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POSITIVE EFFECT OF BASIC SLAG APPLICATION ON CITRUS BLIGHT-AFFECTED 'HAMLIN' ORANGE TREES

H. K. WUTSCHER
U. S. Department of Agriculture
Agricultural Research Service
2120 Camden Road
Orlando, FL 32803

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Abstract. **Citrus blight in 10 pairs of 15-year-old 'Hamlin' sweet orange (*Citrus sinensis* (L.) Osbeck) trees on rough lemon (*Citrus limon* Burm. f.) rootstock showing visual symptoms was confirmed by water injection with a syringe and analysis of the outer trunk wood for zinc. One tree of each pair received 230 kg of basic slag under and around the canopy in Sept. 1984. Syringe injection every 30 days from April to Sept. 1985 showed that the mean water absorption of the slag-treated trees was significantly greater than that of untreated trees. The mean water uptake by gravity injection 8 months after treatment was 64 ml/24 hours for slag-treated trees and 25 ml/24 hours for untreated trees. The zinc level in the wood of slag-treated trees fell 32% between Sept. 1984 and Sept. 1985; there was no significant change in untreated trees. Three of the 10 slag-treated trees, with decreases in wood zinc of 45, 41 and 33%, absorbed water in the range of healthy trees (>19 ml/minute) 12 months after treatment. There was improvement in visual appearance after slag treatment, but most new growth on the 10 treated trees occurred in the interior of the canopy.**

Catastrophic freezes and citrus canker have overshadowed citrus blight in recent years, but it remains one of Florida's most severe production problems. The history of the disease has been reviewed (11), but its cause remains unknown. There is no record of trees having been cured of the disorder, but improvements after sprays with a mixture of nutrients and erythorbic acid (8), and ground applications with clay-type soil amendments (4) have been reported. These improvements were measured by visual ratings or xylem plug counts. Because blight does not have specific visual symptoms, water-injection tests (5, 7) and analyses of the outer trunk wood for zinc (12) are used to provide more accurate diagnoses by objective physical and chemical means. Low water uptake in injections and high Zn in the trunk wood indicate blight. Neither test provides sharp limits for definition of blight. Water uptake of > 100 ml/24 hr by gravity injection (5), > 18 ml/min by syringe injection (7), zinc levels > 5 ppm, and especially a combination of 2 positive tests, are generally accepted as diagnostic criteria of blight.

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Results in solution culture, where addition of SiO_3 prevented zinc accumulation in the trunk of susceptible trees (16), led to an experiment with basic slag, which consists mostly of calcium silicate, in an attempt to improve the condition of citrus blight-affected trees in the field. This is a report of the effect of slag, 1 year after application.

Materials and Methods

Ten pairs of trees with visual blight symptoms were selected in Aug. 1984 in a commercial grove of 'Hamlin' sweet orange (*Citrus sinensis*) on rough lemon (*Citrus. jambhiri*) rootstock. Trees were 15-yr-old and set 7.5 × 7.5 m on filled-in land; about 25% of the trees were affected by blight. The status of the selected trees was confirmed by water injection using a 3-ml instead of a 30-ml syringe as in the original method (7), and by analysis of the outer trunk wood for zinc (12). The Zn level was not the main criterion for pairing the trees, however. They were selected by location, always close to but never next to each other and distributed throughout the grove. In Sept. 1984, about 230 kg of basic slag was spread under and around the canopy of 1 tree of each of the 10 pairs of trees by depositing the appropriate amount with a front-end loader, and then spreading the material with hoes and shovels. The 10 control trees received regular grove care.

The slag was analyzed by fusion with sodium borate and sodium carbonate (3). Phosphorus was determined colormetrically (2), K by flame photometry, and Ca, Mg, Fe, Mn, Si, Zn and Cu by atomic absorption. Sulfur was determined in a carbonate/sodium nitrate melt (10) by nephelometry (9). Sodium (flamephotometrically) and Cl (electrometric titration) were determined in a 1:1 water extract. The results are listed in Table 1.

Water injections with a syringe (7) were conducted every 30 days from April to Sept. 1985, and water injections by gravity flow (5) were made in June 1985. Leaf analysis by standard methods (13) was performed in July 1985, and zinc in trunk wood, water-soluble phenolics, and potassium were determined in Sept. 1984, and June and Sept. 1985 (12, 13). These tests, in addition to visual evaluation, were utilized to measure changes induced by the slag treatment. The data were analyzed statistically by the t-test.

Results and Discussion

There was little difference in water absorption between the 2 sets of trees before the start of the experiment (Fig. 1, range 0-1 ml/min treated trees, 0-4 ml/min untreated trees). Between 6 and 12 months after slag application the water absorption pattern in syringe injection (Fig. 1) showed a significant improvement ($P \leqq 0.05$) in water uptake of the slag-treated trees. The uptake of untreated

Table 1. Analysis of the basic slag used in the experiment.

Percent								ppm				
P	K	Ca	Mg	Fe	Mn	Si	S	Na	Zn	Cu	Cl	Mo
0.96	0.17	17.92	2.31	10.13	1.60	12.09	0.18	576	39	28	9	35

Table 2. Zinc, water-soluble phenolics and potassium concentrations in the outer trunk wood before (Sept. 1984), 9 months (June 1985) and 12 months (Sept. 1985) after treatment with basic slag.

	Sept. 1984			June 1985			Sept. 1985		
Treatment	Zn (ppm)	WSP[z] (mg/g)	K (%)	Zn (ppm)	WSP[z] (mg/g)	K (%)	Zn (ppm)	WSP[z] (mg/g)	K (%)
Slag-treated trees	24.4[yx]	5.8	0.255	15.7	5.2	0.271	16.5[y]	5.2	.301
Untreated control	16.1	5.3	0.270	13.8	5.0	0.314	15.0	4.9	.334

[z]Water-soluble phenolics.
[y]Means of 10 trees.
[x]Difference between Sept. 1984 and 1985 significant at the 1% level.

trees was uniformly low and varied little with sampling date. The relatively large standard error of the absorption by slag-treated trees reflects a wide range in uptake (0.8-37.5 ml/min in Sept. 1985). The range in untreated trees (0.2-3.2 ml/min) was much narrower. Of the 10 slag-treated trees, 4 absorbed in the normal or near-normal range (10.7-37.5 ml/min), and 4 in the same range as the controls (0.8-3.2 ml/min). Water injection by the gravity flow method, 8 months after slag application, confirmed the results obtained by the syringe method. Slag-treated trees absorbed 64 ml/24 hr, untreated trees 25 ml/24 hr) $P \leqq 0.05$). The Zn level in the wood (Table 2) of the trees selected for treatment was higher (24.4 ± 9.0 ppm) at the beginning of the experiment than that of the untreated trees (16.1 ± 4.7 ppm), but the standard deviation indicates that the variability was comparable. Severity of decline and the level of wood Zn do not increase simultaneously. The drop in Zn concentration in June is normal for both blighted and healthy trees (15). Zinc in the wood of treated trees did not rise to the level in the previous year; it was significantly ($P \leqq 0.01$) lower in Sept. 1985 than in Sept. 1984. In untreated trees the Zn concentration was unchanged during the same period.

Potassium in the wood increased significantly ($P \leqq 0.01$) and water-soluble phenolics remained the same 12 months after treatment in both treated and untreated trees (Table 2). Elevated K and phenolics levels are found with

Table 3. Concentrations of 15 elements in the leaves of slag-treated and untreated control trees in July 1985, 9 months after treatment.[z]

	Percent						
	N	P	K	Cu	Mg	S	Si
Slag-treated	3.21	0.155	1.46	3.47	0.303	0.306	0.168[z]
Untreated control	3.20	0.158	1.39	3.46	0.316	0.292	0.126

	ppm							
	Na	Fe	Mn	Zn	Cu	Cl	B	Mo
Slag-treated	595	58	24	16	9	602	166	2.4
Untreated control	678	59	24	19	9	638	139	2.5

[z]Means of 10 trees.
[y]Means significantly different at the 5% level, others are not.

blight (12, 13), but they can also occur in trees declining from other causes (12, 14).

There was no difference in N, P, K, Ca, Mg, Na, Fe, Mn, Zn, Cu, S, Cl, B, and Mo in July 1985, 9 months after the beginning of the experiment, but the treated trees had significantly ($P \leqq 0.01$) more silicon in the leaves than untreated trees (Table 3).

Visual evaluation of the trees was complicated by the Jan. 1985 freeze which caused slight to moderate damage. The appearance of the slag-treated trees improved over the 12-month test period; the foliage was denser and greener and the leaves were larger than the untreated con-

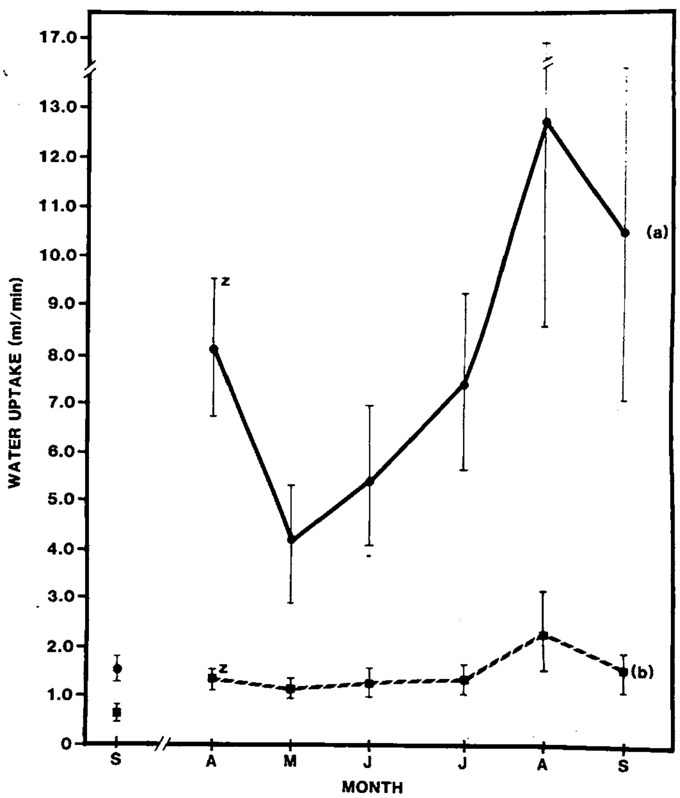

Fig. 1. Water uptake by syringe injection of (a) slag-treated and (b) untreated blight-affected 'Hamlin' orange trees 6 to 12 months after treatment. (z) Bars denote standard error of the means.

trols. Most of the new growth was in the interior of the canopy, however, and some treated trees still showed Zn deficiency symptoms. The treated trees did not visually appear to decline further during the 12 months after slag application.

There is no clear explanation of the positive effect of basic slag on blighted trees. Koo (6) reported favorable results with slag as a soil amendment, but its relatively high price prevented widespread use. Calcium silicate improved the growth of sugarcane on leached tropical soils (1); the effect was explained as a possible essentiality of silicon. Florida soils consist largely of SiO_2, but this form of silicon is highly inert and other forms of Si may influence citrus growth. The analyses in Table 1, with the exception of Na and Cl, give total contents; not all of the material is available to the trees. The effect of slag on mineral uptake is thought to be long-term (6). Thus, the slag treatment did not cure the trees of blight, at least during the time of this experiment. The trees still had high K and water-soluble phenolics in the wood and their visual appearance was far from normal after 12 months of treatment. However, the improved water uptake and the decline of the wood Zn levels indicate a definitive improvement in the condition of the trees which, if it continued for several years, would lead to recovery. Blight develops over several years; it is reasonable to expect that recovery may take more than 12 months as well.

Literature Cited

1. Ayres, A. S. 1966. Calcium silicate slag as a growth stimulant for sugarcane on low-silicon soils. Soil Sci. 101:216-227.
2. Barton, C. Y. 1948. Photometric analysis of phosphate rock. Anal. Chem. 20:1068-1073.
3. Bowman, J. A. and J. B. Willis. 1967. Some applications of the nitrous oxide-acetylene flame in chemical analysis by atomic absorption spectrometry. Anal. Chem. 29:1210-1216.
4. Childs, J. F. L. 1981. Control of citrus blight disease. Proc. Fla. State Hort. Soc. 94:25-28.
5. Cohen, M. 1974. Diagnosis of Young Tree Decline, blight and sandhill decline of citrus by measurement of water uptake using gravity injection. Plant Dis. Rptr. 58:801-805.
6. Koo, R. C. J. 1964. Some results of Fairfield slag. Proc. Fla. State Hort. Soc. 77:26-32.
7. Lee, R. F., L. J. Marais, L. W. Timmer, and J. H. Graham. 1984. Syringe injection of water into the trunk: a rapid diagnostic test for citrus blight. Plant Dis. 68:511-513.
8. Leonard, C. D. 1974. Chemotherapy of Young Tree Decline in Florida citrus. Plant Dis. Rptr. 58:918-922.
9. Quin, B. F. and P. H. Woods. 1976. Rapid normal determination of sulfur and phosphorus in plant material. Commun. in Soil Sci. and Plant Anal. 7:415-426.
10. Robinson, W. O. 1945. Fusion analysis of soils. Soil Sci. 59:7-11.
11. Smith, P. F. and H. J. Reitz. 1977. A review of the nature and history of citrus blight in Florida. Proc. Int. Soc. Citriculture 3:881-884.
12. Wutscher, H. K., M. Cohen, and R. H. Young. 1977. Zinc and water soluble phenolic levels in the wood for the diagnosis of citrus blight. Plant Dis. Rptr. 61:572-576.
13. Wutscher, H. K. and C. Hardesty. 1979. Concentrations of 14 elements in tissues of blight-affected and healthy 'Valencia' orange trees. J. Amer. Soc. Hort. Sci. 104:9-11.
14. Wutscher, H. K. 1980. Observaciones sobre plantas criticas en el litoral y noroeste de Argentina. Rev. Ind. Y Ag. de Tucuman 56:81-89.
15. Wutscher, H. K. 1981. Seasonal changes in zinc and watersoluble phenolics in the outer trunk wood of healthy and blight-affected sweet orange trees. HortScience 16:157-158.
16. Wutscher, H. K. 1984. Induction of citrus blightlike zinc accumulation in the wood and bark of 3-year-old 'Hamlin' orange trees in solution culture. Proc. Fla. State Hort. Soc. 97:59-61.

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EFFECT OF TETRACYCLINE TREATMENT ON THE DEVELOPMENT OF CITRUS BLIGHT SYMPTOMS

L. W. Timmer, J. H. Graham, and R. F. Lee
University of Florida, IFAS
Citrus Research and Education Center
700 Experiment Station Road
Lake Alfred, FL 33850

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Abstract. **'Hamlin' sweet orange (*Citrus sinensis* (L.) Osb.) trees on Carrizo citrange (Poncirus trifoliata (L.) Raf. x *Citrus sinensis*) rootstock in early decline (high wood Zn, low water uptake) and predecline (high wood Zn, normal water uptake) stages of citrus blight were treated 4 times in 1983 and 1984 with trunk injections and soil drenches of tetracycline antibiotics. Tetracycline treatment of early decline trees reduced wood Zn levels but did not improve water uptake, and all trees developed visual symptoms within 1 year. Treatment of predecline trees reduced wood Zn levels but reduced water uptake into the trunk, complicating blight diagnosis. Tetracycline applications appeared to delay the onset and severity of blight, but the number of blighted trees among treated and control trees was similar by the end of the experiment.**

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Citrus blight is a serious decline of unknown cause that results from a dysfunction in the vascular system. Several lines of evidence indicate that xylem-limited bacteria (XLB) may be involved in the etiology of the disease (3,4,9), but other data do not support such a role for XLB (10).

Since other diseases caused by XLB, such as Pierce's disease of grape may be partially controlled by application of tetracycline antibiotics (5), several attempts have been made to reverse blight symptoms with these antibiotics (7,8,11,12). Tucker et al. (12) reported improvement in the canopy condition following treatment of blighted trees with oxytetracycline (OTC). Subsequently, we found that trunk injection and soil drench treatments with OTC reduced Zn levels in trunk wood (7). However, we were unable to demonstrate an improvement in tree condition