HORTICULTURAL CHARACTERIZATION OF CHERIMOLA TREES *in situ*

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SUMMARY

Twelve cherimola trees selected for their fruit quality were studied. Thirty fruit and vegetative variables were measured and analyzed by principal components (PC). Eight PC explained 94% of the total variability of the data. PC 1 was associated with fruit size, and trees 262 and 274 produced large fruit, 810.0 and 729.0 g, respectively. Trees 156 and 258 had the smallest fruit size, averaging 434.5 g. PC 2 mainly showed an association among tree height, length of lateral shoots and seed weight. Trees 156 and 196 were more vigorous with heavy-seeded fruit. CP 3 corresponded to trees with more fruit set, high seed content and more acid juice. Tree 260 had these characteristics. For PC 4, tree 272 produced fruits with bright peel, juice with a high content of total soluble solids (28.9%), and leaves with a large number of stomata. PC 5 determined the bright green color of the peel, length of the peduncle, and peel thickness. Tree 156 had bright green fruit with thick peel and a larger peduncle. Tree 84 had a larger leaf area and the leaves were longer with thick trichomes with CP 6. This tree was also outstanding for PC 7, its larger leaf area, petal length, and fruit with a lower concentration of malic acid. For CP 8, tree 256 scored high for large shoot diameter, leaves with a large number of stomata, long petioles, and a small crown diameter.

KEY WORDS: *Annona cherimola*, principal components, fruit breeding, fruit quality, fruit set, fruit seed number.

INTRODUCTION

Mexico has a broad diversity of fruit resources, of which only a few have been studied in depth to generate cultivars and diversify the country's fruit production (Cruz and Robledo, 1995).

Cherimola (*Annona cherimola* Mill.) is one of the fruits with prospects for the domestic and international market. This fruit tree is native of the inter-Andean valleys of Ecuador, Colombia and Bolivia (Undurraga, 1989), and it is distributed in several countries with subtropical climate. There are large-scale commercial plantations in Spain, Chile, Peru, the United States and New Zealand (Farré, 1986; Dawes and Dodds, 1990). In Mexico, the cherimola is distributed naturally in humid temperate regions of Michoacán, Morelos, Guanajuato, Jalisco, and Mexico State, among others (Luis, 1996). There are reports of cherimola genetic improvement programs being conducted in Spain (Farré and Hermoso, 1986), the United States (Schroeder, 1947), and New Zealand (Dawes and Dodds, 1990).

In Mexico, because of the diversity of cherimola phenotypes, a selection of outstanding genotypes has begun on the basis of productivity, fruit quality and vegetative aspects of the tree. This work has been done in the states of Mexico (Rubí *et al*., 1992; Nicolás *et al*., 1996) and Michoacán (Luis, 1996; Andrés, 1997).

Rubí *et al*., (1992) mentioned cherimola trees with outstanding fruit-producing quality. In this study, data from one growing season (1995-1996) were analyzed with reference to fruit-production, vegetative, and anatomical traits of twelve selected trees.

The objective of this work was to identify some horticultural traits of these individuals to determine their use in later work in genetic improvement and fruit production.

MATERIALS AND METHODS

The study was conducted in 1996 in the Experimental Station "La Cruz" of the Salvador Sánchez Colín Foundation-CICTAMEX, S.C., located in the municipality of Coatepec Harinas, Mexico. Twelve genotypes were selected for their outstanding fruit-producing traits, which were previously determined by Rubí *et al*. (1992). These trees were marked with the numbers 84, 156, 163, 196, 256, 258, 260, 261, 262, 265, 272, and 274.

The variables measured for each of the selections were the following: tree height, trunk diameter, and crown diameter (taken by measuring the N-S and E-W drip area with a

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metric tape and averaging the two readings). Using ten leaves per tree, an index of leaf form (length/width) and length and diameter of the petiole were obtained. Leaf area was measured in 20 leaves per tree using the instrument Area Meter LI-3000. The number of stomata and the thickness of trichomes were obtained from three leaves per selection. To count the number of stomata, leaves were placed in a thermos with water at room temperature after they were taken from the trees. Trichomes were removed with a rubber eraser. A drop of epoxy glue was placed on 1 cm^2 of each leaf, which was then placed on a slide and pressed for 10 seconds. The tissue was then removed to be observed in a Carl Zeiss CO11 optical microscope with a 40x objective lens and an Olympus ocular lens with 10x magnification. To determine trichome thickness, two 2 cm x 3 mm sections were made. These portions of tissue were placed on a slide and the cross-section was observed in the same microscope with the same ocular lens, but with an objective lens with 10x magnification. Ten branches with two-year growth were measured for length, diameter at branch base, number of flowers, number of set fruits, percentage of set fruits, and number of fruits at physiological maturity. The length of peduncle and petals was measured before anthesis of ten flowers per tree.

Seven fruits at harvest maturity per tree were taken to the laboratory immediately. Length and diameter, initial weight at picking and final weight at eating maturity were measured. Peel color was registered with a Hunter Lab D25 Optical Sensor, and the Hue angle and brightness were calculated (McGuire, 1992). When they reached eating maturity, peel thickness, peel weight, pulp weight, weight of seeds, weight of one seed, and total number of seeds per fruit were obtained. The index of seeds per 100 g of fruit fresh weight was calculated (Farré and Hermoso, 1986). Pulp color, peel type, and fruit shape (Schroeder, 1951) were determined visually.

Juice from five fruits per tree picked at random was analyzed for total soluble solids (TSS) using a digital refractometer Atago PR-100 (0-32). The pH was obtained from 10 g of pulp per fruit blended in 50 ml of water. This solution was left to stand for 5 min and the electrode of a Corning power meter Model 12 was placed in it. Titratable acidity (% of malic acid in 100 g of fresh weight) was obtained using the method of Anonymous (1980).

All of the data were analyzed using the procedure PRINCOM in SAS (1989) for the analysis of principal components (PC). Variables were standardized before analysis because the units and magnitudes were different (Manly, 1986). The objective of PC analysis is to take *p* variables x_1, x_2, ..., x_p and find combinations of these that produce indexes or PC that are independent. The absence of correlation is a useful property in that it means that the indexes measure different "dimensions" of the data. PC 1 shows the largest variation of the data, followed by PC 2, PC 3 and so forth. This is var (PC 1)> var (PC 2)> ..., > var (PC*p*), where var (PC)*p* denotes the variance of PC*p* in the data under consideration. This technique of multivariate analysis is useful in horticultural characterization of fruits (Cruz-Castillo *et al*., 1991; Utrera and Martínez, 1994).

RESULTS AND DISCUSSION

Table 1 shows averages of all of the variables measured. Eight principal components were obtained with variances (Eigenvectors) larger than 1.0. These eight components accumulated 94% of the total variability of the data and, therefore, were considered for the description of results (Manly, 1986) (Table 2).

PC 1 characterized, mainly, the aspects of fruit size; fruit length and diameter and fruit, pulp, and peel weight had the highest values (Table 2). Calzada *et al*. (1973) reported high simple correlations between fruit diameter and percentage of pulp, fruit weight and fruit length and diameter. Trees 256 and 262 had the highest values of PC 1 (Table 3), having the largest fruit size with an average of 749 g. Chilean norms of quality classify this as large (Undurraga, 1989). In the 1995 harvest, the size of the fruits of these trees was also superior to those of other individuals (Nicolás *et al*., 1996). In contrast, the fruits of trees 156 and 260 were smaller, with an average of 459 g (Table 1) and had the lowest values of PC 1 (Table 3). However, these fruits were in grade I of the Spanish quality norm for cherimola (Ministerio de Agricultura, Pesca y Alimentación, 1990), and their small size make them attractive for export. The rest of the trees have fruit weight that can place them in grade I and "fancy" (>851 g) under the Spanish norm. In general, all of the individuals studied produced fruit sizes within the best grades for marketing (Undurraga, 1989; Ministerio de Agricultura, Pesca y Alimentación, 1990). Dawes and Dodds (1990) recommend selecting trees that produce fruits with an average weight of 500 to 700 g. Trees 84, 256, 260, 265 and 272 had fruits within this weight range and could be selected using this criterion. Manica (1994) stated that for genetic improvement of cherimola through selection and hybridization, it is important to use trees with large fruit and few seeds. Tree 256 had these characteristics in 1995 (Nicolás *et al*., 1996) and 1996 (Table 1).

For PC 1 greater variability of the data was evaluated (21.2%) (Table 2), and this confirms that the trees studied were selected for fruit size (Rubí *et al*., 1992). Weight and number of fruits per tree were not included in this study. However, it is possible that final fruit size was not significantly affected since in cherimola the number of seeds per fruit is the factor that determines fruit weight in trees with an acceptable number of fruits (Vergara *et al*., 1997). Also, the flowers were pollinated naturally and fruit set was not excessive in the trees studied.

PC 2 was largely differentiated by the variables tree height, branch length, weight of one seed, and weight of all seeds (per fruit). These parameters were related to canopy vigor (Saranga *et al*., 1998). The smaller trees

(4.8 m) with shorter branches (0.52 m) and lighter seeds were 258 and 265 (Table 1). In kiwi fruit, Lai *et al*. (1990) found a significant correlation between seed weight and final fruit size. In the cherimola studied, this relationship was not significant (r=0.18, *P*=0.22). The difference between these two fruits could be than cherimola is an aggregate fruit while kiwi is simple with a larger number of seeds (up to 1400 per fruit). This PC explained 19.8% of the variability in the data (Table 2).

PC 3 was defined mainly by seedy fruits with acid juice (lower pH) produced on trees with smaller diameter trunks and good fruit set ability (Table 2). The tree that had mostly these characteristics was 260 (Table 3). Because of the high number of seeds per fruit (102) it could be used in the propagation of rootstock. In contrast, tree 258 had fruits with few seeds (33), higher pH (4.94), larger trunk diameter, and poor fruit set. In these individuals there was no clear relationship between number of seeds and final fruit weight. For example, tree 260 did not produce heavy fruits despite the large number of seeds, while the fruits of tree 258 surpassed the weight of fruit from tree 156, which had fruits with about double the number of seeds per fruit (Table 1). Therefore, unknown factors influenced final fruit size. Vergara *et al*. (1997) speculated that climate influences size of cherimola when there is a poor relationship between number of seeds and fruit size. Tree 258 had fewer fruits per tree (data not shown), with fewer seeds than the others. In other fruit trees, when the number of fruits is small, there is less competition for carbohydrates, and the effect of the presence of seeds on final fruit size can be minor (Woolley *et al*., 1988; Saunders *et al*., 1993). Regarding juice acidity, the cherimola trees with better fruit set ability (trees 84, 260, 265) tended to have fruits with more acid juice (Table 1). The application of organic acids can improve fruit set in other species of fruit trees (Nitsch, 1953). The best fruit set which was found in tree 260 was related to a large number of seeds in its fruits, so natural pollination was more efficient in this individual than in the other trees studied.

With PC 4 individuals with fruits with shiny peel and a high content of total soluble solids (TSS) in trees with smaller diameter branches and leaves with a larger number of stomata. Tree 272 had these characteristics, and its fruits had 28.9% TSS, a value higher than the mean TSS in fruits of the Spanish cultivars ‘Campas’ (20.7%) and ‘Jete’ (19.2%) (Martín, 1993). Farré and Hermoso (1986) reported that TSS> 23% is associated with high flavor quality. In contrast, tree 256 had leaves with fewer stomata and fruits with duller peel and 18.6% TSS produced on branches of larger diameter (Tables 2 and 3). In the 1995 harvest, tree 272 produced fruits with 22.8% TSS, 3.1% higher than fruits of tree 256 (Nicolás *et al*., 1996). The variability in the data between these two years may be attributed to differences in the samples of fruits within the trees and/or environmental effects.

PC 5 was largely determined by the association between peduncle length and the parameters of fruit quality such as color, brightness and peel thickness (Table 2). This means that in some individuals fruits with longer peduncles tended to have a thicker, very green, shiny peel. This was the case of tree selection 156 (Table 3).

PC 6 was related mostly to leaf area, leaf shape (ratio of length and width of the leaf), and thickness of trichomes (Table 2). Tree 84 was outstanding in the association of these variables (Table 3). This tree had the largest leaf area (1457.7 cm^2) with leaves that were longer than wide, with thick trichomes. The value obtained for leaf shape in tree selection 84 (1.76) was very similar to that found in Spain (Martín, 1993) for the cultivars M-6 (1.70) and M-21 (1.82). Trichomes may protect the mesophyll from excessive heat (Black, 1954) and regulate temperature (Ehleringer and Bjorkman, 1978). Studies on adaptation of tree 84 to less cold climates could be conducted. However, it is necessary to consider that the number of stomata in the leaves of some species may be affected by several environmental factors (Upadhyaya and Furness, 1998). This implies the need to observe the thickness and density of the trichomes in subsequent years. Leaf area and petal length had high values with fruits with low titratable acidity in PC7. Tree 84 also had these characteristics: a larger leaf area and longer petals, which were associated with fruits with a low concentration of malic acid. This selection had more fruits per branch in shorter trees (Table 1), and thus deserves to be included in further work on genetic improvement and cherimola fruit production.

Tree 258 had the smallest canopy diameter and the largest branch diameter, and its leaves had a larger number of stomata and a long petiole in PC 8 (Table 3). This PC was that of least importance, since it explained only 4% of the total variability of the data (Table 2).

Some of the morphological characteristics related to ease postharvest handling of the fruit were also studied. Outstanding were selections 163, 256, 261 and 272 with smooth peel (Table 4). The fruits with embossed peel are also acceptable on the market (Undurraga, 1989), and the fruit of tree 274 showed this peculiarity, which may be maternal in origin (Kahn *et al*., 1994). Cherimola trees 261 and 272 had fruit classed as round, and the pulp in most of the fruits was white (Table 4).

The difference between initial and final fruit weight is very important for postharvest handling when the fruit is marketed in bulk. The fruits that lost the smallest percentage of weight after 10 days of storage at room temperature were those that were picked from trees 84 (2.8%) and 258 (4.6%) (data not shown)

Aspects of fruit quality and morphology of 12 selected cherimola trees were characterized using PC analysis. It is important to quantify fruit yield of the trees studied to determine their productive capacity.

TABLE 1. Means of the variables determined in 12 selections of cherimola (*Annona cherimola* Mill.).

Tree	Tree height (m)	Trunk diameter (m)	Canopy diameter (m)	Branch length (cm)	Branch diameter (mm)	Number of flow-ers	Fruit set (%)	Petal Length (cm)	Peduncule length (cm)	Length/width of leaf
84	4.4	0.1	4.6	55.5	9.4	11.7	8.5	2.6	1.2	1.8
156	6.9	0.2	6.5	66.9	10.2	37.5	2.9	2.8	1.3	1.6
163	5	0.2	8.2	51.5	7.3	29.8	0.6	2.7	1.1	1.6
196	7.7	0.3	8	83	8.1	16.5	0.6	3.3	1.0	2.0
256	6.1	0.2	8	68.9	9.9	15.1	1.3	2.2	1.1	1.6
258	4.7	0.1	6.2	53.2	7.8	13.7	0	2.6	1.0	1.7
260	5.7	0.1	6.6	51.4	7.1	10.0	8	2.8	1.1	1.7
261	6.6	0.2	7.2	52.1	7.1	13.7	2.9	2.3	1.2	1.7
262	6.8	0.1	6.9	70.2	8	13.9	0	2.4	1.2	1.6
265	4.8	0.1	5.5	50.6	7.6	8.9	6.7	2.7	1.1	1.5
272	7.1	0.1	7.6	51.8	7.5	15.3	0	2.3	1.2	1.8
274	6.4	0.1	8.1	47.2	7.6	5.4	1.8	2.3	1.1	1.7

Tree	Petiole lenght (cm)	Petiole diameter	Leaf area (cm^2)	Stomata number	Trichome trickness (mm)	Fruit length (cm)	Fruit diameter (cm)	Fruit weight	Pulp weight	Peel weight
84	0.9	2.4	1457.7	20.0	13.7	9.1	10.3	536.6	391.2	116.4
156	1.0	2.5	1070.6	15.0	18.7	8.7	9.3	405.7	207.3	79.1
163	1.0	2.2	1148.3	21.0	17.7	9.7	10.6	584.7	414.9	98.6
196	1.1	2.4	1137.2	20.2	15.7	10.2	9.7	525.6	341.8	80.8
256	1.3	2.5	1067.82	22.0	15.3	11.3	11.2	688.8	418.5	168.9
258	1.1	1.9	842.4	30.0	16.7	8.8	10.4	465.4	341.9	86.8
260	1.0	2.3	1099.6	25.0	25.3	8.9	10.0	511.6	306.1	80.0
261	1.1	2.3	1082.9	21.0	20.0	10.3	11.1	712.7	4444.8	126.0
262	1.4	2.6	1157.0	24.0	24.0	13.9	12.3	810.0	457.9	168.5
265	1.0	2.2	817.0	19.0	20.0	10.3	10.5	598.6	380.4	115.7
272	1.1	2.3	1096.2	28.0	17.7	10.5	10.2	572.3	295.9	127.3
274	0.8	2.6	959.4	24.0	17.7	10.1	10.9	729.2	430.9	170.6

Tree	Peel trickness	Number of sedes	Weight of sedes	Seed weight	Seed Index	Total soluble solids	Juice pH	Tritatable acidity	Fruit Brightness	Hue
84	2.2	66.0	34.2	0.5	12.7	18.4	4.4	3.4	35.1	114.4
156	3.0	57.0	50.7	0.9	17.8	16.0	4.6	5.8	33.7	120.1
163	2.0	50.6	36.4	0.7	9.2	23.1	4.8	3.0	39.3	113.6
196	2.0	57.4	49.5	0.9	11.9	26.6	4.7	6.7	37.0	119.8
256	2.0	48.0	34.2	0.7	7.7	18.6	4.6	3.8	31.7	99.8
258	2.4	33.4	15.2	0.5	7.5	21.0	4.9	3.4	40.6	113.2
260	1.6	102.4	69.0	0.7	22.5	22.8	4.3	6.8	34.1	107.1
261	3.0	63.2	49.6	0.8	10.2	21.2	4.7	4.1	39.2	115.1
262	2.8	86.6	65.9	0.8	12.2	23.4	4.8	3.6	37.9	117.7
265	1.0	55.8	36.2	0.6	10.5	22.6	4.3	3.7	33.5	102.1
272	2.6	81.6	57.7	0.7	16.9	28.9	4.7	7.0	37.0	117.1
274	2.3	65.0	36.1	0.6	10.2	21.4	4.4	6.5	41.7	114.3

TABLE 2. Eigenvectors of the first eight principal components (PC). Eigenvalues also shown.

Variables	CP1	CP2	CP3	CP4	CP5	CP6	CP7	CP8
Number of seeds	0.0289	0.1447	0.4048	0.1030	0.0528	-0.0136	0.1389	0.0981
Weight of seeds	0.2747	0.2852	0.3070	0.0525	0.0317	-0.1369	0.1003	0.0168
Seed weight	-0.0071	0.3595	-0.0107	-0.1080	-0.0719	-0.1919	-0.0422	-0.2335
Seed index	-0.2015	0.1743	0.3069	0.1047	0.0891	-0.0734	-0.0299	0.1525
Fruit weight	0.3649	-0.0072	0.1184	-0.0873	-0.0172	0.0567	0.0242	-0.1915
Fruit length	0.3359	0.1168	0.0735	-0.1101	-0.0797	-0.0852	0.0809	0.1091
Fruit diameter	0.3695	-0.0586	0.0633	-0.1179	0.0469	-0.0504	0.1032	0.0417
Pulp weight	0.3237	-0.1195	0.0063	-0.0965	-0.0655	0.0890	0.2777	-0.2124
Peel weight	0.3259	-0.0488	0.1058	-0.1499	0.0056	0.1864	-0.2135	-0.0046
Peel thickness	0.0859	0.2137	-0.1370	-0.0287	0.4444	0.1311	-0.0302	0.1112
Total soluble solids	0.1137	0.1024	0.0375	0.3624	-0.1329	-0.0845	0.1685	-0.0327
Juice pH	0.1312	0.14043	-0.3448	0.1101	0.1535	-0.1870	0.1446	0.2176
Titratable acidity	-0.1004	0.2088	0.1650	0.2752	-0.0749	0.1672	-0.3352	-0.0510
Hue	-0.0291	0.2383	-0.1043	0.1365	0.3591	0.1965	0.1914	-0.0223
Fruit brightness	0.1620	-0.0577	-0.1463	0.2840	0.2912	0.1368	0.1153	-0.2280
Tree height	0.0956	0.3567	0.0142	0.0985	-0.0189	0.0753	-0.2375	-0.0629
Trunk diameter	-0.0161	0.1830	-0.2867	-0.0533	-0.2699	-0.0719	0.1991	-0.2109
Canopy diameter	0.1846	01816	-0.1336	0.1503	-0.0940	-0.0173	-0.2799	-0.2903
Number of flowers	-0.1589	0.1966	-0.2063	-0.1597	0.2199	-0.2117	-0.0503	-0.0860
Fruti set	-0.2147	-0.1489	0.2866	-0.1255	-0.0941	0.0737	0.2064	-0.0779
Leaf area	-0.0401	0.1414	0.0724	-0.1559	0.0796	0.3306	0.46325	0.1228
Leaf shape	-0.0209	0.1558	-0.0389	0.2549	-0.1868	0.4521	0.1133	0.1020
Peduncule length	-0.0804	0.1341	0.0963	-0.2833	0.3863	-0.0840	0.0458	-0.1190
Petiole length	0.2213	0.1810	-0.0755	-0.1134	-0.1759	-0.2568	0.0380	0.3755
Petiole diameter	0.1295	0.2222	0.1972	0.2078	-0.0721	0.2802	-0.0894	-0.0968
Number of stomata	0.1573	-0.1267	0.0019	0.3366	0.0626	-0.0252	-0.0443	0.4502
Trichome trickness	0.0677	0.693	0.30336	0.0791	0.0792	-04044	0.0601	-0.0184
Petal length	-0.2385	0.1539	-0.0978	0.0832	-0.2388	-0.0659	0.3067	-0.1089
Branch length	0.0195	0.2892	-0.1411	-0.1320	-0.2733	0.4521	0.726	0.2288
Branch diameter	-0.1174	0.0803	-0.0945	-0.3653	-0.0375	0.2017	-0.2267	0.3123
Eigenvalues	6.3724	5.9500	4.6400	3.9824	2.4611	2.1800	1.5143	1.2389
Proportion by PC	0.2124	0.1983	0.1547	0.1327	0.0820	0.0727	0.0505	0.0413
Accumulated (%)	0.2124	0.4108	0.5654	0.6986	0.7802	0.8529	0.9033	0.9446

TABLE 3. Standardized values of the first eight principal components (PC) of the variables measured in 12 selections of cherimola.

Tree	CP1	CP2	CP3	CP4	CP5	CP6	CP7	CP8
84	-0.9291	-0.8589	0.3989	-10.942	0.3468	1.9514	1.5719	0.6597
156	-1.7472	1.3001	-0.2898	-1.1848	1.2139	-0.3557	-1.2504	-0.0277
163	0.0493	-0.1836	-1.1602	-0.0239	0.4480	-0.9612	1.0056	-1.3834
196	-0.3840	1.6490	1.0491	0.9501	-1.8439	0.7736	0.7363	-0.7847
256	0.8854	-0.1261	-0.5022	-1.5459	-1.3255	0.7456	-1.3277	0.7847
258	-0.1526	-1.4711	-1.6562	1.0992	0.4940	-0.1452	-0.1295	15290
260	-0.9605	0.0293	1.9828	0.9799	-0.6411	-0.7669	0.2371	0.4385
261	0.7125	0.1660	-0.2279	-0.1556	0.9312	-0.1503	0.4454	-1.1892
262	1.9392	0.9157	0.7284	-0.6134	0.5261	-0.6165	0.9452	0.9626
265	-0.4261	-1.3956	0.6538	-0.4814	-1.0516	-1.2270	-0.1225	-0.9188
272	0.1599	0.6292	0.4106	1.3188	0.7378	0.0477	-0.7094	-0.7684
274	0.8534	-0.6540	0.5057	0.7515	0.3410	1.6832	-1.4020	-1.2644

TABLE 4. Form and color of pulp and peel type of fruits from twelve selections of cherimola (*Annona cherimola* Mill.).

Tree	Peel type	Fruit shape	Pulp color
84	Tuberculata	Conic	White
156	Embossed	Herat shape	White cream
163	Smooth	Herat shape	White
196	Embossed	Herat shape	White
256	Smooth	Herat shape	White
258	Embossed	Herat shape	White
260	Mamilada	Herat shape	White
261	Smooth	Round	White cream
262	Embossed	Herat shape	White
265	Mamilada	Herat shape	White
272	Smooth	Round	White
274	Embossed	Round	White

LITERATURE CITED

ANDRÉS A., J. 1997. Descripción varietal de la selección Cortes 11-31 de chirimoya. Memorias. Congreso Internacional de Anonáceas. Chapingo. México. pp.110-123.

ANÓNIMO. 1989. SAS/SIAI users guide, version 6, 4th edition, vol. 1. SAS Institute Inc Institute. Cary, N. O.

ANÓNIMO. 1990. Norma de calidad para chirimoyas -folleto interpretativo. Ministerio de Agricultura Pesca y Alimentación. Dirección General de la Producción Agraria. Madrid, España. 34 p.

BLACK, R.F. 1954. The leaf anatomy of australian members of the genus *Atriplex*. 1. *Atriplex vesicaria* Heward and *A. Nummularia* Lindl. Australian Journal of Botany 2: 269-286.

CALZADA B., J.; BAUTISTA O., V.; BERMÚDEZ R., M. 1973. Correlaciones y regresiones entre siete características del fruto de chirimoya (*Annona cherimola* Mill.) en plantaciones comerciales. An. Cientific. 11(1/2): 27-35.

CRUZ G., J.G.; ROBLEDO, M.J.D. 1995. Perspectivas de comercialización de algunas especies frutícolas poco conocidas en el Estado de Veracruz. Memoria VIII Curso de Actualización Frutícola. Fundación Salvador Sánchez Colín-CICTAMEX. Coatepec Harinas, México. pp. 89-97.

CRUZ-CASTILLO, J.G.; LAWES, G.S.; WOOLLEY, D.J.; VARELA-ALVAREZ, H. 1991. Rootstock influence on kiwifruit vine performance. New Zealand Journal of Crop and Horticultural Science 19: 361-364.

DAWES, S.N.; DODDS, J.B. 1990. Bronceada may be the Hayward of cherimoyas. The Orchardist of New Zealand. pp.15-17.

EHLERINGER, J.R.; BJORKMAN, O. 1978. Pubescence and leaf spectral characteristics in a desert shrub *Encelia farinosa.* Oecologa 36: 151-162.

FARRÉ M., J.M.; HERMOSO G., J.M. 1986. El Chirimoyo (*Annona cherimola* Mill). Críterios para una selección de cultivares. Fruticultura Profesional 3: 2-4.

KAHN, T.L.; ADAMS, C.J.; ARPAIA, M.L. 1994. Paternal and maternal effects on fruit and seed characteristics in cherimoya (*Annona cherimola* Mill.). Scientia Horticulturae 59: 11-25.

LAI, R.; WOOLLEY, D.J.; LAWES, G.S. 1990. The effect of inter-fruit competition, type of fruiting lateral and time of anthesis on the fruit growth of kiwifruit (*Actinidia deliciosa*). Journal of Horticultural Science 65: 87-96.

LUIS L., F. 1996. Caracterización y selección de frutos de chirimoyo (*Annona cherimo/a* Mill.) en los Municipios de chilchota, Tancítaro y Tingambato, Michoacán. Tesis de Ing. Agrónomo Especialista en Fitotécnia. Universidad Autónoma Chapingo. México. 104 p.

MANICA, I. 1994. Fruticultura. Cultivo das Anonaceas, Ata-cherimola. Graviola. De. Evangraf. Porto Alegre. Brasil. pp. 18-21

MANLY, B. F.J. 1986. Multivariate Statistical Methods a Primer. Chapman and Hall. Londo, UK. 159 p.

MARTIN M., L. 1993. Descripción pomológica y análisis de componentes del fruto en una colección de cultivares de chirimoya (*Annona cherimola* Mill.). Tesis Profesional. Estación Experimental La Mayora. España. 113 p.

McGUIRE, R.G. 1992. Reporting of objetive color measurements.

HortScience 27: 1254-1255

NICOLÁS O., M.; RUBÍ A., M.; CRUZ O., J.G. 1996. Exploración y colección de fenotipos sobresalientes de chirimoya. Memoria: IX Curso de Actualización Frutales con Futuro en el Comercio Internacional Fundación Salvador Sánchez Colín CIOTAMEX, S.O. Coatepec Harinas, México. pp. 92-97.

NITSCH, J.P. 1953. Physiology of fruit growth. Annual Review of Plant Physiology 4: 199-236.

RUBÍ A., M.; DE LA CRUZ T., E.; BARRIENTOS P., F. 1992. Mejoramiento genético de la chirimoya a través de selección en poblaciones de segregantes. Memoria de la Fundación Salvador Sánchez Colín GICTAMEX, S.C. Coatepec Harinas, México. pp. 127-134.

SARANGA, Y.; LEVI, A.; HORCICKA, P.; WOLF S. 1998. Large sunflower seeds are characterized by 10w embryo vigor. Journal of the American Society for Horticultural Science 123: 470-474.

SAUNDERS, R.C.; JACOBS, G.; STRYDOM, D.K. 1993. The role of seeds and parthenocarpy in fruit set of Packham Tríumph pears. Journal of the South African Society of Horticultural Science 3(2): 74-75.

SCHROEDER, C.A. 1951. Fruit morphology and anatomy of cherimoya. Botanical Gazette. 112: 436-446.

SCHROEDER, CA. 1947. Hand pollination of cherimoya improves fruit set. California Avocado Society Yearbook pp: 67-70.

UNDURRAGA M., P. L. 1989. El cultivo de la chirimoya (*Annona cherimola* Mill.) en Chile. III Reunión Técnica de la Red Latinoamericana de Agroindustria de Frutas Tropicales. Producción, Transfomación y Comercialización de frutas tropicales. FAGO. ENNC. Colombia. pp. 73-87.

UTRERA, G.L.F.; MARTÍNEZ, T.E.A. 1994. Caracterización *in situ* de sapote (*Pouteria sapota*) (Jacq) Moore Stearm en Ohiquimulilla y Guazacapan, Santa Rosa, Guatemala. Tikalia 12(2): 35-50.

UPADHYAYA, M.K.; FUMESS, N:H. 1998. Primocane morphology and leaf surface characteristics of greenhouse-grown red raspberry cultivars. HortScience 33:330-332.

VERGARA, J.; FICHET, T.; REGINATO, G. 1997. Efecto de la carga frutal y del raleo manual sobre el tamaño de frutos y productividad en chirimoyo cv. Bronceada. Memorias. Congreso Internacional de Anonáceas. Chapingo. México. pp. 28-39.

WOLLEY, O.J.; LAWES, G.S.; LAI, R. 1988. Factors affecting fruit size. New Zealand Kiwifruit. Special publication. No. 2. pp. 11-14.