SUMMARY

Breeding for low-chilling peach cultivars was begun in 1909 in California, other breeding programs being initiated subsequently in Texas and Florida. Native seedlings with low-chilling requirements were crossed with commercial temperate-region cultivars to combine low-chilling with desirable horticultural characteristics. Chilling requirement appears to be genetically controlled by multiple genes and physiologically by a hormone balance. Several thousand acres of peaches have been planted to low-chilling peach cultivars released from the above programs. These cultivars have left much to be desired, but the advanced selections in the current breeding programs indicate that low-chilling peach cultivars will become available in the near future that are comparable to their counterparts in temperate regions.

Literature Cited


**BREEDING FOR COLD HARDINESS IN SUBTROPICAL FRUITS**

Robert J. Knight, Jr.1

U. S. Department of Agriculture, Miami, Florida

The need to breed for cold hardiness (where opportunities permit) is obvious to anyone who grows fruit, under temperate or subtropical conditions, where plants or bloom and young fruit are liable to frost damage or winter injury. The present report will be confined to progress to date with avocados, mangos and passion fruit, and to discussion of some of the possibilities inherent in 2 other fruits, the guanabana and acerola.

Germ plasm collections of 150-odd avocado cultivars and more than 100 mango cultivars are kept at the U. S. Plant Introduction Station, Miami, Florida. Passiflora introductions have been evaluated there through the last 45 years (6). A dozen species and forms, and hybrids derived from these, are kept there at present.

Our efforts toward controlled breeding of avocados and mangos through hand pollination have been unsuccessful. Both species produce panicles of hundreds of flowers, and less than 0.1% of these yield mature fruit; blossom are adapted to outcrossing (3, 11). Thus they typically fruit in response to cross-pollination rather than selfing. Accordingly we have planted open-pollinated seedling populations of these crops, grown from seed parents chosen for their useful characters. Our goal has been to evaluate the seedlings for horticultural quality and cropping potential, and determine the value of various introductions as parents. Passiflora sets fruit well from compatible hand pollinations and this method has been used in the work reported. The Annona species discussed here have not responded well to hand pollination, and additional work on this problem is needed.

**Persea americana Mill.**

Some 1,400 avocado seedlings of 7 different populations were grown at the U. S. Plant Introduction Station, Miami, Florida in 1959 and 1970. Passiflora introductions on screening the seedlings we then had for cold tolerance, using an artificial “cold room” remodeled for that purpose (7). Cumulative scores ranked seedlings from open pollination of Mexican race parents the most cold tolerant, and a population of mixed origin but predominantly West Indian in character (seedlings of ‘Arue’, PI 99805) were ranked least hardy.

At the time of our report none of the hardy seedlings had fruited. We were certain that these young trees were cold-tolerant, and that some of them should be useful in breeding, but we had no idea of the extent of variation among them, or whether any of them had fruit of better quality than the Mexican seed parent. This tree, called ‘Brookville’ (M-18686) grew from seed brought from the old U. S. Department of Agriculture station near Brookville, Florida at Chinesegut Hill. ‘Brookville’ has small dark-colored fruit (Fig. 1) of acceptable flavor that ripens early in season, is more prone to

---

1Research Horticulturist, Plant Science Division, Agricultural Research Service.
anthracnose (Colletotrichum gloeosporioides Penz.) infection than South Florida commercial cultivars, and tends to crack if heavy rains occur when it is ripening. It is the only Mexican-race tree in its block, and is surrounded by a mixed planting of West Indian, Guatemalan and hybrid avocado cultivars. We have planted 300 seeds from this
tree in the last 6 years. The first of these seedlings fruited in 1968, and now we have some idea of what to expect from them.

All seedlings of M-18686 to fruit so far bear larger fruit than the seed parent and show much variation in season, size of fruit and seed, shape, ratio of seed to fruit wt, flavor, and other characters (Fig. 2, Table 1). The most outstanding seedling of those that have fruited to date is selection 7-35, which is still in the initial stages of evaluation. Additional cold-tolerant introductions under investigation are 'Chapulitepec Park' (PI 281755), a small-fruit, reputedly very hardy
cultivar from Mexico City; 'Gainesville', a hardy green-fruitized cultivar obtained from the Department of Fruit Crops of the University of Florida; 'Duke', a Phytophthora-resistant cultivar that originated in California and is a parent of outstanding cold-hardy selections there, and several 'Duke' seedlings: a group of selections from Morocco including 'Romain' and 'Chapot No. 43'; and seedlings of 'Mexicola' (Fig. 3, Table 1).

Experience to date indicates that seedlings of cold-hardy avocado cultivars of Mexican race, or of hybrid in which Mexican characters predominate, show enough variation to justify efforts to select the best of them and carry forward a program aimed at production of high-quality cold-tolerant cultivars for regions where avocado production is now marginal. The precocious associated with Mexican
cultural characters would be an asset to such a program. Under field conditions in southeastern Florida, 10% of the Mexican seedlings have
flowered the second season after they were set, and over 70% the third season.

**Mangifera indica L.**

Unfortunately no sources of cold hardiness have been discovered in
*Mangifera* that match the contribution of the Mexican race avocados in
*Persea*. Oppenheimier reported least cold injury in Israel to mango
cultivars that originated in northern India ('Langra'), Israel (I/15, now
named 'Nimrod') and Egypt ('Bullock's Heart'), but he also observed
that the greater size of the hardest trees afforded them greater
protection from heat loss than obtained for smaller trees in the

collection. He found the Indonesian variety 'Gedong' less hardy than
its size would indicate (9).

Wester recorded 30 "cold resistant" mango cultivars from
Saharanpur, India, and one ('Alfonso' from Lahore) "easily injured by
cold." (14) Most of Wester's "cold resistant" sorts were introduced into
the United States (1), but none showed more than average
designes in Florida.

Young (15) found mango pollen tube growth in vitro to be
reduced by a factor of 4, 5, or 10 (depending upon the cultivar),
through exposure to temperatures of 59-61°F in contrast to 75-80°F.

Even though tolerance to extreme cold has not been found in
*Mangifera* germ plasm, differences in field chilling during the bloom period exist and are economically
important. A condition known to growers and sales people as
"nubbins," "golf balls," "seedlessness," or "gems" has been observed
repeatedly in Florida mangos, particularly after winters of unusual
cold. 'Haden' and 'Irwin' cultivars are severely affected, and low
yields associated with this disorder have helped eliminate 'Haden'
from the list of accepted commercial cultivars. The same problem
follows relatively cold weather during flowering in South Africa, where
the resultant condition is termed "small fruits" and planting of locally
adapted resistant cultivars is recommended (5). The first
bloom of 'Haden' in Israel has produced seedless fruit so often that
research efforts there are now directed toward developing efficient
means of destroying this bloom in order to promote them in April.
Flowering which (under Israeli conditions) follows such destruction
and, appearing in warm weather, gives rise to normal, seeded fruit.
Research on timing mango flowering in Florida deserves investigation.

Fruit that show seedlessness in Florida may be small nubbins, or
they may be larger, approaching normal dimensions but characterized by
a sharper-pointed apex than is usual for the cultivar. The seedless
fruit closely resembles the parthenocarpic mango fruit obtained by
Chacko and Singh, who used plant growth regulators (4). Fruit size
and wt are reduced, and the bony endocarp is present but no embryo
is developed within it. The North American market discriminates
against seedless mangos; this explains their economic importance.

The approximately 1,300 mango seedlings were field-set at the U.S.
Plant Introduction Station, Miami, between 1960 and 1970. Intensive
evaluation of the first seedlings to fruit began in 1964 and has
continued to date. Differences in the amount of seedlessness among

---

**Fig. 1.** Fruit of 'Brooksville' (M-18186) avocado, Mexican race.

**Fig. 2.** Comparison of 1) 'Brooksville', M 18686 and 2-8) seven 'Brooksville' seedlings with 9) 'Simmonds', a large West Indian cultivar of minimal cold tolerance and 'Brogden', the best quality Mexican type cultivar for Central Florida. 'Brooksville' seedlings are: 2) 9-39; 3) 9-40; 4) 9-41; 5) 9-51; 6) 9-54; 7) 7-30, the largest-fruiting, and 8) 7-35, the best-quality fruit in this population.

**Fig. 3.** Sources of cold hardiness in the U.S. Plant
Introduction Station germ plasm collection, compared with 'Simmonds' 10), the large West Indian cultivar: 1) 'Chapulitepec Park', PI 281755; 2) 'Gainesville'; 3) 'Duke'; 4) 'Chapot No. 43', M 19328; 5-8), 'Mexicola' seedlings 24-58, 24-52, 24-50, and 24-54; 9) 'Duke' seedling, PI 277486.
Table 1. Comparison of cold-hardy avocados and 'Simmonds', a West Indian cultivar.

<table>
<thead>
<tr>
<th>Cultivar or seedling</th>
<th>Dates ripe</th>
<th>Fruit wt (g)</th>
<th>Seed wt (g)</th>
<th>Seed tightness in cavity</th>
<th>Seed coat adhesion</th>
<th>Skin color</th>
<th>Anthracnosea</th>
<th>Firmnessa</th>
<th>Fibera</th>
<th>Flavora</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brogden</td>
<td>1 Aug.</td>
<td>285</td>
<td>65</td>
<td>Yes</td>
<td>Seed</td>
<td>Black</td>
<td>6</td>
<td>4</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Brooksville M-18686</td>
<td>10 July</td>
<td>95</td>
<td>21</td>
<td>Variable</td>
<td>Cavity</td>
<td>Black</td>
<td>5</td>
<td>7</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>seedlings:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-30</td>
<td>10 Oct.</td>
<td>380</td>
<td>86</td>
<td>Yes</td>
<td>Both</td>
<td>Black</td>
<td>7</td>
<td>4</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>7-35</td>
<td>12 Aug.</td>
<td>230</td>
<td>36</td>
<td>Yes</td>
<td>Both</td>
<td>Black</td>
<td>6</td>
<td>8</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>9-39</td>
<td>12 Aug.</td>
<td>147</td>
<td>16</td>
<td>No</td>
<td>Both</td>
<td>Black</td>
<td>3</td>
<td>7</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>9-40</td>
<td>3 Aug.</td>
<td>192</td>
<td>37</td>
<td>No</td>
<td>Both</td>
<td>Black</td>
<td>5</td>
<td>6</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>9-41</td>
<td>12 July</td>
<td>180</td>
<td>50</td>
<td>Yes</td>
<td>Seed</td>
<td>Black</td>
<td>2</td>
<td>6</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>9-51</td>
<td>14 July</td>
<td>125</td>
<td>28</td>
<td>Yes</td>
<td>Both</td>
<td>Black</td>
<td>5</td>
<td>8</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>9-54</td>
<td>21 Aug.</td>
<td>240</td>
<td>265</td>
<td>Yes</td>
<td>Seed</td>
<td>Black</td>
<td>2</td>
<td>7</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Chapot No. 43</td>
<td>M 19328</td>
<td>1 Sept.</td>
<td>290</td>
<td>52</td>
<td>Yes</td>
<td>Seed</td>
<td>Green</td>
<td>6</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Chapelitepec Park</td>
<td>PI 281755</td>
<td>1 Aug.</td>
<td>75</td>
<td>15</td>
<td>Yes</td>
<td>Cavity</td>
<td>Black</td>
<td>5</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Duke</td>
<td>PI 277487</td>
<td>1 July</td>
<td>180</td>
<td>35</td>
<td>No</td>
<td>Cavity</td>
<td>Green</td>
<td>5</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Duke Sdlg. 28-26</td>
<td>PI 277486</td>
<td>10 July</td>
<td>130</td>
<td>32</td>
<td>No</td>
<td>Cavity</td>
<td>Green</td>
<td>6</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Gainesvillec</td>
<td>5 Aug.</td>
<td>145</td>
<td>27</td>
<td>Yes</td>
<td>Seed</td>
<td>Green</td>
<td>Green</td>
<td>5</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Mexicoica Sdlg.c</td>
<td>PI 277485:</td>
<td>24-50</td>
<td>5 Aug.</td>
<td>96</td>
<td>25</td>
<td>No</td>
<td>Cavity</td>
<td>Black</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24-52</td>
<td>5 Aug.</td>
<td>80</td>
<td>27</td>
<td>Yes</td>
<td>Seed</td>
<td>Black</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24-58</td>
<td>5 Aug.</td>
<td>55</td>
<td>21</td>
<td>Yes</td>
<td>Cavity</td>
<td>Black</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Simmonds</td>
<td>PI 36270</td>
<td>1 Aug.</td>
<td>795</td>
<td>125</td>
<td>Yes</td>
<td>Seed</td>
<td>Green</td>
<td>9</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

a1 = least desirable rating, 10 = most desirable rating. Anthracnose = degree of resistance to Colletotrichum gloeosporioides Penz.
bWe based upon 10 or more fruits except for Brooksville seedlings, M 19328, PI 281755, and Gainesville, of which fruit supply to date has been limited.
cScions or seeds supplied by Department of Fruit Crops, University of Florida, Gainesville.

the individual seedling trees were evident from the beginning, and in 1968 we decided to evaluate a group of seedling selections for freedom from seedlessness and consistency in respect to this character. All fruit were harvested and counted, from each tree under observation. Trees observed were 3 parental clones, S-1, S-10, and M-1007, and 21 first selections derived from open pollination of the seed parents. All small fruit, or fruit with pointed apical ends, was cut open, and the number of seedless fruit harvested from each tree was recorded as the percentage of the total crop. The results are recorded in Table 2. Each line of data derives from one tree, either a parental clone or selection. Both trees of S-1 (M 13269) bore less than 20% seedless fruit in 1968 and 1969 but 3 seedlings of this parent (15-27, 15-48, and 17-23) bore crops more than 20% of which were seedless in 1969. One selection, No. 17-23, yielded 81.3% seedless fruit in 1969. The contrast with 17-26 is remarkable: although 17-26 tended toward extreme alternate bearing, it produced no seedless fruit in 1968 and only 2.3% in 1969.

The 5 selections derived from S-10 showed much more uniform behavior than the previous group, although at one extreme 13-39 bore 15% seedless fruit in 1968 and 16.9% in 1969, and 13-55, at the other extreme, bore 2.3% seedless fruit in 1968 and 1.9% in 1969. Seedlings of M-1007 showed the highest incidence of seedlessness over-all. Four of the 9 seedlings observed bore more than 20% seedless fruit in 1969, and 3 of them bore crops more than 40% of which were seedless in both 1968 and 1969. The worst record of all was made by 13-14: 71.2% of the 1968 crop was seedless, and so was 86.9% of the 1969 crop.

The results in Table 2 demonstrate the relatively consistent yearly performance of the individual trees: if a selection performed poorly in 1968, it did the same in 1969. The S-1 seedling population showed less consistency than others, specifically in the behavior of 15-48 and 17-23, as well as Tree 2 of the parental clone, but these exceptions do not alter the over-all impression of consistency gained from this work. If a seedling or a recent selection shows a high incidence of seedlessness, then it should be discarded.

The winter of 1969-70 in southern Florida was one of the coldest on record. In the summer of 1970, 361 newly-fruiting seedling trees were examined for occurrence and extent of seedlessness. A high proportion of the crop was seedless in 134 trees, or 37% of the population. Trees remaining 63% will be considered for retention if their performance otherwise justifies this, but selection of any of the seedless 134 would obviously be ill-advised.

Table 2. Production and seedlessness in 3 mango selections and seedlings.

<table>
<thead>
<tr>
<th>Selection</th>
<th>Seed parent</th>
<th>No. fruit</th>
<th>% seedless fruit</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-1 (M 13269) and seedlings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S-1 (tree 1) Saigon type</td>
<td>889</td>
<td>600</td>
<td>0.6</td>
</tr>
<tr>
<td>S-1 (tree 2) Saigon type</td>
<td>413</td>
<td>505</td>
<td>1.2</td>
</tr>
<tr>
<td>S-1 (seed)</td>
<td>99</td>
<td>637</td>
<td>38.4</td>
</tr>
<tr>
<td>15-48</td>
<td>S-1</td>
<td>129</td>
<td>388</td>
</tr>
<tr>
<td>15-51</td>
<td>S-1</td>
<td>127</td>
<td>94</td>
</tr>
<tr>
<td>16-36</td>
<td>S-1</td>
<td>249</td>
<td>762</td>
</tr>
<tr>
<td>16-38</td>
<td>S-1</td>
<td>213</td>
<td>842</td>
</tr>
<tr>
<td>17-26</td>
<td>S-1</td>
<td>66</td>
<td>1,401</td>
</tr>
<tr>
<td>17-47</td>
<td>S-1</td>
<td>74</td>
<td>240</td>
</tr>
<tr>
<td>S-10 (M 4329) and seedlings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S-10 Saigon type</td>
<td>373</td>
<td>160</td>
<td>2.9</td>
</tr>
<tr>
<td>13-39 S-10</td>
<td>160</td>
<td>468</td>
<td>15.0</td>
</tr>
<tr>
<td>13-42 S-10</td>
<td>51</td>
<td>216</td>
<td>5.9</td>
</tr>
<tr>
<td>13-44 S-10</td>
<td>49</td>
<td>143</td>
<td>12.2</td>
</tr>
<tr>
<td>13-55 S-10</td>
<td>86</td>
<td>54</td>
<td>2.3</td>
</tr>
<tr>
<td>14-51 S-10</td>
<td>52</td>
<td>231</td>
<td>3.9</td>
</tr>
<tr>
<td>S-1007 and seedlings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S-1007 Saigon type</td>
<td>2,173</td>
<td>0</td>
<td>16.9</td>
</tr>
<tr>
<td>9-15 M 1007</td>
<td>102</td>
<td>174</td>
<td>40.2</td>
</tr>
<tr>
<td>9-45 M 1007</td>
<td>140</td>
<td>117</td>
<td>3.6</td>
</tr>
<tr>
<td>11-8 M 1007</td>
<td>52</td>
<td>102</td>
<td>3.8</td>
</tr>
<tr>
<td>11-12 M 1007</td>
<td>293</td>
<td>171</td>
<td>9.9</td>
</tr>
<tr>
<td>11-25 M 1007</td>
<td>55</td>
<td>216</td>
<td>18.9</td>
</tr>
<tr>
<td>11-54 M 1007</td>
<td>238</td>
<td>59</td>
<td>5.5</td>
</tr>
<tr>
<td>12-28 M 1007</td>
<td>60</td>
<td>92</td>
<td>10.0</td>
</tr>
<tr>
<td>12-29 M 1007</td>
<td>171</td>
<td>233</td>
<td>54.4</td>
</tr>
<tr>
<td>13-14 M 1007</td>
<td>208</td>
<td>572</td>
<td>71.2</td>
</tr>
</tbody>
</table>

Passiflora spp.

Two forms of one species, the purple passion fruit (Passiflora edulis Sims) and the yellow passion fruit (P. edulis f. flavicarpa Deg.) are sources of the passion fruit juice of most commercial importance. Both forms are grown in tropical or warm subtropical regions to which the species, a native of Brazil, is adapted. The maypop, P. incarnata L., is taxonomically close to P. edulis but unlike that species...
survives winter well into the North Temperate zone. Its perennial growth there results from its ability to bud from the roots which grow below the depth to which the soil freezes.

While making test pollinations among several Passiflora species I found the P. incarnata is self-incompatible even though it is geographically close to the center of distribution in South America. (The plant I used was collected in Tennesse.) Better-quality fruits of the hardiness of P. incarnata are needed. Passiflora incarnata accepts pollen of P. edulis f. flavicarpa; we obtained an average of 57 seeds per fruit from 10 pollinations. Seeds from P. incarnata pollinated by P. cinerata Masters have also been obtained. Passiflora incarnata forms fruit in response to pollination by P. laurifolia L., the water lemon, whose embryos are abortive when in hybrid form. Seedlings from the hybridization of P. incarnata with both P. edulis f. flavicarpa and P. cinerata have germinated. Chlorosis afflicts all plants of the first combination, and they are weak growers, but in contrast the hybrid between P. incarnata and P. cinerata grows vigorously and appears healthy. Many interspecific Passiflora hybrids have been made during the past 100 years (2, 8) and recent experience suggests that more can be made. How P. incarnata combines genetically with additional species should be determined. Neither of the interspecific hybrids reported here has yet reached flowering age, so their fruiting capacity has not been determined. Hybrid sterility may be a problem, and in such a case use of colchicine to double chromosome numbers—and hopefully to establish hybrid sterility—will be necessary.

Annona muricata L.
The guanabana or soursop has been planted in Florida for at least 84 years (10), but has never become important economically, as it has in tropical American countries. Problems involving pollination may share responsibility, but the chief reason for failure of this crop to develop here is its extreme sensitivity to cold. Temperatures near 40°F, well above freezing, cause leaf fall and die-back which delays the next summer’s flowering until the tree has partly recovered. Two related Annona species, one native (A. glabra L., the pond apple) and one introduced (A. montana Macf., the mountain soursop) grow vigorously in southeastern Florida and endure normal winters without obvious damage. Some individuals in both species fruit abundantly; unfortunately the fruit’s quality does not justify their use except as famine foods. Their close relationship to A. muricata makes the 2 harder species likely candidates for hybridization to produce cold-tolerant fruits of acceptable horticultural quality. The pond apple blooms every spring after a normal winter, but the sour sop unfortunately is often so affected by cold injury or spring drought that it may not bloom until midsummer; therefore timing of cross-pollinations is difficult, and it may be necessary to store pollen to achieve success. Midsummer flowering of the mountain soursop and the guanabana overlap, so pollinations between these 2 species are possible without pollen storage. I have made a number of such pollinations without obtaining seeds; fruit set late in season and was destroyed by early cold. This suggests the possibility of success in such work: Annona muricata reportedly was successfully crossed with A. montana in Cuba some years ago (2). The results that could follow successful crosses justify continued efforts to obtain them.

Malpighia punicifolia L.
The acerola or West Indian (or Barbados) cherry is of interest as an abundant source of Vitamin C, and a fruit used to make ade drinks and jellies. Commercialization on a large scale has not succeeded, but this crop has great potential for dooryard planting whenever climate permits. The acerola grows naturally in the West Indies, northern South America, and Yucatan. The related species, M. glabra L., occurs through much of Mexico, and north to southern Texas where sub-tropical conditions prevail, as well as in the West Indies and Central and South America (12). A few seedlings that grew at the Miami station from open pollination of PI 98866 (an acerola of ordinary type from Surinam) vary so greatly from the seed parent in leaf form and fruit characters that the possibility of hybridization from another species in the collection, M. glabra L., is indicated (though not yet proved). No edible-fruited Malpighia species collected near the northern extremes of the range for the genus have been established at the Miami Plant introduction Station, but the possibility of collecting such plants and hybridizing them with acerola clones of high ascorbic acid content deserves investigation.

Summary
Means of raising the level of cold tolerance vary with the crop under consideration. Within the species Persea americana Mill. certain individuals of the Mexican race of avocados tolerate occasional temperatures 14°F below freezing without twig or leaf injury, whereas most West Indian avocados are severely injured by temperatures as low as 28°F. Genetic factors that effect Mexican-race tolerance of low temperatures are at least partially dominant, judging from the performance of seedlings. Other dominant fruit characters make it likely that F1 hybrids of Mexican and West Indian parental type will produce commercially acceptable cultivars, although acceptable phenotypes should appear in the second generation.

The mango (Mangifera indica L.) has no regional race showing hardness comparable to that of certain Mexican avocados, although cultivars from northern India reportedly show more cold tolerance than do avocados from southern India. Of equal importance in subtropical regions is the ability to produce normal seeded fruit rather than “nubs” containing aborted embryos, despite prolonged cool weather during the (winter and spring) flowering season. Seedlings vary in the degree of seedlessness exhibited, and their performances are consistent enough to justify eliminating any seedling that shows much seediness at first fruiting age.

The hardest North American passion fruit, the maypop (Passiflora incarnata L.) survives northern winters through its durable underground stems. This species crosses readily with close relatives, and hybridization with species of commercial importance (a procedure currently under investigation) may combine production of acceptable passion fruits with enhanced winter hardiness. The soursop or guanabana (Annona squamosa L.) is the hardest of the commercially important Annonas. Prolonged exposure to temperatures above freezing but below 40°F is extremely injurious, even to mature trees. Two related species, Annona montana Macf. (mountain soursop) and A. glabra L. (pond apple, native to southern Florida), endure prolonged periods of near-freezing weather without visible injury. Both species bear fruit of inferior quality. Hybridization of the soursop with one of the harder related species may produce an acceptable fruit tree better adapted to subtropical conditions.

The acerola or West Indian cherry (Malpighia punicifolia L.), a rich source of ascorbic acid, is native to the West Indies and northern tropical America. Its close relative Malpighia glabra L., occurs as far south as southern Texas and 2 species appear to have crossed spontaneously at the U. S. Plant Introduction Station, Miami. Deliberate hybridization is desirable to obtain cultivars with the acerola’s quality and vitamin content but with enhanced cold tolerance.

Literature Cited