Grower Summary

TF 194 (HL0189)

Developing biocontrol methods and their integration in sustainable pest and disease management in plum and cherry production

Final 2014

Disclaimer

The results and conclusions in this report may be based on an investigation conducted over one year. Therefore, care must be taken with the interpretation of the results.

Use of pesticides

Only officially approved pesticides may be used in the UK. Approvals are normally granted only in relation to individual products and for specified uses. It is an offence to use non-approved products or to use approved products in a manner that does not comply with the statutory conditions of use, except where the crop or situation is the subject of an off-label extension of use.

Before using all pesticides check the approval status and conditions of use.

Read the label before use: use pesticides safely.

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GROWER SUMMARY

Headline

- An IPDM programme has been developed for plums and cherries which is as effective as growers' standard programmes.

Background and expected deliverables

The overall aim of the project is to develop alternative, sustainable, non-pesticidal methods for managing brown rot, aphid pests, plum fruit moth and light brown apple moth in UK plum and cherry crops by incorporating biocontrol approaches. These are the most important crop protection problems in UK stone fruit production and they are currently controlled with pesticides. The non-pesticidal methods developed for the individual pests and diseases will be combined with existing non-chemical methods for other pests and diseases in Integrated Pest and Disease Management (IPDM) programmes which will be tested and refined.

Residue surveillance shows that approximately 60% of UK produced stone fruit contain pesticide residues with multiple residues in 25% of samples. The IPDM system will reduce pesticide use in stone fruit (by > 50%) and greatly reduce, hopefully eliminate, the occurrence of detectable pesticide residues on harvested fruit.

The IPDM programmes will be more sustainable than current systems which rely on pesticides which are harmful to natural enemies. Natural enemies and biodiversity will be enhanced in the orchard environment.

The work set out to develop these new control methods under six different objectives:

Objective 1 - To develop alternative non-fungicidal methods for management of brown rot on plum and cherry
Objective 2 - To develop a novel biocontrol method for the aphid pests of plum and cherry by exploiting ants as vectors of entomopathogenic fungi (EPF)
Objective 3 - To identify effective methods for autumn control of the aphid pests of plum and cherry
Objective 4 - To develop an Integrated Pest Management system for plum fruit moth combining sex pheromone mating disruption, a female host volatile attractant and biocontrol with autumn sprays with entomopathogenic nematodes

Objective 5 - To develop a sex pheromone based control attract and kill or mating disruption method for light brown apple moth (LBAM) in cherry

Objective 6 - To develop Integrated Pest and Disease Management strategies for plums and cherries combining the biological methods developed in objectives 1-5 with best crop husbandry practices and evaluate them including their economic and environmental impact

Summary of the project and main conclusions

Objective 1 - To develop alternative non-fungicidal methods for management of brown rot on plum and cherry

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.

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 cherries is in progress.

Objective 2 - To develop a novel biocontrol method for the aphid pests of plum and cherry by exploiting ants as vectors of entomopathogenic fungi (EPF)

Three different aphid control strategies were considered, including the use of the common black ant as a vector of entomopathogenic fungi (EPF) (Objective 2), the exclusion of ants from aphid colonies to encourage natural predation (Objective 2) and the use of post-harvest aphicide sprays to reduce the size of over-wintering populations (Objective 3).

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.

The research to exclude 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 excluded ants from plum and cherry trees by providing sugar feeders at the base of the trunk 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, earwigs and ladybirds.

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, 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 pea sized wood flour granule formulation which gave promising results and is now being tested in larger scale commercial trials.

Objective 3 - To identify effective methods for autumn control of the aphid pests of plum and cherry

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.

Objective 4 - To develop an Integrated Pest Management system for plum fruit moth combining sex pheromone mating disruption, a female host volatile attractant and biocontrol with autumn sprays with entomopathogenic nematodes

Three novel approaches for controlling plum fruit moth were investigated 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 efficacy data package from this work has been provided to Suterra and they are seeking a registration for the product in the UK using the mutual recognition system between EU countries.

Objective 5 - To develop a sex pheromone based control attract and kill or mating disruption method for light brown apple moth (LBAM) in cherry

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.

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.

Objective 6 - To develop Integrated Pest and Disease Management strategies for plums and cherries combining the biological methods developed in objectives 1-5 with best crop husbandry practices and evaluate them including their economic and environmental impact

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 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.

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	£249.50	£165.80	Barn Field	Due to extra two sprays of copper + codacide oil
Cherry	2013	£173.40	£166.30	Barn Field	
Cherry	2013	£434.70	£526.80	Torry Hill	
Plum	2012	£350.30	£174.20	Barn Field	Due to extra two sprays of copper + codacide oil and one round of Serenade
Plum	2013	87	84	Victoria Farm	
Average		**£247.20**	**£221.00**		

Financial benefits

Modern intensive UK stone fruit production requires high capital investment and the crops are valuable. In 2006, 1,100 tonnes of cherries worth £2.03 million and 14,100 tonnes of plums worth £10.56 million were produced from 420 ha and 950 ha of orchards grown in Britain, respectively. 22,300 tonnes of cherries worth £48.4M and 66,000 tonnes of plums worth £57.1 million were imported. A very large proportion of the fruit consumed in the UK is imported because the UK industry is currently too small: Only 5% of cherries and 17% of plums are produced in the UK (see below) and there is considerable scope for home production to be increased. The UK fresh market is even undersupplied during the main seasons in July (cherries) and August-September (plums). Multiple retailers including Sainsbury's, the leading supplier of UK produced stone fruit, are seeking to source a far greater proportion of stone fruit from the UK as well as improving the environmental acceptability of stone fruit production and to improve consumer trust by eliminating the occurrence of reportable pesticide residues.

Better rootstocks which are more productive and crop reliably, new varieties which extend

the season and effective methods of avoiding frost damage and rain induced splitting of cherries, coupled with increased demand for locally produced fruit, are resulting in an expansion of UK stone fruit production. The recent development of an effective protein based spray treatment which stimulates the plant's defences against fruit splitting in cherries, caused by wet conditions before and during harvest, means that serious unpredictable losses which have hitherto dogged the UK industry, can be avoided. Establishing new crops requires substantial investment (£50,000/ha for cherries) and growers need confidence that their orchards will crop reliably and that their fruit will find a profitable market. Growers are gaining confidence and it is expected that UK production will increase substantially through new plantings over the next few years.

Annual value in area of impact

Brown rot, aphids, plum fruit moth and light brown apple moth are the main pest and disease problems of UK stone fruit production and are very common wherever and however stone fruits are grown in the UK. A very high percentage of stone fruit orchard plantations are infected by these pests and diseases. A survey of the incidence of brown rot in plum and cherry orchards in Defra project HH2604STF completed in 2004, showed that losses in cherries after one week post-harvest cold storage, ranged from 11 to 96% and losses in Victoria plums after one week's cold storage varied from 12% to 100%. Storage losses averaged about 50% in both crops. Losses in the orchard varied from 0-32% and averaged about 20%, despite pesticide treatment. This is equivalent to 220 tonnes of cherries, worth £400,000 and 2,820 tonnes of plums worth £3.2 million per annum.

Market potential

If, conservatively, the UK industry were able to double production substituting imports or increasing consumption, the increased production would be worth £12.6 million per annum.

Expected annual added value

The knowledge and technologies delivered by this project will give UK producers confidence that serious losses due to pests and diseases can be avoided, without more intensive use of pesticides, which will underpin the expected expansion in production. If potential imports were only reduced by 20%, this would be worth >£20 million/annum to the UK economy. Cherry and plum crops are typically worth £6,800 and £3,700 per ha.

Grower uptake and customer acceptance

The project benefits the entire supply chain. Involvement of all elements of that supply chain in the consortium shows strong support for the project objectives. There is a high degree of confidence that the novel crop protection methods identified will be adopted by the industry.

Grower capital investment and cost recovery

It is not anticipated that this project will result in substantive additional capital investments for growers. Pesticide control methods used currently typically cost £150/ha per annum. It is likely that crop protection costs will increase because it is probable that the selective biological and semiochemical based control methods will be more costly than broad spectrum pesticides used currently. However, even if they were two to five times more costly, their cost of would still be small in relation to the value of the crop.

Action points for growers

- An IPDM programme has been developed for plums and cherries which is as effective as growers' standard programmes.
- The IPDM programme has the potential to reduce the number of residues in harvested fruit.
- 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 excludes 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 Suterra is currently seeking 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 biological control agents have been identified which 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.