increased from 1800 to 2400 boxes of oranges. This increase would mean a potential cost saving of about 16 cents per box.

Fruit counts from the mechanically harvested sample trees averaged 16 fruit left on each tree and 9.5 fruit left on the ground after harvesting was completed. Average fruit production was 859 fruit per tree. Since the rake and pickup operations were only involved with fruit on the ground, the overall rake and pickup machine efficiency was 99%. The handpicked sample trees had an average yield 849 fruit per tree and 8 fruit were left on the tree and 7 fruit left on the ground. Counting only the ground fruit, for comparison purposes, the handpicked fruit recovery was 99%.

Conclusions

The windrowing rake and pickup machines performed satisfactorily in these bedded grove conditions. Fruit recovery efficiency was equivalent to a hand harvesting operation in the same bedded grove area. However, before recommending full-scale operation of the handling system, further improvements should be made. The mass of grass and weeds encountered in preraking and picking up must be reduced to prevent fruit damage and loss, especially during wet operation. Frequent mowing prior to harvest appears to be the best solution. The field efficiency of the pickup machine should be improved by reducing the idle time generated by long hauls with the high-lift truck.

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CITRUS TREE DECLINE COMPLEX AND DIAGNOSTIC IDENTIFICATION OF BLIGHT[1]

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Abstract. **Many citrus tree disorders that result in the decline of tree vigor and in die-back have been mistakenly attributed to citrus blight. Nematodes, root weevils or beetles, viruses, foot rot, and mushroom foot rot cause decline and may occur alone or in combination with blight. Of 22 groves with unidentified declines that were tested, 10 groves had problems other than or in addition to blight. Control measures are unknown for citrus blight but are known for some of these other problems. Identification of the causes of tree decline in a grove would facilitate appropriate action. Accurate diagnostic tests for blight are needed. Trees in at least 5 of the 22 groves tested had indistinct visible symptoms for blight or symptoms suggestive of blight when another cause of decline was present. Trees with blight had reduced water uptake rates and often had higher zinc concentration in trunk wood than healthy trees and trees declining from other causes. A simple procedure for diagnosis of accumulation of Zn is described for samples of bark taken above the bud union. Bark is easier to gather than wood and the samples are better indicators of blight in certain rootstock combinations and seedling trees.**

A complex of citrus tree declines occurs in Florida (3, 7, 9, 12). Diagnostic tests are available that allow citrus blight (young tree decline, sand hill decline, herein referred to as blight) to be distinguished from other declines. In blighted trees, Zn accumulates in trunk wood (6, 10, 12) and trunk water uptake is depressed (1, 12). With these diagnostic tests, we undertook a survey to objectively estimate the actual occurrence of blight in groves and to establish the validity of visible diagnosis of blight by leaf Zn deficiency pattern, trunk water sprout development, and dieback. Methodology was developed to help growers test groves for blight.

Materials and Methods

Healthy and declining trees of bearing age were selected in 22 groves on both ridge and flatwood soils. These groves were selected on the basis of presence of declining trees and probable presence of blight. Declining trees were compared to nearby apparently healthy trees. Trees in 4 additional groves with decline problems other than blight were sampled. Of these 4 groves, 3 were infested with burrowing nematodes and were selected on the basis of Florida State Department of Agriculture nematode surveys. In the 4th additional grove, the presence of tristeza virus as the cause of decline was determined by indexing with Mexican lime (8, 12). This grove was tested for blight and examined for foot rot. Foot rot was determined by visual inspection of bark areas at the soil line. Citrus root weevils (*Pachnaeus litus,* 2) were identified by local entomologists. The lesion nematode (*Pratylenchus coffeae*) was identified by a Florida State Department of Agriculture nematode survey.

Wood and bark samples for Zn determination were

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taken 6 to 12 inches (15 to 30 cm) above the bud union or soil line. Contaminants on the bark surface were removed by scraping away the brown-green outer layer to the white or yellow-brown inner layer in 2 areas larger than 1 inch wide x 2 inches (2.5 x 5 cm) long on opposite sides of the tree, but on convex, actively growing areas. A 1 x 2 inch *patch was* scored through the bark to the wood in each cleaned area. The bark patches were separated from the tree at the cambial layer. The patches were cut and broken into small pieces. After the bark was removed, wood samples were collected by drilling out wood fragments to a depth of 1 inch (2.5 cm) with a 1/2 inch (1.25 cm) diam Zn-free wood bit with an electric drill (10). Samples were dried at 80 to 85°C for 12 hr. Dried samples of 0.028 to 0.042 oz (0.8 to 1.2 g) were ashed, dissolved in 0.007 to 0.17 oz fl (2 to 5 ml) of 25% HCl, transferred to 0.34 to 3.38 oz fl (10 to 100 ml) volumetric flasks with sufficient 25% HCl solution and diluted to final volume with deionized H_2O to give a final solution of 0.2 to 1.0 ppm Zn in 5% HCl. All Zn determinations were made by Atomic Absorption Spectrophotometry (4).

Trunk water uptake tests, after Cohen (1), were conducted by infusion from 33.8 oz fl (1 *l*) bottles attached to tree limbs to give approximately 20 inches (50 cm) of water pressure head. The outlet hoses were plugged into stainless steel tree taps inserted in holes 2 inches (5 cm) deep by 1/4 or 5/16 inch (6.4 or 8 mm) wide drilled with a wood brace and bit.

Results and Discussion

Of 22 groves with unidentified declines, at least 11 had problems other than blight (Table 1). In these 11 groves, at least half of the trees sampled were not positive for blight by the combination of the water uptake and Zn accumulation methods. In 7 of the 11 groves, foot rot, citrus root weevil (2), or lesion nematode were identified as an additional or total cause of the tree declines. Of 3 groves with burrowing nematodes, one grove (HH2, Table 1) had a recent outbreak of blight in the nematode free half of the grove. The tristeza affected grove (USI in Table 1) was apparently free of blight.

At least 5 groves had indistinct or confusing visible symptoms. Decline trees in CC1 with lesion nematode had prominent visible Zn deficiency patterns, some water sprout growth, dieback, and leaf wilting, which are usually associated with blight. Many of these trees were negative for blight by at least one diagnostic procedure and at least one tree was negative by both procedures in spite of characteristic visible symptoms typical of blight. On the other hand, the one blighted tree in HH2 (Table 1) looked exactly like the declining trees in the nematode positive area with no leaf Zn deficiency symptoms or water sprouts. A second tree in HH2, near the first, recently developed wilting and dull color symptoms in a sectored canopy pattern typical of early blight. Most declining sweet seedling trees diagnosed as having blight did not have the specific visible symptoms

Table 1. Results from use of blight diagnostic procedures to survey declining citrus groves.

Grove ID	Scion	Rootstock	Decline[z] trees tested	Diagnostic trees positive for blight			Other problems identified
				Zn	H_2O	Both	
LG1	Valencia	Rough lemon	3	3	2	2	foot rot
	Valencia	Sw. orange	5	0	0	0	foot rot
LG2	Valencia	Rough lemon	3	3	2	2	
	Grapefruit	Rough lemon	3	2	1	1	
LG3	Valencia	Rough lemon	3	3	2	2	
LG4	Early orange	Rough lemon	3	2	3	2	
D	Valencia	Rough lemon	4	2	2	3	
CC1	Valencia	Rough lemon	6	5	3	3	*Pratylenchus coffeae*
CC2	Valencia	Rough lemon	3	3	3	3	
W1	Valencia	Rough lemon	3	3	3	3	
W2	Pineapple	Rough lemon	8	7	4[y]	4[y]	
S	Pineapple	Rough lemon	6	2	4	1	Citrus root weevil
M	Grapefruit	Rough lemon	3	2	2	1	
TR1	Valencia	Rough lemon	9	8	—[x]	—	
TR2	Valencia	Rough lemon	4	3	—[x]	—	
HI	Valencia	Rough lemon	5	3	4[w]	3	
C	Grapefruit	Rough lemon	3	0	0	0	Burrowing nematode
B	Valencia	Rough lemon	3	0	0	0	Burrowing nematode
HH2	Pineapple	Rough lemon	4	1	1	1	Burrowing nematode
F	Mid-season orange	Milam	3	3	3	3	
W3	Pineapple	Rough lemon	3	3	3[w]	3	
	Queen	Sw. orange	3	3	3[w]	3	
DC	Valencia	Cleo	4	1	4	1	foot rot
Y	Parson Brown	Cleo	3	3	3	3	
HH2	Valencia	Rough lemon	2	2	1	1	
	Sw. orange	seedling	10	4	4	3	foot rot
HC1	Sw. orange	seedling	2	1	2	1	foot rot
	Grapefruit	sour orange	3	2	2	2	
HC2	Sw. orange	seedling	3	3	2	2	
HC3	Sw. orange	seedling	3	0	0	0	foot rot
USI	Valencia	sour orange	3	0	0	0	tristeza

[z]The same number of apparently healthy trees were tested for comparison; trunk wood or bark Zn analysis was used in conjunction with Cohen's (1) water uptake test.
[y]Three trees not tested for trunk H_2O uptake.
[x]No. trees tested for trunk H_2O uptake.
[w]Water uptake low for all trees in grove.

associated with blight, but appeared identical to trees determined to be affected by foot rot with dieback, little new flush, and dull leaf color as the only symptoms. Trees in the grove identified as HI (Table 1) had prominent Zn deficiency leaf patterns on all declining trees but only 3 of 5 declining trees tested positively for blight by both diagnostic tests. This grove had not received Zn sprays for 4 years.

This survey substantiated earlier conclusions (1, 7, 10) that blight cannot be diagnosed reliably by visible symptoms alone. The diagnosis of blight requires quantitative testing. Analytical methods to measure Zn accumulation and water uptake have been modified to allow growers to test their own blocks for blight. Previous work (11) suggested that bark Zn values might be higher than those of corresponding wood and that blighted trees had significantly higher bark Zn levels than healthy trees. From an equipment standpoint, to sample bark is easier than wood. In our studies, detailed examination of wood and bark Zn levels showed that blight affected trees accumulated Zn in bark tissues (Table 2). These values are useful as a guide for growers in evaluating *Zn data* from their groves. As with Zn in wood (10), Zn accumulates in bark of blight affected trees but not in declining trees such as those affected by burrowing nematodes and tristeza (Table 2). Furthermore, when seedling trees and trees on Cleopatra mandarin rootstock are affected by blight, Zn accumulates in the bark but may not accumulate in the wood. The failure of blight trees on Cleopatra mandarin, sweet orange, or sour orange rootstocks to consistently accumulate Zn in the wood was reported previously (12). For diagnostic testing of these rootstocks, analysis of Zn in bark patches apparently is more reliable than analysis of trunk wood; bark patch samples are easier to collect, less variable because of elimination of errors in sampling depth, and result in less tree damage because wounds heal quickly when properly treated with a tree wound dressing. Care should be taken to avoid contamination of the bark patches after they are scraped. Rinsing the bark patches with distilled water before cutting them up for drying also reduces the risk of contamination.

Table 2. Bark patch and adjacent xylem zinc levels for trunk samples of healthy and decline trees with several causes of citrus tree declines.

Grove	Scion	Rootstock	Tree condition	Zn ppm Wood	Zn ppm Bark
1	Valencia	Rough lemon	Healthy[5z]	2a[y]	57c
			Blight[5]	10b	215d
2	Valencia	Rough lemon	Healthy[3]	1a	54c
			Blight[3]	24b	128d
3	Valencia	Rough lemon	Healthy[3]	3a	56c
			Blight[3]	15b	122d
4	Valencia	Rough lemon	Healthy[3]	3a	27c
			Blight[3]	8b	60d
5	Valencia	Rough lemon	Healthy[2]	5a	65c
			Blight[2]	14b	127d
6	Valencia	Rough lemon	Healthy[4]	4a	65c
			Blight[4]	16b	123d
7	Welch Valencia	Sanguine (sweet)	Healthy[2]	10a	89c
			Blight[2]	27b	209d
8	Parson Brown	Cleo	Healthy[3]	2a	15b
			Blight[3]	3a	38c
9	Sweet orange	Seedling	Healthy[3]	3a	14b
			Blight[3]	3a	56c
10	Valencia	Rough lemon	Healthy[3]	4a	28b
			Burrowing nematode[3]	3a	33b
11	Valencia	Sour orange	Healthy[3]	2a	23c
			tristeza[3]	1a	9b
12	Valencia	Sw. orange	Healthy[4]	—	29a
			foot rot[4]	—	14a

[z]Number of trees sampled, blight trees had reduced trunk water uptake by infusion testing.
[y]Different letters for values in a grove indicate significant differences at 5% level.

Where Zn analysis is inconclusive, trees can be tested for trunk water uptake by gravity infusion. Use of modified expended hospital I.V. bottles and a brace and bit to drill the trunk feeding hole eliminates the need for expensive equipment. Healthy trees take up 10 to 20 times as much water as blighted trees (1, 12).

Declining trees should not be assumed to have blight without diagnostic testing. Zinc analysis and H_2O uptake procedures are available for grower use (5). Some commercial labs are equipped and have instructions for analyzing the Zn content in bark samples. Bark sampling procedures are available through the county Agricultural Cooperative Extension Service Offices. These offices in counties with major citrus production also have equipment and instructions for testing water uptake of declining trees. In many cases, tests may reveal that more than one cause of tree decline exists in a block. This information will aid the grower in making decisions on appropriate control measures and rootstocks for replanting.

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