Control of Root Pathogens in Peach Decline Sites

Floyd F. Hendrix, Jr., and W. M. Powell

Associate Professors, Department of Plant Pathology and Plant Genetics, University of Georgia, Athens 30601.

Journal Series Paper No. 347, University of Georgia College of Agriculture Experiment Stations, College Station, Athens. Supported by USDA Cooperative Agreement No. 12-14-100-8446(34) and the Georgia Peach Commodity Commission.

The peach tree decline complex has caused extensive loss in Georgia for several years. In 1962, 200,000 trees died. By 1965, an estimated 33% of the trees in the state were dead and an additional 17% diseased (1, 11, 12). Peach tree decline is especially severe when peach trees are grown on land previously planted to peaches. Aboveground symptoms of peach tree decline in Georgia are essentially those caused by any condition that deprives the plant of an adequate root system. One symptom observed on trees in all orchards where the disease was present was a greatly reduced feeder root system associated with *Pythium* spp. and various nematodes (5). Many causes of peach decline have been suggested, including deficiency, excess, imbalance of nutrients, compaction of soil, toxins produced by peach trees and by microorganisms utilizing peach tissue, and several pathogens. Various workers have concluded that nutrient deficiency is not the cause of peach tree decline except in isolated instances (3, 9, 13, 15). Nutrient imbalance may be a complicating factor in some cases, but would affect the first crop of peaches grown on land as well as succeeding crops (13). Compaction of orchard soils is not considered serious (14). Toxins produced by the action of microorganisms invading old peach roots is reported to be a problem only in the absence of adequate nitrogen (2).

Hine (6) attributed poor growth of replanted peach trees to *Pythium ultimum* Trow, *Fusarium*, and *Rhizoctonia*. *Pratylenchus penetrans* populations have been correlated with peach replant problems (10).

Damage to the root system caused by disc cultivation also occurs, since peach root systems are shallow (8). Our objectives were to find means of reducing root damage from these three factors.

Methods and Results.—Methyl bromide (Dowfume MC2) and Telone-propargyl bromide-chloropicrin mixture (Telone-PBC) were applied to an orchard replant site with a high population of both *Pythium* and nematodes in 1965. Methyl bromide was applied at the rate of 454 g/22.5 m^2 and Telone-PBC at 190 1/0.4 ha. Telone-PBC was applied with and without tarps. To reduce the rate of re-infestation, 4.1 kg/0.4 ha of 35% wettable powder of sodium *P*- (dimethylamino) benzenediasulfonate (Dexon) were applied with the fumigant in half of the plots, and incorporated with a rototiller. Each treatment was replicated five times. *Pythium* population was determined using soil dilution technique and modified Kerr's medium, and nematodes were extracted from samples by a centrifugation-sugar flotation technique (4, 7). Fumigants were applied in March 1965. After the exposure period, tarps were removed and soil samples taken periodically. Daily rainfall occurred for 2 weeks after the tarps were removed. All data presented in this paper was subjected to an analysis of variance and Duncan's Multiple Range Test.

The primary species of *Pythium* present were *P. irregulare* Buis. and *P. vexans* DBy. Both methyl bromide and Telone PBC reduced the nematode and Pythium population. In the absence of Dexon, the *Pythium* population increased rapidly, and equaled the check population within 4 weeks. In plots treated with Dexon and a fumigant, the population remained under 10 propagules/g (p/g) for 24 months (Fig. 1). Dexon alone, at this rate, did not reduce the *Pythium* population. We concluded from this test that it was feasible to reduce the population of these microorganisms using fumigants. In some cases, re-infestation by *Pythium* species resulted in higher populations than were originally present.

In September 1965, a mixture of dichloropropanes, dichloropropenes, and associated chlorinated hydrocarbon plus methyl isothiocyanate (Vorlex); methyl bromide, chloropicrin, propargyl bromide (Trizone); and Telone-PBC were each applied to separate 30 m × 36 m plots at the rate of 190 1/0.4 ha, 91 kg/0.4 ha, and 190 1/0.4 ha, respectively. Fumigants were injected at a depth of 20 cm, and the Trizone plots were covered solidly with polyethylene tarps. Dexon was applied to half of each plot at the rate of 4.1 kg/0.4 ha. The Dexon was sprayed on the soil surface and incorporated immediately by discing. Thirty trees were planted in each plot in March 1966. Each treatment was replicated four times.

The principal species of *Pythium* present were *P. vexans* and *P. irregulare*. Seven days after fumigation, *Pythium* had been reduced from about 40 to 7 p/g except in the check plots. After 21 days, the *Pythium* had increased to the initial level where Dexon alone

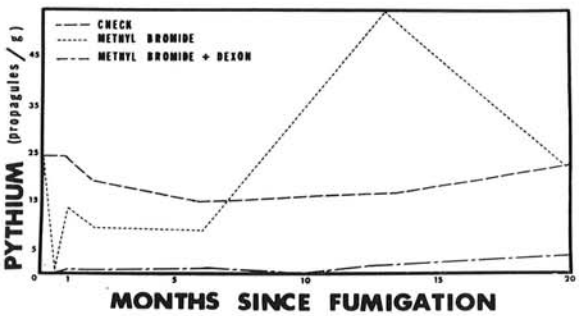

Fig. 1. Influence of Dexon on re-infestation of soil by *Pythium* spp. following fumigation with methyl bromide.

was used. The population had not increased in the other treatments (Table 1). *Pythium* increased to the initial level after 70 days in the Vorlex plots and after 180 days in the Telone-PBC plots. The addition of Dexon retarded this rise, but did not prevent it.

Root knot (*Meloidogyne* spp.), lesion (*Pratylenchus* spp.), stunt (*Tylenchorhynchus* spp.), ring (*Criconemoides* spp.), dagger (*Xiphinema* spp.) and stubby root (*Trichodorus* spp.) nematodes were present in the orchard prior to treatment. Only ring and lesion nematode distribution was consistent enough to allow analysis. After 21 days, nematode assay of fumigated soil revealed 60 ring nematodes/100 g of soil in the check and a reduction to 1-2 in fumigated plots. After 180 days, the population had not increased in the fumigated plots, and was lower in the check plot than in the Dexon plot. Lesion nematodes were reduced to 0-2/100 cc soil by all fumigants (Table 2). All fumigants were effective down to the deepest sampling depth—61 cm. There was no appreciable nematode re-infestation after 30 months.

Tree response was measured in terms of trunk diam. After 2 years, trees in Trizone and Trizone + Dexon plots had an average trunk diam 29% and 31% greater than the checks. There was no significant increase over the check in the remaining plots (Table 3).

A new test was established in November 1966 to determine an effective dosage of Trizone and to measure the effect of discing vs use of herbicides for weed control. Trizone was applied at 91, 77, and 64 kg /0.4 ha, and the 30 m × 96 m plots were fully tarped. In an additional treatment, a 3 m × 96-m strip was treated with 77 kg/0.4 ha. Sinbar (3-tert-butyl-5-chloro-6-methyuracil) was used for weed control in the fumigated plots. Two check plots were included, one being treated with Sinbar and the other disced. Dexon was applied to half of each plot as described previously. Sixty trees were planted in each plot in January 1967. Four replications of each treatment were established.

The *Pythium* population, consisting mostly of *P. vexans* and *P. irregulare,* was approximately 75 p/g in the test site prior to treatment. After 21 days, all rates of Trizone tested reduced the level to less than 8 p/g (Table 4). After 330 days, *Pythium* had increased to the initial level in the 77 kg/0.4 ha strip and 64 kg /0.4 ha broadcast treatments. Dexon added to these treatments prevented the increase. Only plots treated with 91 and 77 kg/0.4 ha, with or without Dexon, and 64 kg/0.4 ha with Dexon had populations lower than the initial population after 760 days.

Root knot, dagger, lesion, ring, stunt, spiral (*Helicotylenchus* spp.), and lance (*Hoplolaimus* spp.) nematodes were present in the plot area prior to treatment.

TABLE 1. Influence of Trizone, Telone PBC, Vorlex, and Dexon on *Pythium* spp. population in a Georgia peach orchard

Treatment	Initial	Days after fumigation			
		7	21 (Propagules/g of soil)	70	180
Check	36_a[a]	$47_{a,1}$[b]	$58_{a,1}$	$65_{a,1}$	$39_{a,2}$
Dexon	37_a	$0_{b,3}$	$37_{a,1}$	$37_{a,1}$	$20_{a,1,2}$
Telone PBC	32_a	1_3	4	5_2	$68_{a,2}$
Telone PBC + Dexon	37_a	$0_{b,3}$	0_b	$7_{b,2}$	$14_{a,b,1,2}$
Trizone	39_a	0_3	0	0_2	1_1
Trizone + Dexon	39_a	0_3	2	0_2	2_1
Vorlex	$41_{a,b}$	$7_{b,2}$	11_b	$45_{a,b,1}$	$58_{a,2}$
Vorlex + Dexon	44_a	$0_{b,3}$	1_b	$28_{a,b,1,2}$	$17_{a,b,1,2}$

[a] Letters used to compare means between times within treatment. Means not followed by a common letter or number significantly different at 0.05 level (DMT).
[b] Numbers used to compare means between treatments within time.

TABLE 2. Influence of Trizone, Telone PBC, Vorlex, and Dexon on lesion nematode population in a peach orchard

Treatment	Initial	Days after fumigation			
		7	21 (Nematodes/100 cc soil)	70	180
Check	$42_{a,1}$[a]	$22_{a,1}$	$55_{a,1}$	$77_{a,1}$	$35_{a,1}$
Dexon	$29_{a,1}$	$25_{a,1}$	$53_{a,1}$	$38_{a,1}$	$20_{a,1}$
Telone PBC	$32_{a,1}$	2	0	0	2
Telone PBC + Dexon	$67_{a,1}$	2	0	1	4
Trizone	$36_{a,1}$	0	0	0	0
Trizone + Dexon	$4_{a,1}$	0	0	0	2
Vorlex	$64_{a,1}$	1	0	0	2
Vorlex + Dexon	$25_{a,1}$	0	0	0	2

[a] Letters used to compare means between times within treatment. Numbers used to compare means between treatments within time. Means not followed by a common letter or number significantly different at 0.05 level (DMT).

TABLE 3. Influence of Trizone, Telone PBC, Vorlex, and Dexon on growth of peach trees as measured by trunk diam 15 cm above the soil line

Treatment	Growth of peach trees, cm		
	1966	1967	1968
Check	1.2	3.0	5.4
Dexon	1.1	2.6	5.7
Telone PBC	1.1	3.0	5.7
Telone PBC + Dexon	1.1	2.6	5.6
Trizone	1.2	3.7_a[a]	6.7_a
Trizone + Dexon	1.3	3.7_a	7.0_a
Vorlex	1.1	2.5	5.4
Vorlex + Dexon	1.2	2.6	5.7

[a] Means followed by same letter within each year not different at 0.05 level.

The total population of these averaged 80-100/100 g of soil in plots where they were present. Ring comprised about half the population in each case. Occurrence of nematodes in the test area was sporadic, negating the analysis of data. However, all rates of Trizone tested appeared to control these genera where they occurred.

Trunk diam of the seedlings averaged 1.0 cm at planting. During the first season, tree growth was greater in Trizone plots than in the checks. Use of an herbicide instead of a disc for weed control resulted in increased growth in nonfumigated plots and use of Trizone and an herbicide in additional growth increase (Table 4). In the second growing season, only trees in plots treated with the two higher rates of Trizone grew more than trees in the check plots. Discing, with or without Dexon, increased tree mortality. Tree loss in fumigated plots was 0.8-2.5%; in nonfumigated herbicide plots it was 4.5-5%; in disced plots with Dexon it was 10%; and 22% in the checks.

DISCUSSION.—Feeder roots are active in water and mineral salt uptake, and are important sites of protein synthesis. Reduction of this portion of the root system seldom results in plant death, but reduces vigor of plants. With perennial plants, such as peach trees, poor root systems increase response to stresses, such as extreme environmental conditions, fruit set, and facultative parasites.

Factors active in the reduction of feeder root systems of peach trees in Georgia include *Pythium* species, nematodes, and cultural practices. From our data, we concluded that although all three are important, the first step in any control program is the reduction of root injury from discing.

Peach trees are shallow-rooted, and the majority of the feeder roots are in the top 20 cm of soil. Discs frequently penetrate 15-20 cm, destroying most of the surface feeder roots. However, even when present in moderate numbers, both *Pythium* spp. and nematodes reduce vigor of peach trees enough to result in greatly increased mortality. While either type of pathogen alone is capable of reducing vigor, they usually operate simultaneously in orchards. If the *Pythium* population is low to moderate, elimination of discing and a reduction of the nematode population will reduce disease severity. *Pythium* populations above 50 p/g may be sufficiently damaging to the roots to cause peach tree decline.

We feel that the role of Dexon in a fumigation program involving methyl bromide-type fumigants is to provide a specific, artificially induced mycostasis preventing re-infestation by pythiaceous fungi until natural

TABLE 4. Influence of Trizone, Dexon and cultural practices on *Pythium* population, tree growth and mortality in a Georgia peach orchard

Treatment	Days after fumigation				Tree growth		Tree mortality
	Initial	21	330	760	1968	1969	
	Pythium propagules/g of soil				*cm*		%
Disced	74_a[a]	$13_{b,2,3}$	25_a	$33_{a,1,2}$	1.5	4.5_2	22.0_1
Disced + Dexon	74_a	$20_{b,2}$	15_b	$34_{a,b,1,2}$	1.6	4.7_2	10.0_1
Herbicide	42_a	$49_{a,1}$	13_b	$19_{a,3}$	2.1_2	5.2_2	5.0
Herbicide + Dexon	42_a	$31_{a,1}$	15_a	$37_{a,1,2}$	2.2_2	5.1_2	4.2
Trizone + Herbicide							
200 lbs/ acre Broadcast	52_a	0_b	8_c	$4_{c,3}$	3.2_1	6.3_1	2.5
200 lbs/acre Broadcast + Dexon	52_a	0_b	19_c	$20_{c,3}$	3.2_1	6.1_1	1.7
170 lbs/acre Broadcast	97_a	0_b	28_c	$13_{b,c,3}$	3.1_1	6.1_1	0.8
170 lbs/acre Broadcast + Dexon	97_a	0_b	9_b	$21_{b,1,2,3}$	3.2_1	6.2_1	1.7
170 lbs/acre—10 ft strip	45_a	0_b	19_a	$29_{a,1,2}$	2.7_1	$5.9_{1,2}$	1.7
170 lbs/acre—10 ft strip + Dexon	45_a	0_b	10_c	$56_{a,1}$	2.8_1	$5.9_{1,2}$	3.3
140 lbs/acre Broadcast	61_a	0_b	16_a	$28_{a,1,2}$	3.1_1	6.2_1	1.7
140 lbs/acre Broadcast + Dexon	61_a	$8_{b,3}$	14_b	$26_{b,1,2,3}$	2.8_1	$5.9_{1,2}$	2.5

[a] Separate analyses were made of the *Pythium* population data, tree growth, and tree mortality data. Letters used to compare means between times within treatments. Numbers used to compare means between treatments within time. Means not followed by a common symbol are significantly different at 0.05 level (DMT).

antagonists colonize the food bases made available by the fumigation. Value of this protection seems to depend upon weather conditions following fumigation. If cool and wet conditions prevail, Dexon is of considerable benefit. The effect of Dexon is reduced, however, when warm, dry weather follows fumigation.

The effect of solid tarping versus strip treatment is well demonstrated. Trees in plots which were solidly tarped after the injection of 77 or 91 kg/0.4 ha lb./acre of Trizone were larger, more vigorous, and more uniform than those growing in plots strip treated with 77 kg of Trizone. *Pythium* populations were effectively reduced in the strip treatment, but increase was more rapid than in plots treated using the broadcast method. This probably accounts for the lack of uniformity in these plots.

LITERATURE CITED

1. CHANDLER, W. A., J. H. OWEN, & R. L. LIVINGSTON. 1962. Sudden decline of peach trees in Georgia. Plant Dis. Rep. 46:831-834.
2. GILMORE, A. E. 1963. Pot experiments related to the peach replant problem. Hilgardia 34:63-78.
3. HARRIS, A. L. 1962. Some effects of old peach soil treatments on young peach trees in the greenhouse. Amer. Soc. Hort. Sci. Proc. 50:203-205.
4. HENDRIX, F. F., JR., & E. G. KUHLMAN. 1965. Factors affecting direct recovery of *Phytophthora cinnamomi* from soil. Phytopathology 55:1183-1187.
5. HENDRIX, F. F., JR., W. M. POWELL, & J. H. OWEN. 1966. Relation of root necrosis caused by *Pythium* species to peach tree decline. Phytopathology 56: 1229-1232.
6. HINE, R. B. 1961. The role of fungi in the peach replant problem. Plant Dis. Rep. 45:462-465.
7. JENKINS, W. R. 1964. A rapid centrifugal-flotation technique for separating nematodes from soil. Plant Dis. Reptr. 48:692.
8. LYONS, C. G., & A. H. KREZDORN. 1962. Distribution of peach roots in Lakeland fine sand and the influence of fertility levels. Fla. State Hort. Soc. Proc. 75: 371-377.
9. MARTIN, J. P., & W. W. JONES. 1954. Greenhouse response to vinyl acetate-maleic copolymer in natural soils and in prepared soils containing high percentages of sodium or potassium. Soil Sci. 78:317-324.
10. MOUNTAIN, W. B., & H. R. BOYCE. 1958. The peach replant problem in Ontario. VI. The relation of *Pratylenchus penetrans* to the growth of young peach trees. Can. J. Bot. 36:135-151.
11. OWEN, J. H., W. M. POWELL, & F. F. HENDRIX, JR. 1965. Occurrence of peach tree decline in Georgia in 1965. Plant Dis. Rep. 49:859-860.
12. POWELL, W. M., J. H. OWEN, & W. A. CAMPBELL. 1965. Association of Phycomycetous fungi with peach tree decline in Georgia. Plant Dis. Rep. 49:279.
13. PROELISTING, E. L., & A. E. GILMORE. 1941. The relation of peach root toxicity to the re-establishing of peach orchards. Amer. Soc. Hort. Sci. Proc. 38: 21-26.
14. SAVORY, B. M. 1966. Specific replant diseases. Commonwealth Bur. Hort. Plantation Crops Res. Rev. No. 1. 64 p.
15. SHANNON, C. M., & E. G. CHRIST. 1954. Replanting peaches. Amer. Fruit Gr. 74:5, 14-15.