

studied. They are mostly microscopic - 400 to 3000 microns (0.4– 3mm) in length and most are armed with a stylet or other weapon, which is used to pierce plant cells to enable the worms to feed on the cell contents.

The majority of plant parasitic nematodes feed on the roots of their host and can be divided into two sub-groups: -

Endoparasitic – the nematode invades the living host, entering the root system and moving into the vascular tissue. Some species, e.g. Root Knot Nematode, secrete substances that modify the host plant cell division to create specialised enlarged cells to accommodate the parasites while they feed.

Ectoparasitic – the nematode remains outside the host and pierces the plants cell walls to extract the cellular contents for food.

Many different species of nematodes are known to infest turf throughout the world. An article published in the journal 'Biologist' in May 2008 (see references) lists 14 different species that were found in 272 turf samples taken from European soccer pitches and golf courses during 2006. These included both endo and ectoparasites.

Listed next are the main characteristics of the more commonly found nematodes infesting turf:

a) Endoparasitic species

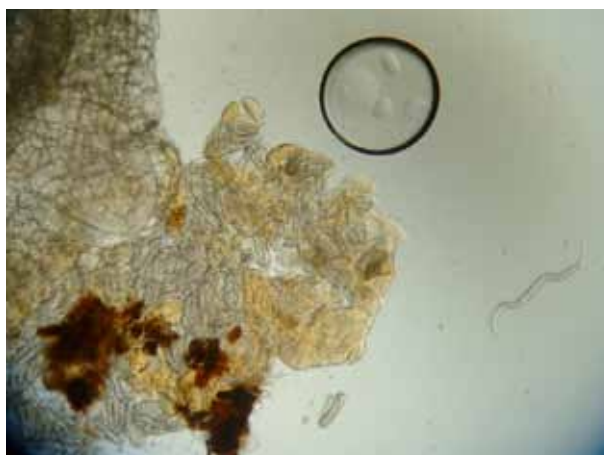
- The Cyst Nematode *Heterodera spp.* causes galls or lumps where the roots swell up. Immature nematodes move through the soil in search of a host. When they find a suitable root, they enter and inject substances that cause the cells to enlarge and provide accommodation and an on-going food source. The female nematode is fertilised inside the feeding cell where she remains and eventually dies. Her dead body becomes a swollen bag of fertilised eggs known as a cyst. As the damaged root breaks up the cyst is released into the soil where it can remain 'dormant' for a long time, eventually releasing the eggs and emerging juveniles.

- The Root Knot Nematode *Meloidogyne spp.* produces 'knotty' galls in the root. It bears similarity to the Cyst nematode in the way it enters and feeds in the root but it does not form an egg cyst; instead the eggs are released into the soil when the root knots break down, where they hatch and develop into juveniles. Damaged roots are often much shorter than unaffected roots.

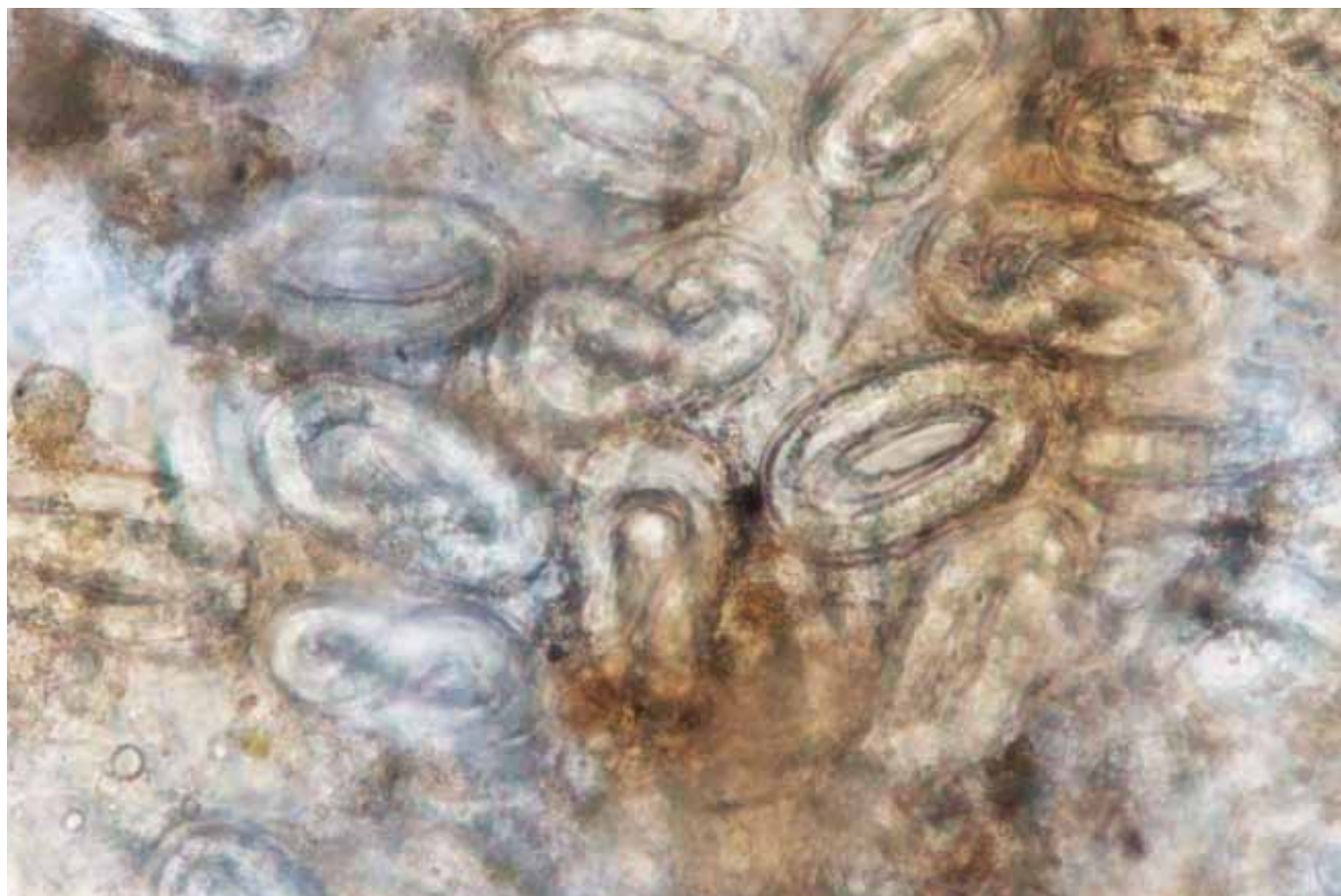
- The Root Lesion Nematode *Pratylenchus* is one of the most damaging and widespread pests in agriculture. This nematode initially attacks roots from the outside, but



Cyst Nematode *Heterodera spp.*
Dr Kate Entwistle, The Turf Disease Centre



Root Knot Nematode – *Meloidogyne spp.*
Dr Kate Entwistle, The Turf Disease Centre





LEFT: Spiral Nematode *Helicotylenchus* spp.
Dr Kate Entwistle, The Turf Disease Centre

RIGHT: Sheath Nematode feeding *Hemicyclophora* spp.
Dr Kate Entwistle, The Turf Disease Centre



LEFT: Ring Nematode *Cricone-mella* spp.
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as death of the cells progresses, it moves into and through the root, destroying tissue as it goes.

b) Ectoparasitic species

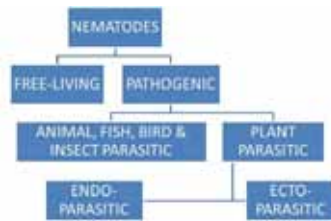
The Spiral Nematodes *Helicotylenchus* spp. & *Rotylenchus* spp. These nematodes typically adopt a spiral posture. They 'graze' around the outside of roots using a short, hollow stylet to pierce cells and feed on the contents. The cells die after this attack, leaving many damaged areas in the roots.

The Stunt Nematode *Tylenchorhynchus* causes the plant to be stunted both above and below ground. Adults feed around the outside of the roots using a short, hollow stylet. Numbers can build up quickly so while individual nematodes do not cause much damage, their combined effect can be significant.

The Sheath Nematode *Hemicyclophora* - so named because the adult female has a protective sheath around her body. This picture below shows the hollow stylet penetrating root cells during feeding.

The Ring Nematode *Cricone-mella* spp & *Macroposthonia* spp appear to be segmented like the earthworm. However, closer examination reveals this is due to corrugation of the outer membrane.

The Stubby Root Nematode *Paratrichodoros* feeds from the root tips causing damage which



prevents further root elongation, hence its name. The nematode pierces the roots with a solid stylet, sucking up the sap with the mouth. Stubby Root nematodes are known to transmit viruses and have a synergistic effect with *Fusarium*.

SYMPTOMS OF NEMATODE ATTACK ON TURF

From the surface of the turf, the visual signs of nematode infestation are fairly non-specific and depend on the severity of infestation and the species of nematode involved.

Symptoms can vary from a yellow discolouration to wilting and general thinning of the sward. The physical damage to the root system results in a reduction in wear tolerance that can devastate heavily used turf.

Damage is particularly evident with endoparasitic species such as *Meloidogyne* spp., the Root-Knot Nematode and the severity of symptoms can be made worse by external factors such as fungal disease attack and also by low

Claim 2 BASIS points

SELF ASSESSMENT

Use the questions below to check your understanding of this topic. Readers can claim BASIS points if answered correctly! Circle the correct answer(s)

1) Approximately how many species of plant parasitic nematodes have been studied?
a) 80,000, b) 1 million, c) 4,100, d) 3000

2) What term is used to describe the process of asexual reproduction that can occur with some nematodes?
a) mutagenesis, b) parthenogenesis, c) mitosis, d) symbiosis

3) Which of the following are endoparasitic nematodes? (More than one may apply)
a) *Cricone-mella* spp.
b) *Meloidogyne* spp.
c) *Heterodera* spp.
d) *Hemicyclophora* spp.

4) Why do nematodes require a muscular pharynx?
a) To keep food in once it has been ingested
b) To propel the stylet into the host root cell
c) For respiration purposes
d) To force food into the intestines against the internal body pressure

5) Problems with nematodes on turf are more likely to occur in . . .
a) Dry soils,
b) acid soils,
c) wet soils,
d) nutritionally deficient soils

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ACKNOWLEDGEMENTS

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light levels that are often found in football stadiums.

In the last 15 years we have seen a dramatic increase in golf construction to the USGA standard, which utilises pure sand or a high sand percentage in the rootzone, seeded with creeping bent (*Agrostis stolonifera*). This type of golf green has been found to be particularly susceptible to the root knot nematode *Meloidogyne minor*, its presence affecting both visual appearance and the roll of the ball as a result of turf thinning. Affected turf responds badly to routine maintenance such as aeration and feeding and the wear tolerance is greatly reduced.

Problems with nematode infestations are especially frequent in wet climates. It has been reported that in Ireland 90% of sand-based golf greens built since 1977 are infested with *Meloidogyne minor*. It is believed that the parasite is distributed in the sand used for construction, since it has been found to occur naturally in sand dunes all around the UK.

In many cases the presence of a nematode infestation can go unnoticed if the attack is less severe. Due to their small size examination of a soil core may not reveal the true cause.

Control of nematodes in turf

There are no chemical pesticides approved for nematode control in turf. However, a natural product based on garlic extract and sold under the brand name 'Eagle Green Care', has CRD approval for use on established turf in the UK.

Research has been carried out on the use of plant bio-stimulants to relieve the stress caused by nematodes feeding on the roots. Such products can improve the health (depth and thickness) of the root system and enable the grass to endure nematode attack without showing adverse visible symptoms. Of these, seaweed extracts obtained from *Ascophyllum nodosum* e.g. 'Seavolution' appear to give the best results. Research on some soil amendment products, such as Bio-Mass sugar and mustard bran, has also revealed benefits to the health of turf that is being damaged by feeding nematodes. The effect is deemed to be similar to that experienced with the use of bio-stimulants, encouraging the development of strong roots that can help to compensate for the damage caused by the nematodes. But, it must be stressed that these products are not authorised nematicides for use in reducing nematode numbers in turf.



ABOVE: General yellowing and thinning
RIGHT: Root knot symptoms

Dr Kate Entwistle, The Turf Disease Centre



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Improving the golfing experience

Wimbledon may be most associated with another sport altogether but, as Barry Heathcote discovered, the golf club which carries its name is building a reputation for itself in its own right

Wimbledon Park Golf Club has just completed the first phase of works that will transform the course.

Course Manager, Dave Langheim has been the driving force behind a project which will see the complete renovation of the course and installation of a state-of-the-art Toro Links irrigation system.



Course Manager, Dave Langheim

Dave moved to Wimbledon, across the road from the famous All England Club, in 2008, having previously been Course Manager at the Bernhard Hunt course at Foxhills.

“Wimbledon Park was looking for a person to improve the course and during my first few months I put forward a five year plan which took account of the members concerns with the inconsistency of the greens tees and bunkers.”

He also put together a proper



labour structure, took on an extra member of staff and turned the mechanic's role from part to full time.

“A programme of general good practice was put into place to improve the playing surfaces of greens and tees and a major emphasis was put into machinery purchase with an investment with Toro machinery to ensure the correct machinery was available to carry out the works required,” said Dave.

He also initiated a wildlife and environmental plan working closely with the wildlife and wetland trust. In addition a tree planting programme.

Within year three of the five year plan a course audit was put into place.

Initially the club decided to appoint a Golf Course Architect and after a process of interviews with a number of qualified architects, in February of last year Thomson Perrett and Lobb was appointed to



undertake a full design review of the course.

Part of the brief was to strengthen the finishing holes of the course and add further interest for the members. Adding interest for members is often the greatest challenge for a golf course architect as the ability and expectation of golfers vary enormously. Tim explained that expectations of golf include the competitive challenge of the game on the one hand to a social walk as a form of exercise and catching up with friends. Therefore creating a golfing experience which is fun and challenging is a difficult thing to achieve.

With that in mind Tim began the process of undertaking a full strategic review of the existing course. He made numerous visits to the club, walking the course and discussing the issues with members of varying playing ability. This helped to solidify some of the initial design concepts Tim wished to adopt. One of the overriding observations he made from the course analysis was that the existing course frequently punished the higher handicap golfer. This was prevalent from some of the bunkering being situated quite a distance from the

green, penalising the more inaccurate shot.

Tim's initial concepts were presented to the club and following a process of discussion with the board and membership were approved.

The course is built around a 85,000m³ lake and a number of the holes are low lying.

It was apparent that ground water may become an issue, particularly with drainage outfalls and potential depths of the proposed new bunker bases. A detailed GPS survey was carried out to the entire site. This provided a contour plan that assisted Tim with his proposals and design.

"That survey enabled us to plan accurately the works and have a logical approach to drainage and outfalls. Interestingly within the final design the net sand area of bunkers was reduced from the existing course and the team were happy with the proposed placement of the new bunkers," explained Tim.

The final design and tender package was completed during the summer of 2011 at which time the tender package was sent to three approved contracting companies. Following tender submission each

IMAGES: Bunkers at Wimbledon Park Golf Club showing various stages of completion





ABOVE: A renovated bunker under construction at Wimbledon Park Golf Club

company was invited to attend a meeting to discuss their bid.

Profusion Environmental Ltd was chosen and awarded the contract. Dave felt that it was clear during the interview that Profusion had a passion and approach to the project which impressed the committee.

While Profusion is a new name in this sector the people behind it have a level of experience second to none. Nigel Wyatt, Simon Hatcher and Ian Martin have been working in the golf construction industry for 30, 20 and 40 years respectively.

Nigel was delighted with the appointment saying that this opportunity will be invaluable for Profusion, this being the company's first major course reconstruction.

"We were pleased to have the opportunity of working with the club, Tim Lobb, Dave Langheim and his team to achieve the club's goals," said Nigel.

The site was mobilised and the works commenced last October on the first phase of the works which included holes 1-3 and 12-18 a total of 10 holes. Tim worked closely with Ian Martin, Profusion site manager in order to achieve his design philosophy in the build.

Bunkers were rough shaped initially and then tweaked following Tim's visits. The site is made up of London clay, which not only is challenging from a drainage point of view, is enormously difficult to shape. Having completed the final shaping a sand line was sprayed within the bunkers and a ledge created for the revetted edge. This revetted turf edge gives a very distinctive appearance and really helped the new bunkers be visually striking.

Knowing his course and problems that had been experienced with the existing bunkers Dave recommended that the club install a bunker lining system, something that would prevent sand from being contaminated with the clay, associated problems with drainage and other issues. He trialled a number of bunker lining systems and found that the best solution was Blinder.

Penny Long, a director of The Blinder company, said that working with prominent Course Managers and industry professionals Blinder has been created to provide the perfect solution to consistent playable and easy to maintain bunkers.

Blinder enabled Tim to design very steep faces up to an angle of 45°

as Blinder has proven to minimise sand wash from the faces. Blinder uses environment agency approved recycled rubber granules mixed with a binding agent throughout. The rubber granules are placed in a pan mixer together with the binding agent which gives the product great consistency and strength.

The mixed product is wheeled into the bunker and laid by hand trowelling. This ensures consistency of depth and allows the product to be laid on steep faces and intricate shapes created by the golf course architect.

"The product drains effectively throughout and once it has cured is durable and resistant to club strikes. Importantly being a rubber based product will not cause damage to the golfer or the club," said Penny.

Phase One of the works has now completed and Dave is delighted with the results.

"The Profusion team have been excellent in what have been some extremely trying conditions."

Phase Two commences this October and while Dave will have the course to himself over the summer is very much looking forward to completing his five year plan.

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Rough mowing to a high standard

James de Havilland presents the rough guide to rough mowers

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width of 2.23m. Height
of cut adjusts between
a nominal 2.5cm to
10cm*



Rough mowers have evolved to the point where modern rotary models offer good contour following and an excellent finish. In some cases, a wide area model can be drafted in at certain times to mow a fairway too. So what should you look for?

As is so often the case, it is dangerous to generalise. However, it is fair to say a large proportion of golf courses will mow roughs with a rotary mower. Versatile, robust and able to operate with minimal maintenance, a rotary mower can combine a good finish with moderate operating costs.

The trick when looking at a new model is to consider exactly what you want the mower to achieve. A lot will depend upon the way in which the fairways are bounded by the roughs and how your mowing passes are set up to optimise productivity.

Is your priority to have a model to mow around bunkers without the risk of damage or do you need the ability to cover a wide area?

It of course follows that a wide area cylinder mower can cut the roughs; some courses will have moved from a 'heavy fairway' model to a lighter design and relegate the 'old' fairway model to taking care



John Deere 7400 mowers work at a variable width of 1.73m to 1.88m. The front units can be swung out when mowing next to a bunker to help prevent the mower's wheels damaging the edges. Each of the three units is 68.6cm in width



Each measuring 53.3cm, the rear discharge cutting units fitted to the John Deere 8400 feature anti-scalp front- and full width rear-rolls to leave a striped finish. Designed to follow undulations, the units are 'narrower' than those of the JD 7400.

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Jacobsen offer a range of mowers suitable for cutting roughs, the 2.30m five-gang AR-522 featuring 56cm Trim Tek decks that will mow down to between 1.9cm to 13.3cm. At the other extreme, the company's HR-9016T offers a 4.90m mowing width, will cut down to 2.5cm and offers the potential to cover around 6.7 ha – or 16.5 acres- an hour.



of the roughs. But where a rotary mower is the key choice, there are a few pointers that can help when trying to select the right model.

- Total area to be mown: Not always as simple as it seems. A 'new' mower may end up being employed differently once it is in service.

The key is to establish primary mowing duties and the area it will need to cut. Remember, theoretical mower performance is based upon a clear run. Halve these rates to get an idea of true performance.

- Terrain: Undulating ground and slopes may influence choosing between smaller individual cutting units and wider multi-blade decks.

On sloping ground, all-wheel drive may provide improved traction but it is overall stability that will be of primary importance.

A wide track mower may be a good choice but will it suit all the work required?

- Finish: Modern multiple 'gang' rotary mowers have improved contour following, individual cutting unit sizes varying between makes and models.

Smaller units will tend to suit undulating ground but a lot will also depend upon height of cut. How rough are your roughs?

- Height of cut: A rough mower that can be used as part of a fairway mowing regime may be very useful at certain times of the year.

Can the mower be used to help reduce grass height following a prolonged period of heavy spring / summer rain?

How important is height of cut and finish? Do you need a mower that can deliver a really fine cut or will a more conventional wide area rotary be more in line with your demands?

- Variable width: The ability to push out the outer units of a mower to increase mowing width goes beyond helping increase productivity over wide, flat areas. It can also be used to push the units out around bunkers or tuck more easily under bushes and hedges.

As with all mowing equipment, the key is to try different models and work out how the mower integrates with existing equipment.

Modern rotary mowers can achieve an excellent finish, particularly when exploited on a 'little and often' regime in periods of fast grass growth.

But some rotary models will also enable you to tackle much heavier growth that can include light scrub. The best mower will always be the one that is right for your individual needs.



Toro Groundsmaster rotary models include the seven gang GM 4700D. Offering a 3.80m cut, the mower can be operated with the two outer units raised. As with other rival designs, the rear discharge units can be fitted with a mulch kit. Note wide track width for stability on slopes. US style 'bump cap' a good idea when mowing around trees.