Factsheet 10/12

Soft Fruit

Midge, mite and caterpillar pests of cane fruit crops

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This factsheet provides growers with key information about the biology of, and the damage caused by, midge (Figure 1), mite (Figure 2) and caterpillar pests of cane fruit crops. The factsheet also offers guidance on how best to manage their control.

Action points

- There are several potentially serious midge, mite and caterpillar pests of cane fruit crops, all of which can potentially benefit from protected cropping.
- Protected cropping may reduce the opportunity to use conventional crop protection products due to limitations in their field of use, the need to minimise risk of pesticide residues or because a tunnel protected crop is inaccessible to sprayers.
- Growers should make sure that field staff are capable of identifying midge, mite and caterpillar pests and the damage they cause (see HDC Cane Fruit Crop Walkers Guide).
- Employ monitoring, predictive models and scouting techniques to detect their presence at an early stage and to determine the need for control measures.
- Where possible biological control should be used as part of an integrated approach. Any crop protection products used as part of this approach should be selected to have the minimum impact on native and introduced beneficial invertebrates and the environment.
- Apply control measures early to prevent pests from reaching damaging thresholds and to avoid the use of crop protection products close to harvest.

1. Raspberry cane midge larvae feeding on raspberry cane

2. Serious damage caused to raspberry by two-spotted spider mite

Introduction

The market and value of UK grown cane fruit has increased substantially in recent years. To meet the higher demand the industry now uses glasshouses and polythene clad tunnels to extend the production season and provide the high quality of fruit now expected by the consumer. Protected cropping also allows growers to adopt a new range of crop management techniques. Double cropping of primocane (autumn) fruiting raspberries and planting successive batches of 'long cane' summer fruiting raspberry plants helps to provide a continuity of production through the year, while using pot raised blackberry plants helps to produce high quality blackberries from April to November.

Recent changes in crop management have had a significant effect on the incidence of, and damage caused by several cane fruit pests. However, while the protected environment may result in increased incidence and damage caused by some pests, if not effectively controlled, it has also provided conditions which are conducive to the use of biocontrol agents and adoption of Integrated Pest Management (IPM) programmes. This factsheet focuses on the damage caused by the midge, mite and caterpillar pests of cane fruit and details the control measures available.

Midges

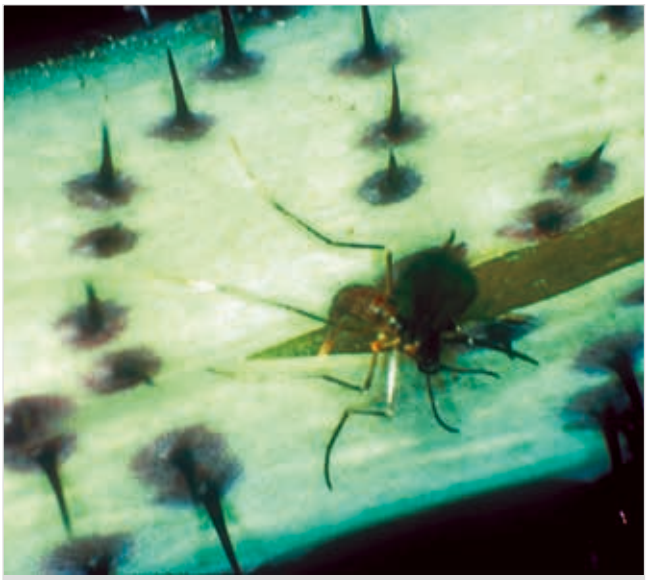
Introduction

Most species of fly (Diptera) found on cane fruit in the UK are gall midges. As adults, these small flies are similar in size and appearance to the biting midges that are such a nuisance to humans in the summer and autumn months. Fortunately only a small number of gall midges cause significant damage to cane fruit crops.

Raspberry cane midge (*Resseliella theobaldi*)

Biology

Adult raspberry cane midges are 1.4-2.1 mm in length. These delicate midges have a reddish brown body and long legs. Adults first emerge from the soil in the early spring. After mating the female midge (Figure 3) uses her long ovipositor (egg-laying tube) to lay small, elongate, translucent white eggs (Figure 4) beneath the rind of primocanes in raspberry and some *Rubus* hybrids such as Loganberry. This usually occurs in natural splits in the rind, or where frost, machinery or other agents have caused damage to the primocane. The eggs hatch within a week. The larvae are initially translucent but when fully grown are approximately 3.5 mm in length and turn yellowish orange or salmon pink in colour (Figure 5). Mature larvae drop to the soil at the base of plants and spin whitish cocoons, within which they pupate (Figures 6 & 7).



3. Female midge laying eggs in cane split

4. Raspberry cane midge eggs

5. Raspberry cane midge larvae

6. Raspberry cane midge pupa

7. Raspberry cane midge earth cocoon

In open field grown raspberries and other susceptible *Rubus* crops (readily splitting varieties), two or three generations of raspberry cane midge can occur each year. However, on protected crops as many as five generations may be completed. The second generation is generally larger than the first and has a greater impact on crops. When second generation adults emerge from the soil, there is usually an abundance of primocane present with fresh natural splits in the rind, providing plentiful oviposition sites. Emergence of the generation usually also coincides with flowering or the start of harvest so that pesticide application for control is difficult if not impossible to carry out. The complete life cycle of the raspberry cane midge is illustrated in Diagram 1.

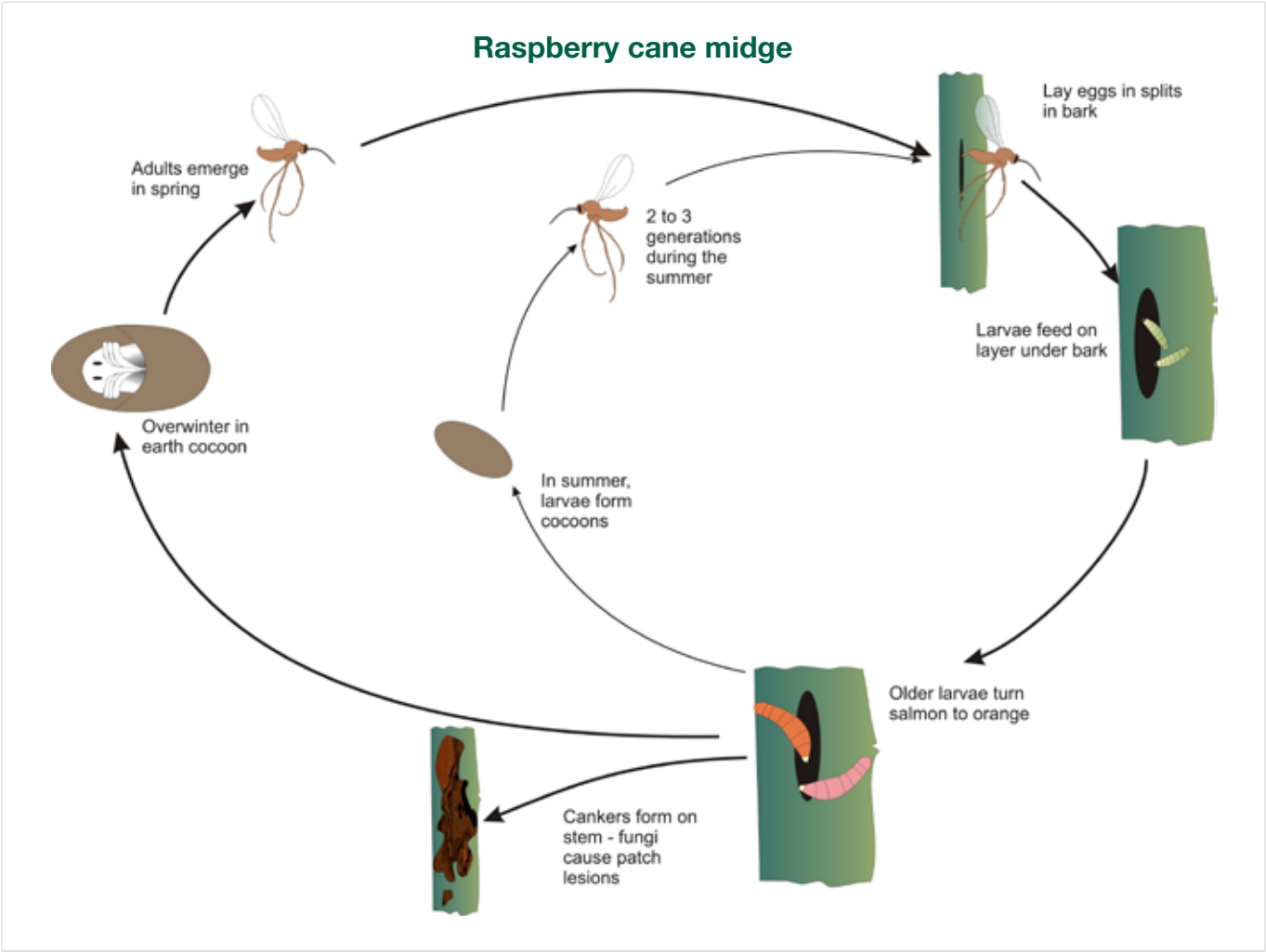
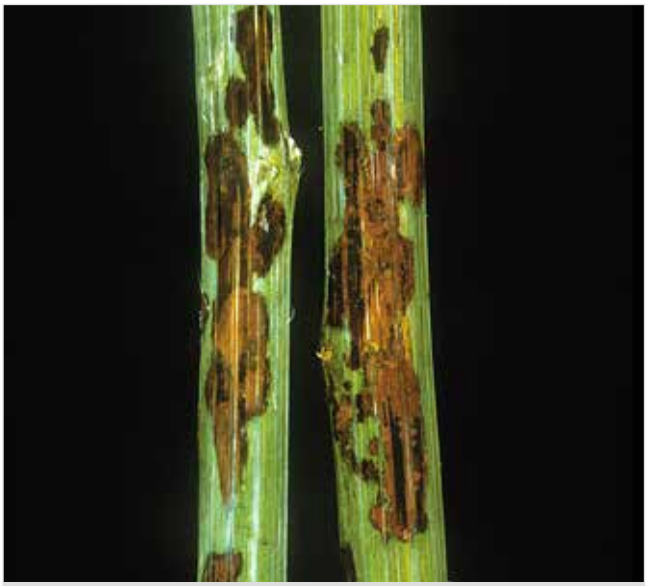


Diagram 1. Life cycle of the raspberry cane midge

Damage

The damage caused by first generation midge larvae, feeding on the outer cortical tissue of young canes, is not usually severe. However failure to control the first generation will allow populations to increase so that subsequent generations cause greater levels of damage. The areas of damage on the outer cortical tissue are known as 'patch lesions' (Figure 8). These may extend well up the length of a primocane. The damaged canes usually continue to grow normally, but are weakened and made susceptible both to cold injury during winter and a range of pathogenic fungi. These fungi include *Leptosphaeria coniothyrium* (the principal cause of 'cane blight'), *Fusarium* and *Phoma* species. Infection by such pathogens can give rise to a disease complex known as 'midge blight'. In the following spring and early summer, affected canes (now floricanes) may fail to break bud or break bud and then die before or during harvest (Figure 9 – overleaf). Sections of canes bearing a high concentration of patch lesions may become so brittle, that they are easily broken by the passage of machinery or by pickers working in the plantation (Figure 10 – overleaf).



8. Patch lesions caused by cane midge feeding

9. Plantation displaying dead fruiting canes in spring following development of 'midge blight'

10. Brittle floricane broken by machinery as a result of 'midge blight'

Blackberry leaf midge (*Dasineura plicatrix*)

Biology

Blackberry leaf midge feeds on blackberry, raspberry and loganberry. In recent years it has become a serious pest of protected blackberry and its biology was studied by ADAS in 2009 and 2010 in HDC project SF 102. The pest overwinters as larvae in cocoons, mainly in the top few centimetres of soil beneath the plants, but also in plant debris at the base of plants. The first generation adult midges emerge in the spring, usually in May/June on outdoor crops or from early April onwards in protected crops, depending on temperatures. Adult midges are small (1.5-2 mm long), delicate insects with pale pink bodies, long legs and long beaded antennae. The body colour is paler than that of raspberry cane midge. Within a week of emergence, females lay small, transparent, cigar-shaped eggs on young unfurled leaves. Eggs are very difficult to see without a microscope as they are laid at the base of the dense leaf hairs. The newly hatched, transparent larvae quickly move inside the folded leaves to feed (Figure 11). As they grow they become opaque white and sometimes pale pink (Figure 12). Like other midge larvae they have no legs and no obvious head. After about two weeks on protected blackberry, fully fed larvae drop to the ground to pupate. On outdoor blackberry only two generations are reported, in May/June and July/August. In protected blackberry, depending on the season, there can be three or four generations between April and September, with numbers peaking in July.

11. Blackberry leaf midge larvae feeding on young folded leaf

12. Blackberry leaf midge larvae before pupating

Damage

Larval feeding in young leaves causes the mid-rib to thicken and the leaves to twist (Figure 13). Severely damaged leaves then turn brown and wither. Feeding damage checks the growth of infested shoots, leading to cane stunting and branching and reduced yield in the following year's crop.

13. Blackberry leaf midge damage to primocane tip

Other gall midge pests of cane fruit crops

Blackberry flower midge (*Contarinia rubicola*)

Eggs are laid within blackberry flower buds and larvae feed gregariously within these buds. Infested flower buds swell and often fail to open but if only a few larvae feed on the bud then a distorted fruit may be produced. Although widespread, blackberry flower midge is only an occasional pest of blackberry.

Blackberry stem gall midge (*Lasioptera rubi*)

Eggs of this midge are laid at the base of buds and lateral shoots of blackberry, loganberry or raspberry. The larvae burrow into the shoot causing it to swell, producing a distinct gall up to 40 mm in length. Affected plants may become stunted and their yield reduced. Despite being widespread and common, blackberry stem gall midge is not currently an important pest.

Other fly pests of cane fruit crops

Loganberry cane fly (Raspberry cane maggot) (*Pegomya rubivora*)

Adult cane flies resemble small house-flies and emerge from the pith of the canes in which they have pupated in April or May. Adult females lay their eggs in the axils of the terminal leaves of current season primocanes. The larvae burrow into the pith and then girdle the cane so that the tip of the cane wilts and branching is induced (Figure 14). If damage to the canes is near the base, then the whole cane may wilt and rapidly die. Raspberry and *Rubus* hybrids such as Tayberry, Loganberry and Sunberry are susceptible to this pest. Blackberry is occasionally susceptible.

14. Damage caused to loganberry by loganberry cane fly

Mites

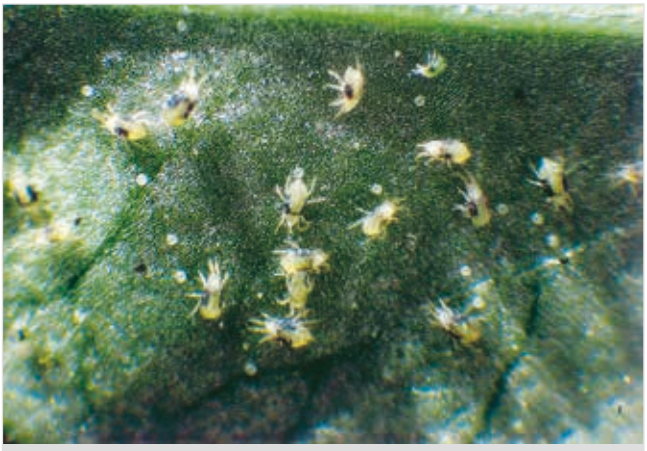
Introduction

Three species of mite are of importance to cane fruit. The largest and most spider-like is **two-spotted spider mite** with adult females measuring up to 0.6 mm in length. In contrast, **raspberry leaf and bud mite** and **blackberry mite** are tiny at less than 0.2 mm in length.

Two-spotted spider mite (*Tetranychus urticae*)

Biology

Overwintering female mites become active in March or April when they leave their overwintering sites and move onto the crop plants, colonising the underside of leaves where they feed and lay eggs. The eggs are 0.13 mm across, globular and translucent (Figure 15), becoming pale red before hatching. They hatch after about a week but take longer at temperatures below 12°C. Larvae develop through a series of nymph stages before developing into adults. Adult females are 0.6 mm long, pale yellow or green, with two dark patches on the body (Figure 15). The overwintering form is orange to brick red in colour. Adult males are similar to females but smaller. There are several overlapping generations throughout the summer and into the early autumn. In the summer, female mites take three to four weeks to complete their development from egg to adult. Male mites make up only about 20% of the population. Each female mite can lay about 100 eggs, with fertilised eggs developing into females and unfertilised eggs developing into males. Winter-female forms are produced in response to shorter days and are seen within crops from September onwards. After mating they seek shelter amongst weed litter, dead leaves, soil and wooden supporting structures where they overwinter. The complete life cycle of the two-spotted spider mite is illustrated in Diagram 2 – overleaf.



15. Adult two-spotted spider mites and their globular translucent eggs

Two spotted spider mite

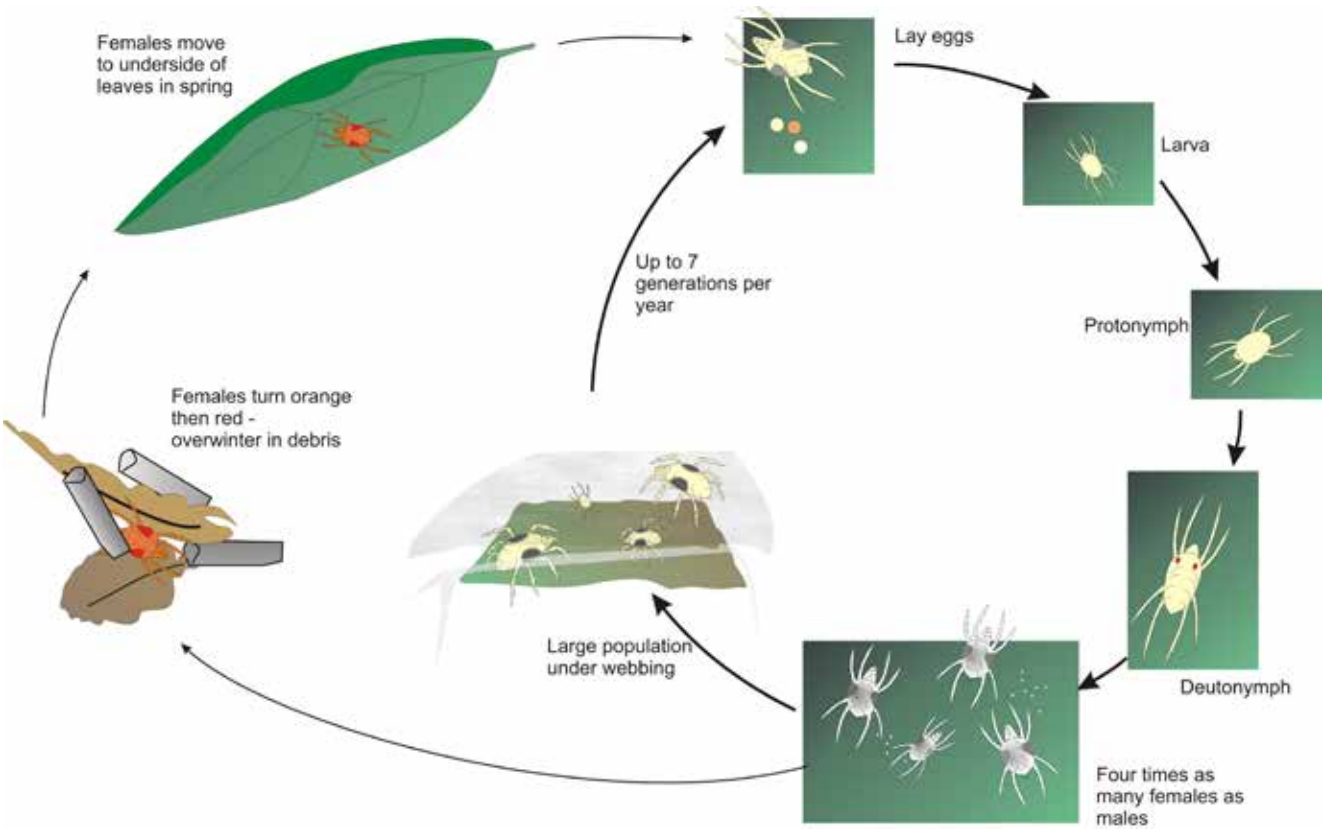


Diagram 2. Life cycle of the two-spotted spider mite

Damage

Two-spotted spider mites feed by piercing plant cells and sucking out the sap. Initially silver or pale yellow spots (Figure 16) may be seen on the upper surface of affected leaves, but where damage is severe the upper leaf surface may appear speckled and bronzed (Figure 17) or the leaf may wither and fall. This pest is most damaging when conditions are hot and dry (>21°C), which favours the rapid build up of mite populations. When present in large numbers the adult mites can produce and shelter within fine webbing (Figure 18), which may cover and extend from infested leaves down canes.

16. Early signs of two-spotted spider mite feeding on the upper surface of a raspberry leaf

17. More severe damage caused by spider mite feeding on raspberry leaf

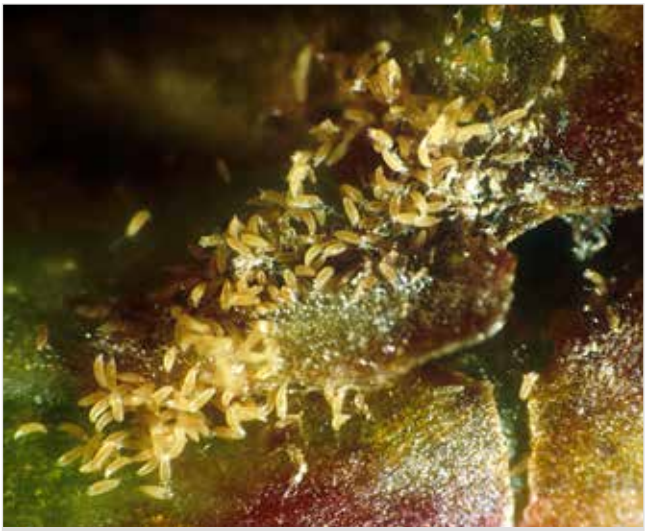
18. Typical webbing produced by large numbers of two-spotted spider mite

Raspberry leaf and bud mite (*Phyllocoptes gracilis*)

Biology

Adult raspberry leaf and bud mites are cigar-shaped, have four legs at their head end and a pair of long hair-like appendages at their rear (Figure 19). Females over-winter beneath bud scales but may also be found in cracks in cane bark (Figure 20). At bud burst the mites move to the underside of leaves where eggs are laid amongst leaf hairs. There are several overlapping generations throughout the year. Typically, fruiting canes are infested first and as the leaves on these canes harden, the mites move to the leaves of the current season's primocane. If populations are high then flowers and developing fruits may also be infested. The complete life cycle of the raspberry leaf and bud mite is illustrated in Diagram 3.

19. Adult raspberry leaf and bud mite photographed under a microscope



20. Adult raspberry leaf and bud mites emerging from bud scales

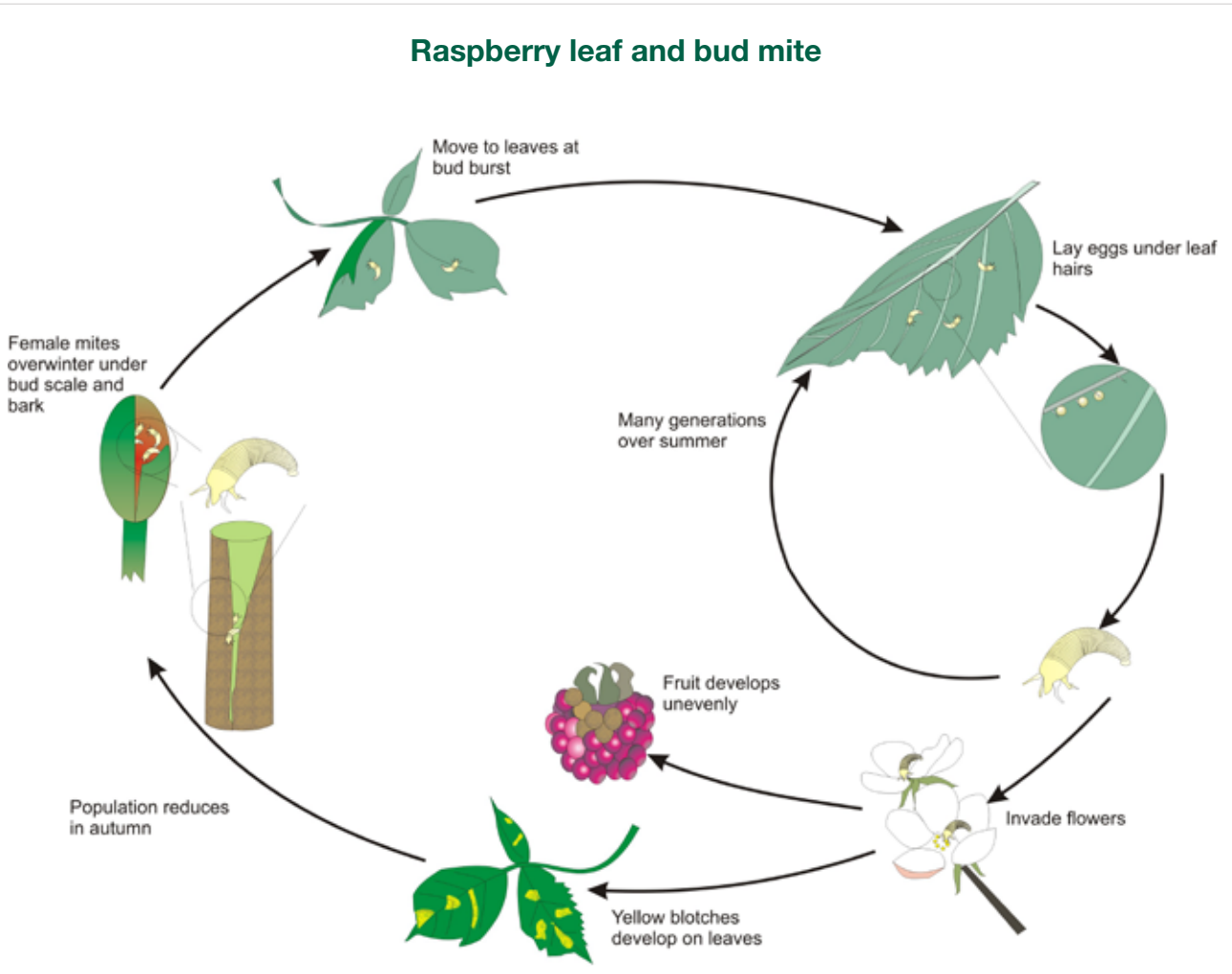


Diagram 3. Life cycle of the raspberry leaf and bud mite

Damage

Greatest damage is found on canes grown in sheltered and hot dry conditions, with tunnel and glasshouse crops being particularly vulnerable to attack. Feeding on raspberry leaves produces chlorotic blotches (Figure 21) and the leaves themselves may become distorted. Apical buds of young canes may be killed, resulting in development of weak side shoots. Where the fruits are attacked, development of drupelets is irregular with uneven ripening and malformation occurring. The damage caused by the feeding of this pest is often confused with that caused by leaf spot or aphid and nematode borne viruses (Figure 22). Recent research at the James Hutton Institute has shown that raspberry leaf and bud mite is the vector of raspberry green leaf blotch virus (RGLBV). Leaf hairiness is associated with the susceptibility of the raspberry cultivar. Those cultivars with few if any hairs, such as Glen Ample, are particularly susceptible to attack by this mite.

21. Typical chlorotic blotching effect produced by raspberry leaf and bud mite feeding

22. Damage caused by raspberry leaf and bud mite – this can sometimes be confused with virus infection

Blackberry mite (*Acalitus essigi*)

Biology

Blackberry mite is widely distributed in Europe on wild and cultivated blackberries. The mite overwinters in bud scales or within dried out fruits and in the spring, migrates from these sites to new leaf growth. The mites feed and reproduce amongst the hairs on the undersides of the leaves as well as on leaf petioles. There are several overlapping generations throughout the season. At flowering, they colonise floral parts and continue to feed on the developing drupelets.

Damage

Affected drupelets remain red as the berries ripen leaving the fruits with a two tone (red/black) colour. This condition is often referred to as ‘red berry’ and the mite referred to as ‘red berry mite’. The fruit is rendered unmarketable (Figure 23). In recent years this has become one of the most serious problems affecting blackberry crops. Drupelet discolouration is thought to result from the injection of a toxic saliva as the mite feeds. Damage typically increases through the season with late-maturing fruits often most severely affected. Recent work at East Malling Research (EMR) in HDC project SF 116 has indicated that the numbers of mites found in buds and feeding on foliage, flowers or fruits does not correlate with the amount of ‘red berry’ affected fruit. Therefore, it is now thought that other agents, most probably a virus, may be responsible for the persistence of ‘red berry’ affecting plants, which are otherwise pest free.

23. Damage caused to blackberry fruits by blackberry mite feeding

Caterpillars

Introduction

The term ‘caterpillar’ normally refers to the larvae of moths or butterflies, but in this factsheet we refer also to the larvae of sawflies, a group of insects that also includes ants, bees and wasps. Most species of caterpillar attacking cane fruit crops are of minor importance. The most damaging are the **raspberry moth** and the climbing cutworms such as the **double dart moth**. Only one species of sawfly, the **small raspberry sawfly**, is considered to be a sporadic, but locally important pest of raspberry.

Raspberry moth (*Lampronia corticella*)

Biology

This small moth can be a very serious pest of raspberries. The adult has a wingspan of 9-12 mm and has shiny, dark golden-brown forewings with cream/yellow spots and a yellowish head (Figure 24). After mating, the females lay a single egg in each flower at the base of a stamen or a petal, in May and June. The larvae feed on the surface and then tunnel into the receptacles of developing fruits. The larvae at this stage are bright red with a black head (Figure 25). Three to four weeks later they leave the fruit and hibernate in the soil near the plant roots. In the following spring, the larvae crawl up the cane (Figure 26) and bore into a bud or young shoot to continue feeding. More than one bud or shoot may be damaged in this way. The larvae pupate within a silken cocoon either within the bud or shoot or on a leaf. Adults emerge about three weeks later.

24. Raspberry moth adult

25. Raspberry moth larva

26 Raspberry moth larvae crawling up cane in spring

Damage

Damage to fruit is not considered to be important but damage to the buds and young shoots the following spring may cause the floricane to wither and die (Figure 27). If both primary and secondary buds are attacked, fruit yields are substantially reduced.

27. Total removal of developing buds caused by raspberry moth larvae, leading to death of floricane

Double dart moth (*Graphiphora augur*)

Although this species is present throughout the UK, economic damage has been confined to Scottish raspberry plantations. Adult moths (Figure 28 – overleaf) lay eggs during the summer and their larvae feed leaving small holes in the foliage at the base of the primocane. After passing through two larval stages, they drop to the ground to hibernate. The larvae (up to 45 mm in length) emerge in the spring when they climb the floricane and devour developing buds (Figure 29 – overleaf). If emergence coincides with a relatively mild period, small numbers may cause severe defoliation similar to that caused by raspberry moth larvae (Figure 27).

28. Double dart moth adult

29. Double dart moth larvae feeding on developing buds

Other caterpillar pests of cane fruit

A large number of other species of caterpillar are minor or occasional pests of cane fruit crops. Amongst these are several species of tortrix moth (Figure 30). The larvae of these small moths often feed within spun or rolled leaves (Figure 31) and characteristically wriggle backwards if disturbed. The larvae of some species such as Flax tortrix (*Cnephasia interjectana*), feed on stamens and receptacles of raspberry flowers, causing fruit malformation or loss, and has been an important pest in the past. Other species such as *Lozotaenia forsterana* and winter moth (*Operophtera brumata*) may feed on raspberry leaves while *Ditula angustiorana*, light brown apple moth (*Epiphyas postvittana*) and fruit tree tortrix (*Archips podana*) feed on leaves, flowers or developing fruits but rarely cause economic damage.

30. Tortrix caterpillar on raspberry leaf

31. Tortrix damage to raspberry

Of more importance is the bramble shoot moth (*Epiblema uddmanniana* – Figure 32), which can cause substantial damage to the foliage and tips of primocanes and developing lateral buds of floricane of raspberry, blackberry and loganberry. Similar damage can be caused by the larvae of bud moth (*Spilonota ocellana*) and Carnation tortrix moth (*Cacoecimorpha pronubana*).

32. Bramble shoot moth caterpillar

Other occasional moth pests of cane fruit crops include *Schreckensteinia festaliella*, vapourer moth (*Orgyia antiqua*), garden tiger moth or woolly bear (*Arctia caja*) and clouded drab moth (*Orthosia incerta*). Most species feed on foliage and some, like the yellow-tail moth (*Euproctis similison*), on leaves and developing fruitlets.

The damage caused by the larvae of other species of moth may be less obvious. Garden swift moth (*Hepialus lupulinus*) feeds on the roots, while the rosy rustic (*Hydraecia micacea*) bores into canes, and a number of species including *Nepticula aurella* and *Tischeria margenea* mine leaves.

Small raspberry sawfly (*Priophorus morio*)

Biology

Small raspberry sawfly adults are green, 4.5-7.0 mm in length and are active from May onwards. Eggs are laid on the underside of raspberry leaves and occasionally on blackberry and loganberry leaves. Individual larvae feed on a single leaf, fall to the ground and pupate within a semitransparent, pale brown, double walled cocoon, spun on the leaf or amongst leaf debris. A second generation is then completed and adults may remain within crops until August.

Damage

Feeding by larvae produces elongated holes in leaves, which although obvious, is rarely of economic importance unless numbers are high. Larvae can potentially be a crop contaminant.

Other sawfly pests

The larvae of the raspberry leaf-mining sawfly (*Metallus pumilus)* feed between the upper and lower leaf surfaces and may consume up to half of the total leaf area. Although the damage caused may be very obvious, it is rarely of economic importance.

Crop monitoring for midges, mites and caterpillar pests

Midges

Raspberry cane midge

Accurately determining the date that the first adult midges emerge from the soil in the early spring is vital to decide when or if to spray and to achieve effective control.

Several methods can be used to determine when adult midges are first present in plantations of raspberry and susceptible hybrid berries:

- For open field grown crops, a predictive model developed by the James Hutton institute and ADAS UK Ltd may be used. This is based on cumulative soil temperatures above a threshold of 4°C. This relies on daily maximum and minimum temperatures recorded at a depth of 10 cm, collected locally from late winter onwards, and can predict a date of midge emergence within ± 4 days.
- Determining when egg laying has commenced may be done by artificially damaging the rind of primocanes to create sites for oviposition. Starting when the first canes reach 15 cm, small batches of canes are selected at random, tagged and damaged. Each batch is harvested seven days later and using a hand lens or under a microscope, the cortex beneath the edge of the slits is checked for the presence of eggs.
- More recently, as part of Defra Horticulture LINK project HLO175 (HDC project SF 74), the female sex pheromone, which is highly attractive to male raspberry cane midge, has been identified and synthesised by EMR and the Natural Resources Institute (NRI). Further information is available in HDC Factsheet 13/11. Delta traps are now commercially available containing this pheromone (Figure 33). It is recommended that two traps per plantation are set up in March for early protected crops and late March to early April for outdoor crops. Traps should be hung 0.5 m above the ground in the crop rows and the trap catches recorded weekly until a threshold of 30 midges per trap is exceeded. If required, spraying with a suitable insecticide should be carried out a few days later. By continuing to monitor these traps throughout the season, the effectiveness of insecticide sprays can be determined as well as the need for further applications.

33. Sex pheromone trap used for monitoring purposes

When adult midge emergence has been predicted, confirmed or egg laying has commenced, the following points should be considered before deciding upon the need for control measures:

- If there is no primocane present in the crop rows or alleys, there are no potential sites for midge egg laying. Continue to monitor the midges using traps, but delay any necessary control measures until a later date when canes are present.
- To remove excess primocane in the crop row or to reduce the numbers, vigour and height of primocane during harvest, some growers remove the first flush in the spring before it reaches 20 cm in height, using the contact acting herbicide carfentrazone-ethyl (Shark). This practice can also remove egg laying sites for the first generation of cane midge. However it should not be assumed that this will completely avoid the first generation of midge. Spawn removal is not always complete, especially where a polythene mulch covers the soil surface and protects the bases of canes from the desiccant sprays.
- The rind of certain cultivars such as Malling Leo or Georgia may not readily split. With such cultivars, there may be no need to apply control measures, even if monitoring reveals the presence of high numbers of midge, as there are no suitable sites for cane midge to lay eggs.
- Mechanical or cold injury to the primocane may accentuate the splitting of cane rind. This substantially increases the risk of damage even for cultivars that normally do not require protection against this pest.

The size of the raspberry cane midge population and the susceptibility of crops can vary greatly each spring. Thus, growers should routinely monitor their individual plantations for the presence of this pest and not rely on previous experience and crop growth stage as the basis for decisions on whether to spray.

Blackberry leaf midge

As with raspberry cane midge, identifying when first generation adults emerge is critical for timing of any pesticide effective against adults or larvae. In HDC project SF 117, the female sex pheromone was identified by NRI and EMR in 2011 and traps with pheromone lures are now commercially available for monitoring this pest.

- In HDC project SF 102, soil temperature data was modelled by ADAS in a similar manner to the raspberry cane midge model, to predict first generation emergence and egg-laying dates. In 2009, results were promising, with predicted dates being only a few days earlier than dates when eggs were first found. This pest seems to emerge and lay eggs slightly earlier than raspberry cane midge. Although adults can be trapped in water traps placed on the ground underneath plants, they can only be reliably identified by an entomologist using a binocular microscope.
- Growers who decide to use pheromone traps should place

them in plantations well before the first adults are usually expected to appear. For early protected blackberry or double cropping primocane raspberry crops, this should be in late March-early April. Two traps are recommended to monitor a uniform plantation up to 2 ha in size. The traps should be hung 0.5 m above the ground in the crop rows and placed at least 50 m apart. Check the traps once per week. The threshold for spraying for control is a cumulative catch of 10 midges/trap.

- Where pheromone traps are not used growers should monitor young leaf tips in blackberry, raspberry and loganberry crops from early April onwards. A hand lens is needed to see young larvae or cast larval skins inside folded leaves.

Mites

Two-spotted spider mite

From bud burst onwards, check the underside of expanding foliage of floricanes and the basal leaves of emerging primocanes for the presence of overwintered adult female mites. Monitor throughout the crop but pay particular attention to areas where this pest was a problem the previous year. Also check for the presence of any natural predators of this pest such as *Amblyseius andersoni*. Continue to check the foliage (floricane and primocane) throughout the season in each plantation for presence or absence of all developmental stages of this pest. If the pest is found and insufficient native beneficials are present, introduce appropriate predators or continue to monitor until the threshold for damage is reached (i.e. an average of 10 motile mites or eggs per leaf, recorded on 50 leaves selected at random across the plantation). If this threshold is reached, either introduce more predators or apply a suitable acaricide.

Raspberry leaf and bud mite

Look out for yellow blotches on the upper surface of leaves on floricanes in spring and early summer. Later in the summer and in early autumn check current season primocanes. Also look out for canes bearing poorly set misshaped or unevenly ripened fruit. To confirm mite damage, using a x 20 hand lens, look for eggs or adult mites feeding on the underside of leaves bearing yellow blotches.

If mites are present, the hairs on the underside of the foliage will be damaged, producing a scuffed and green coloured section of leaf lamina. If the presence of mites cannot be confirmed then collect and send suitable samples of affected foliage to a plant clinic where they can be examined under a microscope.

There is no apparent correlation between the number of over-wintering mites in buds and damage to plant foliage, flowers and fruits the following spring, summer and early autumn. If despite apparent control of this mite the symptoms persist, then it is likely that raspberry green leaf blotch virus is now present. This can only be confirmed by a laboratory.

Blackberry mite

This mite can be found beneath the outer scales of buds on floricanes in the late winter and early spring months. Later mites can be found at the base of leaf petioles. This mite is extremely difficult to detect. It is possible to see the mites using a x 20 lens but microscopic examination of buds may be necessary to confirm their presence and even very small numbers may be responsible for considerable damage to some very sensitive cultivars such as Loch Ness or Karaka Black. Monitoring of crops for this pest therefore tends to rely upon the early detection of damaged fruit ('red berry'). This would necessitate post harvest spray application and repeat application the following spring or early summer to bring this mite under control.

Caterpillars & sawfly

Pheromone traps can be used to detect the presence of some tortrix moths, including summer fruit tortrix, fruit tree tortrix and carnation tortrix moth. Pheromone trap catches may also be used to establish a threshold, above which spraying for control is necessary. However, in most cases growers rely on checking the foliage of their crops every 7 or 10 days throughout the growing season for the presence of these pests. Existing and potential damage to the crop as well as the risk of crop contamination at harvest will determine whether or not a spray is required.

Control of midges, mites and caterpillar pests of cane fruit crops

Cultural control

Midges

Raspberry cane midge

The propensity for rind to split on primocanes varies between cultivars. In some, the rind splits very readily and early in the season, providing ideal sites for egg laying. In others, such as Glen Prosen, Georgia, Malling Leo and the hybrid berries tayberry and loganberry, the rind does not readily split. These are rarely affected by midge blight because female midges are unable to find suitable oviposition sites apart from those caused by mechanical injury.

Other *Rubus* species and crosses have been investigated as sources of resistance to raspberry cane midge. *Rubus parviflorus, R. odoratus* and crosses of *R. crataegifolius x R. idaeus* were found to be resistant when exposed to raspberry cane midges. This is because the periderm around midge infested wounds repairs itself rapidly in resistant plants, offering the midge larvae little nourishment.

Removal of the first flush of primocane from summer fruiting raspberry plantations can also be used as a means of preventing damage by this pest. This is only possible where a desiccant herbicide such as carfentrazone-ethyl (Shark) is applied at the correct rate and volume to rapidly kill the canes. If the desiccant herbicide fails to provide a complete kill, any remaining canes from the first flush which have been damaged or split, are likely to offer the female midges ideal egg laying sites. Growers should also be aware that in some situations with certain cultivars, the process of spawn removal can be slow and the return of a second flush may be delayed, leading to a reduction in cane number and loss of vigour.

Blackberry leaf midge

Covering the soil surface beneath the plants and in the alleys with a polythene mulch may provide some control of blackberry leaf midge, as larvae will collect on the surface of the polythene thereby preventing their pupation in the soil.

Predators and natural enemies

A range of naturally-occurring beneficial invertebrates can often be found in cane fruit plantations. Some of those mentioned in this section are also available to purchase from biological control suppliers to introduce into a crop. It is important that growers and agronomists are aware of the different beneficial invertebrates that occur and which of the pests they will feed on. Such knowledge will aid decisions on the need to provide additional control measures.

Midges

Although natural predators will prey upon raspberry cane midge, they cannot be relied upon to provide effective control at any stage of its life cycle.

The adults and nymphs of naturally occurring anthocorid bugs (Figure 34 – *Anthocoris nemorum*) and *Orius* species have been observed predating on blackberry leaf midge larvae in commercial crops. Recent HDC funded research (SF 102) indicated that in the laboratory, the anthocorid bug *Orius laevigatus* was capable of devouring up to five midge larvae a day and *Neoseiulus (Amblyseius) cucumeris, A. andersoni* and *Macrocheles robustulus* would also predate on the eggs and young larvae of this pest. However, when introduced into a commercial blackberry plantation, only *Neoseiulus cucumeris* and late introductions (August) of *Orius laevigatus* had any real impact on this pest. Further work is required to develop these biocontrol agents for use in blackberry.

34. Anthocorid bugs have been observed predating on blackberry leaf midge

Mites

The naturally occurring predatory mite *Typhlodromus pyri* (Figure 35) will provide some control of two-spotted spider mite in *Rubus* crops. However its preferred prey is fruit tree red spider mite, so where two-spotted spider mite is established it is unlikely to provide effective control.

35. *Typhlodromus pyri* feeding on two-spotted spider mite

Anthocorid bugs such as *Anthocoris nemorum* and *Orius* species are also often found feeding on the foliage of cane fruit crops and may help to keep numbers of both fruit tree and two-spotted spider mite in check.

Recent HDC funded research (SF 115) identified *Amblyseius andersoni* as being present and capable of successfully over-wintering in many commercial raspberry plantations. This predatory mite may provide useful control of two-spotted spider mite for both outdoor and protected raspberry crops during the early part of the year, when conditions are cooler and the pest population is relatively small. *Amblyseius andersoni* has recently been made commercially available to growers so can now be introduced to commercial crops (see Biological control section).

The naturally occurring predatory gall midge *Feltiella acarisuga* will also control two-spotted spider mite in cane fruit crops. This midge is a particularly useful predator of two-spotted spider mite as it can fly into crops and seeks out spider mite colonies where it lays its eggs. The cream to brown midge larvae can be found feeding on nymph and adult stages of spider mites (Figure 36). It can be a particularly useful predator in protected crops, where it can be contained and utilised to best effect.

36. Feltiella acarisuga larva feeding on two-spotted spider mite

Research in HDC project SF 81 showed that under laboratory conditions, *Amblyseius andersoni* is capable of consuming more raspberry leaf and bud mites than either *Neoseiulus cucumeris* or *Typhlodromus pyri.* Unfortunately, when assessed in commercial raspberry plantations, they did not achieve the same level of success.

Caterpillars

A large number of different naturally occurring invertebrates will feed on caterpillars. Nabid bugs, ground beetles, rove beetles, parasitic wasps, parasitic flies, solitary and social wasps and bees will all feed on caterpillars. In addition, anthocorid bugs, ladybirds and hoverflies will all feed on small caterpillars.

However, none of these naturally occurring invertebrates can be relied upon to control significant populations of the caterpillar species which are known pests of cane fruit. Fortunately, there are biological control agents available which do offer control of caterpillar pests of cane fruit (see Biological control section).

Biological control

To be effective, naturally occurring or introduced predators or parasites need to be present within the crop early in the season to prevent a large build up of pests. However, naturally occurring predators and parasites do not always arrive in sufficient numbers early enough to suppress pest populations. Careful and thorough crop monitoring is therefore required to decide if natural control needs to be augmented by the introduction of biocontrol agents.

A number of biocontrol agents are now available from commercial biocontrol suppliers. The commercial names of each differ between suppliers. In addition, the rates of introduction recommended may vary considerably depending on the delivery system developed by the supplier, the crop situation, the time of year and the level of pest infestation.

Table 1 provides a list of the main midge, mite and caterpillar pests discussed in this factsheet and the commercially available biocontrol agents which might be used to gain some level of control.

Table 1 Biological control agents offering control of main midge, mite and caterpillar pests of cane fruit

Pest	Biocontrol agents offering control
Raspberry cane midge	None currently available
Blackberry leaf midge	*Neoseiulus (Amblyseius) cucumeris, Orius laevigatus*
Two-spotted spider mite	*Phytoseiulus persimilis, Neoseiulus (Amblyseius) californicus, Amblyseius andersoni, Feltiella acarisuga, Beauveria bassiana, Orius laevigatus*
Raspberry leaf and bud mite	*Neoseiulus (Amblyseius) cucumeris, Amblyseius andersoni*
Blackberry mite	None currently available
Raspberry moth	*Bacillus thuringiensis var kurstaki, Beauveria bassiana*
Double dart moth	*Bacillus thuringiensis var kurstaki, Beauveria bassiana*
Tortrix moth	*Bacillus thuringiensis var kurstaki, Beauveria bassiana*
Small raspberry sawfly	*Beauveria bassiana*

The following notes provide further information about these biocontrol agents. As the introduction rates vary considerably depending on the delivery system developed by the supplier, the crop situation and the time of year, the rates quoted should only be used as a guide and specific professional advice should be sought before using biological control agents.

Amblyseius andersoni – Predatory mite available for use on outdoor and protected crops. Recommended rates: 1 sachet/m^2 (preventive) or 2 sachets/m^2 (curative). This predator also feeds on pollen and other small invertebrate prey and is more tolerant of high temperatures in protected crops in mid summer than some other predatory mites. However, numbers may not build up fast enough to cope with large mite populations.

Neoseiulus (Amblyseius) californicus – Predatory mite only permitted for use in closed protected crops. Recommended rates: 2/m^2 every 3 weeks from April onwards (preventive) or at 6/m^2 (curative). This predator will tolerate a wider range of temperatures and pesticides than *Phytoseiulus persimilis* and can overwinter within the crop.

Neoseiulus (Amblyseius) cucumeris – Predatory mite available for use on both outdoor and protected crops (Figure 37). The recommended rates of introduction are; 50/m^2/week (preventive), or 100/m^2/week (curative). This predator may be used from mid to late-May onwards.

37. *Amblyseius cucumeris*

Bacillus thuringiensis var *kurstaki* – A bacterial insecticide used for tortrix and other moth caterpillar control, but not sawfly larvae (Figure 38). Recommended rates: 0.5-1.0 kg/ha in a minimum of 1,000 l of water. There is no restriction on the number of applications permitted/year. The best results are obtained when applications are made using high volumes and target newly hatched larvae.

38. Caterpillars killed by application of *Bacillus thuringiensis*

Beauveria bassiana ATCC-74040 – A pathogenic fungus which can provide control of some mites and caterpillars in protected crops. Recommended rates: Maximum rate of use is 3 l of product/ha, with up to 5 applications permitted/year. It is active between 10-37°C and at a relative humidity of 50-100%, although sporulation does not take place below 80%, which is high for cane fruit crops. Achieving a high relative humidity is also likely to encourage the development of cane, foliar and fruit diseases.

Feltiella acarisuga – A predatory midge used to control two-spotted spider mite on protected crops. Recommended rates: introduce from April onwards as soon as pest is seen. Establishes and performs best where there is plenty of prey and relative humidity is above 70%. Introduce 250 cocoons (Figure 39) into hot spots of mites or use 4 introductions per week, each using 2,500 cocoons/ha.

39. Cocoon of *Feltiella acarisuga*

Phytoseiulus persimilis – Predatory mite available for use on outdoor and protected crops for controlling two-spotted spider mite (Figure 40). Recommended rates: Introduction rates will vary according to the level of spider mite infestation, from 25,000 – 40,000/ha of crop row. Apply to protected crops as soon as the pest becomes active and in open field crops from mid-May onwards as soon as pest is seen. This predatory mite performs best when the relative humidity is above 70% and the temperature is between 18-30°C.

40. *Phytoseiulus persimilis* can be introduced to control two-spotted spider mite

Chemical control

Despite being able to influence the numbers and levels of infestations through use of cultural, natural and biological control measures, for many of the midges, mites and caterpillars described in this factsheet, some form of chemical insecticides may be required to keep the pests fully under control. A list of all the chemical insecticides approved for use on raspberry, blackberry and hybrid berry which offer control of midges, mites and caterpillars are included in Table 2 (see insert in back cover).

It should be noted that some of the insecticides listed have a broad spectrum of activity and will have varying harmful effects on non-target insect species, including beneficial insects. Further details on the effect of the active ingredients listed on predators commonly used in cane fruit production are included in Table 3 (see insert in back cover).

Midges

Raspberry cane midge

Growers currently rely on sprays of the organophosphate insecticide chlorpyrifos for control of this pest. These should be applied in high volume sprays directed to the base of primocanes where the majority of rind splitting occurs. Timing of these applications has been greatly improved through the use of the raspberry cane midge prediction model and more recently by monitoring the pest with pheromone traps using the female sex pheromone.

Research work continues to seek active ingredients which are environmentally safer, more compatible with IPM and far less injurious to native and introduced predatory insects, mites and pollinating insects. In a recent HDC funded project (SF 101) two neonicotinoid insecticides were shown to have activity against this pest. However, in later work these insecticides were found to work well only when applied a few days after egg hatch. The aim is to provide effective control of the first generation of this pest so that later generations cause little if any damage to primocanes.

Blackberry leaf midge

Chlorpyrifos is currently the only insecticide that can provide reasonable control of this pest. However, timing is critical to catch newly hatched larvae produced by adult midges emerging from the soil in the early spring. Use of this insecticide is permitted on both open field and protected raspberry but only on open field blackberry crops. Trials have indicated that deltamethrin will also provide control of adult blackberry leaf midge but is ineffective against the larval stages of this pest, primarily because of the contact activity of this insecticide.

Other midge pests

Chemical control of the other midge pests of *Rubus* crops is usually unnecessary.

Mites

The range of acaricides available for control of the mite pests in cane fruit crops is limited. To minimise the risk of resistance occurring, it is important to use these acaricides only when other measures of control have failed. In protected raspberry and blackberry crops there is now considerable reliance on the use of biological control of two-spotted spider mite. Provided that this pest is detected early, the introduction of predators is made at the correct time and the crop protection products used are compatible with these predators, then effective control can be achieved.

An HDC project (SF 81) demonstrated that the acaricide abamectin provides effective control of raspberry leaf and bud mite when applied in the spring soon after mites have emerged from the floricane buds.

Abamectin may also provide useful control of blackberry mite. However, recent HDC funded research (SF 116) indicated that although it has activity against blackberry mite, it does not completely eliminate the pest and its use may be harmful to Phytoseiid mites, which are potentially important natural predators of this pest. Sprays of sulphur early in the growing season followed by the use of the adjuvant Codacide Oil may also be effective. Similarly, a fortnightly programme of Codacide oil also provided good control of this pest. Be aware that the use of sulphur close to harvest may result in unsightly deposits on fruit.

Caterpillars

There are a limited number of insecticides available for use in cane fruit crops for the control of moth and sawfly larvae. In addition, many caterpillar pests are difficult to target with insecticide applications. For example, climbing cutworms are nocturnal and have a very long life cycle while tortrix moth caterpillars (e.g. bramble shoot moth caterpillar) bind leaves together with webbing and feed within this protected environment.

Further information

Suppliers of biological control agents

Agralan Ltd (Biobest products)
The Old Brickyard
Ashton Keynes
Swindon
Wiltshire
SN6 6QR
Tel . (01285) 860015
www.agralan.co.uk

Becker Underwood UK
Unit 1 Harwood Industrial Estate
Harwood Road
Littlehampton
West Sussex
BN17 7AU
Tel. (01903) 732323
www.beckerunderwood.co.uk

BCP Certis
Newbury House
Court Lodge Farm
Hinxhill
Ashford
Kent
TN25 5NR
Tel. (01233) 667080
www.bcpcertis.com

Biowise
Hoyle Depot
Graffham
Petworth
West Sussex
GU28 0LR
Tel. (01798) 867574
www.biowise-biocontrol.co.uk

Fargro Ltd
Toddington Lane
Littlehampton
West Sussex
BN17 7PP
Tel. (01903) 721591
www.fargro.co.uk

Koppert UK Ltd
Unit 8
53 Hollands Road
Haverhill
Suffolk
CB9 8PJ
Tel. (01440) 704488
www.koppert.co.uk

Syngenta Bioline
Telstar Nursery
Holland Road
Little Clacton
Clacton
Essex
CO16 9QG
Tel. (01255) 863200
www.syngenta-bioline.co.uk

Biocontrol agents can also be obtained through most horticultural merchants.

Suppliers of raspberry cane midge pheromone traps

AgriSense
Treforest Industrial Estate
Pontypridd
South Wales
CF37 5SU
Tel. (01443) 841155
www.agrisense.co.uk

Other useful publications

HDC Factsheet 13/11. Pesticide residue reduction in commercial raspberry crops

SAC Technical Note. Recognising pest damage on raspberries

HDC Crop Walkers' Guide. Cane Fruit

Useful HDC project reports

SF 74 – Integrated pest and disease management for high quality protected raspberry production (Horticulture LINK HL 0175)

SF 81 – Developing techniques to manage raspberry leaf & bud mite in tunnel produced raspberry

SF 101 – Alternatives to chlorpyrifos for raspberry cane midge control

SF 102 – Biology and integrated control of blackberry leaf midge on blackberry and raspberry

SF 116 – Preventing red berry disease by monitoring and control of blackberry mite

SF 117 – Sex pheromone trap for monitoring blackberry leaf midge

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Notes

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Table 2 Insecticides and acaricides currently approved (May 2012) for use on cane fruit crops offering control of midges, mites and caterpillars

Active ingredient	Typical products	Target pests on label or EAMU (if specified on EAMU)	Raspberry		Blackberry		Hybrid Berry		Harvest interval	Midges, mites and caterpillars controlled incidentally by use	Max no. of applications and other information
			Outdoor	Protected	Outdoor	Protected	Outdoor	Protected			
abamectin	Dynamec	Raspberry leaf and bud mite Two-spotted spider mite	X	✓(E)	X	✓(E)	X	X	3 days	-	A maximum individual dose of 0.5 l/ha or 50 ml/100 l of water. A maximum of 1 l/ha/annum. Application should not be made between 1 November and end of February. Application to crops under temporary covers should not be made once the covers have been removed.
Bacillus thuringiensis var. *kurstaki*	Dipel DF	Moth caterpillars	✓	✓	✓(E)	✓(E)	✓(E)	✓(E)	None	-	A maximum concentration of 75 g/100 l of water – high volume recommended.
chlorpyrifos	Equity	Aphids Raspberry beetle Raspberry cane midge	✓	✓	✓(E)	X	X	X	7 days	Midges Moth caterpillars Sawfly some populations of Two-spotted spider mite	Dursban WG – 3 applications or max 1.8 kg/ha. Equity – 3 applications or max 3 l/ha. May cause crop scorch under protection. Organophosphate pesticide.
clofentezine	Apollo 50SC	Two-spotted spider mite	✓ (E)	✓(E)	✓(E)	✓(E)	X	X	7 days (protected crop) 14 days (outdoor crop)	-	3 applications. 400 ml/ha or a maximum of 400 ml/1000 l of water.
deltamethrin	Decis	Raspberry beetle	✓	✓	✓(E)	X	X	X	Nil	Midges (adults) Moth caterpillars (contact action)	Rate varies according to product. Synthetic pyrethroid pesticide.

Active ingredient	Typical products	Target pests on label or EAMU (if specified on EAMU)	Raspberry		Blackberry		Hybrid Berry		Harvest interval	Midges, mites and caterpillars controlled incidentally by use	Max no. of applications and other information
			Outdoor	Protected	Outdoor	Protected	Outdoor	Protected			
lambda cyhalothrin	Hallmark with Zeon technology	Clay-coloured weevil Capsids	✓(E)	X	✓(E)	X	✓ (E)	X	28 days	Midges (adults) Moth caterpillars (contact action)	Maximum individual dose 75 ml/ha, 4 applications or max 150 ml/ha per annum. Synthetic pyrethroid pesticide.
maltodextrin	Eradicoat Majestik	Spider mites Aphids Whitefly	✓	✓	✓	✓	✓	✓	None	-	Maximum concentration 25 ml/1 l of water. 20 applications. Eradicoat protected crop only.
pyrethrins	Spruzit	Two-spotted spider mite Caterpillars Sawfly	✓	✓	✓	✓	✓	✓	None	-	6-12 l/ha - rate according to method of application, size of plant & target pest. Maximum concentration of use 2 l/100 l of water. Minimum volume 300 l/ha.
spinosad	Tracer	Thrips	✓ (E)	X	✓ (E)	X	X	X	3 days	Moth caterpillars	Maximum individual dose 200 ml/ha, not less than 1000 l water/ha 2 applications.
tebufenpyrad	Masai	Two-spotted spider mite	✓ (E)	X	✓ (E)	X	X	✓ (E)	21 days (raspberry & blackberry) Pre flowering or post harvest Protected *Rubus* hybrids	-	1 application. 375 g/ha - minimum volume of 1000 l water/ha.
thiacloprid	Calypso	Common green capsid Raspberry beetle	✓ (E)	✓(E)	✓ (E)	✓ (E)	✓ (E)	X	3 days	Sawfly (larvae)	Maximum individual dose of 250 ml/ha, 3 applications/annum. Max total dose 750 ml/ha. Neonicotinoid pesticide.

NB: (E) = EAMU

Table 3. Harmful effects posed by approved insecticides to predators commonly used in cane fruit

Active ingredient	Typical product	*Neoseiulus (Amblyseius) californicus*	*Neoseiulus (Amblyseius) cucumeris*	*Feltiella acarisuga*	*Phytoseiulus persimilis*	Bees
abamectin	Dynamec	Harmful (1-2 weeks)	Harmful (2 weeks)	Harmful (7 days)	Harmful (1-2 weeks)	Remove for 1.5-3 days
chlorpyrifos	Equity	Moderately harmful to adults & nymphs (2 weeks)	Harmful to adults & nymphs (6-8 weeks)	Harmful	Moderately harmful to adults & nymphs (up to 3 days)	Incompatible for at least 7 days
Bacillus thuringiensis var *kurstaki*	Dipel DF	Safe	Safe	Safe	Safe	Close hive before application
clofentezine	Apollo 50SC	Safe	Safe	Safe	Safe	Remove for 24 hours
deltamethrin	Decis	Moderately harmful to adults & nymphs	Harmful to adults & nymphs (> 8 weeks)	Harmful (> 8 weeks)	Harmful to adults & nymphs (> 8 weeks)	Remove for 2-3 days
lambda cyhalothrin	Hallmark with Zeon technology	Moderately harmful to adults & nymphs	Harmful to adults & nymphs (> 8 weeks)	Harmful (> 8 weeks)	Harmful to adults & nymphs (> 8 weeks)	Incompatible for 15 days
maltodextrin	Eradicoat/Majestik	Harmful until spray residue dry	Harmful until spray residue dry	Harmful until spray residue dry	Harmful until spray residue dry	Remove before application, until spray residue dry
pyrethrins	Spruzit	Harmful (1 day)	Harmful (1 day)	Harmful (1 day)	Harmful (1 day)	Close and cover hive for 1 day
	Pyrethrum 5 EC	Harmful (up to 1 week)	Harmful (1 week)	Harmful (> 1 week)	Harmful (1 week)	Remove for 1.5 days
spinosad	Tracer	Safe	Harmful (1-2 weeks)	Conflicting information (safe or harmful)	Slightly harmful (1 week)	Remove for 1-2 days
tebufenpyrad	Masai	Safe	Slightly harmful	Harmful (1-2 weeks)	Harmful (1-2 weeks)	Remove for 12 hrs
thiacloprid	Calypso	Safe	Moderately harmful (2 weeks)	Harmful to larvae, moderately harmful to adults	Moderately harmful (2 weeks)	Remove for 1-2 days

Safe: kills<25%
Slightly harmful: kills 25-50%
Moderately harmful: kills 50-75%
Harmful: kills >75%
(Persistence against bio controls given in brackets)

This data has been compiled from the following websites, and from the practical experience of BCP Certis: http://www.biobest.be http://www.koppert.com