Horticultural
Development
Company

Grower summary

SF 74

Integrated pest and disease management for high quality raspberry production

Annual Report 2008

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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

A Minimal Pesticide Residues Integrated Pest and Disease Management programme has been devised for raspberries, ready for testing in large scale grower trials in years 4 and 5 of the project.

Background and expected deliverables

Raspberries are very susceptible to *Botrytis*, powdery mildew, raspberry beetle, raspberry cane midge and aphids. Pesticides are currently relied on for control and are applied close to harvest. Intensive use of pesticides, including the organophosphate (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 causes serious yield losses. Poor shelf-life reduces repeat buying. Retail surveillance has demonstrated 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 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. Recent observations indicate that this increases the risk of powdery mildew infection 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 project and main conclusions

Progress on each objective of the project is summarised below:

Botrytis

Symptomless systemic infection in canes

Examination of floricane buds and cane base tissue from visibly healthy canes in February 2008, produced no evidence of symptomless systemic infection. By contrast, on floricanes with visible *Botrytis* lesions or sclerotia, *B. cinerea* was recovered from most lateral buds. This result indicates that *B. cinerea* may develop from a localised point on a cane and infect other areas of the cane before any symptoms develop at these distant points. Experiments that test for symptomless systemic infection in primocanes were inconclusive. The occurrence of external inoculum as a common source of *B. cinerea* on primocanes was confirmed.

Sporulation of sclerotia

No sporulation was observed from sclerotia on fruiting canes immediately before or during flowering in an early crop covered by a Spanish tunnel in February. This result was in contrast to that in a covered crop at another site, in 2007, where sporulation from sclerotia occurred from early flowering and was still occurring when harvest ceased at the end of July. Sclerotia overwintering on fruiting canes are normally considered an important source of *Botrytis* inoculum in spring. The results suggest that sclerotia overwintering on canes may not be a major source of inoculum in crops covered early in the year, possibly because sclerotia are insufficiently wetted by winter rain.

Sources of B. cinerea *on tunnel crops*

Isolates of *B. cinerea* were collected from raspberry cane debris (15), primocanes (4), raspberry flowers (44), weeds in a tunnel crop of raspberry (1) and the air outside the crop (4) between April and October 2008. The isolates will be characterised by sequencing part of their DNA in order to determine the population structure of *B. cinerea* associated with raspberry.

Fruit infection

The incidence of flower infection was determined three times a week for 5 weeks in commercial crops in Kent and Cambridgeshire. Levels of infection varied greatly between sampling occasions, from 4% to 50% at the Kent site and from 2% to 39% at the Cambridgeshire site. Associated data on air temperature and relative humidity was also collected. The data will be used to refine the regression model developed in 2007 for prediction of flower infection from weather data.

Control by canopy manipulation

Primocane and leaf removal in a dense tunnel crop of cv. Glen Ample in 2007 reduced humidity around the canes and subsequent cane *Botrytis*. Examination of this crop in 2008 found no consequent effect on levels of fruit *Botrytis*. Lateral bud development from floricanes was generally better in the thinned areas of crop than in the areas with a dense canopy.

Suppression of sporulation from Botrytis scelotia by fungicides and natural products

Six fungicides (Folicur, Rovral WG, Signum, Switch, Teldor, UK3846) and two natural products (urea and potassium bicarbonate) were compared for their ability to suppress sporulation of *B. cinerea* from sclerotia on naturally-infected raspberry canes. None of the products worked except 5% urea which gave almost complete sporulation suppression. Any possible phytotoxic effects of this treatment on canes are currently being investigated.

Control of Botrytis fruit rot by fungicides and biocontrol agents

A field experiment in 2008 on Glen Ample evaluated programmes of new fungicides (Coded product HDCF 5, Switch) applied during flowering, with a natural product Chitoplant (chitosan from crushed crab shells) and two biocontrol agents – Serenade (*Bacillus subtilis*) and Shemer (*Metschnikowia fructicola)*. These biocontrol agents were also included in programmes with Switch. Teldor, as the standard fungicide, and an untreated control were included. The incidence of *Botrytis* on fruit at harvest was negligible at all four picking dates. In post-harvest tests the incidence of *Botrytis* fruit rot ranged from 8 to almost 70% and varied considerably in most of the picking dates. Fungicide treatments were most effective but only gave partial control. Shemer gave a limited degree of control but the other products were ineffective.

Management of fruit Botrytis by cooling

The incidence of raspberry fruit infected by latent *B. cinerea* at harvest varied between picks and crop source. Levels ranged from 70-89% in an outdoor crop untreated with *Botrytis* fungicides, from 18-79% in a covered untreated crop, and from 8-69% in a covered crop treated with *Botrytis* fungicides.

Development of infection causing visible damage within 9 days of harvest was greatly reduced in fruit given a specific experimental temperature regime. This was 1 day of field heat removal in air cooled to 2 ºC aiming to bring fruit temperature down to 6ºC, followed by 3 days cold storage at 3ºC and then 3 days at 17ºC to mimic transport and display followed by 2 days storage at 23ºC.

Incidence of visible *Botrytis* in weekly samples from a covered, unsprayed crop subjected to this cooling treatment were consecutively 16%, 1%, 3% and 49% at 9 days after harvest, compared with 37, 8, 40 and 78% in fruit stored at ambient (23ºC). Botrytis incidence was generally greater in fruit that was placed in 3ºC rather than the field heat removal area on the first day. It was also greater in fruit that was kept at at 23ºC rather than 17ºC to mimic the transport and display stage.

Fruit from all three crops had zero or near zero levels of visible *Botrytis* when assessed immediately after a storage period comprising 1 day in 2ºC, 3 days at 3ºC and 3 days at 17ºC.

Powdery mildew

Host-specificity

Electron microscopy of powdery mildews from raspberry and strawberry revealed no morphological difference between them. Previous work in this project, in which the DNA of isolates from raspberry and strawberry was analysed, suggests that they are two distinct groups.

Raspberry beetle

Flower volatile monitoring traps for raspberry beetle

The lure and trap system was tested at two sites in Scotland, but not England, since suitable raspberry beetle sites (sufficient pest pressure) were not available. In Scotland a combination of insecticide use (Calypso) and previous trapping resulted in very few beetles being caught and no fruit damage, even in control areas where insecticides had not been sprayed. Some bees were caught in the traps but this was largely due to very high local populations. The numbers of bees caught had no impact on bee populations or pollination. Final modifications (2009) will include a coarse mesh to prevent bees falling into the bucket trap. Generally the grid system (50 traps / ha placed within tunnels) was more effective than perimeter trapping, especially if RB populations are low to moderate.

In parallel studies using the traps and lures in Norway (mainly organic), Switzerland (organic and conventional) and France (mainly conventional), the trap and lure system produced good results. Where pest populations were very high (organic sites surrounded by wild hosts) some fruit damage still occurred, but the addition of extra traps (lattice within crop + crop perimeter , with additional traps near wild host reservoirs) and the use of 2 attractants (A+B) are proving to be beneficial in such extreme conditions.

Interestingly, in Switzerland and Norway the improved bucket traps continued to catch raspberry beetles well into the flowering period (not seen with sticky traps in the same experiments) and thus helped to reduce subsequent pest populations in following seasons. Trials will continue in 2009 with the finalised trap and lure system (easy snap fit and bee proof) with the aim of commercialising the monitoring system in 2009, using an action threshold of about 5-10 raspberry beetles / trap week (as previously developed in EU CRAFT 'RACER' project). This guideline threshold is likely to be conservative, since it was developed using sticky traps without the improved lures currently used. Growers should adjust the threshold to suit their local conditions and fruit quality requirements.

Raspberry cane midge

Sex pheromone monitoring traps for raspberry cane midge

Raspberry cane midge and sex pheromone traps for pest monitoring are now available from Agralan. UK raspberry growers should be using the trap to monitor populations and improve the timing of sprays for control of the pest. A trap should be suspended at a height of 0.5 m in the centre of each of the main cropping plantations on the farm and monitored weekly though the season from 1 April – 30 September. A treatment threshold of a total of 30 midges per trap is proposed. Sprays should be targeted against the first generation (in May outdoors, but much earlier on early protected crops) and applied a few days after a threshold is exceeded. Chlorpyrifos is the only effective insecticide available. Sprays should be directed at the base of the canes.

Control of cane midge with sex pheromone Mating Disruption and Attract and Kill

One large-scale experiment was conducted on three farms in Kent from April - October 2008 to evaluate a mating disruption (MD) and an attract-and-kill (A&K) method of using the raspberry cane midge sex pheromone for control. The MD treatment used 3 kg of Ethyl Vinyl Acetate granules (~50,000 granules/kg) containing 10 g pheromone/ha, broadcast to the surface of the soil in the alleyways. The A&K treatment used 2000 lambda cyhalothrin treated cards (~ 7 × 7 cm) each bated with a rubber septum lure containing 200 µg of the pheromone. Untreated control plots were provided for comparison. One 1 ha plot of each treatment was provided on each of three farms in Kent. The sites had varying populations of raspberry cane midge, season totals of 2670, 5505 and 6569 midges being captured per trap in the untreated control plots at the three sites. The efficacy of the treatments was assessed by determining the numbers of midges caught in a sex pheromone trap in the centre of each plot together with counts of midge larvae that developed in artificial splits in the primocane.

The MD treatment failed to reduce total season catches at one site, but reduced catches by 94.2% and 85.1% at the other sites. Better and longer lasting trap suppression was achieved with the A&K treatment (91.6%, 99.2% and 98.2% respectively). Where the lowest degree of pheromone trap suppression occurred, total numbers of larvae recorded in splits in the treated plots were as great, or greater, than in the untreated controls. However, numbers of larvae were reduced by 99.7% and 97.4% and by 68.1% and 86.0%, by the MD and A&K treatments at the other two farms.

These results are encouraging because it is the second time that control of the raspberry cane midge using the sex pheromone has been demonstrated. The most likely reason for the variation in results are differences in cane midge populations. MD and A&K treatments are known to perform poorly when populations are high. The high degree of trap shut down that is necessary for good control probably only occurs at low population densities. This indicates that the MD and A&K treatments perform well at low population densities, but not at high. The overall conclusion is that where populations are moderate to high, then MD and A&K treatments have to be used in combination with chemical control methods initially.

Because of efficacy and registration considerations, it has been decided to develop a practical A&K formulation for testing in the large scale IPM trails in the final two years of the project.

Identification of volatile substances from cane splits to attract female cane midge

Good progress was made with identifying a female attractant for raspberry cane midge. Mated females are known to be strongly attracted to odours from recently split raspberry primocanes. Fresh splits are preferred over old ones. Using SPME microfibres to sample the volatiles in situ followed by GC-EAG (gas chromatography coupled to an electro-antennogram), a number of volatile substances produced in larger amounts from wounded canes were identified. Most of these are produced by other plants when damaged, but two are more unusual and might be responsible for the specific attraction of female midges to raspberry canes. Experiments with several raspberry cvs showed consistency in the patterns of volatile emission from cane splits, indicating that development of an attractant lure will be feasible based on a few, consistent compounds now identified. Synthetic lures (polyethylene sachets containing 100 µl of a mixture of compounds) were developed that emulate the bouquet from cane splits and preliminary testing of their attractiveness to females was started, showing promising results in a small pilot study against 3rd generation female midges. The females are the damaging sex that lay eggs and control is likely to be more effective if we can target them rather than just the males as is the case if the sex pheromone is used only. Further tests to optimise the trap and lure system for female midges will be continued in 2009 at suitable field sites.

Aphids

In an experiment to evaluate three different timings of single sprays of pirimicarb (Phantom), thiacloprid (Calypso) and pymetrozine (Plenum) for the control of small and large raspberry aphids, in commercial raspberry production, Calypso sprayed on 19 October was the most effective treatment reducing numbers of aphids by 99% the following spring.

Minimal Pesticide Residue Integrated Pest and Disease Management (MPR-IPDM) programme

Based on the research conducted in the first 3 years of the project, a Minimal Pesticide Residue Integrated Pest and Disease Management programme has been devised ready for testing in years 4 and 5 of the project.

The key features of this programme are:

1. Good crop hygiene and cane management together with rapid fruit cooling and high quality cool chain marketing to avoid the need for fungicide sprays for *Botrytis.*

2. Apply 1-2 sprays of a powdery mildew fungicide in the spring as soon as the tunnel is covered then spray potassium bicarbonate subsequently for eradication of powdery mildew if the disease is observed.

3. Use raspberry beetle host volatile funnel traps with white cross vanes at a rate of >50/ha. Localised treatment with Calypso can be justified when trap catches exceed economic damage thresholds.

4. For raspberry cane midge, use a sex pheromone attract and kill treatment. Additional trapping of female cane midges using identified female cane midge attractants are under development and should complement the sex pheromone based traps in future.

5. Apply an autumn spray of thiacloprid (Calypso) for aphid control supplemented with introductions of predators and parasites for biocontrol in summer.

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 cropping 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 integrated pest and disease management (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, powdery 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.

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

- The work has demonstrated that the need for fungicide sprays for *Botrytis* can be greatly reduced/avoided if good crop hygiene and cane management are combined with rapid fruit cooling and high quality cool chain marketing.

- Mildew can be controlled with 1-2 sprays of a powdery mildew fungicide in the spring as soon as the tunnel is covered, supplemented with subsequent sprays of potassium bicarbonate to eradicate powdery mildew if the disease is observed.

- Raspberry beetle traps (a green funnel trap with white cross vanes bated with a host volatile sachet lure lasting 6 weeks) may become commercially available in 2009. They should be used to monitor populations and direct local application of insecticide sprays.

- Raspberry cane midge sex pheromone traps should be deployed in the main raspberry plantations on each farm and used for monitoring cane midge and determining the timing and need for insecticide sprays.

- A spray of an aphicide such as thiacloprid (Claypso) or pirimicarb (Aphox) applied in early – mid October will reduce spring populations of large raspberry aphid by > 90% and should be considered as part of normal practice.