Effects of Organic Components in Container Media on Suppression of Fusarium Wilt of Chrysanthemum and Flax

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ABSTRACT

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Container media amended with mature hardwood bark compost (CHB) suppressed chrysanthemum and flax Fusarium wilts, but green CHB was significantly less suppressive. Media amended with raw and aged pine bark were mildly suppressive and those amended with Canadian peat were conducive. Heating of mature CHB negated the suppressive effect, but only partially reduced the suppressiveness of green CHB.

Additional key words: *Fusarium oxysporum* f. sp. *chrysanthemi*, *Fusarium oxysporum* f. sp. *lini*.

During the past decade a variety of tree barks have been used in the preparation of container media. This has decreased losses caused by soilborne plant pathogens of containerized ornamental plants (5). CHB suppresses Phytophthora root rots caused by *Phytophthora cinnamomi* Rands (7,15,16), Rhizoctonia damping-off (10,17), and some diseases caused by nematodes (9). In a preliminary report, Fusarium wilt of flowered chrysanthemum cultivar Yellow Delaware was suppressed in media amended with CHB (6). Pine barks have also been shown to suppress soilborne plant pathogens (4,14,16).

The purpose of this research was to provide quantitative data on the suppression of Fusarium wilt of chrysanthemum and flax by organic components of container media and whether the suppressive effect can be negated by heating.

MATERIALS AND METHODS

Preparation of container media. The organic components tested were Canadian sphagnum peat (CP), green (2-mo-old) CHB, mature (1-yr-old) CHB, raw pine bark (RPB), and aged (pyrolized in 4-m-high windrows for 8 mo) pine bark (APB). The sources and species composition of these tree barks were previously reported (10).

Green or mature CHB was mixed with CP, coarse perlite, and sharp silica sand (5:2:2:1, v/v). A CP medium was prepared by mixing CP with perlite and sand (2:1:1, v/v). RPB or APB were amended with CP and sand (7:2:1, v/v). The air-filled pore spaces (at container capacity) in all media were 15–20% (in a 10-cm-tall column). Fertility levels were adjusted as described (10). The pH of all media ranged from 6.4 to 6.8.

Bioassays. The two bioassays used to detect suppression were the flax wilt bioassay described by Scher and Baker (13) and the chrysanthemum wilt bioassay of Engelhard and Woltz (3). *Fusarium oxysporum* f. sp. *chrysanthemi* (supplied by A. W. Engelhard, AREC, Bradenton, FL 33508) was cultured on potato-dextrose agar slants under fluorescent lights (14-hr photoperiod) at 24 C. After 14 days, spores were harvested in sterile distilled water and hemacytometer counts were used to adjust their concentration. Suspensions (microconidia and macroconida) contained some mycelial fragments. This inoculum was blended with container media in a 30-L liquids/solids twin-shell blender (Patterson-Kelly Co., East Stroudsburg, PA 18301). Conidial suspensions (200 ml per 30 L of container medium) of various concentrations were added during blending for 3 min. The actual inoculum concentrations after blending were determined by dilution plating on Komada's Fusarium-selective medium (8). Unrooted, suberized chrysanthemum cuttings of cultivar Yellow Delaware (Yoder Brothers, Inc., Barberton, OH 44203) were potted the same day in the infested container media in 14-cm-diameter, 400-ml polyvinyl containers (one per pot) and incubated under intermittent mist (22–28 C) for 4 wk. Thereafter, plants (five replications of six plants per treatment) were moved to a greenhouse bench and fertilized at each watering with a 20-20-20 fertilizer solution (200 mg of ammonium nitrate N per liter). The pH of the media remained between 6.4 and 6.8 throughout. Temperatures ranged from 30 to 35 C during the day and from 24 to 26 C at night. Percentage of wilted leaves on each plant was determined 6 wk after planting. Sections from stems of wilted chrysanthemum plants were plated on Komada's medium to ensure correct diagnosis. The experiment was repeated four times. The experimental design was a completely randomized factorial with five replications and two main effects, container medium and inoculum level. To stabilize unequal variance of the original data, disease incidence data were arc sine transformed ($\sqrt{(X)}$], in which X is the proportion of wilted leaves.

A culture of *F. oxysporum* Schlecht. f. sp. *lini* was obtained from R. Baker (Colorado State Univ., Fort Collins). Inoculum (chlamydospores) was produced on sterilized carnation tissue that was air dried, ground, screened, and added to container media at a rate of 1% (w/w) as described by Scher and Baker (13). Flax (*Linum usitatissimum* L. 'Punjab 47') was seeded in pots (10 pots per treatment) in a greenhouse (27–35 C) and thinned after emergence to 10 per pot. Percentage of wilted plants was determined every 3 days for 30 days. Wilted seedlings were plated on Komada's medium to ensure correct diagnosis. The Weibull model was fit to the disease progression data using previously described methods (12). Inspection of the estimated Weibull-shape parameters revealed that a single transformation could not be used to represent disease progress over time. We therefore calculated the area under the disease progress curve (AUDPC) for each medium, heat treatment, and replication (2). AUDPC provides a univariate representation of disease incidence over time (2). The experiment consisted of a randomized factorial design with two main effects, heat treatment and organic medium.

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RESULTS

Analysis of variance indicated a significant effect of media, inoculum level, as well as the media × inoculum level interaction. Due to this interaction, an LSD equal to 0.07 was used to separate individual transformed means for media and inoculum level. Fusarium wilt of chrysanthemum was suppressed in media amended with CHB, whereas the CP-amended container medium was conducive. Transformed values of proportion of wilted leaves, determined 6 wk after cuttings were placed in infested media, showed significant differences in disease incidence at all inoculum levels (Table 1). Similar data were obtained in four other trials with different batches of CHB.

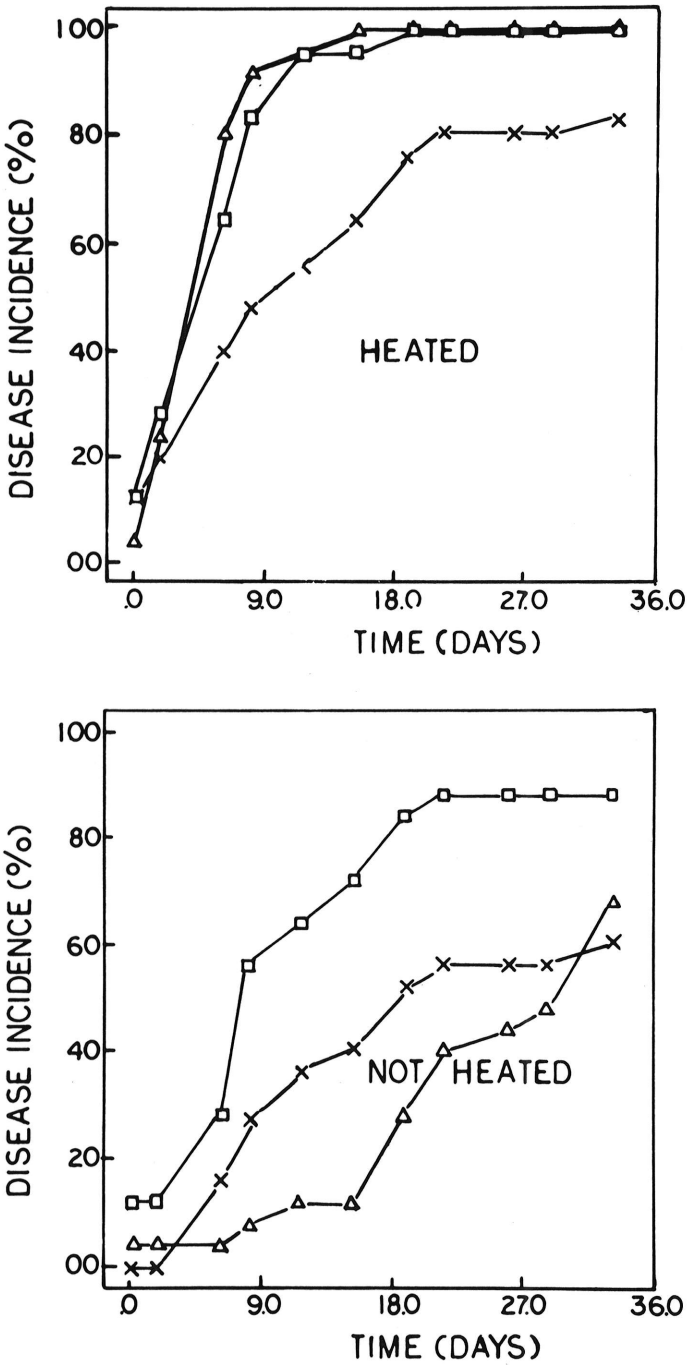

Fig. 1. Effect of heating container media prepared with various organic amendments for 5 days at 60 C on the incidence of Fusarium wilt of flax. Container media (× = green composted hardwood bark [CHB], △ = mature CHB, and □ = Canadian peat) were infested with *Fusarium oxysporum* f. sp. *lini*. See Table 2 for statistical evaluation.

Analysis of variance of the flax wilt data indicated significant effects of heat treatment, container medium, and the treatment × medium interaction. An LSD of 3.5 was used to separate individual AUDPCs. Mature CHB was significantly more suppressive than green CHB (Fig. 1 and Table 2). Green CHB was slightly more suppressive than APB or RPB. However, both CHBs were significantly more suppressive than was CP.

To determine whether the suppressive effect in CHB was biological in origin, samples were heated 5 days at 60 C as described (10). Heated samples were incubated for 2 days at 25 C and then tested with the flax wilt bioassay. Heating negated the suppressive effect of mature CHB and significantly reduced suppressiveness of green CHB (Fig. 1). The Canadian peat medium was significantly more conducive after heating. Similar results were obtained in two other trials.

DISCUSSION

Apparently, suppression of the Fusarium wilts in mature CHB is biological in origin and/or due to the presence of heat-labile chemical inhibitors. In green CHB, heat-stable factors appear to play a role. These findings are similar to those found for suppression of Rhizoctonia damping-off in CHB in which heating as well as exposure to gamma radiation negated suppression that could be restored by adding small amounts of unheated CHB to the heated CHB (11).

The low levels of suppression of Fusarium wilt of flax and chrysanthemum in plants grown in pine bark media seemingly contradicts a report from Japan on suppression of Fusarium wilt of Chinese yam with composted pine bark (14). Our APB, however, was obtained from windrows in which pyrolysis had occurred (80 C and higher). In such high-temperature windrows, spontaneous

TABLE 1. Effect of composted hardwood bark and Canadian peat container media on Fusarium wilt of chrysanthemum cultivar Yellow Delaware

Inoculum level[x]	Wilted leaves (%)[y]		Transformed values[z]	
	Bark	Peat	Bark	Peat
2.0×10^5	30.5	88.9	0.54	1.38
6.6×10^4	19.9	94.3	0.39	1.46
2.0×10^4	10.1	37.5	0.22	0.63
6.6×10^3	6.1	16.4	0.13	0.33
2.0×10^3	1.7	7.1	0.04	0.15
6.6×10^2	0.0	6.0	0.00	0.13
LSD ($P = 0.05$)			0.07	

[x] Number of colony-forming units in container media at planting after incorporation of macroconidia and microconidia and mycelial fragments of *Fusarium oxysporum* f. sp. *chrysanthemi*.
[y] Mean percent wilted leaves per plant in five replications of six plants each, determined 6 wk after cuttings were potted in infested container media. Analysis was not performed on the percentage data.
[z] Arc sine-transformed value = $\sqrt{}$ (% wilted leaves/100).

TABLE 2. Effects of heat treatment on estimated areas under disease progress curves (AUDPC) for Fusarium wilt of flax

Medium organic component[y]	AUDPC	
	Not heated	Heated[z]
Canadian peat	21.5	27.8
Raw pine bark	16.1	···
Aged pine bark	16.2	···
Green composted hardwood bark (CHB)	12.5	19.9
Mature CHB	8.5	28.3
LSD ($P = 0.05$)	3.5	

[y] Container media were infested with *Fusarium oxysporum* f. sp. *lini*.
[z] Container media were heated 5 days at 60 C before infestation and planting.

combustion occurs frequently. Therefore, readily available carbon (1), which is required as a food base for recolonization by microorganisms, was largely absent in this pyrolyzed bark residue. The RPB on the other hand, which also was not suppressive, had been removed from trees less than 2 wk before use and perhaps was not a suitable food base for recolonization since microbial inhibitors occur in raw barks (5). In addition, most of the wood had been removed from this bark during processing, so that the total cellulose content was low, which also may affect its suitability as a food base (1).

In the Japanese experiments, 6-mo-old composted pine bark was prepared from "bark" that contained 20–40% wood before composting (14) and therefore differed from the APB in our media. Container media prepared from APB are now available commercially in the eastern United States. Bark from which this compost is prepared, however, contains 10% or less wood and thus may not have the same effect as the Japanese pine bark compost. In addition, the effects of bark from different pine species also may differ (5).

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