

Pest insects infesting Brassica crops

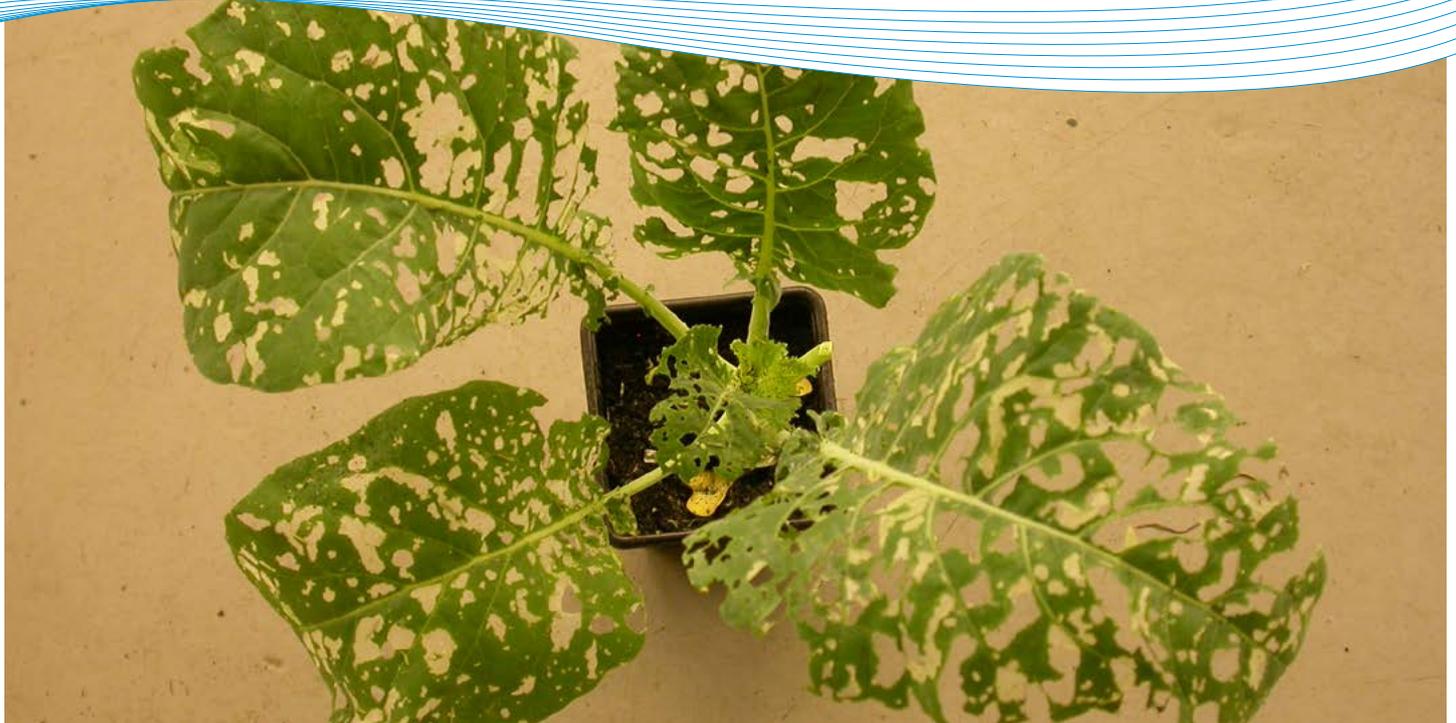


Figure 1. Diamondback moth damage

Brassica crops can be infested by up to 49 different species of pest insect. Fortunately, most of these occur infrequently on horticultural Brassicas. They include flies, beetles, caterpillars, aphids and whiteflies. Pests can reduce yield and crop quality through direct feeding damage, transmission of plant viruses and contamination. This factsheet does not cover nematodes or slugs.

Action points

- 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
- The use of net covers may be beneficial for the control of several pest species, if they are deployed at the appropriate time and with a suitable mesh size
- All of the module treatments approved for control of cabbage root fly larvae provide effective control during the period when the plant is most susceptible to damage and this is regardless of whether transplanting has been delayed. However, it is important to ensure uniform and accurate application of products to modules before transplanting
- To aid treatment timing, information on the timing of activity of a range of pests can be obtained from the AHDB Pest Bulletin, AHDB Aphid News and other sources
- Adult males of all pest moth species can be captured in specific pheromone traps and captures of male moths indicate when female moths are likely to be laying eggs. Treatment timing is particularly critical for the diamondback moth (Figure 1), whose life cycle is very rapid
- Some insecticide treatments have activity against more than one pest species and programmes should be planned to take this into account
- There is clear evidence that pyrethroids should be used sparingly and only under particular circumstances, as resistance to this group of insecticides has been identified in several Brassica pests. This, coupled with their adverse effects on natural enemies, means that inappropriate use of pyrethroids has the potential to increase pest damage rather than reduce it

Introduction

The scale of losses due to pest insects varies considerably, depending on the crop and type of infestation, but, for example, in field trials, insecticide-free control plots of cauliflower can suffer >20% losses due to cabbage root fly (*Delia radicum*) and 100% of plants may be infested with cabbage aphid (*Brevicoryne brassicae*).

As '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 that they will become active earlier following a warm spring and that they are usually active earlier in the South of the UK than in the North.

The life cycles of these pests are diverse but there are periods when more than one species is active and control programmes should be planned to take this into account.

Fly pests

The main fly pest is the cabbage root fly. The roots of Brassicas may also be infested by turnip fly larvae (*Delia floralis*) and bean seed fly larvae (*Delia platura*) (although the latter rarely cause economic damage). Larvae of *Pegohylemyia fugax* occur occasionally on crops such as cauliflower that are starting to rot in places. Other pest flies include the leaf miner *Scaptomyza flava*, which is increasingly common in oilseed rape crops and horticultural Brassicas such as rocket and swede midge (*Contarinia nasturtii*).

Cabbage root fly and turnip fly

Life cycles

The cabbage root fly is ubiquitous in the UK. It overwinters in the soil in the pupal stage. The first generation of adult flies usually emerge in April–May and the second generation emerges in July–August. In warmer parts of the UK, a third generation of flies may emerge in late August to September. There are some areas of the UK where a proportion of the cabbage root flies emerge later in the spring than would be expected. We call these 'late-emerging' flies and they are genetically different from 'early-emerging' flies. Relatively large numbers of late-emerging flies occur in some parts of Devon and South West Lancashire and these complete no more than two generations per year. In areas where both 'early' and 'late' flies occur, there may be continuous pest pressure throughout most of the growing season. Once they have emerged, female cabbage root flies require time to feed, mate and mature their eggs: this is equivalent to about 80 day-degrees (D°) above 6°C. The eggs are usually laid in the soil close to the base of the plant and the newly hatched larvae move through the soil to burrow in the roots. Fully fed larvae form pupae in the soil close to the plant roots.

The turnip fly occurs in Scotland and some parts of Northern England, e.g. South West Lancashire. It has a similar life cycle to the cabbage root fly but the first generation of adults emerges later than first generation of early-emerging cabbage root flies. Turnip flies may complete one or two generations per year.

Damage

Damage is due to feeding by the fly larvae. In leafy Brassicas, slight damage to the root system may not be a problem but heavy damage may cause the plant to wilt and even die. As the plant grows, it becomes more able to tolerate feeding damage and so most transplanted Brassicas are only susceptible to significant damage during the first 4–5 weeks in the field. In root Brassicas such as swede, turnip and radish, even slight feeding damage is more problematic due to its effect on the appearance of the root or 'bulb'. Under certain circumstances, female cabbage root flies may lay their eggs on the aerial parts of Brassica plants, including Brussels sprout buttons, broccoli florets and at the base of Chinese cabbage plants. It is believed that this occurs most frequently when the soil is hot and dry. The larvae cause feeding damage and are contaminants.

Monitoring and forecasting

Adult cabbage root flies can be monitored using water traps or sticky traps. In practice, it is easier to identify them from water trap samples. These traps are usually yellow in colour (Figure 2). In water traps, the surface tension of the water is lowered by adding a few drops of detergent and it can be kept fresh by adding metabisulphite tablets. All the insects captured in the traps are scooped out at intervals and taken away for identification. Growers can purchase a proprietary trap that uses a volatile attractant, related to the 'mustard' chemicals that Brassicas contain. This trap is more selective for cabbage root flies than the other types of trap, making identification easier. Cabbage root fly eggs can be sampled from around the base of Brassica plants by scooping up the soil, taking it away and floating the eggs out in water, to which a small amount of antifoam is added. There are no reliable treatment thresholds for cabbage root fly.



Figure 2. Yellow water trap

The timing of the various stages in the cabbage root fly life cycle can be predicted using a computer program developed with funding from Defra and AHDB. The output from this program is currently available as part of the AHDB Pest Bulletin, which is hosted on the Syngenta UK website. The forecast indicates when flies of each generation will emerge from pupae and when they will lay eggs.

Non-chemical methods for control

Female cabbage root flies, in particular, are very mobile insects and may disperse over several miles once they have mated. Since oilseed rape is an important host crop for cabbage root fly, in most instances it is impossible to attempt to manage local cabbage root fly populations through crop rotation and the separation of new crops from sources of flies. The dispersal behaviour of turnip fly has not been studied.

It is possible to exclude cabbage root flies from susceptible crops using fine mesh netting and this approach has been used widely to manage cabbage root fly on swede and turnip crops. More recently, this approach has been used on radish (Figure 3). The netting certainly prevents flies from getting into the crop, but they may still lay some eggs through or on the netting where it touches the crop and the larvae hatching from these eggs may reach the crop below. When using crop covers, it is important to consider the life cycle of the fly so they are applied before egg-laying starts. In addition, if Brassica crops are to be grown in fairly rapid succession in the same land, it is important to ensure that flies have emerged from any pupae remaining in the soil before applying net covers. A complete generation from a newly laid egg to a newly emerged adult cabbage root fly requires approximately 500D° above a base temperature of 6°C. If there are tears in the netting, cabbage root flies will get in. For the leaf miner, the most successful treatment in FV 376 consisted of covering crops of rocket, from emergence to harvest, with insect-proof netting, which produced a significant reduction in puncturing damage caused by female flies.

Methods for biological control have been considered for the cabbage root fly, including the use of predators/parasitoids – either beetles or wasps. None of these has yet been shown to be a commercially viable management approach. However, some of these species occur naturally in Brassica crops at quite high levels, particularly where insecticides have not been applied, so they can make a contribution to suppressing the overall population. In terms of releasing natural enemies, using predators is a more viable option as the parasitoids do not kill the cabbage root fly until it has reached the pupal stage. Cabbage root fly adults are susceptible to a fungal pathogen that occurs in nature and this can lead to high fly mortality under certain conditions (usually relatively high temperatures and humidity). Biopesticides containing the fungus *Metarhizium* or nematodes have been shown to be effective when applied to Brassica modules but the approach needs further refinement before it is robust and commercially viable.

Beetles

The most important pest beetles are flea beetles (several species), pollen beetles (*Meligethes* spp.) and the cabbage stem weevil (*Ceutorhynchus quadridens*). Both pollen beetles and cabbage stem weevil are occasional pests.

Life cycles

All of these species complete one generation a year and overwinter as adults in field margins and other vegetation. Adult beetles become active in the spring as the temperature rises, then mate and lay eggs. The larval and pupal stages follow on quite rapidly and a new generation of adults emerges, usually feeding for a while before hibernating.



Figure 3. Use of fine mesh netting to exclude cabbage root fly from a radish crop

Damage

Adult flea beetles can cause considerable damage by feeding on the foliage of newly emerged drilled crops, e.g. swede. If not controlled, they can annihilate the crop. Feeding by flea beetles also causes cosmetic damage to older crops such as radish (for bunching) (Figure 4), rocket and leafy Brassicas. The older literature says the period of greatest activity is from mid-April to late May – but, more recently, damage appears to have occurred over a much more extended period (Figure 5).



Figure 4. Radish foliage damaged by adult flea beetles

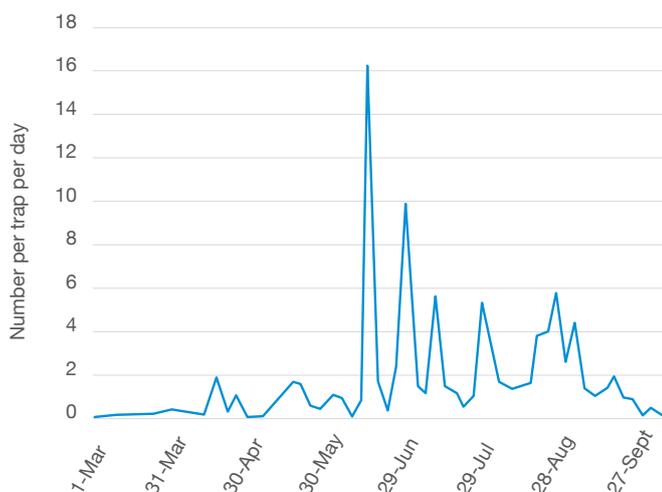


Figure 5. Number of adult flea beetles per trap per day at Wellesbourne in 2016

Adult pollen beetles are occasional pests of cauliflower and broccoli. The beetles feed on the curds or florets causing damage (Figure 6). This type of damage usually occurs in mid-summer when new adults emerge from oilseed rape crops and move into other areas to feed (Figure 7). They are also often found in flowers such as sweet peas at this time. These new adults feed for a period of time and then seek hibernation sites.

Adult cabbage stem weevils chew the foliage of Brassica plants and lay eggs in the holes they make. The larvae tunnel through leaf veins and stalks and make them brittle. If the larvae move to the main stem in large numbers they may destroy the plant. Their tunnels can cause cosmetic damage in cauliflower, for example.



Figure 6. Adult pollen beetles and feeding damage on a cauliflower curd

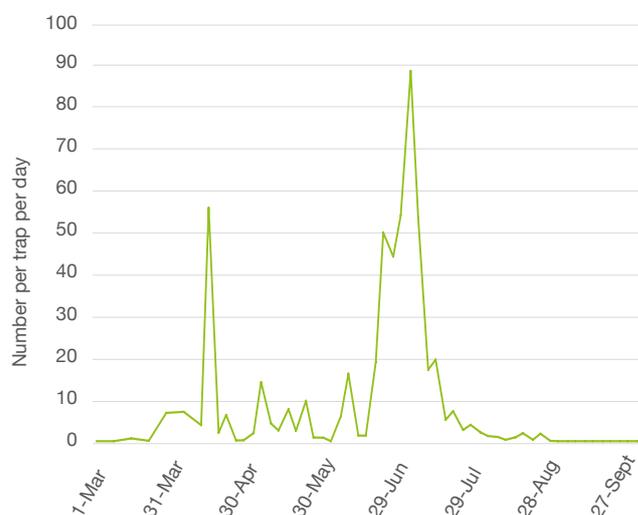


Figure 7. Number of adult pollen beetles per trap per day at Wellesbourne in 2016

Monitoring and forecasting

All species can be monitored with yellow sticky traps, or yellow water traps as for the cabbage root fly. The timing of the migration of newly emerged pollen beetle adults from oilseed rape fields to feeding sites such as broccoli and cauliflower crops can be predicted using a computer program developed with funding from Defra and AHDB. The output from this program is currently available as part of the AHDB Pest Bulletin, which is hosted on the Syngenta UK website.

Non-chemical methods for control

There are no established methods for reducing the overall population. In the case of pollen beetles, close proximity to oilseed rape crops is likely to increase the risk of damage. Fine mesh netting used to exclude cabbage root fly will also exclude adult beetles, provided the mesh size is small enough. However, it is likely that flea beetles will still feed on the foliage through the netting where it touches the crop.

Caterpillars

The caterpillars of a number of species of moth and butterfly can be pests of Brassica crops.

Life cycles

With the exception of the diamondback moth and Silver Y moth, which are migrant species (FV 440), all species overwinter throughout the UK, in the pupal stage or as larvae (turnip moth). There is increasing evidence that small populations of diamond-back moth may be able to overwinter in warm locations (e.g. South West England) but this species does not have a specific overwintering stage. For all but the migrant species, there are two generations per year (Table 1). The diamondback moth may complete two or more generations, depending on when it arrives in the UK. The silver Y moth will complete at least one generation.

Damage

All species of caterpillar cause direct feeding damage and can be contaminants in harvested produce (Table 1).

Monitoring and forecasting

Adults of the two species of pest butterfly can be monitored using yellow water traps or sticky traps as for the cabbage root fly. Adult males of all moth species can be captured in specific pheromone traps (Figure 8) and captures of male moths indicate when female moths are likely to be laying eggs (Table 1). For the turnip moth, data from trap captures in 2005–2007 at Wellesbourne were used to estimate a D° sum for the start of flight activity. This was $340D^{\circ}$ above a base of $7^{\circ}C$ from 1 January. The cutworm model published by Bowden et al (1983) is a computer program that uses weather data to predict the rate of development of turnip moth eggs and caterpillars. It also predicts the level of rain-induced mortality among the early instar caterpillars. The cutworm model has been programmed

into the MORPH decision-support software and can be used to produce forecasts with the weather data used to produce the cabbage root fly and pollen beetle forecasts. Regular crop walking is important to identify developing problems. Treatment timing is particularly critical for the diamondback moth, whose life cycle is very rapid.



Figure 8. Pheromone trap for diamondback moth

Non-chemical methods for control

There are no established non-chemical methods for reducing the overall population. Fine mesh netting used to exclude cabbage root fly will also exclude adult butterflies and moths. However, it is likely that some species, particularly the diamondback moth, will lay eggs on the netting where it touches the crop and that the larvae will access the foliage.

Table 1. Pest caterpillars of horticultural Brassicas

| Species | Activity periods | Importance | Monitoring methods |
|---|---|---|--------------------------------------|
| Small white butterfly (<i>Pieris rapae</i>) | May/June and late summer – more abundant in late summer | Can be damaging and hard to detect on plants | Yellow water trap or sticky trap |
| Large white butterfly (<i>Pieris brassicae</i>) | May/June and late summer – more abundant in late summer | Can be damaging but usually infests a small number of plants in large numbers and damage is generally obvious | Yellow water trap or sticky trap |
| Cabbage moth (<i>Mamestra brassicae</i>) | May/June and late summer – more abundant in late summer | Localised pest – can be hard to detect on plants when young | Pheromone trap |
| Garden pebble moth (<i>Evergestis forficalis</i>) | May/June and late summer – more abundant in late summer | Localised pest – hard to detect on plants | Pheromone trap |
| Diamondback moth (<i>Plutella xylostella</i>) | Mainly migrant species and can arrive at any time – usually from June onwards | Can be very damaging and hard to detect on plants when small | Pheromone trap |
| Silver Y moth (<i>Autographa gamma</i>) | Migrant and can arrive at any time from early spring | Rarely causes significant damage on Brassicas | Pheromone trap |
| Turnip moth (cutworm) (<i>Agrotis segetum</i>) | Late May–early July, sometimes a second generation in later summer | Rarely causes significant damage on Brassicas | Pheromone trap Forecast available |

Aphids

Life cycles

Brassica crops can be infested by several species of aphid, including cabbage aphid, peach-potato aphid (*Myzus persicae*) and potato aphid (*Macrosiphum euphorbiae*). The cabbage aphid feeds only on Brassica species, while the other species have a wider range of hosts. In the UK, all species overwinter as mobile aphids on a range of cultivated and wild host plants, including oilseed rape. Some cabbage aphids may also overwinter as eggs. 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.

Damage

All species cause direct damage if sufficiently abundant, particularly the cabbage aphid, which can distort plant foliage and may kill smaller plants. All are contaminants and produce honeydew that can support sooty moulds, which also become a contaminant. The peach-potato aphid, in particular, can transmit plant viruses, especially Turnip yellows virus, which may reduce yield significantly.

Monitoring and forecasting

All three species are captured in the network of suction traps run by the Rothamsted Insect Survey. The information on captures is updated weekly, and bulletins released on the website on a Friday 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. In early March each year, the Rothamsted Insect Survey releases long-term forecasts predicting the timing of the first migration of all three species into crops in the spring/early summer and their relative abundance early in the year. Over the last 50 years, the timing and size of aphid migrations has shown the strongest correlation with the mean January/February air temperature and this is used to produce the forecasts for different locations.

Non-chemical methods for control

There are no established non-chemical methods for reducing the overall population of aphids. However, all species are attacked by a range of predators (e.g. ladybirds, hoverfly larvae, lacewing adults and larvae) and parasitoid wasps. In addition, aphids can be infected with a naturally occurring fungus that can lead to considerable mortality within an infestation. A combination of predators, parasitoids and fungi often leads to a rapid decline in aphid numbers in the middle of the season, known as the 'aphid crash'. Fine mesh netting used to exclude cabbage root fly may also exclude winged aphids if the mesh size is sufficiently small. However, if aphids manage to access the crop, for example, through a tear, their numbers can increase very rapidly.

Cabbage whitefly

The cabbage whitefly (*Aleyrodes proletella*) is an increasingly important pest of kale in particular, but also of Brussels sprout.

Life cycles

Cabbage whiteflies overwinter as adult females on Brassica crops, including oilseed rape, and certain species of weed (e.g. sow-thistle). These females lay eggs in early spring, once the temperature rises and some of the females disperse to new crops, probably quite locally, before laying eggs. The eggs hatch into larvae that soon attach themselves to the foliage, and are known as 'scales'. The larvae feed on the plant and develop into pupae, which produce a new generation of adults. It appears that multiplication on the host is a key factor influencing the size of infestations, but there may also be further movement of adults (CP 091). There is a period in the autumn when at least some female cabbage whiteflies migrate to new hosts.

Damage

The cabbage whitefly is important, mainly as a contaminant.

Monitoring and forecasting

CP 091 has demonstrated that when cabbage whiteflies undertake migration, particularly in the autumn, they fly sufficiently high to be captured in the Rothamsted suction traps. However, this information is not available to growers on a weekly basis. Adult cabbage whiteflies can also be captured on sticky traps, particularly yellow traps. Regular crop walking is important to identify developing problems. D° sums can be used to indicate when the next generation of adults will emerge within a crop (CP 091).

Non-chemical methods for control

There are no established non-chemical methods for reducing the overall population of cabbage whitefly and the species appears to be attacked by few predators (CP 091). There is a native species of parasitoid wasp and in FV 406 and FV 406a, efforts were made to rear and release the wasp to manage field infestations. However, it was not possible to demonstrate the efficacy of the method convincingly and the wasps are difficult and potentially expensive to rear. CP 091 showed for the first time that cabbage whitefly can be infected with a naturally occurring fungus that may, on occasion, lead to considerable mortality within an infestation. In CP 091, the fungus led to considerable mortality of adults in the autumn. Fine mesh netting used to exclude cabbage root fly may also exclude adult whitefly if the mesh size is sufficiently small.

Control with insecticides and biopesticides

Label recommendations should always be followed. The information below outlines the activity of insecticides and biopesticides from AHDB-funded research and highlights where there is clear evidence of insecticide resistance in UK pest populations (Table 2).

Flies

Three module drench treatments are approved to control cabbage root fly (and turnip fly) on leafy Brassica crops. These use chlorpyrifos (not approved for leafy crops such as kale/collard), cyantraniliprole or spinosad. All of these treatments provide good control of cabbage root fly larvae during the period when the plant is most susceptible to damage and this is regardless of whether transplanting

has been delayed (FV 416, FV 416a). However, it is important to ensure uniform and accurate application of products to modules before transplanting (FV 416a, FV 416b). All of the treatments are effective against larvae. Extensive research at Wellesbourne has shown no evidence that any foliar spray treatment approved on Brassicas kills adult cabbage root flies. There is no evidence of resistance to these insecticides in these pest flies. A biopesticide containing *Metarhizium anisopliae* is also available. AHDB-funded research has indicated that leaf miners may not be controlled by pyrethroid insecticides (FV 376) and that cyantraniliprole applied as a module drench has activity against these pests (FV 375).

Beetles

Pyrethrins and several pyrethroid insecticides are specifically recommended for control of flea beetles. AHDB projects have shown that cyantraniliprole (FV 375) and thiamethoxam (FV 242c) have activity against flea beetles. While there are no specific recommendations for pollen beetle control on edible Brassicas, indoxacarb, pymetrozine, several pyrethroids, and thiacloprid are recommended on oilseed rape. There is now established resistance to pyrethroid insecticides in UK populations of pollen beetle.

Caterpillars

The insecticides specifically recommended to control caterpillars on Brassica crops are indoxacarb, several pyrethroids and spinosad. Biopesticide treatments containing the *Bacillus thuringiensis* toxin (Bt) or entomopathogenic nematodes are available. AHDB projects have shown that cyantraniliprole applied as a module drench has activity against caterpillars (FV 328b, FV 375, CP 077 SCEPTRE (2014)). There is no evidence of insecticide resistance in any species of pest caterpillar apart from the diamondback moth. The diamondback moth has a considerable propensity to evolve resistance to insecticides and also to the Bt toxin. The resistance status of diamondback moth populations will vary around the world and, so, when a new population of moths arrives, it is important to determine its resistance status. Scientists at Rothamsted Research showed that the moths that arrived in the UK in 2016 were resistant to pyrethroid insecticides. Information about insecticide resistance in the diamondback moth is available on the IRAC website irac-online.org

Aphids

The insecticides specifically recommended to control aphids are fatty acids, pymetrozine, pyrethrins (expires Jan 2020), several pyrethroids, spirotetramat, thiacloprid and thiamethoxam. There is no evidence of insecticide resistance in the cabbage aphid or potato aphid. However, populations of peach-potato aphid can be resistant to pyrethroids. Resistance to neonicotinoids such as thiamethoxam is now apparent in Southern Europe. AHDB projects have shown that cyantraniliprole applied as a module drench has activity against aphids (FV 375, CP 077 SCEPTRE 2012, 2014).

Cabbage whitefly

Fatty acids, pyrethrins, certain pyrethroid insecticides and spirotetramat are specifically recommended for control of cabbage whitefly. Insecticides that have systemic activity are most effective, e.g. spirotetramat. Cabbage whitefly populations with resistance to pyrethroid insecticides have been identified.

Wholecrop IPM strategy

Reducing the overall level of infestation

The use of net covers may be beneficial for the control of several pest species, if deployed at the appropriate time and with a suitable mesh size.

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. Field sampling in 2016 indicated that a high proportion of diamondback moth pupae were parasitised by a small wasp (FV 440).

At Wellesbourne, the inappropriate application of pyrethroid insecticides has led to increased problems with cabbage root fly and peach-potato aphid 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 leafy Brassica crops are shown in Table 2. Several of these insecticides are effective against more than one pest species and, so, careful selection of insecticide treatments based on the life cycles of all potential pests is recommended. For example, cyantraniliprole applied as a module drench will also have some efficacy against aphids and caterpillars, although its efficacy will depend on the interval between sowing and the arrival of pests. 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 because resistance to this group of insecticides has been identified in several Brassica pests. This, coupled with their adverse effects on natural enemies, means that pyrethroids have the potential to increase pest damage rather than reduce it.

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. Resistance to pyrethroid insecticides and pirimicarb in *Myzus persicae* is well established.

Table 2. Activity of insecticides approved on one or more Brassica crops (users should check current approvals for specific crops). The table 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 eventually. It also indicates where insecticide resistance has been established in some UK populations of the pest

| Chemical subgroup or exemplifying active ingredient | Active ingredient | Application method | Cabbage root fly | Beetles | Caterpillars | Aphids | Cabbage whitefly |
|---|--|-------------------------|---|--|---|--|------------------------------------|
| Diamides | Cyantraniliprole Chlorantraniliprole | Module drench/ spray | Label target FV 328a FV 328b FV 375 FV 416a CP 077 SCEPTRE (2011, 2012 and 2013) | FV 375 – flea beetle | FV 328b FV 375 CP 077 SCEPTRE (2014) | FV 375 CP 077 SCEPTRE (2012 and 2014) | FV 399 CP 077 SCEPTRE (2014) |
| Neonicotinoids | Thiacloprid Acetamiprid | Spray | No efficacy | No efficacy On oilseed rape label (thiacloprid pollen beetles) | No efficacy | Label target FV 328a (thiacloprid) FV 375 (thiacloprid) | * |
| Organophosphate | Chlorpyrifos | Module drench/ spray | Label target FV 328a FV 416 FV 416a CP 077 SCEPTRE (2013) | No efficacy | No efficacy | No efficacy | No efficacy |
| Oxadiazines | Indoxacarb | Spray | No efficacy | On oilseed rape label (pollen beetles) | Label target FV 375 CP 077 SCEPTRE (2013) | No efficacy | No efficacy |
| Pyrethroid | Alpha-cypermethrin Beta-cyfluthrin Cypermethrin Deltamethrin Esfenvalerate Lambda-cyhalothrin | Spray | No efficacy | Label target (flea beetles). On oilseed rape label (pollen beetles). Resistance in pollen beetle | Resistance in diamondback moth | Resistance in peach-potato aphid | Resistance |
| Pyridine azomethine derivatives | Pymetrozine (approved until 30 Jan 2020) | Spray | No efficacy | On oilseed rape label (pollen beetles) | No efficacy | Label target FV 328a FV 328a FV 375 | * |

Table 2 continued

| Chemical subgroup or exemplifying active ingredient | Active ingredient | Application method | Cabbage root fly | Beetles | Caterpillars | Aphids | Cabbage whitefly |
|---|-------------------------------|--------------------|--|--------------------|---|---|---|
| Spinosyns | Spinosad | Module drench | Label target FV 328a FV 416 FV 416a CP 077 SCEPTRE (2011, 2012 and 2013) | No efficacy | * | No efficacy | No efficacy |
| Spinosyns | Spinosad | Spray | No efficacy | No efficacy | Label target FV 440 | No efficacy | No efficacy |
| Tetronic and Tetramic acid derivatives | Spirotetramat | Spray | No efficacy | No efficacy | No efficacy | Label target FV 328a FV 328b CP 077 SCEPTRE (2011, 2012, 2013 and 2014) | Label target FV 375 FV 399 FV 406a CP 077 SCEPTRE (2012) |
| | Fatty acids | Spray | * | * | * | * | * |
| | Maltodextrin | Spray | * | * | Label target | * | Label target |
| Biopesticide | <i>Bacillus thuringiensis</i> | Spray | No efficacy | No efficacy | Label target FV 440 CP 077 SCEPTRE (2013) | No efficacy | No efficacy |
| Biopesticide | Entomopathogenic nematodes | Various | * | No efficacy | Label target | No efficacy | No efficacy |
| Biopesticide | <i>Metarhizium anisopliae</i> | Incorporated | Label target | * | * | * | * |

Approved – no specific efficacy data.

This factsheet includes information available on the Health and Safety Executive (HSE) website (pesticides.gov.uk), on product labels and in supplier technical leaflets. Please check the HSE website or with an appropriate adviser before using the information, as regulations may have changed.

EAMU – Extension of Authorisation for Minor Use.

Growers must hold a paper or electronic copy of an EAMU before using any product under the EAMU arrangements. Anyone using a plant protection product via an EAMU should follow EAMU (or label) recommendations.

Use is carried out at the grower's own risk. If specific crop safety information is not available, consider undertaking small-scale tests and/or obtain professional advice before widespread commercial use.

If in doubt about which products are permissible, or how to use them correctly, seek advice from a BASIS-qualified consultant.

Details of compatibility of plant protection products with biological control agents are available from biological control suppliers or IPM consultants.

All information is correct as of July 2019.

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Further information

AHDB project reports

- CP 077 SCEPTRE: Sustainable Crop & Environment Protection – Targeted Research for Edibles
- CP 091 – Studentship – Biology of cabbage whitefly (*Aleyrodes proletella*)
- FV 242c Brassica crops: evaluation of non-organophosphorus insecticides for controlling the cabbage root fly
- FV 328a Brassica crops: evaluation of novel insecticides for control of cabbage root fly and aphids
- FV 328b Brassica crops: evaluation of novel insecticides for control of cabbage root fly and aphids – continuation of FV 328a
- FV 375 Novel strategies for pest control in field vegetable crops
- FV 376 Baby-leaf Cruciferae: leaf miner identification, biology and control
- FV 399 Improving control of Brassica whitefly (*Aleyrodes proletella*)
- FV 406a Brassicas: improving control of whitefly
- FV 416 Brassicas: module drenches to control cabbage root fly
- FV 416a Brassicas: comparison of treatments to control cabbage root fly
- FV 416b Brassicas: treatments to control cabbage root fly
- FV 440 Lettuce and baby leaf salads: investigation into control measures for Silver Y moth and caterpillars

Other useful information

Insecticide Resistance Action Committee (IRAC website) irac-online.org

Insecticide Resistance Action Group website cereals. ahdb.org.uk/irag

Rothamsted Insect Survey website rothamsted.ac.uk/insect-survey

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