This factsheet offers guidance on the biology and control of tarsonemid mite in strawberry. It provides helpful information on cultural control as well as biological and chemical control options including introduction rates of predatory mites.

**Background**

Strawberry tarsonemid mite (*Phytodromus pallidus*) has been a pest of commercial strawberry crops for several decades in the UK and is difficult to eradicate. In some years and in some crops, damage from the pest can result in economic losses. The mite is small and initially difficult to find but regular crop walking and experience in assessing leaf symptoms will lead to proficient identification of plant damage and the mite itself. It has a very rapid lifecycle in protected polytunnel and glasshouse crops and is believed to be spread by farm staff working in the crop, on farm equipment and as a result of poor hygiene.

It is vital that new crops are established using ‘clean’ stock and that biological control is routinely applied to prevent a build-up of the pest. However, there are some occasions where the pest may still proliferate and additional action may be needed. This is more likely during hot summers in crops under protection. Everbearer varieties tend to be more susceptible as the pest has a longer period to produce more generations, although June-bearing varieties are also affected. Crops which are in their second year are at greater risk of financial damage if the pest was present the previous season.

Monitoring and rigorous, systematic checking of plants is essential alongside regular introductions of predatory mites, which should begin before the pest becomes visible.

**Action points**

- When acquiring new strawberry plants, seek reassurance that stocks are free from the presence of tarsonemid mite before planting.
- Employ trained staff to monitor strawberry plants for the presence of the mite from the start of the growing season onwards.
- Make regular introductions of predatory mites to gain early season control even if tarsonemid cannot be found by visual inspection initially.
- The rates of predator introduction should be governed by population levels of tarsonemid mite.
- Choose crop protection sprays for other pest/disease control programmes which are harmless to the predatory mites.
- Where tarsonemid mite populations reach economically damaging levels a chemical acaricide may be needed, which should be chosen in consultation with a BASIS qualified advisor.
Crop damage

Injury to the strawberry plant is caused when tarsonemid mites feed on the contents of the surface cells of very young strawberry leaves. Feeding usually takes place on the upper surface of the main vein between the two halves of the folded leaflets, before they have expanded and opened. The mite feeds using a pair of pincer like jaws (chelicerae) and then inserts its needlelike mouthparts to inject toxic saliva. As the damaged leaflets expand, the feeding injury makes the surface leaves rough, twisted, wrinkled (Figure 2) and discoloured with a characteristic brown bronzing appearance. The leaves sometimes display signs of leaf-edge curl (Figure 3).

Attacked plants are stunted (Figure 1 - Front cover) and young leaves and flower trusses often turn brown and die (Figure 4) in severe infestations. Patches of stunted plants throughout the crop can be observed. Flower bud formation can be reduced and the number and size of fruits reduced, affecting yield. On everbearers, the later fruits may turn brown and dry up (Figure 5). Another indication of damage in some varieties, is the formation of roughened stolons, or ‘dog tooting’ on runners (Figure 6), presumably from previous feeding damage when the runner was in the crown of the plant. Symptoms are sometimes confused with nematode or shallot aphid damage. However, nematode injury shows up earlier in the spring and never shows any leaf-edge curl. Nematode damage is also less likely in plants grown is substrate such as coir.

Figure 2. Affected leaves displaying rough and wrinkled appearance following tarsonemid mite feeding

Figure 4. Symptoms of flower truss die-back as a result of tarsonemid mite feeding

Figure 3. Affected leaves which are curling upwards at the margins

Figure 5. Fruits on everbearers tend to turn brown and dry up

Figure 6. ‘Dog-tooth’ effect on runners caused by earlier mite feeding as the stolon was developing in the plant crown

Pest identification

Regular inspections of the crop should take place to identify the pest before plant damage begins to occur. However the mite is only 0.2-0.25 mm in length making it difficult to detect especially early in the season or if populations in the plants are small. However, with practice, it is possible to see tarsonemid mites using a x10 or x20 hand lens. The adult mites are pale brown and oval in shape (Figure 7) and move slowly between the leaf hairs. Immature mites (larvae) are smaller and whitish (Figure 7). The eggs are oval and whitish (Figure 7) and can be distinguished from other particles on the leaves by their shiny appearance. Eggs are approximately half the length of the adult females.
Life cycle

Female adult tarsonemid mites overwinter deep in the crowns of plants, although the survival rates are thought to be low (<10%). Males are not known to overwinter in outdoor crops. Eggs are laid mostly along the main vein of leaves (up to 50 per female), but can be found between the folded leaflets. Egg laying begins when temperatures rise in the spring and individual females can lay 1-3 eggs per day. Eggs hatch into 6-legged opaque white larvae which develop and then pupate before becoming adults. Mating is not required for females to produce offspring. However small numbers of males (5% or less) are produced later in the season, when populations are high in the plant, and at this stage sexual reproduction occurs.

The size of the pest population is influenced by temperature. In heated glass (Figure 8) and polythene tunnel grown crops, the higher temperatures allow for more rapid rates of reproduction, so the pest, if present in such crops, is more likely to cause damage. Table 1 outlines the rate of development at different temperatures up to 25°C. Crucially, the higher the temperature, the more rapid the rate of development. At 25°C, typical in protected crops, the mite can develop from egg to adult in only 9 days.

Spread

Tarsonemid mite can be introduced to the crop on new planting material. Once the crop is growing, spread can also occur through husbandry practices such as crown thinning, runner removal and harvesting, with the pest being transported on the hands or clothing of workers or on packaging material. Little data is available to quantify this or how much the mite can move on air currents.

Overseas research has also shown tarsonemid mites to exhibit phoresy, an association which allows them to cling to other insects to allow movement from place to place. They have been shown to move on whitefly (Figure 9), but it is likely that they move on other pests too.

Crop monitoring

Severe crop damage will be obvious to those monitoring a crop by the appearance of areas of stunted plants with rough, twisted leaves and leaf-edge curl. However if crop monitoring is carried out correctly, the pest should be identified before severe symptoms develop.

To monitor for tarsonemid mite, remove and inspect unfolded young leaves in the crown of the plant. Open the folded leaves and inspect them using a hand lens.

Table 1. Effect of temperature on the development time (days) of strawberry tarsonemid mite life stages (from Easterbrook et al 2003)

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>Egg stage</th>
<th>Nymph + Pupa</th>
<th>Total</th>
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<td>–</td>
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<td>10.5</td>
<td>14.0</td>
<td>15.3</td>
</tr>
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<td>17.5</td>
<td>7.3</td>
<td>8.0</td>
<td>15.3</td>
</tr>
<tr>
<td>20.0</td>
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<td>12.3</td>
</tr>
<tr>
<td>25.0</td>
<td>4.0</td>
<td>4.8</td>
<td>8.8</td>
</tr>
</tbody>
</table>

Figure 7. Tarsonemid mite eggs (oval whitish structures), larvae (similar to adults but white) and adult female (pale brown elliptical shaped - see insert)

Figure 8. The pest reproduces more rapidly under higher temperatures afforded by glass and polythene structures

Figure 9. Tarsonemid mite can be carried by whitefly and possibly some other pests of strawberry
If present, mites can be seen at the petiole end of the leaf along the main vein. Tarsonemid mite can also be found in runner tips as the tips grow away from the plant so this is another good place to inspect for presence of mites. Crops should be monitored systematically and regularly to avoid plant damage and yield loss:

- Start monitoring in spring shortly after new growth has commenced.
- It is recommended that each strawberry field is examined at least fortnightly, and preferably weekly, for pests and diseases during the growing season.
- A sample of at least 50 young folded leaves from the plant crowns should be inspected following a zigzag transect across the crop, sampling one leaf per plant.
- An attempt should be made to focus on sampling from plants that look, potentially, damaged by tarsonemid mite to increase the likelihood of identifying the problem.
- With experience, mites can be seen with a x10 or x20 hand lens (Figure 10), although x20 is often more reliable. For those with less experience, it is wise to examine leaves under a microscope until confidence in detection and identification is acquired.
- Unfold the leaflets of the trifoliate leaf and inspect the area on the upper surface at the base of the leaf where the main vein meets the petiole.
- When sampling in glasshouses consider focusing on warmer areas such as southeast corners, areas near to glass panels or near heating systems. Mite development is likely to be more advanced in such areas making the mites easier to detect.
- Consider starting in areas of field grown crops where there has been a problem in previous years.

Control

Start with clean planting material

Control should begin at the propagation stage and growers should obtain a source of clean certified planting material from a reputable source. Candidate nuclear stock/pre basic mother plants are initially grown in a quarantine house to allow testing and inspection for freedom from quarantine pests, a process that includes weekly microscopic inspection by trained staff for freedom from mites (Figure 11). Progeny from these plants move to the designated nuclear stock / pre basic grade production house only if no mites are detected following destructive analysis of the mother plant – a routine process prior to moving any plants.

Plants in pre basic propagation houses are grown in strict isolation from fruiting crops and older stock plants to prevent new infestations. The plants are grown under strict conditions of hygiene according to the Fruit Propagation Certification Scheme rules and are inspected regularly for the presence of tarsonemid mite. Staff working in a propagation business are trained about the dangers of pest and disease to help to minimise risks of cross infection. Prior to dispatch all batches of plants produced from the process are split and a proportion sent for destructive sampling to verify freedom from tarsonemid mite and other pests defined within the scheme. Growers purchasing plant material should satisfy themselves that regular crop inspections for tarsonemid mite have been made and enquire about any control measures used.

Cultural control measures

Crops of less than one year in age are not usually severely attacked unless the runners/planting material have been substantially infested. Ideally newly received plants would be quarantined and inspected before planting. Crops should be planted as far away from currently infested fields as possible. Isolation is especially important for nursery crops.

The older the plant, the more severe the infestation and damage is likely to be. Short term cropping will reduce the risk of serious crop losses.

In cases where small outbreaks occur on a few plants, the immediate removal of infested plants might at least slow the spread of this pest throughout the field. Subsequently, plants in a radius of two metres around the central area should be removed and destroyed.

Mites have been found living on buried plant material, in cool conditions for up to four weeks, so good hygiene both during and at the end of cropping is essential. Dead and dying material should be removed and destroyed. Farm staff should be trained to recognise and report damage and understand the mechanism of spread and prevention measures.

Biological control

In recent years, with the continuing decline of available acaricides to control tarsonemid mite on strawberry crops, growers have successfully gained control using the predatory mite Neoseiulus cucumeris and under glass and fixed tunnel structures, Neoseiulus californicus, or...
combinations of the two. \textit{N. cucumeris} is also employed to control western flower thrips (\textit{Frankliniella occidentalis}) in strawberry.

\textbf{Neoseiulus cucumeris}

\textit{Neoseiulus cucumeris} (Figure 12) feeds on all life stages of tarsonemid mite. It can sustain itself by feeding on pollen and is often found feeding in strawberry flowers. In strawberry crops, \textit{N. cucumeris} is most easily recognised under the calyx of developing fruitlets, but can also be seen running over the surface of leaves. Mobile stages are beige-pink in colour and droplet shaped. Unlike tarsonemid mites, predatory mites are fast moving in warm conditions. Predatory mite eggs are spherical in shape, white and have a shiny appearance. They can often be seen near to tarsonemid mite colonies.

Predatory mites can be introduced either through ‘slow release’ devices or by application of loose formulation. The former is often a sachet containing breeding colonies (Figure 13), which release individual mites continuously over several weeks. The sachets are recommended for introduction at planting and early spring even before flowering and before the pest is detected. At this stage, the population growth of the pest is slow and there may not be alternative food for the predatory mite. However, it should also be noted that the emergence of \textit{N. cucumeris} from sachets during cool early season conditions can be slow.

Therefore in cool conditions, if the pest is known to be present, release of loose mites can provide higher numbers quickly onto the plants and may provide better control. As a loose formulation \textit{N. cucumeris} is sprinkled directly (Figure 14) into the crown of the strawberry plants for maintaining predatory mite numbers and fast establishment. Loose predatory mite releases should be made at least fortnightly coupled with weekly monitoring for the pest and the predator to establish efficacy of control.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure12.png}
\caption{Figure 12. \textit{Neoseiulus cucumeris} predatory mites are successfully used as biocontrol agents for tarsonemid mite}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure13.png}
\caption{Figure 13. Sachet containing \textit{Neoseiulus cucumeris} offering slow release of the predators into the strawberry crop}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure14.png}
\caption{Figure 14. \textit{Neoseiulus cucumeris} predators being sprinkled loosely into the crowns of the strawberry crop}
\end{figure}

\textbf{Recommended introduction rates}

- For prevention of thrips with \textit{N. cucumeris} using sachet formulations, introduce around one sachet per 2.5 m².
- Using loose formulation rates for thrips prevention, introduce 50 \textit{N. cucumeris} per m², doubling the rate to 100 once tarsonemid mite is detected.
- Routine introductions at fortnightly or weekly intervals depending on pest pressure and temperature should be made.
- Once an infestation of tarsonemid mite occurs, the rate should be increased to 200-400 per m². This rate should be used on infested areas and their immediate surroundings, on the assumption that the infestation has already spread, even if damage is not yet visible. Repeat until the problem is under control.
- If crop damage is already occurring, it may be necessary to spray an acaricidal product then reintroduce \textit{N. cucumeris}.
- Side-effects of applied plant protection products on \textit{N. cucumeris} should be checked on the biocontrol suppliers web sites and reintroductions made once the persistance of the product has diminished.
- Leave the minimum necessary interval for the harmful effects of the product to decline, but be aware that the rates of degradation are highly dependent on the levels of sunlight and leaf expansion.

\textbf{Neoseiulus californicus}

For tarsonemid mite control under glass, the predatory mite \textit{Neoseiulus californicus}, may also be released. \textit{N. californicus} is a non-native species to the UK and it is only permitted to release this predator on glasshouse protected crops. Under glass \textit{N. californicus} is also effective at predating two-spotted spider mite (\textit{Tetranychus urticae}) and is active within the temperature range of 13-35°C. Mobile stages look very similar to \textit{N. cucumeris}. They are transparant white-orange to yellow and droplet shaped. Eggs are transparent to white and can be found attached to hairs along veins on the underside of leaves. \textit{N. californicus} has recently been made available for introduction in slow release sachets and can also be applied as a loose formulation.
**Recommended introduction rates**

- Sachets should be deployed at one sachet per 1.2 m² for prevention and one sachet every 1 m² for curative control.
- Loose product should be deployed at 25 mites per m² for prevention and up to 200 mites per m² for curative control.
- As with *N. cucumeris* repeat applications should be made.

**Changing recommendations and deployment**

Commercial predatory mite production is an evolving area of pest control with new dispensing systems and release rates being recommended as new knowledge becomes available. Growers should keep up to date with the latest products and recommendations from suppliers. Devices and techniques for deployment may vary but, most importantly, live biological controls should be applied to the crops as soon after delivery as possible for maximum benefits. The recommendations from the suppliers should be read and followed for product preparation and application (see Further Information section).

**Other predatory mite species**

In AHDB funded project SF 133, six predatory phytoseiid mite species were evaluated for their effectiveness at controlling tarsonemid mites in one year in glasshouses. In these experiments, *N. californicus* provided greater reduction of tarsonemid mites compared to *Amblyseius swirskii* and *A. montdorensis*. However, *A. montdorensis* has successfully controlled tarsonemid mites in protected edible and ornamental crops and also predates thrips and whitefly.

In a second polytunnel test *A. barkeri* and *N. cucumeris* gave significant control compared to *A. andersonii*. The former two species gave good preventive control and two releases of *N. cucumeris* reduced populations as a curative treatment. *A. barkeri* is not, currently, commercially available.

**Other predators**

Other potential predators may include predatory flower bugs, pirate bugs (anthocorids and *Orius* sp. – Figure 15) and predatory thrips. However, naturally occurring predators are unlikely to completely control tarsonemid mite and regular releases of commercially available predatory mites are recommended.

Many predators, introduced or naturally occurring, will be affected by crop protection products and other plant health products such as vaporised sulphur. Products applied to control spotted wing drosophila (SWD – *Drosophila suzukii*) are likely to have residual effects on introduced predatory mites, so reintroductions need to be timed appropriately following spray applications targeted to control SWD.

**Chemical control**

**The importance of good spray cover**

Tarsonemid mites are susceptible to most acaricides when directly intercepted by sprays. However the majority of the mites and eggs reside between the blades of folded leaves and are relatively inaccessible to sprays. Most currently used acaricides are contact acting and the spray penetration can be the chief factor limiting efficacy. In addition, strawberry leaves are waxy and hairy and spray droplets can be prevented from reaching the inner leaflets.

To achieve maximum penetration, sprays should be applied in high water volumes (at least 1,000 l/ha) using efficient application equipment (Figure 16) to ensure the crowns of the plants are thoroughly penetrated. Spray operators should use water sensitive papers or other spray deposit technology to ensure the crown of the plant has been reached with good coverage.

**Crops for fruit production**

In crops for fruit production, where it is especially important to minimise pesticide residues, biological control with the predatory mites (see above) is the preferred option for control of tarsonemid mite. Chemical control should only be used as a last resort, where extensive infestation and damage is present.

Early AHDB trials in the 1990s indicated that abamectin (Dynamec) and tebufenpyrad (Masai) are both effective for control of the pest. Floramite (bifenazate) is currently approved for use on protected strawberry for two-spotted spider mite control, but is not considered effective for tarsonemid control. All the synthetic pyrethroid insecticides tested in the AHDB trials have been ineffective against tarsonemid mite.

Control can be improved by using a silicone wetter mixed with the effective acaricide. AHDB Project SF 79 in 2006 demonstrated that the activity of Dynamec, Masai and Borneo could be improved with the addition of a silicone wetter. Note that Envidor was not approved for use on strawberry at the time of testing. The adjuvant label should be carefully checked before application as there is often a requirement to reduce the acaricide concentration by 50% when applied in combination.
<table>
<thead>
<tr>
<th>Active ingredient</th>
<th>Product</th>
<th>Approval type</th>
<th>Activity against</th>
<th>Target pest on label</th>
<th>Mode of action*</th>
<th>Harvest interval</th>
<th>Max. number of applications/year and other information</th>
<th>Side effects on predators**</th>
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<td>Dynamec/Clayton Abba</td>
<td>EAMU</td>
<td>Larvae and adults</td>
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<td>Very harmful, 1-2 week persistence Very harmful, 1-2 week persistence</td>
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<td>EAMU</td>
<td>Eggs, larvae and adults</td>
<td>Two-spotted spider mite</td>
<td>10B</td>
<td>3 days</td>
<td>1 application Approved on protected crops only More effective with the adjuvant Silwet</td>
<td>Moderately harmful, 2 week persistence Harmful</td>
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<td>Envidor</td>
<td>EAMU</td>
<td>Larvae</td>
<td>Two-spotted spider mite</td>
<td>23</td>
<td>3 days</td>
<td>2 applications – outdoor crops 1 application – protected crops</td>
<td>Moderately harmful Moderately harmful</td>
</tr>
<tr>
<td>tebufenpyrad</td>
<td>Masai</td>
<td>Full</td>
<td>Eggs, larvae and adults</td>
<td>Two-spotted spider mite</td>
<td>21A</td>
<td>3 days</td>
<td>Max no. Applications – not listed. Approved on outdoor and protected crops More effective with the adjuvant Silwet</td>
<td>Moderately harmful Harmless, no persistence</td>
</tr>
</tbody>
</table>

*IRAC code – Further details about IRAC (Insecticide Resistance Action Committee) and the full IRAC code list, can be found at http://www.irac-online.org/modes-of-action/. Products with the same Mode of Action should not be applied consecutively.


Growers should seek advice from a BASIS qualified consultant before choosing to apply a crop protection product.
**Choice of product**

Table 2 (see insert in back cover) lists those acaricide products currently approved for use on strawberry crops which offer direct control of tarsomomid mite or incidental control when applied against other mite species. A range of factors should be considered when choosing which product to use in particular circumstances. Important considerations are:

- Both Dynemec/Clayton Abba and Masai have translaminar activity and can reach mites in the folded leaflets to some extent. The residue of Masai on foliage is likely to be more persistent, preventing the migration of tarsomomid mites to new growing points over a longer period.
- Masai is active against eggs, larvae and adults. Dynemec/Clayton Abba is active against adults and larvae only.
- Dynemec/Clayton Abba remains harmful to predatory mites for approximately two weeks. It degrades somewhat more rapidly in high light conditions, which may allow a slightly shorter interval between spraying and introducing the predators. Masai is considered to be comparatively safe to predators.
- Envidor and Borneo/Clayton Java are moderately harmful to predatory mites and the latter can persist in the crop for two weeks.

**Crops in propagation**

Like fruiting crops, biological control is the preferred option for tarsomomid mite as it is more effective at gaining access to mites which are inaccessible to sprays. Should high populations require to be reduced quickly, recourse to acaricides may be necessary, in which case propagators should choose from the products in Table 2. The EAMU approvals for Dynemec and Clayton Abba permit their use on outdoor strawberry in propagation, but if used for this purpose, should be applied before the end of October.

**Further information**

**Useful AHDB project reports**

- SF 46 – Strawberry: strategies for the chemical control of tarsomomid mites in propagation material
- SF 79 – Evaluation of foliar sprays of acaricides for control of tarsomomid mite in strawberry
- SF 124 – Development and validation of a molecular diagnostic test for strawberry tarsomomid mite
- SF 125 – Evaluation of acaricides and adjuvants for strawberry tarsomomid mite control
- SF 133 – Optimising tarsomomid control on strawberry using predatory mites

**Other useful AHDB publications**

Grower Guide – Biocontrol in soft fruit

Biocontrol video on introducing Neoseiulus predators for tarsomomid mite control – AHDB training video found at: https://horticulture.ahdb.org.uk/biocontrol-videos

**Information on the side effects of crop protection products on biological control agents for tarsomomid mite**

Useful information can be found at the following websites:

- https://www.koppert.com/side-effects
- http://www.biolineagrosciences.com/products

(Readable compatibility database on the downloadable Bioline App)

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