Western flower thrips control in strawberry

Western flower thrips (WFT) cause significant financial losses for strawberry growers in the United Kingdom. This factsheet provides information on the pest, the damage it causes to strawberries and the results of AHDB funded research in Projects SF 80, SF 90, SF 120 and a study of control in commercial strawberry production sites, which have led to a series of control guidelines.

Action points

Most successful control of WFT in commercial strawberry production has been found where:

- Strawberry crops are only grown for one season.
- Well-managed regular predator release strategies are used in all crops from either before flowering or from the first flowers, using Neoseiulus cucumeris, combined with one or more of: Stratiolaelaps scimitus, Orius species (later in the season when temperatures are high enough for establishment) or mass trapping with blue sticky roller traps.
- Phytoseiulus persimilis is used as the main control method for two spotted spider mite.
- Crop protection programmes that are harmful to predators are avoided.
- Advice on biological control programmes is sought from an adviser who is experienced in using predators.
- Product compatibility tables are consulted to check if proposed crop protection products are likely to be harmful to the predators being introduced.
**Introduction**

Western flower thrips – WFT (Frankliniella occidentalis) first became a pest of protected ornamental and edible plants in the UK in the 1980s and considerable research has been done since then on management in protected crops. It wasn’t until 2002 and later that the pest was found to be damaging protected and outdoor strawberry crops, the first outbreaks being found in the midlands of England. Feeding by the pest was causing serious damage to developing flowers and fruits and this prompted AHDB to commission a series of research projects on WFT control in strawberry, running from 2006 until 2015 and a further study in 2014, comparing poor and successful control on commercial sites. This culminated in a set of management and control guidelines for commercial strawberry growers that are summarised in this factsheet.

**Thrips species**

There are many different species of thrips native to the UK. Those that can commonly occur in strawberry flowers include the onion thrips (Thrips tabaci), the rose thrips (Thrips fuscipennis) and Thrips major (no common name). Often these occur in species mixtures. WFT is not a native species of the UK, having been first introduced to the UK on infested plant material in 1986. It thrives in warmer temperatures and with the increase in strawberry production under protected structures, the pest is now widespread in all areas of the UK including Scotland.

**Recognition and biology**

**Adults**

Like other thrips species, WFT adults are small slim insects, with narrow wings fringed with hairs. Female WFT are slightly larger (1.5–2mm long) and darker than the males. The females (Figure 4) usually have a yellowish head and front half of the body and a brownish back half. The males are yellowish all over. Adults can live for several weeks. The temperature threshold for WFT flight is 20°C but they can be active and egg laying in flowers at temperatures below this. Confirmation of species present in the crop needs to be done under a microscope.

**Eggs**

WFT eggs are not visible as the females lay them directly into plant tissue. Time to egg hatch is about five days at 20°C.

**Larvae**

Larvae (Figure 5) hatch from the eggs after a few days, depending on temperature. There are two larval stages, neither of which have wings. First stage larvae are less than 1mm long and colourless or white. They feed for two or three days before developing into the second stage larva, which are about 1mm long and yellow. The second larval stage lasts for about 11 days at 20°C and five days at 25°C, but develops more slowly at lower temperatures. When fully grown, most of the late second stage larvae drop from the plants to pupate in the soil, growing media or substrate. However, a small proportion may pupate on the plants, in sheltered places such as behind the calyx on fruit or hidden in flowers.

**Pupae**

There are two pupal stages, the prepupa and the pupa (Figure 6), neither of which feed. Both these stages are yellowish in colour and about 2mm long. The prepupa has short immature wings and short, forward-pointing antennae. The prepupal stage lasts only for a day or two then develops into the pupa, which has longer immature wings and longer antennae that fold backwards over the body. The pupal stage lasts for about five days at 20°C and three days at 25°C. When pupation is complete, the adult thrips emerges from the pupal case.
Research in Project SF 80 confirmed that WFT tends to be a greater problem in fields with a history of WFT and where plants or beds are kept from one year to the next. It was found that adults emerged in March from the soil in planting holes directly under the strawberry plants, the soil or substrate close to the plants within the raised beds or grow bags, the straw in the alleys and the soil under the straw. Project SF 120 also found WFT overwintering as adults in senescent or dead strawberry flowers and weeds such as chickweed, groundsel (Figure 7) and dandelion and the first larvae were found in groundsel flowers in late March, indicating that females were laying eggs in early March. WFT are often found on the edges of the crop and especially in weedy field margins. Second year crops can start the season with significantly more WFT that first year crops.

Western flower thrips eggs, larvae and pupae can develop slowly below 10°C, but most information on development rates has been obtained at 10–35°C. WFT can survive in a quiescent state at lower temperatures over the winter. At typical summer glasshouse fluctuating temperatures, WFT can develop from egg to adult in only 11 days. The pest can therefore breed very quickly during the summer and can go through many generations per year, particularly in heated structures (Figure 8) and on everbearers, which have a long season with several flower flushes. Once the pest is established, the highest numbers tend to be concentrated where temperatures are higher, and in the case of field grown crops, in the mid to top areas of sloping fields.

Damage is often first seen on the flower petals as characteristic brown markings (Figure 9), but WFT adults and larvae prefer to feed on the flower receptacle, and significant damage may have occurred to an individual flower before the petals become marked. When numbers of WFT are high, damage occurs rapidly and the whole flower may gain a brown unsightly appearance. Feeding continues on the surface of developing fruits, which also develop brown markings around the seeds and under the calyx and have a dull, brown or bronzed appearance when ripe, rendering the fruits unmarketable (Figure 10). Yield loss of 15–20% is typical in strawberry crops where WFT control has broken down. Where high populations develop, on everbearers for example, even more severe crop losses can occur, leading to crop write-offs in some cases.

A sex aggregation pheromone specific to WFT was developed by scientists at Keele University and is available from Syngenta Bioline. The pheromone is produced by WFT males and attracts both male and female WFT for mating. The pheromone is supplied commercially, adsorbed onto small rubber lures that are stuck onto the lower section of blue sticky traps (available from most Integrated Pest Management – IPM – suppliers) to help monitor for WFT. A different thrips attractant for various thrips species including WFT is available from Koppert. As this attractant is not selective, it will not help to distinguish thrips species. If used on sticky traps it will also attract natural enemies such as Orius, so possibly reducing numbers of predators in the crop.

Before the crop starts flowering, early emerging WFT adults that have overwintered in the crop can be found on flowering weeds. At this time, blue sticky traps together with the pheromone lure are very effective at catching WFT. Each trap can catch several hundred adults per week at times in Spanish tunnels in the UK, depending on the numbers of WFT that have overwintered in the crop. In strawberry, the best position for traps is to mount them onto a post (a cheap bamboo cane is sufficient), held in place with a rubber band with the bottom of the trap (landscape orientation) about 10cm (one hand width) above the top of the crop, orientated to face south so it catches more light (Figure 11). Once the strawberry flowers start to open, counts of thrips in flowers have been found to give a better correlation with damage than pheromone trap catches. This is because thrips flight onto sticky traps varies with the daily temperature and wind strength, so does not reflect the population density as well as counts of thrips in flowers.

The use of a hand lens is essential when monitoring for thrips.
The first strawberry flowers in tunnel crops are usually seen in March. They attract adult thrips, and the females immediately start to lay eggs. Thrips concentrate in the yellow stamens and anthers as they feed on the pollen. When monitoring for thrips in strawberry flowers, the selection of flower age and position affects population estimates. For monitoring thrips adults, select flowers of medium age (all petals present, pollen shed) from the top of the plant, as young (petals fresh, pollen not shed) or senescent (petals drooping) flowers will result in an underestimation. For monitoring thrips larvae, select senescent flowers (petals dropping).

Look in the flower centres using a x10 hand lens (Figure 12 – page 5). The yellow parts (carpel) host the thrips, although the adults side of the carpel. Neoseiulus cucumeris feeds on the first larval stages of WFT. Significant damage that might result in downgrading of fruit, occurred when there were about four adult thrips per flower on cv. Camarino. However, in controlled experiments, when the predator mite Neoseiulus cucumeris was present in flowers, this figure was higher, with significant damage being avoided when there were up to eight adult thrips per flower. No detailed information on damage thresholds is available for other everbearer varieties. Interestingly, in experiments in commercial crops where predators had been released but their establishment had been poor, economic damage was observed where numbers of adult WFT were at five per flower or above. In contrast, in commercial crops where predators had been released and established well, economic damage was not observed until numbers of adult WFT were as high as 11 adult thrips per flower.

**Damage thresholds**

Research on damage thresholds in everbearers (Project SF 120) demonstrated that in the absence of predatory mites to control WFT, significant damage that might result in downgrading of fruit, occurred when there were about four adult thrips per flower on cv. Camarino. However, in controlled experiments, when the predator mite Neoseiulus cucumeris was present in flowers, this figure was higher, with significant damage being avoided when there were up to eight adult thrips per flower. No detailed information on damage thresholds is available for other everbearer varieties. Interestingly, in experiments in commercial crops where predators had been released but their establishment had been poor, economic damage was observed where numbers of adult WFT were at five per flower or above. In contrast, in commercial crops where predators had been released and established well, economic damage was not observed until numbers of adult WFT were as high as 11 adult thrips per flower.

**Control**

Within the Defra and AHDB funded projects, research has investigated three forms of control including the use of sticky roller traps, biological control using predatory mites and bugs and the use of biostimulants and selective crop protection products.

**Sticky roller traps**

Research was done (Project SF 120) to assess the efficacy of using blue sticky roller traps (30cm wide, 10m long) with and without additional WFT aggregation pheromone along the tunnel legs to reduce adult WFT populations (Figure 13). The traps were tested in addition to releases of predatory mites as part of an IPM programme. In one season, the cumulative WFT numbers in the crop by 61% and resulting fruit damage by 55%. However, the traps alone (without predatory mites) were not sufficient to prevent fruit damage in crops with high thrips numbers. In 11 trials over three seasons, the traps typically reduced thrips numbers by about 50%, however results were variable. In some trials, WFT numbers were successfully reduced by the traps, but not the level of fruit damage. Where WFT numbers were low, for example, when good biological control programmes were used, the traps did not help to reduce numbers of WFT.

**Biological control**

In initial studies on biological control of WFT using the predatory mite Neoseiulus cucumeris in Project SF 80, it was demonstrated that use of the predator could reduce the numbers of damaged or bronzed fruit when compared to untreated control plots (Figure 14). It should be noted that N. cucumeris feeds on the first larval stage of WFT, but not the adults or second stage larvae. Like other predatory mites, it seeks its prey by crawling across the foliage, flowers and fruit. Orius axyrius predatory bugs were also found to offer some level of biological control. A number of commercial growers have had some success with N. cucumeris, so further work was done in the Defra Horticulture LINK project (SF 120) to determine the best ways to improve efficacy.

To provide acceptable control of WFT, it was found that it is best to release N. cucumeris early in the season before thrips numbers begin to increase. In commercial practice, this is normally in-mid-March in tunnel grown crops. It was shown in the trials that equal control was given whether the predators were released in-season (Figure 12) or in the loose formulation (Figure 16). However, whichever release system is used, it is necessary to continue to release N. cucumeris regularly throughout the season. Commercial success has been achieved in tunnel everbearer crops when the predator has been released using the loose product every two weeks from mid-March onwards, when flowering is beginning, through to mid-September. The normal rate per plant per application although this rate is often increased to 50 per plant if numbers of thrips per flower increase. This rate of introduction is based on

the experience of ADAS consultants working closely with grower businesses where successful control is now regularly achieved. An AHDB Horticulture training video is available on the AHDB Horticulture website to guide staff on how to best introduce the predatory mite Neoseiulus cucumeris to a strawberry crop.

Further work in Project SF 120 investigated the use of Orius axyrius (Figure 17 – page 8) to supplement the control gained by N. cucumeris. Unlike N. cucumeris, Orius adults can fly to find WFT and the predator feeds on both adults and larvae, which is advantageous. However, it only works well in the warmer months from late May and June onwards, as it needs a minimum of 15°C for egg-laying to occur and needs over 20°C for good establishment. As a result, populations take time to build-up so can’t be relied on as a preventive measure. Commonly used rates of introduction for Orius are a minimum of 0.25 to 1 bug per strawberry plant, which should be repeated every two weeks later. Higher release rates have successfully been used in recent years when temperatures have allowed good establishment.
**Biocides**

Work in Project SF 120 investigated the use of several biopesticides for controlling WFT. Products tested included foliar applications of Mycotox (Lecanicillium muscardinum), foliar and drench applications of Naturlite L (Stratiolaelaps scimitus – Figure 19), soil drench application of Met52 (Metarhizium brunneum – formerly Metarhizium anisopliae) and foliar and drench applications of a coded botanical biopesticide. Despite some favourable results using Naturlite L in laboratory-based experiments, in field experiments none of these products were effective. Further work is required to evaluate the persistence of the fungal spores on the strawberry crop and to determine the number of spores per thrips required to cause death.

**Traditional crop protection products**

Soon after the first appearance of WFT in UK grown strawberry crops, the AHDB secured an Extension of Authorisation for Minor Use (EAMU) for the use of Tracer (spiromesifen) on strawberry crops to control WFT. However, experience of using spiromesifen overseas had indicated that populations of WFT can develop resistance to this product quite rapidly. In anticipation of resistance developing in the UK, AHDB funded Project SF 90 to assess alternative control products.

A number of approved and non-approved products were included but none of these consistently reduced numbers of WFT during flower development throughout the trial. Interestingly, the population of WFT used in the second year of this trial was shown to be resistant to Tracer.

In the early stages of Project SF 120, some other coded products were assessed for their potential at controlling WFT and compared with Tracer. In Year 2 of the project, two coded products compared favourably with Tracer, providing 80 and 81% control respectively, compared to 69% control achieved by Tracer. These coded products are not currently approved for use on strawberries in the UK. AHDB Horticulture is investigating the potential for securing future approvals on strawberry.

However, in the short to medium term, growers will need to rely primarily on the use of biocontrol techniques for controlling WFT.

**Reasons for success and failure occurring in commercial practice**

In 2013 and 2014, a significant number of UK strawberry growers suffered particularly heavy losses of yield as a result of failing to achieve acceptable control of WFT (Figure 20). In light of the knowledge gathered both from AHDB-funded research projects and related experience gained working with commercial strawberry producers, AHDB Horticulture funded a study of selected strawberry production sites. The aim of this study was to identify factors that may have led to the success or failure of WFT control in tunnel grown strawberry, which could be disseminated to growers to improve their control.

Six growers were visited or interviewed (two in Kent, three in Staffordshire and one in East Anglia) and details were collected from six crops where WFT control was successful and six crops failing to achieve acceptable control (Figure 21 – page 10) were employed (in first – or second-year crops) either from or before flowering, using Neoseelus cucumeris combined with:

- Stratiolaelaps scimitus (formerly named Hypoaspis miles)
- Orius spp.
- Mass trapping with blue sticky roller traps.
- Phytoseiulus persimilis
- Pesticide programmes that are harmful to predators were avoided.

**Summary of the crucial findings**

WFT control was most successful where:

- Only one-year strawberry crops were grown.
- Well-maintained regular predator release strategies (Figures 21 – page 10) were employed (in first – or second-year crops) either from or before flowering, using Neoseelus cucumeris combined with:
  - Stratiolaelaps scimitus (formerly named Hypoaspis miles)
  - Orius spp.
  - Mass trapping with blue sticky roller traps.
  - Phytoseiulus persimilis
  - Pesticide programmes that are harmful to predators were avoided.
WFT control broke down where:

- There was a large carry-over of WFT from the previous season, either from overwintered first-year crops or from reused, untreated growbags, resulting in damage at first flowering.
- Predators were released too late.
- Insufficient *N. cucumeris* releases were made early in the season.
- Crop protection products (Figure 22) that are harmful to predators were used during the time when predatory mites were being released, or there was repeated use of slightly/moderately harmful products, which prevented predator establishment and interrupted WFT control.

**Specific control guidance for growers**

At the end of the study to identify the differences between the successes and failures, practical guidance was produced for growers to follow to achieve successful control of WFT. This guidance is reproduced in the insert in the back cover of this publication.
Further information

Other useful publications

AHDB Grower guide. Biocontrol in soft fruit.
AHDB Factsheet 14/09. Thrips control on protected ornamental crops.
AHDB Study report. Management of pesticide-resistant western flower thrips on tunnel-grown strawberry: a study of the reasons for successes and failures on commercial production sites.
AHDB Biocontrol training video. Using Neoseiulus cucumeris for western flower thrips and tarsenemid mite control (translated into Bulgarian, Romanian, Latvian, Lithuanian, Polish, Slovakian).

Useful AHDB project reports

SF 80 – Tunnel-grown everbearer strawberry: biology and integrated control of western flower thrips (Project leaders: Jude Bennison, ADAS and Jean Fitzgerald, East Malling Research).
SF 90 – Chemical control of western flower thrips in strawberry flowers (Project leader: Jerry Cross, East Malling Research).
SF 120 – Biological, semiochemical and selective chemical management methods for insecticide resistant western flower thrips on protected strawberry (Defra Horticulture LINK HL01107).
PC/SF 276 (HL0184) – Pheromone technology for management of capsid pests to reduce pesticide use in horticultural crops (Project leader: Michelle Fountain, East Malling Research).

Defra Horticulture LINK project (HL01107 – SF 120) consortium details

Project leader: Jerry Cross, East Malling Research
Industry leader: Richard Harnden, Berry Gardens Growers
Consortium members:
East Malling Research
Natural Resources Institute
ADAS
Keele University
Warwick Horticulture Research International (HRI)
AHDB Horticulture
Bayer CropScience
Belchim Crop Protection
Berry Gardens Growers
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