CHAPTER TWENTY-SIX

Nematodes

Pratylenchus penetrans; Xiphinema bakeri

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There are two nematodes of concern in forest nurseries, the root-lesion nematode, *Pratylenchus penetrans,* and the Baker dagger nematode, *Xiphinema bakeri.* While these nematodes produce similar above-ground symptoms, each has a unique biology and feeding habit and causes unique symptoms below the ground.

Distribution and hosts

Both nematode species are indigenous to the Pacific Northwest. *Pratylenchus* is more widely distributed and has a broader host range. It attacks all species of conifers, but appears to be most damaging to Douglas-fir and true firs in the Pacific Northwest. *Xiphinema* has been observed to damage spruce (Sitka, white, and Engelmann), western hemlock, Douglas-fir, and noble fir. The greatest damage occurs on Douglas-fir.

Nematode damage may be confused with:
Charcoal root disease
Fusarium hypocotyl rot
Fusarium root rot
June beetle larvae damage
Mineral nutrient deficiency
Phytophthora root rot

Pratylenchus penetrans has an extremely wide host range that includes many weed species. Nematode densities can be quite high on certain weed species, notably grasses, without a significant effect on the plant. On susceptible crops such as conifers, damage can be greater when weeds are present because nematode densities may be high under the weeds and because weed competition further weakens the conifers. The host range of X *bakeri* is more limited. This species does not interact with weeds as *P. penetrans* does.

Figure 26-1. Field symptoms of *Pratylenchus* damage on Douglas-fir. Note chlorosis and differing degrees of stunting shown by the seedlings in the two beds.

Symptoms

The above-ground symptoms of damage from both *Pratylenchus* and *Xiphinema* resemble those caused by any root-destroying organism. Infected seedlings may be stunted, chlorotic, or unthrifty; or in severe cases may even die. Symptoms may be confused with those of mineral deficiency, since root damage by these nematodes may reduce mineral uptake even when soil fertility is adequate. Infected plants are more susceptible to drought stress during periods of low soil moisture than are uninfected plants.

The distribution pattern of nematode damage in the nursery is characterized by circular or irregular patches of stunted seedlings. These patches cut across rows and beds. Stunting is observed in a gradual progression from noninfested areas to infested areas (Figure 26-1). In contrast, other types of soilborne problems are frequently characterized by a marked difference in size between contiguous healthy and affected seedlings.

Each nematode species causes unique damage below the ground. *Pratylenchus* causes necrosis of the cortex, resulting in general decay of the feeder roots (Figure 26-2). During the early stages of infestation the feeder root terminal is destroyed, stimulating proliferation of lateral roots above that point. This process is repeated many times on the newly developing roots, resulting in a proliferation of the root system known as witches' brooming. This type of root damage is a good early clue to severe infestations of *Pratylenchus.*

Damage from *P. penetrans* differs from that caused by *Phytophthora,* which exhibits a similar symptom, in that the necrosis is not as obvious and there is no sharp line between living and dead tissue. However, with increased destruction by the nematode, all feeder roots are killed and the seedling eventually dies from an inability to take up nutrients and moisture. Frequently fungi enter the stressed tissue and hasten mortality.

Roots of seedlings attacked by *Xiphinema* are dark, swollen, and often club-tipped, and have few if any laterals. A condition known as corky root disease frequently develops as the result of infection by the fungus *Cylindrocarpon destructans* following feeding by the nematode. This corky, swollen, and deformed root tip can often be used to diagnose *Xiphinema* in the field. However, other conditions can cause a similar appearance. A nematode assay of the soil should be made for confirmation.

Nematode biology

Both *Pratylenchus* and *Xiphinema* are microscopic, thin, colorless roundworms. They have a hypodermic-needle-like feeding structure called a stylet, which is used to puncture plant cells and deliver digestive gland fluid into them (Figure 26-3). This fluid predigests

Figure 26-2. A healthy Douglas-fir seedling and two damaged by *Pratylenchus.* **Note the stunting and ack of root development on the two lamaged seedlings.**

the contents of the cell, which are then drawn into the nematode through the stylet by a muscular pumping bulb.

Pratylenchus is much smaller (0.5 mm) than *Xiphinema* (2 mm), and has a shorter stylet. After feeding on a cell for a period of time, *Pratylenchus* cuts a hole in the cell wall and enters the cell. As it repeats this procedure, cell after cell, the nematode penetrates deep into the cortex of the root. Intensive feeding in a limited area of the root frequently causes a lesion, from which the nematode derives its common name.

By contrast, *Xiphinema* possesses a very long stylet, which is the only part of the nematode that penetrates the root tissue. Feeding activity causes the tissues to swell and prevents the formation of lateral feeder roots, but roots do not rot.

As the *Pratylenchus* female moves through the soil and roots, she deposits one or two eggs per day along the way. The first-stage larva develops within the egg and goes through one molt to become a second-stage larva, which emerges in about a week. The larvae begin to feed on the root. They go through three more molts before becoming adults, a process that takes about 50 days (Figure 26-4). The life cycle of *Xiphinema* is similar, but reproduction is slower; the cycle takes almost 2 years to complete.

While all stages of the nematode are active throughout the year in the Pacific Northwest, the rate at which these processes occur increases during the warmer summer months. Population densities are generally tied to root growth activity—the nematode population increases after a period of plant growth.

Soil types most suitable for conifer nurseries are also ideal for the proliferation of both *Pratylenchus* and *Xiphinema.* Populations can build to high numbers in loamy soils. Heavier clay soils, because of their higher moisture-retention capacity and lower oxygen supply, tend to restrict growth of the nematode population.

Nematode damage appears:
1+0, 2+0
Mid-summer (1+0) through fall (2+0)

Xiphinema is best adapted to sandy soils. These soils tend to have a low nutrient-holding capacity and, in combination with nematode damage and the fungus *Cylindrocarton,* are conducive to the development of corky root disease.

Loss potential

Loss can occur in many forms. At worst, nematodes may kill seedlings. At best, they may act

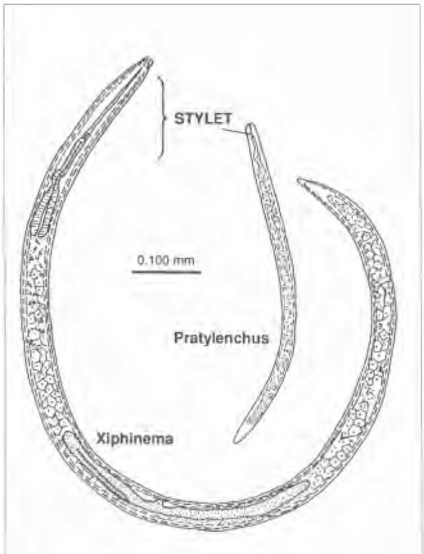

Figure 26-3. Size comparison of *Xiphinema* and *Pratylenchus,* showing size and location of stylets.

only as contaminants of roots, from which they may be introduced into a new environment. In between these extremes, seedlings may survive but may not make packing standards; severely infected seedlings must usually be culled at the time of lifting. Damaged seedlings may be inefficient users of water and nutrients. They may have difficulty surviving or may remain stunted when transplanted to a new environment. These seedlings are more susceptible to damage from other organisms and from environmental factors such as frost and heat. Frost heaving often occurs on seedlings with poorly developed root systems.

The younger the seedling or the smaller its root system, the more susceptible it is to damage from nematodes. *Pratylenchus* populations of fewer than 500 per pint of soil may cause severe stunting or even mortality of a 1-year-old seedling, but only moderate stunting of a 2-year-old or 1+1 seedling. By the time the seedling is at the 2+1 stage, much higher densities of nematodes—greater than 1,000 per pint of soil—are necessary for significant damage. Similar damage may result from lower densities of *Xiphinema,* however. The degree of damage caused by *Pratylenchus* to 1+0 and 2+1 seedlings as described above requires *Xiphinema* populations of only about 100 and 500 per pint of soil, respectively.

One-year-old seedlings, either bareroot or container-grown, are frequently damaged severely when transplanted into nematode-infested soil. These stock types have the disadvantage of a limited root system, have suffered pruning and transplant shock, and frequently lack significant mycorrhizal development, and then are introduced into an environment where nematodes are already established. Nematodes immediately attack the newly developing roots and prevent the seedlings from becoming well established.

Both nematode species interact with soil fungi on a wide range of crops. Feeding by *Pratylenchus* not only creates wounds on the roots through which other organisms can enter, but also alters the host's physiology, breaking down resistance to soil fungi. It has not been determined whether this phenomenon occurs in conifers, but it has been well demonstrated in other crops.

Mycorrhizae apparently play an important role in protecting seedlings from nematode damage. Seedlings lacking mycorrhizae suffer more damage from nematodes, and the presence of nematodes prevents mycorrhizal development. The direct damage caused by the nematode and the prevention of mycorrhizal establishment both contribute to unthrifty growth and stunting of the seedlings.

Management

Nurseries located on old forest sites rarely encounter a significant problem from nematodes. Nematodes on such sites are usually few and spotty in distribution and are consequently easy to control. Old agricultural sites, however, have a wider distribution of nematodes at higher, frequently damaging densities. Such sites may also harbor nematodes deeper in the soil profile, making control more difficult than for forest sites.

Routine fumigation of seedbeds prevents nematodes from becoming a problem during the first 2 years of seedling growth. If seedbeds are not routinely fumigated, assays for nematodes should be done because the potential for damage is much greater at the early stage of seedling development than later. Damage is also frequently encountered in unfumigated transplant blocks within the nursery.

Each block within the nursery should be surveyed for the presence of nematodes. If no nematodes are detected and proper sanitation procedures are maintained, there will probably be no need for further assays. Nurseries that routinely grow transplant stock from other bareroot facilities should obtain a laboratory report from the source nursery for each lot certifying that the incoming stock is free of nematodes. A periodic assay of the transplant blocks is a further safeguard.

CULTURAL

Xiphinema is easier to control than *Pratylenchus,* since it remains generally in the upper 10 centimeters of the soil and does not enter into the roots. *Xiphinema* has been controlled by fallowing in combination with disking or rototilling of infested soils during the hot, dry days of August and September.

CHEMICAL

Many fumigants are available for controlling nematodes before planting. A combination of methyl bromide and chloropicrin controls nematodes, soil fungi, insects, and weed seeds. It is the most costly chemical treatment. Dazomet and metam sodium also control the same range of organisms to varying degrees. They are safer to handle, and metam sodium is slightly less expensive than the methyl bromide-chloropicrin combination. Dichlo-

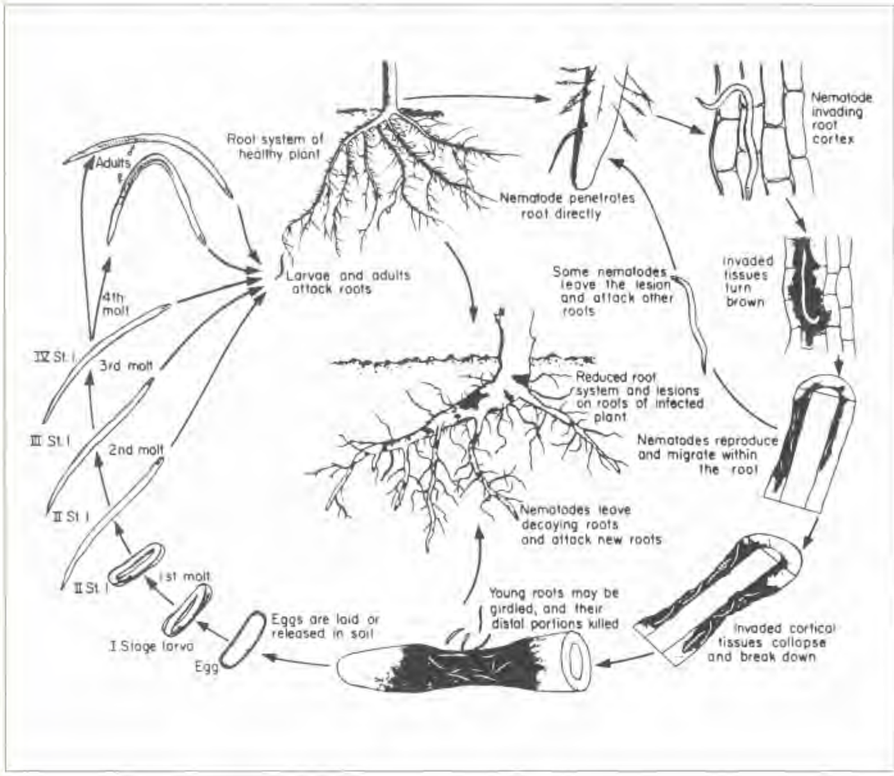

Figure 26-4. Life and disease cycle of *Pratylenchus* Reprinted from *Plant Pathology.* Used by permission.

ropropene is primarily a nematicide, but is also affords control of soil fungi when combined with varying amounts of chioropicrin. It is the least costly of the soil fumigants.

Postplant nematicides such as fenamiphos and oxamyl have been tested and found effective. They belong to a class of compounds called contact nematicides, which prevent nematode feeding and reproduction.

Selected references

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