TB01 - Cereal Cyst Nematodes in the Pacific Northwest

Introduction

Nematodes are tiny round worms that are widely distributed in most soils worldwide. Many nematodes are harmless to plants and animals and contribute to the recycling of nutrients from organic matter. These saprophytic nematodes are important components of the microbial food chain. Some other nematodes, however, can be parasites of either plants or animals and can have economic consequences for growers that include reduced yields and even field quarantine.

Most of the plant-parasitic nematodes are introduced species and are not uniformly distributed across the landscape. These nematodes are tiny but are capable of attacking and weakening plant roots (Figure 1), thereby stunting the plant. The nematodes that attack roots of wheat, barley and other field crops are generally pencil-shaped, colorless, and microscopic: 1/16-inch long and 1/1000-inch in diameter.

The nematodes most frequently detected in agricultural fields in the Pacific Northwest are called cereal cyst nematodes, root-lesion nematodes, stunt nematodes, or other such descriptive names. This paper discusses the cereal cyst nematodes.

Figure 1. Roots of spring wheat plants, showing the abnormal branching pattern caused by *Heterodera avenae*, from a field near Union, OR. The roots on the left are less heavily invaded than the roots on the right.

Occurrence

Cereal cyst nematodes reproduce only on the roots of small grains plants and a few grasses. These nematodes do not attack broadleaf crops and they can't reproduce without a susceptible plant, as in the case of bare fallow.

The major economic hosts of cereal cyst nematodes are wheat, barley, and oats. One or more species of cereal cyst nematode are found in most countries of the world where small grains are produced, including Asia, Australia, Europe, the Indian subcontinent, North Africa, and the Middle East.

Two species of cereal cyst nematode occur in the Pacific Northwest and are known by their biological names: *Heterodera avenae* and *Heterodera filipjevi*. These nematodes were once considered to be a single species, *H. avenae*. More recent studies in both Oregon and Washington have shown that some of the nematodes previously called *H. avenae* are actually *H. filipjevi*. Detailed taxonomic studies revealed reasons for separating them as two distinct species. This division was justified not only by minute differences in their body dimensions, but also by evidence that wheat, barley, and oat varieties sometimes vary in their response to attack by the two species. While *H. avenae* is far more common than *H. filipjevi*, these two species have similar host ranges and they cause similar symptoms and economic losses.

These nematodes are generally not distributed uniformly across infested fields. Within an infested field, there are areas where the nematode densities are high and nearby areas where they are not even detectable (Figure 2).

Scientists in the Pacific Northwest have considerable experience in managing the more widely dispersed of the two species, *H. avenae*. This nematode can reduce yields of winter wheat by as much as 50% in patches where the nematode density is high ("hot spots"). However, in most cases, the field-wide average reduction in yield is estimated to be 10% or less, except in cases where a field is more uniformly infested after a practice such as producing wheat or barley for three or more consecutive years. Using the 10% maximum field average, *H. avenae* was estimated to reduce the farm-gate value of wheat by $3.4 million annually across the Pacific Northwest (Idaho, Oregon and Washington), using 2007 dollars.

Before these nematodes were detected in some fields, the growers had attributed the low yielding patches to such possibilities as salinity caused by a shallow water table, leaching of nitrogen, a patch of concentrated volcanic ash, or a root disease such as Rhizoctonia root rot or take-all. One grower in the Palouse region wondered why winter wheat produced a lower yield on sub-irrigated flats than on eroded hilltops and slopes, while the opposite was true for pea or chickpea. A grower in Idaho initially attributed low yielding patches in his fields to areas of “light soil.”

Figure 2. A stunted patch of dryland winter wheat in a field infested with *Heterodera avenae*, near Palouse, Washington.

Most discoveries of cereal cyst nematode in a field or a new region occur a decade or more after the nematodes had been inadvertently introduced into that field or region. When discovered, they have typically already spread to other areas but are still at low enough numbers that they will not be discovered in the newly infested fields for many more years, if not decades.

These nematodes spread in every manner in which soil is spread, such as on equipment and vehicles that contain dust or clumps of soil, on plant materials that include soil on the roots or tubers, in surface runoff water and blowing dust, or on domestic or wild animals that have traversed an infested area, particularly when the surface soil was moist.

The life cycle of these nematodes include a rugged cyst that contains and protects eggs from effects of harsh environmental conditions. Each tiny cyst is about 1/32-inch in diameter and can contain hundreds of eggs. Survival is further enhanced by the fact that only a portion of the eggs within a cyst hatch each year. Some of the remaining eggs hatch during each of the following years. In some soils, a few of the eggs may survive for up to six years. These features of the life cycle contribute to the survival and spread of these nematodes.

Identification

Distinguishing between *H. avenae* and *H. filipjevi* has generally taken a similar path in all countries where they have been found. Before the advent of modern molecular diagnostic procedures, nearly everyone except highly specialized nematode taxonomists used the name *H. avenae* when they discovered a cereal cyst nematode in a field. If the nematode was actually *H. filipjevi*, the taxonomic clarification was made at a later time, sometimes many years after the identity was initially mistaken. Such has been the experience in Oregon during 2008, in Washington during 2014, and at earlier times in many countries of Asia, Europe and the Middle East.

Identification of these cereal cyst nematode species is now much easier. During earlier times a researcher had to make precise measurements of microscopic features on the nematode body. That was very difficult and time consuming, and could only be done by people who were highly skilled in making those distinctions. Today, molecular diagnostics, based on extractions of DNA from the nematodes or directly from soil, make species identification easier and more accurate. The procedures can be done by anyone who has been trained to extract DNA and to follow prescriptive laboratory procedures. These procedures are now used routinely in research laboratories and by some commercial nematode diagnostic laboratories, such as at Western Laboratories in Parma, ID (800-658-3858; http://www.westernlaboratories.com). It is likely that these relatively new methods will be used to identify additional areas where the cereal cyst nematode currently thought to be *H. avenae* is actually *H. filipjevi* or a mixture of these species.

Management

Management of cereal cyst nematodes, regardless of the species, follows a similar pattern worldwide. It is best to avoid spreading nematodes into fields that are not already infested, but that is often impossible, particularly when it is not already known to occur in an infested field. Even when a field is known to be infested, it is usually impractical to thoroughly clean all equipment, vehicles, shoes, or animals before moving from one field to another. The most practical approach proven to be effective and economically viable is to reduce the nematode population to a low enough level that it does not cause an appreciable reduction in grain yield in the infested field.

Cereal cyst nematode numbers can be significantly reduced by crop rotations that include resistant cereal varieties, broadleaf crops, or fallow, with only one crop of susceptible wheat, barley, or oats in a three-year period. There are several economically viable ways to reduce the nematode numbers on fields infested with high numbers of a cereal cyst nematode. Suggested options are as follows:

1. **A sequence of winter wheat and two years of a non-host.** The two non-host years could include two years of a broadleaf crop, two years of fallow, or a single year of each.

   Broadleaf options of greatest popularity in the PNW are brassica crops such as canola, mustard, or camelina, and pulse crops such as chickpea (garbanzo bean), pea, or lentil. The type of fallow does not matter; chemical fallow and cultivated fallow are similar in their ability to cause nematode mortality in the absence of a host. Volunteer cereals and some grassy weeds can serve as hosts for these nematodes, so all plants need to be controlled during the fallow period.

   Although not yet studied, overwintering volunteer wheat could be expected to serve as a trap crop before the volunteer plants are killed in the spring. Nematodes that invade the roots of volunteer plants would produce a new generation of viable eggs at the time of plant flowering (anthesis), which is long after volunteer plants are generally killed by glyphosate in fallow fields. However, burial of volunteers by cultivation in mid- to late-spring may not immediately kill the roots and prevent egg maturation.

   This 3-year rotation could include a susceptible variety of winter wheat but it would be even more effective if a resistant variety was planted. Varieties are being evaluated for that purpose.

   A recent finding that may be applicable to the PNW occurred in China. The well-known variety Madsen, which was developed and released at Washington State University, is highly resistant to every population of *H. filipjevi* that has been evaluated in China. It is now being evaluated locally. Likewise, a recent screening of international winter wheat accessions against a *H. filipjevi* population in Turkey revealed that 114 of the 719 test entries were resistant to *H. filipjevi* and another 90 entries were moderately resistant. That research showed definitively that ample resistance to *H. filipjevi* is available in the international collection, and that 12 of the resistant entries in the Turkish trials were derived from 99 entries acquired from wheat breeders in the United States.

2. **A 3-year sequence of winter wheat, spring cereal, and either fallow or a broadleaf crop.** The principles described above would be the same for the winter wheat and a non-host year of this rotation. The difference would be that a resistant variety would need to be planted during the year of winter wheat or the year of the spring cereal.

   Many spring cereals were recently found to be resistant to *H. avenae*, including varieties of hard red spring wheat, hard white spring wheat, soft white spring wheat, 2-row malting barley, 2-row feed barley, 6-row malting barley, and 6-row feed barley. This range of entries in various marketing classes has not yet been tested in fields infested with *H. filipjevi*, but current tests have already shown that varieties of spring wheat that are resistant to *H. filipjevi* are available. This information will be published and made available to growers very soon. For instance, screening trials conducted during the past three years on a field now known to be infested with *H. filipjevi* are currently being summarized.

   One early finding is that the hard red spring wheat variety SY Steelhead is highly resistant to *H. filipjevi* in Washington. Other entries in those trials were also resistant but have not yet been released for production.

A Pacific Northwest Extension publication on the biology and management of cereal cyst nematodes (PNW620: *Cereal Cyst Nematodes*; Smiley and Yan 2010) is currently being updated to include new management options that have become more clearly defined. The revised publication is expected to be published later this year (2014).

Selected Resources

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