provided control the following spring. These results are similar to those of Langemeier and Witt (1986), who found one application of haloxyfop provided better control of johnsongrass than sethoxydim or fluazifop. Defelice et al. (1987) found that two applications of fluazifop and sethoxydim were required to control johnsongrass in no-till soybeans.

In 1986, excellent control of johnsongrass by all treatments was apparent at the 10 June rating (Table 4). Some regrowth had occurred by 15 July, but, by 31 July, all herbicide treatments provided >85% control. Two years of applications of all herbicide treatments, except sethoxydim (0.4 kg·ha^{-1}) and haloxyfop (0.14 kg·ha^{-1}), provided at least 80% control of johnsongrass spring regrowth.

The grass herbicides fluazifop, sethoxydim, haloxyfop, and quizalofop show promise for control of the bermudagrass and johnsongrass in grapes. Unlike the standard treatment with gylphosate, they are active only on grass species, with no risk of grapevine injury. Removal of low-hanging grape foliage is not necessary. As bermudagrass and johnsongrass are very competitive and persistent, it appears that a program of at least 2 years of herbicide applications is required for control. After that, spot spraying would probably be necessary to prevent reinfestation.

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Fresh Conifer Bark Reduces Root-knot Nematode Galling of Greenhouse Tomatoes

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Additional index words. growth media, pH, *Lycopersicon esculentum, Meloidogyne incognita*

Abstract. **Experiments were conducted to evaluate the effect of fresh and aged conifer barks on galling by the root-knot nematode [*Meloidogyne incognita* (Kofoid and White) (Chitwood)] on tomato (*Lycopersicon esculentum* Mill.) roots. Fresh bark (stored at sawmill) exhibited significant nematicidal activity (reduced galling) when used as a medium component [50% or 75% with sand (v/v)]. Galling on tomatoes grown in aged bark (used as a culturing medium for tomatoes for 5 years) was extensive. When 10% or 20% fresh conifer bark was mixed into beds, galling was less extensive on tomato roots than on roots from tomatoes grown in an unamended medium. The nematicidal property of conifer bark diminished during long-term use. Increases in medium pH, which occurred during continuous cropping, could have contributed to the reduced nematicidal activity with time.**

The root-knot nematode infects more than 2000 species of plants around the world (Sasser, 1977). The pervasiveness of this nematode and the increasing costs of chemical control have focused attention on alternative means of reducing its population. Reduction of nematode-induced root galling by the addition of organic amendments to soil is well-documented. Many crop residues (Johnson, 1959, 1962; Linford et al., 1938), various oil cakes (Goswami, 1971; Singh et al., 1980), sewage sludge (Habicht, 1975), and hardwood (Malek and Gartner, 1975) and conifer barks (Cotter and Corgan, 1974) exhibit nematicidal activity. However, in the New Mexico State Univ. horticulture greenhouse, tomato roots growing in local conifer bark that had been cropped continuously for 3 years exhibited galls (unpublished data); by the 5th year, galling was extensive on all susceptible cultivars. The purpose of the experiments reported here was to evaluate the short- and long-term nematicidal activity of conifer bark.

Bark from a mix of several conifer species stored in an undisturbed pile for up to 3 years in an arid climate was designated as fresh bark (Cotter and Corgan, 1974). Aged bark was similar material that had been used as a growth medium for 5 years (10 successive greenhouse tomato crops) before testing.

In the initial experiment, four media were prepared using 75% peat, fresh bark, sterilized aged bark, or perlite mixed with 25% sterilized sand (v/v). The aged bark and sand were autoclaved separately at 117C and 103 kPa for 1 hr. Nematode eggs and larvae were extracted from freshly collected, heavily infested tomato roots by the NaOCl-sieve method (Hussey and Barker, 1973). The gelatinous matrices of egg masses were dissolved with a 0.5% NaOCl (Clorox) solution, and eggs and larvae collected on a 400-mesh sieve. Four inoculum densities (0, 1000, 5000, and 20,000 eggs and larvae per 50 ml of water) were prepared. The factorially combined media–nematode treatments were replicated four times and arranged with one pot per treatment in a randomized complete-block design on a greenhouse bench. A 50-ml aliquot of the appropriate inoculum was carefully mixed with 1 liter of medium in each 1.2-liter pot. One 5-week-old 'Vendor' tomato plant was transplanted into each pot on 5 Feb. and fertilized with 4.6 g Osmocote (18N–2.6P–9.9K). Medium pH was determined for each treatment 2 weeks after the experiment began. After 6 weeks, plant height was measured and the tops severed, dried to constant weight at 65C and weighed. The roots were washed free of medium and nematode infections were determined using a

Received for publication 1 Aug. 1988. Arizona Agr. Expt. Sta. Journal Series no. 7011. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

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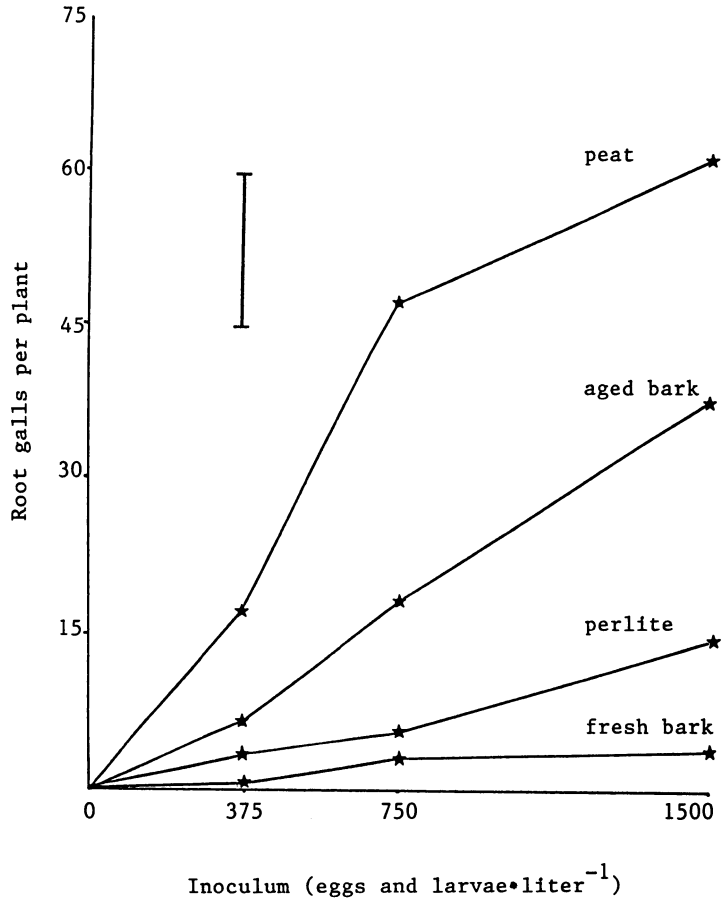

Fig. 1. Effect of medium [50% components as shown, 50% sand (v/v)] and inoculum density on the mean number of nematode galls on roots of tomato transplants cultured for 8 weeks (Expt. 2). Bar denotes LSD 5%. Interaction significant at $P < 0.01$; LSD 0.05 = 12.3, 0.01 = 16.5.

Table 1. Effect of media components [75% + 25% sand (v/v)] and root-knot nematode (*M. incognita*) inoculation on tomato top growth and root galling index (Expt. 1).

Growing medium	Top		Galling index (1–10)
	Dry wt (g)	Height (cm)	
Peat	14.7	64.3	3.6
Fresh bark	12.2	69.5	1.1
Aged bark	15.2	67.8	1.6
Perlite	11.8	62.3	1.0
Significance[z]	**	**	**
LSD 0.05	1.8	5.2	0.5
0.01	2.4	6.9	0.6
Nematode concn (eggs + larva)			
0	14.1	66.0	0.0
1,000	13.4	65.7	0.9
5,000	13.0	65.9	1.8
20,000	13.3	66.3	2.8
Significance	NS	NS	L**
Medium × nematode	NS	NS	**

NS,*,**Nonsignificant or significant at $P < 0.05$ or 0.01, respectively; Linear (L).

standard root-knot galling index of 0–10 (DiSanzo et al., 1978). Roots then were dried and weighed.

In Expt. 2, four media were tested that consisted of 50% peat, fresh bark, sterilized aged bark, or perlite mixed with 50% sterilized sand (v/v). Nematode eggs and larvae were extracted (Hussey and Barker, 1973) from carrot (*Daucus carota* L.) roots and added at the rate of 0, 375, 750, or 1500 nematode eggs and larvae per liter of medium. Three-week-old 'Vendor' tomato seedlings were transplanted into each pot on 28 Mar., as in Expt. 1. Treatments were arranged in a randomized complete-block design with four replications. After 8 weeks of growth, plant data were obtained as in Expt. 1. Nematode effects were assessed by counting galls on each root system.

Experiment 3 was conducted in a greenhouse in 12 1 × 4.5-m raised (40 cm deep) beds containing aged conifer bark that had been continuously cropped with tomatoes for 5 years. The initial mean nematode population of the aged conifer bark in the beds was 24 eggs and larvae per 500 cm^3 medium as determined by Baermann funnel extraction (Southey, 1970). Ten percent or 20% of the bed volume was removed from a randomly determined one-half of each bed and the respective volume replaced with fresh conifer bark; these were the amended plots. Unamended controls consisted of the other half of each raised bed. Amended and unamended areas each were thoroughly mixed. Treatments were arranged in a randomized complete-block design with six replications. Twenty 4-week-old tomato transplants were planted in two rows in each bed on 15 Jan. and cultured according to normal commercial greenhouse procedure. After 4 months, 410-ml cylindrical core samples were taken from the middle of each plot to a depth of 20 cm between two interior plants. Galls were counted on root fragments and root dry weight (including galls) was determined.

In the first two experiments, the results were similar; galls developed early in the tests and were relatively large at evaluation. More extensive galling at lower inoculum levels in Expt. 2 may be attributed to the use of younger transplants. There were significant media × nematode concentration interactions (Tables 1 and 2); galling increased linearly in response to increasing inoculum levels, but the slope of the line (Fig. 1) was affected by the media components. At 375 nematodes/liter, only fresh bark was significantly lower than peat in galls/plant, and this difference increased as nematode concentration increased. Galling in a standard peat–sand mixture was extensive and in approximate proportion to inoculum concentration (Tables 1 and 2, Fig. 1). Galling was almost completely controlled by fresh bark, even at the high inoculum levels. Aged bark exerted intermediate activity, but galling response was similar to peat. Roots on plants cultured in the inorganic perlite–sand medium contained few galls.

The low number of galls noted on plants in the sand–perlite medium and the lower plant top weights may be explained by the rapid drying of this very porous medium in relation to the other media. This drying would enhance the chance of larval desiccation before infection and reduce plant root growth and, thus, availability of roots for larval penetration.

Top dry weights of plants grown in fresh bark were also lower than those of plants grown in aged bark or peat (Tables 1 and 2). Here, pH (5.9) was not inhibitory to plant growth and the medium remained moist. However, in addition to the nematicidal effect, there may have been an allelopathic effect of fresh bark leachates on tomato plants. Short-term infection periods were apparently insufficient to limit plant growth in peat or aged bark. Root dry weight increased at in-

Table 2. Effect of media components [50% + 50% sand (v/v)] and root-knot nematode (*M. incognita*) inoculation on tomato root and top growth and root galling (Expt. 2).

Growing medium	Dry wt (g/plant)		Galling	
	Top	Root	No./plant	No./g root dry wt
Peat	17.2	3.5	31.4	9.4
Fresh bark	13.4	2.2	1.8	1.2
Aged bark	16.5	3.1	15.7	5.1
Perlite	12.7	2.8	5.9	2.4
Significance	**	*	**	**
LSD 0.05	2.8	0.8	6.2	2.0
0.01	3.7	---	8.2	2.6
Nematode concn (eggs + larva)				
0	15.0	2.2	0	0
375	15.3	3.1	6.9	2.6
750	15.2	3.7	18.6	5.1
1500	14.3	2.7	29.5	10.5
Significance	NS	Q**	L**	L**
Medium × nematode	NS	NS	**	**

NS,*,**Nonsignificant or significant at $P < 0.05$ or 0.01, respectively; Linear (L), Quadratic (Q).

Table 3. Effect of an aged conifer bark growing medium amended with fresh bark on spring-grown greenhouse tomato root weight and nematode galling in a 410-ml medium core.

Growing medium	Root wt		No. galls	
	Fresh (g/core)	Dry (mg/core)	Sample total	Thousands/g dry wt
		10% Fresh bark (v/v)		
Fresh bark amended	1.30	130	141	1.0
Aged bark control	1.63	165	234	1.2
Significance	**	***	***	NS
		20% Fresh bark (v/v)		
Fresh bark amended	0.87	76	40	0.6
Aged bark control	1.04	93	96	1.2
Significance	*	**	***	**

NS,*,**,***Nonsignificant or significant at $P < 0.10$, 0.05, or 0.01, respectively.

termediate inoculum levels (Table 2). This increase was most probably due to greater biomass resulting from the galls.

In Expt. 3, the total number of root galls in the core sample in aged bark was substantially greater in unamended plots than in those amended with 10% or 20% fresh bark (Table 3). When the number of galls were expressed on a root dry-weight basis, galling was significantly reduced when the medium was amended with 20% fresh bark treatment. After final harvest (6 months), the galling index was high and not significantly different on plants in the amended fresh bark and unamended media (data not shown). The lack of prolonged suppression was probably due to insufficient quantities of fresh bark to effect adequate, long-term control.

The results of the three experiments show that fresh bark possesses high nematicidal activity, but that its activity diminishes over time. Such a condition could be analogous to the report that spent mushroom compost provided little nematode protection (Verma, 1986). Intermediate gall reductions with aged bark treatments in Expts. 1 and 2 could have resulted from added decomposition caused by mixing or from formation of decomposable products during sterilization. In addition, various chemicals, including limonoids (Verma, 1986), phenols (Devakumar et al., 1985; Singh et al., 1980), and aromatic acids (Sayre et al., 1965; Sitaramaiah and Sing, 1978), have been suggested as being responsible for the nematicidal activity from organic matter of various origins. Sayre et al. (1965) have shown that *N*-butyric acid is an active nematicidal component of decomposing timothy (*Phleum pratense* L.). The nematicidal activity of *N*-butyric acid is fully effective at pH 4, intermediate at pH 5.3, and relatively low at pH 7.0. In Expt. 2, the initial pH of the bark medium was 5.0 and 6.2 for fresh and aged bark, respectively. If *N*-butyric acid is the active nematicidal product involved, differences in pH of bark media would be sufficient to explain the differences noted. However, other products that inhibit nematode infection also may have been present.

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