Fusarium Wilt of Tomato: Interaction of Soil Liming and Micronutrient Amendments on Disease Development

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ABSTRACT

A hydrated lime + ground limestone soil amendment increased the pH of the soil solution to 9.0 and reduced the incidence and severity of *Fusarium* wilt of tomato caused by *F. oxysporum* f. sp. *lycopersici* race 2. However, soil additions of Mn + Zn or Fe + Zn lignosulfonates, which are available for plant growth at pH 9.0, reversed disease control given by the lime amendment with an increase in the incidence and severity of wilt. Phytopathology 60:812-813.

Jones & Woltz (1, 2, 3) demonstrated in greenhouse and field tests that soil amendments of hydrated lime inhibited development of *Fusarium* wilt of tomato, *Lycopersicon esculentum* Mill., caused by *Fusarium oxysporum* (Schlecht.) f. sp. *lycopersici* (Sacc.) Snyd. & Hans. race 2. They suggested that the inhibition was due to decreased availability of micronutrients created by the increased pH of the soil solution. This induced deficiency, they further suggested, would decrease the growth, sporulation, and virulence of the pathogen. Their micronutrient data, however, were variable and inconclusive.

To help resolve the issue, an experiment was designed and carried out involving the addition of lignosulfonate-metal complexes (which are available to plants at high soil pH values) to hydrated lime + ground limestone and gypsum-amended soil. If the addition of micronutrients in an available form reversed the hydrated lime effect and wilt developed, this would be strong evidence that the basis of wilt control by hydrated lime was an induced deficiency or imbalance of micronutrients due to the increased soil pH.

MATERIALS AND METHODS.—Leon fine sand from a virgin Palmetto-pine vegetation area was used in the test. The soil had a moisture equivalent of 3.1%, an organic content of 2.0%, an initial pH of 4.8, and a cation exchange capacity of 3.1 meq/100 g. The soil was divided into 2 main lots: one lot was amended at the rate 1,000 mg of ground limestone ($CaCO_3$) plus 1,000 mg of hydrated lime [$Ca(OH)_2$]/kg of soil; the second lot was amended at the rate of 2,000 mg of gypsum ($CaSO_4 \cdot 2H_2O$)/kg of soil. These two main lots of soil were then subdivided and amended with various rates and combinations of iron (Fe), manganese (Mn), and zinc (Zn) lignosulfonate complexes (5% metal). The amended soil was then put into 6-inch plastic pots and the pots arranged into four randomized blocks in a greenhouse.

Race 2 of *F. oxysporum* f. sp. *lycopersici* used to infest the soil was grown 7 days at 28 C in a liquid medium (7). The mycelial mat was filtered off, rinsed twice with distilled water, and weighed fresh, and 16.3 g were mixed into the upper 2 inches of each pot. One week later, four Manapal (resistant to race 1, susceptible to race 2) tomato seedlings (14 days old) were transplanted into each pot. The roots of each plant were cut 2 weeks later to facilitate invasion by the pathogen.

Plants were rated for disease severity 2 months after transplanting as follows: 0, no disease symptoms; 1, no external symptoms, slight vascular browning; 2, slight downward curvature of petioles and slight stunting, vascular browning; 3, up to 50% of the leaves yellow, vascular browning; 4, 51-80% of the leaves yellow or abscised, vascular browning; and 5, plants dead.

All plants were irrigated as needed with distilled water containing 50 ppm nitrogen and 50 ppm potassium, adjusted to pH 8.0 with NaOH. Micronutrients were supplied to the tomato plants grown in the limed soil which did not receive lignosulfonates by foliar spray applications of Fe, Mn, and Zn sulfates. The pH of a soil sample from each pot was determined 5 weeks after plants were set.

TABLE 1. Effect of soil amendments of lignosulfonate-metal complexes, hydrated lime + ground limestone, and gypsum on the incidence of *Fusarium* wilt of tomato

Rate of each lignosulfonate	Lignosulfonate-metal complexes[a] used				
	Fe + Mn + Zn[b]	Fe + Mn[b]	Mn + Zn[b]	Fe + Zn[b]	Fe + Mn + Zn[c]
Mg/kg soil	%	%	%	%	%
400	37.5	37.5	93.7	87.5	87.5
200	37.5	25.0	87.5	81.2	93.7
100	37.5	37.5	62.5	67.7	100.0
50	37.5	50.0	25.0	50.0	100.0
0	56.2				81.2
LSD = .05 micronutrients = 40.0					

[a] 5% Metal.

[b] Amended with $Ca(OH)_2 + CaCO_3$ each at rate of 1,000 mg/kg soil.

[c] Amended with $CaSO_4 \cdot 2H_2O$ at the rate of 2,000 mg/kg soil.

TABLE 2. Effect of soil amendments of lignosulfonate-metal complexes, hydrated lime + ground limestone, and gypsum on the severity of *Fusarium* wilt of tomato

Rate of each lignosulfonate	Lignosulfonate-metal complexes[a] used				
	Fe + Mn + Zn[b]	Fe + Mn[b]	Mn + Zn[b]	Fe + Zn[b]	Fe + Mn + Zn[c]
Mg/kg soil	*index*[d]	*index*	*index*	*index*	*index*
400	1.06	1.12	3.25	3.12	3.37
200	1.37	0.81	2.68	2.50	3.43
100	1.06	1.18	1.50	1.50	3.75
50	1.25	1.37	0.68	1.37	3.93
0	1.62				2.81
LSD = .05 micronutrients = 0.98					

[a] 5% Metal.
[b] Amended with $Ca(OH)_2 + CaCO_3$ each at the rate of 1,000 mg/kg soil.
[c] Amended with $CaSO_4 \cdot 2H_2O$ at the rate of 2,000 mg/kg soil.
[d] Based on a 0-5 scale where 0 = no disease and 5 = dead plants.

RESULTS AND DISCUSSION.—The application of hydrated lime and ground limestone increased the soil reaction to pH 8.6-9.0. After 5 weeks, the soil reaction had decreased uniformly to pH 7.5-8.0. The gypsum soil amendment did not affect the initial pH of 4.8, but, 5 weeks later, the soil pH had increased uniformly to 5.4. None of the lignosulfonate-metal complex treatments significantly affected the soil reaction of either the hydrated lime + ground limestone or the gypsum-amended soil.

The hydrated lime + ground limestone soil amendment increased the soil pH and decreased the incidence (% diseased plants) and severity of wilt. Neither the addition of Fe + Mn + Zn nor of Fe + Mn lignosulfonates, regardless of rate, significantly affected wilt development. However, the addition of Mn + Zn or Fe + Zn lignosulfonates reversed the control given by liming, and the incidence and severity of wilt increased as their rates were increased (Tables 1, 2).

It is clear (i) that the addition of certain micronutrient combinations in available form will reverse wilt control given by lime amendments, and (ii) that micronutrients are involved in the pathogenesis of tomato by *F. oxysporum* f. sp. *lycopersici* race 2. Why certain combinations encouraged wilt development in limed soil whereas others did not is unknown.

Woltz & Jones (7) reported that Zn was essential for the growth, sporulation, and virulence of *F. oxysporum* f. sp. *lycopersici* race 2. *F. vasinfectum* Atk. also requires zinc for growth and for the production of fusaric acid (5). Kalyanasundaram (4) reported that soil amendments of zinc altered the susceptibility of cotton to *F. vasinfectum,* and Subramanian (6) induced resistance of pigeon pea, *Cajanus cajan,* to *Fusarium udum* by application of Mn to soil. The effect of micronutrients on the pathogenesis of tomato by *F. oxysporum* f. sp. *lycopersici* race 2 as reported herein may be upon the host, the pathogen, or both host and pathogen. Nevertheless, certain micronutrient combinations added to the soil as lignosulfonate complexes reversed the disease-inhibiting effects of lime and the concomitant high soil pH. This supports the hypothesis that an imbalance in micronutrient supply may be the mechanism by which liming retards pathogenesis.

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