**TECHNICAL NOTE TN631 (Revised) / March 2024**

# Potato tuber pests

Farm Advisory Service

National Advice Hub
T: 0300 323 0161
E: advice@fas.scot
W: www.fas.scot

## Summary

- **Identification and integrated control of tuber pests**

## 1. Soil potato pests

There are a variety of pests that feed below the soil surface on potato roots and tubers. Most of these pests can be detected and population estimates obtained prior to planting and managed using resistant varieties and pesticide regimes or avoidance by choosing an alternative field.

## 2. Nematodes

### Potato cyst nematodes

There are two prominent species of potato cyst nematode (PCN) present in the UK: *Globodera rostochiensis* and *Globodera pallida*. Both species feed on the roots of the crop, hatching from cysts in the soil in response to chemicals given off by potato roots. This leads to stunting of growth and yellowing of foliage, subsequently lowering yield and sometimes quality (Figure 1).

Figure 1 - Potato cyst nematode symptoms in field. Stunted, uneven growth in large patches - termed a hotspot.

Cysts can usually be seen on the roots of the growing crop from late June - July onwards (Figure 2). Historically *G. rostochiensis* was the most common species but was managed using resistant varieties such as Maris Piper and Cara. Resistant varieties disrupt the life cycle of this nematode and prevent an increase in population numbers. Unfortunately, the use of *G. rostochiensis* resistant varieties which are susceptible to *G. pallida* has selected for the latter species. Consequently the levels of *G. pallida* have increased significantly over the last 30 years or so. There are currently a small number of varieties resistant against *G. pallida*, such as Innovator and Elland. Planting these varieties in fields will help to reduce the immediate *G. pallida* problem, however *G. rostochiensis* should not be forgotten about as it could become a problem again if there is an increase in use of varieties susceptible to it. Dual resistant varieties (having a resistance score between 7-9 for both *G. pallida* and *G. rostochiensis*) are the key to reducing the PCN problem. Only about 1% of PCN can reproduce or complete their lifecycle on resistant varieties so planting these will reduce the PCN population to below detectable levels. Viable PCN cysts can persist in the absence of potatoes for 20 years or more, and whilst there is some spontaneous hatching of cysts each season, natural PCN decline to below damaging levels can take several decades.

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Figure 2 - PCN cysts on potato roots. PCN cysts can be different colours depending on species and point in their life cycle. G. pallida cysts are pale yellow (pictured), while G. rostochiensis cysts are golden yellow. Over time PCN cysts turn a dark brown.

In Scottish soil samples tested by the SRUC Crop clinic between 2021 and 2023, an average of 44% of samples tested were positive for PCN. A subset of these positive samples was pathotyped - with 85% containing G. pallida, 3% contained G. rostochiensis, and 9% containing a mix of both PCN species.

The best estimate for how much of Scotland's growing area is infected with PCN stands at approx. 55,000 ha of 150,000 ha available – or around 35% of area (based on data from SASA, ScotGov). However, this could be an underestimation due to the high volumes of ware land going untested. Seed potatoes cannot be grown in fields where PCN is detectable, so the use of resistant varieties to reduce population numbers is imperative for reintroducing land for seed potato production.

Legislation covering the control of potato cyst nematode can be found in The Plant Health (Official Controls and Miscellaneous Provisions) (Scotland) Regulations 2019 No. 421. This draws upon previous legislation from the European Union (2007/33/EC). To grow seed potatoes land must be confirmed as PCN-free via statutory soil sampling completed by SASA through the Seed Potato Classification Scheme (SPCS). Any land found to fail this soil test will become "recorded", resulting in no seed legally allowed to be grown there until future tests deem it PCN-free. For land to be derecorded (Descheduling), a PCN test cannot be conducted until at least six years after the initial positive result was determined. Ware crops may be planted on recorded land, however an "Official Control Program" must be in place prior to planting.

Fields destined for farm-saved seed also need to have a statutory PCN test unless the seed is to be planted at the same place of production (i.e. the same holding) which has previously been tested. Farm-saved seed grown on untested land cannot be moved and planted 'off-farm'.

Seed growers can define how a field is to be divided into "sampled units" (minimum size 4 ha). The standard sampling rate is 1500 ml of soil per hectare. A lower rate of 400 ml/ha can be used if specific requirements are met. Using larger sampled units will reduce the amount of soil to be taken, and therefore the fees, but if PCN is found, the whole sampled unit will be classed as infested with PCN and subject to restrictions. A single cyst found in a 400 ml/ha soil sample roughly equates to a population of 5,000,000 cysts/ha.

When taking a PCN soil sample it is advised to take no less than 50 soil cores per hectare (Using a corer sized between 10-15 mm sampling to a depth of 25 mm). Increasing the number of cores taken and/or testing larger volumes of soil will increase the likelihood of PCN detection if it is present in the field. A sample should be taken in a "W" or zigzag pattern across the direction of cultivation of the sampled unit (Figure 3). Starting at one corner of the sampled unit, cores should be taken every few paces depending on stride length.

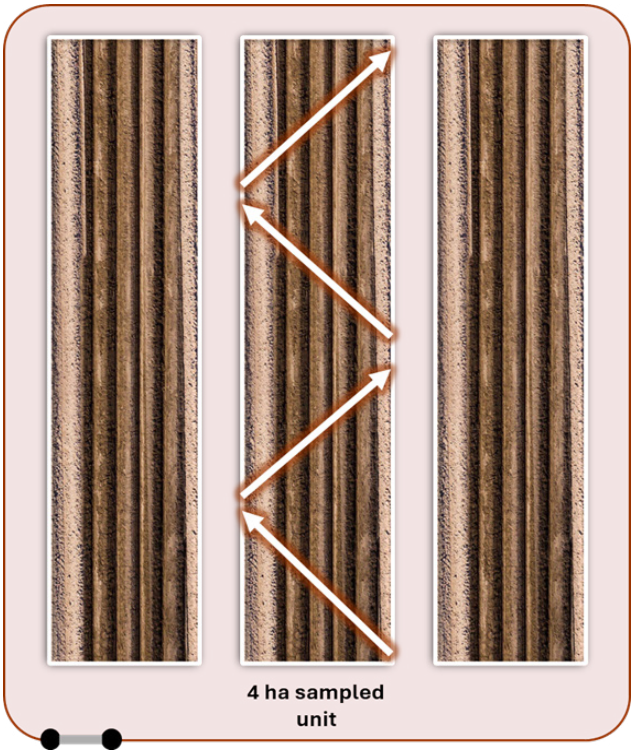


Figure 3 - Diagram depicting "W" or zigzag walking pattern required for PCN soil sampling.

An annual PCN survey of at least 0.5% of ware potato land is also conducted. Ware land is randomly selected each year for a post-harvest PCN test (approximately 16 fields in Scotland) at no additional cost to the grower. If PCN is found this land will be "recorded" as having PCN, However, a negative PCN test as part of the ware survey does not permit this land to go into seed production.

To grow ware potatoes in recorded land an official control programme (OCP) must be approved by the government prior to planting. The aim of the OCP is to suppress PCN populations by incorporating 'best practice' integrated pest management strategies such as:

- Increasing the length of rotations (a minimum of six years between potatoes is recommended)
- Groundkeeper (Volunteer) potatoes should be controlled as early as possible as they allow for PCN populations to persist and multiply while other crops

populations to persist and multiply while other crops are in the field.

- Growing resistant varieties –highly resistant varieties actively reduce PCN populations in field. Planting dual resistant varieties (a score of 7-9 for both *G. rostochiensis* and *G. pallida*) would be 'gold standard' practice.
- Use of certified seed stocks.
- Chemical control - Nemathorin (Fosthiazate) and Velum Prime (Fluopyram) are available for use against PCN. It should be noted these chemicals are not generally effective at reducing PCN populations, rather they slow their ability to infect the plant, therefore providing protection of crop yield.
- Other methods – Biofumigation, trap cropping, and biocontrol (under certain conditions)

It is also good practice for those growing susceptible ware varieties to test soil after potatoes have been harvested. This provides a baseline to determine when it is suitable to grow another ware crop and what measures may be appropriate to reduce PCN population size.

Management of PCN relies on knowing what species are present. This is particularly important if renting land for ware production. Soil sampling and testing soil for the species and population size of PCN is strongly recommended, as this can influence choice of variety planted and whether the population of PCN will reduce yield. Note that even if a resistant variety is to be planted, yield loss can still occur if PCN populations are above 10 eggs or juveniles/g soil, as the resistance is expressed by a reduction in PCN multiplication, not in prevention of feeding. Some varieties, regardless of resistance status, are not particularly tolerant of PCN feeding. Intolerant but resistant varieties will still display symptoms and possibly yield losses, associated with PCN infested land while reducing the overall population.

## Free-living nematodes

These are nematodes that live in the soil and can feed on a wide range of plants including weeds. They were covered in detail in a previous Technical Note (TN603: Soil Dwelling Free-Living Nematodes as Pests of Crops). The three main groups of free-living nematodes (FLN) that affect potatoes are the needle nematodes (Longidorus spp), the stubby-root nematodes (*Trichodorus* and *Paratrichodorus spp*) and the root-lesion nematodes (*Pratylenchus spp*). The needle and stubby-root nematodes feed externally on the roots and root hairs, whereas root-lesion nematodes will also feed internally within the 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. FLN feeding can increase root biomass by thickening and proliferating the roots. This delays tuber initiation and gives an uneven spread of tuber size and number, reducing the marketable yield. Reductions in marketable yield by as much as 50% have been seen in SAC field trials. There may also be effects on fry quality and sugar content, which are important for potatoes destined for processing. FLN can also cause reduced, stunted top growth at higher populations (Figure 4).

Figure 4 - Free living nematode damage to plants - Nematicide protected (left), unprotected (right)

*Trichodorus* and *Paratrichodorus spp.* have the additional threat of being vectors for tobacco rattle virus (TRV) where even lower population levels may cause severe crop losses due to "spraing" symptoms (Figure 5). On average only 2% of samples sent to the SRUC Crop Clinic for FLN testing return a negative result (Zero *Longidorus, Trichodorus,* or *Pratylenchus spp.* detected).

Figure 5 - Spraing symptoms due to TRV infection of tubers.

### Control

Management of FLN in soil is challenging as they can feed on a wide diversity of host species and build up their numbers on other crops and weeds in the period between potatoes. They can cause damage to other crops such as stunting in cereals, as well as causing misshapen growth of root crops such as carrots, parsnips,

and onions.

Obtaining an estimate of the population of FLN in soil pre-planting is essential, as is determining whether Trichodorids present are carrying TRV. If populations are high, then there is a threat of feeding damage (and/or TRV), so the crop will need protecting using a nematicide. Nemathorin (Fosthiazate) and Velum Prime (Fluopyram) can be applied as a broadcast treatment prior to planting. Nemathorin is only approved for use in potato crops, but Velum Prime is approved for use in both carrots and parsnips too, adding a wider range of control for FLN/TRV across a rotation.

These treatments will protect the crop from root damage and TRV, but because they do not directly kill the nematodes, only paralyse them until the concentration of the active ingredient declines and the nematodes 'wake up'. Use of these nematicides does not significantly reduce the nematode population in the soil. Maintaining relatively weed free crops in a rotation may help to reduce persistence of TRV in the soil.

## 3. Wireworm

Wireworms are the larvae of click beetles, of which there are approximately 70 known species in the UK. The most damaging species to crops such as potatoes are *Agriotes lineatus, A. obscurus,* and *A. sputator.* Depending on the species, the larvae take 3-5 years to complete their life cycle. Typically click beetles lay their eggs in soil, just below the surface. It can take 4-6 weeks for the eggs to hatch into wireworm. Historically it is known that fields where there has been grass in the rotation (particularly long-term grass) are more likely to have wireworm present. However, wireworm is now frequently and increasingly being found in fields where:

- No grass has been in the rotation in recent history.
- There have been no cover crops planted.
- Multiple cereal crops are in rotation.
- Land is ploughed every year.
- Land is left bare (high weed population)

It is clear now that wireworm can thrive under diverse field conditions and therefore becoming a larger problem across the UK.

Once wireworm is established, they can remain in the soil feeding upon the roots and shoots of many crop plants such as vegetables (potatoes, onion, leek, parsnips, radish, & sugar beet), cereals (maize, wheat & barley etc.), and fruit (strawberry). The larvae feed on the roots and tubers of potatoes, having a significant impact on tuber quality (Fig. 6). Fallow and the increased use of over-winter cover crops will increase the risk of wireworm as will the presence of weedy grassy stubble. The inclusion of flower strips and widening headlands as part of integrated pest management strategies to increase natural enemies of pests such as aphids is becoming more prevalent. This may see an unintended increase in wireworm problems in coming seasons by increasing/improving habitats in which they are likely to reproduce in.

Tolerances for wireworm damage by potato processors and supermarkets usually vary between 0-5% of tubers with holes less than two peels deep, consequently wireworm management often resorts to 'don't plant potatoes in fields where wireworm is present'. However, there are management options open to growers to reduce the threat from wireworm.

Figure 6 - Wireworm damage to a potato tuber.

Because of the long-life cycle of the wireworm, their presence in soil can be determined 1-2 seasons before potatoes are to be planted. Core samples from soil can be taken to detect wireworm presence/absence. Crop damage usually occurs in the region of 10-20k wireworm per hectare depending on variety and duration of the crop. The threshold for wireworm detection is ~60-65k/hectare so it is possible to observe wireworm damage in the field but be under the limit of detection. Bait trapping is also used to detect wireworm in the soil. A bait trap could be a plastic container with holes in the side which is filled with a mixture of cereal seed (e.g. maize or wheat) and bran which is buried in the soil or burying some potatoes and assessing them for wireworm damage. For either bait trap method to give valid assessments of wireworm presence, they need to be buried to a depth of around 15 cm, and when soil temperatures exceed 8 ºC (daily average temperature). Wireworm are less likely to feed at temperatures below 8 ºC, as well as the seed used in traps being less likely to grow at lower temperatures. More information can be found in the EPPO standard (EPPO PP1 - PP1/046(3) - Wireworms). Ideally bait traps should be used between early spring (late March to mid-April) and early autumn (Sept-Oct) but this is very dependent on the soil temperature. Traps need to be left for 2-3 weeks to allow wireworm to feed. Detection of 1 wireworm in 10 traps will usually result in damage to the crop. Either approach requires the trap and soil immediately surrounding the trap to be assessed for the presence of wireworm as well as looking for wireworm damage to the potato. It should be noted that using numbers from a bait trap or soil cores to determine risk status is not always advisable – extensive damage can be seen in fields where only small numbers of the pest are observed.

An alternative approach is to use pheromone traps to detect click beetles emerging from the soil the season before potatoes are to be planted. The pheromone trap needs to be in place from April to August, which is when the beetles emerge from the soil, however installing

traps in late March will give the best chance of capturing early activity. Setting up multiple traps using different lures specific to the three main species (*A. lineatus, A. obscurus*, and *A. sputator*) can give better population estimates. Use caution when judging risk from any type of trap data as all methods can be unreliable in terms of equating population size to damage observed in the crop.

**Control**

If there is a threat from wireworm, and there is no opportunity to change fields, then the options open to the grower are choice of a less susceptible variety, use of an insecticide, and early lifting.

Some potato varieties are less prone to damage (Tolerant) than others, but it should be noted that there are no potato varieties resistant to wireworm damage. Varieties less susceptible to damage include Maris Piper and King Edward, while Maris Peer, Marfona, and Rooster are examples of more susceptible varieties. It is not currently known why some varieties are less likely to be damaged by wireworm. It has been theorised however that it could be due to variations in sugar levels or other metabolites (glycoalkaloids) produced by the plant as these are known deterrents of other pests e.g. Liriomyza spp. (leaf miner) and *Spodoptera spp.* (moths). Although there are no resistant potato varieties, there is wireworm resistance in terms of planting less susceptible crops in rotation such as buckwheat and mustard. If these could be built into the rotation of an infested field, they could serve to reduce numbers. Incorporation of certain crops as biofumigants have had varying results against wireworm.

Currently Nemathorin (Fosthiazate) is the only insecticide available with approved use for wireworm on-label. Nemathorin needs to be broadcast prior to planting, but it should be borne in mind that these will only reduce wireworm damage to some extent. Test digs should be undertaken from early August to see if wireworm damage is occurring. If so, then crops should be lifted as soon as practically possible, as the longer potatoes are in the ground, the greater the damage will become. Other options to try and reduce populations include soil cultivation (inversion carried out at a slow speed) in the autumn and/or spring to allow birds to feed on the exposed wireworms. Although not approved for use in the UK yet, there are biological agents (Fungi/Bacteria) in the pipeline for wireworm control. There are new wireworm chemistry and biologicals coming to market soon, however at time of writing they are still in the regulatory process so not available for the current season.

## 4. Slugs

Of the several species of slugs found in arable soil, some are more damaging to potatoes than others. The most common slug species seen is the grey field slug (*Deroceras reticulatum*), however this slug is more opportunistic as it prefers to feed on tubers already damaged by other pests or disease. The slugs that particularly target potato tubers are the keeled slug (*Tandonia spp.*) and the garden slug (*Arion hortensis*). Like many pest species, slugs can establish quickly in a field as they can lay hundreds of eggs (species dependent) which hatch coinciding with crop growth.

Lower slug populations are needed for damage to potatoes than for damage to cereals, and slugs tend to attack damaged tubers in preference to undamaged. Slug damage can continue in potato stores if slugs have been lifted with the crop – both by causing feeding damage and leaving trails over the tuber surface (Figure 7).

Figure 7 - Slug on potato tubers in cold storage.

Most growers will be aware of ‘sluggy’ fields or areas within fields perennially prone to slug problems. Slug management can start in the previous crop by reducing the population of adult breeding slugs by creating fine seed beds, consolidated by rolling or ploughing the areas particularly prone to slug damage. Use of slug pellets in the preceding autumn on crop stubble can also reduce slug populations to some extent by targeting slugs prior to breeding, consequently reducing the numbers of eggs hatching the following spring. Harvesting tubers as early as possible will also minimise slug damage as it reduces tuber exposure to the pest.

Slug monitoring using baited traps can gauge the risk level prior to planting and throughout the season. As with wireworm, some potato varieties are less susceptible to slug damage than others, but if slugs are hungry, they will still damage these less susceptible varieties. Varieties such as Pentland Dell, Lady Rosetta, and Hermes are less susceptible to slug damage than the very susceptible cultivars Maris Piper, Cara, and Saxon. If slug damage is seen when carrying out test digs, then crops should be lifted as soon as possible. In an SAC trial, a Maris Piper crop lifted on 8th August had 10% of tubers damage, when lifted on 3rd October had 30% damaged, and lifted in early November had 45% damaged.

**Control**

If there is a risk of slug damage, gauged by previous experience and/or slug trapping, then slug pellets can

be applied, but the timing of these treatments is crucial for their success. Trials have consistently demonstrated that at least an equivalent of 2 full-dose pellet treatments are needed to protect tubers from slug damage. The most important timing for slug pellet application is just before the crop canopy meets across the rows. It is important to apply a single full-dose at this timing. If this timing is missed then regardless of how many applications are made, slug damage will still occur. This timing is crucial as slugs will come up onto the soil surface once the crop canopy meets, as the humidity under the crop draws slugs up onto the surface. Once crop canopies have met it is more difficult to get the pellets to the base of the plants. Timing for subsequent applications is usually during tuber bulking and just before or just after haulm destruction. Typically, a half-dose is applied at these later timings. Slug pellets (ferric phosphate) are available for field use – killing slugs within 3-6 days on contact.

A novel approach to slug management in potatoes (including organic crops) is the use of a slug-specific pathogenic nematode *Phasmarhabditis hermaphrodita* which actively seeks out soil-dwelling slugs. Slug death occurs between 7-21 days after nematode application, slower than slug pellets, however the slugs cease feeding immediately once infected with nematodes. These are available as Nemaslug Xtra and must be watered into soil during the season. A programme of 2-3 applications has been shown to be very effective and can also be used in conjunction with slug pellets in an integrated management programme.

## 5. Symphylids

Over the last few years some crops in the UK on light land have had poor emergence in patches, with plants within these patches having stunted roots, with distinct dark stem lesions which have allowed fungal rots to take hold. Closer examination of the soil reveals the presence of small (1-9mm) white insects with 6-12 pairs of legs, which resemble tiny millipedes. These are symphylids (*Scutigerella immaculata*).

Because of their size, symphylids are difficult to detect in the soil, and it is only after the damage has been noticed does thought usually turn to symphilids being the culprits. The symptoms observed can often go misdiagnosed as being caused by free-living nematodes and *Rhizoctonia solani*. The 'bucket of water' test can usually detect them; dip the roots of damaged plants in a bucket of water and shake about, remove, and wait a few minutes. The small, white symphylids will float up to the surface and will still usually be wriggling around. Other small, white insects called springtails may also be present. Differentiation between symphylids and springtails can be made as springtails only have 3 pairs of legs. Large populations of springtails need to be present to cause damage to potatoes, but only 2-3 symphylids per plant may be enough to damage potato roots under the right conditions. Symphylids move up and down the soil profile depending on the moisture content, as they dislike the dry conditions near the soil surface. They can live for several years, and population levels may reach between 100 to 600 individuals per square metre. It is difficult to obtain an accurate assessment of symphylid numbers before sowing, as they will still be relatively deep down in the soil.

**Control**

Symphilids rarely cause widespread damage to potato crops. To try and minimise any problems due to feeding by symphylids, avoid planting tubers in cold, wet soils where emergence may be prolonged and allow greater time for damage to occur pre-emergence. As there may be other causes of patchy, poor emergence such as free-living nematodes, soil borne *Rhizoctonia*, dry rot, and skin spot, ensure that correct diagnosis of the problem is obtained. Pesticides applied for control of PCN, free-living nematodes and wireworm may have a positive effect against symphylids although there is currently no insecticide with symphylid control on label.

## 6. Cutworm

Cutworms are the larvae of turnip-, heart- and dart moths which lay their eggs on the lower leaves of potatoes and other vegetable crops. The caterpillars initially cause superficial damage to the older leaves of potato, but then drop down to the soil and feed at or just below the soil surface where they can chew their way through the stem of the plant. The presence of cutworms will only be noted at night when they come to the soil surface to feed. The egg-laying moths prefer weedy crops so good weed control will reduce the likelihood of a cutworm problem. Also young cutworms cannot survive in wet soils so irrigation or rainfall at the time of egg hatch will kill off a lot of young larvae.

**Control**

Spraying for this pest can be applied if moths are observed in pheromone traps. The young larvae initially feed on the lower leaves and so are vulnerable for a short time to foliar sprays. However, if the spray necessity coincides with wet weather, then no chemical treatment will be needed. Sprays containing the actives cypermethrin or zeta-cypermethrin are approved for cutworm use. Seed potato crops tend to be more at risk than ware. Biological control agents for cutworms also exist, including *Bacillus thuringiensis*, an entomopathogenic bacteria. Entomopathogenic nematodes such as *Steinernema spp.* and *Heterorhabditis spp.* can also be used to control cutworm populations.

**Author:**

Andy Evans, SAC Consulting

**Revised by:**

Kerry Leslie, SAC Consulting
Stuart Wale, SAC Consulting
Martyn Cox, Blackthorn Arable Ltd.

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