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Project leader:	Dr Carolyn Mitchell, SCRI
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Key staff:	Dr Jean Fitzgerald, EMR
Location of project:	SCRI, Invergowrie, Dundee, DD2 5DA EMR, East Malling, Kent, ME19 6BJ Thomas Thomson Ltd, Haugh Road, Blairgowrie, PH10 7BJ Euan McIntyre, Cruachan, Wester Essendy, Blairgowrie, PH10 6RA
Project coordinator:	Mr Peter Thomson, Thomas Thomson Ltd, Haugh Road, Blairgowrie, PH10 7BJ
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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.

[Name]
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[Organisation]

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[Name]
[Position]
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Report authorised by:

[Name]
[Position]
[Organisation]

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[Name]
[Position]
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Grower Summary

Headline

- Dynamec and the predatory mite *Amblyseius andersoni offer potential control measures for raspberry leaf and bud mite.*

Background and expected deliverables

The raspberry leaf and bud mite (*Phyllocoptes gracilis*) is becoming a serious pest in protected and semi-protected production in the UK. Severity of damage is dependent on environmental conditions and variety. One of the most commonly grown commercial raspberry varieties, Glen Ample, has been shown to be very susceptible. Damage can be extensive and result in considerable loss of crop quality and yield. Currently, there are few acaricides approved for use in cane fruit which offer control.

This project aimed to identify new control measures which are compatible with IPM and meet the demand for high quality, pesticide residue free fruit.

The expected deliverables from this work include:

- An evaluation of available acaricides for their effectiveness at controlling the raspberry leaf and bud mite and their effect on predator species.
- An assessment of the efficacy of predatory phytoseiid mites.
- An investigation into new approaches to managing mites under tunnel production.

Summary of the project and main conclusions

2007

Evaluation of acaricides and predatory mites

In 2007 several products were tested in a commercial plantation to assess their efficacy at controlling raspberry leaf and bud mite. These included Dynamec (abamectin), Masai (tebufenpyrad), Agri-50E (a seaweed based compound) and predatory mites (*Amblyseius andersoni*).

- Dynamec showed potential as a control method for the raspberry leaf and bud mite.

- Masai and Agri-50E displayed very variable results.

- The predatory mites were unsuccessful.

Varietal susceptibility

Varietal susceptibility was investigated in a mesh tunnel. Eight raspberry varieties and a hybrid were assessed. Malling Landmark and Tayberry were the most susceptible. Autumn Bliss was the least susceptible. It was hypothesised that leaf or bud morphology may be important in controlling susceptibility.

2008

Evaluation of acaricides at a commercial site

An experiment was set up at a commercial site to assess whether Dynamec on its own would be successful at controlling the raspberry leaf and bud mite or if a combination of products (Masai and Dynamec) were required to gain successful control. Unfortunately, the results were very variable and no conclusions could be drawn.

Evaluation of acaricides in a mesh tunnel

The efficacy of products was tested in a mesh tunnel to provide a more controlled environment. There were 4 different combinations of products tested; Dynamec, Dynamec with Agri-50E, Floramite and Floramite with Agri-50E.

- Dynamec greatly reduced the numbers of mites.

- The addition of Agri-50E did not further reduce mite populations.

- Floramite did not reduce numbers.

Mite performance study

Eight raspberry varieties and a hybrid were compared to identify any link between mite numbers and leaf hair density. The most susceptible variety Malling Landmark had the fewest leaf hairs, suggesting a correlation does exist.

Evaluation of predatory mites

A laboratory based evaluation of predatory mites was undertaken which studied the number of raspberry leaf and bud mites eaten by individual predatory mites over a four hour period. Three predatory mites were tested: (1) *Amblyseius andersoni*, (2) *Amblyseius cucumeris*, and (3) *Typhlodromus pyri*.

- All three predatory mites consumed the raspberry leaf and bud mite on raspberry leaf discs.

- *Typhlodromus pyri* and *A. cucumeris* consumed a mean of 8 and 9 raspberry leaf and bud mites out of 20 whereas *A. andersoni* consumed a mean of 17 out of 20 within 2 hours.

The full results of these experiments are set out in the science section of the report and is available from the HDC.

2009

Testing predatory mites at a commercial site

The efficacy of predatory mites at controlling raspberry leaf and bud mite was tested on a large scale at two commercial sites. Commercial sachets of *Amblyseius andersoni* (sold as Anderline aa - each Gemini sachet contains a breeding colony of 200-250 predator mites) were distributed every two metres along three rows in two tunnels at both sites. The number of mites on leaf samples picked randomly from the treated tunnels was compared with leaves sampled from two tunnels that had been subjected to the growers' own standard practice for leaf and bud mite control. Six leaf samples were collected throughout the season.

- After three samplings it was decided to treat all the tunnels with Dynamec as there were large numbers of leaf and bud mite in the tunnels.

- Overall the number of leaf and bud mite in the predator treated tunnels were higher than in the tunnels subjected to the grower's own standard practice.

Testing susceptibility of varieties and the efficacy of predatory mites in a mesh tunnel

This experiment was set up in a mesh tunnel using four different varieties: Malling Landmark, Glen Magna, Glen Moy and Latham. The success of the predatory mite (*A. andersoni*) was compared for the four varieties to identify any link between varietal susceptibility and predatory mite activity.

- The varieties varied in their susceptibility to the leaf and bud mite with Landmark having the most mites and Latham having the fewest.

- The plants treated with predators had far fewer leaf and bud mites, suggesting that in small scale controlled conditions, this predator is successful at controlling the raspberry leaf and bud mite.

- The predatory mites reduced raspberry leaf and bud mite numbers on all varieties suggesting that they are not affected by density of leaf hairs.

Predatory mite feed tests

The two-spotted spider mite (*Tetranychus urticae*) is also a pest of raspberry. Laboratory experiments were conducted to assess the effects of the presence of this pest on the consumption of raspberry leaf and bud mite by the predators; if this alternate prey is preferred by the predator it could influence its effectiveness as a biocontrol agent against raspberry leaf and bud mite. Since *T. pyri* was not the most effective predator in the initial experiments and it is not mass produced for artificial release, these experiments concentrated on *A. cucumeris* and *A. andersoni*.

- In tests where both spider mite and raspberry leaf and bud mite were present there was no apparent preference for either pest by either predator.

- The presence of other prey did reduce the number of raspberry leaf and bud mite consumed compared to the number consumed if they were the only prey present.

- From these laboratory test results, of the predators tested *A. andersoni* appears to have the greatest potential to reduce populations of raspberry leaf and bud mite.

- Although no overall preference for spider mites was seen the presence of alternative prey on plants will be likely to reduce the number of raspberry leaf and bud mite consumed.

Overall main conclusions

- Dynamec (abamectin) gives good control of the raspberry leaf and bud mite.

- In laboratory feeding tests the native UK predatory mite species *Typhlodromus pyri*, *Amblyseius cucumeris* and *Amblyseius andersoni* all consumed raspberry leaf and bud mites, but *A. andersoni* consumed greater numbers of the pest than the other two species.

- No overall preference for raspberry leaf and bud mite or the two-spotted spider mite was observed in either *A. andersoni* or *A. cucumeris*.

- *Amblyseius andersoni* greatly reduced the number of leaf and bud mite in a small scale experiment.

Financial benefits

There are no financial benefits from this work.

Action points for growers

- The acaricide Dynamec (abamectin) shows great potential in controlling raspberry leaf and bud mite in tunnel produced raspberries. Note that Dynamec is only approved for use under protection.

- The predatory mite *Amblyseius andersoni* shows potential as a control agent for the raspberry leaf and bud mite when tested in the laboratory and on a small scale so could be tested as a control option on growers' own sites using an Anderline aa Gemini sachet every 2 metres.

- Carefully consider raspberry varietal susceptibility to leaf and bud mite when planting in leaf and bud mite susceptible areas.

Science Section

Introduction

Distribution

The raspberry leaf and bud mite (*Phyllocoptes gracilis*) is widespread in Europe and North America. It is found on both wild and cultivated *Rubus* species: raspberry, blackberry, tayberry, loganberry, Himalaya berry, boysenberry and thimbleberry. Varieties vary in their susceptibility. For example, Malling Jewel and Glen Ample are thought to be very susceptible.

Description

The adult mites are 0.15 mm long and have 4 legs. The summer form is pale straw to translucent white and the overwintering form is brown.

Lifecycle

The females overwinter under bud scales and in petiole scars. When the new growth appears the mites emerge from their overwintering sites and migrate to new shoots and leaves where they live freely within the leaf hairs and lay eggs. Breeding continues throughout the summer and the numbers of mites increase. When the floricane leaves become mature the mites migrate to the primocane leaves.   If very high populations are present the berries become infested. During autumn, at the beginning of leaf fall, the mites move to the overwintering sites. The population peaks in mid-summer on the floricanes and also in early autumn on the primocane. At 25°C, the life-cycle can be completed in 14 days, which means that there are many generations per year.

Damage

The symptoms observed are very dependent on the age of plant at the time of infestation and the environmental conditions. An infestation during early development of leaves results in pale green areas that later turn into noticeable and irregular chlorotic blotches. Leaf hair development beneath the patches is arrested and the appearance of these areas changes from greyish to light green. The growing leaves can become distorted and twisted. If an infestation occurs on berries it causes a rapid development of drupelets, premature ripening and drying. Apical buds of young canes can be killed which causes weak branched lateral shoots. Infestations are most severe in sheltered conditions.

Sources of infection

In summer a migratory form is produced about harvest time. These either walk from leaf to leaf to infest new canes or can travel on air currents to spread further afield. Mites can also be spread on the bodies of other animals or on workers hands and clothing.

The use of predatory mites

In a report on potential biocontrol agents for a range of soft fruit pests (HDC SF 66), Fitzgerald *et al*. (2005) suggested that predatory phytoseiid mites should be assessed for their effectiveness against raspberry leaf and bud mite. In the UK the introduction of non-native species into the environment is not permitted without a licence, and this can only be obtained after extensive research to ensure that no damage to native species is likely to occur as a result of the introduction. Therefore only native UK species were considered for testing in these experiments. The UK native predator *Typhlodromus pyri* is an effective biocontrol agent against the fruit tree red spider mite, *Panonychus ulmi*, in apple (reviewed in Solomon *et al*. 2000), and has also been shown to reduce populations of the apple rust mite, a species that is closely related to raspberry leaf and bud mite. The commercially produced species *Amblyseius* (*Neoseiulus*) *cucumeris* and *A. andersoni* are also UK native species. They occur naturally in some soft fruit plantations but can also be released in large numbers. *Amblyseius cucumeris* is currently sold for control of tarsonemid mites in strawberry and thrips on a range of crops, whereas *A. andersoni* is sold as a spider mite predator. No comparisons of the consumption rates of the different predator species on raspberry leaf and bud mite had been made so it was not clear which, if any, of the species available would be useful as biocontrol agents for this pest. The project includes feeding tests with the aim of determining if predatory phytoseiid mites could contribute to biocontrol of raspberry leaf and bud mite.

The overall aim of this project is to identify strategies of controlling this pest which are compatible with IPDM strategies. At present there is very little knowledge of suitable acaricides or phytoseiid predatory mites which are successful in controlling mite numbers.

Summary of the previous two years work

2007 work

Evaluation of acaricides and predatory mites

Chosen acaricides and predatory mites were tested in four tunnels in a commercial plantation. The following treatments were applied:

- The acaricide Masai (tebufenpyrad) used alone
- Masai used in combination with released predatory mites (*Amblyseius andersoni*)
- A seaweed derived compound, Agri-50E used alone
- Agri-50E used in combination with predatory mites
- A newly approved acaricide, Dynamec (abamectin), which was approved for use in covered raspberry in August 2007.

Leaf samples were taken to assess the number of mites in both treated and untreated areas. Bud samples were also assessed to determine the number of mites overwintering after each treatment.

Results showed that the treatments had variable effects on mite numbers, which also varied between the four experimental tunnels. Overall the application of Masai reduced the number of leaf and bud mites on one sampling date but this reduction was not seen on another sampling date. Although Dynamec was used late in the experiment, it showed potential as an option for controlling raspberry leaf and bud mite as it reduced the number of leaf and bud mites on the sampled leaves. The predator application was not successful and an increased knowledge of the interaction between the predator and the leaf and bud mite would be required before it could potentially be used as a biological control option.

Varietal susceptibility

Varietal susceptibility was also tested in 2007 and an experiment to test variety preferences was set up using small plants in an experimental gauze house. Eight varieties were used: Glen Ample, Malling Delight, Glen Moy, Malling Landmark, Autumn Bliss, Glen Prosen, Malling Jewel and a hybrid, Tayberry.

Plants were inoculated with 20 raspberry leaf and bud mite and destructively sampled on three dates to show:

1. How well the mites colonise plants with the technique used
2. Any differences in susceptibility of the varieties
3. Any varietal differences in the number of mites overwintering in the buds.

The results showed that that there were no significant differences in the number of mites surviving the inoculation and that the number surviving was low. The data from the other two sampling dates suggest that the most susceptible varieties were Tayberry and Malling Landmark and the least susceptible was Autumn Bliss. From the results it was hypothesized that leaf or bud morphology was very important in determining the susceptibility of the variety.

2008 work

Evaluation of acaricides at a commercial site

An experiment took place to discover whether one acaricide alone would be sufficient to provide control of the leaf and bud mite or whether a combination of acaricides would be more effective. Two acaricides were evaluated in three tunnels at a commercial plantation. One tunnel was treated with Masai (tebufenpyrad) and Dynamec (abamectin) another tunnel was treated with Dynamec and a third tunnel was left untreated. Leaf samples were taken to assess the level of mite infestation prior to treatment and to assess the efficacy of the acaricides after treatment. The results were disappointing as there was great variation in the number of mites and therefore no conclusions could be drawn from the results.

Evaluation of acaricides in a mesh tunnel

Acaricides were also tested in an experimental mesh tunnel to provide more control over the experimental conditions. An experiment was set up in an experimental mesh tunnel to test six different treatments which were applied to small individual plants that had been inoculated with raspberry leaf and bud mite. The six treatments were Dynamec, Floramite, Dynamec plus Agri-50E, Floramite plus Agri-50E, chemical free with mites and chemical free without mites.

Bud samples were collected and the number of overwintering mites counted. From the results it could be concluded that Dynamec greatly reduced the number of overwintering mites. The addition of Agri-50E did not further reduce the numbers. Floramite had no effect on mite numbers.

Mite performance study

An experiment to test mite activity and performance on different varieties was set up using small plants in an experimental mesh tunnel. Eight varieties were used: Glen Ample, Glen Rosa, Glen Magna, Glen Moy, Malling Landmark, Octavia, Malling Jewel and a hybrid, Tayberry. Plants were inoculated with 20 raspberry leaf and bud mites and the number of mites overwintering in the buds was recorded. The morphology of the underside of the leaf hair was studied by observing thin leaf sections under a microscope and categorizing the hairiness of the leaves. The greatest number of mites was found on Malling Landmark and Glen Ample and these varieties also had the least amount of hair. Tayberry also had very few hairs but the number of overwintering mites was found to be low. Tayberry is reported to have high levels of infestation in the field. It is unclear why the discrepancy in the findings occurred.

Evaluation of predatory mites

A laboratory based evaluation of predatory mites was undertaken which studied the number of raspberry leaf and bud mites eaten by individual predatory mites over a four hour period. Three predatory mites were tested: *Amblyseius andersoni*, *Amblyseius cucumeris* and *Typhlodromus pyri*.

Analysis showed that there were significant differences between predators for consumption of raspberry leaf and bud mites ($P<0.01$). In the two hour period *A. andersoni* consumed significantly more than the other two species. *Amblyseius cucumeris* and *T. pyri* consumed similar numbers of raspberry leaf and bud mites in this period. Mean numbers consumed by the different predator species were 17, 9 and 8 respectively out of 20 RLBM prey. These results show that all three predator species will consume raspberry leaf and bud mite, and that *A. andersoni* was the most effective predator in terms of numbers of the pest consumed over a short period.

2009 work

Testing predatory mites at a commercial site

To assess the potential of using the predatory mite (*A. andersoni*) on a large scale, Anderline aa sachets were tested in two leaf and bud mite infested commercial plantations. Little information was known about using them for raspberry leaf and bud mite so knowledge obtained from previous experiments and from other target pest species was used to develop a strategy for application timing and density.

Testing susceptibility of varieties and the efficacy of predatory mites in a mesh tunnel

This experiment was set up to compare the success of the predatory mite (*A. andersoni*) on four varieties to access any interaction between the susceptibility of the variety to leaf and bud mite and the success of the predatory mite. It was hypothesised that the density of leaf hairs on the underside of the leaf, which has already been shown to affect the susceptibility of the variety to the leaf and bud mite, may also affect the success of the predatory mite.

Predatory mite feeding experiment

Laboratory experiments were set up to assess effects of the presence of the glasshouse red spider mite (*Tetranychus urticae*), which is also a pest of raspberry, on the consumption of raspberry leaf and bud mite by the predators; if this alternate prey is preferred by the predator it could influence its effectiveness as a biocontrol agent against raspberry leaf and bud mite.

Materials and methods

Testing predatory mites at a commercial site

Treatment	Details	Registration status
Dynamec (Syngenta Bioline)	**Active ingredient** – abamectin **Spray rate** – 25 ml/ 100 litre water	**SOLA No 2290/2007** Protected crops of blackberry, raspberry (not between 1st Nov and end of Feb
Anderline aa (Syngenta Bioline)	**Contents** – *Amblyseius andersoni* **Application info –** Gemini sachet - hang every 2-4 metres. Each Gemini sachet contains a breeding colony of 200-250 predator mites Mini sachet - hang every 2 metres in crop Sachet activity last 6 weeks Shaker tube – contains 1 litre (25,000 mites)	not applicable

Table 1. Details of the products used

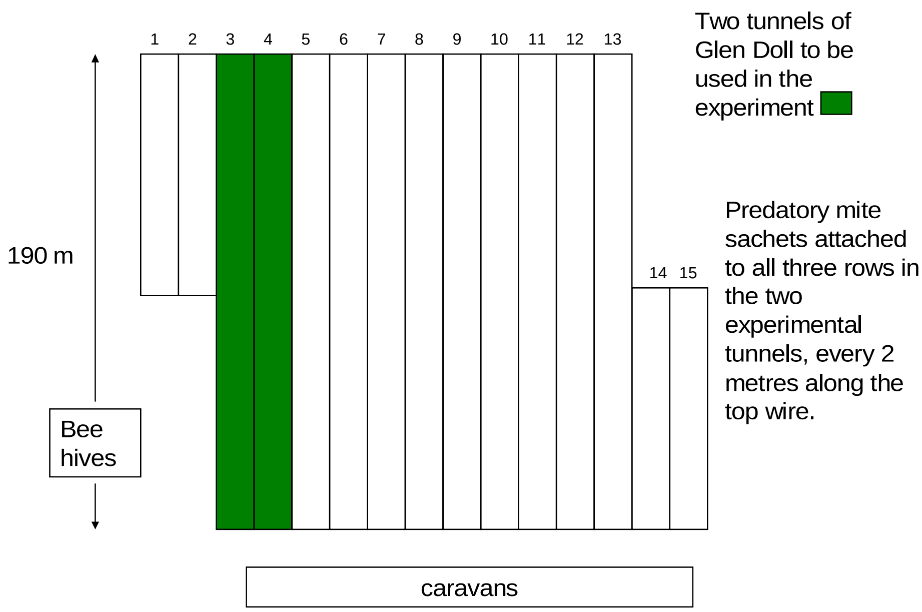
Two sites were used in the experiment:

- Site 1: Peter Thomson, T Thomson Ltd. Haugh Road, Blairgowrie PH10 7BJ (Glen Doll)
- Site 2: Euan McIntyre, Cruachan, Wester Essendy, Blairgowrie PH10 6RA (Glen Ample) (See Figure 1)

The development of the plants was observed weekly to predict emergence of the raspberry leaf and bud mite. At emergence, predatory mite sachets (Anderline aa Gemini sachets) were positioned along all three rows in two tunnels at each site. A density of 1 sachet every 2 metres was used. On three sampling dates, leaf samples were taken to access the effectiveness of the treatment. These leaves were removed by randomly choosing forty leaves along the length of each of the two treated rows at both sites. Forty leaves were also removed from two additional tunnels at each site to allow a comparison. The leaves were placed in plastic bags and kept chilled until they were processed.

It was decided that the numbers of leaf and bud mite were too high at both sites and the experimental tunnels were treated with an acaricide to kill the mites and then the tunnels were re-inoculated with predatory mites (Anderline aa Mini sachets). More leaf samples were taken on three dates to assess the effectiveness of the treatment. (All the treatment dates can be found in Table 2)

Site 1



Site 2

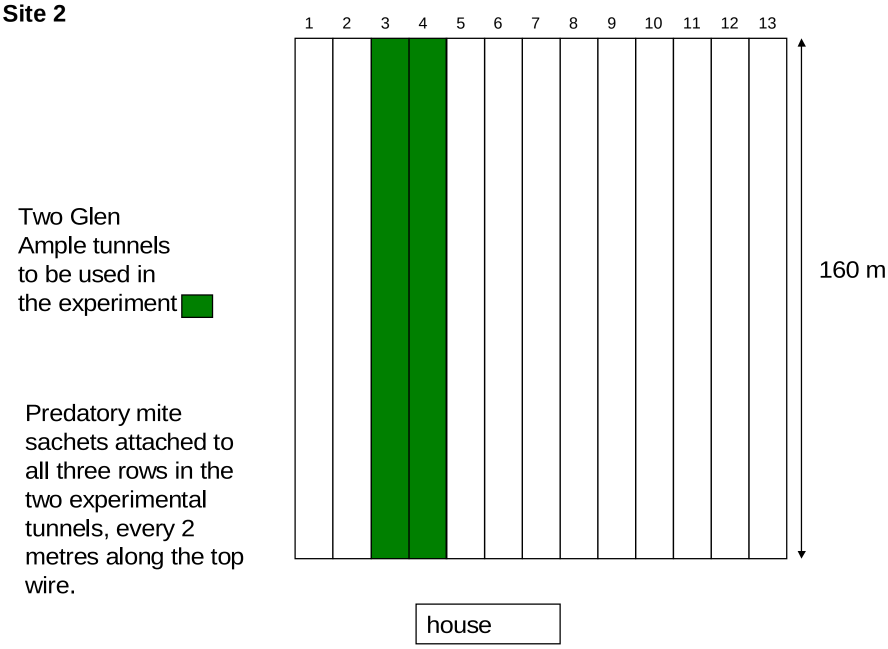


Figure 1. Layout of the experiment at the two sites

Processing leaf samples

The mites were removed from leaf samples using a sonic bath (Branson 2510) containing water. Ten small beakers were filled with 60 ml of 40% ethanol and placed in the sonic bath. The stems were carefully removed and a leaf was positioned in each of the beakers ensuring that they were completely submerged. The sonic bath was turned on for 40 secs and the leaves were checked to ensure that they remained completely submerged. The beakers were removed from the sonic bath and the underside of each leaf was rinsed into the beaker with 40% ethanol. The beakers were left undisturbed for 30 mins to allow the mites to settle at the bottom of the beaker. The top layer of alcohol from the beaker was carefully poured off the sample and the remaining 20 ml was poured into a glass vial which had been labeled with the date and treatment information.

Counting the mites

The mites were counted using a Doncaster dish under a dissecting microscope. A sample vial was carefully poured into the dish and the mites were allowed to settle to the bottom of the dish.

Statistical analysis - Differences in the number of mites between sites was investigated using a Mann-Whitney U test. Differences between treatments were analysed using a Poisson GLMM for each date with treatment as a fixed effects and site as a random effect. The dispersion parameter was set to 1. The maximum value at each date was omitted in the analysis.

Event	**Date**
Sachets positioned in plantation	9th April
Leaf sample	28nd April
Leaf sample	7th May
Leaf sample	20th May
Dynamec application – Site 1	1-5th June
Dynamec application – Site 2	11th June
Sachets positioned in plantation	26th June
leaf sample	26th June
leaf sample	23rd July
leaf sample	26th Aug

Table 2. Dates of leaf sampling and Dynamec application

Testing susceptibility of varieties and the efficacy of predatory mites in a mesh tunnel

Small raspberry plants were set up in a mesh tunnel in randomized blocks. Four varieties were used: Glen Moy, Glen Magna, Landmark and Latham. There were three different treatments:

- (a) Plants only inoculated with leaf and bud mite
- (b) Plants inoculated with leaf and bud mite and predatory mite (*A. andersoni*)
- (c) Control plants

Due to time limitations the control plants were not accessed but visual observations suggested that the mites were absent from these plants. Treatments (a) and (b) were inoculated with 15 leaf and bud mites by clipping an infested fragment of leaf onto the underside of a leaf of the plant. Four weeks after inoculation, treatment (b) was treated with the predatory mite (Anderline aa shaker tube). In March, the number of overwintering mites in the buds was assessed by slowly peeling back the layers of the buds and counting the number of overwintering mites. (Table 3 shows the dates of inoculation and assessment).

Statistical analysis - A generalised linear mixed model analysis with a logarithm link function was used to analyse the data.

Event	**Date**
Position plants in tunnels	19 May
Inoculation with leaf and bud mite	25th-26th May
Treatment with predatory mites	24th June
Overwintering mite assessment	15th – 26th March

Table 3. Dates of inoculation and assessment

Predatory mite feeding tests

Raspberry leaf and bud mites were obtained from raspberry plants showing signs of damage in field plantings at East Malling Research. Adult mites were used in arena feeding experiments. Spider mites (*Tetranychus urticae*) were obtained from infested strawberry plants held in a glasshouse; young immature stages were used in the experiments. Since *Typhlodromus pyri* was not the most effective predator in the 2008 experiments (and it is not mass produced so would be difficult for growers to manage) this species was not used in the experiments in 2009. *Amblyseius cucumeris* were obtained from Certis BCP, Wye, Kent. *Amblyseius andersoni* were obtained from Syngenta Bioline. Commercially produced predators were ordered as required for the feeding tests. Adult female mites were used in the feeding tests and predators were starved for 24 hours before the experiment.

Raspberry leaf and bud mites are most often found on the lower surfaces of raspberry leaves. Since these leaves have many hairs and deep crevices along their mid ribs it is often difficult to count the mites accurately. For feeding tests it is necessary to be able to make multiple records of pest numbers over time. Because of this the arenas made use of the less hairy upper surface of raspberry leaves. Each experimental arena consisted of a 12 mm diameter leaf disc cut from an uninfested raspberry plant. This was placed upper surface uppermost on filter paper above black capillary matting inside a 5.5 cm diameter Petri dish. The filter paper/capillary matting was moistened with water to prevent desiccation of the leaf disc and to reduce movement of mites from the leaf disc arena.

There were three prey treatments:

- raspberry leaf and bud mites alone
- spider mites alone
- raspberry leaf and bud mites plus spider mites

Ten of each prey were used on each arena. Thus for the combined prey treatment there were 20 prey items present. Adult raspberry leaf and bud mites were transferred to the experimental leaf arena using an eyelash glued to the end of a match stick. Young spider mites were transferred from infested strawberry plants using a fine paintbrush. A single predator was then placed on each leaf disc, and numbers of prey consumed and predators remaining on the discs were recorded after 2 hours using a stereo microscope. There were 15 replicates of each treatment for *A. cucumeris*. For *A. andersoni* there were 19 replicates of the combined prey treatment, 15 of the spider mite alone treatment and 20 for the raspberry leaf and bud mite alone treatment (these differences were due to losses of the predator from some arenas within the 2 hour test).

Statistical analysis - Numbers of each prey consumed in the mixed prey treatment were analysed to determine if there were preferences of the predators for particular prey. Numbers of each prey consumed in the mixed prey treatment were then compared with numbers consumed in the single prey treatments to assess the effects of alternate prey on consumption of each pest.

Results

Large scale testing of predatory mites

There were significant differences in the number of mites at the two sites (P<0.001). The data from the corresponding tunnels at the two sites were combined to allow analysis of the treatment. The 4 treatments were Predator treated tunnels 1(one tunnel treated with predators at each of the sites), Predator treated tunnels 2 (the second tunnel treated with predators at each site), Standard tunnels 1 (one tunnel at each site with standard acaricide treatment) and Standard tunnels 2 (a second tunnel at each site with standard acaricide treatment). Analysis of treatment with the two sites combined can be seen in Table 4, which gives the predicted values for the 4 treatments, their standard error and p-value. For samples collected on dates 28 April to 20 May there are no differences between treatments. Results for the last three dates are given below.

Date	**Predator treated tunnels 1**	**Predator treated tunnels 2**	**Standard tunnels 1**	**Standard tunnels 2**	**S.E.**	**significance**
26 June	0.0000	-0.6022	0.0690	-0.8899	0.2734	0.001
23 July	0.0000	-0.5638	0.1713	-0.2569	0.1162	<0.001
26 August	0.0000	-0.5200	-3.7310	-2.4420	0.0939	<0.001

Table 4. Predicted values for the 4 treatments, their standard error and p-value for samples collected between 26 June and 26 August.

On 26 June, the predator 1 and standard 1 tunnels had significantly higher mean numbers of mites than the standard 2 tunnel. On the 23 July, the predator 1 and standard 1 tunnels had significantly higher mean number of mites than the predator 2 tunnel. On the 26 August the predator 1 and predator 2 tunnels had significantly higher mean number of mites that standard 1 and standard 2 tunnels. (See Figure 2)

Due to the nature of the data was not possible to formally test for differences between dates. Table 5 shows that the maximum numbers of mites increased until 26 June, then increased again until the end of the experiment. The median values for numbers of mites also increased with time for the predator treated plants.

	Predator tunnels 1		Predator tunnels 2		Standard tunnels 1		Standard tunnels 2	
date	maximum	median	maximum	median	maximum	median	maximum	median
28 April	5	0	10	0	4	0	3	0
7 May	26	0	4	0	1	0	2	0
20 May	22	2	12	2	21	0	12	0.5

26 June	6	0	5	0	15	0	2	0
23 July	33	1	18	1	67	0	24	0
28 Aug	467	13	182	2	16	0	42	1

Table 5. Maximum and median values

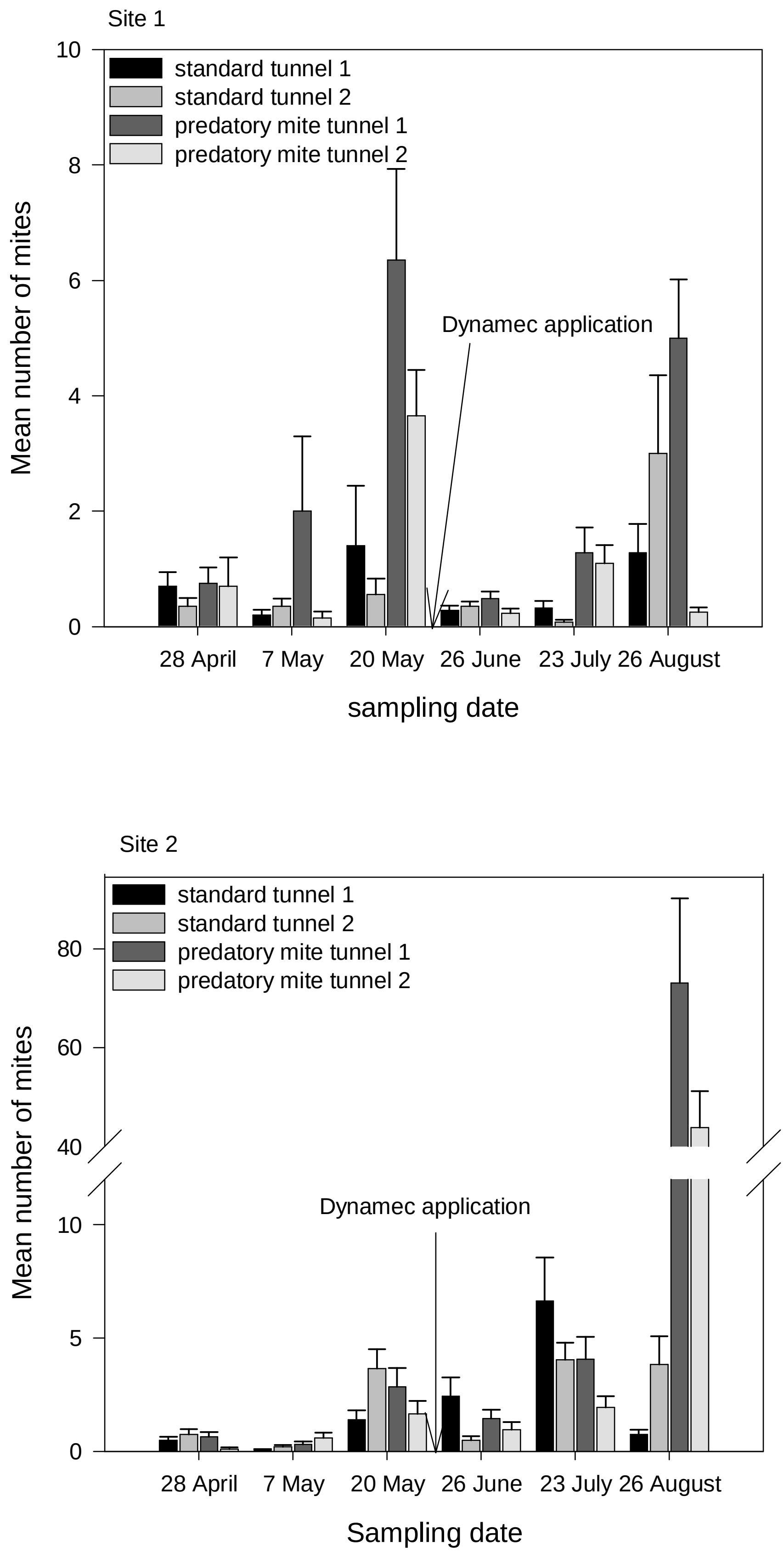


Figure 2. The mean number of raspberry leaf and bud mite on leaf samples collected in the four experimental tunnels

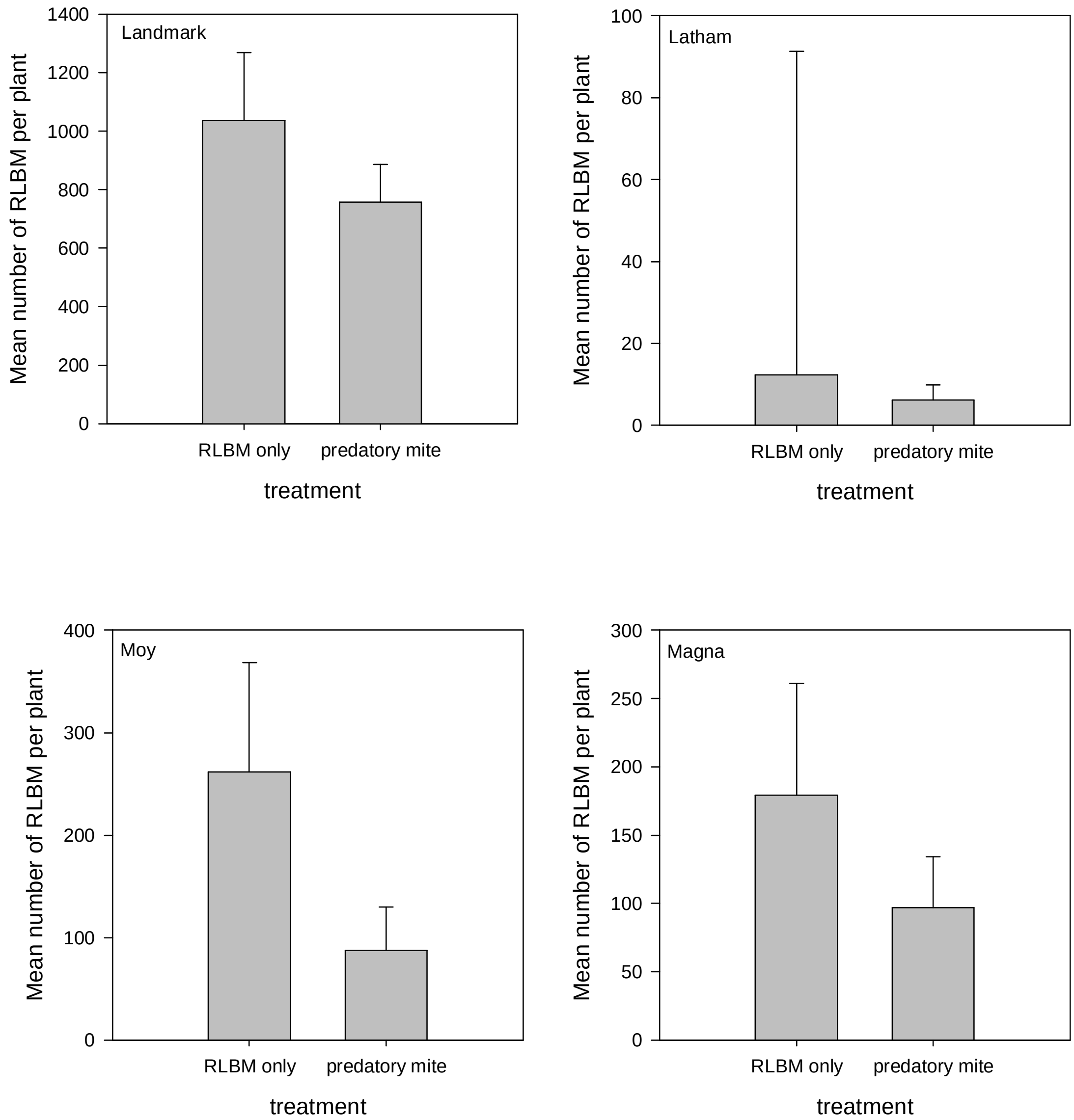


Figure 3. The mean number of overwintering leaf and bud mite on plants treated or not treated with *A. andersoni*

Predatory mite trial in mesh tunnel

Amblyseius andersoni predator treated plants had significantly (F= 4533.90; P<0.001) less RLBM than the plants that were not treated with predators. There were significant differences (F=915.12; P<0.001) in the number of RLBM between varieties with Landmark having significantly more RLBM than the other three varieties. Latham had significantly less RLBM than the other three varieties. There was no significant difference between Magna and Moy. There was also a significant interaction (F=107.43; P<0.001) between variety and treatment. (See Figure 3)

Predatory mite feeding tests

When a mixture of prey was presented, both *A. cucumeris* and *A. andersoni* consumed similar numbers of each of the prey species. There was thus no evidence of a preference for prey by either predator. Results are shown in Table 6.

Prey	***A. cucumeris***	***A. andersoni***
Raspberry leaf and bud mites	2.44	3.53
Glasshouse spider mites	2.50	4.00
P	0.90	0.37
LSD	1.09	1.07

Table 6. Mean numbers of each prey consumed by *A. cucumeris* and *A. andersoni* when they were presented together in laboratory feeding tests

Amblyseius cucumeris consumed as many spider mites in the presence of raspberry leaf and bud mites as in their absence (Table 7). However, significantly more spider mites were consumed by *A. andersoni* in the presence of raspberry leaf and bud mites than in their absence.

Prey	***A. cucumeris***	***A. andersoni***
Spider mites alone	1.93	1.85
Spider mites + raspberry leaf and bud mites	2.50	4.00
P	0.47	0.012
LSD	1.57	1.64

Table 7. Numbers of spider mites consumed by each predator when presented alone or together with raspberry leaf and bud mites

Both predator species consumed approximately half as many raspberry leaf and bud mites in the presence of spider mites as when raspberry leaf and bud mites were present alone (Table 8). This is consistent with the lack of prey preference exhibited by both predators in the results shown in Table 6.

Prey	***A. cucumeris***	***A. andersoni***
Raspberry leaf and bud mites alone	5.67	6.05
Raspberry leaf and bud mites + spider mites	2.44	3.53
P	0.003	0.004
LSD	2.02	1.69

Table 8. Numbers of raspberry leaf and bud mites consumed by each predator when presented alone or together with spider mites

Discussion

There was a great amount of variation in the results obtained from the large scale experiment but overall the results suggest that the *Amblyseius andersoni* predator mite treatment did not have any effect on RLBM numbers. During the first three sampling dates, there was no difference between the four tunnels and therefore, it was decided to treat the predatory mite treated tunnels with Dynamec in order to reduce the numbers of RLBM. This decrease can be seen in figure 2 but the numbers are not reduced to zero indicating that more than one application of Dynamec may be needed for the best results. It was hoped that with the low numbers of RLBM the predators would have more success at control the numbers. Unfortunately, this was not the case and the numbers of RLBM increased during the last three sampling dates. The results show that at present, the *Amblyseius andersoni* predator is not suitable for use in large scale treatment of RLBM.

In the mesh tunnel experiment where four different varieties were used, there were significant differences between varieties showing that there are differences in susceptibility between varieties. The predator treatment applied did manage to significantly reduce the number of RLBM in all four varieties showing that the predatory mite *Amblyseius andersoni* works effectively on a variety of varieties. The susceptibility of the variety to RLBM is thought to be linked to leaf trichome density but the predatory mites do not appear to be effected by the trichomes.

Interactions with other mite species were tested in the laboratory. It was shown that *A. cucumeris* consumed as many spider mites in the presence of RLBM as in their absence. However, significantly more spider mites were consumed by *A. andersoni* in the presence of RLBM than in their absence; there is no obvious explanation for this, although it is possible that the presence of RLBM influenced the behaviour of *A. andersoni* or spider mites, such that encounter rates were increased. Both predator species consumed approximately half as many RLBM in the presence of spider mites as when RLBM were present alone.

These results indicate that the presence of alternative prey is likely to reduce the effectiveness of the predators against RLBM. However, in work on strawberry, Fitzgerald *et al*. (2008) showed that a range of predatory and phytophagous mite species occupied different niches on the strawberry plant. Further work is needed to determine if this is also the case on raspberry and if so, to determine how this may affect biocontrol of mite pests.

From these experiments it can be concluded that under small scale controlled conditions, *A. andersoni* can significantly reduce the number of RLBM but in large scale trials where conditions cannot be controlled they are not yet successful. Further knowledge about application times, rates and interactions with other mite species need to be further investigated before it can be successfully used on a large scale.

Conclusions

- Dynamec (Abamectin) provides good control of the raspberry leaf and bud mite, although one application does not give complete control.
- There are differences in susceptibility of raspberry varieties to raspberry leaf and bud mite with Landmark being the most susceptible and Latham being the most resistant. This has been linked to leaf trichome density.
- Laboratory feeding results show that of the predators tested, *Amblysieus andersoni* appears to have the greatest potential to reduce populations of raspberry leaf and bud mites.
- *A. andersoni* was also shown to reduce mite numbers on small raspberry plants in a mesh tunnel and was not shown to be affected by variety.
- However, in a large scale trial, *A. andersoni* was not successful, showing that more research is required before this predator can be used to control the raspberry leaf and bud mite on commercial farms.
- Although no overall preference for spider mites was seen, the presence of alternative prey on plants will be likely to reduce the number of raspberry leaf and bud mites consumed and thus reduce the effectiveness of biocontrol of this pest by predatory mites.

Technology transfer

An old enemy returns to raspberries. HDC News, June 2007

Presentation at the EMRA/HDC technical up-date on soft fruit research. East Malling Research, Kent. 11 November 2008.

Presentation for the SSCR soft fruit committee. SCRI, Dundee. 25 February 2009.

Mite on mite. HDC News, May 2009

Leaf and bud mite comes under control. HDC News, April 2010

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Fitzgerald, J.D., Xu, X., Pepper, N., Easterbrook, M.A. & Solomon, M.G. 2008. The spatial and temporal distribution of predatory and phytophagous mites in field-grown strawberry in the UK. Experimental and Applied Acarology 44, 293-306.

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