Project Title:	Evaluation of acaricides for the control of blackberry mite (*Acalitus essigi*) to reduce red berry disease on blackberry
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East Malling Research is an officially recognised efficacy testing station and this work is registered as study number ORETO 2010/007

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.

Professor Jerry V Cross
Research Leader
East Malling Research

Signature .... Date ....

Report authorised by:

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CONTENTS

GROWER SUMMARY

Evaluation of acaricides for the control of blackberry mite (*Acalitus essigi*) to reduce red berry disease on blackberry

Headline

Red berry disease is caused in part by blackberry mite and can be partially controlled by acaricides.

Background and deliverables

Red berry disease is causing serious damage and losses in commercial blackberry plantations in the UK, especially in high value crops grown in tunnels. A proportion of drupelets, often those at the base of the fruits round the calyx, remain greenish or reddish and hard whilst the remaining drupelets ripen normally attaining their normal black colouration at maturity. Red berry disease is thought to be caused by the blackberry mite, *Acalitus essigi* (Eriophyidae), which feeds on the flowers (and foliage) injecting toxic saliva into the developing drupelets. The problem has been known for many years but was not significant till the incidence of damage in most UK commercial blackberry plantations dramatically increased and it became the most serious problem in commercial growing. The upsurge in damage coincided with the loss of the fungicide tolylfluanid (Elvaron Multi), a fungicide with known acaricidal properties against Eriophyid mites, including pear leaf blister mite and apple and pear rust mites. Blackberry mites overwinter beneath bud scales and invade the new growth, living and increasing on the flower buds, petioles and leaves. At blossom time they enter the flowers and feed on the developing drupelets, especially those sheltered by the calyx. As fruits mature they become less suitable for mite feeding and at harvest it is often difficult to find mites in the damaged fruits. For this reason it is often difficult to diagnose blackberry mite as the cause of the problem, as uneven ripening may also be caused by poor pollination. The extent of blackberry mite infestation in UK blackberry crops needs to be determined and effective means of monitoring and controlling this pest need to be developed.

Summary of the project and main conclusions

In 2010, the first year of a 2-year HDC project, a survey of populations of blackberry mite in dormant buds from 28 commercial blackberry plantations and an acaricide trial evaluating acaricide treatments for control of blackberry mite and red berry disease were conducted. The acaricide treatments evaluated were; (1) a full seasons fortnightly spray programme of sulphur; (2) a full seasons fortnightly programme of sprays of Codacide oil; (3) two sprays of Dynamec at the start of flowering and 2 weeks later; (4) treatment 1+3 combined; (5) treatments 2+3 combined; (6) untreated control (double replicated). The trial was conducted in polytunnel protected crops of four different blackberry varieties (Loch Tay, Carmel, Chester Thornless, Loch Ness), two at each of two farms (Salmans Farm, Penshurst, Kent; Belks Farm, Otham, Kent). The main findings and conclusions of the first year's work are as follows:

- Overwintering blackberry mites were found in only 10 of 28 samples of 50 dormant buds collected from 28 commercial blackberry plantations in February-March 2010. The highest number found was 0.36 mites/bud. The mites were found mainly beneath the outer bud scales. Numbers were not related to the very considerable losses of fruit due to red berry disease suffered by growers in the preceding season.

- Results suggest that a larger sample of 100 or more buds per plantation, taken from the tops of the canes, would be preferable and that presence or absence of mites under the outer scale of each bud, to give a % buds infested value, might be more useful and cost-effective and reliable.

- In the acaricide trials, there was no obvious relationship between the numbers of mites found in the overwintering buds and the populations that developed subsequently on untreated controls.

- The blackberry mites remained mainly beneath the outer scales of the overwintering buds and were found there in largest numbers throughout the season. Only when mite numbers started to increase in May/June were any mites found at the base of the petioles further up the shoots, and then only in very small numbers.

- No mites were found at any time in the flowers or fruits in any of the varieties, even in the variety Carmel which had the highest mite numbers.

- All the acaricide treatments performed equally well in reducing blackberry mite on the 3 infested varieties (Loch Tay, Carmel, Chester Thornless), and in reducing red berry disease and increasing yield but no individual spray treatment had consistently the lowest numbers of mites, so no optimum treatment was apparent.

- None of the treatments eliminated the mites. This is not surprising because the acaricides tested are contact acting and most of the mites were present under the bud scales where they would be inaccessible directly to sprays.

- Of the treatments tested, the Codacide spray programme appears to be the best for growers, though early applications, when mites are still under the bud scales, may be of little benefit. Sulphur leaves unsightly deposits, might be phytotoxic, and should not be used, especially during fruiting. Dynamec is probably harmful to predatory Phytoseiid mites which are likely to be important natural enemies of blackberry mite and may exacerbate the problem in the longer-term.

- The sulphur deposits that resulted from the full seasons fortnightly programme of sulphur sprays substantively detracted from the visual quality of the fruit whereas the full seasons Codacide spray programme enhanced it, compared with the untreated control. From this point of view, a full spray programme of sulphur sprays is not acceptable, though a small number of applications well before harvest may be acceptable. Measurements of plant growth and fruit size were not taken, but it is suspected that the sulphur spray programmes may have been reducing leaf size and berry weight.

- All the spray treatments reduced the % fruits with red berry disease significantly on Loch Tay, Carmel and Chester Thornless, but there was no reduction on Loch Ness. The reduction was by ~70% on the Loch Tay and Carmel, but only by 33% on the Chester Thornless at Belks Farm. Furthermore, 33% of Loch Ness at Belks Fm had red berry symptoms, but this was not reduced by the treatment (note that no blackberry mites were recorded in this plantation).

- At Belks Farm, the spray treatments significantly increased the yield of marketable fruit by 45% and 106% on the Chester Thornless and Loch Ness, respectively, the latter being despite almost no blackberry mites being detected in the plantations during the growing season.

- On Chester, the increase in yield is consistent with the hypothesis that blackberry mite is the causal agent of red berry disease and that the disease is reduced by control of its causal agent, but it is not consistent with this hypothesis on Loch Ness.

- The positive linear regressions between the mean percentages of fruits with red berry symptoms and the mean numbers of mites found per shoot at the first ripe fruit stage, together with the high level of red berry disease on Loch Ness where no blackberry mite was found, corroborate the hypothesis that there is more than one cause of red berry disease: blackberry mite infestation and at least one other unknown cause.

- The form and slope of the relationships indicate that the varieties Loch Tay, Chester Thornless and especially Carmel were highly sensitive to blackberry mite, small numbers of mites causing large percentages of red berry disease.

- **These findings indicate that, unless very small numbers of mites that cause a hypersensitive reaction were being missed by the visual inspection assessment method used (which seems unlikely in view of the large number of samples examined), there is another major cause of red berry disease, other than infestation by the blackberry mite, and that this other cause is of variable influence in different plantations and it is not affected by the acaricide spray treatments.**

- The results of year 1 of this project provided useful pointers to the effects of blackberry mite on red berry disease and its control. As a single season's results only, the conclusions from the work can only be regarded as preliminary. It is recommended that the work is repeated in 2011, but with several changes.

Financial benefits

A typical 12 tonne/ha crop of blackberries was worth >£60,000 at typical 2010 prices of £5,000/tonne. The large losses caused by red berry disease, which this work shows can be in excess of 30% of the crop, is clearly a huge financial loss to UK blackberry growers. The very substantive reductions in losses due to red berry disease (by up to 70% depending on plantation) recorded in this work and the large increases in marketable yield achieved demonstrate this research is of huge potential financial benefit to UK blackberry growers.

Action points for growers

- Blackberry growers must apply acaricide sprays for control of blackberry mite and avoid the worst ravages of red berry disease, but the sprays are unlikely to eliminate the problem as the mites are not the only cause. A fortnightly programme of sprays of Codacide oil, starting from May onwards, is likely to be the best choice, based on the acaricides tested and the results of this preliminary work.

- Sprays during flowering and fruiting are most likely to be effective as mites are only found under the bud scales at the base of the shoots before this time where they are unlikely to be affected by contact acting acaricide sprays.

- Use of full programmes of sulphur sprays should be avoided especially during fruiting as they leave unsightly deposits on foliage and fruits. Abamectin (Dynamec) may have adverse affects on predatory mites and so exacerbate the problem in the longer term.

Science Section

Evaluation of acaricides for the control of blackberry mite (*Acalitus essigi*) to reduce red berry disease on blackberry

1. INTRODUCTION

1.1. Background

Red berry disease is causing serious damage and losses in commercial blackberry plantations in the UK, especially in high value crops grown in tunnels. A proportion of drupelets, often those at the base of the fruits round the calyx, remain greenish or reddish and hard whilst the remaining drupelets ripen normally attaining their normal black colouration at maturity.

Red berry disease is thought to be caused by the blackberry mite, *Acalitus essigi*, which feeds on the flowers (and foliage) injecting toxic saliva into the developing drupelets. Mites overwinter beneath bud scales and invade the new growth, living and increasing in numbers on the flower buds, petioles and leaves (Davies *et al*., 2001). At blossom time they enter the flowers and feed on the developing drupelets, especially those sheltered by the calyx. As fruits mature they become less suitable for mite feeding and at harvest it is often difficult to find mites in the damaged fruits. For this reason it is often difficult to diagnose blackberry mite as the cause of the problem, as uneven ripening may also be caused by poor pollination. The extent of blackberry mite infestation in UK blackberry crops needs to be determined and effective means of monitoring and controlling this pest need to be developed.

Previous advice was to spray blackberry crops with endosulfan in late April-early May with two more sprays before flowering (Alford, 1979). However, this organochlorine insecticide and acaricide was withdrawn over 10 years ago and no effective replacement treatment has been identified. Screening trials in Poland in the 1980s (Labonowska and Suski, 1990) showed that bromopropylate (Neoron), cyhexatin (Plictran) and azocyclotin (Peropal) were partially effective but more modern acaricides do not appear to have been evaluated. Selective acaricides are needed because naturally occurring predatory mites help regulate blackberry mite populations (Szendrey et al., 2003).

1.2. Objectives

The aim of this project is to develop effective and practical methods for monitoring and control of blackberry mite so preventing red berry disease. Specific objectives were to:

1. Determine abundance and distribution of blackberry mites through the season in different plantations/varieties
2. Investigate the relationship between blackberry mite numbers and red berry disease
3. Determine whether blackberry mite is the only cause of red berry disease
4. Identify effective acaricide products and best time(s) of treatment

2. MATERIALS AND METHODS

2.1. Dormant season survey

Samples of 100 dormant buds were collected from 27 Blackberry plantations in February – March 2010. They were returned to the lab and split into lots of 50. Sites known to have high levels of mites in previous years were examined first. The first batch of 50 buds was examined under the microscope scale by scale for the presence of mites and any found recorded. The second 50 were macerated in an electric coffee grinder set to coarse, and then triple washed and filtered through black filter paper and the number of mites recorded.

2.2. Efficacy evaluation

A small plot replicated experiment was done in four commercial blackberry plantations in 2010 to evaluate the efficacy of acaricide spray treatments for control of blackberry mite, red berry disease and effects on yield.

2.2.1. Sites

The experiment was done in four commercial blackberry plantations, each of a different variety, two crops at each of two farms in Kent, as follows:

Site 1. Salmans Farm, Penshurst, Tonbridge, Kent TN11 8DJ, (kind agreement of Adam Shorter). Located at National Grid reference *TQ 188 517437*

Lower Loch Tay tunnel 6 m x 8.45 m x 17 = 0.09 ha (2 reps)
Adjacent Carmel tunnel 6 m x 4.22 m x 28 = 0.09 ha (2 reps)

Site 2. Belks Farm, Otham, Maidstone, Kent ME15 8RL; (kind agreement Tim Chambers). Located at National Grid Reference *TQ 188 802526*

Chester No. 5, 1 tunnel 6.5 m x 6 m x 20 bays = 0.08 ha (2 reps
National grid reference TQ 802526, Area 1.16 ha
Loch Ness No. 19, 2 tunnels 6 m x 4.8 m x 11 bays = 0.06 ha (2 reps)
National grid reference TQ 802535, Area 1.12 ha

2.2.2. Treatments

Treatments were programmes of sprays of products which experience in California and Koppert, NL, were likely to be effective against red berry mite (Table 1).

Table 1. Treatments

Treatment number	Product (s)	Timing
1	Headland Sulphur	2 week programme bud-burst – ripe fruit
2	Codacide	2 week programme bud-burst – ripe fruit
3	Dynamec + Break Thru S 240	2 sprays, the first at 5% flower the 2nd 2-4 weeks later
4	1+3	Both treatment numbers 1 and 3
5	2+3	Both treatment numbers 2 and 3
6-7	Untreated	

Products, their active ingredients and formulations and rates of use are given in Table 2. Numbers of sprays and their dates of application on the different varieties are given in Table 3.

Table 2. Products, their active ingredients and formulations and rates of use

Product	Active substance and formulation	Product dose rate (/ha)	Product concentration	Harvest interval (days)
Headland Sulphur	sulphur 800 g/l SC	10 l	10 ml/l	0
Dynamec +	abamectin 18 g/l EC	500 ml	0.5 ml/l	3
Break Thru S 240	silicone wetter	1 l	1 ml/l	0
Codacide	rape seed oil	25 l	25 ml/l	0

Table 3. Numbers of sprays and their dates of application on the different varieties

Farm	Salmans Farm				Belks Farm			
Variety	Loch Tay		Carmel		Chester		Loch Ness	
	Sulphur, Codacide	Dynamec	Sulphur, Codacide	Dynamec	Sulphur, Codacide	Dynamec	Sulphur, Codacide	Dynamec
No. sprays	7	2	8	2	9	2	9	2
Application dates	09-Apr		09-Apr		08-Apr		08-Apr	
	23-Apr		23-Apr		22-Apr		22-Apr	
	06-May		06-May		05-May		05-May	
	20-May	20-May	20-May		20-May		20-May	
	03-Jun	03-Jun	03-Jun	03-Jun	03-Jun		03-Jun	03-Jun
	15-Jun		15-Jun	15-Jun	16-Jun	16-Jun	16-Jun	16-Jun
	01-Jul		01-Jul		01-Jul	01-Jul	01-Jul	
			15-Jul		15-Jul		15-Jul	
					28-Jul		28-Jul	

2.2.3. Experimental design and statistical analyses

The experiment was done twice, simultaneously at two sites. Randomised complete block designs with four replicates of seven treatments including a double replicated untreated control were used (Tables 4 and 5). At each site, two replicates were deployed in each of two crops of different varieties. Plots were 8 m lengths of row arranged end to end in a block at site 1 (note post separation is irregular at site 1), and 6.6 m at site 2 (distance between posts was uniform).

Because of difficulties of access for spraying, where there are 3 rows per tunnel, only the central row was sprayed, the other two rows acted as unsprayed guards.

Table 4. Randomisation of the treatments to be applied at Salmans Farm, Penshurst

Lower Loch Tay						**Adjacent Carmel tunnel**					
Plot	**Colour**	**Trt**	**Plot**	**Colour**	**Trt**	**Plot**	**Colour**	**Trt**	**Plot**	**Colour**	**Trt**
101	R	1	201	G	7	301	R Y	4	401	B	2
102	G	6	202	R Y	4	302	R	1	402	G	7
103	R Y	4	203	R	1	303	G	7	403	G	6
104	G	7	204	G	6	304	Y	3	404	R	1
105	B Y	5	205	B Y	5	305	B	2	405	Y	3
106	B	2	206	B	2	306	B Y	5	406	R Y	4
107	Y	3	207	Y	3	307	G	6	407	B Y	5

2.2.4. Treatment application

Treatments were applied at a volume rate of 1000 l/ha using knapsack sprayer with a hand lance (not air-assisted). This minimised inter-plot contamination by spray drift. The accuracy of application of each treatment was estimated by measurement of the amount of spray that had actually been applied (calculated from the initial minus the final volume of sprayate left in the tank, minus the amount that should have been left had the spray been applied at exactly the correct volume rate). Applications were generally within 10% of required (Table 6). Though some larger deviation occurred, applications were all within 18% of target.

Table 5. Randomisation of the treatments to be applied at Belks Farm, Otham

Chester No. 5						Loch Ness No. 19					
Plot	**Colour**	**Trt**	**Plot**	**Colour**	**Trt**	**Plot**	**Colour**	**Trt**	**Plot**	**Colour**	**Trt**
501	R	1	601	Void		701	G	6	801	G	7
502	B	2	602	Y	3	702	G	7	802	R Y	4
503	G	6	603	G	6	703	R Y	4	803	B Y	5
504	B Y	5	604	R Y	4	704	B Y	5	804	B	2
505	G	7	605	B Y	5	705	Y	3	805	R	1
506	Y	3	606	R	1	706	R	1	806	Void	
507	R Y	4	607	B	2	707	B	2	807	Y	3
			601	G	7				808	G	7

Note: Plots 601 and 806 had to be abandoned and replaced because of misapplication of treatments at the first spray

Table 6. Accuracy of spray application estimated from the amount of sprayate remaining in the spray tank after spray application

Date	Farm	Accuracy of application (%) Trt No.				
		1	2	3	4	5
09-Apr	Salmans	99	116		99	116
23-Apr	Salmans	84	96		92	101
06-May	Salmans	94	95		105	98
20-May	Salmans	96	101	95	94	95
03-Jun	Salmans	106	103	105	107	109
15-Jun	Salmans	102	97	102	97	94
01-Jul	Salmans	99	99		97	102
15-Jul	Salmans	105	110		105	110
08-Apr	Belks	107	82		107	82
22-Apr	Belks	94	107		97	105
05-May	Belks	95	89		101	99
20-May	Belks	99	80		104	93
03-Jun	Belks	104	87	98	108	88
16-Jun	Belks	93	98	102	110	94
01-Jul	Belks	99	90	89	99	99
15-Jul	Belks	99	98		100	92
28-Jul	Belks	99	111		99	111

2.2.5. Meteorological records

Dry and wet bulb temperature, wind speed and direction were recorded before and after each spray occasion (Table 7). RH% was estimated from the dry and wet bulb temperature readings. In addition, USB-502 loggers were used to take hourly temperature and humidity readings inside a polytunnel at Salmans Farm (Appendix 1).

2.2.6. Growth stage development

The growth stage of the crops was recorded fortnightly for the duration of the experiment (Table 8).

Table 7. Weather conditions at the time of spray application

Date	Farm	Time	°C dry	°C wet	% RH	Kmph	DIR
09-Apr	Salmans	12:19	16.5	11	50	0	N/A
23-Apr	Salmans	07:50	4	3	85	0	N/A
06-May	Salmans	09:15	9	7	75	2	NW
20-May	Salmans	09:40	20	17	75	0	N/A
03-Jun	Salmans	07:54	13	12	90	0	N/A
15-Jun	Salmans	10:46	15	12	80	6	N
01-Jul	Salmans	07:27	15	15	100	0	N/A
15-Jul	Salmans	09:30	17	15	70	0	N/A
08-Apr	Belks	14:36	15.5	10	50	0	N/A
22-Apr	Belks	10:15	10	8	75	5	N
05-May	Belks	09:20	9	7	75	0	N/A
20-May	Belks	15:38	20	16	62.5	0	N/A
03-Jun	Belks	15:30	20	16	60	4	E
16-Jun	Belks	12:50	12.5	10	72.5	4	W
01-Jul	Belks	15:22	25	19	57.5	0	N/A
15-Jul	Belks	16:10	20	15	60	4	SW
28-Jul	Belks	10:20	18	15	72.5	0	N/A

Table 8. Growth stage at the time of spray application

Date	Farm	Variety	Growth stage
09-Apr	Salmans	Carmel Loch Tay	bud break bud break
23-Apr	Salmans	Carmel Loch Tay	1st leaf 5% leaf
06-May	Salmans	Carmel Loch Tay	5% leaf 1st flower
20-May	Salmans	Carmel Loch Tay	1st flower 5% flower
03-Jun	Salmans	Carmel Loch Tay	5% flower 50% flower
15-Jun	Salmans	Carmel Loch Tay	1st red fruit 50% red fruit
01-Jul	Salmans	Carmel Loch Tay	1st red fruit 1st ripe fruit
15-Jul	Salmans	Carmel Loch Tay	1st ripe fruit harvesting
08-Apr	Belks	Chester Loch Ness	dormant bud break
22-Apr	Belks	Chester Loch Ness	bud break 1st leaf
05-May	Belks	Chester Loch Ness	1st leaf 5% leaf
20-May	Belks	Chester Loch Ness	5% leaf Pre flower
03-Jun	Belks	Chester Loch Ness	Pre flower 5% flower
03-Jun	Belks	Loch Ness covers erected	
16-Jun	Belks	Chester Loch Ness	5% flower 1st green fruit
16-Jun	Belks	Chester covers erected	
01-Jul	Belks	Chester Loch Ness	1st green fruit 50% green fruit
15-Jul	Belks	Chester Loch Ness	50% green fruit 1st ripe fruit
28-Jul	Belks	Chester Loch Ness	1st red fruit harvesting

2.2.7. Assessments

Mite population development on untreated: The development of the *A. essigi* populations on the untreated guard rows in each plantation at each site was monitored fortnightly for the duration of the trial.

Effects of treatments on mite populations: At the first ripe fruit stage, a sample of 50 fruiting shoots was taken from each plot and the numbers of *A. essigi* in each sample estimated. Sample type and size was adjusted so that statistically sound comparisons between treatments could be made. Mites were observed directly in the laboratory by counting under a binocular microscope.

Effects of treatments on incidence of red berry disease: The percentage berries in each plot affected by red berry disease was estimated in each plot on three occasions through the harvesting period *viz* early, mid- and late-harvest. Typical red berry disease symptoms are shown in Figure 1.

Figure 1. Typical red berry disease symptoms on cv. Carmel

Effects of treatments on yield and quality: At harvest, the host grower picked the fruit from each plot and recorded the weight of marketable and discarded waste fruit.

3. RESULTS

3.1. Dormant season survey

Overwintering blackberry mite was found in 11 of the 27 samples of 50 buds taken from different plantations in February-March 2010 (Table 7). The highest number was 16 mites/50 buds, the lowest number 1 mite/50 buds and the median number 5 mites/50 buds. These numbers did not correlate in any way with the severity of the red berry problem in the crop the previous year, as scored by the grower, nor was there any apparent association with any variety. For the seven plantations where repeat samples were taken, six had originally contained mites and one no mites, but mites were only found in three of the repeat samples. One sample (Belks Loch Ness 19) was found to contain 14 mites in the first sample but none in the second. Blackberry mites were only found in the top of the shoots in the samples from different height strata from Belks Chester No. 5 on 12 March. Raspberry leaf and bud mite was found in small numbers in one sample only.

Table 7. Total of numbers of blackberry and raspberry leaf and bud mite in a samples of 50 dormant buds from commercial blackberry plantations 2010 and the growers assessment of the severity of red berry disease in the crop in 2009

Farm	Variety	Date	Plot name/No.	Protected?	No. blackberry mite		No. Raspberry leaf & bud mite	Growers severity score
					1st sample	2nd sample	1st sample	
Belks	Chester‡	10 Feb	5	no	16	14	0	1
Belks	Chester	10 Feb	7		5	18	0	3
Belks	Loch Ness	10 Feb	11		5	0	0	4
Belks	Loch Ness	10 Feb	12		0	0	0	6
Belks	Loch Ness	10 Feb	14-15		0		0	8
Belks	Chester	10 Feb	16		4	2	0	10
Belks	Chester	10 Feb	17		0		0	5
Belks	Loch Ness	10 Feb	17		0		0	5
Belks	Chester	10 Feb	18		0		0	8
Belks	Loch Ness‡	10 Feb	19		14	0	0	4
Belks	Chester	10 Feb	20		0		14	new planting
Belks	Chester	10 Feb	21-24		0		0	6
Belks	Loch Tay	10 Feb	25		2		0	8
Nashes Farm	Carmel‡	09 Feb		no	4		0	9
Penshurst	Carmel	09 Feb		no	0		0	9
Penshurst	Chester	09 Feb		no	0		0	5
Penshurst	Loch Ness	09 Feb		no	6		0	5
Penshurst	Loch Tay	09 Feb		no	0		0	5
Sunclose	Loch Ness	15 Feb	Meadow 1	no	0		0	bad
Sunclose	Loch Ness	15 Feb	Logan 19	no	0		0	bad
Sunclose	Obsidian	15 Feb	31	no	3	0	0	bad
Sunclose	Loch Tay	15 Feb	Chivers south 50	no	0		0	bad
Sunclose	Chester	15 Feb	Chivers North 52	no	0		0	bad
Sunclose	Chester	15 Feb	Chivers west 52	no	0		0	bad
Sunclose	Loch Ness	15 Feb	Chivers south 58	no	0		0	bad
Hugh Lowe Fms	Obsidian	12 Mar	Golf course	yes	8		0	
Hugh Lowe Fms	Obsidian	12 Mar	Golf course	no	1		0	
Hugh Lowe Fms	Wild Type	12 Mar	Golf course	no	0		0	
Belks	Chester	12 Mar	Top of shoots 5	no	30		4	1
Belks	Chester	12 Mar	Middle of shoots 5	no	0		0	1
Belks	Chester	12 Mar	Bottom of shoots 5	no	0		0	1

3.2. Efficacy evaluation

3.2.1. Mite population development on untreated

There were 0, 0, 16 and 14 blackberry mites per 50 buds were found in the Salmans Carmel, Salmans Loch Tay, Belks Chester and Belks Loch Ness, respectively. Numbers in the Loch Ness stayed near zero throughout the season. However, numbers started to increase in the other varieties in late May/early June, especially on the Belks Chester (Figure 2). Numbers on the Belks Chester and Salmans Carmel reached peaks of 132 and 43 mites per shoot on 15 July and then declined thereafter. Numbers on the Salmans Loch Tay reached a peak of 27 mites per shoot on 15 June and then declined thereafter. Note that the shoots grew steadily in length (Figure 3) and increased enormously in leaf surface area during the growing period. Most mites were found on the surface of the green tissue beneath the old outer scales of the overwintering buds (Figure 4). As the season progressed more were found in the buds at the base of the leaf petioles, but none were found elsewhere (see section 3.3.2. below).

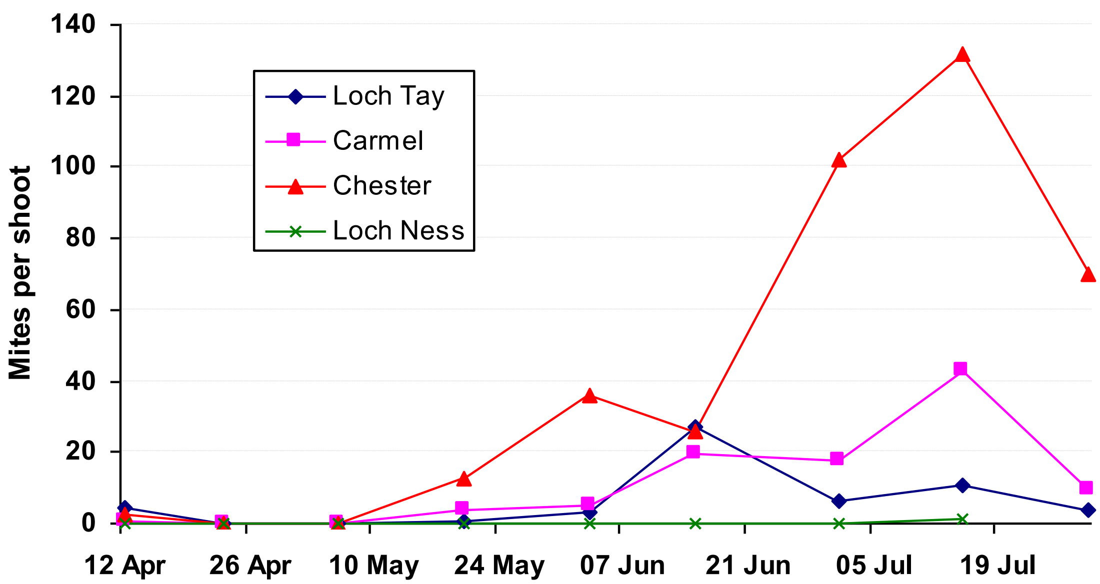
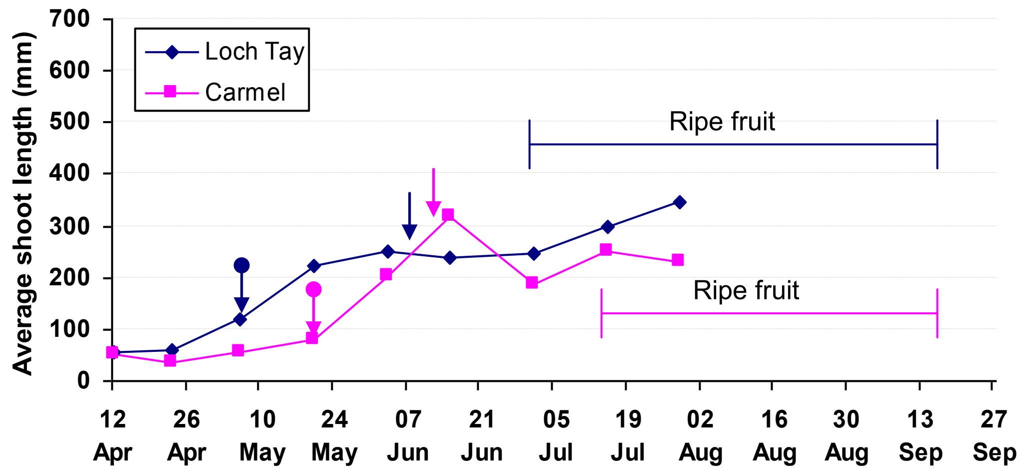


Figure 2. Numbers of mites per shoot through the season on untreated plants

Shoot growth - Salmans Farm



Shoot growth - Belks Farm

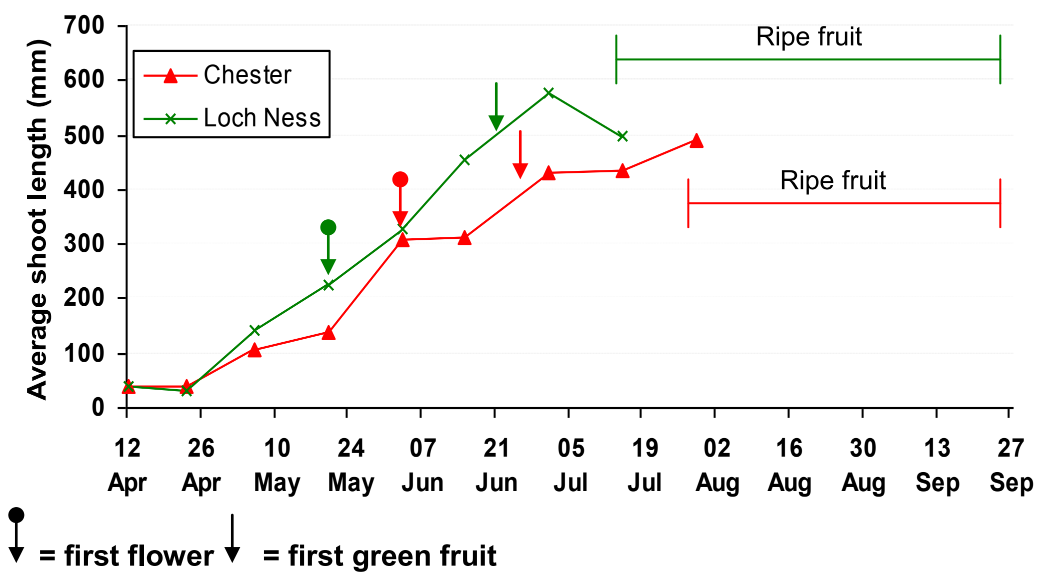


Figure 3. Average shoot length (mm) of the four varieties through the growing season

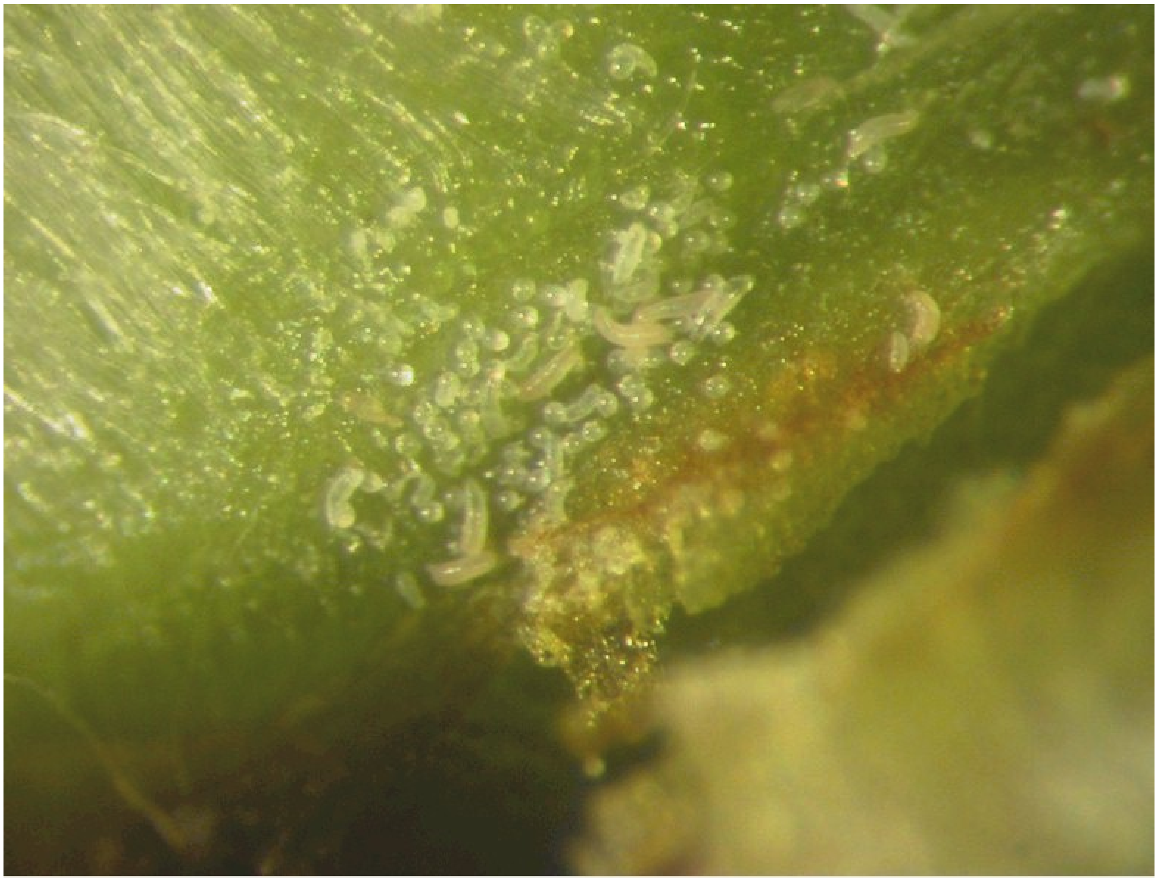


Figure 4. Blackberry mites and eggs on green tissue underneath bud scales. The mites are approximately 300 µm (= 0.3 mm) long

3.2.2. Effects of treatments on mite populations

At the first ripe fruit stage when counts were made, no blackberry mites were found at all on any of the plots of Loch Ness at Belks Farm (Table 8). Highest mean numbers (11.4) per shoot were found on the untreated plots of Chester at Belks. Mean numbers were similar but slightly lower on the Loch Tay and Carmel at Salmans. Most mites (grand mean = 2.6 mites/shoot) were found at the base of the shoots, under the old outer bud scales where the overwintering ones had been found (Table 9). Smaller numbers (grand mean = 0.55 mites/shoot) were found at the base of the petioles. No mites were found in flowers or green/pink fruit. Most mites were motiles (grand mean = 2.7 mites/shoot) with smaller numbers of eggs (grand mean = 0.4 eggs/shoot. ANOVA not including variety as a factor revealed highly significant treatment effects ($P = 0.022$) though with a high plot stratum coefficient of variation (135%). All the spray treatments on the three infested varieties (Loch

Tay, Carmel, Chester) had lower mean numbers of mites than their respective untreated controls but no individual spray treatment had consistently the lowest numbers of mites, so no obvious best treatment was apparent.

Table 8. Mean numbers of blackberry mite found per shoot in the different plantations at the start of fruiting. Note that no mites at all were recorded in flowers or green fruits

Treatment	Base of shoots	Base of petioles	Number of motile mites	Number of mite eggs	Total
			Loch Tay, Salmans Farm (15 June)		
1. Sulphur	1.4	0.0	0.9	0.5	1.4
2. Codacide	4.0	0.0	1.9	2.1	4.0
3. Dynamec	0.3	0.0	0.2	0.1	0.3
4 1+3	0.0	0.0	0.0	0.0	0.0
5. 2+3	6.3	0.0	4.7	1.6	6.3
6. Untreated	8.1	0.1	6.0	2.2	8.2
			Carmel, Salmans Farm (1 July)		
1. Sulphur	2.5	0.0	2.5	0.1	2.5
2. Codacide	1.9	0.0	1.9	0.0	1.9
3. Dynamec	0.9	0.0	0.9	0.0	0.9
4 1+3	0.1	0.0	0.1	0.0	0.1
5. 2+3	3.7	0.0	2.4	1.3	3.7
6. Untreated	9.8	1.1	10.4	0.5	10.9
			Chester, Belks Farm (15 July)		
1. Sulphur	0.7	0.6	1.5	0.0	1.5
2. Codacide	6.2	1.6	7.7	0.1	7.8
3. Dynamec	4.7	2.2	6.7	0.2	6.9
4 1+3	5.0	1.0	6.0	0.0	6.0
5. 2+3	1.4	0.0	1.4	0.0	1.4
6. Untreated	5.5	6.0	10.4	1.0	11.4
			Loch Ness, Belks Farm (1 July)		
1. Sulphur	0.0	0.0	0.0	0.0	0.0
2. Codacide	0.0	0.0	0.0	0.0	0.0
3. Dynamec	0.0	0.0	0.0	0.0	0.0
4 1+3	0.0	0.0	0.0	0.0	0.0
5. 2+3	0.0	0.0	0.0	0.0	0.0
6. Untreated	0.0	0.0	0.0	0.0	0.0

Table 9. Grand mean numbers of blackberry mite found per shoot at the start of fruiting. Note that no mites at all were recorded in flowers or green fruits

Treatment	Base of shoots	Base of petioles	Number of motile mites	Number of mite eggs	Total	Log_{10}(Total + 1)

1. Sulphur	1.2	0.2	1.2	0.1	1.4	0.14
2. Codacide	3.0	0.4	2.9	0.5	3.4	0.24
3. Dynamec	1.5	0.6	1.9	0.1	2.0	0.22
4 1+3	1.3	0.3	1.5	0.0	1.5	0.11
5. 2+3	2.8	0.0	2.1	0.7	2.8	0.19
6. Untreated	5.8	1.8	6.7	0.9	7.6	0.52
					Fprob	0.022
					SED (49 df) comparisons with control	0.134
					SED (49 df) other comparisons	0.155
					LSD (P=0.05) comparisons with control	0.269
					LSD (P=0.05) other comparisons	0.311
					CV%	135.2

3.2.3. Effects of treatments on incidence of red berry disease

Overall, 22.6% of berries had red berry symptoms at harvest (Table 10). The ANOVA of the angular transformed % fruits with red berry symptoms showed strong treatment (P <0.001), variety (P <0.001) and Treatment.Variety (P = 0.002) interaction effects. The between plot coefficient of variation (11.4%) was low. LSD (P = 0.05) tests showed that the four varieties all differed significantly from each other in their mean % red berry with Loch Tay < Carmel < Chester < Loch Ness. For the Treatment factor, all the spray treatments had significantly lower overall mean % red berry fruit than the untreated control, but the spray treatments did not differ significantly. On the variety Carmel, where the greatest variation between spray treatments was apparent (and where mite numbers were greatest) LSD (P = 0.05) testing suggests that Treatment 4 (Sulphur + Dynamec) had a lower % red berry than Treatment 3 (Dynamec alone). However, none of the other differences between spray treatments were significant and LSD testing between the greatest and smallest values in a range is of questionable validity.

Table 10. Mean % and mean angular transformed % fruits with red berry symptoms at harvest

Treatment	Loch Tay	Carmel	Chester	Loch Ness	Mean
		Untransformed data			
1. Sulphur	6.0	12.2	25.9	28.4	24.0
2. Codacide	4.7	9.9	28.4	33.8	26.1
3. Dynamec	6.2	15.9	24.3	29.0	22.0
4 1+3	5.2	7.2	27.1	36.8	23.1
5. 2+3	4.6	12.4	24.8	31.8	22.3
6. Untreated	18.7	36.6	38.7	35.6	37.2
Mean	9.1	18.7	29.7	33.0	22.6
		Angular transformed data			
1. Sulphur	14.1	20.3	30.6	32.2	24.3
2. Codacide	12.3	18.3	32.2	35.6	24.6
3. Dynamec	14.4	23.4	29.5	32.6	25.0
4 1+3	12.9	15.5	31.3	37.1	24.2
5. 2+3	12.3	20.4	29.9	34.4	24.2
6. Untreated	25.5	37.2	38.5	36.6	34.4
Mean	16.7	24.6	32.9	35.0	27.3
			Treat	Variety	Treat.Variety
		Fprob	<0.001	<0.001	0.002
		SED (31 df) min rep	1.56		3.11
		SED (31 df) max-min rep	1.35	1.18	2.70
		SED (31 df) max rep	1.10X		2.20
		LSD (P=0.05) min rep	3.18		6.35
		LSD (P=0.05) max-min rep	2.75	2.40	5.50
		LSD (P=0.05) max rep	2.25X		4.49
		CV%	11.4		

Note: There are no comparisons in categories where SED or LSD marked with an X

3.2.4. Effects of treatments on yield and quality

At Salmans Farm, the grower recorded yields of marketable and waste fruit on 8 occasions between 14 July and 19 August (14, 28 July, 1, 5, 9, 13, 15, 19 August). Factorial ANOVA (details not shown) showed highly significant differences between varieties in both waste (P = 0.023) and marketable yield (P < 0.001) but no significant Treatment or Treatment.Variety interaction effects. The total mean marketable yields for Loch Tay and Carmel were 14.47 kg/plot and 4.47 kg/plot, respectively (Table 11). ANOVA showed no significant treatment effects for either waste fruit (P = 0.590) or marketable fruit (P = 0.978). Note the high between plot CV% values (> 60%).

Table 11. Mean weights (kg) of fruits harvested per plot by the grower at Salmans Farm

	Loch Tay		**Carmel**		**Mean**	
Treatment	**Waste**	**Marketable**	**Waste**	**Marketable**	**Waste**	**Marketable**
			Weights of fruit per plot (kg)			
1. Sulphur	0.25	9.59	0.47	4.85	0.36	7.22
2. Codacide	0.19	14.18	0.44	4.11	0.31	9.14
3. Dynamec	0.21	15.23	0.38	4.72	0.29	9.97
4 1+3	0.35	16.98	0.35	4.04	0.35	10.51
5. 2+3	0.21	15.13	0.35	5.68	0.28	10.40
6. Untreated	0.33	15.11	0.66	3.94	0.49	9.52
Mean	0.27	14.47	0.47	4.47	0.37	9.47
				Fprob (P)	0.590	0.978
				CV%	61.2	66.1

At Belks Farm, the grower recorded yields of marketable and waste fruit on 17 occasions between 23 August and 29 September (23, 25, 27, 30 August, 1, 3, 6, 8, 10, 13, 15, 17, 20, 22, 24, 27, 29 September). Factorial ANOVA showed highly significant differences between varieties in both waste (P = 0.007) and marketable yield (P = 0.001) (Table 12). Chester and Loch Ness had mean marketable yields of 18.98 and 13.87 kg/plot, respectively. Their waste yields were 9.44 and 7.76 kg/plot, 33% and 36% of the total yields for the two varieties, respectively. The Treatment factor was highly significant (P < 0.001) for the marketable yield but not significant (P = 0.403) for the waste. The Treatment:Variety interaction was not significant (P = 0.181) for the marketable fruit, but highly significant for the waste (P = 0.004). For the marketable fruit, LSD (P = 0.05) testing showed that all the spray treatments had higher yields than the untreated control. The grand mean marketable yield for the sprayed plots was 17.45 kg/plot, 68% greater than for the untreated control which was 10.36 kg/plot. LSD (P = 0.05) testing suggested that the yield for Treatment 5 (Codacide + Dynamec) (19.05 kg/plot) was significantly greater than the yield for Treatment 3 (Dynamec) (15.31 kg/plot) in this group. However, none of the other differences between spray treatments were significant and LSD testing between the greatest and smallest values in a range of 5 values is of questionable validity. The data for the waste fruit was highly variable and there were no consistent treatment differences.

Table 12. Mean weights (kg) of marketable and waste fruits harvested per plot by the grower at Belks Farm

Treatment	**Chester**	**Loch Ness**	**Mean**
	Weight of marketable fruit per plot (kg)		
1. Sulphur	16.95	16.80	16.88
2. Codacide	18.25	18.75	18.50
3. Dynamec	18.20	12.43	15.31
4 1+3	19.55	15.45	17.50
5. 2+3	20.20	17.90	19.05
6. Untreated	12.85	7.88	10.36
Mean	16.98	13.87	15.42
	Treat	Variety	Treat.Variety
Fprob (P)	<0.001	0.001	0.181
SED (15 df) min rep	1.458		2.061
SED (15 df) max-min rep	1.263	0.779	1.786
SED (15 df) max rep	1.031X		1.458
LSD (P=0.05) min rep	3.107		4.395
LSD (P=0.05) max-min rep	2.691	1.661	3.806
LSD (P=0.05) max rep	2.197X		3.107
CV%		13.4	
	Weight of waste fruit per plot (kg)		
1. Sulphur	8.65	9.18	8.91
2. Codacide	9.35	10.10	9.73
3. Dynamec	10.15	7.50	8.83
4 1+3	9.30	8.35	8.83
5. 2+3	7.25	9.15	8.20
6. Untreated	10.70	5.01	7.86
Mean	9.44	7.76	8.60
	Treat	Variety	Treat.Variety
Fprob (P)	0.403	0.007	0.004
SED (15 df) min rep	0.999		1.413
SED (15 df) max-min rep	0.865	0.534	1.223
SED (15 df) max rep	0.706X		0.999
LSD (P = 0.05) min rep	2.129		3.011
LSD (P = 0.05) max-min rep	1.844	1.138	2.608
LSD (P = 0.05) max rep	1.506X		2.129
CV%		16.4	

Note: There are no comparisons in categories where SED or LSD marked with an X

3.2.5. Relationships between numbers of blackberry mites per shoot and % fruits with red berry symptoms

Linear regression analysis (not constrained through the origin) of the mean percentages of fruits with red berry symptoms (D) against the treatment mean numbers of mites found per shoot (M) at the first ripe fruit stage for each plot showed significant relationships, with R^2 values of 0.38, 0.54 and 0.26 for Loch Tay, Carmel and Chester, respectively (Table 13, Figure 5). The slopes and intercepts were all positive and statistically significantly greater than zero (Table 13). Note that Loch Ness could not be analysed because the mite counts were all zero. The relationship was strongest (slope = 2.09) for Carmel, which was the most heavily infested with blackberry mite and which had the greatest treatment affects. Note the large value of the constant (25.91) for Chester which clearly had large amounts of red berry symptoms not associated with mite infestation, as did the Loch Ness, where no mite infestation was detected at all but 33.0% of fruits on average had red berry symptoms.

Table 13. Linear regression equations between the mean % fruits with red berry symptoms (D) and the mean numbers of blackberry mites per shoot (M) found at the first pink fruit stage on each plot and for the varieties Loch Tay, Carmel and Chester

Variety	Equation	R^2 (%)	Slope			Intercept		
			SE	t (12 df)	t prob	SE	t (12 df)	t prob
Loch Tay	D=1.19M+5.78	37.6	0.040	2.97	0.12	1.80	3.22	0.007
Carmel	D=2.09 M+10.19	54.3	0.516	4.05	0.002	3.10	3.28	0.007
Chester	D=0.061M+25.91	26.0	0.257	2.36	0.036	2.21	11.73	<0.001

Note: no mites were found on Loch Ness at all and linear regression is thus not possible

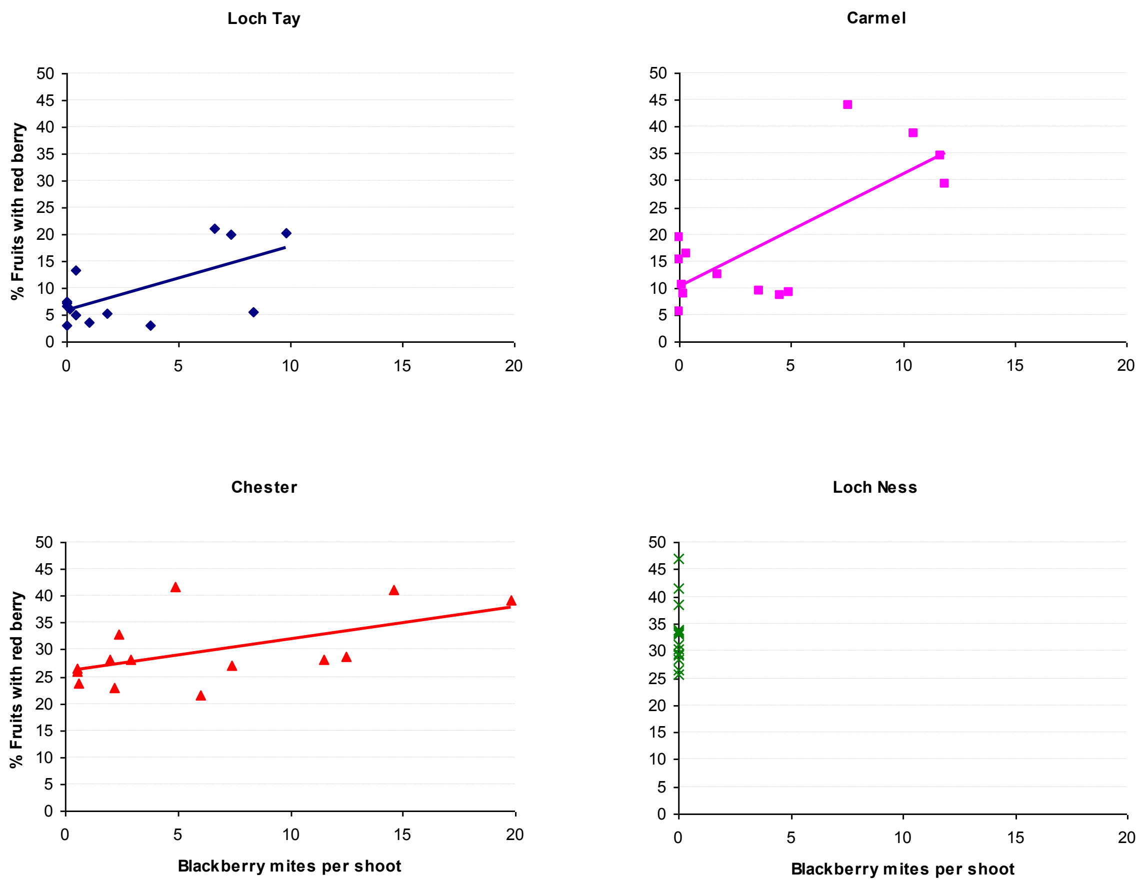


Figure 5. Linear regression equations between the mean % fruits with red berry symptoms and the mean numbers of blackberry mites per shoot found at the first pink fruit stage on each plot and for the varieties Loch Tay, Carmel and Chester. Note: no mites were found at all on Loch Ness and linear regression was thus not possible

3.2.6. Phytotoxicity

Visual inspection of the plots during fruiting revealed heavy sulphur spray deposits on plots receiving the programme of sprays of sulphur whereas those that had received a programme of sprays of Codacide oil were bright and shiny (Figure 6). The sulphur deposits substantively detracted from the quality of the fruit whereas the Codacide sprays enhanced quality, compared with the untreated control.

Figure 6. Foliage and fruits treated with a programme of sprays of Codacide oil (upper and lower left) is bright and shiny, whereas foliage and fruits treated with a programme of sprays of sulphur (upper and lower right) is dull and discoloured with heavy sulphur spray deposits clearly visible

4. DISCUSSION

4.1. Dormant season survey

The counts of overwintering mites in the samples of 50 buds from the different growers' crops had to be done manually, by picking the buds apart scale by scale with fine forceps and counting the numbers of mites present under a binocular microscope. The mites were present mainly under the outer (brown) bud scales. Washing methods detected very few mites. Identification of the mites was not difficult since the blackberry mite is white/translucent, whereas the raspberry leaf and bud mite is straw coloured. The counting took 2-3 hours per sample, which is too laborious and costly for a regular monitoring programme. Overwintering blackberry mite populations found in the randomly selected samples of 50 buds were very small; the highest numbers found being <1/bud. They did not reflect the very considerable losses of fruit due to red berry disease suffered by growers in the preceding season. Note the numbers found were very much smaller than the numbers found in a trial at East Malling Research in 1978, where M A Easterbrook recorded a mean of 26 mites when shoots were 2-3 cm long on 5 April. The mites were aggregated, with most mites being found in just a few buds and all the other buds containing none. The height stratified samples from Belks No. 5 (Chester) on 12 March indicate that most mites, perhaps all, are present in buds in the upper portion of the canes. Two conclusions may be drawn: (1) A larger sample of 100 (or even more) buds per plantation, taken from the tops of the canes, would be preferable; (2) recording presence or absence of mites under the outer scale of each bud, to give a % buds infested value, might be more time efficient, though the relationship between the % buds infested and the mean numbers of mites per bud would be needed.

4.2. Efficacy evaluation

4.2.1. Mite population development on untreated

There was no obvious relationship between the numbers of mites found in the overwintering buds and the populations that developed subsequently. Fourteen mites per bud were found on the Belks Loch Ness but no mites were found during the growing season. No overwintering mites were found in the Salmans Carmel, but numbers reached the highest peak of 132 mites per shoot in that plantation. The reasons for the differences in population development between the varieties are unclear. Possible explanations are:

(1) the dormant season sampling was unreliable with too small a sample size;

(2) the varieties varied greatly in their susceptibility to attack by blackberry mite, Loch Ness being of very low susceptibility, Carmel being the most susceptible;

(3) differences were caused by another unknown factor such as predation, e.g. by Phytoseiid mites;

(4) a combination of factors 1-3. Explanation (2) seems unlikely as overwintering mites were found in the buds.

The mites were found mainly beneath the outer scales of the overwintering buds and were found there in largest numbers throughout. Only when numbers started to increase in May/June were any found at the base of the petioles, and then only in very small numbers. The surface area of the shoots increased rapidly as the shoots grew and it became progressively more difficult and time consuming to count the numbers of mites on the whole sample. Note that no mites were found at any time in the flowers or fruits in any of the varieties, even in the Carmel which had the highest numbers.

4.2.2. Effects of treatments on mite populations

All the spray treatments on the three infested varieties (Loch Tay, Carmel, Chester) had lower mean numbers of mites than their respective untreated controls but no individual spray treatment had consistently the lowest numbers of mites, so no obvious best treatment was apparent. None of the treatments eliminated the mites. This is not surprising because the acaricides tested are mainly contact acting and most of the mites were present under the bud scales where they would be inaccessible to sprays. Further work is needed to explore the efficacy of the treatments, preferable in plantations more heavily infested with blackberry mites where better discrimination between treatments would be achieved. If all the treatments were of equal efficacy, the Dynamec alone treatment (Treatment 3) would be the best for growers since application of full programmes of sprays of high doses sulphur or Codacide oil is very laborious.

4.2.3. Effects of treatments on incidence of red berry disease

All the spray treatments reduced the % fruits with red berry disease significantly on Loch Tay, Carmel and Chester but there was no reduction on Loch Ness. The reduction was by ~70% on the Loch Tay and Carmel at Salmans Farm, but only by 33% on the Chester at Belks Farm. Thirty three % of Loch Ness at Belks had red berry symptoms, but this was not reduced by the treatment (note, no red berry mites were recorded in this plantation). This finding indicates that there is almost certainly another major cause of red berry disease, other than infestation by the blackberry mite, that this other cause is of variable effect in different plantations and that it is not affected by acaricide spray treatments.

4.2.4. Effects of treatments on yield and quality

lthough varieties varied significantly in their overall yield, there were no significant treatment effects on yield on either variety at Salmans Farm. This may be because of the high plot-plot coefficient of variation (> 60%) possibly due to unevenness in vigour of the crop. At Belks Farm, the spray treatments significantly increased the yield of marketable fruit by 45% and 106% on the Chester and Loch Ness, respectively, the latter being despite almost no blackberry mites being detected in the plantations during the growing season. On Chester, the increase in yield is consistent with the hypothesis that blackberry mite is the causal agent of red berry disease and that the disease is reduced by control of its causal agent but it is not consistent with this hypothesis on Loch Ness.

4.2.5. Relationships between numbers of blackberry mites per shoot and % fruits with red berry symptoms

The positive linear regressions between the treatment mean percentages of fruits with red berry symptoms against the treatment mean numbers of mites found per shoot at the first ripe fruit stage, which did not pass through the origin but through the % Fruits with red berry axis at values >0, together with the high level of red berry disease on Loch Ness where no blackberry mite was found, corroborate the hypothesis that there are at least two causes of red berry disease, blackberry mite infestation and at least one other unknown cause.

The form and slope of the relationships indicate that the varieties Loch Tay, Chester and especially Carmel are highly sensitive to blackberry mite, small numbers of mites causing large percentages of red berry disease.

4.2.6. Phytotoxicity

The sulphur deposits that resulted from the full season's fortnightly programme of sulphur sprays substantively detracted from the visual quality of the fruit whereas the full season's Codacide spray programme enhanced it, compared with the untreated control. From this point of view, a full spray programme of sulphur sprays is not acceptable, although a small number of applications well before harvest may be acceptable. Measurements of plant growth and fruit size were not taken, but it is suspected that the sulphur spray programmes may have been reducing leaf size and berry weight.

4.3. Future work in year two of the project

The results of year 1 of this project were good and provided useful pointers to the effects of blackberry mite on red berry disease and its control. As a single season's results only, the conclusions from the work can only be regarded as preliminary. It is recommended that the work is repeated in 2011, but with several improvements:

1. In a smaller number of plantations with higher populations of blackberry mite, and with greater uniformity of plant size/vigour/cropping potential
2. With programmes of smaller numbers sprays of sulphur versus Codacide comparing pre-, post- fruiting and pre-dormant season applications
3. Including spray treatments with oxamyl (Vydate). Oxamyl is a hyper systemic acaricide which is likely to control a higher proportion of blackberry mites in inaccessible places. The inclusion of this treatment is purely to explore the underlying causes of red berry disease. It is not an option for commercial use.
4. Greater attention is paid to control of other insect pests, especially aphids and capsid bugs, by overall applications of non-acaricidal insecticides
5. Records are taken of the numbers of predatory Phytoseiid mites in the different plantations

5. CONCLUSIONS

- Overwintering blackberry mites were found in only 10 of 28 samples of 50 dormant buds collected from 28 commercial blackberry plantations in February-March 2010. The highest number found was 0.36 mites/bud. The mites were found mainly beneath the outer bud scales. Numbers were not related to the very considerable losses of fruit due to red berry disease suffered by growers in the preceding season
- Results suggest that a larger sample of 100 or more buds per plantation, taken from the tops of the canes, would be preferable and that presence or absence of mites under the outer scale of each bud, to give a % buds infested value, might be more useful, cost-effective and reliable
- In the acaricide trials, there was no obvious relationship between the numbers of mites found in the overwintering buds and the populations that developed subsequently on untreated controls
- The blackberry mites remained mainly beneath the outer scales of the overwintering buds and were found there in largest numbers throughout the season. Only when mite numbers started to increase in May/June were any mites found at the base of the petioles further up the shoots, and then only in very small numbers
- No mites were found at any time in the flowers or fruits in any of the varieties, even in the variety Carmel which had the highest mite numbers
- All the acaricide treatments performed equally well in reducing blackberry mite on the three infested varieties (Loch Tay, Carmel, Chester Thornless), and in reducing red berry disease and increasing yield but no individual spray treatment had consistently the lowest numbers of mites, so no optimum treatment was apparent
- None of the treatments eliminated the mites. This is not surprising because the acaricides tested are contact acting and most of the mites were present under the bud scales where they would be inaccessible directly to sprays
- Of the treatments tested, the Codacide spray programme appears to be the best for growers, though early applications, when mites are still under the bud scales, may be of little benefit. Sulphur leaves unsightly deposits, might be phytotoxic, and should not be used, especially during fruiting. Dynamec is probably harmful to predatory Phytoseiid mites which are likely to be important natural enemies of blackberry mite and may exacerbate the problem in the longer-term

- The sulphur deposits that resulted from the full seasons fortnightly programme of sulphur sprays substantively detracted from the visual quality of the fruit whereas the full season's Codacide spray programme enhanced it, compared with the untreated control. From this point of view, a full spray programme of sulphur sprays is not acceptable, though a small number of applications well before harvest may be acceptable. Measurements of plant growth and fruit size were not taken, but it is suspected that the sulphur spray programmes may have been reducing leaf size and berry weight
- All the spray treatments reduced the % fruits with red berry disease significantly on Loch Tay, Carmel and Chester Thornless, but there was no reduction on Loch Ness. The reduction was by ~70% on the Loch Tay and Carmel, but only by 33% on the Chester Thornless at Belks Farm. Furthermore, 33% of Loch Ness at Belks Fm had red berry symptoms, but this was not reduced by the treatment (note that no blackberry mites were recorded in this plantation)
- At Belks Farm, the spray treatments significantly increased the yield of marketable fruit by 45% and 106% on the Chester Thornless and Loch Ness, respectively, the latter being despite almost no blackberry mites being detected in the plantations during the growing season
- On Chester, the increase in yield is consistent with the hypothesis that blackberry mite is the causal agent of red berry disease and that the disease is reduced by control of its causal agent, but it is not consistent with this hypothesis on Loch Ness
- The positive linear regressions between the mean percentages of fruits with red berry symptoms and the mean numbers of mites found per shoot at the first ripe fruit stage, together with the high level of red berry disease on Loch Ness where no blackberry mite was found, corroborate the hypothesis that there is more than one cause of red berry disease, blackberry mite infestation and at least one other unknown cause
- The form and slope of the relationships indicate that the varieties Loch Tay, Chester Thornless and especially Carmel were highly sensitive to blackberry mite, small numbers of mites causing large percentages of red berry disease
- **These findings indicate that, unless very small numbers of mites that cause a hypersensitive reaction were being missed by the visual inspection assessment method used (which seems unlikely in view of the large number of samples examined), there is another major cause of red berry disease, other than infestation by the blackberry mite, and that this other cause is of variable**

influence in different plantations and it is not affected by the acaricide spray treatments

- The results of year 1 of this project provided useful pointers to the effects of blackberry mite on red berry disease and its control. As a single season's results only, the conclusions from the work can only be regarded as preliminary. It is recommended that the work is repeated in 2011, but with several changes

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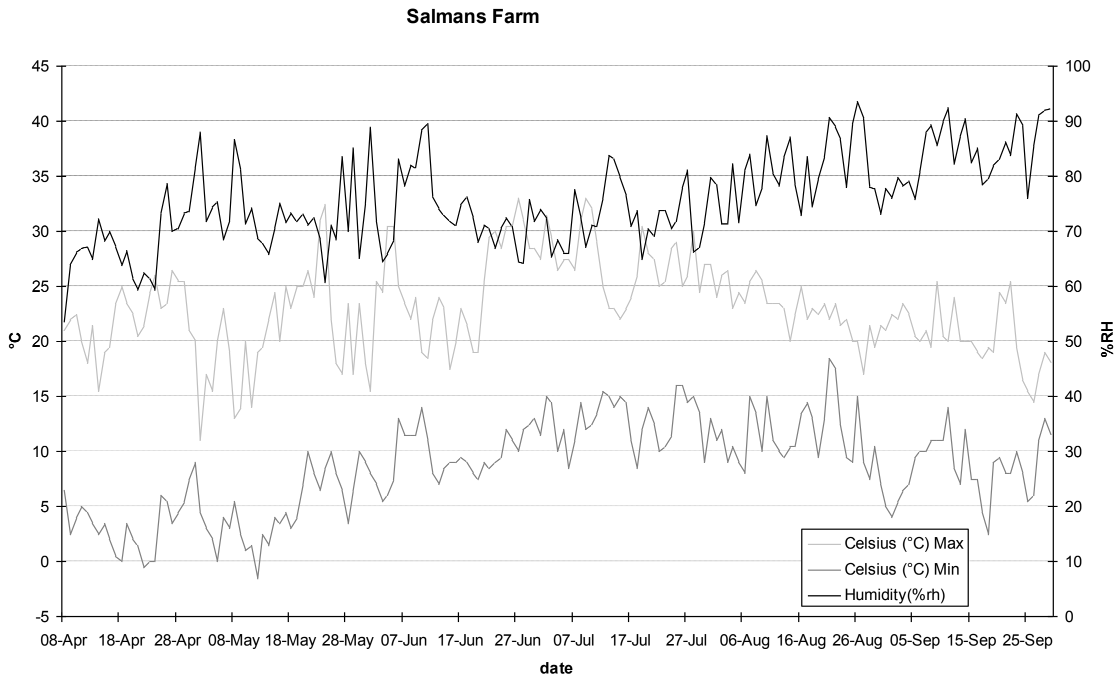
Appendix



Daily max/min temperature, and relative humidity in tunnels at Salmans Farm