Table 2. An example of continued intensive decline in the Swann grove near Avon Park of Valencia/rough lemon over an 11-year period.

Year	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
No. trees[z]	980	918	829	752	700	629	580	504	448	408	339	281
Blight[y]	26.2	6.3	9.7	9.3	6.9	10.1	7.8	13.1	11.1	8.9	16.9	17.1
Replants[x]							0.7	0.7	1.0	0.7	2.5	1.8

[z]Number of healthy trees remaining from 1328 original trees.
[y]Percentage of remaining healthy trees showing new blight symptoms. Eleven-year average was 10.7%.
[x]Percentage decline of replants in 290 spaces where original blighted trees were removed. Blight occurred in second generation trees 5 to 12 years old.

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SIMILARITIES BETWEEN MARCHITAMIENTO REPENTINO DISEASE IN URUGUAY AND ARGENTINA AND BLIGHT OF CITRUS IN FLORIDA[1]

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Abstract. **Marchitamiento repentino, a disease whose cause is still unknown, has slowly spread over much of the Uruguayan and Argentinian citrus-growing areas since 1960. The visual aspects of marchitamiento, zinc and manganese deficiency symptoms, small leaves, wilting of a sector of the tree, and eventual decline of the whole tree, are very similar to those of blight (young tree decline) in Florida. Blight-affected trees accumulate zinc and water-soluble phenolics in the wood. Analyses of 36 samples of 'Valencia' and navel orange** (Citrus sinensis **(L.) Osbeck), 'Marsh' grapefruit** (C. paradisi **Macf.), and mandarin** (C. reticulata **Blanco) wood from Uruguay and Argentina showed that 16 of 18 trees visually diagnosed as being affected by marchitamiento also had higher Zn and water-soluble phenolics levels than 18 comparable, apparently healthy trees. Earlier work has shown that tristeza and 6 other causes of citrus tree decline do not increase the Zn content of the trunk wood, suggesting that marchitamiento repentino and blight could be similar disorders.**

It is generally believed that blight (young tree decline) occurs only in Florida. In recent years, however, it has been reported that citrus trees in Central and South America are declining with visual symptoms similar to those of blight (2, 3). Considering the differences in climate, soil, rootstock, and cultural practices, it is rather difficult to make comparisons on the basis of visual symptoms; however, analysis of the wood offers an objective method for investigating similarities between tree declines in different places. The accumulation of Zn in the wood (4) has been shown to occur on trees with blight but not with 7 other causes of decline (5). The original test for blight, water injection into the trunk (1), in combination with Zn and phenolics analysis of the wood, permits almost certain diagnosis of the disease (5).

Salibe et al. (3) recently published observations on visual symptoms and susceptibility of citrus varieties to marchitamiento repentino. The appearance of symptoms—Zn and manganese deficiency, small, narrow leaves, wilting of a sector of the tree, and eventual decline of the whole tree—is similar to what is commonly observed on the Ridge in Florida. In addition, Salibe et al. (3) reported small and sometimes lopsided fruit, aborted seed, necrotic lines in the cambial area of large branches, and xyloporosislike pitting on the affected side of the trunk. Like blight, marchitamiento repentino has not been found in trees less than 5 years old and is most common in trees older than 10 years. In contrast to blight, graft transmission of marchitamiento to young 'Valencia' trees (11 of 44 index trees) was possible.

[1]The authors gratefully acknowledge the help of Mr. Carlos Casafus in collecting wood samples in Concordia.

Mechanical and seed transmission, as well as attempts to find a causal agent by electron microscopy, have been unsuccessful.

Materials and Methods

Wood samples were collected from paired trees, one sample from a declining tree and the other from an apparently healthy tree on the same rootstock, of the same age, and in the same grove. Drill bits previously tested to show that they did not contaminate the samples with Zn were used. The bark was removed and the chips resulting from drilling into the outer 2.5 cm of wood on 2 sides of the trunk 20 cm above the bud union were collected and oven-dried at 60°C. Two-gram aliquots were ashed overnight at 550 C. The ash was dissolved in 25 ml of 5% HCl, and Zn, Ca, Mg, Fe, Mn, and Cu were determined by atomic absorption, K and Na by flame emission. A second aliquot of 100 mg of dry wood was shaken with 20 ml of glass-distilled water for 2 hr, and the extract was analyzed for phenolics by determining the height of the peak at 277 nm, using a spectrophotometer and tannic acid as the standard. The quantity of phenolics was expressed as mg tannic acid/g dry weight (5).

Twelve wood samples were collected from three pairs of grapefruit, *Citrus paradisi* Macf. on rough lemon, *C. limon* (L.) Burm. f., and three pairs of 'Valencia', *C. sinensis* (L.) Osbeck, trees on trifoliate orange, *Poncirus trifoliata* (L.) Raf., rootstock in June 1977, near Concordia in Entre Rios Province in Argentina. The declining trees showed symptoms on 25 to 100% of their canopies. Marchitamiento in this area usually appears on isolated trees, at a lesser rate than in Uruguay, and there are no symptoms on the fruit. The soil is acid sand.

Wood samples were also collected in June 1977, at 4 locations near Paysandu in Uruguay, where marchitamiento was first observed about 17 years ago, from 6 pairs of 'Valencia' trees, 4 pairs of navel orange trees, and 2 pairs of common mandarin, *C. reticulata* Blanco, trees on trifoliate orange rootstock. The soil in this region is acid clay, and the trees showed symptoms ranging from 1/8 of the canopy affected to severe decline of the whole canopy. Water injections by Cohen's (1) method were carried out at 2 locations on 29 healthy and 18 declining trees. Marchitamiento is rampant in this area, and 5 to 8% of the trees are lost annually.

Simultaneously, wood samples from a total of 18 pairs of trees were collected in Florida from 3 locations on the Ridge and 1 location in the flatwoods area.

Five pairs of 'Marsh' grapefruit trees on rough lemon were sampled in a well-cared-for grove near Avon Park, where many trees in moderate-to-severe stages of decline were concentrated in one corner of the grove. Five pairs of 'Valencia' on rough lemon trees were selected from an otherwise very healthy and productive grove near Tildenville. Trees in moderate-to-severe stages of decline were scattered through part of the grove. Four pairs of 'Valencia' trees on rough lemon were sampled in a grove near Howey-in-the-Hills. This grove was in poor condition, with many trees declining or missing due to blight and other causes. The trees sampled were in moderate-to-severe stages of decline. In water injection tests in 1976, declining trees in the last 2 groves had sharply reduced water uptake compared to healthy trees (5). Four pairs of 'Hamlin', *C. sinensis* (L.) Osbeck, trees on rough lemon rootstock were sampled in a flatwoods area near St. Cloud. The grove was in generally good condition with about 10% of the trees showing slight-to-moderate decline in an irregular pattern throughout the grove.

Statistical significance of differences between declining and healthy trees was determined by the t-test.

Results and Discussion

The wood of almost all the trees with visual symptoms of marchitamiento repentino contained more Zn and water-soluble phenolics than the wood of healthy trees (Table 1). In 18 pairs of trees, there were only 2 exceptions: a) in 1

Table 1. Zinc and water-soluble phenolics in trunk wood of trees affected by marchitamiento repentino and blight, and healthy trees.

Location	No. pairs of trees	Variety and rootstock	Age of trees (yrs)	Marchitamiento repentino ppm Zn	Marchitamiento repentino mg/g water-soluble phenolics	Healthy ppm Zn	Healthy mg/g water-soluble phenolics
Argentina							
Concordia	3	Marsh grft/rough lemon	16	9	4.7	3	2.6
	3	Valencia/trifoliate	14-15	9	4.7	5	2.8
Uruguay							
Paysandu I	2	Valencia/trifoliate	20	6	4.4	2	3.2
Paysandu II	1	Valencia/trifoliate	16	8	5.0	2	3.1
	2	Navel/trifoliate	15	7	4.9	2	3.2
Paysandu III	1	Valencia/trifoliate	20	4	4.3	3	5.9
	2	Navel/trifoliate	12	8	5.9	2	4.5
Paysandu IV	2	Common mandarin/trifoliate	20	7	3.3	2	2.4
	2	Valencia/trifoliate	20	8	5.1	2	2.8
		Mean		7	4.7	3	3.4
		t-value		8.59	5.92	8.59	5.92
		Probability level		0.001	0.001	0.001	0.001
				Blight		Healthy	
Florida							
Avon Park	5	Marsh grft/rough lemon	9	17	6.0	3	3.8
Tildenville	5	Valencia/rough lemon	20	25	5.9	6	3.5
Howey-in-the-Hills	4	Valencia/rough lemon	26	31	7.4	5	4.4
St. Cloud	4	Hamlin/rough lemon	9	15	3.5	2	2.2
		Mean		22	5.7	4	3.5
		t-value		10.31	9.04	10.31	9.04
		Probability level		0.001	0.001	0.001	0.001

Table 2. Concentrations of K, Ca, Mg, and Na in the wood of trees affected by marchitamiento repentino and blight, and healthy trees.

Location	No. of pairs of trees	Variety and rootstock	% K		% Ca		ppm Mg		ppm Na	
			M[z]	H[y]	M	H	M	H	M	H
Argentina										
Concordia	3	Marsh grft/rough lemon	0.270	0.175	0.732	0.843	551	437	512	337
	3	Valencia/trifoliate	0.274	0.279	0.389	0.279	574	410	418	339
Uruguay										
Paysandu I	2	Valencia/trifoliate	0.247	0.187	0.545	0.461	545	405	352	334
Paysandu II	1	Valencia/trifoliate	0.255	0.186	0.414	0.362	602	287	358	296
	2	Navel/trifoliate	0.215	0.142	0.588	0.526	443	274	406	477
Paysandu III	1	Valencia/trifoliate	0.169	0.185	0.498	0.674	383	437	232	371
	2	Navel/trifoliate	0.164	0.104	0.602	0.589	494	213	387	406
Paysandu IV	2	Common mandarin/trifoliate	0.141	0.112	0.580	0.599	250	136	300	380
	2	Valencia/trifoliate	0.251	0.152	0.388	0.369	572	244	347	481
		Mean	0.218	0.168	0.526	0.522	490	316	346	380
		t-value	7.51		0.22		5.51		0.34	
		Probability level	0.001		N.S.		0.001		N.S.	
Florida			B[x]	H[y]	B	H	B	H	B	H
Avon Park	5	Marsh/rough lemon	0.413	0.285	1.217	1.179	715	620	361	234
Tildenville	5	Valencia/rough lemon	0.308	0.182	0.730	0.684	474	413	311	214
Howey-in-the-Hills	4	Valencia/rough lemon	0.343	0.226	1.199	1.228	720	566	355	359
St. Cloud	4	Hamlin/rough lemon	0.280	0.210	0.570	0.420	396	315	159	192
		Mean	0.336	0.226	0.929	0.878	576	479	297	250
		t-value	9.92		0.98		5.55		2.01	
		Probability level	0.001		N.S.		0.001		N.S.	

[z]Marchitamiento
[y]Healthy
[x]Blight

Table 3. Concentrations of Fe, Mn and Cu in the wood of trees affected by marchitamiento repentino, blight and healthy trees.

Location	No. of pairs of trees	Variety and rootstock	ppm Fe		ppm Mn		ppm Cu	
			M[z]	H[y]	M	H	M	H
Argentina								
Concordia	3	Marsh/rough lemon	22	19	2	2	4	6
	3	Valencia/trifoliate	28	18	2	2	5	5
Uruguay								
Paysandu I	2	Valencia/trifoliate	21	28	2	2	4	3
Paysandu II	1	Valencia/trifoliate	25	19	2	2	5	12
	2	Navel/trifoliate	23	14	2	2	9	6
Paysandu III	1	Valencia/trifoliate	20	34	2	2	3	3
	2	Navel/trifoliate	22	19	2	2	4	4
Paysandu IV	2	Common mandarin/trifoliate	19	18	2	2	4	5
	2	Valencia/trifoliate	28	14	2	1	2	3
		Mean	23	20	2	2	4	5
		Value	1.93		1.84		0.57	
		Probability level	N.S.		N.S.		N.S.	
Florida			B[x]	H[y]	B	H	B	H
Avon Park	5	Marsh/rough lemon	18	20	2	2	3	3
Tildenville	5	Valencia/rough lemon	22	15	4	4	4	3
Howey-in-the-Hills	4	Valencia/rough lemon	28	20	3	2	3	2
St. Cloud	4	Hamlin/rough lemon	14	11	2	2	2	2
		Mean	21	17	3	3	3	3
		Value	2.46		0.19		0.70	
		Probability level	0.025		N.S.		N.S.	

[z]Marchitamiento
[y]Healthy
[x]Blight

pair of grapefruit trees in Concordia, located next to each other, the Zn level was 10 ppm in the declined tree and 11 ppm in the apparently healthy tree, b) at location III in Paysandu, wood of a 'Valencia' tree showing decline symptoms contained 4 ppm Zn, and an adjoining healthy tree, with 3 ppm Zn, contained more phenolics (5.4 mg/g) than the declining tree (4.3 mg/g). Comparing the means of all 18 declining trees with the means of the healthy trees shows significantly higher levels of Zn and water-soluble phenolics in trees affected by marchitamiento.

Although the Zn levels in blight trees in Florida (Table 1) were higher than those in Argentina and Uruguay, the pattern of Zn and phenolics accumulation in declined trees is basically the same.

The same is true for K and Mg (Table 2). The wood of both blight-and marchitamiento-affected trees contained higher levels of these elements than the wood of healthy trees, an effect not found in earlier investigations (4). On the other hand, there were no significant changes in wood Ca, Na, Mn, and Cu with either blight or machitamiento (Table 3). Iron was slightly higher in the wood of diseased trees in both areas, but the difference was significant only in Florida.

These similarities strongly suggest that blight and marchitamiento are, if not identical, at least closely related. This hypothesis is further supported by the results of water injection tests by Cohen's (1) method at locations I and IV in Paysandu: Mean uptake of 29 healthy trees—316 ml/24 hr; mean uptake of 12 declining trees, healthy sector—50 ml/24 hr; and mean uptake of 6 declining trees, diseased sector—26 ml/24 hr. These values are very similar to those observed on blight trees in Florida (1, 5). In spite of unresolved differences in transmissibility and some visual symptoms, it seems certain that blight and marchitamiento repentino have the same effect on internal reallocation of Zn, K, and Mg, and that both cause a build-up of phenolics in the wood, which previously has been observed with blight and exocortis, but not with tristeza, xyloporosis, foot rot, water damage, or burrowing nematodes (5).

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