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CONTROL OF CITRUS BLIGHT DISEASE

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Abstract. **That the filamentous plugs in the vessels of blight-affected citrus trees, reported in 1953, are of fungus origin and cause the citrus blight syndrome, and that deficiencies of certain unidentified essential elements stimulate the fungus growth was suggested in 1979. In a previous experiment, 40% of 227 Valencia trees treated with montmorillonite clay as a source of essential elements, recovered noticeably, whereas 214 untreated trees lost 27 additional trees to blight. In recent experiments, (a) 1,086 "healthy" and 293 blight-affected Valencia trees on rough lemon rootstock were treated for four years with 4 to 5 lbs. of montmorillonite clay/tree/year with recovery of 202 trees (68.9%), whereas 1,173 "healthy" and 242 blight-affected check trees lost 139 (57.6%) additional trees to blight; (b) 586 "healthy" Murcott orange trees and 125 Murcott-decline trees were treated with 5 lbs, of montmorillonite clay per tree for two years and not treated for two years, had recovery of 71 trees (56.8%); and (c) 25 Murcott-decline affected trees treated with 15 lbs. of montmorillonite clay showed recovery of 22 trees (88.0%) in one year.**

Florida citrus blight is perhaps the strangest and most perplexing plant disease known and its causal relations are by no means completely established. It is without question the most economically serious disease of citrus trees in Florida. When the replacement value of a mature tree is $100 or more, and when 1600 blight trees are pulled from 1400 acres of one ranch in one year (40,000 from the entire 3500 acres in four years) and these figures are repeated more or less, throughout the State we have an economically serious problem.

The earliest report of citrus blight seems to be Fowler's (16) publication in 1874 but Swingle and Webber's (30) paper in 1896 and Rhoads' (24) paper in 1936 were the first papers to shed much light on the disease. Swingle and Webber (30) and others (4, 6, 10, 12, 13, 14, 25, 29, 38) generally agree on the symptoms of blight but a detailed discussion would require several pages. Briefly however and in the order of their development, the symptoms are as follows: dehydration, delayed leaf flushes and blooming, deficiency symptoms especially zinc (27), defoliation, twig and branch die-back, usually accompanied by vigorous sprout growth from the trunk and lower branches, absence of tree-to-tree spread or carry-over in the soil and complete failure of all transmission and perpetuation experiments (6, 7, 14, 24, 28, 30). The name citrus blight as used here, includes such names as young tree decline (YTD), sand hill decline (SHD), rough lemon decline (RLD), etc., because the name blight, poorly chosen or not, has scientific priority over later names based on artificial distinctions such as age of trees, area of the State, rootstock, etc.

The presence of filamentous plugs (Figs. 2-7) of peculiar shape in the vessels of blight-affected trees was first reported by Childs (6) who suggested that they impede the flow of water and nutrients from the roots. Later, Childs and Carlysle (8) showed the fungus nature of the plugs with scanning electron microscope (SEM) photographs. The mycological aspects were discussed in detail (7) in 1965. On the basis of citrus specimens examined from many parts of the world, Childs (10) suggested that the fungus in the vessels is an obligate parasite that is present in citrus wherever cultivated, which commonly grows in a benign symbiotic relationship with the host. But, if tree growth is weakened by deficiencies of certain essential elements, fungus growth accelerates and becomes actively parasitic on the pectic materials exposed at vessel junctions and pits in the vessel walls (10, 33, 34, 37), where it forms fungus colonies which constitute the plugs (Figs. 2-7) that impede the flow of water and nutrients through the vessels and cause the symptoms called blight disease, exactly contrary to Hanks and Feldman's (19) opinion.

Impeded water flow (6) is now widely accepted as the cause of blight symptoms (3, 4, 10, 12, 17). While theories regarding the cause of the impeded flow are conspicuously scarce, explanations of the nature of the plugs are more numerous. It has been suggested (22, 32) that many vessel plugs are amorphous (meaning in this case composed of gum) instead of being filamentous. The fungus hyphae composition of the plugs is clearly shown (6, 8, 10) by SEM photographs (Figs. 2, 3, 5, 6), but they are often impregnated with gum. This gum results from Rio Grande gummosis (9), a disease entirely distinct from blight (10). Blight, Rio Grande gummosis and several other diseases are often present in the same tree but the symptoms of one does not implicate the others.

Several other causes of blight have been suggested which fail to fit with the known facts of the disease. It has been implied for example that Pierce's disease of grapevines (20) is implicated in some way because the causal agent (of Pierce's disease) was isolated from a blight-affected citrus tree. Pierce's disease got its name from Newton B. Pierce, who worked on it around 1900 when it was devastating the grape industry of Orange County, California. The destroyed vineyards were replaced with orange trees which were not affected by Pierce's disease. Also, a rickettsia-like organism has been described (15) as possibly having some connection with citrus blight although there is overwhelming evidence that blight is not contageous and cannot be transmitted by budding or grafting (10, 14, 24, 28, 30).

The only cause of blight suggested to date that fits at all well with the known facts of its symptoms and its occurrence is the one mentioned previously (10), namely that of a systemic, obligately parasitic fungus that is present in citrus trees wherever grown, which under favorable conditions produce the plugs that impede the flow of water

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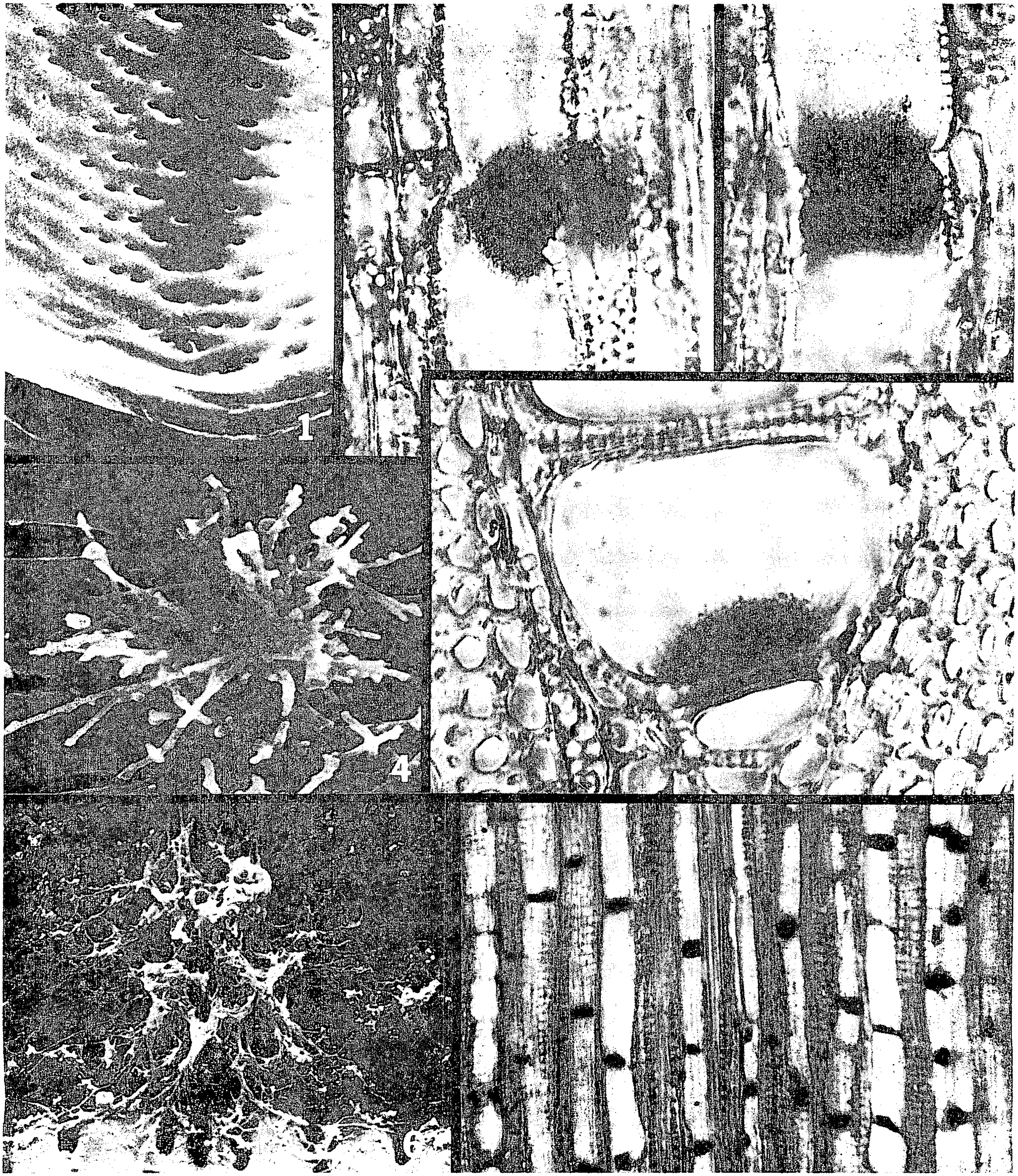

Figs. 1 through 7., Internal Symptoms of Citrus Blight Disease. 1.—Vessel wall free of fungus growth as it should be in a healthy tree, S.E.M. photo.; 2.— and 3.—Vessel plugs such as occur typically in blight-affected citrus trees, longitudinal view, light microscope photo; 4.—Young fungus colony on vessel wall, S.E.M. photo.; 5.—Young fungus colony on vessel wall, cross-sectional view, light microscope photo.; 6.—Older fungus colony on vessel wall. Note hyphae growing over and across pits in wall, not out of them, S.E.M. photo.; 7.—Longitudinal view showing numerous plugs in vessels as is typical of tree in late stage of citrus blight diseases, light microscope photo. S.E.M. photos courtesy of T. C. Carlysle, U.S.D.A., Gainesville, Fla.

and nutrients through the vessels, and so causes the desication, dieback and mineral deficiency symptoms of the disease. If this hypothesis is correct regarding vessel plugging and the etiology of citrus blight, and the basic cause is a deficiency of certain unidentified trace elements, then blight (or a reasonable facsimile) should occur outside Florida and possibly on some other crops. The answer to both questions is yes it does, but at this time I point out only that citrus blight has been identified from nine foreign countries (11, 25, 26) and from two other States, Louisiana and Arizona (31) to date.

However, the only value to be derived from knowing the cause of any disease is that it provides some clues as to where the problem of control may be attacked most effectively. I know of only one plant disease control that was developed before the cause was discovered, namely Jagger's (21) control of brown blight of lettuce. On the other hand, Albrecht (1, 2) showed ten years ago that adequately nourished plants (and animals) are resistant to infectious diseases. And Haas and Reed (18) pointed out 50 years ago that citrus tree growth could be improved by "the addition of traces of elements ordinarily considered unessential for plant growth." In the case of citrus blight, the fact that the deficient elements have not been identified proves only that (14, 19, 28).

Treatment of blight-affected trees with cytokinins has been reported (5, 23) to give a measure of control. However, Wheaton and Young (35) were unable to confirm that claim and several citrus grower's experience (personal communication) agrees with Wheaton and Young.

Methods and Results

Further experiments with volcanic ash montmorillonite clay were commenced in 1977, with the treatment of 20-year-old Valencia trees on Rough lemon rootstock. Six plots were treated and six received only standard fertilization (Table 1). Before treatment there were 1,086 "healthy" and 293 blight-affected trees in the (to be) treated plots, and 1,173 "healthy" and 242 blight trees in the check plots. I chose to treat the six plots (even numbered) with the most blight trees. After four years treatment, 1977 through 1980, with 4 to 5 lbs. of montmorillonite clay per tree per year, the number of blight trees in the treated plots *decreased* from 293 to 91 (68.9%). However, the number of blight trees in the check plots *increased* from 242 to 381 (57.6%). I am not implying that trees rated as recovered looked like trees never touched by blight, because they did not. They looked like trees recovering from a freeze, with new leaves flushing in normal size and color, in contrast to the small, pointed, zinc-deficient leaves typical of blight. In 1981 no treatment was applied and the manager had all trees that they considered blight-affected pulled out, including some 135 that had commenced to recover in the treated plots. However, on the basis of the tractor driver's opinion, blight trees in the treated plots had decreased from 293 to 228, a decrease of 22.18%. But in the check plots the number of blight trees had increased from 242 to 426, an increase of 76.03%, in this 2,794 tree experiment.

Table 1. Treatment of Valencia orange trees on Rough lemon rootstock with montmorillonite clay, 6 treated and 6 untreated plots, 2,794 trees total.

Date	Treated Trees[z]		Check Trees	
	Healthy	Blight	Healthy	Blight
7/15/77	1,086	293	1,173	242
7/18/78	1,135	244	1,193	216
7/9/79	1,166	213	1,132	283
8/19/80	1,288	91[y]	1,034	381[x]
7/5/81[w]	1,151	228	989	426

[z]Treated plots received 4 to 5 lbs. per tree per year, 1977 through 1980.
[y]293 decreased to 91 is a 68.9% decrease.
[x]242 increased to 381 is a 57.6% increase.
[w]Owner pulled all trees that appeared blight-affected, including about 135 that had started to recover. Even on that basis, 293 decreased to 228 is a 22% decrease; and, 242 increased to 426 is a 76% increase.

In 1977 the vessel plugs typical of citrus blight (6, 8, 10) were found abundant in the roots of Murcott orange trees with typical Murcott-decline symptoms in the Frostproof area and elsewhere. On the possibility that Murcott decline might be a type of citrus blight and basically a nutritional deficiency disorder, as Stewart (29) suggested, an experiment to treat such trees was commenced in January, 1978. As counted before treatment, there were eight double-row beds, 96 trees long of 10-year-old Murcott trees. On beds 1, 3, 5, 7 there were 586 "healthy" and 125 decline trees. And on beds, 2, 4, 6, 8, there were 587 "healthy" and 99 decline trees. I chose to treat the odd numbered beds with the most decline trees, using 5 lbs. of montmorillonite clay per tree. The day of application was windy and the mineral was of finer grind than usual so that it drifted badly. A second application was made in 1979. At that time the grove was sold and no mineral was applied in 1980 or 1981. As counted in July 1980, the treated beds had 699 "healthy" and 14 decline trees; whereas the checks had 665 "healthy" and 21 decline trees. In May, 1981, two years after the last application, the treated beds had 657 "healthy" and 54 decline trees; whereas the check beds had 612 "healthy" and 74 decline trees. This means that two years after the last treatment, the number of decline trees had decreased by 56.8% in the treated beds; and by 25.2% in the check beds. Whether the wind-drifted mineral of the first application affected the level of decline in the check beds is not known but the possibility exists.

A third experiment was performed on a small block of Murcott trees on Rough lemon rootstock, of nine rows, 36 trees long, that had been decimated by decline in previous years. In April, 1980, before treatment, there were 96 "healthy" trees, 27 decline and 201 DMR (dead, missing or replant) trees. Because of a shortage of mineral at the time, only 50 trees were treated, as follows: 25 decline trees each received 15 lbs. spread by hand within the drip line and raked in by hand; and 25 "healthy" trees each adjacent to one of the decline trees, each received 10 lbs., applied in the same manner, on May 13, 1980. Before applying the montmorillonite clay, eight root specimens, each from a separate root, were collected from the first five decline trees and the adjacent "healthy" trees. The number of vessel plugs in the five decline trees (average of 40 root specimens) averaged 28,357/cu. cent. (141,784/cu. in.). In the five "healthy" trees (also the average of 40 specimens) the number of plugs averaged 30,683/cu. cent. (153,414/cu. in.). One year later, May 8, 1981, 22 of the 25 treated decline trees were almost completely recovered, a decrease in decline of 88.0%. No change was noted in the 25 "healthy" trees that were treated.

Discussion and Results

Attempts to correct citrus blight by nutritional treatments of several known mineral elements (10) were unsuccessful, but treatment with a montmorillonite clay as a source of a wide variety of elements was successful in a preliminary experiment (10). In later experiments described here, 20-year-old Valencia trees on Rough lemon rootstock treated with 4 to 5 lbs. of montmorillonite clay per tree per year for four years, showed a decrease in the number of blight trees of from 293 to 91 (68.9%), whereas in the six untreated plots the number of blight-affected trees increased from 242 to 381 (57.6%). On the basis of the manager's evaluation one year later (1981) however, there was a 22.18% decrease in blight trees in the treated plots and a 76.03% increase in blight trees in the check plots of a 2,704 tree experiment. On a cumulative basis, the blight trees in the treated plots were decreased by 98.21%.

In a second experiment, after two years treatment with 5 lbs./tree/year there was a 90.4% decrease in the number of blight trees in the treated plots, and a 78.8% decrease in the check plots. Two years after the last application however, the decrease was 56.8% in the treated plots and 25.2% in the check plots. As mentioned previously, the montmorillonite clay drifted badly in the first application which may explain the decreased blight in the check plots.

In the third experiment, 15 lbs. of montmorillonite was applied per tree to 25 Murcott-decline trees and 10 lbs. to the 25 adjacent "healthy" trees. In one year, 22 of the treated decline trees showed almost complete recovery. This suggests that 4 or 5 lbs. per tree may be insufficient for the rapid recovery of larger trees. This montmorillonite clay appears to contain some essential elements that blight-affected trees require in order to resume normal growth. The large number of plugs found in "healthy" trees, here and elsewhere (25), suggests that many supposedly healthy trees suffer from impeded water flow long before typical blight symptoms appear.

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