Influence of Planting Media and Soil Sterilization on the Uptake of Benomyl by American Elm Seedlings

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ABSTRACT

Benomyl fungicide was applied to 6-month-old American elm seedlings grown in sand, soil, or a mix of soil:peat:perlite (1:2:2). Zones of inhibition, around tissue sections from treated plants placed on petri plates with potato-dextrose agar seeded with *Ceratocystis ulmi* conidia, were indicative of the relative concentration of fungitoxicant in the plants. The most fungitoxicant accumulated in plants grown in sand, and the least, in those grown in the mix when bioassayed 5, 30, 60, and 90 days after treatment. The planting medium affected the total amount as well as the rate of accumulation of the fungitoxicant. Highest levels of accumulation of the fungitoxicant were in seedlings grown in media with the lowest content of organic matter and the highest pH. No direct correlation existed between benomyl uptake and the growth in height of the plants. Heat sterilization of soil, prior to benomyl treatment and planting elm seeds, resulted in increases in the accumulation of fungitoxicant in plants compared to those grown in nonsterile soil. Phytopathology 61: 1512-1515.

Additional key words: systemic fungicide.

The systemic and fungitoxic activities of benomyl have been well established. Benomyl has been incorporated into the planting medium to control vascular wilt diseases (1, 2, 5, 7). Investigators have shown that chemical movement and uptake are affected by the composition and porosity of the planting medium (4, 6, 8, 10, 11). There is still, however, little information on the influence of the constituents of the planting media, pH, and microbial populations on uptake of benomyl into plants. We conducted this research to determine the effects of specific components and sterilization of planting media on the rate and total amount of benomyl uptake by American elm seedlings, *Ulmus americana* L.

MATERIALS AND METHODS.—*Effects of planting media composition on benomyl uptake.*—Hock et al. (8) reported greater uptake of benomyl by American elm seedlings from sand planting medium than from either soil or a soil:peat:perlite mix. We decided to determine whether the rate of uptake, as well as the total amount of fungitoxicant in the seedlings, was influenced by the planting medium.

Ten-week-old American elm seedlings were transplanted into 18-cm plastic pots in either white silica sand (flint shot, grain size 34), soil (Morley silt loam), or a mix (soil:peat:perlite [1:2:2]). They were grown under a 16-hr photoperiod (incandescent, ca. 600 ft-c) with weekly applications of 200 ml of modified Hoagland's solution (9). Benomyl was applied as a drench 13 weeks after transplanting at the rate of 200 ml of a 1,500 ppm active aq suspension/pot. It was shown previously (8) that benomyl was taken into elm seedlings equally well either whether applied as a drench or incorporated directly into the potting media. Twelve treated and two check plants from each medium were bioassayed 5, 30, 60, and 90 days after treatment. Leaf, bark, and wood tissue from the top, center, and bottom of each plant were bioassayed by using a seeded plate technique (8) to determine the relative concentration of the fungitoxicant.

Another experiment was conducted to determine the effect of soil, peat, and perlite alone, and in all combinations on uptake of benomyl into elm seedlings. Eight-week-old American elm seedlings were transplanted into 18-cm pots containing the following media: soil; peat; perlite; soil 1:peat 2:perlite 2; soil 1:peat 2; soil 1:perlite 2; and peat 1:perlite 1. Sand was used as a standard to compare uptake of benomyl with the other media. The medium in each pot was drenched 8 weeks after transplanting with 200 ml of a 1,500 ppm active suspension of benomyl. Fifteen treated and three untreated seedlings were grown in each planting medium. The seedlings were bioassayed 30 days after treatment by using the seeded plate technique. Plant heights were recorded before bioassaying, and the pH of each planting medium was determined from a combined sample from eight treated pots.

Effects of soil sterilization upon chemical uptake.—Air-dried soil was placed into 18-cm pots and brought to maximum water-holding capacity with 600 ml distilled water. The pots were covered with aluminum foil and autoclaved twice for 1 hr with 48-hr incubation between sterilizations. American elm seeds were surface-sterilized for 5 min in 1% sodium hypochlorite before planting in the sterile soil.

Each pot was drenched with 200 ml of a 1,500-ppm active aq suspension of benomyl 30 days after seeding. The amount of fungitoxicant present in seedlings grown in sterile soil, nonsterile soil, and sand was determined by the seeded plate technique 90 days after treatment with benomyl. Sterile and nonsterile soil without benomyl were used as checks. Fifteen replications were used for each treatment.

RESULTS AND DISCUSSION.—*Effects of*

planting media composition on benomyl uptake.—Most fungitoxicant accumulated in plants grown in sand, and least in those grown in the mix (Fig. 1). The amount of fungitoxicant in the plants increased between 5 and 30 days after treatment, decreased up to 60 days, then remained fairly constant up to 90 days. This pattern was particularly constant for bark and wood tissue, but increases in the amount of fungitoxicant occurred in top leaves, and to some extent in top bark between 60 and 90 days. This may reflect a period of increased growth and leaf expansion with a concomitant accumulation of benomyl. Data is not available from bottom leaves after 30 days since they abscissed. Accumulation of the chemical from soil and mix was similar to that in sand only in center leaves 90 days after treatment. With this exception, there is no indication, even after 90 days, that total benomyl uptake from soil or mix will approach that from sand. These data indicate that planting media influence the total uptake rather than the rate of benomyl accumulation.

Benomyl uptake was influenced by the various combinations of planting media (Table 1). Most fungitoxicant accumulated in plants grown in sand or perlite, and the least in plants grown in peat or soil. These data agree with the findings of Hock et al. (8), and Zaronsky & Stipes (11) that the benzimidazoles are taken up by elm seedlings more readily from sand than from soil, sand-soil, or soil-peat-perlite. Hine et al. (6) and Pellissier et al. (10) also found that soil restricted uptake of benzimidazoles. A soil:peat mix reduced uptake below that from either constituent, whereas uptake from soil:perlite or peat:perlite was intermediate between that from either component used alone.

Reduced uptake of benomyl is related to the presence of peat and, to a lesser degree, soil in the planting medium. Cimanowski et al. (4) attributed reduced control of apple powdery mildew by benomyl, when plants were grown in perlite, to increased medium porosity. Our data do not indicate this relationship, as soil and peat, while varying greatly in porosity, both reduce benomyl uptake. We found increased chemical accumulation in elms with the addition of perlite to either soil or peat as a means of increasing porosity. Finally, benomyl was present in highest concentrations in elms grown in perlite or sand, two of the more porous media.

Our data indicate that chemical uptake is reduced by the addition of organic matter to the growth medium (Table 1). Similar results were reported by Bristow & Katan (3), who found uptake of

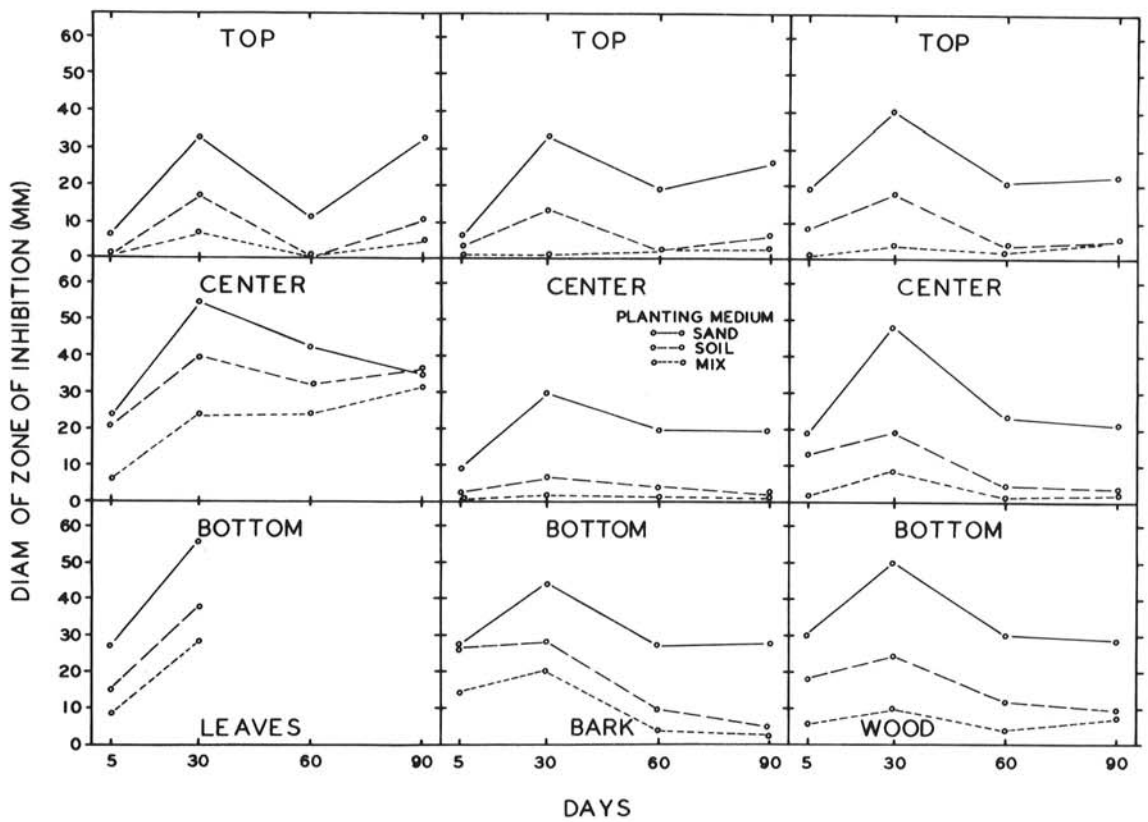

Fig. 1. Residual fungitoxicant present in top (characterized by fully expanded leaves), center, and bottom (50 mm above severed base of stem) leaf, wood, and bark sections of American elm seedlings 5, 30, 60, and 90 days after treatment with benomyl fungicide. Ten-week-old seedlings were transplanted into white silica sand, soil, or a mix of soil 1:peat 2:perlite 2. Benomyl was applied as a drench at the rate of 200 ml of a 1,500-ppm active aq suspension 13 weeks after transplanting. Leaf discs are 13 mm in diam; bark and wood sections are 25 mm long.

TABLE 1. Effect of different planting media components used singly and in combination on the uptake of benomyl by American elm seedlings

Planting medium[a]	Plant ht (cm)	pH	Tissues and portions of plant sampled[b,c]								
			Leaves			Bark			Wood		
			Top	Center	Bottom	Top	Center	Bottom	Top	Center	Bottom
			Diam of zone of inhibition (mm)[f]								
Sand[d]	89	7.7	11 u	44 t	34 tu	23 u	30 u	38 t	24 u	32 u	36 t
Perlite	56	7.5	25 t	42 t	39 t	30 t	36 t	34 t	32 t	36 t	37 t
Peat	40	3.7	0 w	14 x	19 vw	2 xy	5 y	15 v	2 x	3 yz	6 x
Soil[e]	94	6.1	0 w	31 v	21 v	7 vw	14 w	21 uv	7 w	13 w	16 v
Peat 1: perlite 1	85	4.0	1 vw	20 w	13 wx	4 wx	10 wx	18 uv	6 w	8 x	11 w
Soil 1: perlite 2	97	6.4	4 v	36 u	32 u	8 v	22 v	23 u	13 v	21 v	24 u
Soil 1: peat 2	108	4.9	0 w	6 y	9 x	0 xy	0 z	8 w	0 x	0 z	0 y
Soil 1: peat 2: perlite 2	116	5.2	0 w	20 w	14 wx	1 y	7 xy	17 uv	2 x	4 y	8 wx

[a] Benomyl applied once as a drench at the rate of 200 ml of a 1,500 ppm (active ingredient)-aq suspension/container. Plants bioassayed 30 days after treatment using *Ceratocystis ulmi*.

[b] Leaf discs (13 mm diam); bark and wood sections (25 mm long).

[c] Top (characterized by fully expanded terminal leaves), center, and bottom (50 mm above severed base of stem).

[d] White silica, flint shot, grain size 34.

[e] Morley silt loam.

[f] Means followed by different letters in the columns are significantly different at the 1% level according to Duncan's multiple range test.

TABLE 2. Effect of soil sterilization on uptake of benomyl by American elm seedlings.

Planting medium[a]	Tissues and portions of plant sampled[b,c]								
	Leaves			Bark			Wood		
	Top	Center	Bottom	Top	Center	Bottom	Top	Center	Bottom
	Diam of zone of inhibition (mm)[f]								
Sand[d]	25 x	39 x	44 x	21 x	32 x	29 x	24 x	30 x	31 x
Nonsterile soil[e]	5 y	32 y	31 y	13 y	15 z	15 y	11 y	12 y	13 y
Sterile soil[e]	5 y	31 y	33 y	21 x	20 y	22 y	16 y	16 y	17 y

[a] Benomyl applied once as a drench at the rate of 200 ml of a 1,500 ppm (active ingredient)-aq suspension/container. Plants bioassayed 90 days after treatment using *Ceratocystis ulmi*.

[b] Leaf discs (13 mm diam); bark and wood sections (25 mm long).

[c] Top (characterized by fully expanded terminal leaves), center, and bottom (50 mm above severed base of stem).

[d] White silica, flint shot, grain size 34.

[e] Morley silt loam.

[f] Means followed by different letters in the columns are significantly different at the 5% level according to Duncan's multiple range test.

pentachloronitrobenzene by beans greatest from soils with low organic content.

Plant height was affected by the planting medium, but not by the benomyl treatment. The average height of the treated plants was 86 cm, and of untreated plants, 90 cm. The shortest plants were grown in peat and perlite (40 and 56 cm average height, respectively), but those in peat accumulated the least, whereas those in perlite accumulated the most benomyl. These data indicate that the composition of the planting media has a direct effect on benomyl uptake rather than an indirect effect through its influence on plant height growth. However, composition of the planting media may affect other growth characteristics that in turn could influence benomyl uptake.

The pH of the various media was related to the uptake of benomyl. Media pH varied between 3.7 and 7.7. The amount of fungitoxicant in seedlings grown in the four media with the lowest pH values was lower than in those grown in the media with the highest values. Since the media containing peat were also lowest in pH, the influence of pH and increased organic matter on benomyl uptake are not differentiated by the data. Further studies are underway to separate the influence of media pH and organic matter content on benomyl uptake.

Effects of soil sterilization on chemical uptake.—The amount of fungitoxicant was greater in most tissues from plants grown in sterile than in nonsterile soil. Significant differences, however, were found only in bark tissue. Benomyl uptake from sterile soil was significantly less than from sand in all plant tissues (Table 2). There was no evidence from bioassays of controls that fungitoxic products were produced from soil sterilization. Thus, the increased fungitoxicity in tissues from plants in sterile soil may be attributed to increased benomyl uptake.

In addition to the qualitative and quantitative changes in the microbial population, chemical and physical changes may also occur. Thus, sterilization may produce changes in any or all of these soil characteristics resulting in the slight increase in benomyl uptake. Further experimentation is needed to learn more about the influence of soil factors on benomyl uptake and how they may be controlled.

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