Grower Summary

SF 158

Integrated Pest Management (IPM) of Cane Fruit Pests and Diseases

Annual report, March 2019

Project title:	Integrated Pest Management (IPM) of Cane Fruit Pests and Diseases
Project number:	SF 158
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Report:	Annual report, March 2019
Previous report:	Annual reports March 2016, 2017 & 2018
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Date project commenced:	1 March 2015
Date project completed **(or expected completion date)**	31st March 2020

DISCLAIMER

The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

Dr Erika F. Wedgwood

Plant Pathologist, SF 158 Project Leader

RSK ADAS Horticulture, RSK ADAS Ltd

Signature E.F. Wedgwood Date: 29 March 2019

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Signature Date: 29 March 2019

GROWER SUMMARY

Raspberry root rot

Objective 1 - Investigating the effect of cold storage and biopesticides on Phytophthora root rot in long cane raspberry.

Headline

- Cold storage of substrate raised raspberry canes can increase Phytophthora root rot incidence.

Background and expected deliverables

Phytophthora root rot, principally attributed to *P. rubi* (previously known as *P. fragariae* var. *rubi*) is now the most destructive disease of raspberries worldwide. Outbreaks of this disease across Europe at the same time in traditional raspberry-growing areas suggests that the disease may have spread through the propagation network and has been distributed to farms in new planting material. It therefore arises in both soil (where it forms long-surviving resting spores) and substrate grown crops. Current approaches for Phytophthora control rely on a single fungicide application per year either as a soil-applied drench or through the drip irrigation. A soil drench of Paraat (500 g/kg dimethomorph) is currently used, but resistance developing in pathogens where products have only a single mode of action is a major concern. Biofungicides such as Prestop (*Gliocladium catenulatum* strain J1446) and Serenade ASO (*Bacillus subtilis* strain QT 713) have action against oomycetes such as a *Phytophthora* spp. and certain fungi.

In the UK, cold storage of long cane raspberry propagation material is becoming common practice to guarantee sufficient chilling over winter, with the removal from store timed specifically to allow the programming of fruit harvest. Such plants may be discarded by growers after fruiting, thereby avoiding the carry-over of any pests and diseases into the next cropping year. In strawberry, cold storage of propagation material has been shown to increase susceptibility to *Phytophthora cactorum*, but it is uncertain if increased susceptibility also arises in raspberry long cane with *P. rubi*. This project aims to examine any effect of cold storage on Phytophthora root rot susceptibility in raspberry, and any benefit from biofungicide drench application before or after overwintering.

Summary of the project and main conclusions

Two experiments were set up to investigate whether storing long cane raspberry (cv. Tulameen) over winter affects root rotting and cane infection by *P. rubi* following Spring inoculation. It was also hoped to determine whether there is any benefit from applying protectant fungicide drenches of Prestop, Serenade ASO or Paraat. One experiment was treated in Autumn while the second received drenches in April, prior to inoculation with *P. rubi* a month after potting on. This inoculation timing was chosen to simulate a natural Spring infection, with increased pathogen activity favoured by warming temperatures and free water provided by regular irrigation, allowing dispersal of *Phytophthora* spp. zoospores.

Half the plants were placed in cold store at -1°C and the other half remained outdoors in the field, as ambient stored, over the winter period (December 2017 – March 2018). All plants were then potted up, and placed in a polytunnel with drip irrigation.

A baseline root assessment after winter storage, showed that ambient stored plants, treated in Autumn, had higher levels of root browning than those that were cold stored (Figure i). In these ambient stored plants, black-to-white root discolouration occurred, and was attributed to extreme drop in temperature in February 2018, not encountered by plants in cold storage. A greater root ball surface area of healthy white roots was present in Spring on ambient stored plants drenched with Paraat in Autumn.

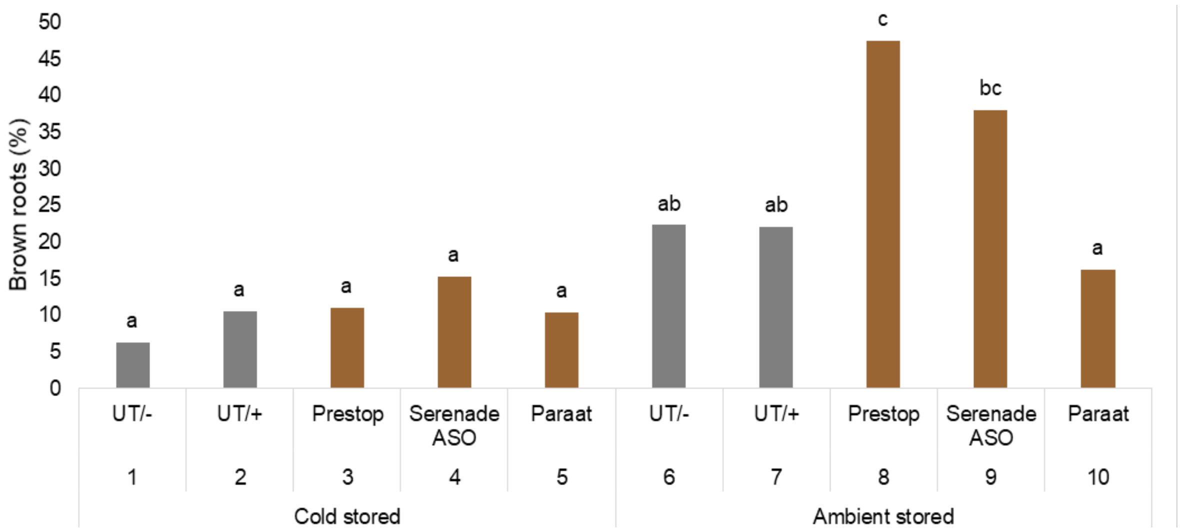

Figure i. Autumn treated plants. Percentage of root ball with brown roots at re-potting in March 2018. Significant differences indicated by differing letters. Brown root surface area in ambient plants includes freeze damaged black roots. No *P. rubi* inoculation had been carried out at this stage.

In contrast to the Autumn treated plants, the ambient stored plants yet to receive Spring drenches showed no more root browning than cold stored plants. This suggested Autumn biofungicide applications to ambient stored plants were linked with increased root browning.

By June, significantly more primocanes had emerged from the Spring treated cold stored plants (mean 3.1) compared with ambient plants (mean 2.0; P<0.001). Wilted canes were present in some uninoculated plants, and molecular testing of a sample plant showed the presence of *Phytophthora idaei* (or less likely *P. cactorum*) but not *P. rubi*.

By October 2018, a mean 46% of cold-stored Spring treated plants displayed symptoms of wilting in canes produced since Winter. This was significantly above the mean 28.3% following ambient storage (**Figure ii;** P<0.05). Autumn treated plants also displayed symptoms of wilting, but there were no storage or treatment differences.

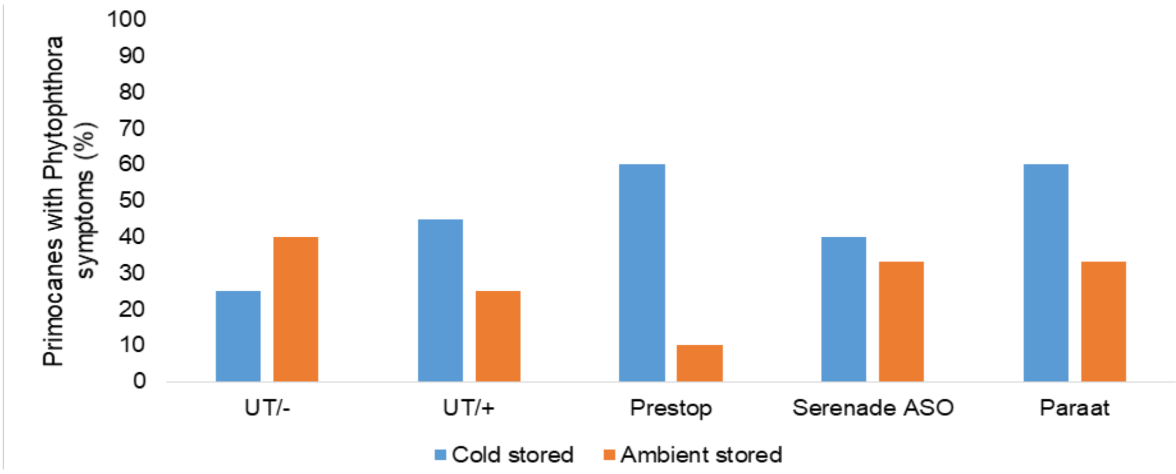

Figure ii. Percentage of primocanes per plant, Spring treated, showing *Phytophthora* spp. symptoms, October 2018. Significant difference (P < 0.05) between storage regimes.

Some Autumn treated plants from both storage regimes had developed red roots, in which *Phytophthora* spp. were detected by LFD test. Significantly more (P<0.05) ex-cold stored plants had this symptom (31.3%) than ambient stored (14.0% incidence) (**Figure iii**).

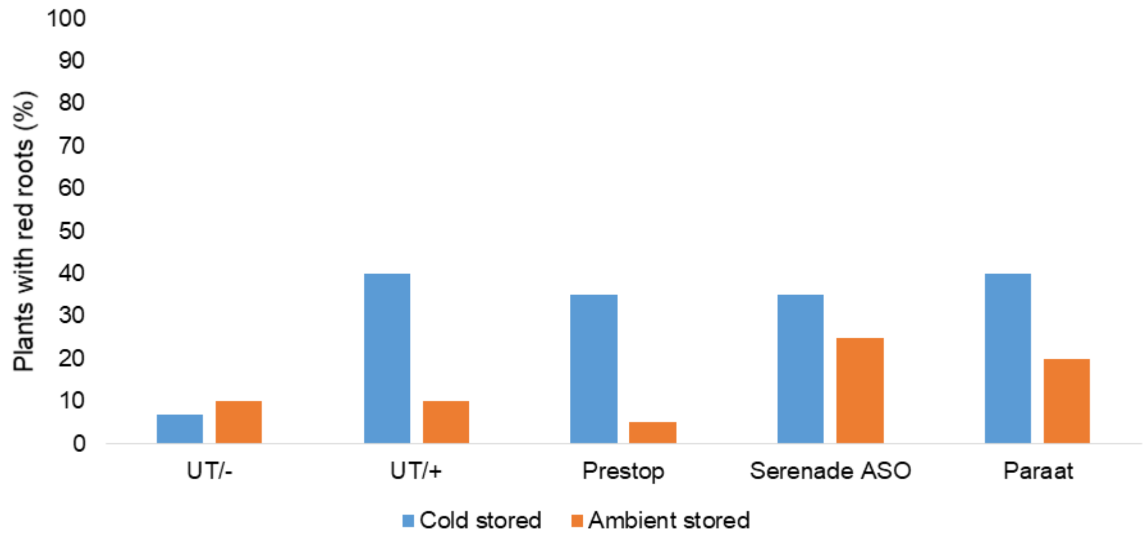

Figure iii. Incidence of red roots (associated with *P. rubi*) in the Autumn treated experiment, October 2018. Untreated UT/- remained uninoculated, all other treatments had *P. rubi* inoculation in April 2018. Significant difference (P<0.05) between storage regimes.

Spring treated plants had similar incidence of red rooted plants in each storage regime, with a mean 14.5% incidence across treated and untreated. Double the incidence of red roots in cold stored Autumn treated plants compared with the other three storage/treatment combinations may indicate either a greater susceptibility to *P. rubi* infection or poorer control.

Some uninoculated plants also had red roots present (mean 8.4%) and as care was taken to reduce any cross-infection from the *P. rubi* inoculation stage, it suggested a *Phytophthora* spp. was in a few of the plants received from the propagator. Limited molecular testing of other plants at the end of the experiment confirmed the presence of *P. rubi*, but *Phytophthora idaei* was also found in some roots.

Financial benefits

Raspberry root rot (caused by *Phytophthora rubi*) is the most devastating disease currently faced by cane fruit growers and in particular by raspberry producers. The disease spreads rapidly through the root system of the crop, leading to complete death of large areas of a plantation. Where severe, in soil grown crops, it commonly kills 75% of a raspberry plantation within two to three years of establishment. Although perhaps slower to spread in container grown crops, it has a similar effect in killing significantly large areas of a plantation within a few years of planting and establishment. Not only do growers make significant financial losses, they also incur additional labour costs in setting up new replacement plantations more frequently, along with the associated costs of establishing a new plantation along with the support system that goes with it.

Assuming a typical return for raspberries of £6.49/kg to growers (Defra Basic Horticultural Statistics 2014) and a yield of 14 tonnes/ha, then 75% crop loss would lead to a financial loss of £68,166/ha. Increasing the health of propagation material and providing material that is more resistant to the disease would not only significantly reduce such losses but lengthen the life expectancy of a raspberry plantation, thereby reducing the additional costs of re-establishing new plantations on a frequent basis.

Action points for growers

- Be aware that some propagation material may carry *Phytophthora* spp. into a crop, so check for rotted roots when potting-on to indicate the extent of any problem. LFD test kits used to detect Phytophthora spp. will distinguish between the disease and browning caused by freezing that can arise following outdoor overwintering.

- Before being placed in tunnels in Spring/Summer, ensure plants have sufficient time to acclimatise after leaving cold storage. Heat stress may increase the susceptibility of plants to infection.
- In recent Springtimes, hotter than average periods have arisen, so minimise heat stress by venting polytunnels and glasshouses and ensure the correct amount of irrigation is delivered to pots. Be aware that too much free water favours *Phytophthora* spp. infection.
- Be vigilant for early symptoms of Phytophthora such as the characteristic 'shepherd's crook' seen in emerging primocanes. Remove affected plants or pots to stop *P. rubi* spread in run-off water.
- Note that *Phytophthora* spp. are still able to survive in containerised plants when temperatures outside the pot are either below freezing or above 30°C.
- Be alert to any changes in the timing and severity of root rotting as this could indicate the presence of species other than *P. rubi,* such as *P. idaei* which is favoured by warm conditions, and might require preventive treatment at a different time of year.

Two-spotted spider mite

Objective 2.1 – To develop and maintain IPM approaches to successfully control two-spotted spider mite whilst controlling SWD and other pests with insecticides.

Headlines

- Two-spotted spider mite was successfully controlled by and IPM programme before the grower needed to apply a plant protection product for control of spotted wing drosophila.
- Although not consistent on all assessment dates, there was evidence that adding pollen (Nutrimite®) may have led to improved *Amblyseius andersoni* establishment on some dates.

Background and expected deliverables

Two-spotted spider mite (TSSM) is increasingly a common pest of raspberry that can cause severe foliar damage, leading to cane stunting, reduced fruit size and subsequent yiled reduction. The current shortage of acaricides approved for use on outdoor & protected raspberry means that effective biological control of the pest within an Integrated Pest Management (IPM) programme is needed for all stages of the crop's production.

Plant protection products applied for the control of spotted wing drosophila (SWD) and other pests such as aphids and capsids, can have harmful effects on spider mite predators.

Naturally-occurring predatory mites including *Amblyseius andersoni* seem to be more tolerant of spray products than the released predatory mite *Phytoseiulus persimilis*. *A. andersoni* will also feed on pollen, fungal spores, plant sap and other invertebrates as well as on TSSM. In addition to occurring naturally, *A. andersoni* is also commercially available for release. Work on the continent has shown that *Typha* pollen (Nutrimite®) can boost populations of other omniverous predatory mites such as *Amblyseius swirskii* for control of thrips and whiteflies on other protected crops, by providing an alternative food source.

Nutrimite has not yet been tested on cane fruit crops but *A. andersoni* is known to feed on pollen and can be reared on *Typha* pollen in the laboratory. The work in this project aimed to determine whether Nutrimite can boost numbers of *A. andersoni* on a raspberry crop so that higher numbers survive sprays applied for control of SWD or other pests and thus benefit biological control of TSSM.

Summary of the project and main conclusions

This work set out to determine the effect of Nutrimite on numbers of both released *A. andersoni* and any naturally-occurring predatory mites that feed on TSSM on a raspberry crop. It also set out to determine the effect of plant protection products applied for the control of SWD and other pests on spider mite predators and biological control of TSSM on a raspberry crop with or without Nutrimite.

Four different treatments were tested on a commercial second year raspberry crop. Each treatment was applied to a different poly tunnel.

The treatments were:

- An untreated control
- Nutrimite applied to the crop four times every two weeks between 26 April and 7 June at 500g/ha
- *Amblyseius andersoni* applied at one sachet per two linear metres on 26 April and 7 June
- A combination of Nutrimite and *A. andersoni*

The grower released *Phytoseiulus persimilis* on 4 and 8 June and applied spinosad (Tracer) for control of SWD to all tunnels on 31 July, 29 August and 10 September. Assessments on Nutrimite deposition, numbers of TSSM, predatory mites, TSSM and predatory mite eggs, any other TSSM predators and TSSM damage were made on three randomly selected terminal leaflets from both the upper and lower canopies in ten replicate plots per tunnel (60 leaflets per tunnel) on eight dates between 26 April and 17 September.

Nutrimite was detected on both upper and lower leaflet surfaces in the two tunnels where it was applied but significantly more was found on the upper than the lower leaflet surfaces in the tunnel treated with both pollen and *A. andersoni.* This might have influenced the availability of alternative food for *A. andersoni* which lives on the undersides of leaves. *Amblyseius andersoni* were not found in any of the tunnels before they were released. Numbers of naturally-occurring *A. andersoni* were low throughout the trial in the untreated and pollen only tunnels and adding pollen to these tunnels did not increase numbers of the predators. However, adding pollen to the tunnel where *A. andersoni* was released led to significantly higher numbers of the predators than the naturally-occurring population in the control and pollen only tunnels on four assessment dates and led to significantly more than in the *A. andersoni* only tunnel on two dates. Although not consistent on all assessment dates, these results provide some evidence that adding Nutrimite improved the establishment of *A. andersoni* after release on some dates.

There were no significant differences in numbers of TSSM between any of the treatment tunnels. However, on 30 July, 7 August and 5 September, in the tunnel treated with *A. andersoni* and pollen, the mean percentage leaf area damaged by TSSM was significantly higher. This indicated that there had been more TSSM present in these tunnels at some point, possibly in between assessment dates, which could explain the higher numbers of *P. persimilis* in the tunnel treated with *A. andersoni* and pollen. *Phytoseiulus persimilis* established by 30 July by which time the TSSM population had crashed in all tunnels. Therefore the Tracer application programme starting on 31 July for SWD control did not disrupt biological control of TSSM. It is not possible to quantify the control of TSSM provided by *P. persimilis* or *A. andersoni* individually but it is likely that *A. andersoni* supplemented the control offered by *P. persimilis*. The naturally-occurring predators *Feltiella acarisuga*, *Stethorus punctillum* and *Orius* sp. were also found in low numbers and these will also have contributed to TSSM control.

Financial benefits

The estimated value of the UK raspberry crop is £122.2 million (Defra Horticulture Statistics 2018). Accurate figures for crop losses in both fruiting plantations and crops in propagation due to TSSM damage are not available, but even if only a mean of 5% crop losses occurred, annual losses amount to £6.11 million. If biological control of TSSM was disrupted, much higher losses are likely to occur due to the current absence of a 'fall-back' acaricide for use on protected & outdoor raspberry. Thus research on reducing the risk of disruption of biological control of TSSM could save the industry significant financial losses.

Action points for growers

- Aim to establish *P. persimilis* as early as possible and be aware of the contribution of naturally-occurring predators to the control of TSSM.
- Consider early release of *A. andersoni* for preventive TSSM control before temperatures are suitable for *P. persimilis* as this predatory mite is more tolerant of low temperatures and could give some control of other pests such as raspberry leaf and bud mite. However, released predators of this species may be less tolerant of certain plant protection products such as pyrethroids, than naturally occurring populations.
- Further work is needed before the use of Nutrimite® to boost numbers of *A. andersoni* for improved control of TSSM on raspberry can be recommended.
- Use IPM-compatible plant protection products or those with the least harmful effects on biological control agents for control of all pests including TSSM and SWD wherever possible.

Spray deposition

Objective 2.2 – To develop and maintain IPM approaches to successfully control two-spotted spider mite whilst controlling SWD and other pests with insecticides.

Headline

- Using very fine spray and half-rate air-assistance may provide slightly better distribution of spray deposition in a raspberry canopy, when sprayed at around 800 L/ha with an air-blast tractor mounted spray machine.
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Background and expected deliverables

Restrictions on the use of acaricides in raspberry production means that two-spotted spider mites (TSSM) are primarily controlled using beneficial insects rather than conventional spray products. However, populations of beneficial insects can be adversely affected by product sprays targeting other pests. Previous semi-field trials have shown that overhead spraying provides more spray refuges than air-assisted knapsack spraying, and that plots with more spray refuges had significantly more natural phyotseiids in them, but also more aphids.

On-farm spray trials were undertaken with a commercial tractor mounted air-blast sprayer to assess the effect of two key settings on spray machines that affect spray deposition: air-assistance and spray quality (droplet size). Farm spray machines are often set to generate a fine spray with air-assistance set to full speed. The trials investigated firstly how spray quality: very fine compared to medium sized droplets, and air-assistance: full rate or half rate, whilst maintaining the same water volume, affects spray deposition throughout the raspberry canopy. Secondly we investigated the effects that these sprayer settings have on the number of refuges for beneficial insects within the raspberry canopy.

Summary of the project and main conclusions

Field trials were done to assess the spray coverage, spray deposition, and distribution of spray throughout the crop canopy. The spray was applied to a raspberry crop in July, using an Ideal Alsazia spray machine at 840 L/ha, with either yellow Albuz ATR 80 nozzles (very fine spray quality) or blue ATR 80 nozzles (medium spray quality), and with the air-assistance set to full rate or half rate. Measurements were taken from the canopy in four zones: top, middle, bottom, and inner canopy (see Figure 1). At each of the zones, the spray deposition was measured on both upper and lower leaf surfaces.

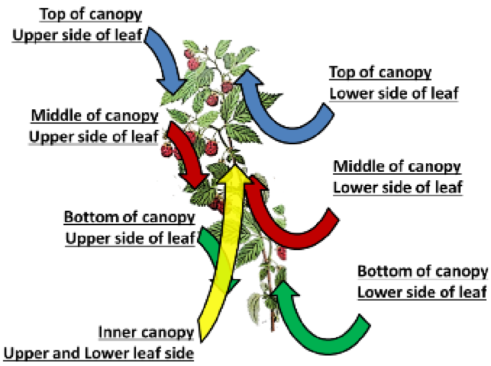

Figure 1: For measuring the spray deposits the raspberry crop canopy was divided into 4 zones: top (blue), middle (red), inner (yellow) and bottom (green). These were approximately 650 mm in height each. The inner zone was at the same height as the middle zone but in the centre of canopy. Within each zone the spray deposition on both sides of leaves was measured. Thus 8 groups of data were collected for each treatment.

Spray deposition (Figure 2) and volume of spray (Figure 30) were highly variable throughout the raspberry canopy. A common trend developed with lots of spray deposited at the top and middle sections of the canopy, much less deposition at the bottom of canopy, and very little deposition at the inner section of the canopy.

The very fine quality spray in combination with half-rate air-assistance spray settings provided a more even distribution of spray throughout the canopy, with significantly more spray coverage and deposition in the bottom and inner canopy sections. The medium quality spray in combination with half-rate air-assistance also partially increased spray deposition at the middle and inner canopy sections.

The percentage of leaves with less than 5 % spray coverage were assessed. Leaves that received less than 5 % coverage could provide a refuge for beneficial insects from product spray. Leaves that received less than 5 % coverage may also benefit pests such as aphids. Previous AHDB funded trials (SF 158, interim report 2018) on raspberry crops which had been sprayed with overhead nozzles to increase refuges for beneficial insects showed that aphid populations also increased.

Greater than 50 % of leaves sampled from the middle canopy section-lower leaf side, inner canopy-both leaf sides, and bottom canopy-lower leaf side received less than 5 % spray coverage, potentially providing many refuges for insects from product sprays. At these canopy-leaf sections, coverage was broadly the same for all of the spray settings assessed.

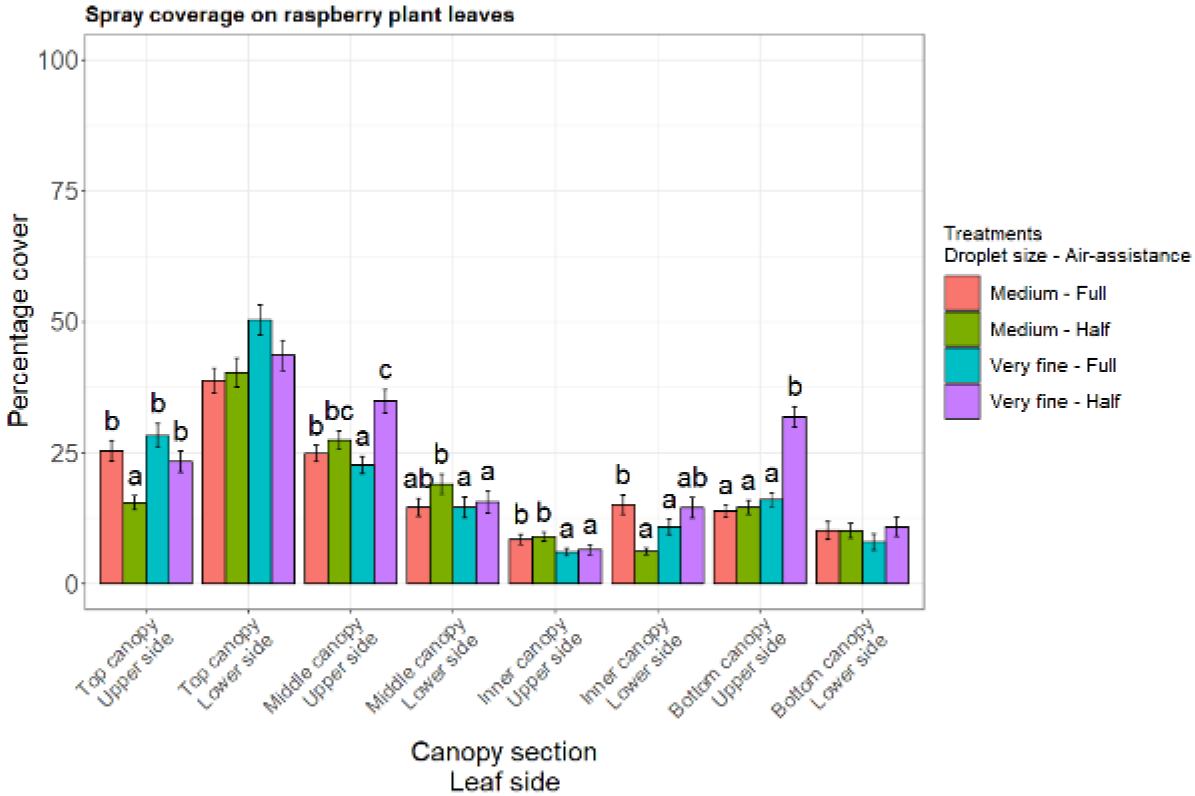

Figure 2: Percentage of leaf area covered with spray deposits at each canopy zone and leaf side, for each of the four spray treatments. The error bars show standard error. Significant differences were identified by GLMER and multiple comparisons Tukey's tests. If significant differences were identified, letter labels denote significant differences between the treatments within each canopy zone/leaf side.

Main conclusions

- Spray deposition was highly variable across the different parts of the raspberry canopy, in particular high coverage and deposition was found at the top and middle sections, whilst the inner and bottom sections of the canopy experienced much lower coverage and deposition.

- All of the spray settings tested provide a high number of leaves with less than 5% spray coverage. It is thought that these leaves could act as refuges for beneficial but also pest insect species.
- The results of this study suggest that using very fine spray and half-rate air-assistance may provide slightly better distribution of spray deposition in a raspberry canopy, when sprayed at around 800 L/ha with an air-blast tractor mounted spray machine.
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Financial benefits

The application of plant protective products (PPPs) (fungicides, herbicides, insecticides) in raspberry production can cost between £450 – £1,700 per hectare, depending on the cropping system. With additional costs for labour, fuel, machinery, water, etc. the cost for applying PPPs is substantial. Ensuring PPPs are applied in the most efficient way possible will minimise input costs and maximise returns. Growers should ensure that applied predatory mites are not adversely affected by sprays for other pests, and that the output from spray machines is efficient and hitting the intended target.

Action points for growers

- Minimise the exposure of beneficial mites (natural and released) to crop protection sprays. Even though spray machines are likely to provide a high number of 'spray refuges', *Phytoseiulus persimilis* and other predatory mites are known to be adversely affected by many active ingredients (e.g. spirotetramat, lambda-cyhalothrin, thiacloprid) .
- When product sprays are required, ensure the applications are as efficient as possible. Check the spray deposition produced by the farm's spray machines. Currently Water Sensitive Papers can be used to do this. Pay particular attention to the distribution of the spray deposition throughout the canopy and the location of the target pest or disease within the canopy. Adjust spray to match crop canopy development.
- Consider reducing the fan speed if spray is being blown right through or over the top of plant canopies.

If growers are considering modifying their spray machines to provide more spray refuges for beneficial insects, they must also take into account the risk of providing refuges for other pests, such as aphids. An alternative approach may be to check and optimise the spray output from their spray machines to maximise the effect of sprays, and then modify the timing of spray applications and applications of predatory mites to avoid damaging one with the other.

Cane blight

Objective 3 – To review the current threat posed to the UK raspberry industry by cane blight (*Leptosphaeria coniothyrium*) and identify new control options

Headline

- Control of cane blight in UK raspberries is of increasing importance and requires immediate attention due to the lack of available plant protection products and insufficient control of cane midge

Background and expected deliverables

A literature review was conducted to establish what information was available on the issue of *L. coniothyrium* in UK raspberry. Changes in practice to growing commercial raspberry has resulted in new windows of opportunity for pest and diseases, including *L. coniothyrium*, a relatively weak pathogen, and cane midge, which plays a role in introducing the disease to raspberry canes.

Financial benefits

The estimated value of the UK raspberry crop is £122.2 million (Defra Horticulture Statistics 2018). The levels of crop loss currently being caused by raspberry cane blight in the UK raspberry industry are currently unknown but are believed to be increasing. Potential damage can vary from 1% crop loss through to 90% in very severe cases, although this is very unusual. Some cultivars are more susceptible than others, but if the cultural practices of the day lead to damage of the prmocane rind and the weather conditions favour infection, damage can be very much more serious. Crop losses of as little as 1% would amount to a financial loss of £1.2 million to the industry. Any work that reduces the risk of this level of damage would therefore be very beneficial.

Summary of the project and main conclusions

Cane blight (*L. coniothyrium*) is a relatively weak pathogen and often requires damage to the cane in order to enter the plant. This includes mechanical damage from pruning, strimmer damage to cane base, frost damage, cold injury, hail and pest damage. The poor application of a desiccant (e.g. carfentrazone-ethyl - Shark) for primocane control can also give rise to cane damage which can become infected.

No new information on efficacy testing for *L. coniothyrium* on cane fruit is available, with no relevant Plant Protection Products available for growers in the UK. No work on epidemiology/spray timings/forecasting has occurred since previous AHDB funded work in 2006 (Projects SF 69 and SF 69a).
In other countries where cane blight is a major issue, such as in Canada, primary control is through the use of good crop husbandry and hygiene.

Action points for growers

- Monitor and control raspberry cane midge populations, to limit damage caused to the periderm tissue of primocanes and subsequent development of midge blight disease.
- Pinch off the tips of tender primocanes rather than cutting them, and ensure where possible, to prune when at least 4 days of dry weather is expected.
- Where canes are removed, ensure they are cut close to the ground, to avoid rubbing damage to newly emerging canes, which causes a wound for *L. coniothyrium* to enter.

