Catching the Worm

Kate Entwistle investigates nematodes, their effects on cool season turfgrasses and possible methods to control them.

WHAT ARE NEMATODES?

Nematodes are a large and diverse group of unsegmented roundworms that occur in virtually every conceivable location worldwide. They can be found in films of water in all natural soils, in bodies of water across the planet and in plant and animal tissues both as saprophytes and parasites. There are about 2000 described species of nematodes that obtain their nutrition from different plants around the world and cause damage or disease to their host in the process.

Given these facts, why should the association of certain nematodes with turfgrass disease problems still be viewed with scepticism by some in our Industry? I can only think that it is related to the relatively little attention that they have been given over the years compared with that afforded to other invertebrate pest and fungal disease problems. This is especially the case on cool-season turfgrasses although nematode damage on warm-season turfgrasses has long been acknowledged and accepted worldwide.

NAMING NEMATODES

The nematodes associated with plant diseases are commonly named so as to describe the symptoms that are seen on infected roots, for example stubby-root, root-knot, lesion and cyst rather than by their Latin names, Paratrichodorus, Meloidogyne, Pratylenchus and Heterodera for example. In other cases, common names describe a specific characteristic of the nematode's shape or anatomy, for example sting, spiral and lance (Belonolaimus, Helicotylenchus and Hoplolaimus, respectively).

These are all examples of plant parasitic nematodes but the phylum 'Nematoda' as a whole contains two additional major groups of nematodes, the saprophytic nematodes and the entomopathogenic nematodes. Any healthy rootzone will support high populations of various saprophytic nematodes. They will aid the natural breakdown of decaying organic material and their presence should be an indicator of a healthy rootzone.

Entomopathogenic nematodes of the genera Heterorhabditis and Steinernema feed only on insects and their larvae and they are currently being investigated and used as a biological control for insect pests including chafers in amenity turfgrass. These nematodes will not cause damage to turf since they do not feed on the plant and application of products containing these nematodes can be made in the confidence that they will target only the invertebrate pest populations in the treated area.

Damage to roots caused by *Meloidogyne minor* infection

APPEARANCE AND LIFE CYCLE

With regard to plant parasitic nematodes, those that are capable of damaging turfgrasses are generally transparent and about 1mm long x 0.02mm wide, although their length will vary between the different genera and between males and females of the same nematode type. Male nematodes are invariably 'eel-shaped' being round in cross-section and unsegmented along their length. The females of some species, however, become swollen at maturity and can have distinctly rounded bodies. All nematodes produce eggs that hatch in to juveniles. The juveniles often resemble the adult and enlarge through four moults, the first usually occurring inside the egg. After the final moult, the nematodes differentiate in to male or female and the female completes the life cycle by producing eggs, either after mating or parthogenetically (i.e. reproduction without fertilisation) if there is no male around.

The length of the life cycle will vary depending on the type of nematode and the local conditions but on average it will be around 30 days. One feature common to all plant parasitic nematodes is that they possess a stylet or 'spear-like' structure in the head end that they use to pierce the plant cells and feed on the cell contents.

FACTORS AFFECTING NEMATODE POPULATIONS

Almost all plant parasitic nematodes live part of their life cycle in the rootzone with temperature, moisture and aeration affecting their movement and population development. Nematode populations will fluctuate both seasonally and spatially across any given area but generally it is thought that their populations frequently peak during spring and autumn. However, damage to the sward is generally only observed some time after these periods of population growth when the turfgrass is under additional environmental stress.

The exact size of any nematode population that is likely to cause damage (i.e. the threshold level) is still largely undefined for cool-season turfgrass. Details of damaging population numbers have been published for certain nematodes but much of this work refers to situations in the US

General yellowing patch symptoms of *Meloidogyne minor* infection

and since factors including rootzone material, temperature, grass type and nutrient status can affect nematode population effects, this information may be of limited value in the UK. Presently, the best way to determine population effect and cause of symptom expression is likely to be achieved by comparing population levels between affected and adjacent unaffected areas of turf. This is by no means a scientific way of determining threshold levels but it is a method that will show if local population increases are likely to be causing damage in the affected area.

The ideal conditions for maximum nematode population growth are, unfortunately, the same conditions that support ideal plant growth, i.e. mild to warm rootzone temperatures, adequate, but not excessive or limiting, soil moisture and light textured rootzone materials. Low levels of plant parasitic nematodes can be found in most rootzones but damage to the turf is caused when their populations increase and especially when affected plants are further stressed by unfavourable growing conditions or high temperature and low water/nutrient availability.

Since most nematode damage will be confined to the turfgrass roots, the symptoms expressed on the sward will resemble those generally associated with water and nutrient stress or other root feeding insects, i.e. yellowing, wilting or loss of turf vigour. Movement of nematodes can be facilitated by water movement across the sward or through the rootzone and as such, it is possible to see symptoms of 'streaking' across the sward, following the known pattern of water flow.

WHAT ARE THE MOST COMMONLY SEEN COOL-SEASON TURFGRASS NEMATODES?

Over the past four years I have noticed a definite increase in turf samples received in to my laboratory where the plants are showing symptoms associated with nematode infection. There are several different nematodes that have been found, but those most commonly seen are the root-knot nematode Meloidogyne sp. (both on creeping bentgrass and on annual meadowgrass) and the root galling nematode Subanguina sp. on meadowgrasses.

Meloidogyne species of nematodes feed on over 3000 plant species worldwide and the females are referred to as sedentary endoparasites. In turf, this means that they are parasitic nematodes that enter the root, migrate to a feeding site and then become non-motile. Once the female has established a feeding site, she remains in place for the rest of her life. These nematodes are able to alter the entire physiology of the infected turfgrass plant causing significant damage as the nematode population increases.

After emerging from the egg, the juvenile nematodes can invade previously infected roots, further enlarging the swellings that are already present. Normal development of the water and nutrient channels in the roots (the xylem and phloem) is disturbed and root functions decline directly reducing plant growth and quality (Shurtleff & Averre III, 2000).

In 2001, Meloidogyne minor was identified as a new species of root-knot nematode associated with yellowing circles and patches that had been recorded on creeping bentgrass greens across the UK and Ireland since the late 1990's (Entwistle, 2003). Although both the male and the female nematodes enter the plant roots during their life cycle, it is the female which remains inside the root, causing the formation of so-called giant cells which facilitate her feeding and disrupt the water and nutrient movement through the plant. The stimulated deformity of the roots is clearly apparent if they are washed free of rootzone material but the female herself is difficult to see without the use of a hand lens or microscope.

Although most nematodes are colourless, the mature female root-knot nematode resembles a small, white pearl approximately 0.5mm diameter. She lives with her body embedded in the root but the egg masses that she produces during her life, which can be five times larger than the female's body, protrude on the outside of the root and are tan in colour. Each egg mass will contain up to around 500 eggs.

Comparisons made between affected and unaffected areas of a golf green that were showing symptoms of infection by this nematode, recorded differences in population levels from <100 per 100g dry soil in the unaffected areas to between 1700 and 3400 per 100g dry soil in the affected areas (Karssen et al, 2004).

The fact that these nematodes are colonising the root system of the creeping bentgrass cultivars and annually causing the yellowing patch symptoms of damage between April and November, is no longer in doubt, but what is still under investigation is how best to deal with them. Since the nematodes disrupt the healthy flow of water and nutrient through the plant it is essential to help the plant to take up sufficient nutrient to maintain its growth during the year and this can best be achieved through foliar feeding.

Encouraging strong root growth will also benefit the plant by minimising the overall effect of the damaged root system on the sward. Knowing that the nematode is present in the rootzone with the potential to cause damage will enable you to adjust your management of the infected turf accordingly to try and minimise the potential damage during times of increased turfgrass stress. We have noticed that the apparent severity of damage by these root knot nematodes declines after about 5 years and this is likely to be, at least in part, as a result of the eventual build-up of antagonists in the rootzone that will stabilise the nematode population.

Over the past four years, an increasing number of turf samples with Poa annua swards have come through my laboratory and which have associated root galls caused by Subanguina species of nematode. These galls resemble peanuts in appearance although they are much smaller, generally being only around 2mm in length. The Subanguina nematodes are referred to as migratory ecto- and endoparasites being able to feed from the plant cells whether they remain outside (ecto-) or live completely within (endo-) the plant cells.

After feeding on and causing damage to plant roots, they are able to move through the rootzone and cause subsequent damage to other, previously uninfected roots. If individual root galls are removed and broken apart in water, they will be seen - using a

hand lens - to release eggs and juveniles that are capable of future damage. Mechanical movement of the galls and infected rootzone is possible on affected turf but as with all other nematodes, their movement relies on the presence of a water film around the rootzone particles.

As with all plant parasitic nematodes, identification of their presence in a turf sample that shows symptoms of damage does not necessarily mean that they are the primary cause and nematodes can certainly be present in a turf area that is not showing any symptoms of damage at all. However, if symptoms of damage are present, the nematode population is high (compared with unaffected samples from the same area of turf) and there is no other possible cause for the symptom development (i.e. no fungal disease, no other invertebrate pest and no chemical/physical/environmental damage), then the nematode must certainly be regarded as the most likely cause of the problem.

There are many parallels that can be drawn between diseases caused by plant pathogenic fungi and those caused by plant pathogenic nematodes. Perhaps the most important is the understanding that the mere presence of the organism (fungus or nematode) does not necessarily mean that they are causing disease.

As with fungi, these organisms are likely to always be present but their localised populations, rate of growth and quality of the turfgrass at any given time will determine whether or not disease symptoms develop on the sward. If they do, accurate identification of the cause of the symptoms is essential and hopefully with a little more information on what potential problems nematodes can cause, you can ensue that all options are fully assessed before chemical applications or other management decisions are made.

General symptoms of *Subanguina* damage to a *Poa annua* sward

Entwistle, K. 2003. Root knot nematode infection of creeping bentgrass greens. Greenkeeper International. February. 21-22.

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Shurtleff MC & Averre III CW. 2000. Diagnosing plant disease caused by nematodes. APS Press, Minnesota. 187pp.

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***Subanguina radicicola* showing head end with stylet (photo: CSL)**