experiment. Further experiments are needed to examine the possibility that only a low percentage of seed transmit blight. Further experiments are also needed to examine the possibility of seed transmission from the blight-affected seed source.

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RELATIONSHIP OF CITRUS BLIGHT TO TREE SIZE OF 'VALENCIA' ORANGE ON ROUGH LEMON ROOTSTOCK

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Abstract. **Incidence of citrus blight was recorded yearly in a Florida grove where 33 'Valencia' orange lines had been budded on rough lemon (*Citrus limon* (L.) Burm. f.) rootstock. Between 6 and 10 years following planting, the number of trees exhibiting visual symptoms of blight increased 0 to 10% per year. However, between the 10th and 11th years following planting, the percentage of trees with blight increased from 19 to 74%. There was no difference in blight incidence between trees with old-line and those with seedling sources of budwood. Trees in those areas of the grove where average tree size was greater prior to the appearance of blight tended to develop blight earlier than areas with smaller trees.**

Citrus blight, a decline of unknown etiology, has affected citrus in Florida for over 100 years (15). Affected trees exhibit wilt-like symptoms, zinc deficiency in the foliage, and delayed flush (2, 3, 12). Symptoms of citrus blight which are diagnostic for the disease include elevated zinc levels in wood (13, 16) and bark phloem (1), and reduced water uptake in the xylem (4). Citrus trees which appear healthiest in a field are often the initial trees to succumb to blight (3, 9, 10, 12).

The experimental site studied in this report was originally designed to assess fruit quality, tree size, and yields between sources of budwood in a grove of 'Valencia' orange on rough lemon (*Citrus limon* (L.) Burm. f.) rootstock (5). During the study, the presence of trees with citrus blight was recorded. Relationships between citrus blight, budwood source, and tree size during the latter seven years of this study are reported.

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Materials and Methods

The experimental site was located on the Minute Maid Groves Corporation (now the Foods Division of the Coca-Cola Company), Holman R. Cloud Grove, in the St. John's Marsh area of St. Lucie County, Florida. The soil was classified as a depressional Riviera Soil (a variation of Felda soil, capability subclass VIIw), characterized by a layer of acidic grey sand 20 inches deep over a layer of sandy clay loam subsoil extending to approximately 30 inches. The substratum is a layer of dark sandy clay loam extending to 80 inches or more in depth (11). The grove was bedded in 1960.

Trees propagated from 33 different budwood sources of 'Valencia' orange on rough lemon rootstock were planted in 1961 in a randomized complete block design. One 4-row raised bed, 1/2 mile long, was divided into five replicate blocks. Within each block, four trees of each budline were planted adjacent to each other across the 4-row bed. Trees (79.8 per acre) were spaced 15 ft apart within a row, and 27 ft were left between rows. Ditches were located on either side of the bed.

Of the 33 budwood sources, 23 were from old-line, mature, budded trees where the ancestral seed origin was old or unknown. The 10 remaining budwood lines were from seedling parent-trees which originated from seed planted in 1940. Trees from a 34th budwood source, an old-line selection, were planted 2 years later. All selections were propagated in two grower nurseries. Additional information on the budwood selection lines was reported by Cohen (5).

Starting in 1965, the condition of each tree was recorded yearly on a 0 to 3 scale, where 0 = tree healthy and 3 = tree nearly defoliated or dead. A rating of 0.5 was assigned to trees which were almost completely foliated and had indications of decline. Those trees were identified as being "partially" symptomatic for blight. Trees with a rating of 1.0 or greater had definite symptoms of blight, and were identified as "fully" symptomatic. Since the majority of tree ratings were performed prior to available diagnostic tests for blight, i.e., zinc level or water uptake, visual tree ratings of 1.0 or greater were used in the statistical analysis. "Time to disease" was calculated for each

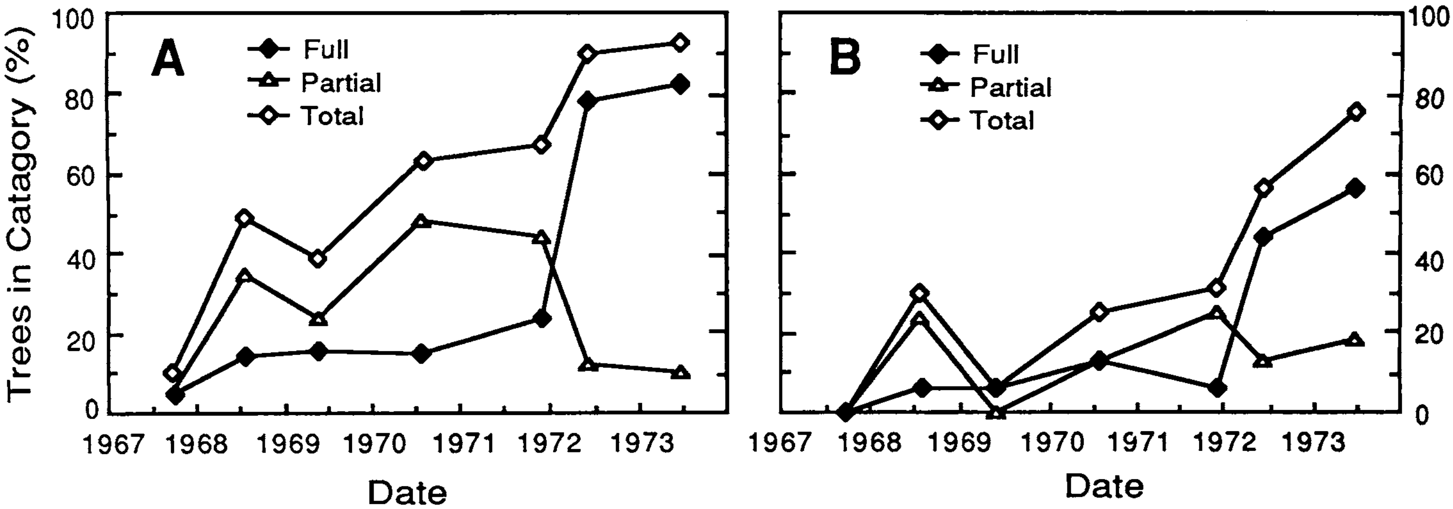

Fig. 1. Incidence of trees fully symptomatic for blight (percentage with disease rating >= 1.0) and of trees partially symptomatic for blight (disease rating = 0.5) plotted against evaluation date for A) budwood selections 1 to 33, and B) budwood selection no. 34.

tree as the number of years from 1966 to the year when the tree first received a rating of 1.0 or greater. In order to facilitate computations, trees which did not display symptoms by the last year of the study were assigned a time to disease of 8.0. Measurements of tree growth (tree height, trunk circumference, and canopy width) were recorded in 1968.

Results and Discussion

The incidence of partially symptomatic trees (disease rating of 0.5) generally increased through 1972 and then decreased (Fig 1a). There was a considerable amount of fluctuation in this rating category due to year-to-year variation in the overall appearance of the trees. The incidence of fully symptomatic trees (disease rating >= 1.0) increased from 0 to 10% per year during the first five years of the study period, and then increased from 19 to 74% between 1972 and 1973. Approximately 70% of this large increase was due to partially symptomatic trees becoming fully symptomatic, and approximately 30% was due to previously asymptomatic trees exhibiting blight symptoms. Some trees remained partially symptomatic up to five years before becoming fully symptomatic. Disease incidence in selection 34, which was planted two years later than the other selections, also increased between 1972 and 1973 (Fig. 1b). The winter of 1972-1973 was unusually mild when compared with other winters during the experimental period: no temperatures below 2°C were recorded. The recent successful experimental transmission of blight through grafting has suggested that blight may be caused by a biotic agent (14). Perhaps the mild winter temperatures may have favored the biological agent involved.

Progressions of citrus blight have been reported to increase linearly with time (7, 17). The non-linear disease progress curve which we measured may have been attributed to differences in the methods used to identify blighted trees, or to changes in blight behavior at different times and locations (6, 8, 18).

Significant differences in average time to disease occurred between budwood selections (Fig 2); however, there was no overall difference between old-line and seedling sources of budwood (Table 1). The average size of trees from seedling sources was greater for all size variables than the average size of trees from old-line sources (Table 1). However, comparison of average time to disease with average trunk circumference for the budwood selections did not indicate any significant correlation (Fig 3a). In order to examine possible effects of field position, averages of time to disease and size measurements were calculated for the 34 trees in each row of each block. Comparisons of these time to disease position averages with average trunk

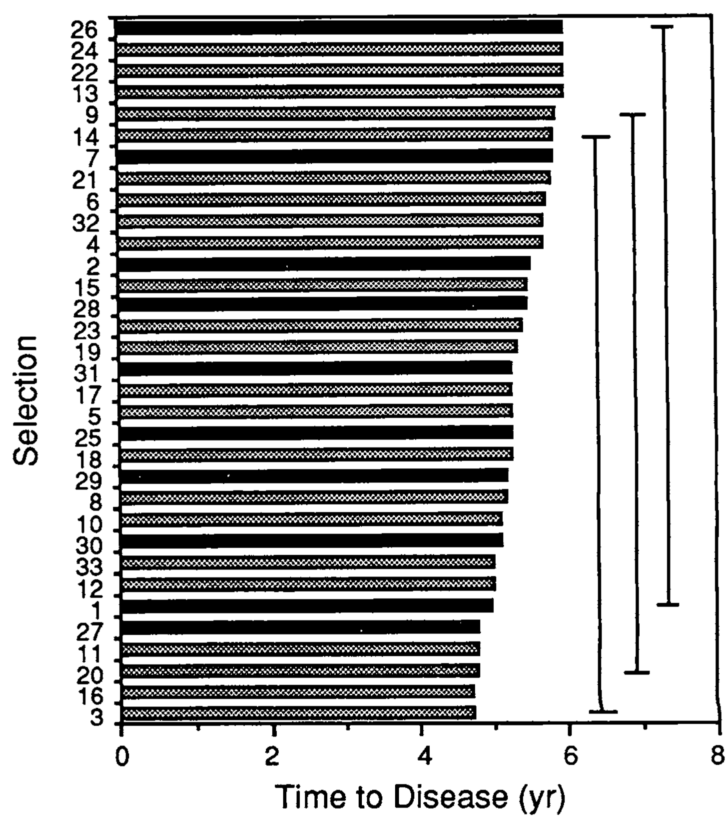

Fig. 2. Average time to disease (yr) for each of the 33 budwood selection lines. Solid bars represent seedling line selections; stippled bars represent old-line selections. Means for selections adjacent to the same vertical line are not significantly different according to the Waller-Duncan K-ratio t-test at P = 0.05).

Table 1. Average trunk circumference, tree height, canopy width, and time to disease for old-line and seedling sources of budwood.

Budwood Source	Trunk Circumference (cm)	Tree Height (m)	Canopy Width (m)	Time to Disease (yr)
Old-line	46.2 ± 0.5**[z]	3.2 ± 0.1**	3.9 ± 0.1**	5.1 ± 0.1ns[y]
Seedling	53.8 ± 0.8	3.7 ± 0.1	4.3 ± 0.2	5.0 ± 0.1

[z]Means ± standard error in a column significant at the 0.1% level (t-test).
[y]Means non-significant.

circumference indicated a significant ($P < 0.001$) negative linear correlation (Fig. 3b). Similar relationships existed between time to disease and average tree height and canopy width; for simplicity's sake, only relationship of tree position to trunk circumference is reported.

Time to disease and tree size measurements were averaged across the four rows for each tree position, and then a running ("smoothed") average was taken of these values for each tree and the five trees on either side of it. In general, areas in the planting where tree size prior to the appearance of blight was greatest were the same areas where blight appeared earliest (Fig. 4). The correlation of time to disease with tree size when trees were grouped by position, but not by selection, indicates that the tree size-citrus blight relationship is associative, rather than causal. Larger trees did not develop blight sooner because they were *larger,* but rather, areas where trees were larger were the same areas where conditions were conducive to the development of blight. Although detailed information on the soil characteristics of this grove is not available, it is attractive to speculate that the pattern of blight measured

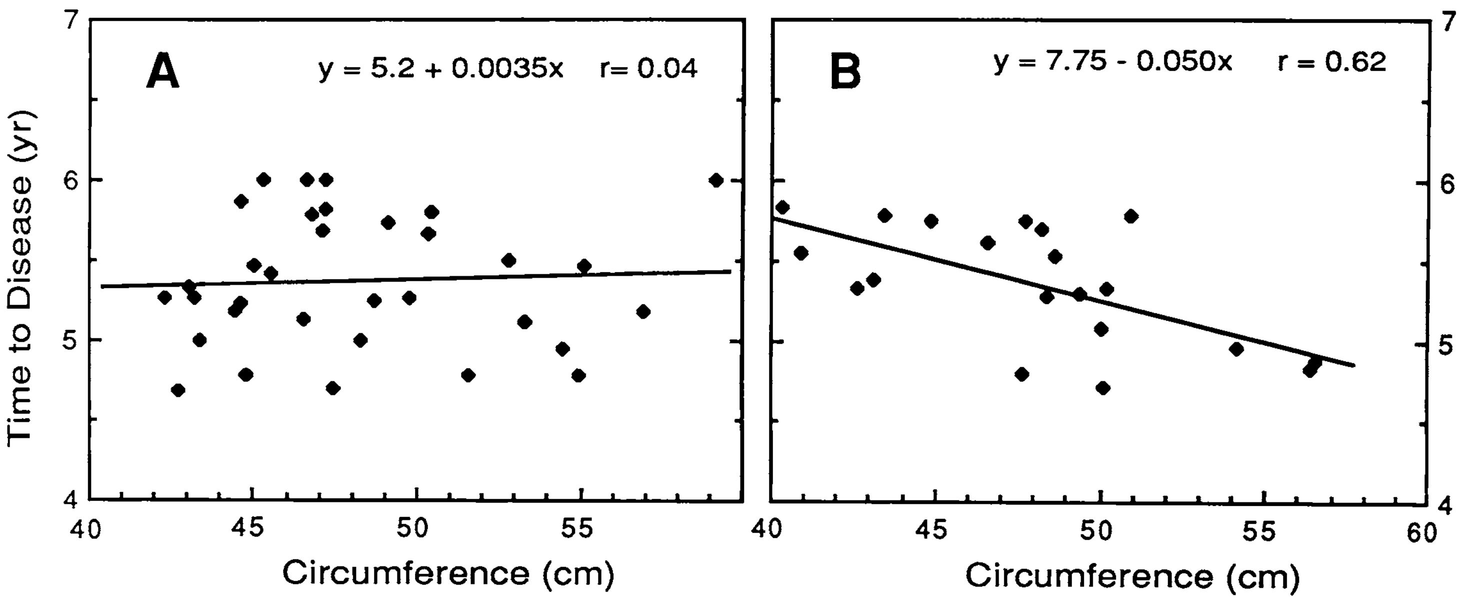

Fig. 3. Average time to disease (yr) plotted against A) average trunk circumference (cm) of trees within each selection line, and B) average trunk circumference of trees within each row of each block.

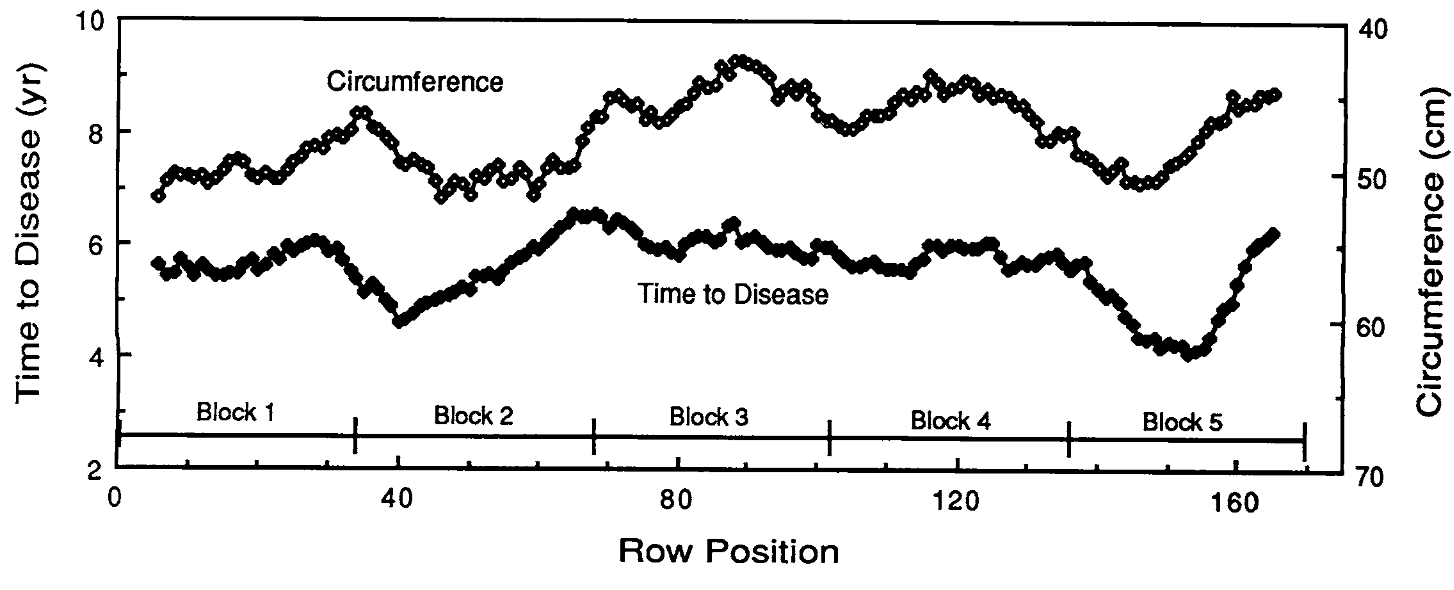

Fig. 4. Average time to disease (yr) and inverse trunk circumference (cm) by tree position. Each point represents the average of eleven trees down row (denoted tree plus five trees on either side of it along the row) and of four trees across the bed.

in this study may be attributed to variations in soil characteristics. The identity of these soil factors is unknown. These results indicate that significant progress in understanding citrus blight might result from a larger research project which was specifically designed to assess the effects of location and soil type.

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THE EFFECT OF WITHHOLDING Fe, Zn, AND Mn SPRAYS ON LEAF NUTRIENT LEVELS, GROWTH RATE AND YIELD OF YOUNG 'PINEAPPLE' ORANGE TREES

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Abstract. **Manganese and zinc sprays were omitted in 7 and Fe in 4 of the 8-year observation period (1979-87) in 7 rows of a 14-row commercial block of 'Pineapple' orange, *Citrus sinensis* (L.) Osbeck, on sour orange, *C. aurantium* L., rootstock. The trees were 5 years old at the beginning of the experiment. The other half of the block was sprayed with these elements twice a year. Copper was applied to the whole block every year for disease control, and Boron (B) was applied to the soil 3 times per year for 4 years until 1983 when the B supply was reduced to a single application per year. Leaves collected every year from 1978 to 1986 between July and October were analyzed for 14 elements. The annual increase in trunk circumference of 4 trees in each of the 6 rows where samples were taken was recorded in the last 4 years of the 8-year test and the trunk circumference of 30 random, healthy trees in each plot was measured in 1986. Withholding Fe, Zn, and Mn sprays did not affect growth rate and tree size. No visual deficiency symptoms developed and production was not affected in crop years 1985/86 and 1986/87, when yields were recorded. A single Mn and Zn spray applied in the 6th year kept the levels of these elements in the optimum range even in the year following the application.**

In contrast to California, where minor elements are usually applied on the basis of leaf analysis (1), minor elements in Florida are routinely sprayed every spring and sometimes again later in the year, although this is not recommended (3). While annual application was probably necessary when citrus was planted on virgin soil, repeated applications over many years have created a nutrient reservoir in the soil which may make it possible to reduce the number of applications in groves on old citrus soil. Experiments of this type have to be long-term because shortages in nutrient supply often have no effect for up to 4 years because of carry-over from previous applications and reserves within the tree. An experiment in special plots omitting 12 nutrients singly from fertilization showed strong effect from macroelement omission on 'Pineapple' orange/rough lemon trees growing on deep sand on the Ridge, but only minor growth retardation after 5 years when single minor elements were withheld (2). The present report shows the results of withholding Fe, Mn and Zn in comparison to a 2-sprays-a-year program on a more fertile soil in southwest Florida where citrus production is expanding rapidly.