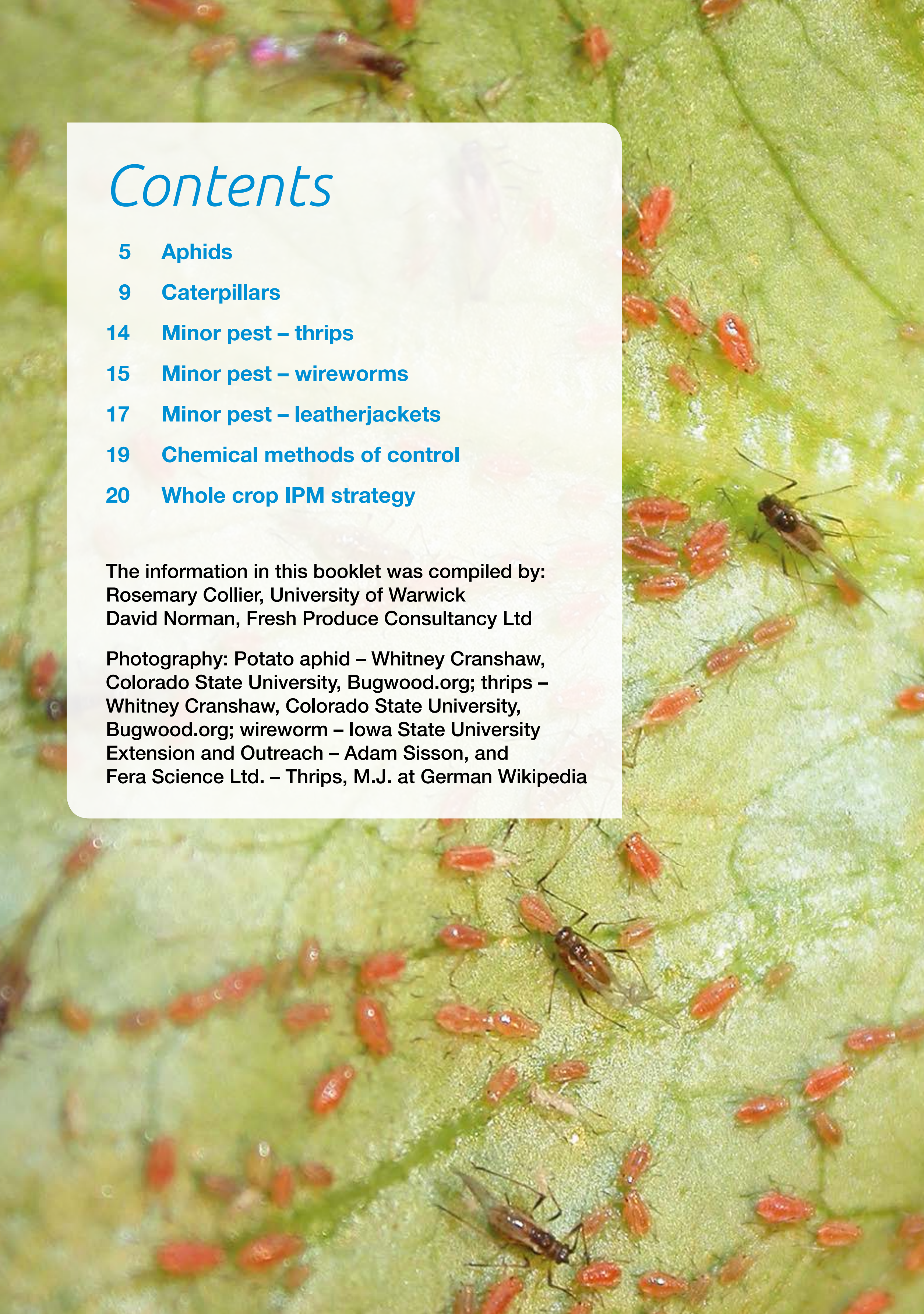
AHDB

Pest insects infesting lettuce crops

HORTICULTURE



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Introduction

In lettuce crops, the scale of losses due to pests varies considerably depending on the crop and type of infestation, but whole crops may be rejected even if a relatively small proportion of the plants are infested with caterpillars or aphids. Virus transmission by aphids may also lead to considerable losses in yield.

As they are cold-blooded organisms, the rate at which pest insects complete their life cycle is driven by the temperature of their surroundings and they will develop more rapidly when the weather is warm. This means they become active earlier following a warm spring and they are usually active earlier in the south of the UK than the north. In addition, weather conditions can have a considerable impact on the abundance of most pest insects; for example, heavy rainfall can lead to high levels of mortality in aphids and cutworms. There is no such thing as a 'typical' year when considering the complexity of pests that infest lettuce and their natural enemies.

Overall, the life cycles of the various pests of lettuce are very different but there are periods when more than one species is active and so, consequently, control programmes should be planned to take this into account.

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Key messages

Lettuce crops can be infested by several species of pest insect, the principal pests being aphids (Figure 1) and caterpillars. Pests can reduce yield and crop quality through direct feeding damage, transmission of plant viruses and contamination. This manual does not cover slugs; for slug control advice, visit **ahdb.org.uk/projects/slugcontrol.aspx**

Figure 1. Lettuce infested with currant-lettuce aphids

- All pest species have natural enemies that regulate their numbers to some extent. Where feasible, selective pesticides and/or methods of application should be used to protect beneficial species
- Be aware of the potential for resistance to insecticides, particularly in the peach-potato aphid and thrips
- To aid treatment timing, information on the timing of activity of most of these pests can be obtained from the AHDB Pest Bulletin, AHDB Aphid News and other sources
- Adult males of the silver Y moth and turnip moth can be captured in specific pheromone traps and captures of male moths indicate when female moths are likely to be laying eggs
- Some insecticide treatments have activity against more than one pest species and programmes should be planned to take this into account

Aphids

Life cycles

Lettuce crops are infested principally by four species of aphid: currant-lettuce aphid (*Nasonovia ribisnigri*, Figure 2), peach-potato aphid (*Myzus persicae*, Figure 3), potato aphid (*Macrosiphum euphorbiae*, Figure 4) and lettuce-root aphid (*Pemphigus bursarius*, Figure 5). The first three species feed on the foliage, while the lettuce-root aphid feeds on the roots. The currant-lettuce aphid and lettuce-root aphid feed only on lettuce crops, while the other species have a wider host range.

Peach-potato aphid and potato aphid

In the UK, the peach-potato aphid and potato aphid overwinter as mobile aphids on a range of cultivated and wild host plants. In the spring, aphid development becomes more rapid and winged forms are produced that fly to new hosts, from which infestations of wingless aphids may develop. Further winged forms are produced later in the summer and may infest new crops. These species reproduce without mating, producing live aphids rather than eggs, and the young aphids are genetically identical to their mother. The peach-potato aphid has a particularly wide range of hosts from different plant families (eg potato, sugar beet, lettuce, brassicas, pepper and a wide range of wild hosts) and, interestingly, lettuce is one of the less-preferred host species for peach-potato aphids.

Currant-lettuce aphid

The currant-lettuce aphid overwinters principally as a cold-resistant egg on members of the currant family (*Ribes* spp.). The eggs hatch in early spring and the young aphids develop into adults which colonise the currant bush, leading to individuals that then disperse to colonise lettuce and wild host plants. During the summer, this species reproduces without mating, producing live aphids (rather than eggs) on its summer hosts. Young aphids are, therefore, genetically identical to their mothers. In the autumn, winged individuals fly to currant, males and females are produced, and males mate with the females which subsequently lay overwintering eggs.

Figure 2. Currant-lettuce aphids (*Nasonovia ribisnigri*)

Figure 3. Peach-potato aphid (*Myzus persicae*)

Towards the south of the UK a proportion of the population may overwinter as mobile aphids on wild hosts. In the AHDB Horticulture-funded research project CP 067, currant-lettuce aphids survived the winter as nymphs and adults on wall speedwell *(Veronica arvensis)* in the Midlands. Other weed species were suitable hosts in the laboratory: *Cichorium intybus* (chicory), *Crepis capillaris* (smooth hawksbeard), *Lapsana communis* (common nipplewort), *Hieracium aurantiacum* (orange hawkweed), *Hieracium pilosella* (mouse-ear hawkweed), *Veronica spicata* (spiked speedwell) and *Veronica officinalis* (common speedwell). In the spring, the development of such overwintering aphids becomes more rapid as temperatures rise and colonies produce winged forms that fly to lettuce and other summer hosts.

Lettuce-root aphid

The lettuce-root aphid has a similar life cycle to the currant-lettuce aphid but overwinters on poplar, as a cold-resistant egg. The eggs hatch in early spring and the young aphids develop into adults which colonise the poplar tree, leading to female winged aphids that then disperse to colonise lettuce. While on lettuce during the summer, the female aphids reproduce without mating, producing live young. In the autumn, winged individuals fly to poplar, males and females are produced, males mate with the females and subsequently lay overwintering eggs. It is not known what proportion of the population spend the summer on wild herbaceous hosts (wild relatives of lettuce) and whether some remain there to overwinter as mobile aphids.

Other species of aphid, such as the black bean aphid (*Aphis fabae*) may also be found in lettuce crops from time to time. More information on the black bean aphid is available in the reports for AHDB Horticulture projects FV 407 and FV 407a.

Figure 4. Potato aphid (*Macrosiphum euphorbiae*)

Damage

All species of aphid cause direct damage if sufficiently abundant, particularly the lettuce-root aphid which may kill plants through desiccation if a sufficiently large part of the root system is damaged. Large infestations of foliage-feeding aphids will lead to distorted foliage. All foliage-feeding aphids are contaminants and produce honeydew that can support sooty moulds, which also become a contaminant.

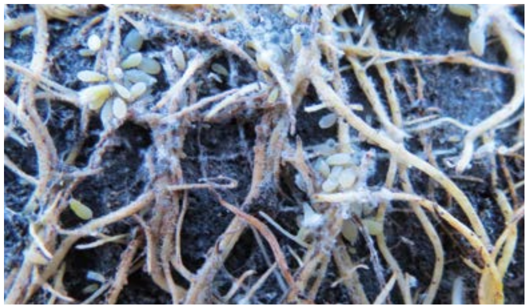

Figure 5. Lettuce-root aphids feeding on the root system

Although the peach-potato aphid is likely to be very important for the transmission of plant viruses, it is currently unclear which species of aphid (including species not named in this manual) and which viruses constitute the greatest threat to lettuce crops in the UK (AHDB Horticulture project FV 427).

Monitoring and forecasting

Monitoring

All four species of aphid are captured in the network of suction traps run by the Rothamsted Insect Survey (Figure 6). However, only peach-potato aphids and potato aphids are captured in relatively large numbers. Lettuce-root aphids cannot be easily distinguished from other species of *Pemphigus* and so are not recorded.

Currant-lettuce aphids are only ever caught in low numbers in both suction traps and water traps and appear to be 'trap-shy'; the best way to monitor infestations of currant-lettuce aphids is to look at lettuce plants.

Figure 6. Rothamsted suction trap at Wellesbourne

During the spring and summer, information on the capture of aphids by the suction traps is updated weekly, and bulletins are released on the Rothamsted Insect Survey website every Friday. These contain information on captures for the week ending on the previous Sunday. Bespoke monitoring services using yellow water traps are available. Regular crop walking is important to identify developing problems.

Forecasts

Peach-potato aphid and potato aphid

In early March each year, the Rothamsted Insect Survey releases long-term forecasts predicting the timing of the first migration of peach-potato aphid and potato aphid into crops in the spring/early summer and their relative abundance early in the year. Over the last 50 years or so, the timing and size of the migrations of these two species has shown the strongest correlation with the mean January/February air temperature and it is this relationship that is used to produce the forecasts for different locations.

Currant-lettuce and lettuce root aphids

Cold-blooded animals such as insects require a certain amount of heat to develop from one stage in their life cycle to another. The amount of heat required to complete a given stage of development is fixed and the combination of temperature (between upper and lower thresholds) and time will always be the same. This is often expressed in units called day degrees (D°). Day-degree forecasts have been developed for the two species of pest aphid that overwinter as eggs; currant-lettuce aphid and lettuce-root aphid. The forecasts for both species are based on accumulated D° from 1 February (lower threshold 4.4°C). The information was collected in projects funded by AHDB, Defra and LINK.

In the study on the currant-lettuce aphid, the mean numbers of day degrees accumulated until the first aphid was found and until peak numbers of aphids were found were 507D° and 935D°, respectively. Comparisons between observed and predicted dates showed that this forecast is likely to be accurate to within a 2–3 week period.

In the study on the lettuce-root aphid, the start of the migration of winged aphids from poplar to lettuce occurred after 672D° had been accumulated since 1 February. Monitoring data collected during the project were compared with this forecast, which was shown to give adequate early warning of the start of aphid migration.

Key risk periods

Although crops are susceptible to infestation by aphids throughout the summer, studies as part of a LINK project showed that there was a particular 'pattern' of infestation in relation to the main pest species (Parker et al. 2002). Peaks of aphid abundance on lettuce foliage occurred in midsummer (June/July) and in the autumn

(September/October) with low abundance in the intervening periods. While all three species of aphid feeding on the foliage could be present during the midsummer period, currant-lettuce aphid tended to dominate during the autumn. Crops are exposed to colonisation by lettuce-root aphid over a relatively short period of time in June/July when the aphids migrate from their winter hosts (poplar) to lettuce. The precise timing of all these events varies between years.

Non-chemical methods of control

With the exception of host plant resistance, there are no widely established non-chemical control methods for reducing the overall population of aphids in the UK. However, all species are attacked by a range of predators eg ladybirds, hoverfly larvae, lacewing adults and larvae and parasitic wasps. In addition, aphids can be infected by naturally occurring fungi that can lead to considerable mortality within an infestation.

A combination of predators, parasitism and fungi often leads to a rapid decline in aphid numbers in the middle of the season, known as the 'aphid crash'.

There have been some attempts to improve the impact of naturally occurring biological control agents (conservation biocontrol). For example, some growers of organic lettuce in California rely on biological control by hoverflies to manage aphids by planting sweet alyssum (*Lobularia maritima*) either in strips at intervals through the crop or in some other configuration. The experimental deployment of wild-flower strips in a Defra-funded project at Wellesbourne (when it was Warwick HRI) led to a reduction in the numbers of lettuce aphids on adjacent lettuce crops during June and July. However, the effect decreased with distance from the strips.

At least one producer releases aphid parasitoids into field-grown organic crops, though improved control of aphids is yet to be substantiated.

Fine mesh netting may exclude winged aphids if the mesh size is sufficiently small. This approach is being used commercially to manage aphids in organic lettuce crops. However, if aphids manage to access the crop, for example through a tear, their numbers can increase very rapidly.

In the case of both the currant-lettuce aphid and the lettuce-root aphid, sources of host-plant resistance have been identified and bred into commercial cultivars. For both species, this is complete resistance, although the resistance mechanisms differ, ie plants resistant to one species are not necessarily resistant to another, unless they contain both mechanisms of resistance. In the case of the currant-lettuce aphid, resistant cultivars have been grown increasingly in the UK and continental Europe and have made a significant contribution to crop quality. However, in 2009, after about 10 years of their use in commercial production, a breakdown in resistance to currant-lettuce aphid in resistant cultivars was reported from some locations in Europe, including the UK.

Resistance-breaking aphids develop and reproduce equally well on resistant and susceptible varieties (CP 067) and they have become relatively widespread. This has further stimulated the search for new genetic material that contains different mechanisms of resistance (by seed companies and in the UK through the Defra-funded Vegetable Genetic Improvement Network project). The loss of neonicotinoid seed treatments will increase the need for lettuce cultivars resistant to foliage-and root-feeding aphids.

Caterpillars

The caterpillars of two species of moth, turnip moth (*Agrotis segetum*) – also known as cutworms – and silver Y moth (*Autographa gamma*) are particular pests of lettuce crops, although both species will feed on a wide range of host plants from different plant families. Both are sporadic pests and infestations do not occur every year.

Life cycles

Turnip moth

Turnip moths (Figure 7) overwinter in the soil in the UK as large caterpillars (Figure 8). The caterpillars form pupae in the spring and adult moths emerge subsequently. The adult moths lay eggs on plants or on pieces of litter and debris in the soil, usually from the end of May or early June. These hatch in around 8 to 24 days, depending on temperature. The young caterpillars seek out and feed on plant foliage. In a further 10 to 20 days, again depending on temperature, the caterpillars go through their second moult, becoming "third instar" caterpillars. It is at this point that they become subterranean and feed on plant parts at or below ground level.

Figure 7. Turnip moth

The survival of young turnip moth caterpillars is affected considerably by rainfall, and survival is poor in years that are very wet.

Thus, outbreaks are usually associated with hot, dry summers, with the very large outbreak of 1976 probably being due to the occurrence of two hot, dry summers in succession (1975 and 1976). The turnip moth completes two generations annually towards the south of the UK. The caterpillars of the second generation are not usually a threat to crops.

Figure 8. Turnip moth caterpillar (cutworm)

Silver Y moth

The silver Y moth (Figure 9) is a migrant species which does not overwinter successfully in the UK. Infestations usually first arise as a result of immigration by moths in May and June.

Spring migrants use fast-moving airstreams, 200–1,000m above the ground, to travel 300km northward per night to colonise temporary summer-breeding grounds in northern Europe, from their winter-breeding grounds in North Africa and the Middle East. Radar tracking by

Figure 9. Silver Y moth

Figure 10. Silver Y moth caterpillar

Rothamsted Research was used to estimate the annual abundance of immigrating moths during the period 2000–2009. Three of those years (2000, 2003, and 2006) had high immigrant migrations in spring, corresponding to an estimated 225–240 million adult moths immigrating into the whole of the UK, whereas, in the other 7 years, the UK received roughly one-ninth of that number (10–40 million immigrants). Other outbreak years in the last hundred years have included 1946 and 1996. In August and September, many silver Y moths return to their winter breeding grounds. Silver Y moths are likely to complete one or, at most, two generations during the summer in the UK.

Damage

Turnip moth

Young turnip moth larvae feed on foliage above ground and, because of their small size, may be inconspicuous and cause relatively little damage. However, the name ‘cutworm’ derives from the habit of the older, and much larger larvae, which feed underground, damaging plant roots and stems, sometimes so badly that the plant topples over and dies.

Silver Y moth

Caterpillars of the silver Y moth (Figure 10) feed on the foliage and sometimes find their way into the lettuce heart. The eggs (Figure 11) are usually laid singly, so newly infested plants can be hard to detect. The larvae are a problem as a ‘contaminant’ as much as for the feeding damage they cause.

Figure 11. Silver Y moth eggs (it is unlikely that they would be laid at this density in the field)

Monitoring and forecasting

Male moths of both species can be captured in species-specific pheromone traps which enable growers to see whether and when activity is occurring. Funnel traps (Figure 12) may catch higher numbers than Delta traps. AHDB-funded studies have investigated, for the silver Y moth in particular, whether there might be the possibility of developing an ‘action threshold’ for this pest based on the numbers of moths captured (FV 163a; FV 440). Unfortunately, the chances of developing such a threshold on an individual field basis seem very limited, possibly because the moths move around a lot, or because the distribution of male moths does not reflect that of females.

However, pheromone traps do have a value. In the case of turnip moth, they are important for focusing crop walking

Figure 12. Funnel pheromone trap

(Figure 13). Use of the cutworm forecast is beneficial as it informs crop protection decision making. In the case of the silver Y moth, it is likely that monitoring at a local and, preferably, wider scale will indicate risk periods where, again, crop walking should be focused.

Turnip moth (cutworm) forecast

Unhatched turnip moth eggs and the older, subterranean cutworms are largely not vulnerable to weather effects. The two early caterpillar instars differ however; most die if there is substantial rainfall (defined as 10mm or more of rain falling in showers of moderate intensity over a 24-hour period) while these caterpillars are feeding above ground.

The cutworm model is a computer program that uses weather data to predict the rate of development of turnip moth eggs and caterpillars.

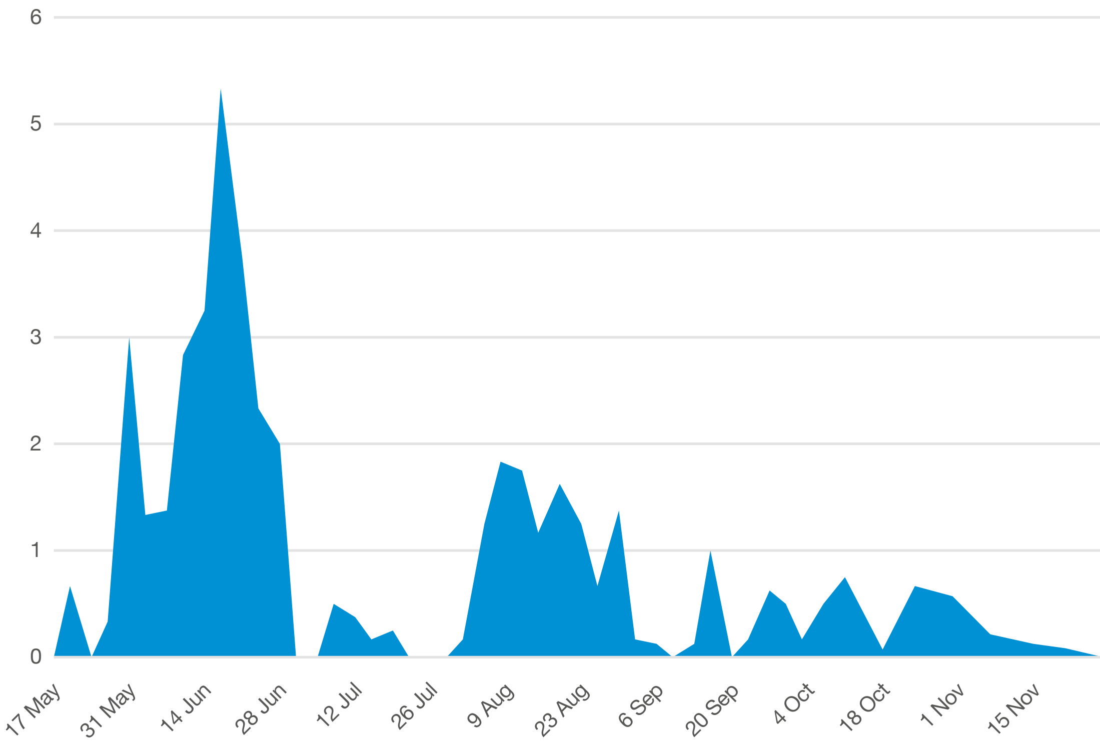

Figure 13. Capture of male turnip moths in pheromone traps at Wellesbourne in 2011

It also predicts the level of rain-induced mortality among the early-instar caterpillars. The cutworm model published by Bowden et al. (1983) has been programmed into the MORPH decision-support software. This version has been used to produce cutworm forecasts in recent years, with the weather data used to produce the cabbage root fly and carrot fly forecasts.

The cutworm forecast can be 'triggered' by the first capture of turnip moths in pheromone traps. Alternatively, data on trap captures at Wellesbourne were used to estimate a day-degree (D°) sum for the start of flight activity. This is 340 D° above a lower threshold of 7°C from 1 January.

Silver Y moth forecast

The day-degree sum for the development of silver Y moth eggs (approximately 60 day-degrees above 7.7°C (estimated from published data) can be used to indicate when eggs laid by a particular cohort of moths might be expected to hatch.

Wider-scale monitoring of silver Y moth and turnip moth

Two approaches have been evaluated recently. For the first, a network of pheromone traps (from Trapview, Figure 14) was established with growers to monitor pest moths (AHDB Horticulture project FV 440). Each trap contained a pheromone lure for the appropriate species, a sticky base to capture the moths and a small camera which photographed the sticky base once each day. The camera was powered by a solar cell. The image was downloaded onto the website managed by Trapview and the images of the captures by all the traps were visible to all trap hosts. In general, the Trapview traps were less effective than 'ordinary traps' (Funnel traps for silver Y moth and turnip moth). Some modifications were made to the Trapview traps in 2016 and, in particular, a trap that was modified to incorporate a Funnel trap was more effective in capturing Silver Y moths (caterpillar shown in Figure 15).

Figure 14. Trapview trap

Figure 15. Silver Y moth caterpillar

Within AHDB Horticulture project FV 440, a small study by Rothamsted Research on the origin of migrant silver Y moths indicated that in 2015 the major source of moths, on the occasions when possible flight paths were tracked, was northern France. As part of the project, information on silver Y moth activity, as reported on north-western Europe websites, was sourced. Since migrations of moths are likely to originate from the continent, monitoring these websites may be a way of receiving an early warning of a large influx of moths, particularly if combined with weather forecast information. As a trial run, this information was summarised for growers in 2017 and made available on a University of Warwick website (Figure 16).

Non-chemical methods of control

Cutworm

The two early caterpillar instars are very susceptible to irrigation while feeding on the foliage and this may be one of the most effective ways of controlling them. Since most transplanted lettuce crops are irrigated regularly, cutworm infestations are generally managed effectively without resorting to the use of insecticides. Unhatched turnip moth eggs and the older, subterranean cutworms are largely invulnerable to the effects of rainfall and irrigation.

Natural enemies

In addition, cutworms can be infected by naturally occurring viruses and bacteria. There are no established methods of increasing the abundance and efficacy of these natural enemies.

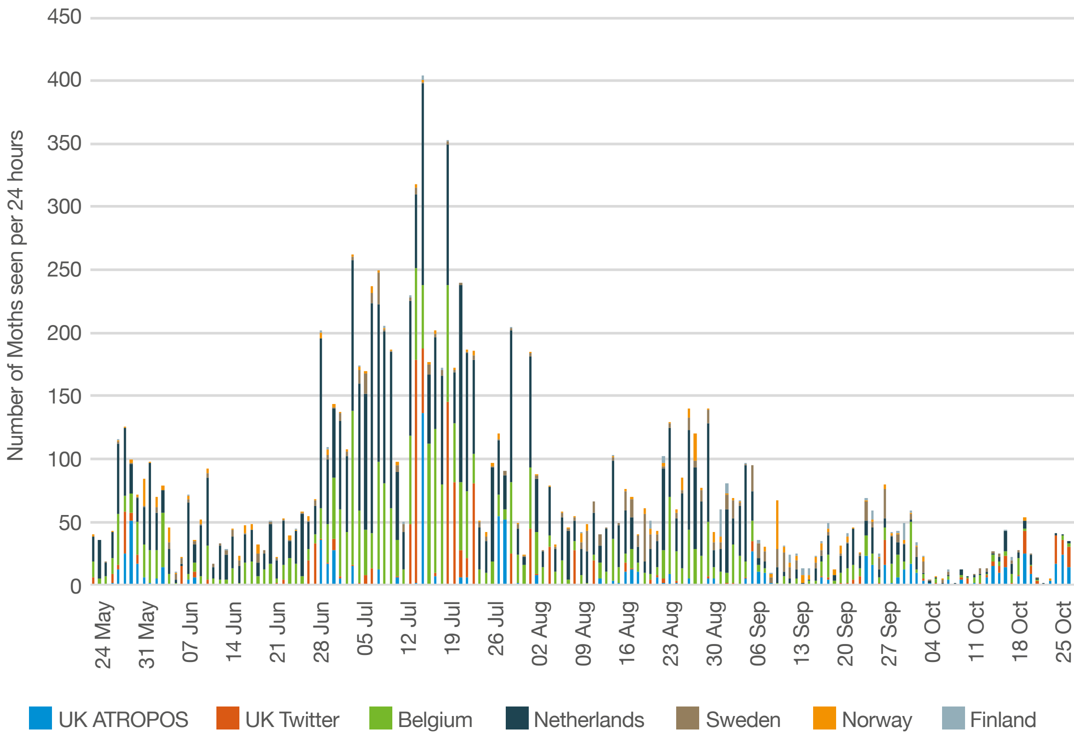

Figure 16. Silver Y moth sightings in 2017 – numbers reported on the Internet per 24 hours

Minor pest – thrips

Life cycle

It is not entirely clear which species of thrips (Figure 17) infest lettuce. Lettuce is not recorded as one of the main hosts of onion thrips (*Thrips tabaci*) or of field thrips (*Thrips angusticeps*). However, onion thrips have been found on lettuce plants in California, which were also infested by western flower thrips (*Frankliniella occidentalis*). The latter species is less likely to be a pest of outdoor crops in the UK.

Figure 17. Onion thrips *(Thrips tabaci)*

In the UK, onion thrips overwinter in the adult stage. Overwintered host vegetable crops such as leek are preferred overwintering sites but they will overwinter in other locations, such as overwintered cereal crops. Once temperatures rise in the spring, female thrips start to lay eggs, either after dispersing to new hosts or on the overwintering host, if this is still a suitable food source. Following egg hatch, there are two active larval stages and two inactive stages (pre-pupa and pupa). A generation (egg to adult) takes about 52 days at 12.5°C and 15 days at 25°C.

Field thrips overwinter in the soil as short-winged flightless adults. They emerge between March and May to feed on young crops and reproduce. Adult field thrips with normal-sized wings are produced in May to September; these migrate to other crops to feed and reproduce.

Damage

Feeding by adult and larval onion thrips damages the host plant via direct removal of cell contents. As individual plant cells are killed, scarring of the leaf in the form of silvering is observed. Field thrips cause damage to the surface of leaves, resulting in mottled patches and distortions.

Monitoring and forecasting

Thrips adults are often captured on coloured sticky traps and, although it is difficult to identify them to species, this is one way of monitoring abundance. Thrips infestations can also be monitored directly by examining the crop and it is probably easier to assess damage than to count thrips on plants.

Non-chemical methods of control

Natural enemies

There has been some success in controlling thrips species with predators or entomopathogenic nematodes, although this is mainly in protected crop environments, and using augmentative or inundative techniques. These approaches have not been evaluated outdoors in the UK.

Irrigation

Irrigation to reduce thrips populations is employed by growers in many countries and there appears to be a consensus that this is effective.

Minor pest – wireworms

Wireworms (Figures 18 and 19) are the soil-inhabiting larvae of click beetles (*Elateridae*). They are, typically, found in grassland but can attack a wide range of crops. Wireworm damage in Britain is generally attributed to three species: *Agriotes lineatus, A. obscurus and A. sputator*. There is some evidence to indicate that certain species may dominate in different parts of the country, but often all three can be found within a single field.

Life cycle

Adults (click beetles) have a dark brown to black elongated body (8–15mm long and 2–3mm wide), which is covered in fine whitish-grey hairs. Newly hatched wireworms are transparent, white and 1.3mm long. They grow to up to 25mm long and are a shiny golden brown. They have a cylindrical body, tough skin, three pairs of legs at the head end and two dark spots at the tail. The head is dark brown, with powerful biting mouthparts. Adult click beetles live for about a year. In May to June, female click beetles lay eggs just below the soil surface and these hatch in July to August. The larvae feed for five years before pupating when fully grown. Pupation usually happens from July to August, with new adults emerging in late autumn. Both adults and larvae overwinter below the soil surface. The largest populations occur in old permanent pastures and numbers increase over the years.

Damage

Larval feeding leaves ragged holes at the base of the stem, and larvae move along rows to attack further plants. A pre-planting assessment of the risk of wireworm infestation is useful if the risk is perceived to be high. Crops sown within two years of ploughing out permanent pasture are at highest risk; however, any rotation with predominantly winter cropping, particularly with grass weeds, is at risk. An increased risk has also been associated with south-facing sloping fields, heavy alluvial soils and minimum tillage cereal crops.

Figure 18. Wireworm

Minor pests – wireworms

Monitoring and forecasting

Bait and pheromone traps can be used to determine the presence or absence of wireworms and click beetles, respectively. There is no clear relationship between wireworm infestations and the number of click beetles caught in pheromone traps or wireworms caught in bait traps; they only indicate presence or absence. Soil samples can be used to assess population size. Populations can be very patchy, however, so accurate estimations are difficult.

Non-chemical methods of control

Natural enemies

The main natural enemies are fungi and parasitic wasps. The larval stages are attacked by ground beetles and the adults are eaten by birds. No commercial biological control agents are currently available for controlling wireworms, although some strains of the insect-pathogenic fungus *Metarhizium anisopliae* have shown encouraging results under experimental conditions.

Cultural control

In arable rotations, plough-based cultivation may help to reduce populations.

Consolidating seedbeds helps restrict movement of the pest, and controlling grass weeds can reduce the availability of food sources.

The use of cruciferous plants as green cover crops or defatted mustard meals as soil amendments has been shown to reduce wireworm populations in Italy but the results have not yet been reproduced in the UK.

Figure 19. Wireworm

Minor pests – leatherjackets

Leatherjackets (Figures 20 and 21) are the larvae of crane flies (daddy longlegs). They are soil-inhabiting pests that feed mainly on roots and the underground parts of plant stems.

Figure 20. Leatherjacket

Life cycle

The larvae (leatherjackets) are greyish-black and grow to 40mm. They have a tough skin and are plump and soft. The adults (crane flies) have a long body (approx. 25mm), ungainly legs and narrow wings.

The adults emerge and lay eggs in August to September and the eggs hatch throughout September.

The larvae feed during the winter when soil temperatures are above 0.5°C but the main larval feeding period is in March to May after which the larvae pupate near the soil surface. Pupae remain in the soil during June and July, after which a new generation of adults emerges.

Damage

Leatherjackets usually feed just below the soil on roots and stems but on warm, damp nights they may feed on the surface, making ragged holes in leaves and cutting off stems, like cutworms. Attacks frequently occur following a grass rotation. Leatherjackets are usually most numerous after prolonged damp conditions in late summer and early autumn. Dry September weather can reduce numbers considerably because eggs and young leatherjackets are vulnerable to desiccation.

Figure 21. Leatherjacket on a lettuce transplant

Monitoring and forecasting

Leatherjacket numbers can be assessed before ploughing by soil sampling using a 10cm diameter soil corer. A total of 20 cores are taken from an area not exceeding 4ha. The soil is then washed and sieved in a laboratory to extract the leatherjackets. Alternatively, a Blasdale apparatus can be used, which drives leatherjackets into trays of water by heating the soil cores from above. An alternative method is to drive plastic pipes into the ground and fill them to near the brim with brine. Any leatherjackets will float to the surface.

Minor pests – leatherjackets

Proprietary brine-based testing kits are available. If damage is observed in established crops, leatherjacket numbers can be assessed by scratching the soil either side of crop rows.

Non-chemical methods of control

Natural enemies

The adult (or crane fly, Figure 22) and larval stages will be attacked by a range of invertebrate and vertebrate predators. No commercial biological control agents are currently available for controlling leatherjackets.

Cultural control

Cultivations decrease the populations of this pest. Ploughing in July and early August (before the main egg-laying period) and ensuring the old sward is well covered by soil can largely prevent attacks. If ploughing occurs later, thorough consolidation and a good tilth can enable a crop to grow away, minimising the period in which it is vulnerable. The larvae of the main pest species, *T. paludosa*, stop feeding by mid-June, so establishing crops later than this can avoid damage to seedlings.

Figure 22. Crane fly

Chemical methods of control

Control with insecticides and bioinsecticides

Label recommendations should always be followed. The content below includes information on the activity of insecticides from AHDB-funded research and highlights where there is clear evidence of insecticide resistance in UK pest populations.

Aphids

The insecticides specifically recommended to control aphids are acetamiprid, fatty acids, pymetrozine, spirotetramat ,fatty acids, pymetrozine and spirotetramat.

Populations of peach-potato aphids (Figure 23) can be resistant to pyrethroids and organophosphates. Resistance in peach-potato aphid to neonicotinoids such as thiamethoxam is now apparent in southern Europe and North Africa.

Resistance in currant-lettuce aphid to pyrethroid insecticides has been detected in the UK in the past.

All species become less accessible to insecticides which work by contact action as the lettuce crop grows but currant-lettuce aphids can be particularly difficult to control as they move into the heart to feed. Thus insecticides with systemic activity are most likely to be effective.

In general, foliar sprays are likely to be ineffective against lettuce-root aphid unless they have systemic activity.

Figure 23. Peach-potato aphids

Caterpillars

The eggs of both species are likely to be invulnerable to insecticides. The insecticides specifically recommended to control caterpillars are alpha-cypermethrin, deltamethirn, diflubenzuron, indoxacarb, lambda-cyhalothrin and spinosad. Bioinsecticide treatments containing the *Bacillus thuringiensis* toxin (*Bt*) are available. There is no evidence of insecticide resistance in the species of pest caterpillar infesting lettuce.

Turnip moth larvae are most susceptible to insecticides during the first two larval instars, when they are feeding above ground on the foliage. It is harder to contact them once they move underground.

Thrips

Onion thrips are resistant to pyrethroid insecticides. Research on Allium crops has shown that spinosad is currently effective against onion thrips, although heavy reliance on this insecticide means that the selection pressure for the development of resistance is high.

Wireworms

It is unlikely that any of the insecticides approved on lettuce will be very effective against wireworms.

Leatherjackets

It is unlikely that any of the insecticides approved on lettuce will be very effective against leatherjackets.

Protection of beneficial insects

All pest species have natural enemies that regulate their numbers to some extent. Studies at Wellesbourne have shown that predators such as ladybirds and parasitoid wasps, together with entomopathogenic fungi, can be very effective in reducing aphid infestations in some years.
At Wellesbourne, the inappropriate application of pyrethroid insecticides has led to increased problems with aphids on sprayed plots, compared with insecticide-free plots.

Where feasible, selective pesticides and/or methods of application should be used to protect beneficial species.

Approved insecticides

The insecticides approved on lettuce crops (Figure 24) are shown in Table 1. Several of these insecticides are effective against more than one pest species and so careful selection of insecticide treatments based on the life cycle of all potential pests is recommended. As mentioned above, application of insecticides to which certain pests are resistant may increase infestations of these pests. There is clear evidence that pyrethroids should be used sparingly, and only under particular circumstances, due to incidence of resistance to peach-potato aphid, coupled with their adverse effects on natural enemies.

Table 1 shows where insecticides have on-label or off-label (EAMU) approval and also gives details of AHDB projects where efficacy has been shown against one or more species, although the dose may not be exactly the same as that approved. It also indicates where insecticide resistance has been established in some UK populations of the pest.

Figure 24. An outdoor lettuce crop

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.

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 manual.

Table 1. Activity of insecticides and bioinsecticides approved on lettuce

Chemical sub-group or exemplifying active ingredient	Active ingredient	Application method	Aphids	Caterpillars	Thrips
Benzoylureas	Diflubenzuron	Spray	**No efficacy**	Label target	**No efficacy**
Neonicotinoids	Acetamiprid	Spray	Label target	**No efficacy**	**No efficacy**
Neonicotinoids	Thiamethoxam (approved under permanent protection only)	Seed treatment Phytodrip	Label target FV 435 – currant-lettuce aphid and lettuce root aphid	**No efficacy**	**No efficacy**
Oxadiazines	Indoxacarb		No efficacy	Label target FV 440 (silver Y moth)	**No efficacy**
Pyrethroid	Alpha-cypermethrin, deltamethrin, lambda-cyhalothrin	Spray	Label target for some products Resistance in peach-potato aphid Possible resistance in currant-lettuce aphid	Label target FV 440 (lambda-cyhalothrin – silver Y moth)	**No efficacy against onion thrips (resistance)**
Pyrethrin	Pyrethrins	Spray	Label target Resistance in peach-potato aphid Possible resistance in currant-lettuce aphid	Label target	**No efficacy against onion thrips (resistance)**
Pyridine azomethine derivatives	Pymetrozine	Spray	Label target	**No efficacy**	**No efficacy**
Spinosyns	Spinosad	Spray	**No efficacy**	Label target SCEPTRE (silver Y moth)	Resistance in onion thrips

Table 1. Activity of insecticides and bioinsecticides approved on lettuce (continued)

Chemical sub-group or exemplifying active ingredient	Active ingredient	Application method	Aphids	Caterpillars	Thrips
Tetronic and Tetramic acid derivatives	Spirotetramat	Spray	Label target FV 435 – currant-lettuce aphid and lettuce root aphid FV 375 – currant-lettuce aphid SCEPTRE	**No efficacy**	**No efficacy**
	Fatty acids	Spray	*	*	**No efficacy**
	Maltodextrin	Spray	Label target	*	**No efficacy**
Biopesticide	Bacillus thuringiensis	Spray	**No efficacy**	Label target FV 440, SCEPTRE (Silver Y moth)	**No efficacy**
Biopesticide	Entomo-pathogenic nematodes	Spray	**No efficacy**	Label target	**No efficacy**
Biopesticide	Garlic	Spray	*	*	**No efficacy**
Biopesticide	Citrus fruit extract	Spray	*	*	**No efficacy**
Biopesticide	Natural plant extracts	Spray	*	*	**No efficacy**
Biopesticide	Metarhizium anisopliae	Spray	Specifically lettuce root aphid		**No efficacy**

*Effective against

Table 2 shows the risk periods for the main pests of lettuce and their location during the winter. The precise timings of these risk periods and the level of risk will vary from year to year. However, this serves as guidance for when the main periods of insect control might be. The risk of virus transmission is linked to the risk of aphid infestation.

Resistance management

Repeated use of one insecticide group can select for insecticide resistance in the local population. It is, thus, good practice to use different modes of action in rotation.

Table 2. Key risk periods for infestation by main pests of lettuce

Pest species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Where do they spend the winter
Currant-lettuce aphid													Mainly as eggs on currant
Peach-potato aphid													As mobile aphids on a range of hosts
Potato aphid													As mobile aphids on a range of hosts
Lettuce root aphid													As eggs on poplar
Silver Y moth													In North Africa
Turnip moth													In the soils as a caterpillar

no risk   low-medium risk   high risk

References

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AHDB Horticulture Projects

FV 163a Brassicas: refinement and field validation of forecasts for the caterpillar pests of brassicas
FV 375 Novel strategies for pest control in field vegetable crops
FV 427 Outdoor lettuce: screening crops for presence of virus
FV 435 Lettuce: Evaluating aphid control strategies
FV 440 Lettuce and baby leaf salads: Investigation into control measures for Silver Y moth and caterpillars
CP 067 Biology and control of currant-lettuce aphid (*Nasonovia ribisnigri*)

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