Comparative Control of Phytophthora Root Rot of Citrus with Sodium Tetrathiocarbonate, Metalaxyl, and Fosetyl-Al

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Abstract

This study was initiated to evaluate and compare the effect of root and soil treatments with sodium tetrathiocarbonate (STTC) (Enzone), metalaxyl (Ridomil), and fosetyl-Al (Aliette) on subsequent development of Phytophthora root rot on citrus. Disease development was significantly reduced on rough lemon seedlings treated with STTC or metalaxyl compared to untreated plants when this citrus rootstock was inoculated with sporangia of P. citrophthora or P. parasitica. Growth of rough lemon seedlings in soil naturally infested with P. parasitica that was treated one week before planting with STTC or metalaxyl was equivalent to that obtained in sterilized orchard soil. STTC applied as a soil drench at 2,450 ppm was lethal to P. citrophthora and P. parasitica on colonized leaf disks of lemon buried in soil, whereas a similar treatment with metalaxyl at 10 ppm or fosetyl-Al at 3,000 ppm did not appreciably affect pathogen viability. Sporangium production on leaf disks of lemon colonized by P. citrophthora and P. parasitica and buried in soil was reduced at least 90% compared to the untreated control six days after treatment of soil with 2,450 ppm of STTC, 10 ppm of metalaxyl, or 3,000 ppm of fosetyl-Al. These studies demonstrate the potential usefulness of sodium tetrathiocarbonate as a fungicide for control of Phytophthora root rot of citrus. Only fosetyl-Al (Aliette) and metalaxyl (Ridomil) currently are registered for control of Phytophthora diseases on citrus.

Introduction

A high incidence of root and crown rot has been observed in commercial citrus plantings in Arizona. Phytophthora citrophthora and P. parasitica are consistently isolated from diseased root and bark tissue as well as from soil adjacent to infected trees. The systemic fungicides fosetyl-Al (Aliette, Rhone-Poulenc Ag. Co.) and metalaxyl (Ridomil, Ciba-Geigy Corp.) are effective fungicides for control of Phytophthora diseases on citrus. Recently, the inhibitory activity of sodium tetrathiocarbonate (Enzone, Unocal Corp.) on sporulation and growth of several species of Phytophthora was reported. When added to water and applied to soil, sodium tetrathiocarbonate (STTC) releases carbon disulfide, a known biocide.

The purpose of this investigation was to compare the effect of root and soil treatment with STTC or metalaxyl on subsequent development of Phytophthora root rot on citrus. The viability of P. citrophthora and P. parasitica in colonized citrus tissue as well as sporangium production following application of STTC, metalaxyl, or fosetyl-Al to soil also was examined.

Materials and Methods

Disease development by inoculation of plants with sporangia. Four-month-old rough lemon seedlings were removed from potting mix, washed in tap water to remove potting mix attached to roots, then placed in plastic cups containing water alone, water plus STTC, or water plus metalaxyl. Each cup contained 10 seedlings with roots totally immersed in water. Plants were inoculated by adding agar disks bearing sporangia of P.

citrophthora or P. parasitica to the liquid in each cup. During the subsequent 4 hr inoculation period, sporangia would release zoospores which could colonize citrus roots. After inoculation, seedlings were planted individually in 4-inch plastic pots in the greenhouse. Final disease incidence and severity were evaluated after 3 months by recording plant mortality and the fresh weight of shoots and roots.

Disease development after a preplant drench of naturally infested soil. Soil infested with P. parasitica was obtained from a citrus orchard on the Yuma Mesa. The soil was placed in plastic trays and drenched with enough water containing 10 ppm of metalaxyl or 4,900 ppm of STTC to saturate the soil and maintain a 1 cm layer of solution over the surface. After a 2-hr incubation period, the soil was allowed to drain freely and remained undisturbed for 7 days. Four-month-old rough lemon seedlings then were planted individually in the treated soil in 4-inch plastic pots and flooded once every 2 weeks for 48 hr to stimulate disease development. Final disease data was collected after 3 months.

Viability of Phytophthora mycelium in soil. Six-mm-diameter leaf disks of lemon were colonized by P. citrophthora or P. parasitica, then buried in nonsterile sandy field soil in 4-inch plastic pots. The soil in each pot was thoroughly drenched with water containing 2,450 ppm of STTC, 10 ppm of metalaxyl, or 3,000 ppm of fosetyl-Al. Pots were allowed to drain freely, then incubated for 5 days, after which the 10 leaf disks in each pot were removed, rinsed in water, and plated on agar plates to determine viability of mycelium in each leaf disk.

Sporulation of Phytophthora in soil. Leaf disks of lemon were colonized by P. citrophthora and P. parasitica, buried in field soil in plastic pots, and drenched with STTC, metalaxyl, or fosetyl-Al as described above. Six days after treatment, leaf disks were removed from soil, rinsed in water, then stained and fixed to preserve sporangia. The number of sporangia along the margins of each leaf disk were counted.

Results and Discussion

Lemon seedlings inoculated with sporangia of P. citrophthora or P. parasitica in the presence of STTC or metalaxyl were as healthy as the noninoculated control plants (Table 1). Likewise, shoot growth of rough lemon seedlings grown in orchard soil naturally infested with P. parasitica and treated with STTC or with metalaxyl one week before planting was equivalent to that obtained in sterilized orchard soil (Table 1). Root growth in soil treated with either chemical was greater than that recorded in untreated soil, but less than the root growth achieved in sterilized orchard soil.

The viability of mycelium of P. citrophthora and P. parasitica was drasticly reduced by STTC at 2,450 ppm, but not by fosetyl-Al at 3,000 ppm or metalaxyl at 10 ppm. Sporangium production on leaf disks of lemon colonized by P. citrophthora and P. parasitica and buried in soil was reduced at least 90% compared to the untreated control 6 days after treatment of soil with 2,450 ppm of STTC, 10 ppm of metalaxyl, and 3,000ppm of fosetyl-Al.

STTC and metalaxyl provided comparable levels of disease control under our experimental conditions. The tested formulation of STTC rapidly releases carbon disulfide, the active biocide, when diluted in water. The quick release of carbon disulfide apparently provides short-term inhibition of Phytophthora.

Currently, STTC is being developed as a nematicide. This chemical also has potential as a control agent for Phytophthora root rot of citrus. The possibility of a single pesticide with activity against Phytophthora and nematodes is especially appealing for citrus production, where Phytophthora root and foot rot and citrus nematode damage are major soilborne problems which often occur together in the same orchard.

Of the tested materials, only fosetyl-Al (Aliette) and metalaxyl (Ridomil) currently are registered for use on citrus to control Phytophthora diseases.

Table 1. Effect of chemical treatment on growth and disease development in rough lemon seedlings in the presence of Phytophthora

Treatment	Fresh weight (g)* Shoots	Roots
Phytophthora citrophthora (Inoculation with sporangia)		
Inoculated control	4 b	1.1 b
Metalaxyl (10 ppm)	12 a	2.8 a
STTC (122 ppm)	10 a	2.5 a
Non-inoculated control	12 a	2.8 a
Phytophthora parasitica (Inoculation with sporangia)		
Inoculated control	5 b	1.2 b
Metalaxyl (10 ppm)	12 a	2.6 a
STTC (122 ppm)	11 a	2.4 a
Non-inoculated control	12 a	2.8 a
Soil naturally infested with Phytophthora parasitica		
Sterilized soil	6.6 a	3.1 a
Non-sterilized soil	3.6 b	1.4 c
Metalaxyl (10 ppm)	6.4 a	2.4 b
STTC (4,900 ppm)	6.2 a	2.4 b

*For each Phytophthora species or for naturally infested soil, numbers in eacch column with a different letter are significantly different ($P = 0.05$) according to Duncan's multiple range test.