

Plant-parasitic Nematodes Affecting Wheat Yield

in the Pacific Northwest

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Nematodes are roundworms with complex organ systems. They occur worldwide in all environments. Most species benefit agriculture by contributing to decomposition of organic matter and are important members of the food chain. Some species are parasitic to plants or animals.

More than 2,000 of the 20,000 identified nematode species are plant parasites. The plant-parasitic species cause estimated annual crop losses of \$8 billion in the United States and \$78 billion worldwide. Most plant-parasitic species live in the soil and are so tiny they can be seen only with the aid of a microscope.

Table 1 lists plant-parasitic nematode species known to occur in fields where small grain crops are produced in eastern Oregon and Washington. Cyst and lesion nematodes (Figures 1 and 2) are known to cause most of the economic damage in the region.

Nematode biology

Plant-parasitic nematodes vary greatly in the complexity of their life cycle. **Lesion nematodes** are an example of a group called migratory endoparasites, meaning that they may become entirely embedded in root tissue but never lose their ability to move within the root or to move back into soil. Adults may reproduce inside root tissue or in soil. Nematode populations in roots and in soil must be extracted separately to determine the total population of migratory endoparasites.

Stunt and pin nematodes exemplify a group called migratory ectoparasites, meaning that they feed only from outside the root tissue. Populations of migratory ectoparasites can be detected only by extracting nematodes from the soil.

Cyst and root-knot nematodes exemplify a group in which adult females become nonmotile, feed exclusively from specialized cells inside the root, and remain attached to the root until after the root and

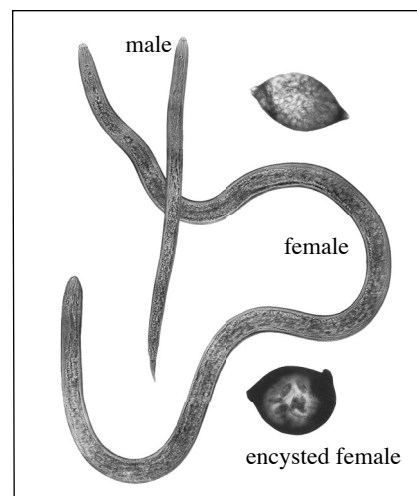


Figure 1.—Microphotographs of a cyst nematode, *Heterodera* spp., showing a vermiform male and female, as well as encysted female bodies containing eggs and/or vermiform juveniles.

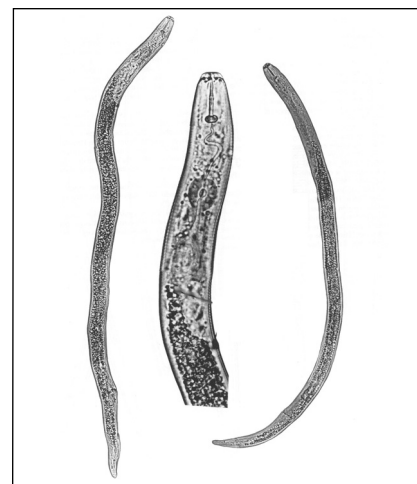


Figure 2.—Microphotographs of two mature female root-lesion nematodes (left and right), *Pratylenchus* spp. Length = 0.5 mm ($\frac{1}{64}$ inch) Diameter = 0.02 mm ($\frac{1}{1000}$ inch) (For comparison, the diameter of a human hair is about 0.1 mm.) At higher magnification (center), the anterior ("head") end shows the feeding stylet and esophagus.

Table 1.—Plant-parasitic nematode species occurring in small grain crops in eastern Oregon and Washington.

Cereal cyst	<i>Heterodera avenae</i>
Root-lesion	<i>Pratylenchus thornei</i> and <i>P. neglectus</i>
Root-knot	<i>Meloidogyne chitwoodii</i> and <i>M. naasi</i>
Stunt	<i>Tylenchorhynchus clarus</i> and <i>Geocenamus brevidens</i>
Pin	<i>Paratylenchus</i> species
Dagger	<i>Xiphinema</i> species
Root-gall	<i>Subanguina radicolica</i>

the female have died. However, juveniles of this group are found in the soil. Both roots and soil must be used to extract and detect cyst and root-knot nematodes.

The sexuality and type of reproduction differs among nematode groups. Reproduction in most parasitic species involves fertilization of eggs produced by the female. Fertilized eggs hatch to release a “worm-like” juvenile stage. Juveniles molt one or more times before a final molt results in an adult male or female.

The time to complete a full life cycle varies greatly among species. The life cycle for a pin nematode can be as short as 3 weeks, while cyst nematodes complete only one life cycle each year.

While sexual reproduction is the norm for most nematodes, males are rare or unknown in the root-lesion nematode species most commonly found in nonirrigated small grains. Females of *Pratylenchus neglectus* and *P. thornei* reproduce through a nonsexual process called parthenogenesis, in which eggs become viable without being fertilized.

Different types of nematodes have different types of feeding structures (Figure 3) and enter roots at different times and at different locations. Cyst nematodes enter only the meristematic tissue near root tips. Lesion nematodes can enter older sections of roots, and stunt and pin nematodes can feed on surface tissues of older root segments. In all cases,

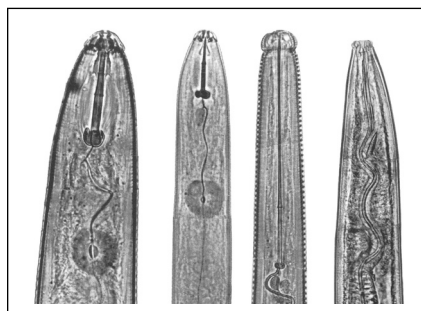


Figure 3.—Contrasting characteristics of feeding stylets of four species of plant-parasitic nematodes. Stylets are thrust in and out of the body very rapidly in order to penetrate plant cells. They are used to “suck” fluids from those cells and, for some species, to inject toxic substances into the plant cells.

root symptoms are unlikely to be detected until plants are more than 6 to 8 weeks old.

Nematode feeding often results in root damage that favors colonization by root-rotting fungal pathogens and by saprophytic bacteria, fungi, and nonparasitic nematodes. These secondary organisms cause more intense rotting and discoloration than that caused by the plant-parasitic nematode itself.

Symptoms of injuries by cyst and lesion nematodes

Cyst nematodes cause different symptoms on different cereal crops. Wheat roots become bushy, knotted, and shallow (Figure 4); oat roots become thicker and shorter; while barley roots exhibit no readily discernible symptoms. Leaf tips often become discolored: reddish-yellow on wheat, red on oats, and yellow on barley. Plants of each cereal crop may become stunted in patches.

Root-lesion nematodes reduce numbers of branch roots (Figure 5). Outer layers of root tissue (the cortex) disintegrate. In many crop species, dark lesions form on the root surface, but this symptom does not occur on small grain cereals. Root symptoms are difficult to detect in the field and are easily confused with symptoms caused by *Pythium* root rot or *Rhizoctonia* root

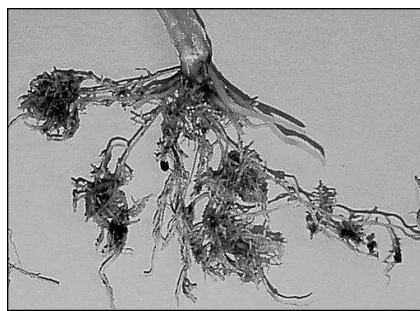


Figure 4.—Damage to wheat roots caused by the cereal cyst nematode, *Heterodera avenae*. Note the witches'-broom, where clusters of branch roots emerge from a single point on the main roots. This symptom occurs on wheat but not on oats or barley.

rot. Affected areas of fields appear generally unthrifty, yellow (especially lower leaves), or droughty. Symptoms of nematode damage can easily be confused with symptoms of nutrient deficiency, drought, root disease, or barley yellow dwarf.

Yield constraints by cyst and lesion nematodes

All plant-parasitic nematodes discussed in this publication reduce the ability of roots to absorb water and nutrients by reducing rooting depth and numbers of branch roots. Yield reductions cannot be proven without studies using nematicides, soil fumigation, or resistant and susceptible wheat varieties. Relationships between parasitic nematode populations and wheat yield reductions are difficult or impossible to generalize over large regions, because yield responses are influenced strongly by a multitude of interacting climate, plant, and soil factors.

Figures 6–9 show results of nematode–yield studies in northeastern Oregon.

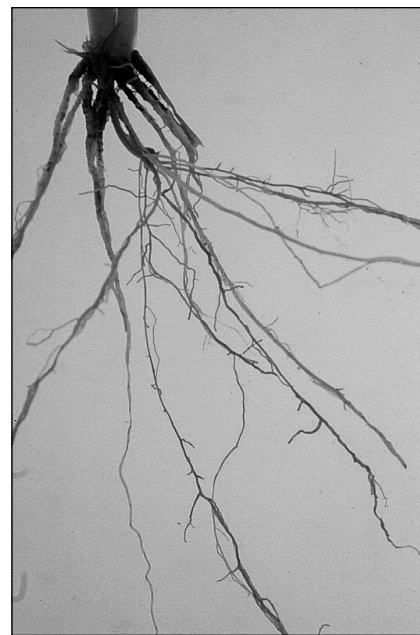


Figure 5.—Damage to wheat roots caused by root-lesion nematodes, *Pratylenchus* species. Note the general absence of branch roots along the main root axes and the thin appearance of most roots.

Controlling damage by cyst and lesion nematodes

Cereal cyst nematodes attack only members of the grass family (Poaceae). Economic damage can be greatly reduced or eliminated by any rotation that includes at least one growing season without cereals or grass weeds. The sanitizing effect of the rotation can be lost if grass weeds are allowed to grow during the spring in any phase of the rotation.

There currently are no chemicals or biological agents available for controlling cereal cyst nematode. Resistant grain varieties are being developed for use in high-risk farming systems in highly infested fields.

Cereal cyst nematode can be spread to noninfested areas on soil carried on equipment, animals, shoes, or root, tuber, and ornamental crops. It also is dispersed by wind (in dust) and water.

Root-lesion nematodes have a very broad host range, including most crops and weeds likely to be found in eastern Oregon and Washington. Management of damage by crop rotation is possible only if resistant alternate crops such as field pea, flax, safflower, or triticale are profitable for growers. Damage is likely to be highest where crops of any type are produced annually.

Damage generally does not occur in winter wheat/summer fallow rotations. However, even in wheat/fallow rotations, the numbers of lesion nematodes can become very high if volunteer cereals and/or weeds are allowed to grow through the winter and into early spring.

There currently are no chemicals or biological agents available for controlling lesion nematodes. Resistant grain varieties are being developed for use in high-risk cropping systems (Figure 9).

Root-knot nematodes that attack potato in irrigated cropping systems also can cause severe damage to spring cereals. However, rotations in irrigated fields often emphasize production of winter cereals rather than spring cereals, thereby minimizing

potential damage to the cereal crop. Also, nematode control measures generally are applied to the highest value portion of the rotation, for example as a preplant application of a nematicide before planting potato. Application of a nematicide at any time in the crop rotation is likely to reduce the potential for damage to small grain cereals.

Nematode diagnostic services

Nematode detection and identification require the services of a professional nematologist. Samples must be collected and handled carefully, because many diagnostic procedures are based on extraction of living organisms, which can

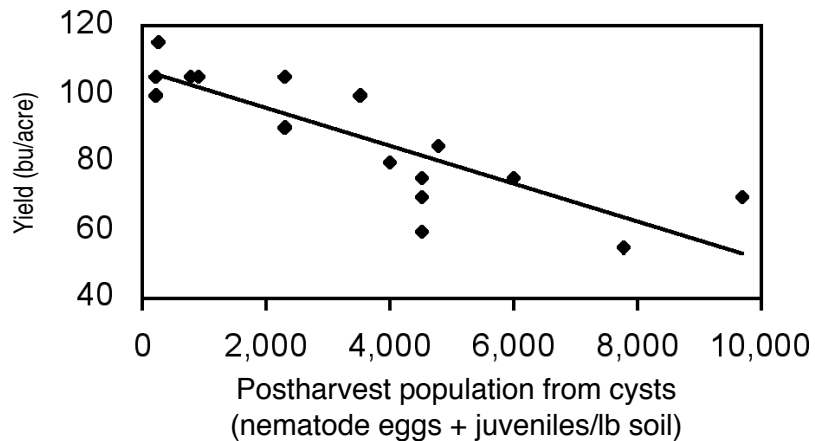


Figure 6.—Influence of cereal cyst nematode (*H. avenae*) on yield of Stephens winter wheat (Union County, OR, 1990).

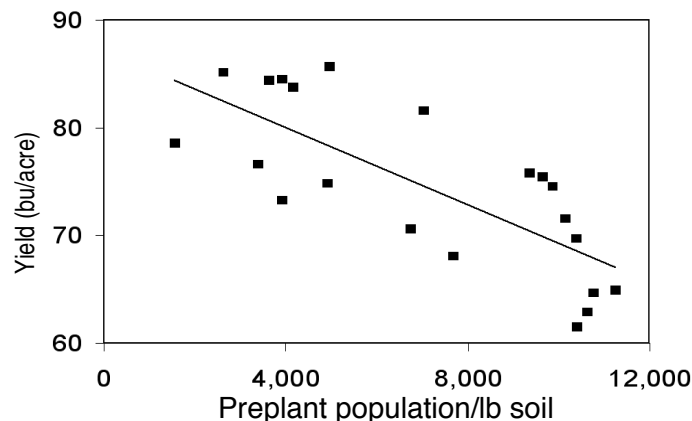


Figure 7.—Influence of root-lesion nematode (*P. thornei*) on yield of Zak spring wheat (Pendleton, OR, 2003).

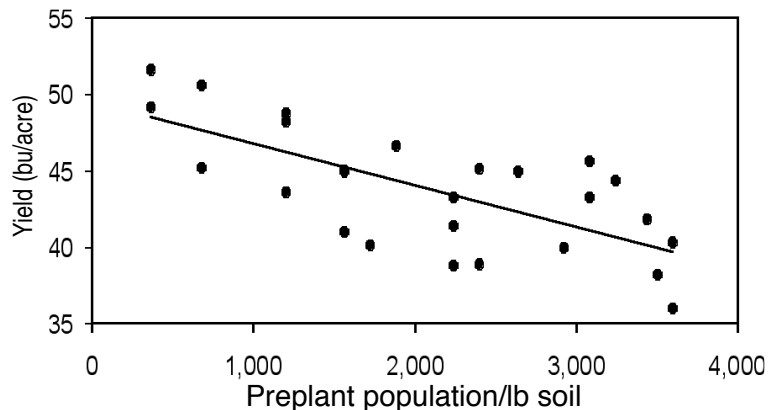


Figure 8.—Influence of root-lesion nematode (*P. neglectus*) on yield of Zak spring wheat (Moro, OR, 2004).

be killed or lost by improper handling. These procedures depend on the ability of living nematodes to migrate from moist soil or moist root systems into a collection container, where they can be counted and identified.

Diagnostic services for migratory nematodes currently cost \$20 to \$30 for each soil or root sample. A higher rate is charged to extract nematodes from both soil and roots, because the procedures required are very different. Basic diagnostic services generally include counting all plant-parasitic nematodes detected in each sample and identifying most of the nematodes to the genus level. Identification of most plant-parasitic nematodes to the species level is laborious and requires great skill, so it is charged as an additional fee. Because of the technical difficulty and labor requirement for species identification, some laboratories will not distinguish among species of lesion nematodes affecting small grain cereal crops.

Cysts of the cereal cyst nematode are not motile, and their extraction requires a special procedure based on buoyancy and sieving. Collected cysts then are broken to determine numbers of eggs and juveniles contained in the protective envelope of each cyst. Services for determining numbers of eggs and juveniles from extracted cysts are charged separately from extractions of migratory (motile) plant-parasitic nematode species.

Directions for collecting and submitting samples are available from diagnostic laboratories or many Extension Service offices. Labs that provide nematode quantification and identification services include those in the following list.

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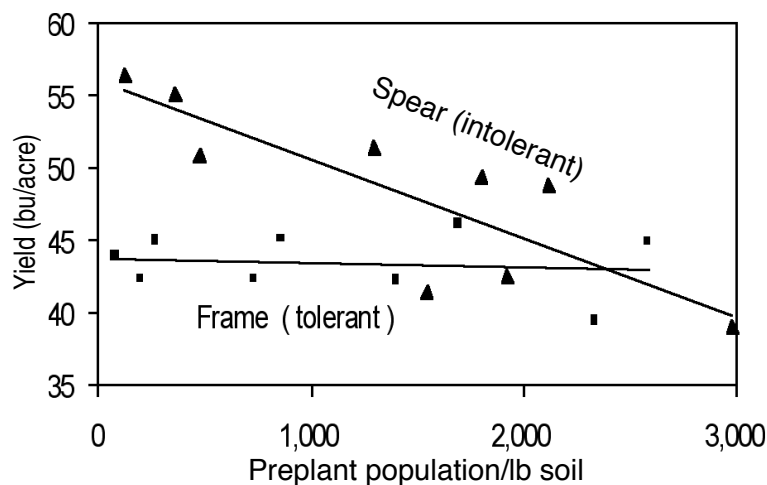


Figure 9.—Influence of root-lesion nematode (*P. neglectus*) on yields of two Australian spring wheat varieties—one intolerant and one tolerant to invasion by this species (La Grande, OR, 2003).

OSU Nematode Testing Service
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* Kuo Testing Labs and Western Laboratories provide complimentary courier service for transporting samples to their labs from many locations in central and eastern Oregon and Washington.

Further reading

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