1771
12B-15	1510	1610
13-26	2195	2210
14-22	2276	2028
20-46	1635	1710
21-26	1730	1672
23-33	1908	2064
25-14	1512	1725

Since PCA was most effective for fruit set, further studies were conducted with PCA and the derivatives of the phenoxyacetic series. IBA was also used in field tests for comparative purposes and will be reported in a later section.

Comparison between the acid and salt forms of PCA

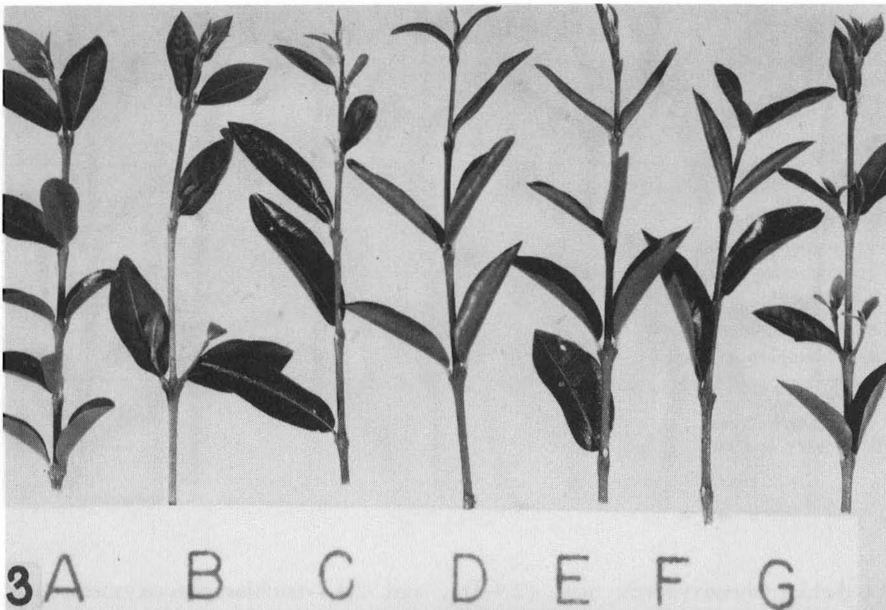
To determine whether or not the salt form of PCA was equally effective as the acid form in fruit setting and to ascertain its phytotoxic properties, both forms were tested on open flowers. The results tabulated in table 3 show that the acid form was superior to the salt form. These results, which are not obviously explainable on the basis of comparable molarities of acid equivalents, are in agreement with those reported by Griggs, *et al.* (*10*), using 2,4,5-trichlorophenoxypropionic acid and its alkonalamine salt on the fruit set of pears. In phytotoxic effects, visual observations of vegetative plant parts showed the occurrence of leaf curling on trees sprayed with both forms and the degree of curling was related to concentration.

TABLE 3. Percent fruit set of acerola treated with acid and sodium salt forms of para-chlorophenoxyacetic acid (PCA) (Maunawili Clone)

TREATMENTS (PPM)	ACID			SODIUM SALT		
	pH	Percent Fruit Set	Confidence Intervals, 95 Percent	pH	Percent Fruit Set	Confidence Intervals, 95 Percent
0	5.6	3.33	0–13	5.6	3.33	0–13
10	5.1	35.00	25–52	5.7	50.00	40–67
50	4.5	58.00	50–76	5.8	53.33	45–70
100	4.0	91.66	81–97	5.8	63.33	55–79
500	3.4	85.00	72–92	5.9	60.00	51–74
1000	3.2	63.00	62–83	6.1	61.66	53–78
5000	2.8	35.00	25–52	6.2	13.33	7–27

Comparative effects of six derivatives of the phenoxyacetic acid series

Muir, *et al.* (*20*), using the Avena straight-growth test to assess the relative activity of some of the chlorine-substituted phenoxyacetic acids, reported that changing the number and the positions of the chlorine atoms on the phenoxy ring drastically changed their activities. To determine the types of effects produced by some of the chloro-derivatives of the phenoxyacetic acid series, six compounds were used at 100 ppm, and the different substituents showed greatly different activities as shown in table 4 and fig. 3. The data show that phenoxyacetic acid and 2,6-dichlorophenoxyacetic acid showed no activity at all, and 2-chlorophenoxyacetic acid failed to set fruits and produced but a slight curling of the leaves. Terminals sprayed with these three chemicals are shown in fig. 3, B, C, and G. On the other hand, 4-chlorophenoxyacetic acid (PCA),



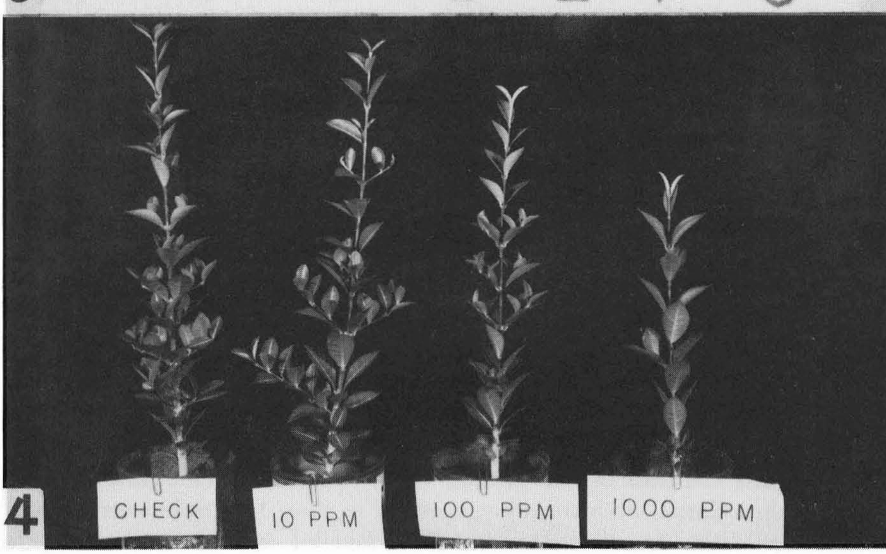


FIG. 3. Terminal leaf deformation by spraying six compounds of the phenoxyacetic acid series. A. control; B. phenoxyacetic acid; C. 0-chlorophenoxyacetic acid; D. p-chlorophenoxyacetic acid; E. 2,4-dichlorophenoxyacetic acid; F. 2,4,5-trichlorophenoxyacetic acid; and G. 2,6-dichlorophenoxyacetic acid.

FIG. 4. Terminal leaf curling and stunting of growth when three concentrations of PCA solutions were fed to seedlings through the roots.

TABLE 4. Percent fruit set of acerola treated with growth regulators of the phenoxyacetic acid series (100 ppm)

TREATMENTS	NUMBER OF FLOWERS	NUMBER OF FRUITS SET	PERCENT FRUIT SET	CONFIDENCE INTERVALS, 95 PERCENT	PHYTO-TOXIC EFFECTS
Control	158	7	4.43	1.0–9.0	–
Phenoxyacetic	162	5	3.08	1.0–8.0	–
2-chlorophenoxyacetic	153	3	1.96	0.0–7.0	+
4-chlorophenoxyacetic (PCA)	147	106	72.10	63.0–80.0	++
2,4-dichlorophenoxyacetic	162	107	66.04	57.0–74.0	++
2,4,5-trichlorophenoxyacetic	179	83	46.36	37.0–55.9	+
2,6-dichlorophenoxyacetic	189	11	5.82	2.0–12.0	–

– Normal
\+ Slight leaf curl
++ Heavy leaf curl

2,4-dichlorophenoxyacetic acid (2,4-D), and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) were highly active, although the latter was least active in setting fruits and in inducing leaf curling. Figure 3, D, E, and F show the leaf curling effects of PCA, 2,4-D, and 2,4,5-T, respectively. In the case of the former two compounds, leaves two to five nodes below the terminal were also affected when sprayed with 100 ppm.

Studies with tomatoes (*28*, *35*), figs (*5*), and pears (*10*) have shown that immature leaves appearing after application of growth regulators (PCA, 2,4-D, 2,4,5-T) resulted in abnormalities, while fully expanded leaves were not affected.

Comparative test between PCA and IBA under field conditions

Since flowering and vegetative flushing occur at approximately the same time in acerola, increasing fruit set with PCA has caused undesirable effects upon the young expanding shoots. Since IBA, at levels effective in fruit set, did not show these concomitant ill effects, a field comparison of the two chemicals was initiated at the Puna orchard.

Treatments consisted of the control, PCA, and IBA in randomized blocks, replicated three times. Each treatment consisted of three 3-year-old trees of clone H-5. When yields for all treatments were compiled and summarized, results showed that significant differences existed among the treatments (mean yields: control, 45 gm.; IBA, 1402 gm.; and PCA, 2840 gm.). PCA treatment gave twice as many fruits as the IBA treatment.

Differences in the mean weight of fruits were also obtained (table 5). The inverse relationship between mean fruit weight and total yield was apparent in all treatments.

TABLE 5. Ranked order of mean weight (gm.) per fruit of clone H-5 set by open pollination, indolebutyric acid and 4-chlorophenoxyacetic acid

	TREATMENTS (100 PPM)		
	PCA	IBA	Control
MEANS	2.30	3.62	5.46

Note: Difference between any two means not underscored by the same line is significant at the 1 percent level.

Examination of terminal leaves on trees of both treatments showed that while young expanding leaves of PCA treatment were curled with some tips turning yellow, similar aged leaves and terminals of the IBA treatment were completely free from these symptoms.

Receptivity at different stages of blossom development to growth regulator (PCA)

The receptivity of the flowers over a wide range of development determines to a great extent the yield and the time interval between spray applications, if more than one is required. Roberts and Struckmeyer (*27*) and Leopold and Scott (*16*) reported that auxin sprays were effective in inducing fruit set over a wide range of blossom development in tomatoes, i.e., from small unopened buds to abscission of flowers.

In preliminary spray studies with PCA, it was noted that greater numbers of fruits were reaching maturity over longer periods than that found in untreated trees. This seems to indicate that flowers in different stages of development were affected. To establish definitely whether acerola blossoms reacted to growth regulators as did tomato blossoms, PCA at 100 and 500 ppm was applied to blossoms at different stages of development. Flower buds 2 days and 1 day before anthesis, and flowers at anthesis and 1 and 2 days after anthesis were used in this study.

When the results (table 6) were analyzed, significant differences in fruit set were shown with the different stages of blossom development and with the concentrations of PCA. Flowers at anthesis were significantly more receptive to PCA than flower buds and flowers after anthesis, and there were no differences in response to 100 and 500 ppm treatments. However, differences in responses to different concentrations at other stages of development indicate that flowers before and after anthesis require greater stimulation than flowers at anthesis.

Although the data indicate that 500 ppm was superior to 100 ppm in fruit setting ability, use of higher concentrations is not warranted because of increased detrimental effects to the trees and to the fruits. As will be shown below, maximum yields from each flowering cycle can be obtained with one application of growth regulator spray, provided the spray is applied during peak flowering.

TABLE 6. Relative effectiveness of growth regulator spray (PCA) on fruit setting of acerola at different stages of blossom development (Maunawili Clone, 60 flowers per treatment)

ANTHESIS TIME	NUMBER OF FRUITS SET AT THE FOLLOWING CONCENTRATIONS OF GROWTH REGULATOR			PERCENTAGE OF FRUIT SET	CONFIDENCE INTERVALS, 95 PERCENT
	Control	100 ppm	500 ppm		
2 days before	1	6	28	19.64	13–26
1 day before	2	25	34	33.88	27–42
Anthesis	4	52	51	51.66	44–60
1 day after	0	24	31	30.55	22–39
2 days after	0	0	0	0.00	0–3
Percent set	2.33	35.66	48.00		
Confidence intervals, 95 percent	1–5	30–42	42–54		

Translocation of growth regulator

The use of growth regulators to induce fruit set in commercial orchards raises the question of whether or not each flower must be sprayed directly for setting. Absorption and translocation of growth regulators within the plant are suggested as being conditioned by certain factors (*4, 7, 17*). The direction of translocation appears to be controversial with Mitchell and Brown (*17*) and Mitchell and Hamner (*18*), reporting that only downward movement took place in the stem; whereas Ennis and Boyd (*8*) stated that translocation, both upward and downward, was influenced by the concentration of the growth regulator and by the addition of Carbowax (polyethylene glycols).

To determine whether growth regulators applied to one flower were absorbed and translocated to another, one of a pair of flowers in each of several inflorescences was treated with PCA at 100 ppm. The pronounced difference in fruit set between treated (76.3 percent) and untreated (6.3 percent) indicated clearly that the growth regulator was not translocated to the untreated flower of the pair to effect fruit set.

To determine whether growth regulator was absorbed by the leaves and translocated to the flowers to effect fruit set, all expanding and mature leaves on several tagged branches were swabbed with 100 ppm PCA at the onset of flowering. Other branches of similar age and size on the same trees were designated as control. The PCA solution resulted in leaf curling only on expanding leaves of the treated branches and did not induce any fruit to set. These results indicated that the growth regulator was absorbed by the leaves but was ineffective in inducing fruit set.

When three concentrations of PCA (10, 100, 1000 ppm) solutions were fed to seedlings through the roots, leaf curling and stunting of growth resulted. Figure 4 shows plants treated with three concentrations compared with the control. Growth was inhibited in relation to the concentration used. The terminals and leaves at the apex of the plants treated with 100 and 1000 ppm showed yellowing and eventually died.

When PCA at the same three concentrations used above was fed to flowering plants growing in cans, flowers were not stimulated to set by systemic means, although translocation took place as indicated by curling and yellowing of terminal leaves. For induction of fruit set, each flower must receive the growth regulator solution directly.

Effect of PCA spraying on flowering cycle

It is well known in fruit crops such as apples, pears, and mangos that high yields in one year affect the yields of the following year. With a heavy crop set artificially with growth regulators in the acerola, the question arises as to the yields in subsequent flowering cycles. Undoubtedly, not only will the quantity of flowers be affected but the frequency of flowering may also be changed.

To ascertain these factors, field experiments were conducted in the Puna orchard. Treatments consisted of spraying different trees with PCA (100 ppm) at one flowering cycle and also at two successive flowering cycles. The trees used were approximately 3½ years old (clone 13½). Each treatment plot consisted of three trees, replicated five times. Since it was not practical to count the number of flowers appearing at each flowering cycle, the fruit yields were used to indicate floral production. All fruits harvested during the period of this study (June 26 to September 25, 1959) were recorded on the basis of individual trees, and in the analysis of data, a single mean from each treatment was derived for each harvest period. A summary of the data is presented in table 7.

The results showed that highest yields were obtained from the treatment in which two successive flowering cycles were sprayed, followed by those sprayed at one flowering cycle. Total yield of the control plots was very low in comparison to the treated plots.

It was also found that subsequent flowering cycles of trees from the treated plots were delayed considerably. Normally in Hawaii, acerola flowering cycles occur approximately every 20 to 28 days, as shown by the intervals between cycles for the control trees. Peak flowering occurs 3 to 6 days after the initial flowering. One spraying of PCA at the first flowering cycle induced a tremendous increase in fruit set and delayed the second flowering cycle by approximately 18 days, when compared to the interval between first and second cycles of the controls. On the second flowering cycle, the yield of the treatment receiving only one spraying at the initial cycle was reduced to approximate the yield of the control. This seems to indicate that residual effects of the growth regulator were no longer present. Trees in this treatment also reverted to normal flowering cycle in the third and fourth cycles, with yields comparable to the control trees.

The treatment receiving another spray of PCA at the second flowering cycle again showed a high yield, though only half of that produced in the first flowering cycle. This reduction in yield in the second flowering cycle resulted from a rather heavy decrease in flowering after growth regulator application. The delay

TABLE 7. Effects of PCA (100 ppm) on flowering cycle and yield of acerola (clone 13½) from June 26 to September 27, 1959

TREATMENTS	1ST FLOWERING (INITIATION OF STUDY)	MEAN YIELD (GM.)	2ND FLOWERING DATE	NO. OF DAYS FLOWERING DELAYED	MEAN YIELD (GM.)	3RD FLOWERING DATE	NO. OF DAYS FLOWERING DELAYED	MEAN YIELD (GM.)	4TH FLOWERING DATE	NO. OF DAYS FLOWERING DELAYED	MEAN YIELD (GM.)	5TH FLOWERING DATE	TOTAL MEAN YIELD (GM.)
Control	June 26	114.0	July 20	0	82.76	Aug. 11	0	96.92	Sept. 2	0	68.70	Sept. 25	362.38
Sprayed once	June 26	2,617.92	Aug. 7	18	103.43	Sept. 2	0	94.98	Sept. 25				2,816.33
Sprayed twice	June 26	2,786.96	Aug. 7	18	1,434.66	Sept. 27*	25						4,221.62

* Estimated.

in the second flowering cycle was the same as that of the one-spray treatment. With the application of PCA spray at the second cycle, the third flowering cycle appeared 49 days later, a delay of 25 days from normal flowering. Because of the delay in the appearance of the third cycle, no yield records were obtained.

The number of flowering cycles for the three lots of trees from June 26 to September 27 is worthy of note, especially when related to the total yields. The control trees growing under normal conditions produced five flowering cycles during this period. When trees were sprayed once during the initial flowering cycle, there were four cycles produced within the same period. When the first and second cycles were sprayed, the number of cycles was reduced to only three. With only three flowering cycles during the period of the investigation, the total yield was almost twice that of the once-sprayed lot and more than 11 times that of the control lot.

In a separate experiment, lower concentrations of PCA (25, 50, 75, and 100 ppm) were tried under field conditions for a period of one flowering cycle to determine differential effects on flowering and fruiting. In table 8 are presented data on mean yields and mean weights of fruits derived from the various treatments.

TABLE 8. Ranked order of mean yields and fruit weights of acerola sprayed with four concentrations of PCA

	TREATMENTS (PPM)				
	Control	25	50	75	100
MEAN YIELD (GM.)	141.0	751.2	2910.0	2845.8	4055.1
	75	100	50	25	Control
MEAN WEIGHT PER FRUIT (GM.)	2.3	2.6	2.7	3.2	4.6

Note: Difference between any means not underscored by the same lines are significant at the 1 percent level.

As expected, 100 ppm treatment gave the highest yield. There was no real difference in yields between 50 and 75 ppm treatments, but they were superior to the yields of the 25 ppm treatment and the control.

As in previous trials, mean fruit weight decreased with increase in yield. Figure 5 shows the reduction in size of fruits set with four concentrations of PCA and the lower half of table 8 shows the mean weights in ranked order. Among the three higher concentrations, there were no significant differences in mean weight of fruits.

Recovery of flowering cycle and affected leaves was related to the concentration of PCA. Trees of the 25 ppm treatment reverted to normal flowering with moderate to heavy flowering 4 to 6 days after harvesting the crop set with PCA 22 days before. During this period, trees treated with 50 ppm produced

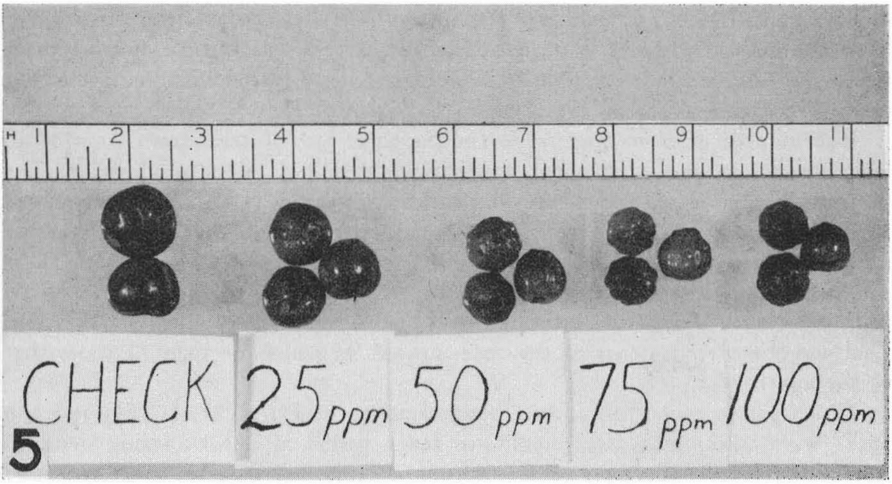


FIG. 5. Reduction of fruit size with increasing concentration of PCA.

scattered flowers only on branches that had not flowered during the previous cycle when sprays were applied. Trees sprayed with 75 and 100 ppm did not produce any flowers for this period and heavy flowering did not occur until 28 days after harvesting the crop set by spraying. At this time all treatments were again in peak flowering.

Leaf curling effects were relatively light at concentrations below 50 ppm. Twenty-four days after application of sprays, only a few leaves were slightly curled on these trees, whereas those sprayed with 75 and 100 ppm were still severely curled. Further observations made 41 days after spraying showed that leaves of all sprayed trees had recovered, except those sprayed with 100 ppm which showed slight leaf curling.

The larger yields from fewer harvests as shown by the different experiments discussed above would undoubtedly reduce operational costs and increase efficiency. However, the effects of such a harvest pattern on other horticultural practices and the effects of longer terms of application of growth regulators will require further study.

SUMMARY

The low natural fruit set of acerola in Hawaii, attributed to absence of pollen-transferring agents, indicated the feasibility of growth regulator application to induce fruit set. Among the several growth regulators tried initially, 4-chlorophenoxyacetic acid (PCA) and indolebutyric acid (IBA) were found to be effective in promoting fruit set, the former being more efficient over a wider range

of concentration. PCA exhibited some phytotoxic effects in the nature of leaf curling, yellowing, and even death of young vegetative tips. Phytotoxic effects were reduced in severity with decrease in concentration. IBA at 100 ppm effected approximately 60 percent fruit set without any apparent phytotoxic effects.

PCA treatments did not affect the ascorbic acid content of the fruits. However, there was a reduction in fruit size and weight when growth regulators were used. The other effects on the fruits were increased firmness and ridging of the fruit surface.

When six derivatives of the phenoxyacetic acid series were tested for their fruit setting ability and phytotoxic properties, it was found that 4-chlorophenoxyacetic acid and 2,4-dichlorophenoxyacetic acid induced the highest fruit set percentage as well as phytotoxic effects. 2,4,5-trichlorophenoxyacetic acid was approximately two-thirds as effective as PCA and 2,4-D in fruit set and less severe in phytotoxic effects. The other three compounds, phenoxy-, 2-chloro-, and 2,6-dichlorophenoxyacetic acids, were ineffective in both fruit setting and leaf curling.

Under field conditions the satisfactory fruit set and lack of phytotoxic effects with IBA at 100 ppm make this a highly desirable compound, but the wide use of it may be prohibited by its high cost. On the other hand, PCA at 50 ppm can induce as much fruit set as IBA at 100 ppm, and phytotoxic effects are mild with early recovery. Furthermore, the very low cost of this material makes its use economically feasible.

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UNIVERSITY OF HAWAII
COLLEGE OF TROPICAL AGRICULTURE
HAWAII AGRICULTURAL EXPERIMENT STATION
HONOLULU, HAWAII

LAURENCE H. SNYDER
President of the University

MORTON M. ROSENBERG
Dean of the College and
Director of the Experiment Station