worthy substitutes for zineb, particularly where copper must be employed, although previous experiments (Johnson, et al. 6) have shown that zineb is somewhat superior to Chlorobenzilate where no copper is involved.

Neither zineb nor Chlorobenzilate or Kepone have any fumigating action on citrus rust mite and are not very effective when applied where rust mite is numerous. For maximum control, these materials should be applied thoroughly when citrus rust mite first appears.

LITERATURE CITED

TWO NEW SEEDLING PERSIAN LIMES

J. F. L. Childs' and W. G. Long

Large seedless limes ('Citrus aurantifolia (Christm.) Swing.), commonly called Persian or Tahiti limes (11), are grown in commercial quantities only in south Florida. W. F. Ward (10) wrote that the first Persian lime planting in south Florida was made near Lake Placid in 1897, and according to Col. Alva Lee (5), commercial production began about 1928. The origin of the names "Persian" and "Tahiti" is not known. If there was originally a distinction between them, it has been lost, since they are used interchangeably in Florida today. Incidentally, lime seeds from Tahiti sent by French officials in 1953 produced only Key lime plants.

By 1959-60 production of Persian limes in Florida amounted to approximately 320,000 boxes (80 lbs.) and returned about $880,000.00 to the grower, on the basis of an average price of $2.75 per box before harvest.

From the beginning of commercial production in Florida, Persian limes have been subject to certain diseases that caused great expense to growers (3, 5, 7, 9, 10). These diseases are still a serious problem. W. F. Ward (10), pioneer nurseryman of Avon Park, summed up the situation by saying, "The average life of lime trees is not as long as that of orange and grapefruit trees because of disease factors. Lime trees are quite susceptible to many bark and virus diseases, causing considerable loss before they reach 20 years of age. The most common of these are the so-called 'lime bark disease', xylorosporosis, psorosis, and gummiosis" and, "when virus-free trees are found and accepted in the Budwood Certification (registration) Program, one of the major headaches of the lime producer will be over". Severe damage by lime-bark disease has caused more than one grower to remove an entire planting before the trees were old enough to produce even one normal crop of fruit. Others "quit growing limes and went back to growing citrus", as one grower expressed it.

That was the situation in 1952 when an attempt was made to grow virus-free lime trees from seed. Although limes are practically seedless, about one seed to a box of fruit, arrangements were made with R. W. Kilburn of Florida Citrus Canners Cooperative to save the seeds from Persian limes being processed at the Lake Wales plant. Attempts to screen seeds from the pulp were unsuccessful. After several days' operation, less than a dozen seeds were obtained and those were damaged. However, approximately 250 lime seeds were obtained by picking over two truckloads of pulp by hand.

When the lime seeds were germinated, less than half of the seedlings developed Persian lime-type leaves. Several developed symptoms of lime leaf blotch, evidence that leaf-blotch can be transmitted through seed (1, 3).

Twenty-two seedlings with Persian lime-type leaves were set out near Lake Placid in 1953 for fruiting and observation. Several developed symptoms of lime leaf blotch, evidence that leaf-blotch can be transmitted through seed (1, 3).
are now producing true Persian lime-type fruits. The purpose of this paper is to give a preliminary report of the characteristics of those two trees and their fruit.

**Characteristics of the Seedling Trees**

The two seedling trees are arbitrarily designated 1 (fig. 1) and 2. Tree 2 is slightly larger than tree 1. Both bear Persian lime-type leaves and neither shows symptoms of leaf blotch. Both trees are larger than adjacent old-line trees budded on Rough lemon ((C. limon (L.) Burm.) set the same year, 1953. Nothing is known about the fruiting habits of the two seedlings, since both are just beginning to bear, but the larger tree produced more fruit this season.

Because budded limes are planted among the seedlings, the question has been raised whether a mix-up could have occurred and whether trees 1 and 2 are seedlings. That both trees are seedlings is confirmed by the fact that neither shows a bud-union, a very noticeable feature on the adjacent budded trees. Also each seedling has a heavy galvanized iron rod protruding from the trunk above the root crown. That happened because each seedling was tied to a wire stake for support when first set out. The stakes were not removed and were later overgrown by the seedlings. None of the budded trees has a galvanized iron rod by it or protruding from it.

**Characteristics of the Fruit**

Approximately 25 pounds of fruit was picked from each seedling tree on August 11, 1960, when some of the fruits showed a break in rind color, indicative of maturity. For comparison, a similar lot of fruit was collected from adjacent budded old-line Persian lime trees. Representative fruits from the three sources are shown in fig. 2.

Part of each lot of fruit was withheld for rind-oil analysis and a preliminary analysis of the fruit, and several small-scale taste tests were performed on the remainder. On September 10-11 a severe hurricane destroyed the crop and prevented further study of fruit. In the absence of a more thorough study, the results of the preliminary tests are presented.

**Fruit Analysis**

Analyses of the three lots show that the total soluble solids of fruit from seedling lime trees was slightly higher and the total acid (as citric) was appreciably higher than it was in fruit from budded old-line trees (table 1). Analysis of fruit of old-line budded trees fell within the range reported by S. J. Lynch (6) for limes budded on Rough lemon. The difference between the seedling fruits and those of budded trees may result from the budded limes being on Rough lemon rootstock and partial girdling by lime-bark disease, or the difference between the seedlings and the old-line trees may be real. The fruits from the seedling trees were slightly smaller, and their percent of juice was slightly greater. In either case the differences are small and are probably not important.

**Taste Tests**

Three small-scale taste tests were made. In the first test the fruits were cut into thin slices. Tasters listed the order of their preference before the origin of the three lots was disclosed. Twenty-four tasters participated. Four could detect no difference between the three lots and 13 of the remaining 20 tasters rated the fruit from budded trees best. The fruit from seedling 1 rated second best, and the fruit from seedling 2 rated last.

In the second taste test, tasters listed their preference for limeade made from each of the
Fig. 2. Limes harvested from seedling trees 1 and 2 and from adjacent budded old-line lime trees.

TABLE 1.—Analyses of fruits from seedling and from old-line budded Persian lime trees†

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Unit</th>
<th>Seedling 1</th>
<th>Seedling 2</th>
<th>Old-line</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit weight</td>
<td>gm.</td>
<td>98.0</td>
<td>102.0</td>
<td>105.0</td>
</tr>
<tr>
<td>Fruit volume</td>
<td>ml.</td>
<td>99.0</td>
<td>103.0</td>
<td>107.0</td>
</tr>
<tr>
<td>Juice</td>
<td>ml.</td>
<td>50.0</td>
<td>52.0</td>
<td>55.5</td>
</tr>
<tr>
<td>Juice (vol./vol.)</td>
<td>%</td>
<td>50.5</td>
<td>49.5</td>
<td>48.9</td>
</tr>
<tr>
<td>Acid, total</td>
<td>%</td>
<td>6.41</td>
<td>6.26</td>
<td>5.41</td>
</tr>
<tr>
<td>Soluble Solids</td>
<td>%</td>
<td>8.10</td>
<td>8.00</td>
<td>7.50</td>
</tr>
</tbody>
</table>

†/ Sample of 10 fruits from each lot.

3 lots of fruit. Extracted juice was diluted with water, and sugar was added as follows: 100 ml. of juice, 750 ml. of water, and 55 grams of sucrose. The order of preference for the juice samples was the same as in the test with fruit slices.

In the third test, juice from each lot of fruit was diluted with the same amount of water as in the second test, but varying amounts of sugar were added to bring each juice sample to approximately the same solids-acid ratio as follows: 100 ml. of juice was diluted with 750 ml. of water, and for each percent of citric acid 10 grams of sucrose was added. In this test the order of preference was reversed. Most tasters rated the limeade from seedling 1 best, from seedling 2 second best, and from the budded trees, last. The tasters’ preferences seem based mainly on acidity or lack of it. The main point is that there was little difference between the fruit of the budded and the seedling trees. An appreciable number of the tasters could detect no difference.

RIND-OIL CHARACTERISTICS

Analyses of the rind oil provided singularly effective means of comparing fruit of
the two seedling trees with fruit of old-line budded trees as Chapot showed in 1949 (1). The characteristics of the rind oil determine the flavor and taste appeal of citrus fruit and if the rind oil of the seedling-tree fruit closely approximates that of old-line limes, the seedlings probably have commercial value, provided their solids and acid analyses are even reasonably close.

Through the cooperation of Henri Chapot, Morocco, arrangements were made for rind-oil analyses by R. Schwob and R. Reigner of the I.F.A.C. (Institute Francais de Recherches Fruitières) laboratories in Paris and 10 pounds of each of the 3 lots of fruit was sent to them for examination. From each lot of fruit a sample of rind-oil was obtained by the standard cold extraction method and separated into three fractions, A, B, and C. The A fractions, of each of the three lots of fruit, were compared by gas chromatography, and the B fractions and C fractions were similarly compared. On the curves obtained by this method, the location of the peaks indicates the presence of certain chemical constituents in the oil sample and the height of the peak indicates the amount of the constituent that is present.

From comparison of the curves obtained with curves from Persian limes from other regions, Schwob and Reigner* found that, 1) "the pattern of the chromatograms is typical of true large-fruited Persian limes", and 2) "the rind-oil chromatograms of the three lots of fruit are identical."

*The report of R. Schwob and R. Reigner, translated into English by J. Bove', was received Oct. 21, 1960. Our sincere appreciation is hereby expressed for this assistance and to I.F.A.C. for making the work possible.

**DISCUSSION AND CONCLUSIONS**

This preliminary report is concerned primarily with the similarity of the fruits of two seedling Persian lime trees and of old-line Persian lime trees. Small-scale tests indicate that fruits from the seedling tree are similar to those of old-line trees in size, appearance, acid, total soluble solids, taste, and rind-oil characteristics.

The characteristic that makes these two seedlings of major interest to lime growers, however, is that they are probably free of bud-transmitted diseases such as lime-bark disease, gummosis, xyloporosis, psorosis, tristeza, lime-leaf blotch and fruit sectoring and, perhaps, stylar-end breakdown. Clean bud-wood of Persian lime offers lime growers a means of escaping the diseases that have given them such a headache for so many years.

**LITERATURE CITED**


**DIFFERENCES IN TEMPLE ORANGE COLOR AND QUALITY ASSOCIATED WITH "STYLAR-END GREENING"**

**WILLIAM G. LONG† AND J. F. L. CHILDS‡**

The fact that the calyx or stem end of a citrus fruit differs from the blossom or stylar end in several aspects is generally recognized. Bartholomew and Sinclair (1)* compared the concentration of total soluble solids, total acidity, pH, and sugar in the calyx half and in the stylar half of carpellary segments of mature citrus fruit. The stylar half of Valencia and Navel oranges and unnamed grapefruit had higher soluble solids in 95 to 99 percent of the segments. Acid was higher in 91 percent and reducing sugars (glucose) was higher in 100 percent of the stylar halves. Haas and Klotz (8) found that specific gravity, sugars,