FACTSHEET 20/17 Revision of March 1997

AHDB

Leaf and bud nematodes in hardy nursery stock

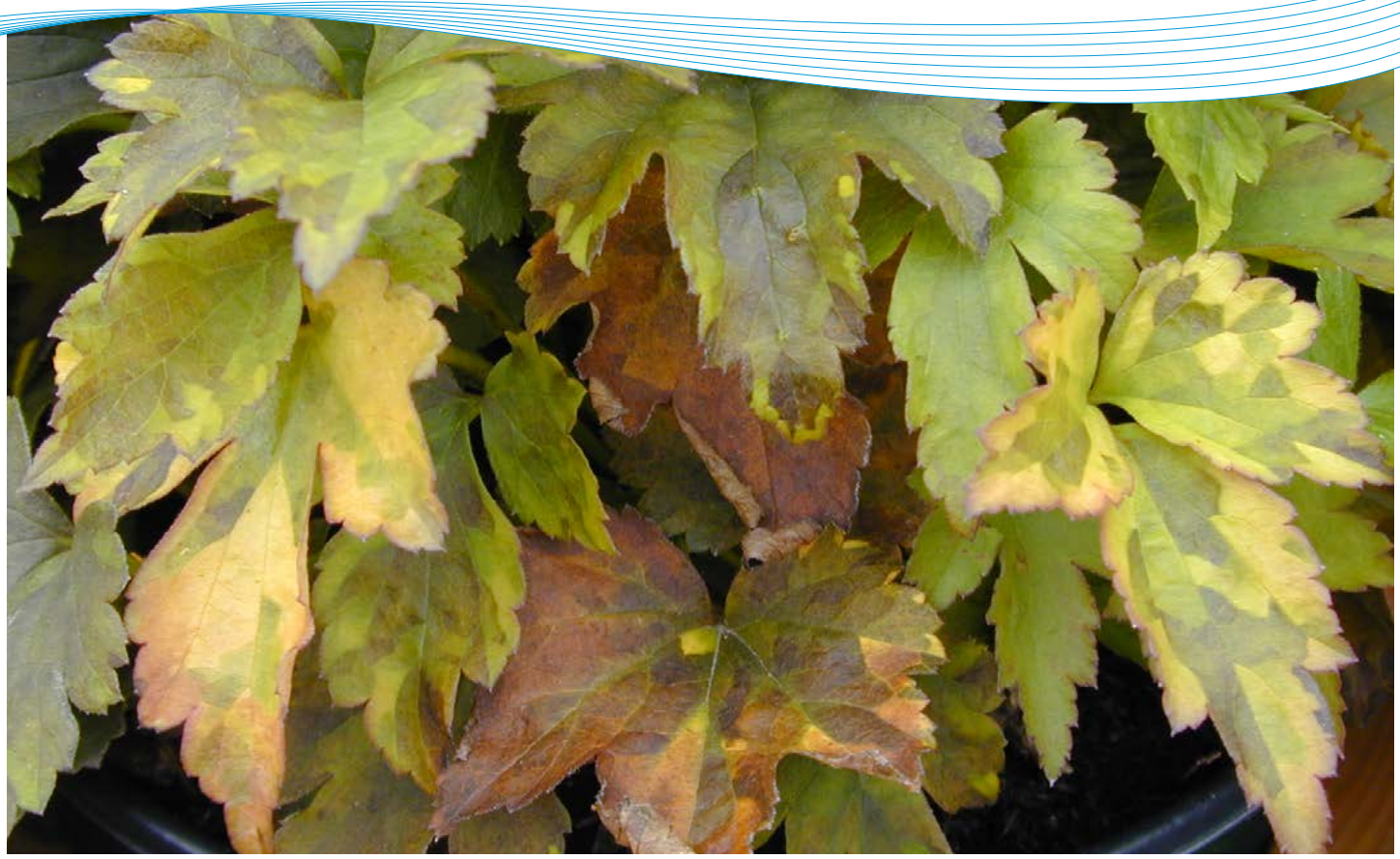

Figure 1. Typical leaf and bud nematode feeding damage symptoms: dark angular leaf blotches on Japanese anemone

Leaf and bud nematodes, *Aphelenchoides* species, are common, persistent and damaging pests of a range of economically important hardy nursery stock (HNS) crops. This factsheet provides guidelines on symptom recognition, and information on the biology and management of leaf and bud nematodes in HNS based on results from AHDB Horticulture-funded project CP 104.

Action points

- **Monitor susceptible plant species for damage symptoms (Figure 1) from spring onwards when plants begin to grow**
- **Check potential weed hosts for symptoms and maintain good levels of weed control**
- **Get any leaves with damage symptoms checked for the presence of leaf and bud nematodes**
- **Do not take cuttings from infested mother plants**
- **Use sub-irrigation for infested plants and other susceptible crops where appropriate**
- **Remove all leaf debris on soil, growing media, capillary beds and ground cover matting between crops to reduce sources of the pest for following crops**
- **Use suitable disinfectants on matting in between crop batches to provide a reduction in leaf and bud nematode numbers**
- **If possible, avoid growing susceptible plant species on beds or areas of the nursery that have previously been exposed to infested plants**
- **Consider using a foliar spray of a plant protection product that may give some control of nematodes on plants with less than 15% leaf area damage. Treatment will be most effective at the first sign of symptoms when the plants are actively growing in the spring**
- **Dispose of plants with over 15% leaf area damage, as these are unlikely to respond to any treatment with a plant protection product**

Introduction

Leaf and bud nematodes, *Aphelenchoides* species, are common pests of a range of HNS crops grown under protection or outdoors. In the UK, both *Aphelenchoides ritzemabosi* and *A. fragariae* can occur. Feeding damage results in angular-shaped, dark blotches on the leaves, delineated by leaf veins. Leaf and bud distortion can also occur as a result of feeding. These damage symptoms can make infested plants unmarketable. There are now very few options for effective chemical control, therefore, cultural control of the pest plays an important role in management strategies.

Host plants

Both *Aphelenchoides* species have a wide range of host plants, and both can infest several weed species.

Cultivated host plants

Aphelenchoides ritzemabosi used to be a serious pest of chrysanthemum in the UK and was often referred to as the chrysanthemum nematode. However, now that fewer cut flower chrysanthemum crops are grown in the UK, the pest is less of a problem on this particular crop. Like *A. ritzemabosi*, *A. fragariae* can also infest strawberry and is sometimes referred to as the leaf nematode. Host plants for *A. ritzemabosi* are often found in the Compositae family and those for *A. fragariae* primarily belong to the Liliacae, Primulaceae, Ranunculacae and various fern families, but the two species also share some common hosts. Commonly cultivated HNS host plants for both nematode species are listed in Table 1.

Weed host plants

Weed hosts for *A. ritzemabosi* include bindweed, buttercup, chickweed, cleavers, daisy, dock, groundsel, sow-thistle and speedwell, and those for *A. fragariae* include chickweed, fat-hen and shepherd's purse.

Biology and symptoms

Biology

Leaf and bud nematodes are microscopic, transparent, thread-like 'eelworms', 0.4–1.2mm in length depending on their age. They enter the host plant through the leaf stomata or physical wounds and also lodge themselves between the tightly folded tissues in buds. Leaf and bud nematodes need a film of water in which to move on the plant surface; this also allows them to spread to adjacent, touching plants. Wet and humid conditions, such as those produced by dew, rainfall, overhead irrigation or misting systems, are therefore ideal for the transmission of the pest.

The nematodes feed and reproduce within leaves or buds. Like other plant-parasitic nematodes, *Aphelenchoides* species have a slender feeding stylet that they insert into plant tissue in order to feed (Figure 2). A single infested leaf may contain many thousands of nematodes feeding within the spongy tissue between the two leaf surfaces (Figure 3).

After mating, the females lay eggs, usually in healthy leaf or bud tissue. After hatching, the nematodes pass through four juvenile life stages before the adults develop. The life cycle from egg to adult may be completed in about 10–15 days, depending on prevailing temperatures.

Table 1. Commonly cultivated HNS host plants

Aphelenchoides ritzemabosi	*Aphelenchoides fragariae*
Aster	*Abelia*
Anemone	*Aster*
Bergenia	*Anemone*
Buddleia	*Aconitum*
Calceolaria	*Azalea*
Campanula	*Begonia*
Chrysanthemum	*Cistus*
Dahlia	*Cornus*
Delphinium	*Ferns* (various families)
Doronicum	*Fragaria*
Fragaria	*Geranium*
Geranium	*Helichrysum*
Helleborus	*Hepatica*
Hibiscus	*Heuchera*
Lamium	*Hibiscus*
Lavandula	*Hosta*
Paeonia	*Hydrangea*
Philadelphus	*Lamium*
Phlox	*Lavandula*
Primula	*Lilium*
Ribes	*Paeonia*
Salvia	*Primula*
Saxifraga	*Salvia*
Verbena	*Saxifraga*
Veronica	*Scabiosa*
Viola	*Verbena*
Viburnum	*Veronica*
Weigela	*Weigela*

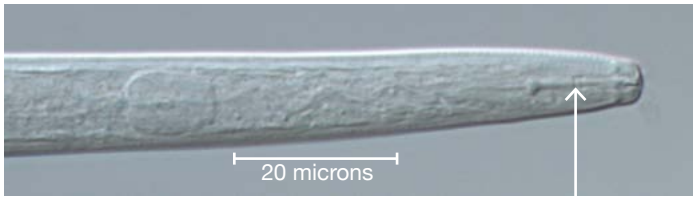

Figure 2. *Aphelenchoides fragariae* nematode showing feeding stylet

Figure 3. *Aphelenchoides fragariae* nematodes inside leaf tissue

Symptoms

The most common symptom of leaf and bud nematode infestation is the angular-shaped leaf blotch. Blotches are initially chlorotic, turning to light, then dark brown, and finally black (Figure 4). These leaf blotches are caused by nematodes feeding within the leaf, where their activity is limited by the leaf veins. Suspicious symptoms should always be checked for the presence of leaf and bud nematodes, as several pathogens can cause similar symptoms, such as downy mildew on *Buddleia* and *Lamium* and bacterial leaf spot on *Delphinium*.

Alternatively, leaf and bud nematodes can feed externally between the folded tissues of leaf or flower buds, resulting in distorted or stunted growing points, leaves or petals (Figure 5). Leaf distortion and blotching often, but not always, occur together on the same plants. Beware of confusing the distortion symptoms with those caused by other pests that feed in growing points and buds, such as thrips and capsid bugs. Example plant hosts that have shown leaf distortion symptoms caused by leaf and bud nematodes include *Buddleia*, *Helichrysum*, *Saxifraga*, *Scabiosa* and *Veronica*. Damage symptoms usually start at the base of the plant in the spring and progress up the plants, rendering them unmarketable.

Survival and spread

One of the main means of spread of the nematodes is by plant propagation. Leaf and bud nematodes can be unwittingly spread in cutting material taken from infested mother stock, particularly if the mother plants are not yet showing symptoms, such as following a period of rapid growth. Symptoms in the new plants eventually become visible when nematode numbers build up as the plants establish and grow.

Leaf and bud nematodes can also be spread locally by moving from infested plants to adjacent, touching plants in films of water and in water splash during irrigation, misting or rainfall events. Nematodes may remain in infested leaves, which often become dry and eventually abscise. The detached infested leaves can potentially be a means of spread to healthy plants by their persistence on the soil surface, sand beds or ground cover matting. Alternatively, detached infested leaves can be moved about by wind or on containers, trays and trolleys to other parts of the nursery.

Aphelenchoides ritzemabosi has been known to survive in a desiccated state in dry leaf debris for up to three years at 4–7°C and to resume activity when there is sufficient moisture, suitable temperatures and when host plants become available. Recent research in the USA has shown that *Aphelenchoides fragariae* can survive the winter in infested, container-grown *Hosta* plants when grown in a polythene tunnel and outdoors. Live *A. fragariae* were found in February in dormant buds, dry infested leaves and the growing media. Nematode survival was higher in the polythene tunnel than outdoors. Other research has shown that 'free-living' nematodes extracted from infested leaves and added to soil as a suspension in water only survived for four weeks.

In spring, any nematodes overwintering in leaf debris or dormant buds move up the plants in films of water on the stems and leaves and start to cause new damage symptoms. This highlights the need for high standards of nursery hygiene, particularly the thorough removal of any leaf debris following a known infested crop. Weed control is also a key component of any management strategy, as many common weeds can harbour leaf and bud nematodes and allow survival of the pest in previously infested beds or soil.

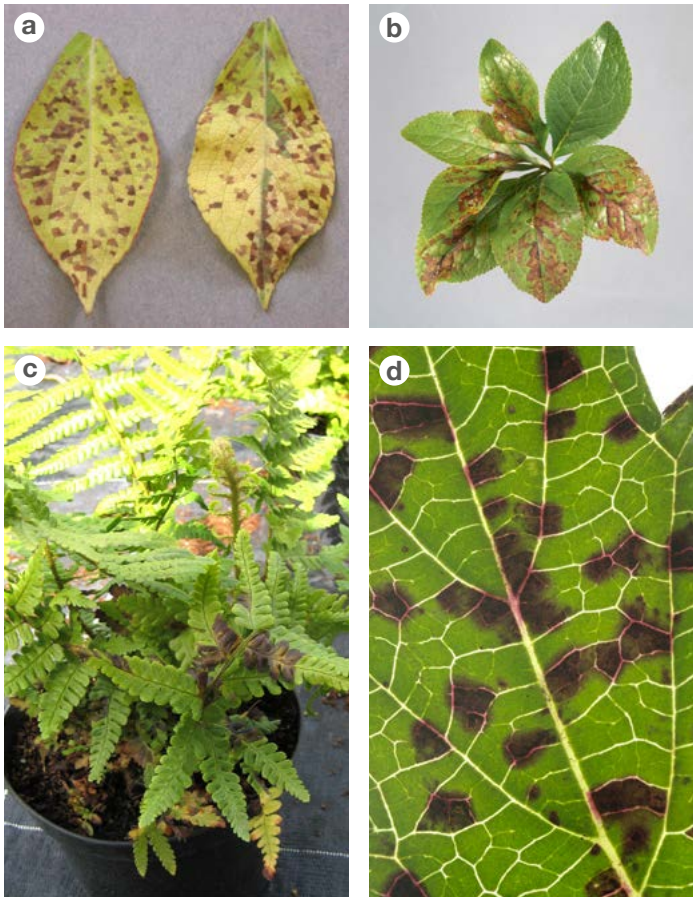

Figure 4. Damage symptoms: (top) (a) *Weigela*, (b) *Helleborus*, (bottom) (c) *Dryopteris* and (d) *Verbena*

Figure 5. Healthy leaf (left) and leaf distorted by nematode feeding (right) in *Scabiosa*

In summary, leaf and bud nematodes can be spread by the following means:

- Propagation from infested mother plants
- Buying-in of infested plant material
- Water splash from infested plants during irrigation, misting or rainfall (Figure 6)
- Direct contact with adjacent infested plants
- Transfer from infested leaf debris or weeds in soil, sand beds and on ground cover matting, pots, trolleys, trays, etc
- Transfer via infested tools and other equipment

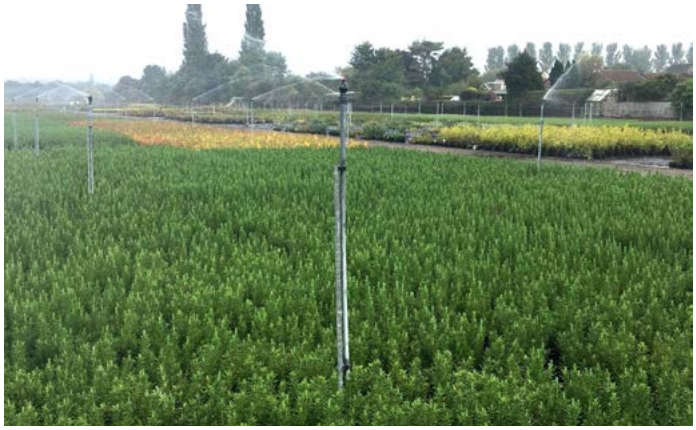

Figure 6. Leaf moisture as a result of overhead irrigation can facilitate the spread of leaf and bud nematodes

Pest diagnosis

If plants are suspected of being infested with leaf and bud nematodes, this can be confirmed by shredding the leaves or buds with symptoms into a Petri dish of water, leaving the plant material for a number of hours, then examining the water under a binocular microscope or high-magnification hand lens and looking for the presence of free-swimming nematodes. If a microscope is not available on the nursery, or if confirmation of the presence of leaf and bud nematodes is required, a sample of plants or leaves with symptoms should be sent to a diagnostic laboratory with nematology expertise. Such diagnostic laboratories include:

- ADAS: contact your local ADAS advisor or **steve.ellis@adas.co.uk**
- Fera: contact **plantclinic@fera.co.uk**
- SRUC (Scotland's Rural College): contact **cropclinic@sruc.ac.uk**

All these laboratories will extract any nematodes from leaf tissue and identify them with a high-magnification microscope, using morphological diagnostic features. Fera also offers molecular identification methods if required.

Management strategies

Effective, long-term control of leaf and bud nematodes can only be achieved through a carefully planned programme. Management of the nematodes depends on taking an integrated approach involving the use of clean mother stock and land, good levels of nursery hygiene and weed control, as well as appropriate use of plant protection products and disinfectants.

Cultural control

- Do not take cuttings from mother plants infested with leaf and bud nematodes. Tissue culture or hot-water treatment should be used to create clean mother stock for further propagation.
- Regularly monitor susceptible mother plants and periodically send samples to a diagnostic laboratory to check for leaf and bud nematode infestation, as symptoms of infestation are not always visible.
- Quarantine new, susceptible plant species and monitor regularly for symptoms of infestation.
- Do not grow susceptible plant species on contaminated beds or soil. If such areas need to be used, remove all remaining plant debris from the previously infested crop and dispose of it via landfill, then clean and disinfect any matting and other equipment. Leaving the contaminated areas free from host plants and weeds over winter for at least four months should reduce the risk of further infestation. A safer option would be to consider growing plants that are not susceptible to leaf and bud nematodes on contaminated beds or soil (Figure 7). Most conifers and grasses do not seem to be susceptible. However, *Pinus* and *Poa* species have been recorded as hosts for *A. fragariae* and *A. ritzemabosi*, respectively.
- Remove badly infested plants and adjacent plants within range of water splash. Promptly dispose of the plants via landfill.
- If infested plants must be retained, minimise spread of leaf and bud nematodes in water splash by the use of sub-irrigation and space plants widely to avoid direct foliar contact.
- Keep weeds in or around glasshouses, polythene tunnels and production beds under control, particularly those that can act as potential hosts for leaf and bud nematodes.
- Avoid re-using containers, trays, etc that have been used for growing infested plants. Research in AHDB Horticulture-funded project HNS 147 showed that use of wet heat by immersion in a water bath at 50°C for one hour was lethal to leaf and bud nematodes so this may be an option if suitable equipment is available.

Figure 7. A field-grown Japanese anemone plant showing symptoms of leaf and bud nematode infestation on older leaves

Chemical control

There are no approved nematicides or insecticides with a label recommendation for the control of leaf and bud nematodes. Currently approved plant protection products that may give some control of the pest are listed in Table 2 (located in the wallet at the back of the factsheet). Research in AHDB Horticulture-funded project CP 104 indicated that a two-spray programme of abamectin (Dynamec), used at the higher of the two recommended label rates (for thrips and leaf miner control) at seven-day intervals, spirotetramat (Movento) used at the rate recommended on the EAMU at 14-day intervals and a coded insecticide product in a three-spray programme at seven-day intervals all gave promising control of leaf and bud nematode. These treatments reduced leaf and bud nematode multiplication in leaves and suppressed the development of damage symptoms on the infested HNS species examined – *Buddleia* and Japanese anemone – compared with water-treated control plants. Commercial growers of HNS have also experimented with foliar sprays of Movento at the first sign of damage symptoms and anecdotal evidence suggests that this has reduced the development of further symptoms.

Results from project CP 104 also showed that an elicitor (a product that induces plant resistance to a pest or disease), acibenzolar-S-methyl (ASM), also has the potential to reduce leaf and bud nematode numbers and damage when used alone as a foliar spray either preventively or curatively, or in combination with either Dynamec or Movento. Although Dynamec has a label recommendation for use on ornamentals (for two-spotted spider mite, thrips and leaf miner control) and Movento has a current EAMU for use on ornamentals, neither product is recommended for the control of leaf and bud nematodes. See Table 2 for the current approval status of both these insecticides and for restrictions on their use on ornamentals, which include using Movento only as a post-flowering treatment. ASM is not yet commercially available, but might play a potential role in leaf and bud nematode management in the future.

Research in CP 104 demonstrated the importance of the timing of foliar sprays. Product efficacy was improved when moisture was present on the leaves at the time of application (either by applying the sprays early in the morning when the leaves were damp with dew or by applying overhead irrigation two to four hours before spraying so that the leaves were still damp at application). The moisture allowed the nematodes to move out onto the leaf surface through the stomata and thus be exposed to direct contact by the treatments.

Results from the project also showed the importance of foliar treatment before the damage symptoms became too severe. Treatment was only effective in reducing nematode populations and the development of severe symptoms if applied when less than an average of 15% of the leaf area was damaged (Figures 8 and 9). This result was consistent with those from the previous project, HNS 131, which demonstrated that on Japanese anemone or *Weigela* plants with severe leaf damage symptoms and high numbers of nematodes, foliar sprays of Dynamec, fatty acids (Savona), garlic, alginate polysaccharide (Agri-50E), extracts of *Tagetes* and

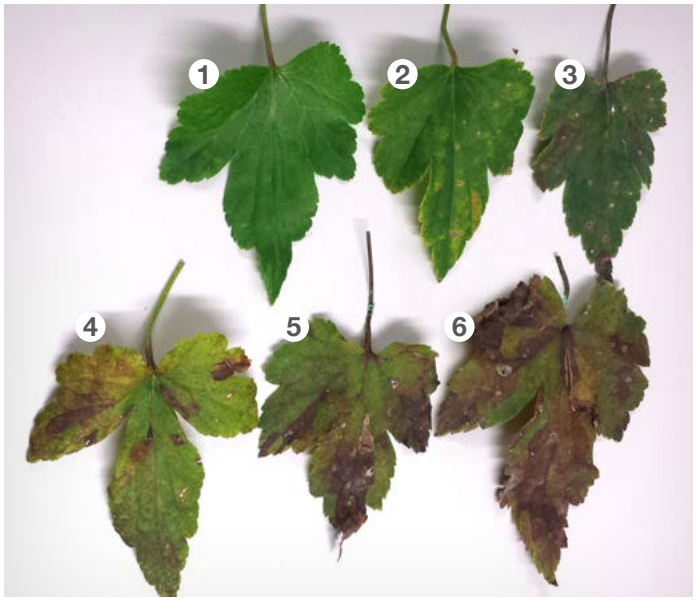

Figure 8. Severity of damage symptoms on Japanese anemone (1 = no damage, 2 = 1–10% damage, 3 = 10–25% damage, 4 = 25–50% damage, 5 = 50–75% damage, 6 = 75–100% damage)

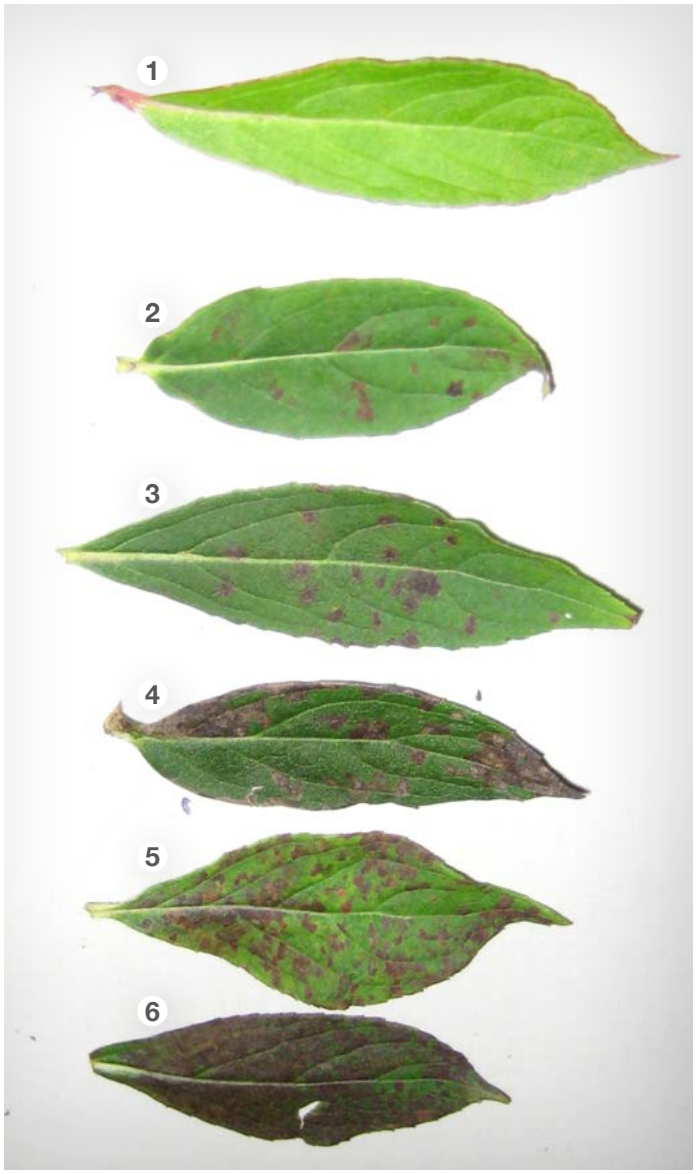

Figure 9. Severity of damage symptoms on Weigela (1 = no damage, 2 = 1–10% damage, 3 = 10–25% damage, 4 = 25–50% damage, 5 = 50–75% damage, 6 = 75–100% damage)

seaweed and the entomopathogenic nematode *Steinernema carpocapsae* did not give effective control of leaf and bud nematode. On the other hand, the systemic insecticide oxamyl (Vydate 10G) applied as a broadcast granular treatment did give effective control. Vydate 10G currently has an EAMU for use at drilling/transplanting outdoor ornamentals only (for control of alien leaf miner and whitefly species as well as stem and bulb nematodes when applied by a conventional granule applicator) – see Table 2. Vydate 10G may no longer be applied to either outdoor or protected ornamentals by handheld equipment and is therefore not an option for control of leaf and bud nematode in container-grown HNS crops.

Research in CP 104 investigated the efficacy of a range of coded insecticides and biopesticides used as growing media drenches for the control of leaf and bud nematodes in Japanese anemone compared with Vydate 10G (used as an experimental standard). All the experimental treatments gave similar reductions in nematode numbers per gram of leaf tissue as Vydate 10G compared with the water control. However, none of the experimental treatments are yet commercially available.

Use of disinfectants

Research in the USA has indicated that a peroxyacetic acid product, ZeroTol (similar to Jet 5) can give some control of leaf and bud nematodes when used as a foliar spray. Jet 5 is not approved as a pesticide for foliar application in the UK. Nevertheless, various disinfectants, including Jet 5, were tested for efficacy against leaf and bud nematodes when drenched onto sand in CP 124 (Figure 10) and other disinfectants were tested as treatments to infested leaf debris in HNS 147. None of the disinfectants were fully effective against the pests in either of these projects. However, results of drenching sand below infested leaves in CP 124 showed that benzoic acid (Menno Florades), a dimethyl benzyl ammonium chloride compound (Hortisept Pro) and a gluteraldehyde and quaternary ammonium compound (Unifect G) gave some reduction of numbers of leaf and bud nematodes compared with the water controls, but did not eradicate them.

Figure 10. Testing disinfectants applied to sand as part of AHDB Horticulture-funded project CP 124

Further information

AHDB Horticulture factsheets and publications

Factsheet 10/07: ‘Guidelines on nursery hygiene for outdoor and protected ornamental crops’.

AHDB Horticulture grower summaries and reports

CP 124: ‘Managing Ornamentals Sustainably (MOPS) – Developing integrated plant protection strategies’ (2016 annual report).

CP 104: ‘Novel approaches for the management of leaf and bud nematodes in hardy nursery stock’.

HNS 147: ‘Ornamentals: control of pests, pathogens and weed seeds on re-used plant containers’.

HNS 131: ‘Hardy nursery stock: evaluation of alternatives to aldicarb (Temik) for the control and management of leaf and bud nematodes’.

HNS 60: ‘Hardy ornamental nursery stock: a review of the biology and control of leaf and bud nematodes’.

Acknowledgements

Thanks go to Idowu Rotifa, SRUC, for sharing results and information from AHDB Horticulture-funded project CP 104.

Table 2. Currently approved plant protection products that may give some control of leaf and bud nematodes in ornamental plant production (November 2017)

Product name (examples)	Active ingredient and IRAC code	Insecticide group	Approval status for ornamental plant production	Application method and mode of action	Compatibility with biological control agents used against other pests*	Comments
Dynamec	Abamectin (IRAC group 6)	Naturally derived product of the soil actinomycete *Streptomyces avermitilis*	On-label (recommended for control of two-spotted spider mite at lower label rate and leaf miner and thrips at higher label rate)	Foliar spray. Contact and translaminar action	Harmful to *Amblyseius swirskii*, *Neoseiulus cucumeris* and *Phytoseiulus persimilis* for up to two weeks. Harmful to adult *Aphidius* species and *Aphidoletes aphidimyza* adults and larvae for up to one week. Harmful to *Encarsia formosa* adults for up to three weeks	Research in AHDB project CP 104 indicated that a programme of two sprays seven days apart using the higher label rate reduced the multiplication of leaf and bud nematodes and the development of further damage symptoms on some HNS species, particularly when leaves were dampened with water before application There is no label recommendation for control of leaf and bud nematodes, so use against this pest is at grower's own risk. Follow all label recommendations for use against other pests. See label for ornamental species not to treat owing to risk of plant damage
Movento	Spirotetramat (IRAC group 23)	Ketoenol	EAMU (1300/2017)	Foliar spray. Two-way systemic action	Safe to *Aphidius* species and *Aphidoletes aphidimyza*. Slightly harmful to *Encarsia formosa*. Harmful to *Neoseiulus cucumeris* and *Phytoseiulus persimilis*	Research in AHDB project CP 104 indicated that a programme of two sprays 14 days apart reduced the multiplication of leaf and bud nematodes and the development of further damage symptoms on some HNS species, particularly when leaves were dampened with water before application. Most effective when plants are actively growing The EAMU does not recommend Movento for control of leaf and bud nematodes. Use on ornamentals and for control of this pest is at grower's risk. See EAMU for ornamental plants not to treat owing to risk of plant damage, and for resistance management instructions, ie maximum number of applications per year and rotation with other chemical groups. Movento should only be used post-flowering
Vydate 10G	Oxamyl (IRAC group 1A)	Carbamate	EAMU (1636/2014) for control of alien leaf miners, whitefly and stem and bulb nematode	Conventional granule applicator at drilling/planting, followed by soil incorporation. Systemic	Harmful to most biological control agents for 8–12 weeks. Not compatible with IPM	The EAMU is for outdoor ornamentals only and is not for application by handheld equipment

Footnotes on reverse.

This table has been collated using information from the Health and Safety Executive (HSE) website (pesticides.gov.uk) and from product labels and supplier technical leaflets. Important – regular changes occur in the approval status of plant protection products, arising from changes in the legislation or for other reasons. For the most up-to-date information, please check the HSE website or with a professional supplier or BASIS-qualified consultant, as information could have changed since the publication of this factsheet.

IRAC – Insecticide Resistance Action Committee.

EAMU – Extension of Authorisation for minor use.

Growers must hold a paper or electronic copy of an EAMU before using any product under the EAMU arrangements. Any use of a plant protection product via an EAMU is at the grower's own risk.

Always follow approved label or EAMU recommendations, including rate of use, maximum number of applications per crop or year and where crop safety information is not available, test the product on a small number of plants to determine crop safety prior to widespread commercial use.

If in doubt about which products are permissible on ornamentals or how to use them correctly, seek advice from a BASIS-qualified consultant with expertise in ornamental plant production.

* Full details of compatibility of plant protection products with biological control agents are available from biological control suppliers or consultants. Check the following websites: biobest.be and koppert.com. 'Safe': kills<25% of the biological control agents; 'slightly harmful': kills 25-50%; 'moderately harmful': kills 50-75%; 'harmful': kills >75%.

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