Management Options for Control of a Stunt and Needle Nematode in Southern Forest Nurseries

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Abstract: Crop rotation and fallow are management options that can be used to control plant parasitic nematodes in forest tree nurseries. Before these options can be put into practice, it is important to determine the host range and survivability under fallow of the parasitic nematode to be controlled. The results of host range tests on a needle nematode (*Longidorus* spp.) and a stunt nematode (*Tylenchorhynchus ewingi*) indicate that crop rotation practices were a factor leading up to the development of damage by these nematodes at 2 Southern nurseries. The needle nematode became a problem in a field following crop rotations of loblolly pine with white oak. The host range of the needle nematode was found to include white (*Quercus alba*), live (*Quercus virginiana*), water (*Q. nigra*), southern red (*Q. falcata*), and northern red (*Q. rubra*) oaks. Results of a fallow study with the needle nematode indicate that control may be achieved with 1 year of fallow or crop rotations with a nonhost.

The host range test of the stunt nematode found that loblolly pine, several legumes, rye, and several sorghum varieties were good hosts for the nematode. Poor hosts of the stunt nematode included wheat, ryegrass, and oats. Pearl and brown top millet were found to be nonhosts of the stunt nematode. Additional research is needed to identify other hosts and nonhosts of the stunt and other nematodes, and the ability of nematodes to survive in the absence of a host.

Keywords: nematode, cover crops, host range, fallow, fumigation, *Tylenchorhynchus ewingi*, *Longidorus*, *Pinus taeda*, pine, *Quercus*, oak, sorghum, rye, wheat, legumes, cowpeas, vetch, alfalfa

Introduction

Plant-parasitic nematodes are common in forest tree nurseries, and some can become agents of damage when populations get above economic threshold levels. A survey of plant-parasitic nematodes in Southern forest nurseries by Hopper (1958) found that the majority of these nematodes occurred at low levels. Severe damage to pine seedlings was observed in only 3 nurseries where populations of stunt nematodes (*Tylenchorhynchus claytoni* or *T. ewingi*) or the pine cystoid nematode (*Meloidodera floridensis*) were high (Hopper 1958, 1959).

Presently, the potential threat of plant-parasitic nematodes to production in forest tree nurseries is difficult to assess. There has not been a survey of Southern nurseries for nematodes since 1958, and there is no mechanism or incentive for managers to report nematode damage. Recent fumigation studies in forest tree nurseries have found that nematode populations in control treatments were low and rarely differed from fumigated plots (Fraedrich and Dwinell 2003a,b; Kannwischwer-Mitchell and others 2003). In the past 6 years, only a handful of Southern nurseries had nematode related damage. Three nurseries were reported to have seedling damage from stunt nematodes (Carey 1999), and 1 nursery had seedlings damaged by a needle nematode (Fraedrich and Cram 2002).

Management options to control nematodes in forest tree nurseries primarily include sanitation, fumigation, crop rotation, and fallow. Nematicides, other than broad-spectrum fumigants, are not currently labeled for use in forest nurseries. Other cultural and biological control practices will not be discussed in this paper because they are mostly unproven and/or not applicable to forest tree nurseries.

Sanitation within a nursery typically means controlling soil and water movement from contaminated to uncontaminated areas. Equipment, irrigation, transplants, and even animals can move soil. In theory, a spreading weed host could also facilitate the movement of a plant-parasitic nematode. Sanitation can reduce the spread of a nematode, and combined with other management options, can help to control damage in a nursery.

Soil fumigation is one management option to depress nematode populations (Dropkin 1989); however, nematode population will often rebound (McKenry and Thomason 1976; Cram and others 2003; Fraedrich and Dwinell 2003c). Crop rotations of nonhosts or the use of fallow are other options to depress nematode populations (Dropkin 1989). Southern forest nurseries often use a combination of these options for control of nematodes and other soilborne pests.

Information on the species of nematodes that cause damage in forest tree nurseries is far from complete, and host range information on individual nematode species is often lacking. Recently, 2 species of nematodes have been discovered to attack loblolly pine (*Pinus taeda*). One nematode is a new species of needle nematode, *Longidorus* spp., which is parasitic on loblolly as well as slash (*P. elliottii*) and longleaf (*P. palustris*) pines (Fraedrich and others 2003). Some work has been done on the host range by Fraedrich and others (2003); however, more information is needed on hosts such as white oak, which was grown in the field where this needle nematode was found (Cram and others 2003). The other nematode is a stunt nematode, *Tylenchorhynchus ewingi*, known to be pathogenic on slash pine (Hopper 1959). Information on the host range of this nematode is almost nonexistent. We have conducted a series of studies in recent years on these 2 nematodes species and potential control practices. This paper provides a summary of some of those studies and a discussion of the management implications for control of nematodes in forest tree nurseries.

Materials and Methods

Needle Nematode Studies

Fallow Study—The population density of the needle nematode was assessed in a fallow field at the Flint River Nursery, Montezuma, GA, from April 2002 until May 2003. The soil samples (6 to 10 cores) were taken in the top 15 cm (6 in) of soil from 10 *Longidorus*-infested plots located in 4 blocks of an infested field (Cram and others 2003). The *Longidorus* spp. were extracted from the 100 cc (6 in^3) of mixed soil by using the procedure outlined by Flegg (1967) and modified by Fraedrich and Cram (2002). This was our standard procedure for assessing population densities of the *Longidorus* spp. in soil. When the needle nematode was no longer detected in the plots, soil samples were then collected from the upper 30 cm (12 in) of soil in each plot and placed into 3 containers (1,600 cc/container [98 in^3/container]) per plot (30 containers total). Another 3 containers per plot (3 plots) were filled with soil from adjacent field areas with pine production and known to be infested with the needle nematode. All containers were planted with 5 loblolly pine seedlings. Containers were placed in growth chambers at 24 °C (75 °F) with 14-hr photoperiod. After 142 days, the *Longidorus* population densities were assessed using the standard procedure.

Oak Host Range—Six species of oak were tested for host suitability to the needle nematode. The oak species were live (*Quercus virginiana*), sawtooth (*Q. acutissima*), white (*Q. alba*), water (*Q. nigra*), southern red (*Q. falcata*), and northern red (*Q. rubra*). Loblolly pine and fallow treatments were also included. A soil of loamy sand was microwaved for 8 minutes in 2,000 g (70.5 oz) batches, and containers were filled with 1,600 cc (98 in^3) of soil. There were 4 replications (containers) of each species, and germinated oak and loblolly pine seeds were established in their respective containers (except the fallow containers). The containers were infested with 100 *Longidorus* spp. nematodes when the oaks were 15 weeks old and the pines were 7 weeks old. Containers were placed in growth chambers at 25 °C (77 °F) with a 14 hr photoperiod. After 13 weeks, the *Longidorus* population densities were assessed using the standard procedure.

Stunt Nematode Host Range

The host range of the stunt nematode, *Tylenchorhynchus ewingi*, was evaluated on loblolly pine and on 13 cover crops that were either used in the past or are used currently in Southern forest tree nurseries. The cover crops tested included forage sorghum (*Sorghum bicolor* 'ET-602' and 'Red Top Cane'), sorghum-sudan (*S. bicolor* 'SG Ultra' and 'Green Graze BMR'), wheat (*Triticum aesivum* 'VNS'), rye (*Secale cerale* 'Elbon'), ryegrass (*Lolium multiflorum* 'TAM 90'), oats (*Avena sativa* 'Mora'), pearl millet (*Pennisetum americanum* 'ET-300'), brown top millet (*Panicum ramosum* 'DW-01'), cowpea (*Vigna unguiculata* 'Pink Eye Purple Hull BVR'), vetch (*Vicia villosa* 'AU Early Cover'), and alfalfa (*Medicago sativa* 'Alfagraze'). A bare fallow treatment was also inoculated with the stunt nematode.

A loamy sand soil was microwaved for 8 minutes in 2,000 g (70.5 oz) batches, and containers were filled with 1,600 cc (98 in^3) of soil. There were 4 replications (containers) of each species, and 5 plants were established in each container (except the fallow containers). *Tylenchorhynchus ewingi* was extracted from stock cultures using a Baermann funnel method (Shurtleff and Averre 2000), and each treatment container was infested with 500 nematodes. Containers were placed in a growth chamber at 25 °C (77 °F) with a 15 hour photoperiod. Population densities of *T. ewingi* after 14 weeks were determined using the centrifugal flotation method (Shurtleff and Averre 2000). The numbers of nematodes from around the roots were also determined on a dry weight basis by soaking roots in approximately 1 L (0.25 gal) of water for 15 minutes, and then using the Baermann funnel method to extract the nematodes. Roots were dried for 48 hr at 80 °C (176 °F) and dry weights subsequently determined.

Results

Needle Nematode Studies

Fallow Study—The population density of the needle nematode decreased steadily during the first 101 days in the fallow field, and only a few nematodes were detected between 128 to 220 days (Figure 1). The nematode was not detected in soil samples from any plot on days 263 (January), 325 (March), or 365 (May). Soil that was collected on day 263 in the fallow fields and planted with loblolly pine did not have needle nematodes after 142 days in the growth chamber. The nematode was present in soil collected from an adjacent study area known to be infested with the nematode and grown with pine for 142 days (range: 9 to 38 nematodes/100 cc [6 in^3]).

Oak Host Range—Water, live, white, southern red, and northern red oaks were found to be hosts of the needle nematode, *Longidorus* spp. (Table 1). Sawtooth oak was the only species that had significantly less nematodes than loblolly pine, and the population density did not differ significantly from the fallow treatment. The final estimated population of the needle nematode per container of sawtooth fell below the initial inoculum level.

Stunt Host Range

Loblolly pine is a host of the stunt nematode, *T. ewingi*, and produced the most nematodes per gram of root on average (Table 2). Rye, the legumes, and the sorghum varieties were hosts for this stunt nematode. Wheat, ryegrass, and oats were poor hosts for the nematode based on the soil population density and total estimated populations. The final estimated population of stunt nematodes for containers with pearl millet and brown top millet fell below the initial inoculum level. Pearl millet was the only crop that had nematode population densities similar to the fallow treatment.

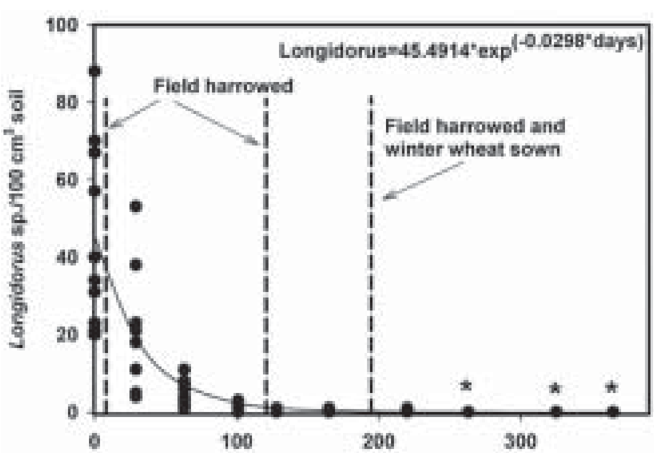

Figure 1—Relationship between the needle nematode (*Longidorus* spp.) population densities and days of fallow in field plots after April 11, 2002. Asterisks (*) at sample days indicate that the needle nematode was not detected in any field plot.

Table 1—Mean number of needle nematodes (*Longidorus* spp.) obtained from soil and roots of plant species 13 weeks after infestation with 100 nematodes/container.

Plant species	*Longidorus* spp./ 400 cc (24 in^3) soil[a]	Total estimated *Longidorus* spp. container
Loblolly pine	74 a	295
Water oak[b]	94 a	377
Northern red oak	56 ab	223
White oak[b]	42 ab	168
Southern red oak	33 ab	131
Live Oak	32 ab	129
Sawtooth oak	17 bc	69
Fallow	1 c	5

[a] Means followed by the same letter do not differ significantly (± = 0.05) according to Tukey's HSD test. Square root transformation of nematode counts was performed before analysis. Data were analyzed as a randomized complete block design.
[b] Means based on 3 replications.

Discussion

Nematode damage tends to surface in fields where nursery managers unintentionally provide an alternate host during crop rotations, or grow the same host continuously. A nematode population will build rapidly under conditions of continuously cropping of hosts (Dropkin 1989; Cram and others 2003). The new needle nematode species (*Longidorus* spp.), discovered in an experimental field at Flint River Nursery (Fraedrich and Cram 2002), originated in a block where loblolly pine production was alternated with white oak (Cram and others 2003). The discovery that white oak is a host of the needle nematode helps to confirm the suspicion that continuous cropping of host species led to the stunting of pine observed in this field. Unintentional use of alternate host crops also appears to have been a factor at another nursery where pine damage was caused by the stunt nematode, *T. ewingi*. The nursery personnel where the stunt nematode was found indicated that cowpeas were grown in the nursery prior to the first pine crop. They also reported using several sorghum varieties and rye as cover crops, all of which are now known to be hosts of this stunt nematode.

Fumigation has been found to depress high nematode populations (Dropkin 1989). Unfortunately, nematode populations can rebound quickly following fumigation and significantly impact subsequent seedling crops (McKenry and Thomason 1976; Cram and others 2003). The rebound of nematode populations after fumigation was demonstrated by Fraedrich and Dwinell (2003c) in a field infested with a *Longidorus* spp. Dazomet and metam sodium eliminated the needle nematode from the upper 15 cm (6 in) of soil, but populations subsequently increased during loblolly pine production to levels comparable to those in control plots by the end of the growing season (Fraedrich and Dwinell 2003c).

Nematodes are able to survive fumigation in a number of ways (McKenry and Thomason 1976) including: (1) a tolerant life stage (for example, cysts, cryptobiotic); (2) protected by plant tissue (endoparasitic); (3) present in soil below the toxic concentration of the fumigant; and (4) escapes fumigation due to restrictive soil layer or high soil moisture. If a

Table 2—Mean number of stunt nematodes (*Tylenchorhynchus ewingi*) obtained from roots and soil of plant species 14 weeks after infestation with 500 stunt nematodes/container.

Plant species	*T. ewingil* g root dry wt[a]	*T. ewingil* 100 cc (6 in^3) soil[a]	Total estimated *T. ewingil* container[a]
Cowpeas	5,230 ab	3,845 a	70,168 a
Alfalfa	252 cde	1,339 ab	23,056 a
Vetch (‘AU’)	4,502 a	1,209 ab	21,630 a
Sorghum sudan (‘BMR’)	293 bcd	834 ab	15,736 a
Loblolly pine	6,635 a	804 b	17,829 ab
Rye grain (‘Elbon’)	497 abc	790 ab	14,370 ab
Sorghum (‘Cane Sumac’)	1,338 abc	743 ab	16,626 a
Sorghum (‘ET-602’)	169 cde	669 ab	12,038 ab
Sorghum sudan (‘Ultra’)	178 cdef	309 bc	5,548 abc
Wheat (‘VNS’)	38 def	65 cd	1,146 bcd
Oats (‘Mora’)	31 def	49 d	830 cd
Rye (‘TAM-90’)	30 ef	45 d	949 cd
Brown top millet (‘DW01’)	29 fg	16 d	303 d
Pearl millet (‘ET-300’)	0 g	3 e	44 e
Fallow	—	3 e	40 e

[a] Means followed by the same letter do not differ significantly (± = 0.05) according to Tukey’s HSD test. Logarithmic transformation of nematode counts was performed before analysis. Data were analyzed as a randomized complete block design.

manager must use a field that is infested with a damaging plant-parasitic nematode and does not have time to fallow or grow a non-host in the field, then fumigation prior to sowing is the only management option. Fumigants that depress nematode populations include methyl bromide, chloropicrin, metam-sodium, 1,3-dichloropropene (Johnson and others 1979; Csinos and others 2000), and dazomet (Harris 1991; Fraedrich and Dwinell 2003c).

The fallow study with the needle nematode demonstrates that this nematode does not survive in soil for extended periods without a suitable host. Fortunately, the small grain cover crops normally used at the Flint River Nursery are not hosts for the needle nematode (Fraedrich and others 2003). The limited host range and inability of the nematode to survive for extended periods without a host helps to explain why this needle nematode has not been a problem at the nursery under their normal production schedule of 2 years of pine production followed by 2 years of cover crops or fallow. The new species of needle nematode has been found outside the nursery on water oak (Fraedrich, unpublished data) and in an adjacent pine seed orchard (Cram and others 2003), which could provide a source for reintroduction in nursery fields through soil and water movement (floods, equipment, wind, and animals). However, the nursery should not have a serious problem with this nematode in the future, based on the host range and survivability of the needle nematode in fallow soils.

The results of the host range test on the stunt nematode, *T. ewingi*, indicate that legumes can be excellent hosts for these nematodes. At one time, legumes were preferred as a cover crop in Southern nurseries because they provided nitrogen to the soil (Wakeley 1954). More recently, nursery managers have favored small grains such as sorghum, rye, and brown top millet as cover crops. Unfortunately, the results of our study suggest that various sorghum varieties and grain rye may be good hosts for this stunt nematode. Managers may wish to favor grains such as pearl or brown top millet in place of sorghum, sorghum-sudan, or rye (grain) in fields where this nematode has been a problem.

The use of fallow or alternating hosts with non-hosts to control parasitic nematodes can be highly effective. Knowledge of the host range and survivability in the absence of a host are essential to effectively applying these cultural control methods. More work is needed to evaluate the suitability of various cultivars of potential cover crops for the stunt nematode (*T. ewingi*) and other nematodes commonly found in forest tree nurseries. Information on the survivability of this and other nematodes in the absence of a host would help establish the length of time a field would need to be in nonhost cover crops or fallow to control individual species of nematodes.

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