Grower Summary

Developing biocontrol methods and #their integration in sustainable pest and disease management in blackcurrant production

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Annual report 2013

Project title:	**Developing biocontrol methods and their integration in sustainable pest and disease management in blackcurrant production**
Project number:	HL01105
Project co-ordinator:	Tom Maynard
Project administrator:	Jerry Cross (EMR)
Researchers:	Jerry Cross (EMR) David Hall (NRI) Angela Berrie (EMR) Xiangming Xu (EMR) Rex Brennan (James Hutton Institute) Michelle Fountain (EMR) Gillian Arnold (EMR)
Collaborators:	GlaxoSmithKline blackcurrant growers research fund East Malling Trust for Horticultural Research Bayer Crop Science Ltd Fargro Ltd Red Beehive Co Ltd Ian Overy Farms, Wellbrook Farms Robert Boucher and Son Maynards Bradenham Hall Farms Bradfield Farm Ltd Corbett Farms Ltd J Youngman & Sons Adamston Farms Ltd East Malling Ltd
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Headline

Background and expected deliverables

The overall aim of the proposed project is to develop new management methods for key pests and diseases of blackcurrants, giving priority to alternative, biological methods, and then integrate them into an Integrated Pest and Disease Management (IPDM) programme which will be evaluated and refined in large scale field experiments in the final two years of the project. Work will target Botrytis, the most important disease of blackcurrants which causes significant losses in fruit quality, and two important pest problems, blackcurrant leaf midge and sawfly which are currently controlled by routine insecticide applications. The aim will be to develop appropriate improved management methods for each target to improve control whilst reducing dependence on and unnecessary use of pesticides.

Summary of project and main conclusions

Progress on each objective of the project is summarised below

Objective 1: *Botrytis cinerea*

Determining whether varietal differences in susceptibility are correlated with physiological characters

Cultivar differences in susceptibility to fruit rot caused by *Botrytis* were previously reported to be linked with the physical properties of the fruit skin, with various cultivars, considered to be tolerant of fruit rot also regarded as having stronger skin properties. Measurements of blackcurrant skin strength were carried out in order to determine whether a relationship with blackcurrant losses through *Botrytis cinerea* infection exists.

A diverse range of blackcurrant genotypes were harvested at full ripeness and tested using previously reported methods for skin resilience to piercing and compression. This data was aligned with information on *Botrytis* development on berries of each genotype following surface sterilisation. The results showed that no correlation was found between the most rapid development of *Botrytis* and either the compression or piercing tests. There is now some doubt as to whether skin strength *per se* is a factor in *Botrytis* infection, as previously postulated. The effects of increased rainfall and water uptake on the fruit skin"s physical characteristics have yet to be quantified.

Results from controlled inoculation of 18-20 genotypes in 2011 and 2012 showed an insignificant correlation in the incidence of fruit infection between the two years. Thus, the response of cultivars to Botrytis infection is inconsistent between years, hence indicating the lack of intrinsic resistance.

Time fungicide application and supplementary sprays of BCAs during flowering to improve control

A small plot replicated experiment was done on Ben Hope and Ben Tiran at EMR in 2012 with the following objectives:1) to evaluate 6-spray programmes of the BCA products Prestop and Serenade; 2) to evaluate Botrytis control based on using an effective fungicide product (UKA386a) for the flowering sprays and with and without

BCAs pre-harvest; 3) to re-evaluate control based on fungicide use early (Signum) and 1 or 2 sprays of the BCA Serenade pre-harvest; 4) to examine the economics of using BCAs for Botrytis control on blackcurrant.

Programmes of sprays were applied *at* 7-10 days intervals from 1st flower. Treatments were Untreated, Signum x4, UK386a x4, Signum x3, UK386a x3, Serenade x6, Prestop x6, Signum x3 + 1 late Serenade, Signum x3 + 2 late Serenade, UK386a x3 + 1 late Serenade, UK386a x3 + 2 late Serenade. The incidence of botrytis rot was assessed pre-harvest and in post-harvest tests.

The incidence of Botrytis was negligible on the fruit before harvest in both cultivars. In post-harvest tests the incidence of Botrytis was much higher in Ben Tirran than Ben Hope. On Hope all treatments reduced Botrytis but the best treatments (3 or 4x UK386a) reduced Botrytis from 13.2 to 0.5%. There was no advantage of substituting the 4th spray with 1 or 2 sprays of Serenade

On Ben Tirran, none of the treatments worked except UK386a which reduced infection from 34% to 5%. There was no advantage in substituting the 4th fungicide spray with 1 or 2 sprays of Serenade.

In conclusion, the novel fungicide product UK386a is a very promising new product for Botrytis control on blackcurrant. The first 3 fungicide sprays are essential for good Botrytis control and there was no significant advantage from late BCAs if an effective Botrytis programme was applied early. BCAs are much more costly than fungicides and therefore uneconomic to use on blackcurrants unless there are constraints on fungicide use.

Effect of pollinating insects on blackcurrant yield and quality

Caged field trials showed that supplementing blackcurrant with *Bombus terrestris dalmatinus* nest boxes at the point of flower opening increased yield and fruit size of berries (Ben Hope and Ben Gairn). This was shown to be particularly important in a period of poor weather when the naturally occurring pollinating insects were less active. Bagging strigs of betties to exclude insects in open field conditions demonstrated that insect pollination contributes up to 35% fruit set of Ben Gairn.

Experiments indicated that bees may vector botrytis but that this was marginal and far outweighed by their contribution to pollination. Field trails with *B. t. audax* were inconclusive as the weather at flowering was good in 2001 and increased sampling of fruit set was needed. Wild bumblebees and solitary bees were important contributors to blackcurrant pollination; honeybees less so.

In 2012 at pre blackcurrant flowering no bees were seen visiting flowers. However, observations on flowering plants were not long enough to be conclusive. All bumblebees seen at this time were queens – mostly searching for nesting sites, although *B. lapidarius* was seem moving between blackcurrant bushes. Solitary bees were mostly seen basking on leaves or flying around bare earth – possibly males waiting for females to emerge. Bumblebee queens were particularly attracted to rough grass verges in headlands. Weather during the flowering period of Ben Garin in 2012 was poor with rainfall throughout. However, provisioning plantations with *Bombus terrestris audax* nest boxes did not improve the fruit in the blackcurrant plantations. High variability of crop management between farms and fields may have made it difficult to tease these effects apart. Bumble bees can forage for up to 2-3 km and so are not restricted to the plantations even though placed in the centres of the crops. However, bumblebees were observed foraging on blackcurrant flowers within a few minutes of opening the nest boxes. It is also likely that botrytis also affected fruit set as withered strigs of fruit were observed at the assessment time.

Although landscape scale surrounding land use varied between plantations provisions for nest sites could be manipulated within the plantation to bolster numbers of solitary and bumblebees (the main foragers of blackcurrant flowers). Many important blackcurrant forager bees were present before and after blackcurrant flowering within the vicinity of the crop. Hence provisioning with nest sites and diverse forage will help to foster better populations for pollination in future years. Most sites in this study were very forage poor, especially pre blackcurrant flowering, and some lacked numbers of bees and nest sites. *Osmia rufa* was a poor blackcurrant flower visitor and, therefore, not an important pollinator of blackcurrant.

Filter blocking

As in 2011, we have continued the study on investigating whether fungal botrytis increased substantially while it remains latent inside infected blackcurrant fruit. Fruit of cv. Ben Hope were inoculated 3-4 weeks after flowering. Thereafter, about 100 fruit were sampled every week for molecular quantification of fungal biomass. qPCR data revealed that fungal DNA did not appreciably increase over time from inoculation to harvest. Thus, mycelia inside the latently infected fruit by *B. cinerea* are unlikely to be responsible for blocking filters. This experiment was repeated in 2012 and samples of fruits are being quantified for *B. cinerea* DNA.

Objective 2: Blackcurrant leaf midge

Crop damage assessment in fruiting plantations

A three year, replicated large plot experiment started in April 2010 in 7 commercial blackcurrant plantations in England to investigate the effects of blackcurrant leaf midge attacks on crop growth and yield was completed in 2012. The plantations included establishing versus fully established crops of the cultivars Ben Alder, Ben Hope and Ben Tirran. Galling damage, yields and shoot growth were recorded in replicate plots treated with synthetic pyrethroid insecticides (bifenthrin and/or lambda cyhalothrin) where blackcurrant leaf midge attacks were low, versus untreated plot where populations were high.

There were large differences in the numbers of midges captured in sex pheromone traps at the different sites in 2012. Smallest numbers were caught at Provender and Bradfields, greatest numbers at Shobdon and Burrs Hill. Although the January – March 2012 was exceptionally dry, the rest of the year was unusually wet, particularly in western England, providing good conditions for blackcurrant leaf midge populations. At the two sites in western England (Shobdon, Bradfieds) four generations of midge flight could be distinguished, at approximately monthly intervals. Generational flight patterns were more difficult to discern at the other sites. The first generation flight started in late March - early April, a week or two earlier than in the previous two years.

As in the first two years of the experiment, in 2012 the insecticide treatments applied to the treated plots reduced but did not eliminate galling damage in the treated versus the untreated plots. For the first generation, the numbers of galls per shoot was significantly reduced by 71% (from 0.112 to 0.033 galls per shoot) by insecticide treatment on average. For the second generation, the numbers of galls per shoot was reduced by 53% (from 0.38 to 0.18 galls per shoot) by insecticide treatment on average. Catches of midges in the sex pheromone monitoring traps were also significantly reduced, by 51% for the first generation and by 42% for the second generation. Numbers of galls per shoot were considerably lower and the percentage reductions due to insecticide treatment considerably smaller than in 2011.

The grand mean yield for the treated plots in 2012 (6460 kg/ha) was very similar to the grand mean yield for the untreated plots (6303 kg/ha) and the yields did not differ significantly. Thus, insecticide treatment for blackcurrant leaf midge provided no yield benefit in any of the 3 years of the project.

Although the grand mean length of the current season"s extension growth was at least 10% shorter in the untreated versus the treated plots after the growing season in all 3 years, differences were not statistically significant when results from each year were analysed individually due to high plot-to-plot variability. Analysis of the data as a whole is to be done in 2013.

Timing and efficacy of insecticides

A small plot replicated field experiment was done in 2012 to evaluate the efficacy of foliar sprays (500 l/ha) of UKA385a or Hallmark for control of 1st and 2nd generation blackcurrant leaf curling midge. This experiment was a repeat of the experiment done in 2011. Treatments were a factorial comparison of single sprays of the 2 products (UKA385a, Hallmark) at 4 timings (1, 4, 8 and 15 days after a threshold catch of >10 blackcurrant leaf midge males had been captured per trap in the two sex pheromone monitoring traps deployed in the plantation) versus a untreated control (double replicated). For the first generation, sprays were applied on 13, 16, 20 and 27 April at growth stages B2-C1, C1-C2, C2 and C2-C3, respectively. For the second generation, sprays were applied on 29 May and 1, 6 and 14 June at the F2, I1, I2 and I3 growth stages, respectively. Numbers of galls and the larvae they contained were assessed in samples of 15 shoots per plot sampled on 15 May and 11 July, 2 weeks after the last sprays for each generation had been applied, respectively. A summary of the findings of the experiment is as follows:

For the first generation treatments, Hallmark significantly reduced the numbers of leaves per 15 shoots galled by 83% from 3.85 to 0.66. Differences between the timings of application of Hallmark were not statistically significant, though there was a marginal trend to better control with earlier treatments. None of the first generation UK385a treatments reduced galling damage._Both Hallmark and UK385a significantly (P <0.001) reduced numbers of larvae, the UK385a by 63% from 5.75 to 2.1 galls per 15 shoots and the Hallmark by 98% from 5.75 to 0.12 galls per 15 shoots

None of the second generation treatments reduced galling damage. Numbers fo larvae present were too low to acertain treatment effects.

Although the weather in January to March 2012 was unseasonably dry and somewhat warmer than average, the weather in from early April to July 2012 was unusually cool and wet in 2012. This affected the emergence pattern of the the midge and made it very difficult to time sprays. The generations were indistinct, especially the first generation. It is possible that the first generation flight may have stated in early April and that the start date of the first generation sprays was too late. Similarly, the second generation sprays may have been wrongly timed.

These dificulties in spray timing may explain the contrasting results in 2012 with those obtained in previous years. It highlights the pitfalls of using simple trap catch thresholds when the flight pattern of the midge is protracted and erratic due to weather conditions. The spray timings may have been wrong, explaining the failure of the UK385 to give satisfactory control and of the Hallmark to give control of the „2nd generation".

The problem of interpretting trap catches for spray timing might be overcome by using the catches in combination with temperature sum predictions of phenology, though this could also lead to difficulties in dry conditions which are known to delay emergence.

Objective 3: Blackcurrant sawfly

The major component of the female produced blackcurrant sawfly sex pheromone (an isomer of isopropyl tetradecenoate) has been synthesised and has been shown to have identical GC retention times and mass spectrum to the compound produced by female sawfly. The synthetic compound elicits a very strong electroantennogram response in males and is proposed to be the major component of the female sex pheromone. Similarly a range of isomers of the 16-carbon homologue has been synthesised and shown to have identical GC retention times and EAG activity to one of the minor compounds produced by female sawflies. Lures containing these compounds were tested in the field in 2012, but no blackcurrant sawflies were captured. Regrettably, attraction was not demonstrated in field tests, possibly due to very low populations of the pest in the exceptionally wet season. A major programme of testing different synthetic blends in multiple crops throughout the UK is planned for 2013.

Commercial benefits

New knowledge obtained in this project will enable growers to manage the important pests and diseases on blackcurrant more effectively with less reliance on pesticides. In particular:

1) Accurate predictions of *B. cinerea* infection risk may enable growers to time sprays and hence to increase spray efficacy.
2) Integration of biocontrol agents with fungicides may reduce botrytis development without increasing fungicide use.
3) Potential correlation of physiological characters with botrytis development may accelerate breeding of less susceptible cultivars.
4) Understanding fungi responsible for filter blockage may enable appropriate control measures to be developed and implemented.
5) Crop damage assessment of blackcurrant leaf midge would allow growers to focus control measures where they are needed and avoid spraying in plantations where damage is cosmetic.
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7) Establishment of thresholds for the newly developed leaf midge sex pheromone trap will enable sprays to be scheduled and timed to improve control and reduce insecticide use.
8) A pheromone based control method for leaf midge would allow growers to control the midge without use of insecticides.
9) A monitoring trap for blackcurrant sawfly and attendant treatment thresholds would allow growers to focus control measures where they are needed and avoid spraying in plantations unnecessarily close to harvest.
10) An improved Integrated Pest and Disease Management programme combining the above components would allow a substantive reduction in pesticide use, reduced incidence of residues and improved sustainability

Action points for growers

- Survey bee numbers in plantations and supplement with bumblebees where populations are low or where there has been a history of poor fruit set or fruit storage problems.

- This may also be necessary in poor weather conditions.
- If provisioning plantations with bumblebee nests, protect from badger attack.
- Sustain and increase bee numbers when plantations are not in flower, by providing alternative food sources.
  - Provide flowers with an open habit (e.g. Umbelliferae, Rosaceae, *Prunus*) to encourage a wider diversity of bees.
  - Blackthorn and Willow can be encouraged in hedgerows as an early source of forage.
  - Compositae/Asteraceae are foraged by solitary bees and can be encouraged in the alleyways. Alleyways can be most before spraying protective insecticides to discourage bees in the crop at that time.
  - Grow natural species, rather than plants that have been subject to horticultural breeding as nectar and pollen are more accessible in the former.
  - Make sure that you have a variety of plants that can provide season long flowers from mid March to late August.
  - Grow good sized patches of favoured plants as these are more attractive.
- Bees need to refuel after emerging from overwintering sites (February to March) and a good food supply (April to September) will help to ensure high populations into the following year.
- Provide undisturbed, south-facing areas of sparsely vegetated ground for solitary bees to nest in.
- Bare ground compacted by vehicles is also good, as long as these areas are in sunshine and not used too frequently.
- Avoid waterlogging soil, and loose, crumbly soil is best for bees to dig.
- Leave untidy areas of rotting wood, preferably areas of woodland, and tussocky grasses for bumblebees to overwinter and nest in (See http://bumblebeeconservation.org/about-bees/habitats/)
- Control of blackcurrant leaf midge in newly planted, establishing or cut down blackcurrant bushes is important, but control in established crops is less important providing there is adequate regenerative growth
- Lambda cyhalothrin (Hallmark) is the most effective currently available insecticide for blackcurrant midge. Sprays should be applied within a few days of threshold catches (>10 midges/trap) for the first and second generation.
- Growers interested in using the newly designed blackcurrant leaf midge trap to time spray applications should contact Jerry Cross (jerry.cross@emr.ac.uk).
- The first three fungicide sprays applied from first flower are the most important treatments for Botrytis control. If an effective fungicide programme is applied at this time then there is no benefit from additional sprays near harvest