Technical Note TN603

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Soil dwelling free-living nematodes as pests of crops

SUMMARY

- **Free-living nematodes feed on the roots of a wide range of crops**
- **Crops especially at risk are potatoes, carrots, cereals, raspberries and strawberries**
- **Several free-living nematode species can transmit plant-pathogenic viruses**
- **Chemical control through the use of nematicides is restricted for some crops**

Introduction

Soil dwelling nematode pests are separated into migratory (free-living) and sedentary types, which relates to their ability to move through soil whilst feeding. Sedentary plant-parasitic nematodes include the cyst forming nematodes such as potato cyst nematodes (*Globodera* spp.) which once they have started to feed and reproduce are permanently attached to the roots of their host-plants. Free-living plant-parasitic nematodes move freely through the soil between feeding bouts, such as the needle nematodes (Longidorids) stubby-root nematodes (Trichodorids) and root-lesion nematodes (Pratylenchids).

Free-living nematodes vary in length from 0.1–5 mm depending on the species, and are not easily seen by the naked eye. Their size and worm-like form are adapted to moving between soil particles. However, movement is affected by moisture and soil type – the lighter the soil, the greater the freedom for movement between soil particles, if there is sufficient moisture present. Waterlogged soils restrict nematode movement as do dry soils and heavy soils. Nematodes can migrate downwards from the topsoil to avoid desiccation and frosts.

Free-living nematodes have "mouth spears" or stylets. They use the hollow stylet to feed on roots and root hairs. The stylet tip is thrust against the surface of plant cells until it finally penetrates into a cell. Digestive enzymes are then pumped through the stylet into the cell, the digested cell contents are withdrawn through the stylet into the nematode gut. Because the stylet is a hard, stiff organ, some nematodes also use it to rasp at the surfaces of roots.

The damage that nematodes cause to plants increases with the numbers of nematodes present, however there may be other organisms that invade the feeding lesions caused by nematodes (e.g. bacteria and fungi) that can exacerbate the damage produced by nematodes.

A reduced or thickened root system due to nematode damage (Fig. 1 and 2) makes plants more susceptible to drought stress and mineral deficiencies and is expressed in the field as patches of stunted plants (Fig. 3), which are often mis-diagnosed as waterlogging, mineral deficiency, or disease.

Several nematode species are also vectors for plant-pathogenic viruses (see Table 1), and in this case nematode numbers are not necessarily related to the symptoms seen on the crop. For example, spraing symptoms in potato tubers due to tobacco tattle virus can occur when there is a relatively low nematode population (Fig. 4). Virus particles are picked up by nematodes feeding on virus-infected host-plants, which may be the crop, or weeds that can act as reservoirs for the virus. Virus particles are carried on the mouthparts or in the gut of nematodes, and depending on the virus, can persist within the nematode for several months, although the virus is lost every time the nematode moults from one growth-stage to the next.

Some nematode species can survive for up to 2 years and multiplication can range from five to a 1000 fold depending on the species, environmental conditions and host-plant. In Scottish soils populations of some nematode species (e.g. *Pratylenchus* and *Trichodorus*) have increased by 300% over the last 12 years.

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Table 1. Nematodes and plant-pathogenic viruses that they can transmit to crops

Nematode species	Virus vectored	Crops affected
Xiphinema diversicaudatum	Arabis mosaic	Cherry, cucumber, hops, raspberry, rhubarb
	Brome grass mosaic	Cereals and grasses
	Strawberry latent ringspot	Blackcurrant, cherry, celery, peach, plum, raspberry, rose
Longidorus attenuatus	Tomato blackring	Celery, lettuce, peach, potato, raspberry, strawberry, sugar-beet, tomato
Longidorus elongatus	Raspberry ringspot	Blackcurrant, raspberry, redcurrant, strawberry
	Tomato blackring	Potato, raspberry, strawberry, sugar-beet, tomato
Longidorus macrosoma	Raspberry ringspot	Blackcurrant, raspberry, redcurrant, strawberry
	Brome grass mosaic	Cereals and grasses
Trichodorus and Paratrichodorus spp.	Pea early browning	Pea, lucerne
	Tobacco rattle	Potato, tobacco, ornamental bulbs

Needle nematodes - *Longidorus* spp.

Needle nematodes feed on a wide range of woody and herbaceous plants. They can also act as vectors for several viruses (Table 1). Crops that are at risk from needle nematodes, through direct feeding damage and/or nematode-vectored viruses include carrots, grasses, sugar beet, raspberry, strawberry and cereals. Damage to sugar beet (docking disorder) and carrots and parsnips where multiple tap roots are formed ('fanging') are the most notable problems associated with needle nematodes, although if numbers are high enough (> 100 nematodes/litre soil) then other crops can be affected.

Recent work at SAC has shown that feeding by needle nematodes on the roots of wheat and potatoes causes an increase in root thickening and weight at the expense of top growth, leading to stunting of plants.

Needle nematodes are important vectors of raspberry ringspot virus and tomato blackring virus (Table 1), and should be routinely assessed for by raspberry and strawberry growers

The primary needle nematode present in the UK is *Longidorus elongatus* and they are prevalent in lighter soils in Scotland.

Stubby root nematodes – *Trichodorus* and *Paratrichodorus* spp.

Stubby root nematodes as the name suggests give rise to thickened 'stubby' roots, with branched lateral roots. Stubby root nematodes prefer coarse sandy soils and can have quite high multiplication rates under the right conditions.

Recent research at SAC has confirmed the effect that stubby root nematodes have on the roots of cereals and potatoes: a thickening and increase in root growth which results in poor top growth and subsequent reduction in yield (Fig. 1).

Docking disorder in sugar beet is a result of a needle nematode and stubby root nematode complex feeding on the roots, and often nematode damage in other crops such as cereals and potatoes may be due to a nematode complex rather than a single species or group of nematodes.

Stubby root nematodes are also vectors of tobacco rattle virus (TRV) which causes the disorder known as 'spraing' in potatoes (Fig. 4). Nematodes feeding on daughter potato tubers at tuber initiation transmit the virus which leads to the production corky rings within the tuber flesh as a consequence of the potato auto-destructing virus infected cells. Not all potato cultivars exhibit these symptoms after TRV infection, and symptomless infection of TRV may explain why the virus has been able to spread itself throughout the UK possibly in TRV–infected seed potatoes. Common weeds such as field pansy, knotgrass, groundsel, shepherd's purse and chickweed can act as hosts for TRV, so even when the nematode loses TRV after moulting, it can re-acquire the virus from feeding on these and other weeds.

Dagger nematodes – *Xiphinema* spp.

These nematodes can reach 5 mm in length and feed on the root tips and sides of roots of crops grown in clay soils. *Xiphinema* nematodes can survive for up to 5 years which compensates for its low rate of multiplication. Crops attacked include raspberry, strawberry, rose, celery and grasses. Its role as a vector for viruses such as arabis mosaic, brome grass mosaic and strawberry latent ringspot is its main concern rather than the direct damage it can cause. Dagger nematodes are not often a problem in Scottish crops.

Stunt nematodes - *Tylenchorhynchus* spp.

Stunt nematodes are common in sandy soils and will feed on the roots of most plants. They do not usually cause noticeable damage to crops unless numbers are excessive - > 5,000/litre soil. Damaging numbers can often be found in turf, especially links golf courses, where the soil is especially sandy.

Stunt nematodes are particularly prone to desiccation, and as a result numbers can drop significantly after a dry summer.

Spiral nematodes – *Helicotylenchus* and *Rotylenchus*

These nematodes tend to burrow into the roots of their host-plants and feed within the root cortex. This leads to brown necrotic areas on attacked roots. High numbers in excess of 5,000/litre of soil are needed for any significant damage to be seen, usually in grass, tomato, carrots and lettuce.

Root-lesion nematodes – *Pratylenchus* spp.

Root-lesion nematodes feed and multiply within the roots of most plants, causing cavities and channels within the root system which allows bacterial and fungal infection to exacerbate the damage done by the nematodes themselves. The nematodes may initially feed on the outer root surface and root hairs before they penetrate the root itself. Root damage and subsequent bacterial and fungal infection can lead to yellowing of the leaves and stunted growth.

Pratylenchus penetrans is the most common root-lesion nematode in the UK. It attacks bulbs, ornamentals, roses, fruit trees, raspberry, strawberry, potato, tomato, carrot and lettuce.

Strawberry and raspberry crops are particularly susceptible to *P. penetrans* and associated fungal attack of the roots. Numbers as low as 50 nematodes/litre of soil can cause damage to strawberries.

Other root-lesion nematodes include *P. vulnus*, which attacks woody plants and *P. fallax*, which is associated with cereal and sugar beet damage on sandy soils.

Management of Nematodes

Nematode distribution within fields tends to be patchy, which is a consequence of their initial introduction into the field and slow expansion from that area. Consequently, symptoms of damage in crops tend to be patchy, maybe restricted to individual or small groups of plants (Fig. 3). Watching out for the occasional plant showing symptoms of nematode damage, followed up by correct diagnosis of the cause can be an important early warning that nematodes or nematode-vectored viruses may be present within an individual field.

Soil sampling for nematodes a few months before planting is highly recommended for crops such as potatoes, strawberries, raspberries, carrots, onions, ornamentals and protected crops, as management is easier if you know what nematode species and population size you are dealing with. For potato crops it is possible to determine whether stubby-root nematodes are carrying TRV that leads to spraing in the tubers (Fig. 4), so nematode counts and a virus test are recommended.

It is virtually impossible to control nematodes once the crop is in the ground – any action needs to be taken before planting, and for perennial crops such as strawberries and raspberries, once the crop is in the ground, you are stuck with the nematodes and their damage.

Cultural control

Various measures can be adopted to minimise or even prevent the risk of nematodes affecting crops. Choice of healthy, certified seed and propagating stock can go a long way in preventing nematodes (and associated viruses) being introduced into a field.

Effective weed control can reduce the hosts available for nematodes to feed on, and to pick up viruses from. For example, controlling weeds in fields in-between growing potatoes can significantly reduce the risk of 'spraing' in potatoes caused by TRV vectored by stubby root nematodes.

Physical control

Rolling cereal crops before GS31 is possible, as the nematodes will be crushed between soil particles and damage will be reduced to some extent.

Soil cultivation can reduce nematode numbers to some extent, particularly in lighter soils where soil abrasion can kill large numbers of nematodes.

Flooding of soils for weeks or even several months can knock back numbers of some nematode species.

Resistance

Choice of resistant or tolerant cultivars can allow some crops to be grown in fields where nematodes (and nematode vectored viruses) are present. However, it should be noted that for tolerant cultivars, whilst they will allow a good yield to be obtained, will still allow nematode multiplication to occur. Resistant cultivars will either prevent significant nematode feeding or prevent nematode multiplication.

Chemical control

Chemicals available as nematicides can be separated into fumigants and non-fumigants (Table 2).

Fumigant nematicides tend to be phytotoxic, so treatments need to be applied several weeks or even months before planting of a crop. Metam-sodium, chloropicrin, dazomet and 1,3-dichloropropene are fumigant nematicides that can be applied to UK fields and/or protected soils, but their cost does tend to restrict their use to high-value crops only.

Non-fumigant nematicides have no phytotoxic effects and these are usually applied to the soil at, or immediately prior to planting of the crop. Non-fumigant nematicides approved for use against free-living nematodes in the UK are benfuracarb, fosthiazate, carbosulfan and oxamyl (carbamates).

Aldicarb products can no longer be used after December 2007 and are not included in the Table of approved UK nematicides (Table 2). Carbosulfan products are included in Table 2, but are only approved for use until December 2008.

Non-fumigant nematicides tend to 'paralyse' nematodes for up to 3-4 months which gives crops such as potatoes, carrots, sugar beet, onions and ornamentals a chance to develop to a stage where they can 'escape' the effects of nematode feeding – either direct damage and/or virus transmission. This approach does not have a significant effect on nematode numbers in the soil unless the sexual stage of nematode reproduction is affected. This technique is suitable for controlling pests on annual crops, but is not effective for perennial crops such as strawberries, raspberries and fruit trees, where long-term nematode control is required.

Integrated control

In practice, effective management of nematodes depends on an integrated approach, which combines nematode identification and population assessments from soil samples, with cultural, physical and chemical methods and choice of resistant or tolerant cultivars.

Table 2. UK approved nematicides and crops they can be used on

Nematicide active ingredient	Product name	Approved crops
Fumigants		
Chloropicrin	Chloropicrin Fumigant, K & S Chlorofume, Custo-fume	Strawberries, top fruit, protected and outdoor blackberry*, protected and outdoor raspberry*, protected and outdoor rubus hybrid*, ornamental plant production
Dazomet	Basamid	Field crops, protected crops
1,3-dichloropropene	Telone II	Potatoes, hops, raspberries, strawberries, outdoor blackberry *, outdoor hybridberry*, ornamental plant production
Metam-sodium	Discovery, Fumetham, Metam 510, Metham Sodium 400, Sistan*, Sistan 38, Sistan 51, Vapam	Field crops, protected crops, elm trees (dutch elm disease)*
Non-fumigants		
Benfuracarb	Oncol 10G	Fodder beet, mangels, sugar beet
Carbosulfan**	Marshal 10G, Posse 10G, Marshal Soil Insecticide suSCon CR granules	Broccoli/calabrese, brussels sprout, cabbage, carrot, cauliflower, collard, fodder beet, kale, mangel, parsnip, sugar beet, forestry, outdoor Chinese cabbage*, outdoor choi sum*, outdoor Pak Choi*
Fosthiazate	Nemathorin	Potato
Oxamyl	Vydate 10G	Carrot, parsnip, potato, sugar beet, outdoor garlic*, protected garlic*, protected onions*, bulb onion*, shallot*, fodder beet*

** Specific off-label approvals for use in these crops* *** Cannot be used after 13 December 2008*

Fig. 1 Stubby-root nematode damage to potatoes: stunting of plants and thickening and proliferation of roots.

Fig. 2 *Longidorus* damage to rye grass.

Fig. 3 Patches of stunted plants in a field of potatoes due to nematode feeding on roots.

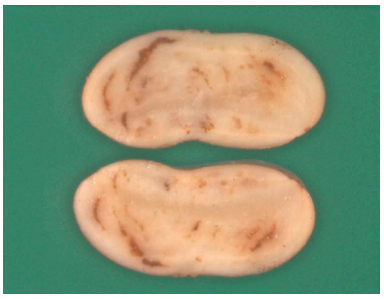

Fig. 4 Tobacco rattle virus infection in potato tubers vectored by stubby-root nematodes.

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