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SOIL pH AND EXTRACTABLE MINERAL ELEMENTS IN AND AROUND AN ISOLATED CITRUS BLIGHT SITE

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Abstract. **Three trees affected by citrus blight were identified by water injection and analysis of the wood for Zn in an otherwise blight-free grove of 44-yr-old 'Hamlin' orange (*Citrus sinensis* (L.) Osbeck) on rough lemon (*C. limon* (L.) Burm. f.). All 3 trees were at the end of rows, next to a grove road. Seven healthy, surrounding trees and 4 trees further inside the grove were examined for comparison. Pits 50 cm deep were dug at the dripline of each tree, and soil samples were taken in 5-cm increments to a depth of 45 cm. Soil pH (1:1 soil-water and 1:2 soil-0.1M $CaCl_2$) was highest at the edge of the grove and decreased rapidly with distance from the end. The soil under all trees on the edge of the grove contained at least twice as much Ca as soil under the trees further in the block; the soil Ca levels at 20 to 30 cm depth under the blighted trees were higher than under healthy trees. The Ca and Mg accumulation was due to the spreading pattern of the application machinery.**

The appearance of citrus blight is influenced by soil preparation (2, 3, 5, 10). This is clearly expressed in a grove of 'Hamlin' orange on rough lemon where the 18-yr-old part on filled-in land, limed with dolomite to a depth of 1.5 m before planting, is riddled with blight, while the 44-yr-old part is essentially blight-free. Differences in pH and soil and plant mineral content between the 2 parts of the block have been described (10). Higher soil pH under blighted trees in 5 widely scattered locations in Florida has also been demonstrated using an intensive sampling technique (11). The appearance of 3 blighted trees in the otherwise blight-free portion of the grove described (10) offered the opportunity to compare soil conditions under blight-affected trees to those under surrounding healthy trees.

Materials and Methods

Three declining trees were diagnosed as blight-affected by analysis of the outer trunk wood for Zn (12) and water injections with a syringe (7). Seven apparently healthy trees immediately surrounding the declining trees and 4 trees, 8 tree spaces down the rows, were also tested. The declining trees were at the end of their respective rows, running from north to south, separated by a 4-m-wide grove road from a 'Hamlin' orange on sour orange (*Citrus aurantium* L.) grove with the rows oriented from east to west. Fig. 1 shows how the tested trees were located in relation to each other. Two of the declining trees were next to each other, one was 3 tree spaces east of the other 2 trees, separated by healthy trees. The trees had been planted with 7.5 X 7.5 m spacing in 1944 on surface-tilled Tavares soil, and received standard commercial grove care and overhead-gun irrigation. The last lime application, 1 metric ton (MT) of dolomite and 1 MT of calcitic limestone per ha, was in May 1976. Spring-flush leaf samples were collected in July 1988 from the 2 surviving blighted trees and 5 surrounding healthy trees and analyzed for N, P, K, Ca, Mg, S, Na, Fe, Mn, Zn, Cu, Cl, B, and Mo using standard methods (13).

Between Oct. 1987 and Mar. 1988, 50-cm-deep pits were dug at the dripline of each test tree and soil samples were collected in 5-cm increments to a depth of 45 cm. The pH of each sample was determined separately within 24 hr of collection on 100 g of soil mixed with 100 ml of distilled water and 50 g of soil in 100 ml of 0.1M $CaCl_2$, according to Peech (9). Five grams of fresh soil were extracted with 30 ml of double acid (0.05N HCl and 0.025 H_2SO_4) and Ca,Mg, Fe, Mn, Zn, and Cu were determined by atomic absorption, K and Na by flame emission, and P by a colorimetric procedure (4). The results were analyzed statistically by the F-test and the means of 4 groups of trees (healthy trees at the end of the rows, blighted trees at the end of the rows, healthy trees second and eighth within the rows) were compared by Duncan's multiple range test.

Results and Discussion

The diagnostic test results in Table 1 clearly show that the 3 declining trees had blight; the visually healthy tree 11-1, next to 10-1, a blighted tree, had an elevated Zn level (8 ppm) and normal water uptake, but all the other healthy-appearing trees gave clear negative tests. The high Zn level in the wood of tree 11-1 is probably a sign of developing blight (14). The 3 declining trees were completely surrounded by healthy trees. The closest blighted trees were 300 m away. Fig. 1 shows the locations of the test trees in relation to each other. Leaf analysis showed the usual lower

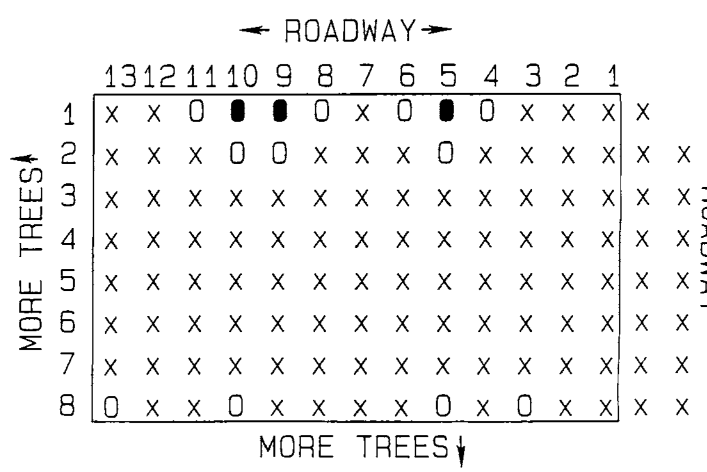

Fig 1. Layout of experiment. Dark circles indicate blighted trees, empty circles healthy trees sampled. Trees planted 7.5 X 7.5 m.

Table 1. Diagnostic tests of trees in experiment. Wood zinc levels and water uptake with syringe injection.

Tree No.	ppm Zn	Water uptake ml/min	Tree No.	ppm Zn	Water uptake ml/min
4-1	4	50.0	5-2	3	75.0
5-1	25	2.4	9-2	3	50.0
6-1	2	75.0	10-2	4	75.0
8-1	5	75.0	3-8	3	50.0
9-1	13	4.2	5-8	3	50.0
10-1	38	6.3	10-8	3	50.0
11-1	8	75.0	13-8	3	50.0

Table 2. Leaf nutrient levels in July 1988 in the 2 surviving blighted trees and in 5 surrounding healthy trees.

	Percent							
	N	P	K	Ca	Mg	S		
Blight	2.95	0.147	1.22	3.16	0.310	0.331		
Healthy	2.86	0.132	1.58	2.67	0.409	0.352		
Stat. Sig.	ns	ns	0.05	ns	0.05	ns		
	Parts per million							
	Na	Fe	Mn	Zn	Cu	Cl	B	Mo
Blight	797	48	24	24	10	818	144	3
Healthy	376	55	16	23	16	455	135	2
Stat. Sig.	0.01	ns	0.05	ns	ns	0.01	ns	ns

K levels in blighted trees (1), Mg was also lower, and Na and Cl were sharply higher (Table 2), an effect of blight that was reported earlier (13). The higher Mn concentration and the normal Zn concentration are the result of a nutrient spray and the failure of blighted trees to translocate microelements applied to the leaves (13).

There were significant ($P = 0.05$) differences in soil pH at all levels down to 35 cm; at 40 and 45 cm there was no difference. The pH under the trees at the end of the rows was clearly higher than under the second or the eighth trees; at the 20-, 25- and 30-cm levels, the pH was higher under the blighted trees than under the healthy trees at the end of the rows (Table 3). Soil calcium levels paralleled soil pH, the highest levels were found at the end of the rows, also to a depth of 35 cm (Table 4). There are 2 reasons for this calcium accumulation: a) when the lime spreader turns around, the end trees receive more lime than trees within the block; and b) extra lime is deposited around the end trees when the grove immediately north of the test site is limed because of the opposite orientation of the rows. Magnesium levels were also higher at the end of the rows, but only in the top 15 cm of soil (Table 4).

There was little correlation between the other elements in the soil extracts and the appearance of blight. The levels under the test trees (means of 9 samples from 0 to 45 cm depth) ranged from 5 to 104 ppm P, 5 to 14 ppm K, 2 to 7 ppm Na, 2 to 13 ppm Fe, 1 to 2 ppm Mn, 1 to 8 ppm Zn, and 0 to 6 ppm Cu.

Table 3. Soil pH (1:1 soil:water andd 1:2 soil: 0.01M $CaCl_2$) at 0 to 45 cm depth under blighted and healthy trees.

	Tree													
Depth (cm)	11-1		10-1[z]		9-1		8-1		6-1		5-1		4-1	
	a[y]	b[x]	a	b	a	b	a	b	a	b	a	b	a	b
5[w]	6.7	6.2	7.1	6.8	6.8	6.4	6.7	6.1	6.7	6.2	7.0	6.6	6.6	6.1
10[w]	6.9	6.1	7.1	6.6	7.0	6.5	6.8	5.9	6.3	5.3	7.1	6.6	7.1	6.3
15[w]	6.7	5.7	6.8	6.4	7.1	6.4	6.4	5.5	6.0	5.2	7.2	6.3	6.7	5.8
20[w]	5.4	4.3	7.0	6.3	7.1	6.3	5.9	4.6	6.2	5.3	6.4	5.6	5.7	5.1
25[w]	5.0	3.9	6.7	6.2	7.0	6.1	5.5	4.4	5.9	4.8	6.4	5.2	5.4	5.0
30[w]	4.8	3.8	5.8	5.4	5.9	4.9	5.3	4.3	5.7	4.6	6.0	4.8	5.3	4.5
35[w]	4.7	3.8	5.5	5.0	5.2	4.5	5.0	4.0	5.7	4.4	5.5	4.3	5.2	4.3
40	4.6	3.8	5.5	4.9	5.1	4.3	4.9	4.0	5.4	4.2	5.3	4.3	5.1	4.1
45	4.7	3.9	5.5	5.0	5.1	4.4	4.9	3.9	5.8	3.9	5.1	4.2	4.9	4.0
			10-2		9-2						5-2			
			a	b	a	b					a	b		
5			5.4	4.8	6.0	5.5					5.7	5.3		
10			4.9	3.6	5.1	4.3					5.3	4.5		
15			4.8	3.6	4.9	3.9					5.1	4.4		
20			4.5	3.7	4.9	3.9					4.9	4.0		
25			4.7	4.0	4.9	3.9					4.9	3.9		
30			4.8	4.1	4.7	3.9					4.7	3.9		
35			4.7	4.3	4.8	4.1					4.7	3.8		
40			4.4	4.4	4.8	4.2					4.7	4.		
45			4.4	4.4	4.8	4.4					4.6	3.8		
	13-8		10-8								5-8		3-8	
	a	b	a	b							a	b	a	b
5	5.8	5.3	5.3	4.9							4.9	4.7	5.4	5.1
10	5.0	4.4	4.9	4.4							4.4	4.1	4.8	4.6
15	4.8	4.0	4.9	4.2							4.3	4.0	4.7	4.5
20	4.7	3.9	4.9	4.2							4.3	4.1	5.0	4.8
25	4.6	3.8	5.0	4.3							4.3	4.3	5.0	4.7
30	4.6	4.0	5.0	4.4							4.4	4.4	4.7	4.4
35	4.3	4.2	5.0	4.4							4.6	4.6	4.6	4.7
40	4.3	4.2	5.1	4.6							4.8	4.6	4.5	4.6
45	4.2	4.3	4.9	4.6							4.8	4.6	4.5	4.6

[z]Trees 10-1, 9-1, and 5-1 had blight.
[y]a = 1:1 soil:water.
[x]b = 1:2 soil:0.1M $CaCl_2$.
[w]Differences significant at the 5% level.

Table 4. Soil calcium and magnesium distribution in and around the blight-affected area (ppm).

Depth (cm)	Tree													
	11-1		10-1[z]		9-1		8-1		6-1		5-1		4-1	
	Ca	Mg	Ca	Mg	Ca	Mg	Ca	Mg	Ca	Mg	Ca	Mg	Ca	Mg
5[y]	903	120	940	118	1777	180	1013	67	787	55	1840	218	1293	93
10[y]	440	39	573	44	713	60	667	46	547	36	1700	98	1120	85
15[y]	227	27	500	27	573	45	833	66	597	33	767	61	513	32
20[y]	123		280		413		280		387		413		313	
25[y]	87		247		207		173		277		233		120	
30[y]	67		293		247		100		130		113		100	
35[y]	93		120		90		153		73		207		100	
40	73		57		73		73		47		93		200	
45	40		57		40		43		97		53		93	
			10-2		9-2						5-2			
			Ca	Mg	Ca	Mg					Ca	Mg		
5			363	25	533	42					697	35		
10			147	13	320	42					283	15		
15			73	6	247	32					160	11		
20			40		167						120			
25			40		83						153			
30			37		67						97			
35			30		40						83			
40			17		53						53			
45			20		27						87			
	13-8		10-8								5-8		3-8	
	Ca	Mg	Ca	Mg							Ca	Mg	Ca	Mg
5	455	50	413	27							300	40	333	35
10	240	22	180	15							107	13	323	32
15	173	22	60	4							60	8	173	20
20	118		57								30		117	
25	112		87								35		60	
30	52		62								23		63	
35	37		63								23		28	
40	48		38								13		28	
45	30		38								28		23	

[z]Trees 10-1, 9-1, and 5-1 had blight. [y]Differences significant at the 5% level.

Concentration of blighted trees next to roads has been observed; one of the names used for citrus blight in the past was "roadside decline" (3). No explanation for this phenomenon has been offered, but the results in Table 3 provide a plausible one. The correlation between higher Ca levels and a higher pH with blight at other sites (2, 3, 5, 11) indicates the same relationship. The great variation in soil characteristics within groves that are level and appear uniform is often overlooked. The solubility and availability of Zn in the soil are negatively correlated with Ca concentration (6). The relationship between soil pH and Zn concentration in the soil solution varies among soils and depends on other solute components, such as Ca and organic acids (8). The pH levels under blighted trees at the site described in this report and in other places (11) were up to 2 units higher than under healthy trees, but they were still in a range considered suitable for citrus. Further work is needed to determine if a combination of susceptible rootstock, climate, and higher pH/lime levels can cause the tree decline observed. Data in the present report only show a correlation; a cause-and-effect relationship between blight and soil Ca could not be established by the experiment.

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