Factsheet 12/14
Project TF 194 (Defra Horticulture LINK HL0189)

Tree Fruit

Developing novel biocontrol methods for plum and cherry crops

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This factsheet summarises the developments from a Defra funded Horticulture LINK project which investigated novel biocontrol methods for plum and cherry crops (Figures 1 and 2).

Action points for growers

- An IPDM programme has been developed for plums and cherries which is as effective as growers' standard programmes.
- The use of post-harvest applications of thiacloprid (Calypso) significantly reduces aphid populations overwintering to the following season.
- The use of a sugar bait at the base of trees in spring distracts ants from the foliage of plum or cherry trees and allows natural predators to reduce aphid numbers to manageable levels. A commercial system for delivering the sugar is being developed.
- The oriental fruit moth sex pheromone provides a form of mating disruption which can be used successfully to control low to moderate infestations of plum fruit moth. The manufacturer is investigating the potential to secure a registration for its use in the UK.
- A granulovirus (Capex) offers a good degree of effectiveness at controlling tortrix moths such as the summer fruit tortrix in plums and cherries. An EAMU for use of Capex on outdoor plums and cherries was issued in May 2014.
- Two microbial biological control agents (which are naturally occurring in the UK) have been isolated, and offer reduction in brown rot spores on mummified fruits. These await the development of commercial formulations in a TSB funded project.
- Serenade ASO offers some reduction in brown rot development, especially on cherry.
- Fenbuconazole (Indar), when applied to mummified fruit (with brown rot) in winter, completely suppressed sporulation the following spring.

1. **Novel biocontrol techniques have been developed for use in cherries**

2. **Novel biocontrol techniques have been developed for use in plums**

Introduction

Commercial plum and cherry growers rely heavily on traditional crop protection products to gain control of the principal insect pests and diseases which affect their crops. With the increasing customer pressure to reduce reliance upon these crop protection products and the occurrence of detectable pesticide residues in harvested fruit, the UK stone fruit industry is keen to find alternative control measures.

This five year Defra funded Horticulture LINK project was set up with the aim of developing alternative, sustainable, non-pesticidal methods for managing brown rot, aphids, plum fruit moth and light brown apple moth, the most important pests and diseases in UK plum and cherry crops. These novel control techniques would be incorporated into integrated pest and disease management (IPDM) strategies for plums and cherries, combining them with existing best crop husbandry practices.

Brown rot

Brown rot occurs as a result of infection by *Monilinia fructigena* or *Monilinia laxa*. *M. fructigena* only infects the fruit, on which it produces yellow or buff-coloured pustules. *M. laxa* can infect flowers as well as fruits. Following infection in flowers, it remains symptomless in green fruits, but develops as a rot as the fruit matures. It can also invade developing fruit through wounds, but unlike *M. fructigena*, *M. laxa* produces grey coloured pustules.

Fruits are generally attacked by *M. fructigena* when approaching maturity (Figure 3), the slightest wound or bruise permitting infections by spores. Skin splitting also provides a ready point of entry as do wounds caused by insects and birds. Once the fungus has gained entry, the fruit is rapidly destroyed and is reduced to a hard, wrinkled mummy. Mummies either fall to the ground or remain attached to the tree during winter. Pustules stop producing spores, but remain dormant until spring when they resume activity and produce more spores, which give rise to further attacks.

The traditional use of fungicides to gain control is now often found to be inadequate as approvals for some of the more effective products have been lost. This Horticulture LINK project aimed to develop non-fungicidal methods for managing the disease. Two hundred yeast and bacterial strains were obtained from brown rot mummified fruit and their potential as biocontrol agents against brown rot was examined in the laboratory. Two microbial strains (one yeast and one bacterium) were found to consistently suppress brown rot development on cherry and plum in laboratory experiments. The bacterial strain was identified as a Bacillus species and the yeast as *Aureobasidium pullulans*. Both were found to significantly reduce numbers of spores on mummified fruits, but treatments in the laboratory failed to control brown rot disease on harvested fruits, possibly because the agents were not properly formulated. The next step is to develop suitable commercial formulations and then test their effectiveness in the field. The two biocontrol agents (BCAs) are now being developed by a commercial company in a research project funded by TSB.

3. Brown rot infection on cherries during harvest

In a study of the commercially available BCAs, only Serenade ASO showed some slight effects in reducing brown rot development, especially on cherry. In work to assess currently available fungicides, it was found that applying fenbuconazole (Indar) to mummified fruit (with brown rot) in winter, completely suppressed sporulation the following spring. A new TSB project developing post-harvest treatment methods for plums and cherries is in progress.

Aphids

In plum, three species of aphid are commonly found, including the leaf-curling plum aphid (*Brachycaudus helichrysi*), the damson-hop aphid (*Phoroden humuli*) and the mealy plum aphid (*Hyalopterus pruni*).

The leaf-curling plum aphid (Figure 4) can be a serious pest. Adults are yellow-green, small rounded and shiny. Damage occurs in the spring and autumn, typically in the form of leaf curl and distortion. Nymphs feed at the base of fruit buds, later attacking fruit/leaf buds and young shoots causing stunted growth. It also acts as a vector of plum pox virus.

Damson-hop aphid is a spring pest of plums found on the underside of leaves, especially on growing shoots.

4. Damage to plum caused by leaf-curling plum aphid

Adults are pale yellow-green with one dark stripe down the back and on each side. The aphid produces honeydew and sometimes causes slight curling of the leaves. It also acts as a vector of plum pox virus.

The mealy plum aphid has a waxy appearance and is pale green with a bluish-grey tinge. Damage occurs in the spring and autumn, when leaves turn yellow and drop prematurely. In addition, honeydew leads to growth of sooty mould.

The primary aphid pest of cherry is the cherry blackfly (*Myzus* (*cerasi*) *pruniavium* – Figure 5) which is black and shiny. The pest migrates to bedstraws and speedwells in June and July, before returning to cherry in August. It attacks the shoot tips. Leaves become curled and shoot tips become stunted and die. Honeydew leads to contamination of fruits and leaves with sooty mould.

5. Cherry blackfly is the primary aphid pest of cherry

In the Horticulture LINK project, three different aphid control strategies were considered, including the use of the common black ant as a vector of entomopathogenic fungi (EPF), the distraction of ants from aphid colonies to encourage natural predation and the use of post-harvest aphicide sprays to reduce the size of over-wintering populations.

Early work to assess the vectoring of EPF species demonstrated that black ants will become contaminated by EPF spores, but the strategy did not succeed in reducing the populations of the aphids sufficiently rapidly.

Field experiments in plums and cherries with the aphicide thiacloprid (Calypso) applied in the autumn months, successfully reduced aphid populations. For leaf-curling plum aphid and mealy plum aphid, best results were obtained from single sprays in early to mid-October. For cherry blackfly, a single spray between late September and late October was highly effective.

The research to distract ants from aphid colonies was based on the premise that removal of ants would expose aphids to natural predation. Many tree fruit aphid pests have a close mutual relationship with ants. Colonies of aphids are attended by ants (commonly the black ant). The aphids benefit from protection from predators, while the ants benefit by acquiring nutritious honeydew excreted by the aphids.

Initial research successfully distracted ants from plum and cherry trees by providing sugar feeders at the base of the trunk (Figure 6) in early spring when aphids emerge. The feeders attracted the ants before they started to climb the trees to find aphids. In the absence of the ants, the aphid colonies were rapidly attacked by predators, especially hoverfly larvae (Figure 7), earwigs and ladybirds (Figures 8 and 9).

6. The use of sugar feeders in the spring prevents ants from climbing into the tree canopy

7. Hoverfly larva

8. Earwigs are voracious predators of aphids

9. Ladybird larva

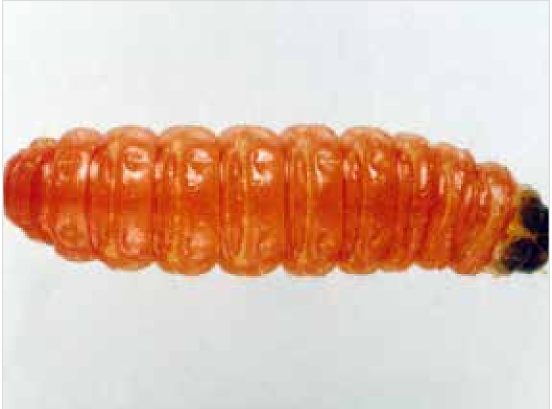
As it is impractical to supply a sugar feeder at the base of every tree, subsequent research assessed different formulations of sugar more suited to commercial orchards. Sucrose was found to be most attractive to ants. Glycerol and sorbitol were added to prevent the sucrose from drying out and this proved effective and attractive to ants. A wide range of sugar formulations were tested for broadcasting the sucrose, such as cotton wool in bamboo canes or cigarette filters (Figure 10), clay pellets and reconstituted wood pellets. All of them successfully attracted ants and reduced aphid numbers, but not all were practical to use.

A commercial company (Germains Ltd) developed a formulation which gave promising results and is now being tested in larger scale commercial trials.

10. Cigarette filters soaked in sugar successfully attracted ants

Plum fruit moth

Caterpillars of the plum fruit moth (*Grapholita funebrana*) are pink with a dark brown head (Figure 11). They feed within the flesh of the fruit (usually one per infested fruit), forming a large cavity that becomes filled with brown frass (Figure 12). If an occupied fruit is cut open, the caterpillar (commonly known as the red plum maggot) may be found inside, often lying close to the stone. Infested fruits tend to ripen prematurely and losses can be severe, particularly in years of light fruit set.



11. Plum fruit moth caterpillar

12. Damaged Victoria plum with frass of plum fruit moth

Three novel approaches for controlling plum fruit moth were investigated in the Horticulture LINK project, including the use of host volatiles as attractants for the moth, insect pathogenic nematodes as control agents and a sex pheromone mating disruption (MD) technique.

In the case of host volatile attractants, chemicals were collected from ripening Victoria and Opal fruits and analysed. Field tests using a blend of these chemical volatiles as lures to attract plum fruit moth were unsuccessful.

The use of high volume sprays of insect pathogenic nematodes applied to the tree trunk in autumn (where the larvae overwinter) significantly reduced plum fruit moth populations the following season. However, success using this treatment is dependent on mild, wet weather conditions prevailing in the autumn when the surface of the bark is continually wet for at least 24 hours. In practice, these conditions are unlikely to prevail and success of control could be compromised.

Research using a sex pheromone mating disruption technique was more successful. The plum fruit moth contains two of the same sex pheromone components as the oriental fruit moth, a serious pest of stone fruits in southern Europe and which is commonly controlled using sex pheromone mating disruption with existing commercial products. Field trials assessed the efficacy of Suterra Checkmate oriental fruit moth (OFM) laminate and sprayable sex pheromone mating disruption formulations for control of plum fruit moth. They were both found to be highly effective, providing populations of plum fruit moth are low to moderate. Only partial control was achieved where populations were high.

This mating disruption technique therefore offers a potential new commercial control option for low to moderate infestations, although they may have to be used in conjunction with insecticides or other control methods when pest populations are high. The manufacturer is investigating the potential to secure a registration for its use in the UK.

Light brown apple moth and summer fruit tortrix moth

This project planned to develop a sex pheromone based mating disruption technique for the light brown apple moth (LBAM). However, the numbers of LBAM that occurred in the early years of the project were insufficient to provide useful data on the efficacy of the treatments used. However, it was found that the summer fruit tortrix moth (SFT) was present in shoots in four of the five commercial sites used in the project, indicating this was the principal tortrix species present. The focus of the work was therefore shifted to SFT.

Summer fruit tortrix larvae can cause damage to plum foliage and fruits. The larvae are 18-20 mm long, yellow-green, olive-green or dark green in colour with a yellow-brown head (Figure 13). Two generations of SFT occur each year, in spring and autumn. The larvae form webs on leaves and feed on leaves and developing fruits, grazing the fruit skin where fruits are bound to leaves by webbing.

The research investigated the use of a granulovirus biopesticide product (Capex) which is approved in Switzerland and several other EU countries. Five large scale field trials using Capex were conducted, giving mixed results, but the correct timing and number of applications is important for good efficacy. An EAMU (0842/2014) was issued in May 2014 for use of Capex on outdoor crops of apricot, cherry and plum.

13. Summer fruit tortrix larva with webbing on leaf

IPDM programmes

In the final two years of the project, the novel techniques developed for brown rot, aphids, plum fruit moth and summer fruit tortrix moth were tested in an IPDM strategy in four large scale commercial field experiments – two cherry and two plum – on different fruit farms in Kent. The IPDM programmes were compared with the standard commercial control programme used at the time by the host growers.

The IPDM programme consisted of autumn aphicide sprays, the use of ant sugar feeders for aphid control, the use of granulovirus for summer fruit tortrix moth (cherry) and sprays of a pheromone mating disruption product for plum fruit moth. Fungicide sprays were applied during flowering in the IPDM plots and Serenade ASO (Bacillus subtilis) was applied pre-harvest for blossom wilt and brown rot in both crops. Myclobutanil was applied for plum rust in July.

Pest control

It was found in both years that for aphid populations to be kept at manageable levels in the plots, the use of an autumn aphicide application was essential. In the following spring and summer, the use of ant sugar feeders was successful in encouraging natural predation of aphids, maintaining aphid numbers at low levels. No further insecticide applications were required. In contrast, the grower control plots required the use of early aphicide sprays to reduce aphid numbers to acceptable levels. These results demonstrated that this technique of aphid control is effective.

For caterpillar control, the granulovirus (Capex) worked successfully in both years. There was less caterpillar damage (primarily summer fruit tortrix) in the IPDM plots than the grower control plots.

In the plum orchards, pest levels in both years were generally low. There was no plum fruit moth damage at harvest in either the IPDM or the grower control plots at either site.

Disease control

In the first year, the incidence of blossom wilt in May (Figure 14) and brown rot pre-harvest in August was similar in both IPDM and grower control plots. Fruit was held in cold store after harvest, assessed on removal from store, then again after seven days incubation at ambient conditions. The incidence of rotting was lower in fruit from the grower control plots. Most of the rotting was due to brown rot, Botrytis and Mucor. No fungicide residues were detected in the cherry samples from the site where samples were taken.

14. Blossom wilt on cherry

In the second year, at both sites, the incidence of blossom wilt in May was similar in both plots, with no infection seen in Sweetheart at either site. At one site, the incidence of brown rot at harvest was similar in the IPDM and grower control plots, whereas in the other, the percentage of brown rot infected fruit from the IPDM plot was twice as high as from the grower control plot. In the plum orchards, no residues were detected from either the IPDM or the grower control plots. However, in the cherry orchards across both sites, there were seven reported residues (all below the MRL) in the fruit from the grower control plots and only one in the IPDM plots.

Success of IPDM programme

Overall, the IPDM programme was demonstrated to be, in general, as effective as the grower's standard programme. In addition, using the IPDM programme reduced the number of detectable pesticide residues in harvested fruit in both cherry and plum.

The average annual cost for crop protection products was not very different between the two programmes (Table 1). However, there were large differences between the two programmes among sites and years. In 2012, at the Barn Field site, the IPDM programme was much more expensive than the conventional one for both cherry and plum, primarily because of the extra two applications of copper and codacide oil, and one round of Serenade (plum only). At the Torry Hill site, the grower's programme was more expensive than the IPDM programme because of a few extra applications of fungicides. This analysis needs to be interpreted in relation to actual yield and pest/disease damage at these trial sites. However, a correct overall interpretation may not be possible since at the Barn Field site, the grower did not use the same fertiliser treatment for the IPDM and grower's programmes.

Table 1 Summary of cost comparison (£) between IPDM and grower's pest control programme

	Year	IPDM	Grower	Site	Comments
Cherry	2012	£250	£166	Barn Field	Due to extra two sprays of copper + codacide oil
Cherry	2013	£173	£166	Barn Field	
Cherry	2013	£435	£527	Torry Hill	
Plum	2012	£350	£174	Barn Field	Due to extra two sprays of copper + codacide oil and one round of Serenade
Plum	2013	87	84	Victoria Farm	
Average		£247	£221		

Further information

Project consortium details

Project leader: Jerry Cross, EMR

Project manager: John Leigh Pemberton, Torry Hill Farms

Consortium members:

Agrii Ltd, AgriSense BCS Ltd, Becker Underwood Ltd, Berry Gardens Ltd, D H Bryant and partners, East Malling Ltd, East Malling Research, East Malling Trust, FAST Ltd, FW Mansfield & Son, G.H. Dean and Co Ltd, HDC, H.L. Hutchinson Ltd, J Sainsbury's plc, M & W Mack Ltd, Norman Collett Ltd, Torry Hill Farms, Total Berry, University of Warwick.

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