Factsheet 22/10

Field Vegetables

Project No. FV 301

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Control of flea beetles and other key insect pests of leafy salad Brassica crops

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Flea beetles, diamondback moths, leafminers and weevils are key pests of speciality leafy salad Brassica crops. This factsheet provides brief descriptions of the pests, outlines their biology in Britain and provides guidance on their control.

Action points

- Learn to identify flea beetle species (Figure 1) and other key pests. The flea beetle distinguishing feature is their enlarged hind-leg femurs (the thickest section of their legs) which gives them great jumping ability.

- The composition of the insect-pest complex that attacks leafy salad Brassicas can change markedly, year-on-year. Learn to distinguish the characteristic types of damage caused by the different insect-pest species.

- Flea beetles can escape from some sticky trap surfaces and so it is important to use yellow traps with a strong adhesive in order to monitor populations accurately. Traps must be checked and replaced regularly and pest numbers recorded.

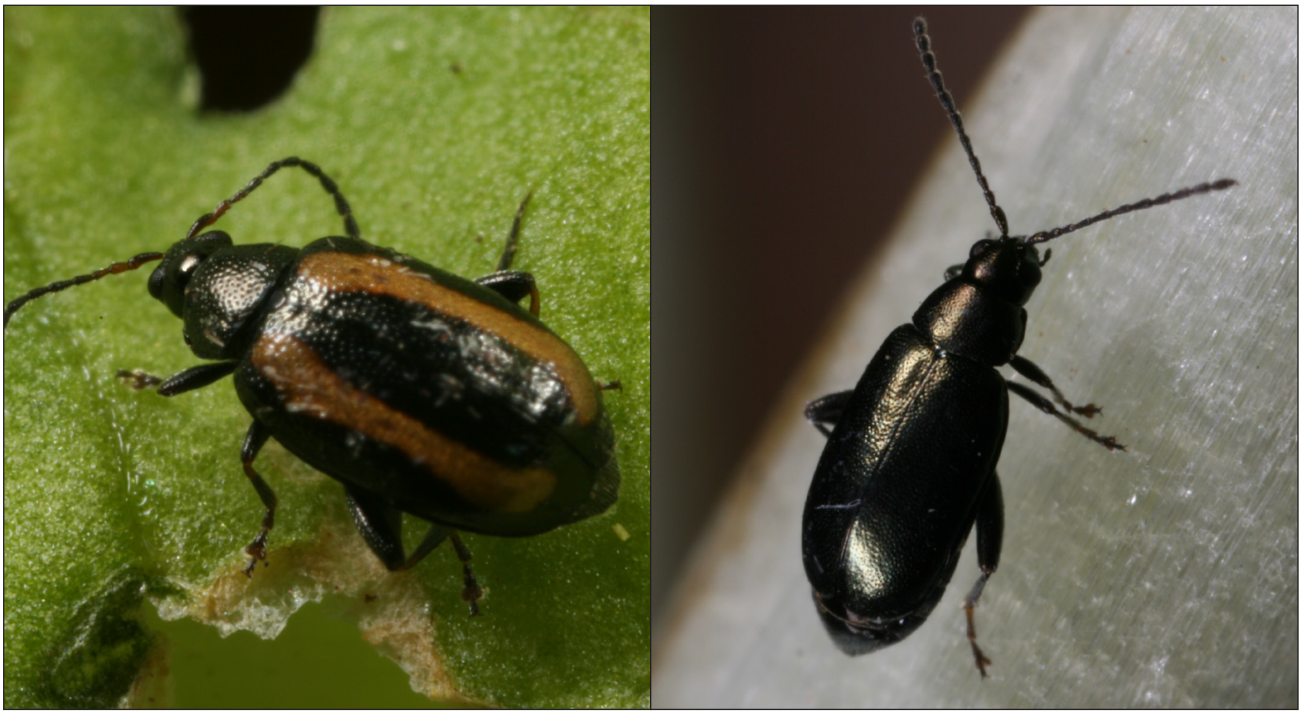
- Flea beetle larvae cause substantial damage to the roots of young Brassica plants, which results in yield loss and plant death. Ensure that mesh covers are placed over beds prior to crop germination and emergence.

- Crop damage early in the season is caused by migrant flea beetle adults that overwinter on other Brassica crops, as well as on wild and volunteer Brassicas. Old Brassica crops are a source of flea beetle adults and so must be removed.

- Mesh covers provide an extremely important element of protection for the crops. On their own, however, they cannot deliver the crop quality demanded by retailers and so it is necessary to provide additional protection in the form of insecticide treatments.

- Products containing deltamethrin, bifenthrin and spinosad are highly effective against flea beetles (see Table 1, page 7). A coded product was also effective against weevils and diamondback moth larvae and may become available in the future.

- Flea beetle adults were detected migrating into crops as early as the end of February and pest pressure was



1 Adult flea beetles - The striped flea beetle, *Phyllotreta undulata* (Kutschera) is on the left. One of the turnip flea beetles, *Phyllotreta nigripes* (Fabricius) is on the right. Note the characteristic enlarged hind-leg femurs.

high by mid-March. Protective mesh covers, therefore, need to be deployed right from the beginning of the growing season.

- Holes and unsealed edges are the main entry points for flea beetles into the crop. It is vital to ensure a good seal at the edges of the mesh during periods when the immigrant pest pressure is high.

- Be aware of potential technological advances. Insecticide-impregnated netting on its own, for example, was highly effective at preventing insect-pest damage, even with a mesh hole size through which the smaller flea beetle species could theoretically pass. This technology works by a rapid knock-down effect and research to prolong the insecticidal efficacy of the nets for longer than two seasons is ongoing.

- Seed treatments can be an effective control strategy for a range of pest species, but trial data has shown that damage due to some pests, such as leafminer adults can actually increase with seed treatment use.

- The use of sacrificial lure-and-kill crops may work, but they will require the availability of insecticidal sprays effective at killing diamondback moth adults rapidly.

Introduction

Most flea beetle, *Phyllotreta* species have a wide host-plant range which includes many Cruciferous plants such as cabbage (*Brassica oleracea* L.), cauliflower (*Brassica oleracea* var. Botrytis), radish (*Raphanus sativus* L.), horseradish (*Armoracia rusticana*), turnip *(Brassica campestris* L.), wild mustard (*Sinapis arvensis* L.) and speciality leafy Brassica crops. The complex of flea beetle species presents a particularly serious problem for speciality leafy Brassica growers who produce crops such as tatsoi (*Brassica narinosa*), Chinese cabbage (*Brassica pekinensis*) and pak choi (*Brasica rapa* var *chinensis*). For these businesses, it is the leaves that are sold and so even low populations can cause sufficient damage that reduces crop quality. The main damage caused by adult beetles, which appear in large numbers in the spring, is the characteristic 'shot-holes' in the young leaves (Figure 2).

This factsheet is based around research carried out in the HDC funded project FV 301, which generated new information on the biology and movement from overwintering sites of flea beetles; data on the use of mesh barriers including insecticide-impregnated mesh; use of insecticide sprays and seed treatments as well as; a potential lure-and-kill technique using a sacrificial crop. The project also demonstrated the economic importance of other damaging pests, such as leafminers, weevils and diamondback moths.

Some of the control techniques tested worked well, but they currently have limitations that would prevent their wide scale adoption. In addition, several effective insecticides and potential new products were identified, which could be of use to growers as they would reduce the risk of insecticide resistance development.

Flea beetles

Flea beetle species are recognised easily by the enlarged femurs which gives them their characteristic jumping ability. Flea beetle adults move into hedgerows or wooded areas in the autumn to overwinter. At this time of year, adult feeding rates are usually low and the risk of economic damage is consequently reduced. Adults were found to leave overwintering sites as early as March and begin to feed, mate and lay eggs in the soil near host plants. Larvae feed on root hairs and roots and, dependent on soil temperatures, develop into the pupal stage within 8-10 weeks. A new generation of adults then emerges from the pupae. It is this generation that is particularly damaging, because newly emerged flea beetles have a strong propensity to feed. The peak pest pressure from flea beetles, therefore, usually occurs from mid-June to late July.

Experiments with emergence cages showed that no emergence took place from ploughed farm fields, which led to the conclusion that pest pressure arose mainly from immigrant flea beetle adults.

2 A young tatsoi leaf with holes and areas of leaf where the epidermis has been removed. As the leaf grows, the holes expand to create the 'shot-holed' appearance.

Host plants

A wide range of Cruciferous plants are acceptable hosts for flea beetle species and these include kale, cabbage, sprouts, cauliflower, radish, horseradish, turnip, mustard, as well as the speciality leafy Brassicas. They also survive well on wild species such as field mustard (charlock) and black mustard (*Brassica nigra*). One flea beetle species, *P. vittula*, has also been reported in Europe as damaging monocotyledonous plants such as maize and other cereals.

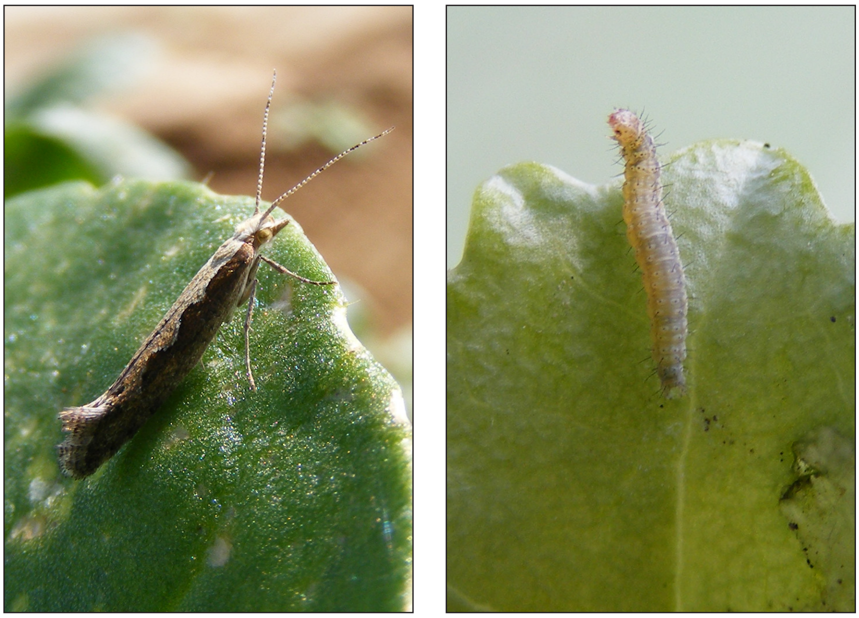
Most Brassica farming regions in the UK have 'green bridges' present throughout the year in the form of winter crops such as cauliflower and oil seed rape, as well as large areas of grassland with wild and volunteer plants. In southern England particularly, these Cruciferous species are present throughout the winter providing a refuge for overwintering adults.

On the first warm spring days in both 2007 and 2008, flea beetle adults were collected after landing on the surface of mesh-protected seedling Brassica crops. The rate of immigrant arrival was approximately 24-30 adults per hour, which would have been sufficient to cause significant economic damage. No flea beetles, however, were either seen or caught inside the emergence cages situated in farm fields. This pest pressure clearly arose from surrounding hedgerows and other adult overwintering areas supporting wild and volunteer Brassicas. Adults first attack the leaves of young plants and feed on the undersides of leaves by peeling off the epidermis and subsequently create larger holes. As a result, the leaves become sieve-like, which interferes both with photosynthesis and the water balance of the plant. The damage creates the 'shot-hole' appearance of leaves as they grow. Flea beetle larvae feed on plant roots, an activity particularly damaging to seedlings. When high numbers of larvae are present in the soil, the damage they cause can be sufficiently serious to kill young seedlings. Some flea beetle species cause an additional problem in that they can act as vectors for several plant pathogenic viruses and *P. striolata*, for instance, has been reported to be able to transmit radish mosaic virus.

Diamondback moths

In the previous 5-10 years, new insect pests have emerged as serious problems of UK Brassica crops, due mainly to insecticide resistance and warmer summers. The most damaging of these is the diamondback moth, which is now well established in southern England and is reported increasingly frequently throughout the UK. Adult diamondback moths can be recognised by the characteristic diamond pattern on their backs when their wings are folded, which has given the pest its name (Figure 3).

The pest has four developmental stages (instars) with average development times of 4.5, 4, 4 and 5 days, respectively. The caterpillars (Figure 3) are active and if disturbed, wriggle violently, move backwards and spin down from the plant on silk strands. One of the major difficulties with controlling this pest is that populations can become resistant to insecticides, thereby making insecticide sprays ineffective.



3 A diamondback moth adult resting on a tatsoi leaf (left) - the caterpillar is on the right.

Host plants

This insect has a strong preference for Cruciferous species including broccoli, sprouts, cabbage, Chinese cabbage, cauliflower, collard, kale, kohlrabi, mustard, radish, turnip, and watercress. Not all are equally preferred, however, and collard will usually be chosen by ovipositing (egg laying) moths relative to cabbage.

4 A mature tatsoi plant showing windowing (a single epidermis is removed that makes the leaf translucent) damage and holes caused by diamond back moth larvae.

The larvae attack all Brassica crops, but are particularly problematic for leafy Brassica producers who grow crops under mesh protection. Whilst mesh is effective against other pests, it does not prevent diamondback moth adults from laying eggs on it. Emerging larvae crawl through mesh holes where they cause 'windowing' and holes in the leaves (Figure 4). They damage leaves initially by windowing, i.e. a single epidermis is removed that makes the leaf translucent - followed later by holes in the leaves.

Adult diamondback moths were caught on yellow sticky traps from March onwards in southern England, suggesting that these populations had successfully overwintered. Pest pressure from diamondback moths therefore occurs throughout the summer and can be particularly intense in southern England when waves of migrant moths arrive from continental Europe.

Leafminers

Leafminer species (Figure 5), were historically important Brassica pests prior to the widespread adoption of insecticide seed treatments. In 2009, however, an upsurge in leafminer populations caused serious economic damage to high value leafy Brassica crops in central and southern England. There are at least five species of leaf miners that have been recorded previously on Brassicas in Britain – *Phytomyza rufipes*, *Chromatomyia horticola*, *Liriomyza strigata*, *Scaptomyza flava* and *S. griseola*. The generation time is short and new adults emerge from pupae in approximately 2-3 weeks. Rapid population build up can therefore occur in a relatively short period of time.

5 A leafminer adult.

6 Damage caused by leafminers - 'pin-prick' puncture marks and narrow mines in leaves.

Host Range

Leafminer pest species are generally considered to have wide host ranges encompassing more than 30 host plants from various taxonomic families. The major vegetable host plants that can be attacked in the UK are speciality leafy Brassicas, Chinese cabbage, cabbage, sugar peas, tomato, capsicum, French beans, leeks, and celery. The damage they cause consists of numerous 'pin-prick' puncture marks in leaves as well as mines. Pin prick damage is due to adult females piercing the upper surface of the leaf to extract plant sap and also from using the holes for oviposition. The typical damage leafminers cause in crop leaves is shown in Figures 6 and 7. In addition to the leaf damage, it was observed that when several leafminer larvae established in a young plant, the damage they caused was often sufficient to kill it.

7 Several species of leafminers attack Brassica crops and produce different shaped mines. The mines in the kale leaf on the right were caused by the same species that caused economic damage to the tatsoi on the left.

Weevils

Cabbage seed weevil (*Ceutorhynchus assimilis*) adults are an ash-grey colour and around 2-3 mm in length with a long narrow snout and elbowed antennae (Figure 8). They emerge from hibernation from late April and fly into Brassica crops where they feed on the leaves, buds and pods, where present.

8 Cabbage seed weevil adult.

Host Range

Cabbage seed weevil is a Crucifer feeding insect, which can cause damage to turnip, rape (*Brassica napus* L.), cabbage, heart-podded hoary cress (*Lepidium draba* L.), white wall-rocket (*Diplotaxis erucoides* DC.), perennial pepperweed (*Lepidium latifolium* L.) and radish. It has also been recorded on wild mustard.

The damage caused by cabbage seed weevil adults to leafy Brassica salad crops is very similar to that caused by leafminer adults. They make clusters of very small leaf holes, scrapes and indentations on the undersurface of leaves, probably associated with feeding activities (Figure 9).

For crops such as oil seed rape, the main damage is caused by their larvae and that of the Brassica pod midge, (*Dasineura brassicae*), which lays its eggs inside the pod via the holes created by cabbage seed weevil adults.

9 Pin-prick damage caused by cabbage seed weevil adults.

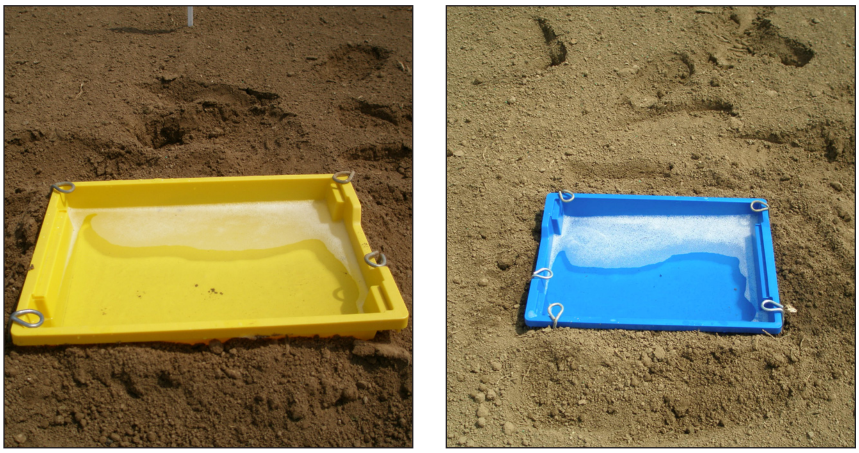
Management

Monitoring

Insect pests are commonly captured on glue-covered surfaces referred to as a sticky traps. Sticky traps are an effective way of monitoring flea beetle populations (Figure 10). It is important to change the traps frequently, because they can fill up quickly with trapped insects and so their efficacy reduces with time.

Other techniques for monitoring include water traps (Figure 11) in which a little surfactant is added to the water, and odour-baited traps. Yellow coloured water traps catch more flea beetles than the blue traps, but the latter are much more effective at catching *Diptera* spp. including leafminer adults. An example of an odour-baited trap design which was tried in FV 301 is the CSALOMON trap, which works effectively in eastern Europe to attract several flea beetle species, as well as weevils. This trap type, however, did not prove effective at catching the flea beetle populations in Kent. It remains unknown why the traps were ineffective.

10 Yellow traps were constructed by attaching strips of sticky yellow "roller trap" around grey poles. Only the yellow-coloured mesh nets covering the experimental plots were insecticide impregnated.



11 Yellow and blue water traps in which a little surfactant is added to the water to prevent the trapped insects from escaping.

Control

Physical methods

The diversity of pests attacking leafy Brassica crops means that pest management techniques and technologies of most use to growers are those that can prevent damage from a wide range of insect and vertebrate species. The standard farm mesh (Figure 12) is highly effective at preventing damage from a range of insect pests including flea beetle spp., weevils, leafminer adults and, to a lesser extent, leafminer larvae. It is less effective, however, at preventing damage caused by Lepidoptera (moth and butterfly) larvae and, in particular, those of the diamondback moth.

An innovative use of mesh covers is to impregnate them with insecticide. Data collected during FV 301 showed that insecticide-impregnated netting was highly effective at reducing damage even with a hole size through which the smaller flea beetle species could pass through (Figure 10). Dead insects of several species were observed frequently on this treatment, demonstrating knock down and kill by contact action. Although this technology shows promise, it still requires further development, particularly with regards to the number of seasons in which the insecticide retains its activity.

12 The standard farm mesh is highly effective at preventing damage from the insect pest complex.

Insecticide sprays

One of the most straightforward ways of protecting leafy Brassica crops is insecticidal sprays. Even though insecticide sprays did not prevent insect damage completely when used on their own, bifenthrin and spinosad did provide significant levels of protection which may be enough for other Brassica crops. Alternatively, these products may provide good alternatives to the deltamethrin currently used on leafy Brassicas, if used in combination with mesh.

Seed treatments

Seed treatments are highly effective for many Brassica crops. In relation to the pest complex that attacks leafy Brassicas, however, seed-treatments produced several interesting effects. Higher numbers of small wounds were caused by leafminer adults in seed treated plots than in the untreated controls. Seed treatments may not therefore provide sufficient protection in geographical areas where leafminers are a problem. Seed treatments were reasonably effective against flea beetles and diamondback moths. When total damage from all pests was accumulated there was a decreasing amount of damage with increasing seed-treatment dose.

Trap and sacrificial crops

A potential non-chemical control tactic is the use of trap crops. A drawback with this approach, however, is that high-value leafy Brassicas are extremely attractive in their own right to flea beetles and it is unlikely that there are plant species that are more attractive than the crops themselves.

A variation on this technique is to combine the use of standard farm mesh over the commercial crop, with plots of ‘sacrificial’ crops situated around the border of the field. The standard mesh provides the main protection, but additional protection, particularly against diamondback moth larvae, is provided by the adjacent ‘sacrificial-crops’ which attract adult females. Sacrificial crops are then sprayed with insecticide to remove the adult females and prevent them from ovipositing on the mesh covering the commercial crop.

Experimental evidence to date suggests that the sacrificial crop beds act as expected to attract insect pests including adult diamondback moth. However, the twice weekly insecticidal sprays were insufficient to kill all of the mobile adults which may have had some resistance to the insecticide that was used. This tactic, therefore, requires further research and improvement before it can be recommended to growers.

Cultural controls

For all Brassica crops, ploughing in crop debris or removal of infected plant material from fields is recommended as a way of reducing the pest species covered in this factsheet. Crop rotations with leafminer resistant crops are an effective pest management tool, although this may not always be practical or economical for growers of speciality leafy Brassicas. Maintaining weed free conditions as far as possible around the edges of fields is also recommended for reducing the numbers of key insect pests.

Table 1. Chemical control - currently available actives.

Actives	Example of product (MAPP No.) and marketing company	Target Pests & Crops
Acetamiprid	Gazelle (12909), Certis	Sucking pests such as cabbage aphid, mealy cabbage aphid, other aphids, whitefly. SOLAs for rocket, baby leaf Brassicas and outdoor Brussels sprouts.
Alphacypermethrin	Contest (10216), BASF Plc	Caterpillars of the diamondback moth, large white butterfly, small white butterfly. Product approved for use on broccoli/calabrese, cabbage, cauliflower, Brussels sprouts and kale. SOLAs for choi sum, collard, pak choi, baby leaf Brassicas and Chinese cabbage.
Bacillus thuringiensis var kurstaki	Dipel DF (14119), Interfarm UK Ltd	Most species of caterpillars. Product approved for use on broccoli/calabrese, Brussels sprouts, cabbage and cauliflower. SOLAs for choi sum, collard, horseradish, kale, baby leaf Brassicas, pak choi, rocket and Chinese cabbage.
Beta-cyfluthrin	Gandalf (12865), Makhteshim-Agan Ltd	Insect pests. Product approved on cabbage and cauliflower.
Bifenthrin	Brigade 80 SC (12853), Belchim Crop Protection Ltd	Provided good protection against flea beetles and diamondback moth caterpillars in HDC-funded trials. Product approved for use on broccoli/calabrese, Brussels sprouts, cabbage and cauliflower.
Cypermethrin	Toppel 100 EC (13704), SBM Développement	Caterpillars and aphids. Product approved for use on broccoli/calabrese, Brussels sprouts, cabbage and cauliflower. SOLAs for horseradish, baby leaf Brassicas and rocket.
Chlorpyrifos	Cyren (11028), Headland Agrochemicals Ltd	Cabbage root fly and larvae. Product approved for use on broccoli/calabrese, kale, cabbage, cauliflower, Chinese cabbage. SOLAs for choi sum, collard, kohlrabi, pak choi and tatsoi.
Deltamethrin	Decis (07172), Bayer CropScience Ltd	Flea beetles, caterpillars, leaf hoppers. Product approved for use on broccoli/calabrese, Brussels sprouts, cauliflower, cabbage, kale, mustard. SOLAs for choi sum, collard, horseradish, baby leaf Brassicas, Chinese cabbage, pak choi and rocket.
Diflubenzuron	Dimilin 25 WP (08902), Chemtura Europe Ltd	Caterpillars. Product approved for use on broccoli/calabrese, Brussels sprouts, cabbage, cauliflower. SOLAs for baby leaf Brassicas and rocket.
Dimethoate	Danadim (11550), Headland Agrochemicals Ltd	Insect pests, aphids. SOLAs for collard, kale, kohlrabi, broccoli/calabrese and Chinese cabbage. Latest application time is before the seven true leaves stage.
Esfenvalerate	Clayton Cajole (14995), Clayton Plant Protection Ltd	Insect pests. Product approved for use on broccoli/calabrese, Brussels sprouts, cabbage, cauliflower, Chinese cabbage, kale and kohlrabi.
Indoxacarb	Steward (13149), Du Pont (UK) Ltd	Diamondback moth caterpillars. Product approved for use on broccoli/calabrese, cabbage and cauliflower. SOLA for Brussels sprouts.
Fatty acids	Savona (06057), Koppert (UK) Ltd	Aphids, thrips. Product approved for use on Brussels sprouts. SOLAs for choi sum, pak choi, baby leaf Brassicas, kale, broccoli/calabrese, collard, cabbage, kolrabi, rocket, cauliflower, Chinese cabbage and komatsuna.
Lambda-cyhalothrin	Major (14527), Makhteshim-Agan Ltd	Insect pests, flea beetle, caterpillars, leafminer, aphids. Product approved for use on Brussels sprouts, cabbage, broccoli/calabrese and cauliflower. SOLAs for horseradish, baby leaf Brassicas, radish, rocket and mustard.
Methiocarb	Draza Wetex (11271), Bayer CropScience Ltd	Insect pests. Product approved for use on Brussels sprouts, cauliflower and cabbage. SOLA for baby leaf Brassicas.
Pirimicarb	Aphox (10515), Syngenta Crop Protection UK Ltd	Aphids, thrips. Product approved for use on broccoli/calabrese, Brussels sprouts, cabbage, cauliflower, Chinese cabbage, collard, kale. SOLAs for choi sum, horseradish, baby leaf Brassicas, pak choi, radish and rocket.
Pymetrozine	Plenum WG (10652), Syngenta Crop Protection (UK) Ltd	Aphids, cabbage aphid, mealy cabbage aphid, peach potato aphid. Product approved for use on broccoli/calabrese, Brussels sprouts, cabbage, cauliflower. SOLAs for choi sum, collard, kale, baby leaf Brassicas, pak choi, Chinese cabbage and rocket.
Spinosad	Tracer (12438), Landseer Ltd	Insect pests, thrips. Provided good protection against flea beetles and diamondback moth caterpillars in HDC-funded trials. Product approved for use on broccoli /calabrese, Brussels sprouts, cabbage, cauliflower, Chinese cabbage. SOLAs for baby leaf Brassicas and rocket.
Spirotetramat	Movento (14446), Bayer CropScience Ltd	Aphids , Brassica whitefly, cabbage aphid, insect pests, lettuce root aphid.Product approved for use on broccoli/calabrese, Brussels sprouts, cauliflower, cabbage kale and collard. SOLAs for choi sum, baby leaf Brassicas, pak choi, Chinese cabbage, mustard, rocket and tatsoi.
Thiacloprid	Biscaya (12471), Bayer CropScience Ltd	Cabbage aphid, mealy cabbage aphid. Product approved for use on broccoli/calabrese, cabbage, cauliflower, mustard. SOLAs for horseradish.
Thiamethoxam	Cruiser OSR (14496), Syngenta Crop Protection (UK) Ltd	Insect pests. Product approved as seed treatment for use on mustard.

- Always check the current approval of products listed in this factsheet as this may have changed since publication. If in doubt, contact CRD (Tel 01904 455775) or search on their website (www.pesticides.gov.uk) or search the LIASON database (www.fera.defra.gov.uk/liason) (subscribers only).
- SOLAs = Specific Off-label Approvals
- Growers must hold a paper or electronic copy of the appropriate SOLAs document before using any product under the SOLAs arrangements.

Additional information:

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