Grower Summary

TF 194 (HL 0189)

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

Annual 2013

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.

Further information

If you would like a copy of the full report, please email the HDC office (hdc@hdc.ahdb.org.uk), quoting your HDC number, alternatively contact the HDC at the address below.

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Headline

Progress is being made to developing novel biocontrol techniques and IPDM programmes for commercial plum and cherry orchards.

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.

The project will investigate new biocontrol methods with a view to subsequent development by industry, as follows:

1. A microbial biocontrol agent or alternative non-pesticidal treatment for brown rot
2. Sex pheromone based systems for control of plum fruit moth and light brown apple moth, the latter a new pest in the UK which is highly damaging to cherries
3. If possible, a novel biocontrol approach for aphid pests which exploits the vectoring of entomopathogenic fungi by ants
4. An autumn entomopathogenic fungal treatment for aphids
5. A sex pheromone attract-and-kill treatment or autumn control approach for damson hop aphid
6. An autumn entomopathogenic nematode treatment for plum fruit moth

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.

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.

Summary of the project and main conclusions

Objective 1 (Biological control agents for brown rot)

We have identified two microbial strains (one yeast and one bacterium) that have consistently suppressed brown rot development on cherry and plum in laboratory experiments. We have identified the two strains based on morphological and molecular data. The bacterial strain (B91) is identified as a Bacillus sp. and the yeast strain (Y126) as *Aureobasidium pullulans*. Further lab work suggested that competition for nutrients play an important role for bioactivity of *A. pullulans* Y126, requiring living cells. Bioactivity of Bacillus sp. B91 may come from antibiosis as well as competition for nutrients. Furthermore, B91 may also produce volatile organic compounds that can inhibit fungal growth.

A post-harvest study was carried out using cherries and plums to compare the efficacy of our two biological control agent (BCA) strains and several commercial BCA products with a fungicide control, when applied as post-harvest dips. It was found that the fungicide control (Rovral WG) was the best treatment to control *Monolinia laxa* and *Monolinia fructigena* on cherries. None of the BCA treatments reduced brown rot infection on cherries. For plums, the level of natural infection was too low to compare treatments reliably.

Objective 2 (exploiting ants in aphid control)

The effects of the presence of root aphids and ant exclusion or supplementary feeding with sucrose on cherry blackfly (Myzus cerasi) and its predators on cherry trees

An orchard experiment was done between April and June 2012 at East Malling Research to determine whether exclusion of ants (*Lasius niger*) from the fruit trees (either with sticky bands or providing alterative sugar sources), can lead to better predation of aphids by aphidophagous predators and a reduction in cherry blackfly (*Myzus cerasi*) damage on cherry, in the presence or absence of grass root aphids.

The experiment was a factorial comparison with two factors:

1. 'Ant' which had three levels:

i) untreated control where ants had full undistracted access to the *M. cerasi* colonies

ii) ants excluded by a sticky band round the base of the tree trunk (EXCLUDED);

iii) ants provided with a liquid sucrose solution feeder at the base of the tree to distract ants from attending the aphids (SUCROSE)

2. '±Root aphid' which had two levels:

i) grass root aphids present (GRASS)

ii) grass root aphids absent (HERBICIDE).

The comparison between the presence and absence of grass root aphid was achieved by killing the grass host of the aphid with the herbicide glyphosate in the plots where root aphids were required to be absent. Replicated plots of young cherry trees (planted in 2011), artificially infested with *M cerasi*, were used in two different old cherry orchards where the old trees had been felled and removed leaving the stumps. Assessments were done in four time periods:

1) assessment of ants foraging in the cherry trees visiting extrafloral nectaries before treatments

2) additional assessment of ants foraging in the cherry trees visiting extrafloral nectaries and flowers and ants visiting the feeders after treatment but before artificial aphid infestation

3) additional assessment of the aphid colony size, ant attendance and numbers of predators after aphid infestation, but before ant exclusion

4) assessments of the aphid colony size, ant attendance and numbers of predators after ant exclusion from EXCLUDED trees.

The two orchards, though close and similar, had somewhat different levels of ant attendance on the *M. cerasi* colonies, possibly due to the different population sizes of ants and the very different populations of spiders (especially *Enoplognatha ovata*) which killed many foraging ants and built webs round the cherry tree trunks to a high degree in one orchard, so greatly reducing ant attendance on aphids.

In both orchards, SUCROSE feeding greatly reduced aphid population growth compared to untreated controls where ants defended the aphids against predators. Ant EXCLUSION also reduced the aphid population growth in HERBICIDE plots, but not to the same level as SUCROSE feeding. Ant EXCLUSION could not effectively reduce aphid populations on GRASS plots: the aphid numbers became even higher on EXCLUDED trees until the end of May. By June, the aphid numbers on CONTROL trees became equal or larger to those on EXCLUDED trees on GRASS plots also. The main predators were hoverfly larvae, earwigs and ladybirds which effectively devoured the aphids on the plots where ants were excluded or were distracted by the sucrose feeders.

In early spring, the presence of grass root aphids greatly reduced ant foraging, and feeding on extrafloral nectaries, flowers and aphid colonies. In the last assessment period in late May/early June, the effects of root aphids on ant attendance on the aphids became less visible, though populations were still lower where the root aphids were present.

In conclusion, this experiment further supported the finding that distraction of ants with SUCROSE feeders is an effective method for control of *M cerasi*, but ant EXCLUSION on cherry applied early in the season is not a completely safe method for aphid biocontrol on young cherry trees.

Sugar formulations

A replicated experiment was done in an apple orchard at EMR in September 2012 to test different formulations of sugar for attractiveness to *Lasius niger* to disturb the ant-aphid relationship between green apple aphids (*Aphis pomi*) and common black ants (*Lasius niger*). Six formulations were tested in comparison with an untreated (no feeding) control:

1) Sucrose bottle feeder
2) Sucrose spraying
3) Sugar cube
4) Sucrose in cotton wool
5) Sucrose in cotton wool protected by a chestnut leaf
6) Sucrose in bamboo cane. The different treatments were refreshed/renewed as necessary.

The results of the experiment show that all kinds of feeder formulations used can attract ants, but in different ways. The bottle feeders provide a large amount of a permanent food source which is safe against severe weather conditions (rain, wind, cold) and against other arthropods and even larger animals. It was found that a few drops of sugar solution need to be tipped onto the soil when they are deployed so that ants can easily find them.

Sucrose spraying is an easy and cheap method of application, even on a large scale. It provides a temporary food source which the ants do not have too much time to collect. The method is not protected against weather conditions and other animals at all, and there is a lot of loss through soil absorption. This method is only safe to use in dry weather conditions, and could work better if some living or dry plant materials are present to prevent moisture loss by soil absorption.

Sugar cube application is also an easy and cheap way of feeding. Ants cannot take the solid sugar as effectively as 30 % sugar solution. This formulation is not protected against weather conditions and other animals, so it can only be used in dry weather or with some protection against rain. This formulation was not very reliable, possibly because concentrated sugar makes the ants thirsty and they use the aphid honeydew to get water.

Applying 30% sugar solution in cotton wool is another possible relatively easy and simple method of feeding. This a semi-permanent sugar source for ants, which can store some sucrose solution for a couple of days, depending on the weather conditions and the size and food requirements of ant colonies. Ants can find and exploit this source very quickly, so, if the weather conditions are good, it can be possible to fill the ant colonies quickly with sugar early in the season. However, this formulation is not protected against weather conditions and other animals, so, cannot be usable for long term feeding without regular replacements. Furthermore, this method with using smaller pieces of cotton is an easy and practical method for large scale ant mapping too.

Applying 30% sugar solution in cotton wool (protected by a rolled dry chestnut leaf to extend the life of the cotton wool feeder), is an alternative method. A dry rolled chestnut leaf provides some temporary protection against moderate weather conditions (such as light rain or short term showers), and maintains the sugar in reasonable condition for a couple of days until the ants exploit it. As the food source remains shaded, the ants can use it during the daytime nearly as intensively as at night (*L. niger* does not like to exploit food sources in direct sunshine during the daytime). Although this formulation takes more time to prepare, all its ingredients are naturally disposable, so after application, it can be left in the orchard.

Applying 30% sucrose solution in bamboo canes is another method to improve the quality and safety of a semi-permanent sugar source. The ends of the canes are tightly closed with 2 pieces of cotton wool, which makes the inner content separated from the outside environment, so if the canes and the cotton wool are sterile, this formulation can exist until the ants completely empty them without getting mouldy and fermented inside. The ants can use this feeder during the daytime nearly as effectively as at night, if the weather is not too hot. This feeder is quite well protected against severe weather conditions until the ants exploit them. All ingredients are naturally disposable.

Some of the formulations are likely to work, but must be applied at the right time (by April at the latest), before the ants start to visit the aphids on the trees. This work needs to be repeated in spring on cherry.

Objective 3 (autumn control of aphids)

Four further replicated large plot orchard experiments, two on cherry and two on plum, were done in 2011-2012 to evalaute the efficacy of end-of-season sprays using the aphicide thiacloprid (Calypso) for control of *Myzus cerasi* (cherry) and the various aphid species that occur on plum *(Brachycaudus helichrysi, Phorodon humul, Hyalopterus pruni)* and to identify the best time of application. Single sprays of Calypso were applied at 2 week intervals from the end of September until mid-November. One of the cherry experiments yielded no results because no aphids (*M. cerasi*) developed even on the untreated control plots. At the other site, aphid populations were too variable for statistical analysis but virtually no *M. cerasi* developed on plots that had received Calypso on 30 September or 14 October, whereas aphids were found on the untreated control plots and those sprayed on 25 October or 8 November.

One plum experiment yielded no results as the orchard was grubbed unexpectedly before the spring aphid assessments could be made. At the other site, the Calypso sprays on 16 Sept,

14 October and 28 October all greatly reduced leaf curling plum aphid numbers and mealy plum aphid numbers compared to the control, though for this latter species populations were too variable to be able to provide statistically significant treatment effects.

Objective 5 (light brown apple moth sex pheromone mating disruption)

Because light brown apple moth (LBAM) has greatly declined as a pest in UK cherry following several cold winters, effort for this objective has been diverted into summer fruit tortrix moth, which is a common and abundant pest. An experimental approval was obtained for a granulovirus biopesticide product (which is approved in Switzerland and several other EU countries for control of summer fruit tortrix moth), and a large scale replicated experiment examining the efficacy of sprays of the product in spring and summer was conducted in 2012.

A small plot replicated field experiment was done in 2012 to evaluate the efficacy of foliar sprays (500 l/ha) of Capex (AoGV) Dipel DF (*Bacillus thuringiensis*) or Steward (indoxacarb), for control of overwintered larvae, 1st and 2nd generation Summer fruit Tortrix moth. Treatments were a factorial comparison of single or double sprays of the three products (Capex, Dipel and Steward) versus an untreated control. The three products were applied at three timings (overwintered larvae pre blossom in April, 1st generation larvae in May/June and 2nd generation larvae in August/September). The applicatons were made 7-10 days after a threshold catch of >30 Summer fruit tortrix had been captured per trap in the two sex pheromone monitoring traps deployed in the plantation.

For the overwintering larvae, sprays were applied on 26 April and 10 May when the crop was in full flower. For the first generation, sprays were applied on 22 and 28 June when the crop was at full fruit set. For the second generation, sprays were applied on 6 and 13 September, after the crop had been harvested. Numbers of leaf rolls and the larvae they contained were assessed in samples of 1,200 shoots per plot, sampled on 16 May, 13 July and 22 October, respectively. A summary of the findings of the experiment is as follows:

Overwintered larvae in leaf rolls in blossom clusters in April May:

Two spray applications of AoGV (Capex) against overwintering larvae feeding in leaf rolls amongst rosette leaves and blossoms on 26 April and 10 May during flowering, failed to significantly reduce larval numbers on 16 May. In contrast, two sprays of *Bacillus thuringiensis* or Steward did significantly ($P = 0.05$) reduce numbers of larvae.

First generation larvae in leaf rolls in shoots in June –July:

Two sprays of AoGV (Capex) on 22 and 28 June did not significantly reduce numbers of leaf rolls or numbers of larvae in leaf rolls when assessments were made on 13 July. Two sprays of *Bacillus thuringiensis* on the same dates, did reduce numbers of leaf rolls and caterpillars they contained, by 61% and 69% respectively. Numbers were not significantly lower on the plots that were sprayed with AoGV in April-May, though they were where *Bacillus thuringiensis* or Steward had been sprayed.

Second generation on leaves:

Two sprays of AoGV on 6 and 13 September did not reduce the numbers of feeding sites on the undersides of leaves caused by second generation larvae. Two sprays of *Bacillus thuringiensis* or Steward at the same timings reduced numbers of feeding sites by 57% and 80%, respectively. The AoGV showed at best very limited efficacy in these trials and did not perform as well as *Bacillus thuringiensis* or Steward. This may have been due to unusually wet weather. Longer term effects of the AoGV still need to be assessed.

Objective 6 (IPDM programme)

An Integrated Pest and Disease Management (IPDM) strategy was devised by combining the findings from Objectives 1-6. The IPM strategy was tested in 2012, in comparison with the standard commercial programme used at the time by the host farmer, in two commercial plantations for each crop (cherry, plum). The new strategy and the „standard commercial programme control were applied to large plots at each site. The IPDM programme comprised autumn aphicide treatments and the use of ant sugar feeders for aphid pests, the use of granulovirus for summer fruit tortrix moth (cherry) and of sprays of a pheromone mating disruption product for plum fruit moth (plum).

On cherry, numbers of cherry blackfly rose steeply in the IPDM no-feeder plots in May and early June, reaching economically damaging levels which had to be oversprayed with an aphicide. Where ant feeders were provided at the base of the trees, these greatly reduced the numbers of ants foraging in the canopy and natural enemies then greatly reduced but did not completely control the aphid infestations. This demonstrated that this technique is effective, but that autumn aphicide sprays are needed to reduce populations of aphids where populations are high as cherry blackfly is an aggressive aphid pest. The grower's plots had virtually no cherry blackfly and no damage due to applications of early aphicide sprays. Other pest populations were generally low. There was less caterpillar damage (mainly caused by *A. orana*) in the IPDM plots than the grower's plots in spring, indicating the AoGV had been effective. At one site, the incidence of blossom wilt in May and brown rot pre-harvest in August was similar in both plots. There was no difference in incidence of blossom wilt between the IPDM and grower plots. The incidence of brown rot was also similar in the two plots. The incidence of rotting in fruit assessed on removal from the cold store was relatively low (7-13%). This increased to 56-71% after 7 days incubation at ambient temperature. The incidence of rotting was lower in fruit from the grower plot. Most of the rotting was due to brown rot, Botrytis and Mucor. No residues were detected in the cherry samples from the site where samples were taken.

On plum, pest levels were very low but the ant feeders did effectively reduce ant foraging in the canopies. There was no plum fruit moth damage at harvest in either the IPDM or grower plots at either site. The incidence of blossom wilt and brown rot was negligible in the orchard at both sites, so no formal assessment was carried out. There was poor fruit set at one site so very little fruit was present at harvest. The incidence of rotting in fruit assessed on removal from the cold store was similar in IPDM and grower plots and varied from 0.7-1.8%. This increased to 13-21% after 7 days incubation at ambient temperature. The incidence of rotting was lower in fruit from the grower plot. Most of the rotting was due to brown rot, Botrytis, Penicillium and Mucor. These trials are being continued for a second year on the same sites in 2013.

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.

Other benefits

There are important environmental and human safety benefits which will result from reduced pesticide use, especially from reduced use of organophosphate insecticdes. Some of the technologies are likely to be transferable to other crops grown under protection.

Action points for growers

From the research work done so far, the following points can be considered by growers:

- Growers may need to consider autumn-winter application of Indar in orchards where a high number of mummified brown fruit is present to reduce inoculum production next spring.

- Several application of Serenade pre-harvest may also be considered, especially for organic orchards.

- A spray of Calypso or another suitable aphicide in late September or early October will greatly reduce aphid populations the following spring.