Since the entrance tube placed in the tree to provide an attachment for the rubber tube connected to the water reservoir partially or completely blocks off the conductive outer wood, water uptake in trees with blight is low. The outer wood is also sealed off in uptake tests with healthy trees, but since almost the entire cross-section of the tree is conductive, the loss of the outer wood has only a slight effect on total water uptake. The action of the tapered metal entrance tube in blocking uptake of water by the outer wood has recently been demonstrated experimentally in living trees by Young, Garnsey and Horanic (4).

The difference in conductivity pattern of healthy and blighted citrus trees may also reveal an important characteristic of the physiology of the healthy citrus tree. Since the low conductivity of the inner wood of trees with blight is the basic difference between blighted and healthy trees, the conductivity of the inner wood of healthy trees may be essential to the maintenance of their healthy status.

**Literature Cited**


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**ZINC AND PHENOLICS IN THE WOOD AND INCIDENCE OF CITRUS BLIGHT IN A GROVE CONTAINING EIGHT SELECTIONS OF ‘HAMLIN’ ORANGE**

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*Additional index words.* wood zinc, visual symptoms, selection differences.

*Abstract.* Analysis of wood samples in 1977 taken from 352 trees in a 7-year-old grove consisting of 11 4-tree replications of 8 selections of ‘Hamlin,’ Citrus sinensis (L.) Osbeck, on rough lemon, C. limon (L.) Burm. f., rootstock showed that 41 of the trees had higher than average (>5 ppm) zinc and elevated levels of phenolics in the wood. The 32 trees showing visual symptoms of blight all were within this group. Visual blight symptoms developed on about 3% of the trees in each of the 2 years following the wood sampling, a total of 21 additional trees in 2 years. One of these trees came from the group of 9 trees with high Zn, but no visual symptoms in 1977; the others had normal zinc levels in 1977 but high Zn levels in 1979. The incidence of blight among the 44 trees of each of the 8 ‘Hamlin’ selections varied significantly from 7 to 27%. Trees propagated from exocortis-carrying budwood sources had only half as much blight as trees propagated from exocortis-free mother trees.

Higher levels of zinc and water-soluble phenolics in the wood of trees affected by citrus blight than in healthy trees make it possible to distinguish between blight-affected trees and trees declining from other causes (3, 4, 7, 8). Trees on rough lemon rootstock are very susceptible to blight (5) and build up higher levels of zinc in the wood than trees on less susceptible rootstocks (9). Little is known about how long the rise in the wood zinc level precedes the appearance of visual symptoms.

Susceptibility to blight of 33 selections of ‘Valencia’ orange, C. sinensis (L.) Osbeck, varied little when the trees were 7-years-old (1). A young grove of ‘Hamlin’ orange was made available to us to study the accumulation of zinc and phenolics in the wood before the appearance of visible symptoms, and the comparison of the susceptibility of 8 selections of ‘Hamlin’ to blight.

**Materials and Methods**

Eight selections of ‘Hamlin’ orange were budded on rough lemon rootstock in a commercial nursery in 1969, and planted in April 1970 with 25 ft X 25 ft (7.5 m X 7.5 m) spacing in the flatwoods area near Holopaw, Florida. The Florida Budwood Registration Bureau numbers of the bud-lines were:

- H 61-3-17-X
- H 61-2-5-X
- H 1-4-1-XE
- H 8-1-4-XE
- H 325-5-XE
- H 3-28-5-XE
- H 8-1-5-XE
- H 43-4-2-X

The suffix “X” indicates the absence of psorosis and xyloporesis; “XE” indicates absence of psorosis, exocortis and xyloporesis. Indexes of the mother trees of the three “X” selections in 1967 were positive for exocortic for selections H 61-3-17-X and H 43-4-2-X and negative for H 61-2-5-X. This does not preclude the possibility that H 61-2-5-X carries a mild strain of exocortis because of the index methods used at the time. No special precautions were taken in the nursery and in the grove to prevent the spread of exocortis by cutting tools; therefore the virus status of the “XE” trees is uncertain. There were 11 4-tree replications of each selection in a randomized, complete block design. The sandy soil was an unclassified mixture, modified by dredging drainage ditches and extensive filling and leveling. Soil pH ranged from 6.1 to 7.2 and the cation exchange capacity from 1.05 to 2.29 m.e./100 g in the top 1 ft (30 cm) of soil. The trees received 180 lb N and 180 lb K per acre per year (202 kg/ha/year) and minor element sprays. Insecticides and fungicides were applied as needed. Contact herbicides were used around the canopies.

The trees were checked for visual symptoms in March or April 1977, 1978, and 1979, using the criteria of Cohen and Wutschcher (3). In March 1977 it was especially easy to spot blighted trees because they were more severely damaged than healthy trees in the January 1977 freeze. In March

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1977 we took wood samples on both sides of the trunks, 10 cm above the bud union, of all 352 trees in the test, and analyzed them for zinc and water-soluble phenolics as described earlier (5, 6).

Trends which developed visual symptoms between March 1977 and March 1979 were resampled in 1979, together with 9 trees which had elevated zinc levels in 1977 but no visual symptoms; also sampled were 10 randomly selected trees which were healthy in 1977 and still apparently healthy in 1979. The Chi-Square was used to test differences in evidence of blight among the 8 selections of ‘Hamlin’ (6).

**Results**

The numbers of blighted trees among the 44 trees of each ‘Hamlin’ selection varied from 2 H 61-3-17-X and H 3-26-5-XE to 7 H 3-28-5-XE trees in March 1977 when the trees were 7 years old (Table 1). The average zinc content of the wood paralleled the number of trees with visual symptoms, ranging from 3 ppm for H 61-3-17-X, H 61-2-5-X, and H 3-26-5-XE to 5 ppm in H 3-28-5-XE and H 8-1-5-XE wood. There was little difference in average phenolics content (range 2.8 - 3.3 mg/g); H 3-26-5-XE trees had the lowest phenolics level.

Thirty-two trees showed visual symptoms in 1977; only 6 additional trees were found in 1978. There was a sharp increase from 1978 to 1979 to 55 trees; the H 8-1-4-XE trees had the lowest incidence of blight (7%), followed by H 3-28-5-XE (20%) and H 8-1-4-XE (27%) and H 3-28-5-XE (20%) (Chi-Square = 54, d.f. = 7; P = 0.005). The trees propagated from exocortis-carrying mother trees averaged only 4/44 trees showing blight, the exocortis-free selections 8/44 trees (Chi-Square = 5.55, d.f. 1, P = 0.025).

From 1 to 6 new trees of each selection developed blight between 1977 and 1979 when the trees were 7 to 9 years old (Table 2). In March 1977, the zinc in the wood of these trees was uniformly low (2.3 ppm). Water-soluble phenolics ranged from 2.0 mg/g in H 61-3-17-X, one of the least affected selections, to 3.5 mg/g on H 1-4-1-XE, with 18% blight, one of the more severely affected lines. Both Zn and phenolics increased sharply during the 2 years when visual symptoms developed, but the highest Zn levels occurred in the least-affected budlines H 61-3-17-X and H 43-4-2-X (21 and 19 ppm), while the most blight-prone selections, H 8-1-4-XE and H 3-28-5-XE, had relatively low (8 ppm) zinc levels in the wood.

Of the 41 trees with wood zinc levels of 5 ppm or above in March 1977, 32 showed visual blight symptoms. Of the 9 normal looking trees, only 1 tree (#9) developed visual symptoms in the next 2 years (Table 3). Analysis of samples taken from these trees in March 1979 showed lower zinc levels in 6 of the 8 trees and a slight increase in 2 trees compared to 1977. The increase in these 2 trees was much smaller than that in tree #9, which developed visual symptoms.

### Table 1. Mean zinc and water-soluble phenolics levels in 1977 and number of trees showing visual symptoms of blight in 1977, 1978, and 1979.

<table>
<thead>
<tr>
<th>Hamlin selection</th>
<th>Zn ppm</th>
<th>Phenolics mg/g</th>
<th>Visual symptoms</th>
<th>% Trees showing blight in 1979</th>
</tr>
</thead>
<tbody>
<tr>
<td>H 61-3-17-X</td>
<td>2</td>
<td>3</td>
<td>3.0</td>
<td>7</td>
</tr>
<tr>
<td>H 61-2-5-X</td>
<td>3</td>
<td>3</td>
<td>3.1</td>
<td>7</td>
</tr>
<tr>
<td>H 1-4-1-XE</td>
<td>4</td>
<td>4</td>
<td>3.2</td>
<td>7</td>
</tr>
<tr>
<td>H 8-1-4-XE</td>
<td>5</td>
<td>3</td>
<td>3.2</td>
<td>7</td>
</tr>
<tr>
<td>H 3-26-5-XE</td>
<td>2</td>
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<td>3.2</td>
<td>7</td>
</tr>
<tr>
<td>H 3-28-5-XE</td>
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<td>5</td>
<td>3.3</td>
<td>7</td>
</tr>
<tr>
<td>H 8-1-5-XE</td>
<td>6</td>
<td>5</td>
<td>3.3</td>
<td>7</td>
</tr>
<tr>
<td>H 43-4-2-X</td>
<td>3</td>
<td>3</td>
<td>3.3</td>
<td>7</td>
</tr>
</tbody>
</table>

*Mean of 44 trees.
* Differences statistically significant. Chi-squares 54; d.f. = 7; P = 0.005.

The average Zn concentration in the wood of 9 healthy trees increased from 2 ppm in 1977 to 3 ppm in 1979 (Table 3). The Zn in the wood of one (#6) of the 10 trees sampled increased from 1 to 12 ppm. The wood of this tree also had a higher phenolics level than the other 9 trees.

**Discussion**

Both the absolute number and the rate of increase indicate a difference in blight susceptibility among the 8 selections of ‘Hamlin.’ Differences between selections are difficult to detect because commercial groves are rarely planted with randomized plots of different selections. Earlier work was inconclusive (1, 2). If further studies confirm the results of this test, both scion source and rootstock will have to be considered in choosing blight-resistant trees.

Blight was twice as common among trees propagated from exocortis-free bud sources than among trees propagated from exocortis-carrying sources. The significance of this effect of exocortis is not clear; there were no noticeable differences in tree size or other visible effects of exocortis infection. On the other hand, exocortis-infected grapefruit trees on exocortis tolerant and exocortis intolerant rootstocks tended to be more blight susceptible than exocortis-free trees in the Indian River area (2); with ‘Valencia’ on rough lemon, there was little difference (1). Exocortis, like blight, raises the water-soluble phenolics level in the wood of trees on susceptible rootstocks (8), which could explain the apparent “cross protection” effect in our experiment.

With only 2 samplings 2 years apart, it is difficult to pinpoint when Zn accumulated in the wood in relation to visual symptoms. All that can be said is that in this experiment many trees built up high Zn levels in less than 2 years. In tests in other areas, there is a lag of about 2 years between Zn accumulation and visual symptoms (unpublished information).

The lower Zn levels in 1979 in 6 of 8 trees which had relatively high Zn concentration in the wood in 1977 are most likely due to contamination of the samples at the first sample collection. The low levels of phenolics support this explanation. The 2 trees with higher Zn in 1979 are probably in the process of developing blight, apparently slower than other trees, like tree #9, which developed visual symptoms and a very high level of wood Zn in the same time period.

**Literature Cited**