



Syngenta
POTATO
SCIENCE



STEWARDSHIP GUIDE



Nemathorin[®]

syngenta[®]

INTRODUCTION

This NEMATHORIN stewardship guide has been produced to provide both the grower and the operator with the necessary knowledge to make safe and effective applications of NEMATHORIN. Without effective stewardship of nematicide products, legislative authorities will not continue to register them for use.

Stewardship documents such as this complement the activities of the Nematicide Stewardship Programme (of which Syngenta is a member). The NSP aims to set a single industry standard for the application of synthetic granular nematicides; ensuring a best practice approach across all aspects of their use, from delivery on farm through to operator handling, machinery set up and maintenance, to application and storage.

For more information on the NSP visit www.nspstewardship.co.uk

Syngenta's area managers are available to offer advice and support through face to face meetings with growers and operators and Syngenta's technical advice helpline is open Monday to Friday with an emergency helpline available 24 hours a day.

Syngenta Technical Helpline: 0800 169 6058

Email: customer.services@syngenta.com

24 hour Emergency Helpline: 01484 538444

www.syngenta.co.uk

▶ **ALL ELEMENTS OF THE PRODUCT LABEL MUST BE FOLLOWED.**

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EFFECTS OF SOIL PESTS

Soil pests such as Potato Cyst Nematode (PCN), Free-living Nematode (FLN) and Wireworm can cause considerable damage to crops. PCN alone is the most important potato soil pest, costing the potato industry millions of pounds each year and additional costs are incurred by processors and retailers due to reduced crop quality from the effects of other pests.

1.1 Potato Cyst Nematode

There are two main species of PCN, *Globodera rostochiensis* and *Globodera pallida*. *G. pallida* populations have risen over the past few years and, being the more difficult of the two species to control, has caused increased problems.

Larvae of both species feed on the plant roots causing dwarfed plants, premature death and therefore lower yields. The eggs hatch in the spring when potato roots begin growing and over the growing season females develop into cysts which can contain up to 600 eggs each. Eggs can remain viable in the soil profile for many years.

1.2 Free-living Nematode

Free-living Nematodes (FLN) live within the soil profile and are responsible for transmitting Tobacco Rattle Virus (TRV) which causes brown internal cork-like effects called Spraing. Spraing can render a crop of potatoes almost worthless and therefore FLN control is very important. FLNs are most mobile in light sandy soils and this is where they are likely to cause most damage.

1.3 Wireworm

Wireworm have become more prevalent in recent years resulting in an increased risk of feeding damage. Wireworm are the larvae of click beetles and they feed on potato tubers. The larval stage can last for 4-5 years resulting in the potential for damage which reduces the value of pre-pack crops and can be particularly costly in processing crops where damage has penetrated through the skin and excessive peeling is required.

NEMATHORIN has been proven to have activity on all three of these major soil pests.

Golden eggs of *G. rostochiensis* and white eggs of *G. pallida*



Internal tuber damage caused by Spraing

Wireworm

PCN ALONE IS THE MOST IMPORTANT POTATO SOIL PEST, COSTING THE POTATO INDUSTRY MILLIONS OF POUNDS EACH YEAR

2 INTEGRATED CROP MANAGEMENT

2.1 Integrated crop management

The principle of Integrated Crop Management (ICM) suggests that the method of cultivation, rotation and variety choice should form the first line of defence in crop protection. Prediction and evaluation by mapping and forecasting should be used where possible and biological control should come before chemical control in an Integrated Crop Management strategy.

2.2 Integrated pest management

Monitor and identify pest:

- Soil sampling
- Pheromone traps
- Bait traps

Record keeping:

Keeping a record of pest species and numbers can help to identify if your pest management strategy is effective and if changes need to be made. A record of the application of any chemical products must be kept. Such records should include:

- Date of application
- Rate applied
- Method of application
- Method of soil incorporation
- Weather conditions at time of application
- First incidence of rain after application

Weather records and irrigation records can also be useful.

Prevention:

Land which is free of PCN, FLN and Wireworm should be kept clean using the following methods:

Good hygiene

- Ensure all machinery is free of soil, particularly contract and shared machinery which operates on other land
- Dispose of waste soil in the field of origin or in a sacrificial area
- Be careful of bringing slurry or manure onto farm as PCN can survive through the digestive system of animals
- Ensure all waste disposal arrangements are in compliance with Waste Management Regulations

Plant certified seed

There is a significant risk of introducing PCN to clean land via seed potatoes. As a result there are significant rules in place related to PCN and the production of seed potatoes. More information can be found in the AHDB PCN Grower Guide.



Wireworm

Trap cropping and biofumigants:

A 'trap-crop' such as Sticky Nightshade (*Solanum sisymbriifolium*) can be used as its root system mimics that of the potato plant and therefore the exudates from it stimulate egg hatch for both species of PCN. This plant is completely resistant to attack by PCN therefore the PCN die, thus reducing the risk to the following potato crop.

Brassica plants with high concentrations of secondary metabolites known as glucosinolates can in some instances be used to suppress soil-borne pests through a process known as biofumigation.

Tissue disruption from mechanical maceration and incorporation of the plants into soil, causes enzymatic degradation of the glucosinolates in plant cells, which subsequently causes the release of a range of plant volatiles from the tissues. Caliente mustards (*Brassica juncea*) are known to release allyl isothiocyanate volatiles following tissue disruption.

Rotation:

The greatest natural decline in PCN populations is usually seen in the first 10 years. The decline is dependent on the starting PCN population, species and environmental factors. Extending rotations may therefore reduce the PCN population in the soil. Volunteer potatoes between potato crops must be controlled for this method to be effective.

2.3 Variety choice

A resistant variety reduces (partial resistance) or prevents (full resistance) nematode multiplication. Root invasion and damage still occurs!

A tolerant variety yields well in spite of root invasion, BUT does not prevent multiplication! Use of a tolerant variety, despite giving reasonable yields, will leave a legacy of high PCN population in the soil and is therefore not a sustainable method of PCN management when used alone.

The AHDB Potatoes Variety Database should be consulted for more information on varietal resistance/tolerance and growers should also speak with their contract provider for details of end market acceptability.

2.4 Chemical control

Use a nematicide product such as NEMATHORIN (which contains the active ingredient fosthiazate).

Granular nematicides in general, have been shown to reduce the multiplication of post-cropping populations of PCN and reduce yield losses.

2.5 Evaluation

Assessing the Pf/Pi ratio (final PCN population (Pf) divided by the initial population (Pi)) indicates the efficacy of the product or method used for control. Lower values for this ratio indicate more efficient control.

3 SOIL SAMPLING, PEST COUNTS AND RECOMMENDATIONS

3.1 Soil sampling for PCN & FLN

PCN

In order to manage PCN effectively it is critical to sample soil from fields prior to planting to know if PCN is present. This soil sampling protocol for PCN has been developed by the Nematicide Stewardship Programme, following an industry consultation. It is intended to provide current best practice guidance for sampling of existing PCN infestations in fields of all soil types selected for the production of ware crops.

The sampling guidance outlined below should not be considered to be one which will guarantee detection of low levels of PCN (e.g. where fields have recently become infested with PCN).

The results from soil tests will assist variety choice and the development of a pest management strategy. Results from your soil tests should be discussed with your agronomist/advisor.

Historically, sampling has been done in autumn/winter immediately before potato cropping – sampling close to the time of planting will provide the best indication of the population levels that will impact on that season’s crops. However, to enable rotations to be planned well in advance of potato planting, sampling can be done at other times within the rotation. Counts will be more reliable if samples are taken once several cultivation operations are completed after potato harvest. This ensures mixing of cysts within the soil profile. At the time of sampling the following guidance should be adopted.

Best practice guidance for PCN soil sampling in fields of all soils types, selected for ware production

- Unit area: 1 ha square block or less (not strips or areas based on soil type)
- Numbers of samples per unit area: a minimum of 49 cores taken on a grid pattern. Grid pattern is preferred for satellite positioning-based sampling
- Auger: 10-15 mm diameter
- Depth of sampling: Insert the corer to a depth of up to 25 cm
- Soil samples should not be ‘topped up’ by adding an extra amount of soil after the last core is taken
- All of the sample should be sent to a laboratory, no sub-sampling should occur in the field

PCN cysts will be extracted from soil in a laboratory. The sample processed to extract the cysts should be as large as is practicable. This reduces the error in the estimation of PCN density.

These best practice guidelines are designed for ware production, but there are statutory regulations covering soil sampling for PCN in fields selected for potato seed production and 2010 saw the introduction of the new arrangements as a result of the implementation of Directive 2007/33/EC. It is a requirement of the Seed Potato Classification Scheme (SPCS) that all crops entered for inspection **must** be grown on land for which a PCN clearance certificate is in force at the time of planting.

For more information refer to the AHDB PCN grower guide.

3.2 Thresholds

PCN Thresholds	
Results Category	Advice
None found	No treatment necessary. However, a result of 0 eggs/g does not mean there is a complete absence of PCN.
Non-viable	Only non-viable eggs found, no treatment necessary. However, this does not mean there is a complete absence of viable PCN eggs.
Low (1-8 eggs/g)	Nematicide use is recommended especially if using a close cropping rotation or in light soils where there is additional stress. The use of a PCN resistant variety may limit nematode multiplication.
Moderate (9-15 eggs/g)	Nematicide treatment is highly recommended. The use of a PCN resistant variety in conjunction with nematicide treatment should be considered.
High (>15 eggs/g)	Consider other ground. Note: Silt land and black land (>50% organic) may withstand higher populations of 20-30 eggs/g.

FLN

The AHDB Potatoes publication ‘Plant Parasitic Nematodes’ provides a summary of the general guidance from several laboratories which process samples to detect and quantify FLN populations. Growers and advisors should refer to this publication for sampling guidance and more information on FLN.

There is currently very little industry information regarding thresholds for FLN. The transmission of Tobacco Rattle Virus (TRV) which causes Spraing is not dependent on a certain number of FLN in the soil, it simply depends if those present are carriers of the virus. The risk of feeding damage is dependent on the population of FLN and the species present. Conditions at the time of planting can also impact upon the risk posed by FLN; if soils are cold or wet then the risk of damage is increased.

With regard to damage thresholds for FLN direct feeding damage, the AHDB Publication referred to previously states:

There is limited published information on the relationship between the numbers of FLN present and yield loss or reductions in quality of potatoes. The reports that are available refer to:

Damage thresholds for Trichodorus being at/above 100 nematodes/250 g soil.

Damage thresholds for Longidorus being 20-25 nematodes/250 g soil.

Damage thresholds for Pratylenchus penetrans ranging from 25 nematodes/250 g soil up to 625 nematodes/250 g soil.

Again, growers and advisors should refer to the full publication for more information.

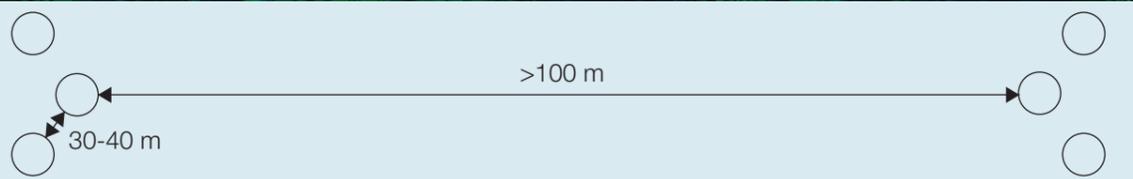
3 SOIL SAMPLING, PEST COUNTS AND RECOMMENDATIONS

3.3 Wireworm monitoring

Wireworm monitoring has been developed by using pheromone traps to detect populations of all three species of click beetle which are the adult form of wireworm. By attracting click beetles using species specific pheromones and trapping them, the population of wireworm can be inferred. The pheromone traps can detect levels that traditional soil sampling and bait trapping are not able to. Labour requirement is low and no identification skills are necessary, since the traps themselves are species specific. Traps should be set in the previous crop in May-July prior to potato cropping, allowing plenty of time for a pest management decision to be made according to IPM practices.

It is recommended that two sets of three traps (one with pheromone for each species of click beetle) are used per field. The distance between each set should be greater than 100 m and traps should be placed well away from headlands.

Bait trapping is another form of monitoring for wireworm, which should be carried out in the spring, prior to planting potatoes the following season, when soil is warming and wireworm rise to the surface. Traps should be buried in the soil close to the surface and filled with a food source such as an old potato.



Example of field set up of pheromone traps

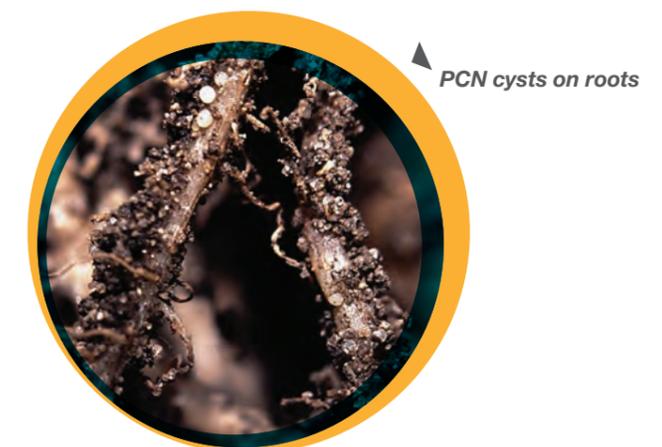
Wireworm pheromone trap result recommendations	
Results Category	Advice
None trapped	If no wireworm are detected in subsequent soil sampling and bait trapping the risk of wireworm damage is very low and it is likely that potatoes may be grown safely without the use of a nematicide.
<50 click beetles trapped	Some tuber damage may occur. Either apply NEMATHORIN at 15 kg/ha to reduce damage or plant a variety that can be lifted early to reduce damage occurring.
50-100 click beetles trapped	Significant tuber damage may occur. Apply NEMATHORIN at a rate of 15 kg/ha to reduce damage but commercially significant damage can still occur.
>150 click beetles trapped	Severe damage is VERY likely. Growers should avoid growing potatoes in this field.

4 USING NEMATHORIN

If you decide that using NEMATHORIN is the best option for the pest problem you have, the following advice must be adhered to:

- For the control of PCN and a reduction of Spraying transmitted by free-living nematodes, the maximum dose of NEMATHORIN is 30 kg/ha broadcast overall and incorporated immediately before or at the time of planting
- For reducing wireworm damage the maximum dose of NEMATHORIN is 15 kg/ha broadcast overall and incorporated immediately before or at the time of planting
- Granules must be applied and fully incorporated to a depth of 15 cm in one pass to avoid leaving granules exposed on the surface
- **DO NOT APPLY NEMATHORIN IN-FURROW**
- Operators must have a PA4G or PA4 qualification, complete the ARTIS training on nematicide stewardship and be a member of NRoSO
- Bury small spillages immediately
- Machinery should be calibrated at the start of every season and checked regularly throughout the season. Machinery must be professionally calibrated every two years
- Applicators must have the facility to shut off granule flow before the row end
- Check treated fields 24 hours after application for adverse effects to wildlife
- Once planted the crop must be grown for a minimum of 119 days (17 weeks) before haulm destruction (flail or desiccation) or green top lifting

- If a prolonged period of dry weather is experienced prior to tuber initiation, consider irrigation
- If a crop starts to senesce before 119 days the grower should consider a pre-lifting residue test
- The grower has responsibility for ensuring that the MRL is not exceeded to avoid the crop being rejected
- Avoid lifting NEMATHORIN Surefills by the stacking ring, use the handles on the containers themselves. Take care when handling and moving Surefills to ensure that no damage is caused to any part of the container, including the stacking ring
- NEMATHORIN Surefills come on a pallet with 27 containers (9 x 3 high), these pallets should never be double stacked



Always read the label and product information before use.

For more information on best practice see www.nspstewardship.co.uk

5 FACTORS AFFECTING NEMATICIDE EFFICACY

There are many factors which affect the performance of granular nematicides, some of which are beyond our control. It is important to understand how these factors influence the products in order to take actions which will help to get the best performance possible.

5.1 The product

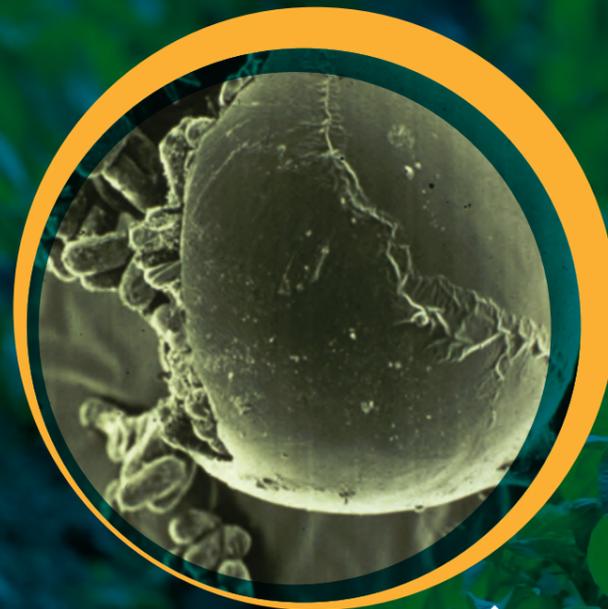
Product degradation – the half life of NEMATHORIN (the time it takes for half of it to degrade) in soil is approximately 35 days. This means that after 70 days only 25% of the initial concentration of the active ingredient will be present. This natural degradation is important to prevent residues occurring in the final crop. However, if PCN eggs hatch late, or a second generation hatches later in the season, then the ability of the nematicide to control these populations is decreased due to the degradation of nematicide in the soil.

5.2 Human error

Soil sampling – the use of improper soil sampling techniques can lead to a misinterpretation of the initial PCN/FLN population. Underestimating the initial population may reduce the efficacy of the nematicide.

Field selection – close rotation can lead to PCN populations building very rapidly. The use of ground which is known to have high PCN/FLN populations is likely to reduce the efficacy of a nematicide.

Application error – reduced efficacy of the product and lower concentrations of a nematicide within the soil may be caused by poor application. Under-applying the product due to poor calibration of machinery and incorporation with too much soil will reduce the efficacy of the nematicide.



PCN cyst

5.3 The environment

Warm, moist soil conditions – warm, moist soil conditions may cause the degradation of the active ingredient to be more rapid.

Soil biology – the degradation of the active ingredient in a nematicide is carried out by bacterial organisms in the soil. With multiple applications of the same active ingredient to the same ground the population of these organisms will increase, and therefore the speed of nematicide degradation will also increase. This effect has not been proven to occur with repeated use of NEMATHORIN. **Do not apply NEMATHORIN more than once every four years on the same field.**

Soil moisture – the active ingredient in the nematicide may not be activated in continuous dry/warm conditions and PCN hatch may occur.

5.4 Pest biology

Species population – an increase in the population of *G. pallida* in recent years is well documented. *G. pallida* egg hatch occurs later than *G. rostochiensis* which was previously more common. Extremely dry weather conditions and slow root development in the early stages of growth may also cause eggs to hatch later. If eggs hatch later when nematicide activity has declined the efficacy of the product can be reduced.

2nd generation – an increase in spring soil temperatures could lead to the development of a second generation of PCN within the growing season resulting in a reduction in efficacy.

Rapid life cycle – rapid life cycling and therefore faster maturation of PCN (possibly caused by warmer soil conditions) could lead to greater competition for root nutrients and the efficacy of the nematicide can be reduced.

5.5 The crop

Unusual crop growth – if early root growth is impeded by environmental conditions then the stimulation of egg hatch will not occur at the optimum time for control.

Variety choice – a number of varieties are classified as resistant to *G. rostochiensis*, however very few are resistant to *G. pallida*. Some species are tolerant to *G. pallida*, however the use of a tolerant variety alone is not a recommended method of PCN management. PCN populations will still multiply over the course of the season, despite the tolerant variety yielding well. The choice of cultivar used should be based upon the AHDB Potatoes Variety Database and end contract acceptance.

6 OPERATOR SAFETY

6.1 Before use

Always read the label thoroughly before considering use of a pesticide product. For the full label visit: www.syngenta.co.uk/product/crop-protection/nemathorin-10g

- Do not use NEMATHORIN if you have been advised by your doctor not to work with anticholinesterase compounds
- Ensure a COSHH assessment has been carried out
- Ensure those dealing with the product have the necessary qualifications (NPTC PA4 or PA4G)

NEMATHORIN 10G

Fine granule containing 10.0% w/w fosthiazate



Signal word: Danger.

Hazard statements:

Toxic if swallowed.
Toxic to aquatic life with long lasting effects.

Precautions statements:

Avoid breathing dust.
Wash hands thoroughly after handling.
Do not eat, drink or smoke when using this product.
Avoid release to the environment.
Wear protective gloves/protective clothing/face protection.
IF SWALLOWED: Immediately call a POISON centre or doctor/physician.
Specific treatment (see first aid instruction on the label).
Rinse mouth.
Wash contaminated clothes before re-use.
Store locked up.

Supplemental information

Toxic by eye contact.
To avoid risks to human health and the environment comply with the instructions for use.
Contains Fosthiazate (ISO) (98886-44-3). May cause an allergic reaction.

6.2 During use

- Ensure there is adequate ventilation in the area of use
- **Wear the correct Personal Protective Equipment:**
 - When handling the product, adjusting granule application machinery, cleaning contaminated equipment and handling contaminated surfaces always use the following:
 - Protective clothing (coveralls)
 - Suitable gloves
 - Eye protection (goggles)
 - Filtering facepiece respirator (disposable filtering facepiece to at least EN149 FFP3)
 - When applying product using tractor mounted/ drawn machinery:
 - Wear protective clothing/coveralls
 - Wash all protective clothing after use. Take off immediately heavily contaminated clothing
 - Wash dust from skin or eyes immediately
 - DO NOT breathe dust. Avoid all contact by mouth
 - Wash hands and exposed skin before eating, drinking or smoking



SUREFILL™ PACKAGING

NEMATHORIN is packed in returnable and refillable Surefill containers (right).

The Surefill system provides a clean, quick and safe closed-transfer system, which minimises the risk of operator exposure or spillage during filling in the field.

Take care when handling and moving Surefill containers to minimise the risk of causing damage to the stacking ring. Refer to section 4 for further information on Surefill handling.

Returnable containers eliminate any packaging waste. Mindful of the need for farmers to meet waste management legislation, Syngenta is committed to minimising waste through concentrated formulation technology and innovative packaging design. Furthermore, Syngenta supports a range of initiatives to reduce and recycle packaging.



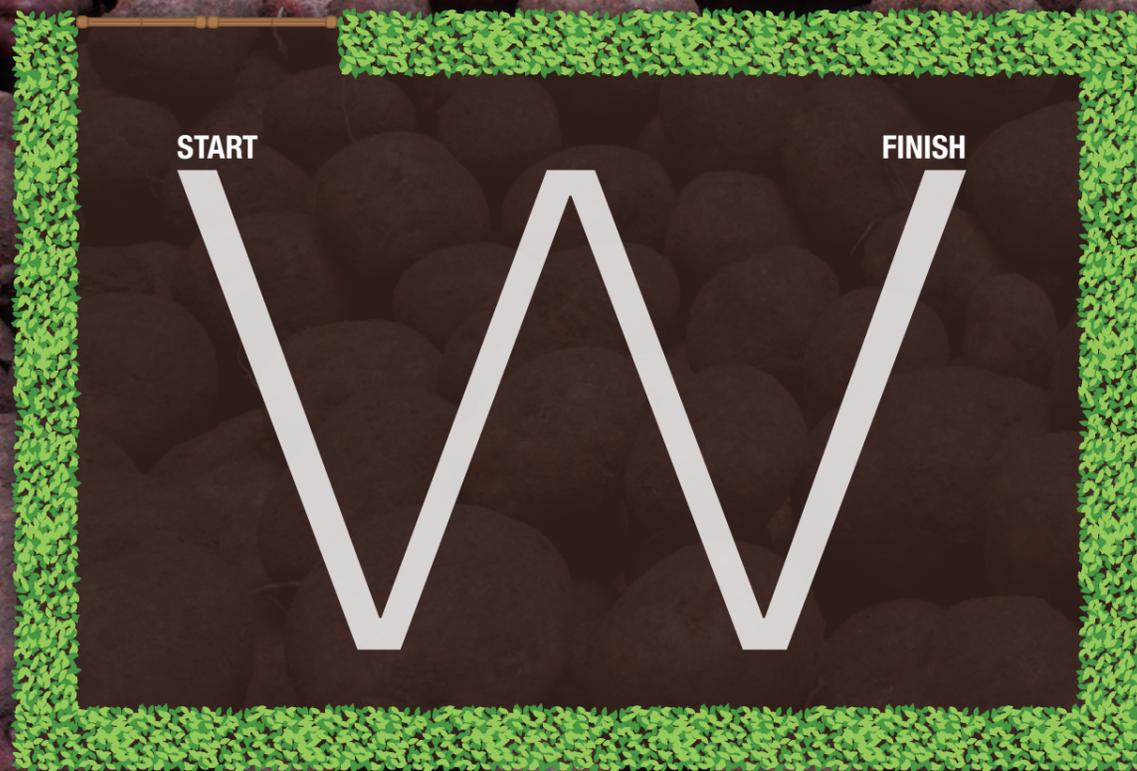
7 MINIMISING ENVIRONMENTAL RISK

- NEMATHORIN is dangerous to livestock therefore livestock should be kept out of treated areas for at least 13 weeks following treatment
- To protect birds and mammals the product must be entirely incorporated in the soil immediately after broadcasting and it must be ensured that the product is fully incorporated at the end of rows
- Fields must be monitored 24 hours after treatment, paying particular attention to row-ends and headlands, and any incidence of adverse effects to wildlife reported to the authorisation holder and Wildlife Incident Investigation Scheme (WIIS). The results of this monitoring must be recorded and kept available for three years
- To protect birds and wild mammals, remove spillages
- Do not contaminate water with the product or its container
- Do not clean application equipment near surface water. Avoid contamination via drains from farmyards and roads
- To protect groundwater do not apply this or any other product containing fosthiazate more than once every four years
- The incorporation of the product into the soil to a depth of 15 cms and ridging-up of treated soil must be carried out immediately after application
- Returnable packaging reduces waste and environmental damage caused by landfill



8 TUBER SAMPLING FOR RESIDUE TESTING

TUBER SAMPLING ACROSS THE WHOLE FIELD



NEMATHORIN must not be used on crops desiccated or harvested less than 119 days (17 weeks) after application. **NEMATHORIN** must be incorporated immediately before or at the time of planting. If residue tests are required by the processor, packer or retailer, it is important that the samples tested are random and therefore a true representation of the whole crop.

8.1 Tuber sampling in field

When sampling consider two key factors:

1. Achieving a representative sample from the field (minimum 2.5 kg tuber weight)
2. Ensuring good sample hygiene to avoid contamination

On very early crops it may be necessary to take all the tubers from each of 20-40 plants across the entire field in a 'W' shaped pattern to get a suitable weight of tubers.

As the crops mature and tuber size increases it may be more appropriate to take a single tuber from 20-40 plants across the entire field.

In terms of sampling pattern, a 'W' shaped pattern within the field will give a fair representation, however it is not always easy in a potato crop and one should avoid the temptation of taking too many samples from the same bed.

- The maximum residue levels (MRLs) for nematicides are set at very low levels, typically around the point of analytical detection. It is very important that no contamination of the tuber sample should occur. Think forensic science
- Sampling equipment should be cleaned before each sample is taken

- The sampler should wear new disposable gloves for each sample
- Tubers should be collected into a clean bag/ bucket stored and transported in a clean environment
- The MRL is set for potato tissue. It is critical therefore that all soil is removed from the sample. Collected tubers should be thoroughly washed and dried before dispatch to the lab for analysis
- Samples should be placed in a labelled inert container to avoid contamination and damage

8.2 Tuber sampling from store

- Bulk crops should be sampled avoiding tubers within 0.5 m of the edges and upper surface of the container. Divide the stored crop into sections according to how many samples are needed and take one sample from each section
- Crates should be sampled by removal of one tuber from each crate for each sample e.g. if three samples are needed three tubers should be removed from each crate and one put into each sample
- Minimum sample size is 10 tubers collectively weighing 1 kg
- Samples should be placed in a labelled inert container to avoid contamination and damage



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Use plant protection products safely. Always read the label and product information before use. For further information including warning phrases and symbols refer to the website www.syngenta.co.uk ©Syngenta AG November 2021. GQ 11756.