REACTION OF EIGHT CITRUS VARIETIES TOPWORKED ON MILAM TREES WITH SEVERE STEM-PITTING SYMPTOMS

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Abstract. Severe stem-pitting symptoms of unknown cause were observed on numerous Milam trees (Citrus limon (L.) Burm. f. hybrid) and several other cultivars in 1972. In 1973, we topworked 6 severely pitted Milam trees with 8 different citrus varieties to investigate the nature of this pitting and determine its possible economic effects. These varieties, each topworked to a separate scaffold branch on each Milam tree, were Marsh grapefruit (C. paradisi Macfad.), Valencia sweet orange (C. sinensis (L.) Osb.), Cleopatra mandarin (C. reticulata Blanco), sour orange (C. aurantium L.), Orlando tangelo (C. reticulata X C. paradisi), Columbia sweet lime (C. limettioides Tan.), Rangpur lime (C. limonia Osb.), and Robinson tangerine hybrid (C. reticulata Blanco X (C. paradisi X C. reticulata)). After 5 years, most scions remained free of stem pitting. Obvious pitting was observed in 1 of 6 propagations of sour orange, and mild pitting was observed in 4 of 6 propagations of sweet lime. Pitting was observed in the Milam scaffold immediately below the scion union on topworked trees. Uninoculated Milam seedlings planted among the larger topworked trees at the time of grafting also showed pitting.

Severe stem-pitting symptoms observed in the trunks of Milam trees in 1972 (5) suggested the presence of a serious new viruslike disease in Florida citrus (2). The effects on Milam were cause for concern, since it was being widely used as a replant rootstock in areas affected by burrowing nematode (Radopholus similis (Cobb) Thorne). Similar pitting was also found in 19 other cultivars, including several mandarin hybrids such as ‘Robinson’, ‘Page’, and ‘Lee’ (5). Natural spread of the stem-pitting factor was indicated since some, but not all, trees of clonal propagations were affected in as many as 16 different locations.

Citrus tristeza virus (CTV) and cristacortis (3) are well-known causes of stem-pitting in citrus. However, severe stem-pitting isolates of tristeza are not common in Florida (2), and cristacortis has not been described in the U.S. (3). Also, preliminary indexing tests did not detect CTV in all stem-pitted trees, and foliar symptoms associated with cristacortis (4) were not observed.

To better determine the cause of stem-pitting in Milam and to ascertain the effect of this factor on other citrus varieties, we established several indexing and transmission experiments soon after its discovery. Here we describe results from topworking large, stem-pitted Milam trees with 8 different citrus varieties selected to help identify the cause of the pitting, and to test the susceptibility of several important commercial scion varieties.

Materials and Methods

In 1973, 6 clonal Milam trees with severe stem-pitting on the trunk (Fig. 1) were selected for the experiment. These 6-year-old trees were vigorous and had a dense canopy and numerous scaffold limbs. Removal of bark patches indicated that pitting was largely confined to the main trunk and lower scaffolds. Pitting was not observed in roots or in smaller limbs.

Fig. 1. Stem-pitting in trunk of Milam tree topworked with different citrus varieties. Photographed at start of experiment in 1973, when Milam trees were 6 years old.
ment of Agriculture. The remaining scions were from greenhouse-grown seedlings. The 'Valencia' source carried a mild isolate of tristeza. All scion sources were free of psorosis, exocortis, and xyloporosis.

![Diagram of topworked tree showing arrangement of different scions on stem-pitted Milam stock.](image)

Fig. 2. Model of topworked tree showing arrangement of different scions on stem-pitted Milam stock. For comparison, a seedling, greenhouse-grown source of Milam was also grafted to an additional scaffold of the Milam stock.

At the time of grafting, 10 young Milam seedlings were interplanted among the large, grafted trees. The topworked trees were desprouted and pruned periodically to encourage uniform growth of the scions. Annual inspections were made for stem-pitting symptoms by cutting a small window in the bark across the union between the scion and the Milam stock. At the final reading in 1978, the entire tree was sacrificed and the grafted scaffold limbs were completely peeled and examined for pitting.

Indexing for CTV was done by graft inoculation to Mexican lime (*C. aurantiifolia* (Christm.) Swing.) and serologically by enzyme-linked immunosorbent assay (ELISA) (1).

Standard leaf inoculation procedures were used for mechanical transmission tests. Young leaf tissue was ground in cold, 0.05 M phosphate buffer, pH 7.0 (approx 1 g tissue/10 ml).

**Results and Discussion**

At least some scions of all varieties except 'Rangpur' lime grew vigorously on the stem-pitted Milam framework (Table 1). None of the 'Rangpur' scions grew vigorously, possibly due, in part, to alternaria leaf spot. The poor growth of 'Rangpur' was not attributed to stem pitting, since none of the 'Rangpur' scions showed pitting symptoms after 5 years.

Most scions did not develop stem pitting (Table 1), even though they had grown vigorously and pitting was often present in the Milam scaffolds just below the graft union (Fig. 3). The mild pitting on sweet lime, and the moderate pitting on a single sour orange scion did not appear severe enough to markedly affect tree vigor. Although pitting in ungrafted Milam trees is most severe on the main trunk, the presence of pitting in grafted Milam scions (Table 1) and in Milam scaffold limbs just below the graft unions suggests that pitting would have occurred in other scion varieties if they had been sensitive to the stem-pitting factor.

Absence of pitting in 'Orlando' tangelo confirmed our preliminary conclusion that cristacortis was not the cause.

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**Table 1. Basal diameter and stem pitting of different citrus cultivars grafted on 6 stem-pitted Milam trees.**

<table>
<thead>
<tr>
<th>Scion</th>
<th>No. scaffold &gt; 2.5 cm diam</th>
<th>No. pitted</th>
<th>Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marsh grapefruit</td>
<td>5</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>Valencia orange</td>
<td>4</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>Robinson tangerine</td>
<td>5</td>
<td>1</td>
<td>mild</td>
</tr>
<tr>
<td>Sweet lime</td>
<td>6</td>
<td>4</td>
<td>mild</td>
</tr>
<tr>
<td>Milam</td>
<td>5</td>
<td>4</td>
<td>moderate</td>
</tr>
<tr>
<td>Orlando tangelo</td>
<td>3</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>Rangpur lime</td>
<td>1</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>Cleopatra mandarin</td>
<td>4</td>
<td>1</td>
<td>mild</td>
</tr>
<tr>
<td>Sour orange</td>
<td>3</td>
<td>1</td>
<td>moderate</td>
</tr>
</tbody>
</table>

*Readings made 5 yr after budding. Bark of scaffold limbs completely removed to reveal pitting.
>Diameter measured just above graft union.

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**Fig. 3. Grafted scaffold limb with bark removed at termination of experiment. Large arrow indicates graft union between 'Orlando' tangelo scion and Milam stock. Smaller arrows indicate pitting on Milam. Note absence of pits on scion.**

of pitting. All 6 Milam trees indexed positively for CTV at the time of grafting, and CTV may have been responsible for some of the pitting. However, not all pitted Milam trees in the original surveys were infected with CTV (5, and Garnsey, unpublished). In addition, several of the Milam seedlings planted among the grafted trees showed distinct pitting after 4 years, but did not index positively for CTV by ELISA even when symptomatic bark tissue was tested.

This test did not identify the cause of stem pitting, and we have failed to obtain definitive answers in other transmission tests with the pitting factor in Milam, and that in 'Page', 'Robinson', and 'Lee' mandarin hybrids. Pitting was not observed in inoculated, potted plants grown in the greenhouse or screenhouse within 2 years. When these plants became too large to maintain satisfactorily under screen, they were planted in the field and have been damaged by cold, hail, and snow scale (Unaspis citri Comstock). Pitting has occurred erratically in some inoculated plants of several varieties, including Milam, but has also occurred in some noninoculated controls. It has not been consistently associated with CTV infection.

A mechanically transmissible, viruslike agent which caused a systemic mottle in Chenopodium quinoa (Willd.) was found in one pitted 'Robinson' tree near the site of the topworking test. However, inoculations to C. quinoa with extracts prepared from prime, new flush tissue of 4 other pitted 'Robinson' trees, 6 pitted Milam trees, 6 pitted 'Page' trees, and 5 pitted 'Lee' trees failed to cause any symptoms. In these same tests, the viruslike agent in the one 'Robinson' tree was transmitted consistently.

Although the cause of the stem pitting in Milam and the mandarin hybrids remains undetermined, it does not appear that the Milam isolate will have a serious economic effect on 'Valencia' orange or 'Marsh' grapefruit. Although we could not test other scion varieties in the present experiment, field observations have not indicated unusual problems with other commercial scions in the ensuing 7 years.

The effect of the pitting factor on Milam trees in commercial plantings has not been severe. Firstly, pitting in orange or grapefruit trees grafted on Milam, when present, occurs only from the soil line to the budunion. Secondly, the severe pitting in unbudded Milam trees has not caused decline. The growth of pitted and unpitted Milam trees has not been closely compared to determine stunting, but pitted Milam trees continue to grow vigorously.

During the 5 years of our experiment, the pitting did not increase in severity on the trunks of the Milam trees and actually may have diminished somewhat.

Literature Cited

YIELD AND GROWTH COMPARISONS OF ONE OLD-LINE AND EIGHT NUCELLAR ‘WASHINGTON’ NAVEL BUDLINES IN A DEMONSTRATION PLANTING ON TEN ROOTSTOCKS

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Abstract. Three-year cumulative yields were compared among one exocortis-infected old-line selection and eight exocortis-free nucellar selections of ‘Washington’ navel on 10 rootstocks at the Budwood Foundation Grove. Two trees each were budded on Poncirus trifoliata (L) Raf., Carrizo, Troyer, Rusk, Uvalde and Norton citranges (P. trifoliata (L) Raf. X Citrus sinensis (L) Osbeck) citrumelo W-2 and F/80-9 (P. trifoliata (L) Raf. X C. paradisi Macf.), Cleopatra mandarin (C. reticulata Blanco), and Smooth Flat Seville (unknown hybrid of sour orange (C. aurantium L.) in a nonrandomized planting.

Highest yielding rootstocks for nucellar selections were Carrizo and Troyer citranges and P. trifoliata. Very poor yields were recorded for Cleopatra and Smooth Flat Seville.

Highest yields for the old-line navel were recorded on Norton citrange and citrumelo W-2. P. trifoliata, Cleopatra mandarin, and Smooth Flat Seville yielded the least fruit.

Canopy volume of the old-line on Norton citrange and citrumelo W-2 was 50% less than that of the nucellar selections on Carrizo and Troyer, but yields compared favorably.

Highest yielding nucellar selections were N-S-F/60-19, 60-18, and 60-15.

Navel oranges comprise a major portion of the citrus crop in many citrus-growing areas of the world, often found as one of only two major varieties being grown. The variety is distinctive in the market and prized as a delicious fresh fruit.

Navel appears to have been introduced into Florida from Brazil via Washington, D. C. in 1873 (6), and although the fruit has proved to be of very good quality, the trees have been rather shy-bearing so the variety has never been planted as extensively in Florida as in other areas. Only 11,329 acres (4,720 ha) were reported in the 1978 Florida tree census (2).

Although navels comprise only 6% of the early orange acreage, they have become a significant part of the fresh fruit market in Florida. In recent years there has been renewed interest in better producing bud-lines, perhaps due to...