Selection, Evaluation, and Naming of Acerola (*Malpighia glabra* L.) Cultivars

H. Y. Nakasone, G. M. Yamane, and R. K. Miyashita

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COVER PHOTO

Red Jumbo Variety, 2 years old.

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THE AUTHORS

DR. HENRY Y. NAKASONE is Associate Horticulturist at the Hawaii Agricultural Experiment Station and Associate Professor of Horticulture, College of Tropical Agriculture, University of Hawaii.

MR. GEORGE M. YAMANE was Assistant in Horticulture in the Department of Horticulture from July 1958 to July 1960.

MR. ROBERT K. MIYASHITA was Assistant in Horticulture in the Department of Horticulture from July 1960 to July 1963.

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INTRODUCTION

Since the discovery of high amounts of ascorbic acid (vitamin C) in the acerola by Asenjo and de Guzman in 1946 (*2*), considerable interest in its commercial potentialities has been shown by horticulturists and food processors. To support industrial development, research in selection, culture, and processing has been conducted in Puerto Rico, Florida, and Hawaii.

The wide variations in fruit and ascorbic acid yields found among seedling populations emphasize the need for improved clones for commercial plantings (*1, 8, 9*). Commercial processing potential is indicated by researches in juice extraction, processing, and ascorbic acid retention in Puerto Rico (*12*) and Hawaii (*6*). Fitting and Miller (*6*) have shown that acerola juice blends well with juices of pineapple, guava, and passion fruit with no deterioration of color and flavor and with superior retention of ascorbic acid under frozen storage. Miller *et al.* (*11*) also reported on the nutritive value of the fruit and the numerous methods of home usage.

Research results suggest the value of acerola as a backyard crop and as a potential crop in the processing industry. In Puerto Rico the acerola is a commercial crop supplying the food industry on the mainland United States. In Hawaii the first commercial orchard, composed largely of unselected seedlings and inferior clones, was established in 1956. To support this infant industry, a selection and testing program was initiated and continued even after the termination of the commercial venture in 1963.

DESCRIPTION

The genus *Malpighia* is one of the 55 genera in the family Malpighiaceae, distributed mostly in Central America and the West Indies. According to Ledin (*10*), only *M. glabra* and *M. mexicana* of the approximately 40 species have large edible fruits.

M. glabra is referred to as Barbados Cherry in Florida (*10*) and West Indian Cherry and Acerola in Puerto Rico (*1, 2, 8*). The name Acerola has been used exclusively in Hawaii.

This plant is a shrub which may be pruned to a single trunk to form a small tree. There is much variation in growth habit, especially among the sour types. Its growth varies from semiprostrate to compact or open types with upright, spreading, or reclining branches. Figures 6 to 10 show a few variant forms. The sweet types are generally alike with rank growth and multiple leaders widely spread and easily torn by winds. Figures 1 to 3 show trees of sweet type which have been trained. In both types, branches are characterized by short lateral spurs.

Leaves are simple, entire, and of opposite arrangement. Size varies but, on the average, they range from 1 to 1½ inches wide and 2 to 2½ inches long. Leaves of trees grown in shade are much larger. In shape they range from elliptical to oval, and ovate with apiculate apex. Young leaves and stems are somewhat hairy.

Flowers are ¾ to 1 inch in diameter with 5 petals ranging in color from white to dark pink, depending upon the clone. There are 10 stamens, 3 styles, and 3 carpels fused into a superior ovary. Flowers are produced in clusters from axils of leaves on new terminals and on lateral spurs. In Hawaii, flowering occurs in cycles approximately a month apart, commencing in April and continuing into November or later.

Fruits mature in approximately 3 weeks after the date of floral anthesis. The fruit resembles the true cherry but it is a three-carpellate drupe. On the surface the three carpels are shown faintly by three very shallow lobes. Figures 4, 5, and 11 to 14 show mature fruits of several clones. Inside are three stones, or pyrenes, each capable of containing a seed. The color of mature fruit ranges from orange-red, red, to deep purplish-red. The skin is delicate and may be easily bruised.

MATERIALS AND METHODS

Accession of seeds, seedlings, and clones

Enough seeds were obtained from the University of Miami, Florida, to grow approximately 1,000 seedlings. In addition around 1,000 seedlings of the variety B-17 from Puerto Rico were received from Mr. Raymond Haley of Oahu. Other accessions consisting of varying quantities of cuttings from experimental and established clones were received from the Plant Introduction Garden, Glendale, Maryland; Florida; Puerto Rico; and local sources. These plants were established on the University of Hawaii Campus, Honolulu, and at the Waimanalo Experimental Farm, Oahu, for testing.

Selection and evaluation methods

Selection—The principal objective in the original selection was based upon high ascorbic acid production. It was found that the sour types produced higher yields of fruit and larger quantities of ascorbic acid than the

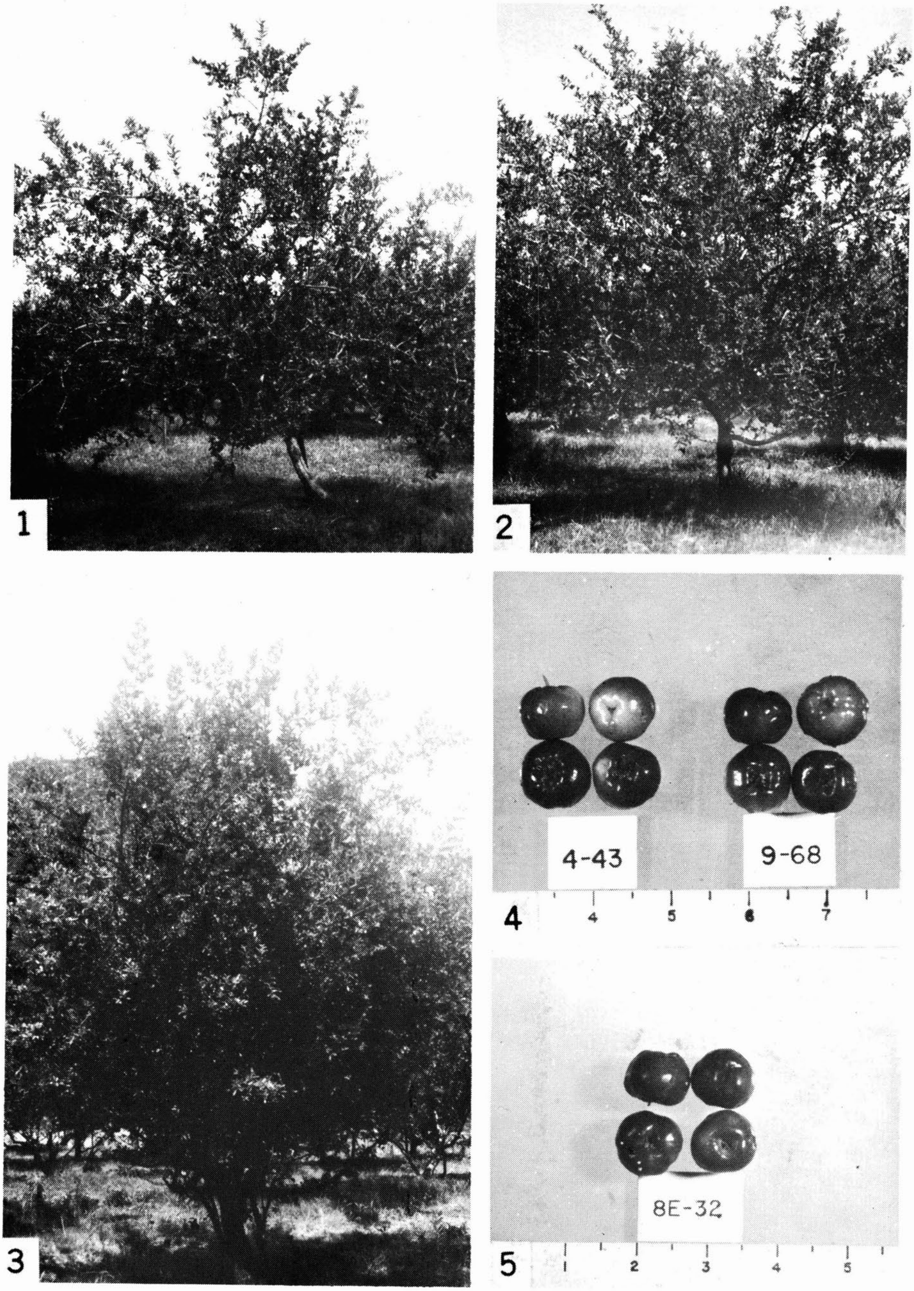

PLATE I

FIGURES 1, 2, 3: Four-year-old trees of the sweet varieties—*Manoa Sweet* (4-43), *Tropical Ruby* (9-68), and *Hawaiian Queen* (8E-32), respectively.

FIGURE 4: Ripe fruits of *Manoa Sweet* and *Tropical Ruby*.

FIGURE 5: Ripe fruits of *Hawaiian Queen*.

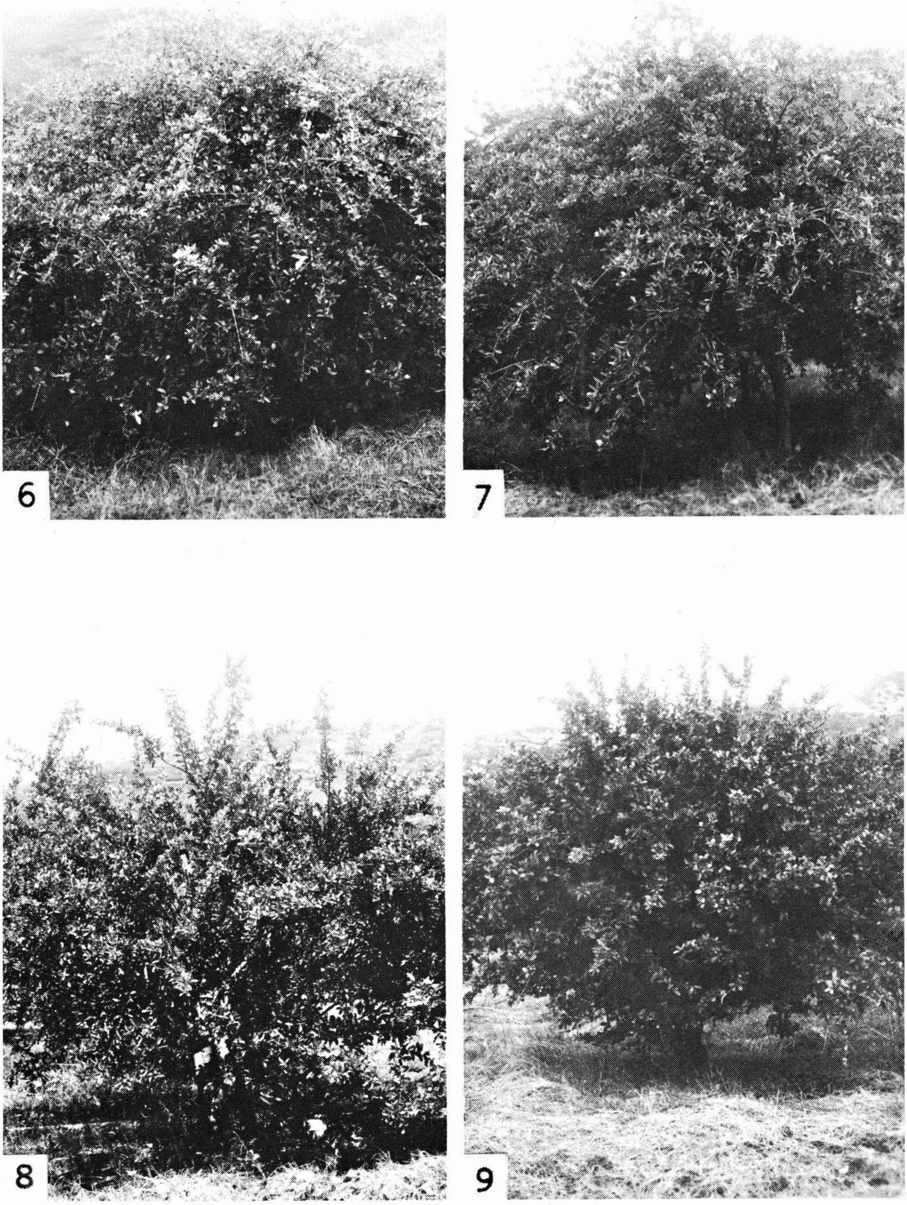

PLATE II

FIGURES 6, 7, 8, 9: Four-year-old trees of sour varieties—*J. H. Beaumont* (3B-21), *C. F. Rehnborg* (22-40), *F. Haley* (3A-8), and *Red Jumbo* (3B-1), respectively.

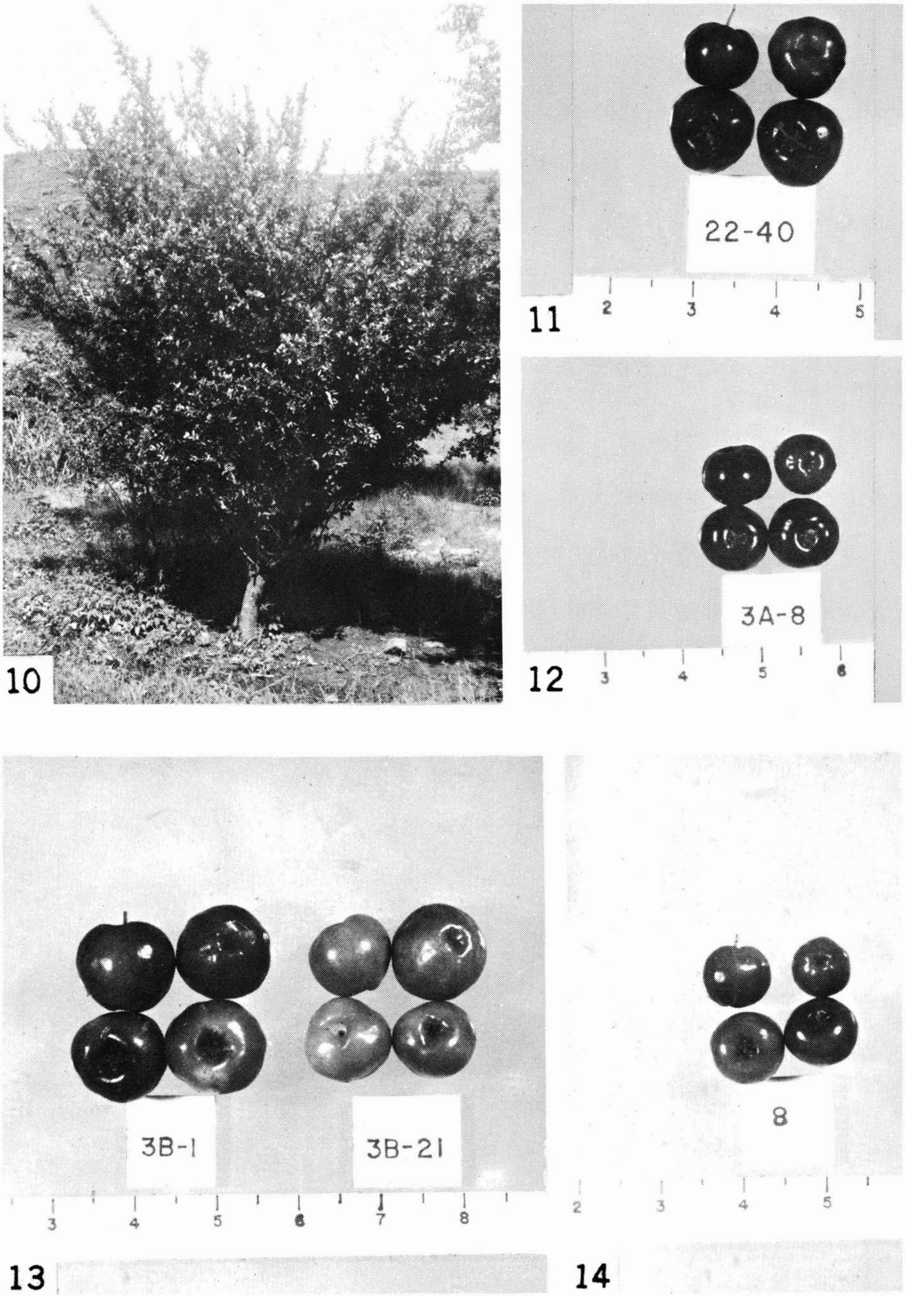

PLATE III

FIGURE 10: Four-year-old trees of *Maunawili* (No. 8).
FIGURES 11, 12: Ripe fruits of *C. F. Rehnborg* and *F. Haley,* respectively.
FIGURE 13: Ripe fruits of *Red Jumbo* and *J. H. Beaumont.*
FIGURE 14: Ripe fruits of *Maunawili.*

sweet types. Fortunately, sour types are also preferred for general processing such as for juices and purees, and the selections based upon the original criteria are adapted to this purpose.

Since seedlings exhibited much variation in growth habits, selection of plants conducive to economical orchard management was carefully considered.

Observations of acerola culture during the past few years in the Puna area of Hawaii, where rainfall is relatively high (90 to 120 inches per year), indicate that the principal disease is the *Cercospora* Leaf Spot, caused by *Cercospora bunchosiae* Chupp and Muller (*7*). Inasmuch as the occurrence of this disease on the campus in Honolulu and in the Waimanalo area of Oahu was almost nonexistent due to lower rainfall, the same selections were also planted in Puna, Hawaii, to observe the incidence of this disease.

Evaluation—Rooted cuttings of seedlings selected for final evaluation were grown and transplanted in three areas:

a. Waimanalo Experimental Farm—18 selections, 3-tree plots, four replications in randomized complete blocks. Orchard was planted in July 1959.
b. UH Campus—15 selections (all sour types), 1-tree plots, six replications in randomized complete blocks. Orchard was planted in August 1959.
c. Puna, Hawaii—17 selections, 3-tree plots, five replications in randomized complete blocks. Orchard was planted in July 1959. Detailed data were not taken from this orchard due to frequent injuries caused by weedicides.

Methods of taking data

a. Ascorbic acid analysis—The iodate titration method after Ballantine (*4*) was used for all ascorbic acid determinations. Fully ripened fruits, approximately 21 to 22 days after floral anthesis, were washed and mashed through a cone-shaped colander to extract a juice-puree mixture. Twenty-gram samples of this extract were used for analysis and the final calculations were based upon 100 grams of fresh puree.

   Whenever possible, fruit samples were analyzed soon after harvest. Otherwise, they were frozen as soon as possible after harvest. Fruits picked on the UH Campus were frozen within 1 hour after harvest while those harvested at Waimanalo Farm had a time lapse of 2 to 4 hours between harvest and freezing. Harvested fruits left in the field under direct sunlight for 4 hours may lose as much as 75 mg of ascorbic acid. Care was taken to leave the fruits in a cool, shady area until they were brought into the field laboratory for freezing, to minimize loss of ascorbic acid. Three samples from each tree were analyzed three times a year.
b. pH and total soluble solids—These data were taken from puree samples at the time of ascorbic acid analysis, with a Beckman Model N pH meter and a hand refractometer, respectively.

c. Yield records—Yields were taken on alternate days by hand-picking only fully colored fruits. In 3-tree plots, fruits from all 3 trees were combined and the average yield per tree was calculated.
d. Puree percentage—Puree percentages were determined by using the Langsenkemp pulper with steel blades, using a 0.060-inch screen. This was followed with a Langsenkemp finisher with rubber blades, using a 0.020-inch screen.
e. Whenever feasible, data were summarized by analysis of variance as outlined by Snedecor (*13*), and the Duncan's multiple range test (*5*) was used to delimit differences between means.

RESULTS AND DISCUSSION

Results of the various factors studied are presented on the basis of comparison between sweet and sour clones and between clones of the same type.

Ascorbic acid range of sour and sweet types

Taste tests showed that the proportion of sour-type seedlings far exceeded that of the sweet type in the population studied and that the ascorbic acid content of the latter type was lower than that of the former type.

In order to show the range of ascorbic acid content of the two types and the mode of distribution of the seedlings according to ascorbic acid content within this range, 110 sweet and 560 sour types were randomly picked and grouped into six ascorbic acid classes as shown in table 1. The distribution range for the sweet type extended from less than 999 mg to 1999 mg. Within this range, 14.5 percent of the seedlings fell into the 0 to 999 mg class, 65.5 percent in the 1000 to 1499 mg class, and 20 percent in the 1500 to 1999 mg class. None of the sweet-type seedlings exceeded the latter class, indicating that this may be the maximum limit for this type.

The distribution range of the sour type was found to be broader with the upper limits approaching 3000 mg. The minimum level was the same for both sour and sweet types. Approximately 10 percent of the population fell into the 0 to 999 mg class and 8 percent into the 2500 to 2999 mg class, with the remaining 82 percent being distributed among the three classes falling between the minimum class and the 2500 to 2999 mg class. While individual sample assays exceeding 3000 mg were obtained for a few seedlings, none could maintain an average ascorbic acid content over 3000 mg.

Weight of fruit

Size of the fruit is presented here in terms of average weight per fruit in grams (gm). Table 2 shows the average weight of the sweet clones while table 3 shows that of the sour clones. Variation in average fruit weight is found to be greater among the sour clones than among the sweet clones, ranging from 3.3 gm to as high as 9.3 gm.

TABLE 1. Distribution of sour and sweet types into six ascorbic acid classes

Types	Ascorbic acid classes (mg/100 gm puree) 0–999	1000–1499	1500–1999	2000–2499	2500–2999	Over 3000	Total number seedlings
Sweet							
Number	16	72	22	0	0	0	110
Percent	14.5	65.5	20.0	0.0	0.0	0.0	100.0
Sour							
Number	54	178	206	78	44	0	560
Percent	9.6	31.8	36.8	13.9	7.9	0.0	100.0

TABLE 2. Performance data for seven sweet acerola clones

Clones	Average wt/fruit (gm)	Average pH juice	Average total soluble solids (percent)	Ascorbic acid average of 2 years (mg/100 gm)	Average fruit yield† (lb) 1960	1961	Natural fruit set (percent)
4-43	6.2^{a*}	3.6	10.0	1537	2.6	17.2^{a**}	18.0
9-68	7.2^{a}	3.5	9.0	1437	2.1	11.7^{ab}	15.0
10-36	5.7^{ab}	3.5	9.3	1440	1.4	5.3^{b}	20.0
4A-8	5.9^{ab}	3.4	8.5	1521	2.3	8.2^{b}	15.0
8E-32	6.1^{a}	3.5	9.6	1577	2.5	11.2^{ab}	8.7
9-11	5.2^{b}	3.6	11.0	1487	0.61	7.6^{b}	10.9
Florida Sweet	5.9^{a}	3.5	9.9	1464	2.7	9.6^{b}	8.0

†Yields presented are natural yields; not chemically induced.
*Means assigned the same letters do not differ significantly at P = 0.05.
**Means assigned the same letters do not differ significantly at P = 0.01.

The average fruit size of 9.3 gm for 3B-1 is largest among all clones tested. This clone has produced occasional fruits as large as 14 gm per fruit. While the large fruit size of clone 3B-1 is desirable, fruit weight over 5 gm may be considered acceptable from the practical standpoint.

In the sweet clones, size range was narrow, although statistical differences at $P = 0.05$ were shown. Selected clones with the exception of 9-11 compared favorably with Florida Sweet, an established clone in Florida.

pH of juice and total soluble solids

These two factors are considered here because of their close relationship. The data on pH and total soluble solids for the sweet clones are presented in table 2, columns 3 and 4; while those of sour clones are presented in table 3, columns 2 and 3. The pH of the two types is fairly well defined with sweet clones being above 3.4 and the sour clones being lower than 3.3.

Using total soluble solids as an approximate measure of sugars in the juice, the data show that both sour and sweet types do not differ in this factor except for the fact that the range is much wider in the former clones.

Mean fruit yield and natural fruit set

Data on fruit yields and natural fruit set percentages for the sweet and sour clones are given in tables 2 and 3, respectively. In considering the yield data, it must be realized that the trees were planted in July (UH Campus plots) and August (Waimanalo), 1959, with rooted cuttings approximately 6 months old. Although acerola is a rapid grower, the plants did not begin to fruit until the summer of 1960. Therefore, the yields presented for 1960 represent harvests from June to December. The 1961 yields are from March to December.

Differences in the 1960 fruit yields for the sweet clones (table 2) fell short of statistical significance at $P = 0.05$. Real differences appear in the 1961 yield data (table 2), with clone 4-43 outyielding all other clones. The differences in yields of clones 9-68 and 10-36 fell just short of being statistically significant at $P = 0.01$. However, from the practical standpoint, the yields of 9-68 and 8E-32 represent twice the yield of 10-36. The latter clone also gave low yield in 1960. Clone 9-11, on the other hand, showed a 12-fold increase in yield over 1960.

Yield data for the sour clones (table 3) are given for two locations. During 1960, yields of plants grown at Waimanalo were generally higher than those on the UH Campus in Manoa Valley. The difference in the 1961 yields between the two areas was significant ($P = 0.05$), with the UH Campus plots giving greater yields. Clone 22-40 gave consistently higher yields for 2 years at both locations.

The increase in yield between 1960 (1 to 1½ years old) and 1961 (2 to 2½ years old) for all clones is quite substantial, indicating that commercial size crop can be expected after 2 years. While complete yield records were not taken for trees of older age, 5-year-old trees of clones 22-40, 3B-1, and 3B-21 have produced as much as 50 to 60 pounds of fruits at one harvest.

TABLE 3. Summary of fruit and yield data for 11 selected sour acerola clones

Clones	Average pH juice	Average total soluble solids (percent)	Average weight per fruit (gm) (1961)	Natural fruit set (percent)	Mean fruit yield per tree (lb)			
					UH Campus		Waimanalo	
					1960	1961	1960	1961
8	3.1†	8.9†	4.3[ef*]	2.0†	0.4†	18.7[cd*]	2.6[b*]	7.4[def*]
3B-21	3.3	11.0	6.9[b]	10.0	0.6	51.8[ab]	4.5[ab]	25.8[cd]
22-40	3.3	8.3	6.2[bcd]	17.0	6.2	70.6[a]	8.0[a]	69.3[a]
21-28	3.2	11.1	5.5[cde]	4.0	0.9	34.5[bcd]	2.0[b]	5.7[ef]
20-26	3.2	8.7	3.3[f]	12.0	1.6	22.5[bcd]	2.6[b]	18.3[def]
3B-1	3.1	8.7	9.3[a]	2.0	7.3	31.0[bcd]	7.6[a]	25.0[cde]
2A-4	3.3	6.9	4.9[cd]	3.0	0.6	11.3[d]	2.1[b]	3.4[f]
19B-16	3.2	9.1	5.2[cd]	16.0	4.3	45.2[abc]	4.7[ab]	40.4[bc]
3A-8	3.2	8.2	4.5[ef]	13.0	3.3	46.7[abc]	4.7[ab]	13.3[def]
3A-4	3.2	9.0	5.1[cd]	31.0	0.8	33.7[bcd]	6.6[ab]	22.0[cdef]
269-2	3.2	6.8	6.7[bc]	8.0	4.0	52.2[ab]	5.1[ab]	44.5[b]

†Not subjected to statistical analysis in 1960 due to weedicide drift injuries, insufficient replications or sampling.
*Means having the same letters do not differ significantly at $P = 0.01$.

In considering the fruit yields of acerola, it is necessary to consider the natural fruit set percentages since it was shown in previous studies (*14*) that natural fruit set was low due to lack of pollinating agents. It was also shown (*15*) that the application of growth regulators, particularly PCA (parachlorophenoxyacetic acid) at 50 to 100 ppm, increased fruit set by as much as 5 to 10 times the natural set, depending upon the clone.

Fruit set percentages and the actual yields may not be closely correlated as shown by the discrepancies between the two factors for clones 22-40 and 3A-4. The latter possesses almost twice the capacity for natural fruit set as compared to 22-40, but produced only half the yield at the UH Campus plot and a third of the yield at Waimanalo. Clone 3B-1, with similarly low natural fruit set percentage, gave relatively good fruit yields at both locations and in both years. On the other hand, the 1961 yields for clones 8, 21-28, and 2A-4 at Waimanalo were low as expected on the basis of their fruit set percentages.

These factors seem to indicate that in certain clones, by virtue of a high flowering capacity, high yields may be obtained in spite of low natural set. This may explain the relatively good fruit set for clones 3B-1 and 269-2 (table 3).

It is noted that, in general, yields of sweet clones are lower than those of sour clones.

Ascorbic acid studies

Tables 2 and 4 show the results of ascorbic acid assays for the sweet and sour clones, respectively. For the sweet clones the mean ascorbic acid assays for the 2 years were combined since differences between clones and between years were not statistically significant. The six selections tested compared favorably with Florida Sweet, an established cultivar.

For the sour clones the average ascorbic acid assays of 2 years are given for two locations. The differences between UH Campus and Waimanalo assays for 1961 were not statistically significant.

Because the amount of ascorbic acid in the fruit depends to a great extent upon the stage of fruit development, fruit sampling assumes major importance. All assays were conducted with fully ripened fruits, 21 to 22 days after the flowers open. According to previous studies (unpublished data), there could be a substantial difference in ascorbic acid content between 21- and 22-day-old fruits. For this reason, the range of ascorbic acid content is given, together with the means (table 4). This range is merely the lowest and the highest assays recorded during the entire period of study. The means of ascorbic acid assays were calculated from replicated plots in the evaluation test only.

The sour types show a wide variation in mean ascorbic acid content between clones as compared to the sweet clones. Clones 3B-21 and 21-28 gave consistently high ascorbic acid assays. These two clones and 3A-8 showed the highest ascorbic acid readings as indicated in column 3 of table 4.

TABLE 4. Ascorbic acid analysis of 11 selected sour acerola clones

Clones	Ascorbic acid range (mg/100 gm)		Average ascorbic acid content (mg/100 gm puree)				Puree percent	Ascorbic acid per tree (lb) 1961 Waimanalo
			UH Campus		Waimanalo			
	Low	High	1960	1961	1960	1961		
8	1500	2650	1880†	1784[ab*]	2401[cd*]	2010[cd*]	85.0	0.1
3B-21	2200	3200	2539	2350[a]	2816[a]	2820[a]	79.0	0.6
22-40	1600	2600	2030	2028[ab]	2172[bc]	1717[b]	70.0	0.8
21-28	1700	3100	2656	2352[a]	2763[a]	2760[ab]	79.0	0.1
20-26	1700	2900	1971	2281[ab]	2442[ab]	2073[bcd]	—	—
3B-1	1700	2800	1977	2234[ab]	2520[ab]	2183[abcd]	79.0	0.4
2A-4	1200	2600	1387	1603[b]	2417†	1537[d]	—	—
19B-16	1500	2650	1959	1804[ab]	2397[ab]	1643[d]	60.0	0.4
3A-8	1400	2900	2350	2131[ab]	2500[ab]	2663[abc]	81.5	0.3
3A-4	1600	2600	2134	1852[ab]	2168[bc]	1800[d]	78.3	0.4
269-2	1400	2300	1821	1598[b]	1845[c]	1753[d]	73.0	0.6

†Not subjected to statistical analysis due to plant injury, insufficient sampling or replications.
*Means having the same letter do not differ significantly at P = 0.01.

While these high ascorbic acid assays are important, of greater concern from the commercial standpoint is the amount of puree and/or ascorbic acid that can be produced per tree or per acre. For this reason, fruits of nine of the clones were passed through a pulper and finisher, and the calculated puree percentages are presented in table 4. Using these figures together with the mean ascorbic acid content and fruit yields for 1961 (Waimanalo), the ascorbic acid yields on the tree basis were calculated and tabulated in table 4. It is interesting to note that clone 22-40 produced the highest amount of ascorbic acid per tree, due to high fruit yields, despite the relatively low ascorbic acid assay. Clone 21-28, on the other hand, produced low yields of ascorbic acid per tree in spite of a high ascorbic acid assay, due to low fruit yields in 1961 (Waimanalo). For these reasons ultimate selection of horticultural varieties must be based upon a number of related factors.

Ratings for incidence of *Cercospora* Leaf Spot

Cercospora Leaf Spot was first observed in Puna, Hawaii, where the rainfall is approximately 100 inches per year. This was the major disease problem in acerola culture. In severe cases the entire tree may be defoliated.

In table 5 are given the averages of ratings for susceptibility to *Cercospora* Leaf Spot taken at different seasons of the year. The sweet clones showed considerable tolerance to this disease, while the sour clones showed variations in the degree of tolerance. Clones 20-26 and No. 8 showed high tolerance, while clone 269-2 was highly susceptible. A completely disease-free clone was not observed. Clones with ratings lower than 2.5 may be considered acceptable for planting in high-rainfall areas.

TABLE 5. Rating* of sour and sweet acerola clones for susceptibility to *Cercospora* Leaf Spot

Sour clones	Mean rating**	Sweet clones	Mean rating**
8	1.8	4-43	2.0
3B-21	2.0	9-68	2.0
22-40	3.0	10-36	2.0
21-28	2.0	4A-8	2.0
20-26	1.5	8E-32	2.0
3B-1	3.0	9-11	2.0
2A-4	3.7	Florida Sweet	2.0
19B-16	2.0		
3A-8	2.5		
3A-4	3.0		
269-2	4.0		

*Rating index: 1 = none to few scattered leaves with spots; 2 = light spotting up to ¼ of tree; 3 = moderate spotting up to ½ of tree; 4 = heavy spotting, almost entire tree.

**Ratings are average of 15 per clone except for clone 3B-21 which was based upon 4 trees.

Naming of selected clones as horticultural cultivars

Listed here are three sweet and five sour clones selected for naming as cultivars because of their superiority in general performance. Superiority of a few clones such as 3B-21, 3B-1, and 22-40 was easily recognized for several outstanding characters. There are others which were difficult to evaluate since analytical data and yields did not distinguish great differences. In these cases growth habits of the tree, including disease tolerance, played a significant part in ultimate selection.

Names of these new horticultural cultivars together with brief descriptions follow:

Sweet varieties

1. *Manoa Sweet* (4-43). Selected from B-17 seedlings, it has upright, spreading, and open type of growth. It is vigorous, a good yielder, tends to produce multiple leaders, and attains a height of around 15 feet. Fruits are orange-red when fully ripe, sweet, good flavored, and are recommended for home planting. Figures 1 and 4 (4-43) show the tree and fruits, respectively.
2. *Tropical Ruby* (9-68). Selected from B-17 seedlings, growth type resembles Manoa Sweet with multiple leader production and requiring some training to develop a single-trunk tree. It grows to around 15 feet if left unpruned, is a good yielder, and the fruits resemble those of other sweet varieties. Figures 2 and 4 (9-68) show the tree and fruits, respectively.
3. *Hawaiian Queen* (8E-32). Selected from B-17 seedlings, growth habit is upright, spreading, and open. It may be trained into a single-trunk tree with less effort than most other sweet types. Fruits are similar to those of other sweet varieties. Figures 3 and 5 show the tree and fruits, respectively.

Sour varieties

1. *J. H. Beaumont* (3B-21). Named after the late Dr. John H. Beaumont, former Director of the Hawaii Agricultural Experiment Station and Chairman of the Department of Horticulture. Dr. Beaumont was instrumental in initiating the project on acerola research and in procuring financial and material assistance from private sources. Until his untimely death in 1957, he was actively engaged as the project leader in this research.

   Derived from seeds obtained from the University of Miami, this clone has a compact, low, densely branched growth habit and can easily be trained to a single-trunk tree. Both fruit and ascorbic acid production are good. Fruits are large with orange-red color when fully ripe. Figures 6 and 13 (3B-21) show the tree and fruits, respectively.
2. *C. F. Rehnborg* (22-40). Named after Mr. Carl F. Rehnborg, President of Nutrilite Products, Inc., Buena Park, California, for his great

interest in acerola as a commercial crop and for providing substantial financial and moral support for this study.

Derived from the Miami seeds germinated in Hawaii, the plant has a compact, densely branched growth type and is easily trained to a single-trunk tree. High fruit-yielding ability more than makes up for the comparatively low ascorbic acid assay. Fruits are large with orange-red color, turning dark red when fully ripe. The tree and fruits are illustrated in figures 7 and 11.

3. *F. Haley* (3A-8). Named after the late Mr. Frederick Haley, Sr., who was the first person to introduce the acerola into Hawaii in large quantities for commercial purposes. While commercialization of this crop has not continued, it is a valuable addition to the list of potential economic crops.

   Derived from Miami seeds, this tree makes a good orchard tree, easily trained to a single trunk, with upright growth habits. Branches tend to be long with short laterals and are not as spreading as the previously described varieties. Fruits are medium sized, becoming purplish-red upon full maturity. This variety is better adapted to the drier areas. Tree and fruits are illustrated in figures 8 and 12.

4. *Red Jumbo* (3B-1). Selected from the Miami seedlings, it is one of the best orchard-type trees, possessing a single-trunk growth with compact, well-branched, densely foliaged, and low-growing habits. Flowering season is prolonged into January and February. Despite its low, natural fruit set percentage, bearing is relatively high, indicating prolific flowering. Fruits are large with an average weight of 9.3 grams per fruit. Fruit color is attractive, becoming cherry red to purplish-red upon full maturity. Tree and fruits are shown in figures 9 and 13 (3B-1).

5. *Maunawili* (No. 8). This clone grew as a single plant in the sugar cane experimental grounds of the Hawaiian Sugar Planters' Association Experiment Station at Maunawili, Oahu. While not outstanding in ascorbic acid content, its superior performance in areas of high rainfall and its easily manageable growth habits make it a desirable clone.

   It develops a single trunk with very little pruning and the branches are upright and somewhat compact. Leaves are generally small and narrow. Fruits are small, cherry red to light purple in color when fully ripe. Figures 10 and 14 illustrate the tree and fruits, respectively.

CONCLUSIONS AND SUMMARY

Usage of fruits determines the direction of selection. While the sweet type generally lacks the qualities associated with processing, the pleasant flavor makes it a desirable table fruit. The ascorbic acid content is considered low only when compared with the sour type, but far exceeds that of other commonly consumed fruits. The mild flavor and nutritional value of the fruit and the attractive, ornamental nature of the plant are desirable qualities for home plantings.

The results reported herein show that the sour type is generally higher in ascorbic acid content, more fruitful, and produces trees better suited to orchard culture than the sweet type. In general the plants of the sweet type showed less variation in the various factors studied. Even the growth habits among the several selections tested were similar to the extent that a description of one sweet clone will closely resemble that of any other sweet clone.

The sour clones showed wide variations. Differences in ascorbic acid content, fruit size, disease tolerance, and fruit yields were quite distinct. Growth habits were different and the clones are more easily recognizable with individually distinct features.

After considering the various factors, three sweet and five sour clones were selected for naming as new cultivars. The sweet varieties are introduced primarily for use as table fruits, while the sour varieties are directed towards utilization in the processing industry.

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

THOMAS H. HAMILTON
President of the University

C. PEAIRS WILSON
Dean of the College and
Director of the Experiment Station

G. DONALD SHERMAN
Associate Director of the Experiment Station