and seedling grower look for eye appeal, e.g. a rich blush to deep red color of the surface of the skin. Flesh that is fiber free, yellow to orange in color with a sweet, slightly sub-acid flavor to give it more than just bland sweetness is also desirable. As small a seed as possible is also desirable. Tolerance of harvesting and post-harvest handling with a long shelf life is also most desirable. Thousands of seedlings have been tested to meet these requirements but very few have been made final selections. The seedling search continues. There is still much land available for mangos in Florida if most of these problems and requirements are met and overcome. The mango grower must be and is a believer and an optimist.

AVOCADO GERM PLASM EVALUATION: TECHNIQUE USED IN SCREENING FOR COLD TOLERANCE

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ABSTRACT

Cold room facilities for exposing large numbers of individual leaves to sub-freezing temperatures in the U. S. Plant Introduction Station's avocado cold tolerance screening program are described. During early 1967, 467 open-pollinated seedlings from 7 progenies: 1) 'Arue'; 2) 'Capac'; 3) 'Capac' F₁; 4) 'Dunedin'; 5) 'Itzamna'; 6) Mexican-race; and 7) 'Taylor' with Mexican clone M-18686 as "hardy check" and 'Collinson' P. I. 55509 as "tender check" were tested. Both blade and vein damage were scored on a scale of 1 (total tissue destruction) to 5 (no visible tissue damage). Cumulative scores rank Mexican-race seedlings most cold tolerant, 'Arue' seedlings least tolerant.

INTRODUCTION

Recent F. A. O. sponsored meetings in Rome stressed the urgency and need for establishing international germ plasm collections of economic crops and in particular, food crops. Reviewed as part of the total program were allied subjects such as plant introduction, plant quarantine, population growth and land use. This last item, land use, relates directly to urban encroachment on agricultural lands in the warmest parts of South Florida. Already a number of avocado and mango groves have given way to urbanization. Others are threatened by it or by the increased tax assessment on grove lands, an implementing factor leading to urbanization.

The First Research Corporation's 1965 report, "A comprehensive economic evaluation of the south Dade County area"(1), recommends that planning measures provide for this unremitting expansion by establishing a balance between industry and agriculture—with much of the former as processing for the latter.

The majority of Florida's avocados are grown in a restricted zone where subtropical temperatures prevail over damaging freezes. Furthermore the Florida avocado industry is based on cold susceptible cultivars of: 1) the West Indian race of Persea americana Miller (P. gratissima Gaertn. f.); 2) the Guatemalan race of the same species; and 3) "hybrids," predominantly natural crosses between cultivars of the two races. A third race, the Mexican, botanically separated from the preceding races as P. americana var. drymifolia (Schl. & Cham.) Blake, is cold tolerant but in Florida there are neither pure cultivars nor hybrids of the race that are commercially important. In California the cultivars 'Fuerte,' 'Hass,' 'MacArthur,' 'Rincon' and 'Bacon,' all Mexican-Guatemalan interfacial hybrids, dominate the industry. (2) In Texas, Mexican seedlings are considered equal to oranges in their cold resistance and in one report (3) where oranges and a Mexican seedling were growing under similar conditions the oranges, following a freeze, showed more twig damage than did the avocado. Individuals of the Mexican race have survived and fruited in the Gainesville area for over 50 years (4), again unquestionable evidence of the existence of stable factors for cold tolerance.
The U. S. Plant Introduction Station, Miami, maintains a *Persea* germ plasm collection containing cultivars belonging to each of the three races, and of "hybrid" cultivars manifesting combined attributes of the races. Overlap in bloom periods between the individuals of the different or mixed races, plus synchronous flowering (types A and B) (5), have afforded opportunities for uncontrolled crossings within the collection.

Growing out open-pollinated seedling populations from selected parent trees in this racially heterogeneous collection provides abundant test material for germ plasm evaluation of cold tolerance. These same populations subsequently will be, or concurrently are being, evaluated for commercially acceptable fruit, extension of crop, productivity and other significant horticultural characters.

**Materials and Methods**

Field testing for cold tolerance of plants at the Miami station would be a circumscribed program—furthermore, freezing temperatures are not always evidenced; the winter of 1966-67 being an example. To overcome the uncertainties of outdoor variables, two walk-in cold rooms were installed in 1959. In these, controlled temperatures could be lowered gradually to a selected point but the uniformity of the temperature throughout the room was practically impossible to maintain. This condition was remedied by installing multi-perforated panels as a ceiling over one entire test room. The sloped ceiling gradually drops toward the rear so as to enclose the refrigeration unit and fan; thus this newly formed space into which the cold air is blown becomes a pressurized plenum (6) from which it is forced uniformly out through the small perforations, settling evenly onto the test material.

Halfway through one series of testing (during March) the minimum outdoor temperature rose to above 70° F. This change from March normal daily minimum of 61.1° F. (7) was sufficient to prevent the cold room temperature from dropping to a mid-teen (Fahrenheit) temperature, the range considered necessary for a satisfactory test. To compensate for this contingency the 2 walk-in refrigerators, located in a partially open stone building, were enclosed in an insulated room to which air conditioning was added. With the resumption of "cool nights" the temperature in the testing room again dropped to the mid-teens. (F.). "Good" testing conditions were restored and now can be produced irrespective of outside temperatures.

Also in need of revision was the testing arrangement. The original set-up provided for only 24 pieces (twigs and branches) to be tested at one time. With new avocado seedling populations being planted each successive year, we soon would have a hopelessly large backlog of untested material unless provisions for handling large numbers of individuals were made.

A rack constructed of heavy grade polyvinyl chloride ("PVC") pipe, insulated with fiber glass, and through which a constant flow of water can be maintained, answered the capacity problem. The system, designed to use single leaves in test tubes inserted in the water tempered rack, now makes it possible to accommodate 210 test samples (Fig. 1) instead of 24. A snug-fitting plastic cap, such as florists use on orchid tubes, gives support to the leaf and prevents both heat loss and water loss from the test tube (except for that transpired through the leaf). The external rim of the plastic cap forms a seal against a seating groove easily formed at the top of each upright PVC pipe. This seal prevents heat loss from the water circulating through the rack. The water in the test tube is maintained at a constant temperature and thus protects the petioles from freezing, permitting transpiration as long as the leaf tissue remains functional.

In the spring of 1967 leaves (Fig. 1) from 7 different groups of open pollinated seedlings were tested together with a tender check and a hardy check. Total defoliation on the south west sides of the trees, as a result of the October salt-laden hurricane "Inez" ruled out 1966 fall or winter evaluation; it did assist in establishing the age of leaves used in the 1967 spring evaluations as those marked for testing developed after the hurricane.

Field preparation procedure followed for tests of the 5 smaller populations, Capac F1, Capac Fz, Itzamna F1, Dunedin, and Mexican-seedling and the checks 'Collinson' P. I. 55509 (tender) and Mexican clone M. 18686 (hardy) was to select a branch with 4 matured leaves from the southeast side of the tree, between 4 and 5 feet high. Prior to removing the branch, leaves other than the 4 selected for testing were clipped and those remaining for test were tagged with the plant number on premarked "Time" adhesive microscope labels, to which a color flag
of plastic marking tape, indicating seedling group, was attached. With good adhesion (leaf surface must be dry) these labels and flags will last for months and even survive hurricanes. The color flags used for each group of seedlings were of invaluable assistance in simplifying and controlling operations involving thousands of leaves.

The two larger populations, 'Arue' and 'Taylor' seedlings, were selected and tagged similarly except that only one leaf was retained on each branch chosen (4 per plant).

In late afternoons the branches, each with 1 or 4 labeled leaves, were cut from the trees and the stems plunged into buckets of water. These were taken directly to the 40°F preconditioning cold room and transferred to open, 3-inch deep, water-filled trays. The basal ends of the branches were recut under water. Branches from 180 seedling plants were brought in at one time. This provided sufficient leaves, 720, plus 120 checks, for four consecutive nights' testing. We then processed one-quarter of each of the 2 larger populations and the entire population of the 5 smaller groups after 24, 48, 72 and 96 hours preconditioning. Which quarter of the larger populations was to be subjected to which preconditioning period was determined at random. During the 4 testing weeks, 4 leaves from each seedling in the 'Arue' and 'Taylor' groups, 16 leaves from each seedling in the smaller groups, and 240 leaves of each of the checks were tested for cold hardness.

Petioles of leaves removed from the preconditioning cold room were recut, inserted into the holes in the plastic caps and these placed on
the test tubes, all under water. Tubes with individual leaves were then randomized in the test room racks. Leaves were removed from the cold box around noon and a new set of leaves from the conditioning room was prepared for the next round of testing.

On removal from the cold chamber the leaves were taken out of the tubes and the petioles immediately submerged in water filled trays, and held at ambient for 48 hours before evaluating. Wire racks supported the leaves individually where they could continue to transpire if they had not been damaged by the low temperatures to which they were subjected. Damage (necrosis) to both leaf vein and leaf blade was evaluated separately. A rating of 1 equaled total tissue destruction while a rating of 5 meant no visible tissue damage; the intermediate values (2-4) were readily assigned on the basis of observable damage. The evaluations are summarized in Table 1.

The cumulative mean scores are based on the averaged evaluation of both leaf vein and leaf blade made independently by the authors. Score was determined by the formula:

\[
\text{rating (1 to 5)} \times \frac{100}{\text{temperature}}
\]

Minimum temperatures for the 16 tests run varied from 13° F. to 21.5°; the mean minimum temperature was 16.9° F.

**RESULTS AND DISCUSSION**

The cumulative mean score for all leaves was 16.95. Only seedlings well above this mean are considered outstanding, i.e., warrant further testing. In this preliminary evaluation a base score of 21.5 was chosen arbitrarily as the minimum standard for selection.

Out of 467 seedlings (Table 1) cumulatively scored during the early 1967 tests, we selected 30 individuals with leaves that consistently tolerated low temperatures, including at least one exposure to 13 or 14° F. These are listed by seedling progeny, field tree number, and cumulative score.

**Table 1.** Summary of Avocado Seedling Progeny, Cold Hardiness Tests, 1967

<table>
<thead>
<tr>
<th>Seedling Progenies and Checks</th>
<th>Number of Plants Tested</th>
<th>No. of Leaves Per Plant</th>
<th>No. of Leaves Per Progeny or Check</th>
<th>Plants and/or Leaves Scoring 21.5 or above</th>
<th>Number</th>
<th>% of Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arue F₁</td>
<td>268</td>
<td>4</td>
<td>1072</td>
<td>6</td>
<td>17</td>
<td>2.24</td>
</tr>
<tr>
<td>Taylor F₁</td>
<td>114</td>
<td>4</td>
<td>456</td>
<td>6</td>
<td>6</td>
<td>5.26</td>
</tr>
<tr>
<td>Capac F₁</td>
<td>10</td>
<td>16</td>
<td>160</td>
<td>None</td>
<td>None</td>
<td>0.0</td>
</tr>
<tr>
<td>Capac F₂</td>
<td>12</td>
<td>16</td>
<td>192</td>
<td>None</td>
<td>None</td>
<td>0.0</td>
</tr>
<tr>
<td>Itzamna F₁</td>
<td>26</td>
<td>16</td>
<td>416</td>
<td>None</td>
<td>None</td>
<td>0.0</td>
</tr>
<tr>
<td>Dunedin</td>
<td>20</td>
<td>16</td>
<td>320</td>
<td>None</td>
<td>None</td>
<td>0.0</td>
</tr>
<tr>
<td>Mexican Seedling</td>
<td>17</td>
<td>16</td>
<td>272</td>
<td>17</td>
<td>100.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Collinson, P.1.55509</td>
<td>1</td>
<td>240</td>
<td>240</td>
<td>67</td>
<td>27.92</td>
<td>0.0</td>
</tr>
<tr>
<td>Mexican clone M-18686 (hardy check)</td>
<td>1</td>
<td>240</td>
<td>240</td>
<td>198</td>
<td>82.50</td>
<td>0.0</td>
</tr>
</tbody>
</table>
The results of these first large-scale trials evaluating avocado leaves for cold tolerance encourage us to believe that in some of the individual seedlings tested, genes for cold hardiness from the Mexican race have combined through open pollination with those of the horticulturally superior West Indian and Guatemalan cultivars; also that homologous or analogous genes which may exist in the Guatemalan race (e.g. ‘Taylor’) are readily brought to light.

With techniques improved by this preliminary work on evaluation of avocado germ plasm for cold hardiness, project expansion is planned. Eventually isolated seed gardens, composed of plants selected for concentration of germ plasm of both cold hardness and superior horticultural characters, are to be established. Testing and selecting from large populations, obtained from both hand pollinations and open pollinations in isolated gardens, is planned to provide suitable avocado cultivars for those areas now considered too cold to sustain commercial avocado production.

LITERATURE CITED


BETTER COLORED LIMES FOLLOWING SPRAY TREATMENTS

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Abstract

Green color of limes was intensified by 2 spring applications of ferbam, ferbam plus triphenyltin hydroxide, and CuFram Z (a dithiocarbamate coordination product of micro elements, iron, zinc, manganese, and copper). These results suggest that these organic compounds may have a nutritional or stimulatory effect on the trees thereby influencing the synthesis of chlorophyll.

Introduction

Intensity of external color is very important in the marketing of limes. They must be marketed as immature fruit prior to the develop-