Horticultural Development Council

Grower summary

SF 74

Integrated pest and disease management for high quality protected raspberry production (LINK)

Annual Report 2007

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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.org.uk), quoting your HDC number, alternatively contact the HDC at the address below.

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Headline

- Good progress is being made in developing integrated pest and disease management strategies in raspberries.

Background and expected deliverables

Raspberries are very susceptible to *Botrytis*, mildew, raspberry beetle, raspberry cane midge and aphids. Currently, pesticides are relied on for control and are applied close to harvest. Intensive use of pesticides, including the organo-phosphate (OP) chlorpyrifos, which is used to control raspberry beetle and cane midge, is undesirable and unsustainable. Raspberry aphids, and the viruses they spread, are becoming more important. Indeed some aphid populations have overcome the natural plant resistance.

Botrytis is the major cause of post-harvest fruit rotting and has causes serious yield losses. Poor shelf-life reduces repeat buying. Retail surveillance has demonstrate that more than 50% of UK produced fruit contains fungicide residues and 22% contains chlorpyrifos residues. The major multiple retail customers are challenging raspberry producers to significantly reduce this incidence of residues.

The future registration of chlorpyrifos on raspberry beyond 2008 is in doubt. Screening trials by East Malling Research have so far failed to identify any alternative insecticides with significant activity for cane midge control, though many different materials of a wide range of types have been tested. Loss of chlorpyrifos would have serious adverse consequences for the UK raspberry industry as there is no alternative control measure for the midge.

Raspberries suffer from rain damage and, to meet the requirements of major multiple retailers, the crop now has to be grown under protection and recent observations indicate that this increases the risk of mildew in protected crops. Plant protection methods have not been adapted for this new growing environment, which provides opportunities to reduce reliance on pesticides.

The strong market demand to reduce, or ideally to eliminate, the occurrence of residues prompted this 5-year HortLINK project which officially started in April 2006, following considerable initial work in 2005. It aims to develop sustainable methods of integrated management of *Botrytis*, powdery mildew, raspberry beetle, raspberry cane midge (with associated disorder 'midge blight') and aphids on protected raspberry crops. Such methods would not rely on sprays of fungicides and insecticides during flowering or fruit development so that quality fruit can be produced with minimal risk of occurrence of detectable pesticide residues at harvest.

Summary of the project and main conclusions

Progress on each objective of the project is summarised below

Botrytis

Botrytis inoculum sources, effects of environmental manipulation and use of control agents

Inoculum sources

Cane infection by *Botrytis cinerea* is believed to arise at the leaf nodes *via* mycelial growth down the petiole. Information on the period when this occurs should help to devise a rational treatment to prevent cane infection. Artificial inoculation of tunnel-grown raspberry plants at different times of the year with a spore suspension of *B. cinerea* revealed no difference in the susceptibility of leaves of different age. However, whereas leaves on young primocanes inoculated in June were not susceptible, leaves of all ages on older primocanes inoculated in September were susceptible. Infection was predominantly symptomless.

- This result suggests that post-harvest control of *Botrytis* may be particularly important to prevent cane infection.

Tunnel-grown crops of Glen Ample in Cambridgeshire and Kent were monitored at intervals from June to October for occurrence of *Botrytis* on leaves and primocanes. *Botrytis* was present at a low incidence in visibly healthy leaves and petioles on primocanes from June to August. The fungus was found at a high incidence in attached old leaves of a dense crop in May. *Botrytis* lesions on primocanes were first seen in October.

- These results suggest that primocane leaf infection can occur throughout the growing season, although canes may not become infected until October. Further work is required to determine if canes may become infected before October.

Tunnel crops of raspberry in Cambridge and Kent were regularly monitored to identify the start and duration of *Botrytis* sporulation on cane lesions, and other likely sources of *Botrytis* (e.g. weeds, crop debris). Sporulation of *Botrytis sclerotia* on fruiting canes occurred from mid-May (when crops were at first open flower) through to August (when canes were cut out). High temperatures (>27°C) reduced sporulation. Weeds and crop debris in the tunnels examined at two sites in 2006 were not found to be a source of *B. cinerea* spores.

The effect of moisture and two temperatures (5 and 10°C) on sporulation of *Botrytis* sclerotia on raspberry canes was investigated. Sporulation occurred on sclerotia that were wetted, or incubated in high humidity for 2 weeks, at both temperatures. Sclerotia incubated in the field at this time did not sporulate.

- Treatments to prevent or reduce sporulation of sclerotia will be evaluated in 2007.

Seasonal variation in airborne inoculum of *B. cinerea* was investigated using a new spore trap. The spores are trapped in small vials prior to extraction of fungal DNA for quantification of *B. cinerea*. The test output is linearly related to the number of spores, indicating the method can be used to estimate the number of spores.

- Spore trapping will be undertaken in two commercial tunnel raspberry crops in 2007.

Environmental manipulation

Information was obtained on cropping practices and diseases of protected summer-fruiting raspberry from a survey of growers in England and Scotland. In 2005, five out of 11 growers reported problems with fruit *Botrytis* and all reported occurrence of cane *Botrytis*, usually at a low incidence. Two growers reported occurrence of powdery mildew on their crops.

Fruit samples from 20 crops were tested to examine whether information on the occurrence of latent *Botrytis* in unripe fruit can be used to help predict the risk of post-harvest *Botrytis* development. Latent *B. cinerea* was detected in unripe (yellow) fruit, with a large difference between crops; many samples had over 50% of fruit infected. No association was found

between sampling date, interval since the last *Botrytis* fungicide spray, variety, and incidence of latent *Botrytis* in unripe fruit. The incidence of *Botrytis* in ripe fruit did not appear to relate to the incidence in unripe fruit. Levels of *Botrytis* were higher in ripe fruit than unripe fruit in 11 out of 20 samples. High levels of *Penicillium* developed on most samples of ripe fruit, except for samples from two organic crops.

The effect of canopy pruning on occurrence of *Botrytis* and powdery mildew was tested in tunnel crops in Cambridge and Kent. Although there was a high incidence of *Botrytis* fruit infection, there was no obvious treatment effect. The incidence of *Botrytis* on leaves and primocanes was negligible at both sites. At the Kent site, despite the removal of large numbers of leaves or primocanes, there was no impact on humidity except nearest the open end of the tunnel where there was more air circulation. No powdery mildew was observed at either site.

Control agents

A series of experiments were conducted to determine the relative efficacy of a range of fungicides and natural products for control of *Botrytis* on raspberry.

In the first experiment, conducted in a tunnel, significant reductions in cane *Botrytis* were observed following treatment with Frupica, Scala, Teldor and Rovral WP. Milsana and Talat were slightly less effective. Scala and potassium bicarbonate at the rates and frequencies used were phytotoxic to raspberry leaves.

In a second experiment (Cambridge, 2006), Amistar, Folicur, Scala and Talat applied to a tunnel-grown crop of Glen Ample were all more effective than several other products at reducing latent *Botrytis* in fruit. Scala and Folicur caused phytotoxicity on the leaves. The ripe fruit had particularly high levels of *Botrytis* at the second pick (early July), with 84% in untreated plots, reduced to 39% by Talat. Ripe fruit infection on samples picked in late June and late July had around 40% of untreated fruit infected by *Botrytis*, with the best treatments developing infection on about 20% of the fruit. In early July, *Botrytis* infection was much greater on ripe fruit than on surface-sterilised yellow fruit picked three days earlier; possibly some infection developed from external contamination rather than latent internal *Botrytis* originating from flower infection.

In a third experiment (Kent, 2006), conducted in an open-field crop, the weather conditions during most of the flowering period were not favourable for *Botrytis* infection. The fungicides applied at the label recommended dose were most effective in reducing *Botrytis* rot in post-harvest tests. None of the other chemicals (natural products) evaluated were effective in reducing *Botrytis*, except possibly Hortiphyte Plus which requires further evaluation.

Powdery mildew

Mildew inoculum sources, effects of environmental manipulation and use of control agents

Inoculum sources

Mildew development was monitored in order to understand the mode of overwintering and subsequent spread during the growing season. Plants infected with mildew were then maintained in a polytunnel throughout the winter and the following growing season (2006). Preliminary results show that:

- mildew appears to overwinter in the buds (as mycelia and/or conidia)
- spread from these primary lesions to leaves of other canes is very rare under the tunnel conditions
- infection conditions appear to be very specific (mildew failed to transfer to healthy leaves in inoculation experiments).

Control agents

A range of fungicides and natural products were evaluated for control of powdery mildew and phytotoxicity on glasshouse crops of cvs Glen Ample and Joan Squire. Mildew failed to develop, despite repeated artificial inoculation. Potassium bicarbonate with and without wetter caused leaf margin browning or necrotic spots. Spray residues on the leaves were not obvious, except with the experimental product UKA 379a and, to a lesser degree, Frupica SC.

Raspberry beetle

Semiochemical-based monitoring and trapping systems for managing raspberry beetle

Two very active volatile attractants from raspberry flowers have been identified for raspberry beetle, compounds A and B. This work aimed to develop monitoring and trapping systems for managing raspberry beetle using these compounds.

The initial field trials were done in open-field sites at SCRI especially set up to provide large numbers of raspberry beetles. Three field trials, one in 2005 and two in 2006, tested different trap designs and different types of lures. Pervious research used non-UV reflectant white sticky traps but these can become contaminated by dust or by non-target insects, especially small flies. The prototype traps developed were based on standard funnel traps using white cross-vanes to visually attract adult raspberry beetles.

In 2005, two forms of the funnel traps were compared with the sticky trap. When used with a standard lure (thick-walled vials with compound B), both funnel traps were equally effective, and at least twice as effective as the sticky trap, in capturing adult raspberry beetles. When compared with other non-target insects, the funnel traps caught many fewer flies than the sticky traps and all traps caught very few pollinators. The cross-vaned funnel trap will be used as the standard for monitoring raspberry beetles in tunnels in 2007.

Also in 2005, two types of dispenser were tested in the laboratory. A thin-walled dispenser, thought to increase the evaporation of the attractant, was compared with the standard thick-walled dispenser. Although the evaporation rates were improved using the thin-walled vials, the design and reliability of the dispensers was problematic and further development ceased.

In 2006, a range of prototype sachet dispensers were manufactured using the attractant chemicals, compound A and compound B. Their efficiency was assessed in both the laboratory and in the field. Two field trials showed that single-sided sachets did not differ significantly compared with the standard thick-walled vial dispenser in two-week exposures trials. However, in longer laboratory evaporation studies, the sachets evaporated at a higher rate than the standard dispenser and may not have sufficient attractant to last for the five to six weeks that may be required in field condition. A new type of sachet with a more controlled vapour release has been found and will be tested in the laboratory and field in 2007.

To date, most of the research has concentrated on the use of compound B. To test the effect of a mixture of compounds A and B on trapping raspberry beetle, a single field trial was set up to compare compound A and compound B on their own versus a mixture of A and B. All three sets of attractants caught raspberry beetles, but compound B was the most effective and compound A the least effective. The mixture was approximately midway between the single compounds. This suggests that, at least with the standard thick-walled dispensers, there is no advantage in using a mixture of compounds A and B. The situation may change if the new type of sachets with variable evaporation rates proves successful.

Raspberry cane midge

Semiochemical-based systems of managing cane midge

Lure and trap optimisation

The raspberry cane midge sex pheromone was identified in previous research by EMR and NRI. The work reported here aimed to utilise the pheromone for managing cane midge.

To date, ten field studies have been conducted. Five experiments aimed at optimising the raspberry cane midge pheromone lure. Different pheromone dispensers and pheromone blends and release rates were evaluated. It was shown that the major component of the pheromone alone is highly attractive to raspberry cane midge males and that three minor components identified in previous work are not essential and did not significantly increase attractiveness. Rubber septa dispensers were shown to be satisfactory with a life of at least one month in the field in the UK. The raspberry cane midge pheromone has two enantiomers (i.e. a left and right hand form). It was shown that the S enantiomer (left hand form) is the natural one but there was no evidence that the opposite enantiomer inhibits the attractancy of the natural enantiomer and, crucially, a mixture of the two enantiomers, which is much less expensive to produce, is highly attractive. Lures containing 0.1 millionths of a gram of the pheromone were shown to be attractive but, interestingly, greatest catches occurred with lures containing 100 millionths of a gram. At higher doses the attractancy greatly decreased, an important finding which will be exploited in control strategies. For pest monitoring purposes, an optimal loading of 10 millionths of a gram was determined.

Based on work with the apple leaf midge, standard delta traps were considered to be most suitable for use by growers for pest monitoring. Standard 20 × 20 cm traps commonly used for monitoring codling and tortrix moths in orchards were adopted and proved satisfactory. However, an experiment was done comparing the attractancy of 6 different colours of trap (white, black, yellow, blue, red, green). The different colours caught similar numbers of raspberry cane midge, but the white, yellow and blue colours caught significantly greater numbers of non-target insects (flies, bees, etc.). Green and black traps are impractical.

- This finding suggests that red coloured traps would be preferable.

Monitoring raspberry cane midge

Using the standard lures and white delta traps, the seasonal temporal pattern and magnitudes of catches of cane midge in raspberry plantations subject to different management have been investigated. Traps were made available to 33 UK growers in a pre-commercial test in 2006. The traps have proved effective and easy to use for monitoring raspberry cane midge. Very large variation between plantations in total numbers caught has indicated plantations which are at risk with a high pest pressure. In polytunnels, first flight occurred much earlier than in field crops and much earlier than the date forecast by the ADAS temperature model. A nominal threshold of 30 midges per trap per week has been used but further analysis of the data is needed to determine if this needs adjusting.

Identifying host plant wound attractant of females

Work is just starting on this part of the project. A suitable site as reservoir of raspberry cane midge has been identified in Scotland and measures are in place to build up a population of midges for experimental work.

Control by disruption, mass trapping or lure and kill

A large-scale, multi-site field experiment was run from April-September 2006 in commercial raspberry plantations in SE and E England to evaluate the efficacy of a sex pheromone Mating Disruption (MD) treatment and an Attract and Kill (A&K) treatment in comparison with an untreated control for control of raspberry cane midge. For each treatment 2000 devices per ha were deployed. The MD and A&K treatments were effective outdoors but were ineffective in the polytunnel crops. Possible explanations for this difference in efficacy are that pheromone release was too rapid from the dispensers when they were deployed in the polytunnels where temperatures were much higher than outdoors and/or is that the pheromone did not disperse so effectively in the enclosed polytunnel environment. A dispenser with a more uniform release rate over a longer period is being sought for further large scale field trials of these promising control methods in 2007.

Aphids

Raspberry aphid controlled by late season sprays of aphicides

A large-scale experiment was conducted in commercial plantations near Maidstone, Kent, to test different timings of autumn sprays of thiacloprid (Calypso) for the control of aphids, including small and large raspberry aphids. Single sprays of Calypso were applied to replicate plots of Glen Ample on 28 August, 8 September, 22 September, 6 October and 20 October 2005. Populations of aphids were assessed in winter (eggs) and spring, though this latter assessment could only be done on half of the trial plots as the others were lost due to the collapse of tunnels under a heavy fall of snow. All the Calypso spray timings greatly reduced populations of large raspberry aphids that developed the following spring but the best control was achieved with the spray on 6 October which reduced populations by 97%. Numbers of small raspberry aphid were too small to draw conclusions from the data. The trial is being repeated in autumn 2006.

Financial benefits

In 2003, 8,000 tonnes of raspberries, worth £28.4M were produced from 1,260 ha grown in Britain. A further 4,800t, worth £18.2M, were imported. The UK fresh market is under-supplied outside of the main season. New varieties are now being utilised to spread the season and it is expected that production will increase substantially, perhaps by three-fold. Surveillance of pesticide residues in soft fruit identifies raspberries as having a high occurrence of detectable residues. For example, the 2003 ACP survey found 50% of imported raspberries and 75% of home-grown raspberries had detectable residues. This greatly damages the consumer acceptability of raspberries and their image as a healthy food.

Control of powdery mildew and *Botrytis* in raspberry crops is already difficult. Anecdotal evidence suggests that 25-30% of bud loss is due to *Botrytis* and, as a result, the UK crop is not producing optimum yields. There is a limited range of pesticides that can be used and other means of crop protection (e.g. biological control) are not available. The knowledge and techniques developed in this project will define an IPDM system for growing raspberries in protected environments. This will reduce or remove the incidence of detectable residues in fresh raspberries and give UK raspberry growers a competitive advantage.

Annual value in area of impact

Botrytis, mildew, cane midge and raspberry beetle are problems wherever and however raspberry is grown in the UK. ADAS estimate that, at any one time, 60% of raspberry plantations are infected by these pests and diseases. Assuming 25% of the crop is forgone as a result of these infestations, this is equivalent to 2,000 tonnes of raspberries, worth £7M.

Expected annual added value

We make the following assumptions that arise from a successful project:

1. Losses in the current crop will be reduced by 10%, yielding an additional £2M of UK sales.

2. Enhanced competitiveness of UK raspberry growing will reduce imports by 50%, yielding an additional £10M of sales.

3. Increased consumer confidence in raspberries will grow the overall market by 20%, yielding a further £5M of sales.

A successful outcome to this project could potentially reduce losses in the current crop by 10%, yielding an additional £2M of UK sales. This will also enhance the competitiveness of UK raspberry growing. It could increase consumer confidence in raspberries. If the overall market grew by 20%, a further £5M of sales would result.

Grower capital investment and cost recovery

It is not anticipated that this project will result in additional capital investments for growers. Pesticides typically cost £690/ha per annum. It is unlikely that costs of crop protection will be reduced and they may even increase if biological control systems are used extensively. However, this increase would be small in relation to the value of the crop.

Action points for growers

- It is too early to provide firm grower guidelines on practices to improve management of disease in raspberries; however, be aware that high volume sprays of potassium bicarbonate for mildew control may cause leaf margin browning and necrotic leaf spots on raspberry grown under protection.

- Raspberry cane midge sex pheromone traps are commercially available and should be used for pest monitoring and timing sprays.

- Good progress is being made in devising semiochemical control methods for raspberry beetle and cane midge.

- One trial showed that excellent control of raspberry aphids can be achieved by a post-harvest application of thiacloprid (Calypso), greatly reducing the need to spray for aphids in spring. The optimum time of application was late September – early October. Other products have not been tested but most good aphidicides are probably effective, though more persistent products are expected to give best results.