Factsheet 02/03

Hardy Nursery Stock

Project No. Various

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Vine weevil control in Hardy Nursery Stock

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The trade in plants between nurseries has been central to the spread of vine weevils within the UK nursery stock industry and, with limited control measures available, vine weevil continues to be the number one nursery stock pest. This factsheet draws on past HDC-funded work and includes up-to-date information to provide practical guidance for growers.

Introduction

The vine weevil (*Otiorhynchus sulcatus* L) is native to the UK and Northern Europe. In the wild, this insect is found at low densities in hedges and woodland margins, feeding on a range of plants including trees such as *Taxus* (yew) and also many herbaceous plants and weeds. Populations tend to be highest on light land, as heavy clay soils do not favour larval survival.

The vine weevil has done so well in the HNS situation because of the suitability of peat based composts for egg survival and larval development, and because they can feed on a very wide range of plants. In addition, both adults and larvae are difficult to control once they are established.

Biology

Only one weevil is needed to start an infestation because the adults are parthenogenetic ie lay fertile eggs without mating, male weevils are unknown.

Adult weevils are 8.5–11.5 mm long (Fig 1). Their overall appearance is shiny black on first emergence from the pupa, but once covered with dust they usually appear as a dull brown or grey colour. There are short tufts of yellow hairs on the front wing cases, giving it a speckled look. When disturbed, these weevils 'play dead', and as they often occur in leaf debris, under pots or trays, they are easily missed. They are only active at night, although when conditions are unfavourable, such as times of drought, they may be seen climbing up walls or on benches during the day.

Adults emerge from the soil or compost over an extended period usually from about May to June, and immediately start to search for and feed on suitable plants, resulting in the characteristic leaf notching (Fig 2). Favourites are evergreen *Euonymus*, *Taxus*, *Rhododendron*, *Primula*, Blackcurrant, *Viburnum davidii* etc, but they are highly polyphagous and can feed on many plant species. Their ovaries do not mature until 3–4 weeks after emergence. This is called the pre-oviposition period and this can be an ideal time in which to apply adult control measures if needed, before egg laying can take place.

Each adult can lay between 300 and over 1000 eggs in a season between

1 Adult weevil

2 Characteristic notching of leaves by adult vine weevils

April (overwintered adults) and October, with the total number depending on their food source and environment. They are laid randomly on the surface of compost in pots, or into cracks in the compost surface.

Eggs are white when first laid, but soon turn dark brown (Fig 3) and are very hard to see. Eggs take around 10 days to hatch into tiny off-white, legless larvae with a brown head capsule, which feed on fine fibrous roots in the root ball of containerised plants. They moult several times over the summer and early autumn, reaching a maximum size of about 12 mm. Their colour varies depending on their food and on many HNS subjects they are pure white (Fig 4). They move through the compost using strong setae or hairs and feed on larger roots as they grow. If plants are grown on capillary matting or uncovered sand beds, it is quite possible for larvae to move out of the pot via the drainage holes and enter another pot.

The final two instars prefer feeding on the stem base tissue, and may kill the plant by girdling the stem base (Fig 5). Larvae normally feed until the end of October outside, but under protection this period may be extended. They stop feeding with the onset of low temperatures, but even freezing conditions are unlikely to kill them. In spring, feeding may commence again until larvae pupate. New adults emerge as before in May or June.

The life cycle of vine weevil under UK conditions is shown in Diagram 1. Outdoors this typically takes between 9 and 11 months; with the greatest time being spent as a larva, eating roots.

Under protection or in areas with relatively mild winters including the South coast, South West, Western Scotland, and much of Northern Ireland, adults can survive over winter and become active again in late spring. They lay eggs much earlier than the new generation, often in April or May, which has important implications when planning control measures. In heated areas, such as propagation houses, the life cycle may be compressed and take as little as four months, and all stages may be present at the same time.

3 Vine weevil eggs

4 Fully developed vine weevil larvae

5 Larval damage to stem of conifer

Sources of infestations

There are several likely sources in the HNS situation:

- Adults moving into container beds from surrounding woodland or hedges
- Adults moving from outdoor stock beds (where very large populations can easily develop)
- *In situ* infestation arising from old liners or stock not sold the previous year
- Buying in the infestation as larvae hidden in the compost in liners, plugs, or other bought in plants.

Behaviour and monitoring

By understanding the behaviour it is possible to monitor adult infestations. Studies in the United States have shown that adult weevils move less than ten metres from the area in which they emerged, unless their habitat is disturbed, or becomes unsuitable for other reasons such as drought. Also movement is limited for the first few months or so in summer, while maximum feeding occurs, but after September there is a tendency for greater movement, up to 35 m from the site of emergence.

Adult weevils emerge soon after dusk and search for suitable host plants to feed on.

- To monitor the adults, go out at night with a good torch and look for them on shoot tips. However, weevils are very sensitive to movement, but not light, and will rapidly drop off the plant and 'play dead', so can be easily missed. If plants are gently shaken the adult weevils will fall and can then easily be seen on light coloured surfaces such as sand beds or white material placed under the plants.

Experimental work has shown that vine weevils will often aggregate together in suitable environments.

- Use a length of grooved board, or a piece of corrugated plastic placed under or near to containerised stock. The weevils may congregate under the board and can be found by inspecting it regularly.

Pitfall traps can also be effective if placed near a suspected infestation,

but they will also catch beneficial insects such as ground beetles.

- Bury a plastic cup in the ground up to its lip, and coat the upper inside edge with grease. To prevent the trap from filling with irrigation water or rain, invert a 3 litre pot (with its drain holes covered with tape) over the pitfall and cut 3 legs into the pot's rim, so the weevils can crawl underneath it into the trap.

The most visible sign of infestation is the notching on a host. This damage may reduce the value of the plant or even affect marketability. It is not always easy to spot this damage however, as it may be hidden or at a low level. Notches are also hard to detect on plants with irregular leaf margins or needles, such as *Spirea* or *Taxus*. Always look for notching on new growth, as old leaves from the previous year may still show the damage.

Use of trap plants as monitoring aids

Plants that are very attractive to weevils, such as *Primula* or *Euonymus*, can be used as monitoring aids.

- Place undamaged plants in areas where attack from the weevil is expected, and inspect regularly for telltale notches. Remove any notched leaves once recorded so new notching can be seen easily. Control measures can be timed accordingly.

- Place a layer of sharp sand on the top of the pots, to help in detecting the start of egg laying. The sharp sand can be removed at weekly intervals and the eggs, if present, can be floated off in a saturated salt solution. Once any debris has been removed by sieving it is possible to see the eggs clearly. Advice on running such a monitoring system is available from consultants.

Sampling for larvae within the compost

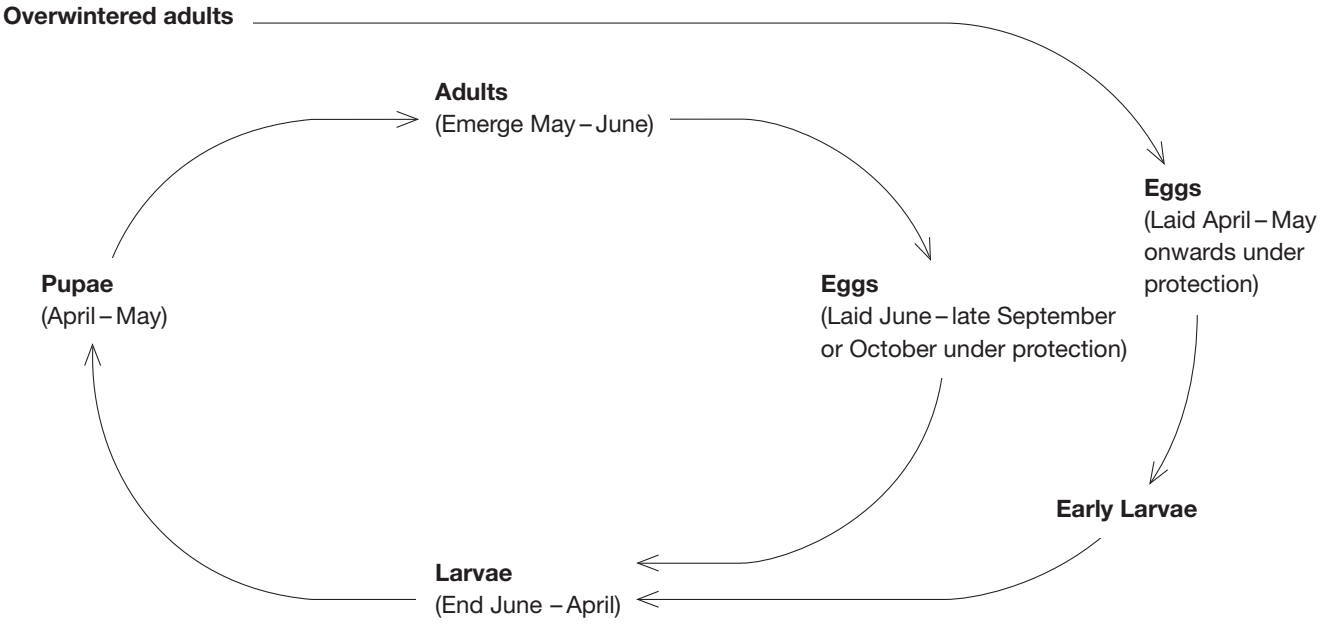
- Knock pots out and examine the root ball. The larvae are sometimes on the outside of the root ball and can be seen easily, however, it may be necessary to split open the root ball to find all the larvae.

Range of plant species affected

Vine weevil adults have favourite plants for feeding; these include evergreen *Euonymus* spp and varieties, *Taxus*, *Parthenocisssus*, *Viburnum davidii*, and others. Other plants such as *Heuchera*, *Sedum* etc, are suitable for oviposition and in fact often have eggs laid on them but are not fed on by adults at all. While shrubs of many species were the traditional hosts of vine weevil, over the past few years the worst outbreaks have been on herbaceous subjects, such as *Heuchera*, where many fine fibrous roots near the surface of the root ball seem to be ideal for larval survival.

Below is a list of some of the most and least susceptible plants which will assist in targeting control measures at the most susceptible species first.

Diagram 1
Generalised vine weevil life cycle in outdoor crops



Life cycle – Egg to adult: About 4 months or less under glass
Usually 9–11 months outside
Under protection, all stages may be present throughout the year

Table 1
Shrubs/climbers – susceptibility to vine weevil

Susceptible	*Azalea, Camellia, Cornus, Cotoneaster, Euonymus, Fuchsia, Hedera, Juniperus, Laurus nobilis, Parthenocissus, Prunus lusitanica, Pyracantha, Ribes, Rhododendron, Taxus, Thuja, Viburnum, Vitis etc*
Less susceptible	*Buxus, Hebe (various spp and cultivars), Prunus laurocerasus, Rosa*
Least susceptible	*Euphorbia*

Table 2
Herbaceous subjects – susceptibility to vine weevil

Susceptible	*Astilbe, Bergenia, Erica, Fragaria, Fuchsia, Heuchera, Heucherella, Hosta, Primula, Potentilla, Sedum, Saxifrage, Tiarella etc*
Less susceptible	*Aster, Penstemon, Phlox*
Least susceptible	*Campanula, Euphorbia*

These lists are not intended to be exhaustive, and even within the same plant family there are big differences in the attraction of cultivars to vine weevil. For instance, some *Rhododendron* varieties are known to be favourites including May Day, Elizabeth and Ginnie Gee whereas others are less favoured for example Cunninghams White. When given no choice, vine weevil can oviposit and develop on most HNS subjects there are very few totally resistant plants known.

The most common weed hosts include rosebay willowherb, dock, dog rose and dandelion.

Influence of growing media on vine weevil numbers

Peat based composts are ideal for vine weevil development and survival. The addition of fine bark in various proportions tends to increase the larval survival, but very coarse bark has the opposite effect. Trials have shown that coir growing media allows greater survival of larvae than peat or peat/bark mixes especially in propagation and in final pots (HDC project HNS 15c). Other media such as woodfibre seem to be intermediate between peat or peat/bark and coir.

Control of vine weevil

After Aldrin, the broad spectrum organochlorine insecticide, was banned there followed several years when no reliable chemical or biological product was available to UK growers. During this time the vine weevil problem became significantly worse. Growers now have various products for controlling vine weevil, in addition to using good cultural control methods.

Cultural control

Vine weevil thrives in neglected areas of the nursery, where old stock plants in which the compost incorporated insecticide has run out, or old liners have been left for more than one season. Most nurseries will have such areas, and they should be cleaned up.

Hygiene

- Remove leaf litter and debris from between pots, pot trays, under benches and other areas, to limit places for the adults to hide.
- Remove leaf debris which may build up where plants are being grown on capillary beds, or in pots on Mypex.
- Remove potential weed hosts.
- Always bury or burn old compost, or sub-standard plants for disposal, to prevent weevils from infesting other plants.
- Sweep up old compost and debris, then apply a suitable general purpose sterilant before bringing in the new crop.

Crop placement

- Consider placing known susceptible crops together if vine weevil has been a problem in the past, so control measures such as sprays for adults, can be applied more easily.

Reduction of egg laying by adults

- Consider top dressing pots with a 1 cm layer of bark or moist sand. Up to ten times fewer eggs

are laid on these surfaces than on those topped with peat.

- Pot toppers may also reduce the number of vine weevil eggs laid on pots.

Prevention of 'buying in' vine weevils

- Check thoroughly bought in plants for the presence of larvae hidden in the compost, and also for signs of leaf notching by adult weevils on new leaf growth.

- Ask your liner supplier what controls are in place against vine weevil before you buy.

Stock plants

- Control in stock plants is difficult, especially in pots above 10 litres, and it may be worthwhile cleaning off all soil, killing any larvae or adult weevils found, and repotting using treated compost.

Biological control methods

Nematodes

Insect parasitic nematodes (IPNs) are the principle biocontrol agent available for larvae.

How do nematodes work?

Commercial nematode products contain infective juveniles, usually in a semi-desiccated state that revive when placed into suspension in water. Once applied to compost, they swim in the film of water between soil particles and locate hosts by homing in on a CO_2 gradient produced by vine weevil larvae. They then penetrate the cuticle or enter via natural openings and release a unique bacterium into the body cavity. These bacteria kill the larva within a matter of days and the nematodes then grow and reproduce in the host. The next generation of infective juveniles then burst out of the host 'cadaver', and swim off to locate new hosts. The total numbers of juveniles produced in this way are always much lower than the initial application rate.

How long does it take to kill vine weevil larvae?

This is dependent on temperatures, but normally within 5–7 days.

How do I tell if they have worked?

Always mark a few pots beforehand (using a flag or similar marker that can easily be found) that contain known numbers of vine weevil larvae. Check after a week to see if the larvae are dead or dying. Infected larvae turn a brown or off-white colour and do not move.

How often do I need to apply the nematodes?

If you found larvae in pots in June or July and applied nematodes immediately, this may work well, but remember that further egg laying continues to take place until October. Therefore, the best time to apply is in September, when most eggs have been laid and larvae are present. A spring application may be needed to catch overwintered larvae before developing into new adult weevils.

Products

There are three products currently available to UK growers:

- *Steinernema carpocapsae* – Exhibit SC WDG (Syngenta Bioline)

- *Steinernema kraussei* – Nemasys L (Becker Underwood, formerly MicroBio)

- *Heterorhabditis megidis* – Larvanem (Koppert)

All the nematode products are aimed at controlling vine weevil larvae in the compost and can give excellent results, but there are specific requirements which must be followed in order to get good control. They can be used outside or under protection. Currently there are no commercial biocontrols available against adult vine weevil.

- They cannot be used preventatively ie to protect against the pest, nematodes are living organisms and need to find a host in order to survive.

- Nematodes are not effective against vine weevil eggs, pupae or adults.

- The compost must be moist prior to application. Nematodes must then be applied in sufficient water volume to penetrate and thoroughly wet the compost around the plants. If the crop canopy is dense, wash off with plain water after application.

- Nematodes are sensitive to dessication, so are best applied on a dull day, or in early evening.

- Compost temperature is very important; it must be between 12–25°C at some time during the day for all nematode species except *Steinernema kraussei,* which is active down to 5°C. The release of this new product, Nemasys L which replaces Nemasys H, enables growers to extend the time period available for application for vine weevil larval control.

Application is limited to two main windows:

1. *spring* – March to late May.
   Control during this period is aimed at the overwintered larvae before they pupate.

2. *late summer* – August through to the end of November.
   This is timed to control the new season's larvae when they are developing in the root ball, and when the majority of eggs have been laid, preventing a new infestation that year.

Application equipment

IPNs can be applied with a normal high volume (HV) sprayer, but it must be free of pesticide or fertiliser residues. Irrigation equipment such as Dosatrons or trickle irrigation can also be used but great care must be taken to ensure that the nematodes do not settle out during application and are not applied unevenly.

Follow manufacturers guidelines when applying through irrigation systems. As a guide, IPNs are resistant to high pressures (up to 100 PSI or 6 bar), such as are found in Dosatron and dripper systems. However, the pipes must be free of filters and any deposits, eg silt, that would restrict the flow of nematodes. Due to the variability of distribution through these systems, twice the label rate for standard (HV) application is recommended.

Rates of use

Normal rates for the Sygenta Bioline, Becker Underwood and Koppert products are: 0.5 million nematodes per m^2 of area (ie when plants are pot thick). The Koppert product also has a recommendation for 1.0 million per m^2 as a curative rate for heavy infestations. With the standard pack size this means that one pack of 50 million nematodes will treat up to 100 m^2 of pots.

Natural controls on the nursery

Although a containerised standing out area or polytunnel with pots standing on Mypex is an artificial environment designed for maximum plant growth, it can still harbour a range of beneficial ground dwelling insects, most notably the carabid beetles or ground beetles (HDC projects SF 15b and SF 15c).

The most effective vine weevil predators in field crops are shown in Table 3. Although these beetles will play a significant part in the natural biocontrol of vine weevil, it is unlikely that full economic control would be achieved.

How can beneficial beetles be encouraged?

- Use slug pellets and broad spectrum insecticide sprays as little as possible and target treatments carefully.
- Use IPM programmes for other pests so that the use of insecticides is kept to a minimum.
- Maintain grass strips alongside tunnels and standing out areas to act as 'beetle banks'.

Other natural predators of vine weevil

Bantam hens have been shown to eat all stages of vine weevil, but are unlikely to be allowed in a commercial nursery. Shrews and hedgehogs will take adult vine weevils, but again they are unlikely to effect economic control.

Table 3
Main species of ground beetle feeding on vine weevil

Egg predators	Predators on larvae	Predators on adult weevils
Notiophilus biguttatus	*N. biguttatus*	*Carabus violaceus*
Bembidion lampros	*Pterostichus madidus*	*Calathus fuscipes*
Ocypus olens	*Harpalus rufipes*	*H. rufipes*

Chemical control methods

1 Compost incorporated products

Insecticide products incorporated into the compost before potting remain the main preventative control method used by HNS growers. Various insecticides are approved for compost incorporation, and all are effective providing the mixing has been even and at the correct rate (Table 4). Growers can either mix their own on the nursery, or purchase compost from one of the major manufacturers that has the product already pre-mixed.

All these products work against vine weevil by killing the young larvae, usually the first instar, either when it comes into contact with insecticide released from one of the granules, or when trying to feed on roots containing the insecticide, where the insecticide is absorbed into the roots. They are less effective against older, larger larvae.

Treatment guidelines

Effect of growing media incorporated pesticide

Results of HDC-funded efficacy trials with suSCon Green (HNS 15c) showed control levels of over 90% were achieved with a peat/bark 75/25 mix, even two years after initial incorporation. However, note that some of the new peat replacement materials, such as woodfibre, reduced the effectiveness, as did coir composts. The mechanisms for this are still not clear, but they indicate that the highest label rate (1000 g/m^3) is needed in these compost types.

Treatment of plugs and liners

HDC-funded work showed how important it is to treat the 'core', plug or liner, with compost incorporated insecticide as well as the final pot. When the liner was left untreated, larvae were able to survive even when potted up into treated compost. Plugs of relatively small volumes (50–150 ml) were still capable of supporting many larvae, so the same principle applies.

Reduced rate applications

Providing the full rate of compost incorporated insecticide is used in the liner then, for one season only, reduced rates (around half label rate) of suSCon Green may be used in the final pot and still achieve good control. This strategy would best be used only on less susceptible subjects, and not on very susceptible plants. With Intercept, the rate seems to be more critical and reduced rates gave much poorer control. Any reduced rate application is at growers' own risk. ADAS and Fargro Ltd offer a service to check the rate of suSCon Green incorporated and this can be done up to two years after use.

Table 4
Products approved for vine weevil control as compost incorporated treatments

Product	Active ingredient	Formulation	Rate of use	Mode of action
suSCon Green	Chlorpyrifos	10% controlled release granule	750–1000 g/m^3	Contact and ingestion
Intercept 5GR	Imidacloprid	5% granule	280 g/m^3	Contact and systemic – can also control foliar pests eg aphids & whitefly
Vi-Nil	Fipronil	0.1% granule	1000 g/m^3	Contact, ingestion and root absorption

2 Drenches

These are not used routinely, but if larvae are found in pots, and biological control with nematodes is not possible, then a drench may have to be used in containerised HNS. Only two products have approval for use as a drench in the UK (see Table 5).

Timing of drench treatments

Often, an infestation of vine weevil is only found at potting on, usually in winter or early spring. At this time the larvae are generally large and this, in combination with low temperatures, can greatly reduce the effectiveness of drench treatments.

Guidelines for effective drench treatment

- Apply a drench before any vine weevil eggs can hatch if no compost incorporated treatment was used in a spring potting (approximately June under protection, early to mid July outdoors).
- Apply at least 20% of the pot volume for best results. Large pots are more difficult to drench than smaller pots so, for a 2 litre pot apply at least 400 mls of solution per pot.
- When treating evergreen or waxy leaved plants wash the drench residue off with plain water afterwards.
- Protective clothing should be worn during the operation in accordance with the approved label, to reduce operator exposure.
- Always mark a few pots beforehand (using a flag or similar marker that can easily be found) that contain known numbers of vine weevil larvae. Check after a week to see if the larvae are dead or dying. Infected larvae turn a brown or off-white colour and do not move.

Integration of nematodes and larval insecticides

Imidacloprid, chlorpyrifos and fipronil have no adverse effects on the nematodes, and so both can be used in the same programme to provide additional control.

Table 5
Products approved for use as drench treatments

Product	Active ingredient	Formulation	Rate of use	Approval
Dursban 4 (other formulations also available)	Chlorpyrifos	44.6% w/w	200 ml/100 litres water	On-label for conifers but can be used off-label – outdoor use on other HNS
Intercept 70 WDG	Imidacloprid	70%	20 g/100 litres water	On-label – not to be applied as foliar spray or through overhead irrigation. One treatment per season

3 Adult sprays

Sprays against adult weevils are not routinely used in the UK, unlike on the Continent where the practice is widespread. However, it may be worth considering where damage is very bad, but there are several points to bear in mind.

- Broad spectrum insecticides are used against adults, which may kill many beneficial insects as well as being potentially harmful to the operator and a possible run-off risk to watercourses. For these reasons, application of HV sprays against adults is the exception rather than the rule, but there are occasions when their use is warranted.
- Vine weevil adults are nocturnal so best results are achieved if the application is made at dusk, or as late as possible in the afternoon or early evening, leaving active spray residue on the plant when weevils emerge and feed.
- No chemical is specifically approved for the control of adult weevils but some are effective and can be used off-label at grower risk, provided all the label conditions are complied with.

The HDC sponsored large scale trials (HNS 61) to test a range of insecticides against adult weevils. The results showed that:

- Bifenthrin (Talstar) and malathion (eg Fyffanon 404), at highest label rate, gave greater than 80% knock-down of weevils. However, by 7 days after spraying the majority of weevils were moribund rather than killed outright. Further assessments after 14 days showed a higher level of kill. All affected weevils were incapable of feeding or ovipositing and would not pose any risk to the crop.
- Talstar, a pyrethroid insecticide, has an anti-feedant, not repellant, action and sprayed leaves were not fed on for up to 21 days after treatment. It is likely that other pyrethroid insecticides, such as cypermethrin (eg Toppel), deltamethrin (eg Decis), lambda-cyhalothrin (eg Hallmark) will be as effective if used at the highest label rate. These insecticides are approved for use on ornamental crops but do not have a label recommendation for vine weevil control. It should be noted that these insecticides are potentially harmful to beneficials and have a long residue period on the crop, so that biological controls cannot be used for up to 8 weeks after application.

- Malathion was not quite as effective as bifenthrin against the adults, and did not show any anti-feedant activity.
- Repeat applications would be needed in the field situation because not all adults emerge and feed every night, so some could be missed with one application, also new adults can move in from other untreated areas.
- All insecticides including bifenthrin, other pyrethroid products and also malathion should be used with great care near to watercourses. Spray drift should be avoided.
- Apply in as much water as possible in order to get really thorough spray coverage (1500–2000 litres water per ha).

Timing of adult sprays

Monitor carefully for new adult damage using *Primula*, other bait plants or one of the other methods described earlier, and use this as a guide to the presence of adults on the nursery. The aim must be to apply the spray before the adults can oviposit successfully, this means around early to mid June under protection, or mid July outside. A repeat application may be necessary two weeks later, but sprays applied in late summer generally are too late, as many eggs will already have been laid.

Note

All recommendations for use of insecticides are as a guide only. Growers should always check the product label before use. Growers using products under the Specific Off Label Approval (SOLA) system do so at their own risk, and must have a copy of the SOLA before starting application.

Calendar of action for vine weevil control

Month	Action
January – February	No action, consider using compost incorporated insecticide if re-potting.
March – April	Inspect pots for overwintered larvae and/or pupae. Check any bought in liners. If larvae found and compost temperature 5°C or above, apply nematodes to all pots.
May	Place *Primula* or other bait plants out under protection.
June	Monitor for leaf notching by overwintered or new season adults. Consider adult spray if necessary.
July	Continue monitoring; apply further adult spray if needed. Drench pots not protected by compost incorporated insecticide.
August – September	Ideal time to apply nematodes as a drench treatment.
October	Still time to apply nematodes under protection, providing compost temperatures of above 5°C are reached for some part of the day.
November	No action, but note areas that had adult damage and plan to treat these again next summer.
December	No action, but if potting up use compost incorporated insecticide in new plants, especially liners.

Further information may be obtained from the HDC Project Reports HNS 15a–e, SF/HNS 36, HNS 61, SF 15a–c and Factsheet 01/03 'Vine weevil control in soft fruit' available from the Office.

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