Project title:	On farm evaluation of zero residue system for apples
Project number:	TF 173
Project leader:	Dr A M Berrie
Report:	Annual report, March 2008
Previous report:	None
Key staff:	Dr A M Berrie Prof. J V Cross
Location of project:	East Malling Research New Road East Malling, Kent ME19 6BJ
Project coordinator:	
Date project commenced:	1 April 2007
Date project completed (or expected completion date):	31 March 2010
Key words:	Apple, residue-free, pest, disease, storage rot, fungicide, insecticide

Disclaimer:

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

AUTHENTICATION

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

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Grower Summary

Headline

- The scab control achieved in the zero residues management system (ZRMS) plots was as good as that achieved in a conventional programme, but with less fungicide input.

Background and expected deliverables

Consumers want perfect apples of known varieties that are free of pesticide residues. Consequently this is also becoming a demand on growers by the major supermarkets. Unfortunately the main UK apple varieties – Cox, Gala and Bramley are susceptible to most pest and diseases and the UK climate ensures that one or other of these problems occur in most seasons. The zero residue requirement is therefore a major challenge for growers.

Zero residue management system (ZRMS) was developed to achieve residue-free apples but be profitable and sustainable for the grower. The system is based on the use of conventional pesticides up to petal fall and after harvest, but during fruit development in summer only biocontrol agents or sulphur is used. The key to success is disease control during the dormant season to minimise inoculum carryover into the new season. The system has been evaluated in experimental plots at EMR on scab susceptible and scab resistant varieties for 6 years as part of Defra funded project HH3122STF and HDC project TF164. In this trial scab, mildew and storage rot control were as good as or better than that in conventional plots and pest control was also satisfactory.

Some limited evaluation has also been conducted in four commercial orchards (two Cox and two Gala) in Kent over three years, also with promising results, particularly on Gala. This funding finished in March 2007.

There is a need for further evaluation of ZRMS in commercial orchards specifically targeting other fruit growing areas, where the disease risk is higher, and other varieties such as Bramley, Braeburn or Cameo. This will provide the industry with more information on the robustness of the system and identify any new problems that could affect its long-term success.

If the extended evaluation is successful then it will provide the industry with a pest and disease management system to satisfy their customers.

Summary of the project and main conclusions

In two established trial sites on cv. Gala (established in 2004 as part of the Defra-funded project) and located at Farm A in West Kent and Farm B in East Kent, the pest and disease control achieved by the Zero Residue Management System (ZRMS) (Table 1), applied to half the orchard was compared to that achieved by the grower's conventional programme applied to the other half of the orchard. Pest and disease incidence was assessed at monthly intervals from green cluster to harvest. At harvest 1,000 fruit were picked from each half of the orchards and assessed for pest and disease.

Weather conditions pre-blossom were dry and did not favour apple scab, whereas May, June and July were exceptionally wet and favourable for scab infection. At Farm B, scab control in the ZRMS plot (0.1% on fruit at harvest compared to 0.8% in conventional plot) was as good as that in the conventionally-sprayed plot. At Farm A no scab was recorded until August when it was noted on the youngest leaves on the extension growth in both plots. Around 2% scabby fruit were present in the ZRMS plots and none recorded in the conventional plot.

The incidence of primary mildew was generally low at both sites but secondary mildew on extension growth rapidly built up in the summer to around 40-100 % infected shoots in both plots at both sites. The high incidence of secondary mildew did not appear to affect yield or fruit quality

Only fruit from the trial at Farm A was stored and only short-term until December. Losses due to rots were very low in fruit from both conventional and ZRMS plots.

The incidence of pests at both sites was in general low and treatments applied in ZRMS plots gave satisfactory control of pests compared to conventional plots. At Mount Ephraim the main pest problem was codling moth. This was adequately controlled by the use of codling moth granulosis virus in ZRMS plots. The incidence of fruit tree red spider mite built up to damaging levels in both ZRMS plots and conventional plots at Farm B in August and required intervention with an acaricide. Reasons for the increase are not clear as there were adequate numbers of predatory mites present in the orchard, butt the problem was not due to the ZRMS.

No pesticides were detected in fruit sampled from ZRMS plots at harvest apart from myclobutanil at 0.01mg/kg. Penconazole, myclobutanil, fenpyroximate, boscalid and pyraclostrobin were detected in fruit sampled from conventional plots but not above the MRL.

Three new sites, two in Kent (cvs Bramley and Braeburn) and one in Gloucestershire (cv. Gala) were identified for trials in 2007/8. The ZRMS plots at these sites were treated post-harvest according to the treatments in Table 1.

Financial benefits

Experience from the Defra-funded project has shown that use of sulphur in the post-blossom period in ZRMS plots results in a saving of approximately £100/ha. However, use of more selective insecticides results in an increased cost so that overall the spray costs for the ZRMS and conventional plots were similar. There are additional costs in management as more careful monitoring is required in ZRMS plots. Currently, there are no premiums paid for fruit from ZRMS plots other than that of satisfying customer requirements.

Action points for growers

- The ZRMS system has been evaluated in commercial orchard trials on cvs Gala and Cox for four seasons without any serious problems
- Growers can now evaluate the system for themselves on these varieties
- It is important initially not to be too ambitious. Select one or two orchards on the farm to manage according to the system to gain experience before embarking on a wider adoption of the system

The following summarises the main points to be considered when setting up a ZRMS in an orchard.

The key feature of the zero residue management system is to reduce the populations of pest and disease during the dormant season to ensure negligible inoculum carryover from one season to the next. Choice of orchard, starting at the right time and meticulous and sustained orchard monitoring and implementation of the management programme are vital to success.

Choice of orchard

It is important that orchards selected for Farm B have a low incidence of pests and diseases, especially powdery mildew, at the outset. Those with a history of disease or pest problems should be avoided. The orchard must be well managed and trees trained and pruned to ensure an open canopy for good air circulation and spray penetration. Our trials experience so far has been on cvs Cox, Gala and Fiesta and on scab resistant cultivars where we have had good success. So use orchards of these varieties first. Evaluation of the system in other varieties such as Bramley and Braeburn is part of this HDC project.

When to start

It is important to start the zero residues programme in the autumn, shortly after harvest to implement the important late season and dormant period tasks that are vital to success.

Zero Residues Management

The features of the zero residue management system are summarised in Table 1.

Management of the herbicide strip

Management of the tree strip is the same as in conventional production. Excessive weed growth is undesirable, but managed could provide soil cover to prevent soil splash to fruit pre- harvest. A dead-grass mulch is ideal. Applying a straw mulch would also prevent soil splash.

Orchard monitoring

A rigorous, regular programme of orchard monitoring for pests and diseases is vital. This enables timely corrective action to be taken. Orchard inspection for scab during blossom and petal fall is critical. If significant levels of scab are present then proceeding with the zero residues programme is not advised. Similarly, if a problem gets out of control between petal fall and harvest then it may be necessary to make pesticide applications to make a correction. This should rarely be necessary and may not result in residues if a sufficiently long harvest interval can be observed.

Table 1. Summary of treatments in the zero residue management system

Timing	Pest/Disease target	Treatment
Post harvest (conventional pesticides)		
September/October	scab/mildew	Systhane+ Captan
October	Nectria canker	Folicur*
October (approx. 7-14 Oct)	aphids	Aphox or other aphicide but different chemical group to Calypso
Pre-leaf fall	scab	urea
Leaf fall	Nectria canker	Cuprokylt Folicur*
Winter	Overwintering codling	Nematodes
Winter	Canker	Removal in pruning
Winter/spring	scab	Macerate leaf litter
Pre bud burst (conventional pesticides)	Scab/Nectria canker	Cuprokylt
Bud burst – petal fall (conventional pesticides)		
Bud burst - petal fall	scab	Dithianon Captan Systhane
Budburst - petal fall	mildew	Systhane or Nimrod or Topas
Mouse ear/green cluster	tortrix/winter moth	Runner
Pink bud	tortrix	Insegar
	aphids/weevils/sawfly/capsids	Calypso
Blossom and petal fall	Nectria/storage rots	Bellis or Captan
Petal fall	Tortrix/codling moth	Insegar
	aphids/weevils/sawfly/capsids	Calypso
Petal fall – harvest (sulphur, biocontrol or cultural control only)		
Petal fall – harvest	mildew	sulphur
Petal fall – harvest	codling moth	Granulosis virus
Petal fall – harvest	tortrix	Dipel* (Bacillus thuringiensis)
Petal fall – harvest	storage rots	Rot risk assessment Inoculum removal Selective picking

* Specific Off Label Approval

Science Section

Introduction

Consumers want perfect apples of known varieties that are free of pesticide residues. Consequently this is also becoming a demand on growers by the major supermarkets. Unfortunately the main UK apple varieties – Cox, Gala and Bramley are susceptible to most pest and diseases and the UK climate ensures that one or other of these problems occur in most seasons. The zero residue requirement is therefore a major challenge for growers.
zero residue management system (ZRMS) was developed to achieve residue free apples but be profitable and sustainable for the grower. The system is based on the use of conventional pesticides up to petal fall and after harvest, but during fruit development in summer only biocontrol agents or sulphur is used. The key to success is disease control during the dormant season to minimise inoculum carryover into the new season. The system has been evaluated in experimental plots at EMR on scab susceptible and scab resistant varieties for 6 years as part of Defra-funded project HH3122STF and HDC project TF164.

At EMR in a large, replicated orchard experiment the ZRM system was applied to established plots (MS, MR) containing scab susceptible (Cox, Gala, Fiesta, Discovery) or scab resistant cultivars (Saturn, Ahra, Discovery) and compared with conventionally (CS, CR) sprayed or unsprayed (US/UR) plots of the same cultivars. Both 2004 and 2006 were high risk years for scab with 56-89% (2004) and 24-92% (2006) scabbed fruit recorded at harvest in untreated plots (US). Despite this, the scab control achieved in ZRMS plots (MS/MR) in 2004 (<1% scabbed fruit) and in 2006 (0.2-5.8%), was as good as or better than that in CS/CR plots (<1% scabbed fruit in 2004 and 0.7-6.2% scabbed fruit in 2006) which had received season-long fungicides. The risk of powdery mildew was high in all three years (up to 100% mildewed shoots in US/UR plots), but the control achieved by the managed programme, based on elimination of primary mildew and fungicides pre-bloom combined with low dose sulphur sprays post-bloom, applied to MS/MR plots was as good as that achieved by the conventional programme of sprays applied to CS/CR plots. Losses due to rots in store were generally less in fruit from MS/MR plots, where the emphasis had been on cultural control, rot risk assessment and selective picking, than in CS/CR plots that had received pre harvest captan or tolylfluanid sprays only, or US/UR plots, that were untreated.

Rhynchites weevil (*Coenorhinus aequatus*), Totrix moth (*Adoxophes orana, Archips podana*) and rosy apple aphid (*Dysaphis plantaginea*) were the main pests recorded at damaging levels in untreated plots. Pest control in MS/MR plots was based on IPM monitoring and treatment pre-bloom and at petal fall with selective insecticides and with granulosis virus for codling control in summer and was as good as that achieved in CS/CR plots where control was based on conventional pesticides (including organophosphate insecticides) pre- and post-blossom. Fruit russet was similar in both MS/MR plots and CS/CR plots, indicating that there was no effect of sulphur on the fruit quality. In all three seasons there were savings in the cost of fungicides in MS/MR plots of around £100/ha, but these were offset by the higher costs of the selective insecticides used resulting in most cases in similar costs in the MS/MR and CS/CR programmes. Additional costs were incurred in MS/MR plots for pest and disease monitoring, inoculum removal and selective harvesting. No residues were detected (analysed to limit of detection) in fruit sampled at harvest from MS/MR plots. In these trial plots the ZRM system has given comparable pest and disease control to that in the conventional system. The key to the success has been the emphasis on control in the dormant season and pre-bloom, meaning that minimal problems have been carried to the post bloom period.

In 2004 to 2006, as part of projects HH3122STF and TF164, trials were conducted in four commercial orchards in Kent (two on cv. Cox and two on cv. Gala) in which the pest and disease control achieved by the ZRM system established in half the orchard was compared to that in the other half receiving the grower’s standard pesticide programme. In general, scab control in the ZRMS was acceptable and as good as in the grower plots. Where scab occurred at higher incidence it was not attributable to the ZRMS approach. Powdery mildew was the main disease problem encountered in three of the sites due to a high incidence of primary mildew at the start of the trial. In such circumstances reduced dose sulphur gave poor control. The ZRM system is not suitable for orchards with a moderate to high incidence of primary mildew and powdery mildew control must be restored by conventional means before adopting the system in these orchards. In the trial sites control of storage rots was similar in both plots, but none of the orchards were stored long-term for the system to be thoroughly tested. Pest control, in the ZRMS in the four orchard sites was variable, but in general similar to that in the growers half. These trials have demonstrated the practical feasibility of the system.

Defra funding for the zero residues system finished in March 2007.There is a need for further evaluation of ZRMS in commercial orchards specifically targeting other fruit growing areas, where the disease risk is higher, and other varieties such as Bramley, Braeburn or Cameo. This will provide the industry with more information on the robustness of the system and identify any new problems that could affect its long term success.

If the extended evaluation is successful then it will provide the industry with a pest and disease management system to satisfy their customers.

Overall aim of project

To test and demonstrate the zero residue management system (ZRMS) under a range of conditions on commercial farms to identify any problems and to encourage uptake of the system by fruit growers

Specific Objectives

1. To continue evaluation of ZRMS in existing trial sites in Kent to monitor the long term effects of the system in commercial orchards.
2. To evaluate the ZRMS in commercial orchards located in UK fruit growing areas outside Kent where the pest and disease risk may be higher
3. To evaluate the ZRMS system in commercial orchards on other varieties such as Bramley and Braeburn

Objective 1 - Evaluation of ZRMS in existing trial sites in Kent

The established trials comparing ZRMS system with the grower's conventional system were continued at the two sites in Kent on cv Gala for a further three years to obtain further data under different weather conditions and identify any new problems that might arise in low pesticide input systems.

Materials and methods

<u>Site</u>

Two existing orchard trial sites were used in 2007. Site one was located at Broadwater Farm, West Malling, (No. 1 Gala), and site two was located at Mount Ephraim, Hernhill, (Resevoir A and B). At site one the orchard was a single row Gala orchard on M26 rootstock with *Malus* pollinators. At site two the orchard consisted of a four-row bed of Gala on M9 rootstock with Cox pollinators. Zero residue trials were established in these orchards in 2004.

<u>Experimental details</u>

Each orchard was split, the grower's current programme being applied to one half as a comparison to the zero residue system applied to the other half. A zero residue protocol was established as part of Defra project HH3122STF. The main principles of the system are as follows:

- Dormant season treatments (DMI fungicide (e.g. myclobutanil) and urea applied pre-leaf fall) to minimize overwintering scab inoculum
- Aphicide applied in early October to control rosy apple aphids returning to apple trees from summer hosts to prevent egg laying
- A pre-bud burst copper spray to control scab overwintering on the tree
- Conventional fungicides and insecticides (no organo-phosphate insecticides) up to petal fall for scab, mildew and pest control. Use of ADEM or other scab warning system where possible to assist in decisions on fungicide use
- Reduced dose sulphur during the post-bloom period for mildew control.
- Biocontrol agents (*Bacillus thuringiensis* and codling moth granulosis virus) for control of Tortrix, codling moth and other caterpillars post-bloom.
- Storage rot management is based on inoculum removal, rot risk assessment and selective picking at harvest.

A typical ZRMS spray programme from bud burst to harvest and post-harvest is shown in Tables 2 and 3.

<u>Assessments</u>

Pest and disease incidence was assessed at standard key times (Cross & Berrie, 2001) and pheromone traps used to assist in decisions on pesticde use. Full assessments of key pests (rosy apple aphid, apple grass aphid, caterpillars, sawfly, capsid) and scab and mildew incidence were made pre-bloom, at petal fall and on two occasions before harvest (Cross & Berrie, 1995). The assessments were done on 50 trees in each half of the orchard. ZRMS plots were monitored more frequently for decision making on pest and disease treatments.

At harvest pest and disease incidence was assessed on a random sample of 1000 fruit from each half of the orchard, consisting of 20 fruit taken at random from 50 trees per plot. A random sample of ten bulk bins of fruit, each containing approximately 2000 fruit, from each plot were labeled and stored. Rot incidence and grade out was assessed at the end of the storage period.

Standard nutrient programmes were applied to both plots. Random samples of 25 fruit per plot were taken at harvest and sent for analysis for pesticide residues. Records of treatments costs were kept for comparison.

Table 2. Typical spray programme applied to ZRMS plots from bud burst to harvest in 2007

Crop: COX, GALA Spray Interval: 10 days Spray Volume: 150-200 L/ha

Growth Stage/ Timing	Pest/Disease	Chemical Product	Rate/hectare	Comments
Pre bud-burst	Scab/canker	Cuprokylt Fl	5 L/1000 L water	Apply before bud burst. Phytotoxic to young foliage **Note maximum spray concentration on label**
Bud burst	Scab/canker Fruit tree red spider	Dithianon WG + Scala	750 g + 1.0 L	Apply promptly at bud burst. Inspect orchards for winter eggs. Where numbers high, earmark for checking and possible treatment later
Mouse ear	Scab/canker	Dithianon WG + Scala	750 g + 1.0 L	**Don't use Dithianon on Gala after green cluster**
Green cluster	Caterpillars Sawfly Scab/mildew Scab	Runner sticky traps Systhane 20 EW + Captan 80	0.6 L 0.33 L + 2.0 kg	See notes re caterpillar control Put out in orchards Add reduced rate Captan to enhance scab protection.and for canker control If weather cold or wet, increase rate of Captan.
Late Green Cluster	Tortrix caterpillars	Insegar	600 g	**See notes re caterpillar control. Insegar is high risk to bees. Do not apply to crops in open flower or where bees are actively foraging or when flowering weeds are present.**

Growth Stage/ Timing	Pest/Disease	Chemical Product	Rate/hectare	Comments
Pink bud	Aphids/ capsid,/sawfly Scab/mildew Scab Primary mildew	Calypso Systhane 20 EW + Captan 80	375 ml 0.33 L + 2.0 kg	Add Captan to enhance scab protection on fruitlets. Increase rate to 2kg/ha if weather wet or cold, especially on Gala. Pick off primaries and remove from orchard. See notes re mildew control
Blossom	Scab/mildew	Systhane 20 EW + Captan 80	0.33 L + 1.5 kg	Time sprays to fall at the start and end of blossom if possible, but if blossom period is extended, spray as necessary.
Late Blossom	Storage rots	Bellis	0.8 kg	In orchards where canker is a problem
Petal fall	Aphids/capsid/sawfly Tortrix/codling Scab/mildew Codling/Tortrix Primary mildew	Calypso Insegar Systhane 20 EW + Captan 80 Pheromone traps	375 ml 600g 0.33 L + 2.0 kg	See notes re caterpillar control Put out traps in orchards, and monitor weekly. Pick off primaries and remove from orchard. See notes re mildew control
+ 10 days	Mildew	Sulphur	5 L	Rate of sulphur use will be adjusted according to the mildew risk. **See notes re maximum number of sprays**

Crop: Cox, Gala   Spray Interval: 7-10 days   Spray Volume: 150-200 l/ha

Growth Stage/Timing	Pest/Disease	Chemical Product	Rate/hectare	Comments
+7- 10 days	Mildew	Sulphur	3.0 L	Rate of Sulphur

Growth Stage/Timing	Pest/Disease	Chemical Product	Rate/hectare	Comments
	Fruit nutrition Codling moth	Calcium chloride Granulovirus	 100 ml	adjusted according to mildew risk Start calcium programme on Cox. Rates see page 11 Check traps: Spray 7-10 days after threshold catch. Repeat at 7-10 days intervals for 3 sprays against first generation **Granulovirus is experimental approval**
+ 10 days	Codling moth Summer fruit tortrix caterpillars Mildew	Granulovirus Dipel Sulphur	100 ml 0.75 kg 3.0 L	Check traps. Repeat sprays as necessary. **Granulovirus is experimental approval.** See notes re caterpillar control**. Dipel is Off label approval** Rate of Sulphur adjusted according to mildew risk
Early July	Fruit tree tortrix/ Blastobasis (codling moth) Mildew	Dipel Sulphur	0.75 kg 3.0 L	Inspect moth traps. Spray 7-10 days after threshold count if necessary. See notes re caterpillar control Rate of Sulphur adjusted according to mildew risk
Late July/earl;y August	Codling moth	Granulovirus	100 ml	Check traps: Spray 7-10 days after threshold catch. Repeat at

Growth Stage/Timing	Pest/Disease	Chemical Product	Rate/hectare	Comments
				7-10 days intervals for 3 sprays against second generation. **Granulovirus is experimental approval.**
Continue a ten day programme of Sulphur sprays at 3.0 L/ha until end of extension growth . See notes re maximum number of Sulphur sprays per crop.				

Notes:

1. Read product label carefully before applying any sprays
2. Scab control
   - The programme is based on Dithianon WG and Captan and Systhane. Topas 100 at 0.5 L/ha could be used in place of Systhane if preferred. Dithianon WG can cause poor fruit finish on Gala. **Do not use after green cluster**
3. Mildew control
   - Mildew control is based on minimising the inoculum post-bloom. This means as far as possible removing any primary mildew promptly at pink bud and petalfall.
   - In 2005 there were high levels of primary mildew, especially primary vegetative mildew, in the trial plots. In 2006 it is essential that the inoculum from the primary mildew is minimised. Primaries will be removed by hand as far as possible. In addition, at pink bud and at petalfall additional fungicide treatments may be applied depending on mildew incidence. Possible treatments include Systhane at 450ml/ha plus Nimrod at 1.4 L/ha or Systhane at 450ml/ha plus Stroby at 0.2kg/ha. These will be advised according to assessed primary mildew incidence
   - The rate of Sulphur used post bloom will depend on the mildew risk, but is usually 30-50% of the full rate. Mildew will be regularly assessed in the Zero residue plots post Bloom and any changes in the sulphur rate requested by email, fax or phone. **Please note that Headland Sulphur Flowable and United Phosphorus Sulphur Flowable both have a maximum number of sprays for disease control of four per crop.**
   - Potassium bicarbonate has been used for mildew control on some farms with success. And could be used to reduce mildew. Up to 60 kg of potassium bicarbonate can be **used per hectare per annum.** A starting rate of 5 kg per hectare in 500 to 1000 litres of water is suggested. A suitable wetter should also be used. **This must be applied as a separate spray.**

4. Caterpillar control
   - Runner (methoxyfenozide) should be applied at green cluster to control winter

moth. At this timing it will also give some control of overwintering tortrix caterpillars. This product appears to be more effective against the younger tortrix caterpillars and therefore should work better if applied earlier pre-bloom

- Insegar (fenoxycarb) will be used for control of summer fruit tortrix caterpillars. To ensure that this product is applied prebloom it will be applied at late green cluster. If the weather is very warm and there is a risk of rapid progression to flowering then the Insegar may need to be applied earlier possibly in combination with Runner at Green cluster. A further treatment must be applied at petalfall when it will also give some control of codling moth
- **N.B. Insegar is high risk to bees. Do not apply Insegar to crops in open flower or to those in which bees are actively foraging. Do not apply when flowering weeds are present**
- After petalfall Dipel (BT) can be used for control of tortrix moth and clouded drab moth caterpillars. This product will give very little control of codling moth. This is an Off label Approval. A copy of the SOLA is included

5. Codling moth control
   - Codling moth granulosis virus (CpGV) is widely used for codling moth control in other parts of Europe. This product is currently not approved for use in the UK. However there is Experimental approval for a CpGV product for use in these trials. This will be used in response to pheromone trap catches to control codling moth. Sprays are applied at the start of egg hatch. A maximum of 3 sprays should be applied against each generation, at 7-10 day intervals, starting 7-10 days after the threshold catch
6. Woolly aphid
   - Woolly aphid was starting to appear in some plots in 2005
   - The aphid appeared to be suppressed by the use of magnesium sulphate at 2.5-3.0 kg/ha. For more details contact Jerry Cross
7. Nutrients
   - **NB Nutrients can be applied as normal to both plots**

Table 3. Treatments applied to ZRMS plots post-harvest in 2007

Timing	Target pest/disease	Treatment	Rate/hectare
Early October	Scab/mildew	Systhane 20EW + Captan	0.45L + 1.2kg
October (approx 7-14 October)	Aphids	Aphox or Mainman	420g or 0.14kg
October (pre leaf fall)	Scab/canker	Folicur (Off Label Approval)	0.6L
Pre leaf fall	Scab	Urea	5%
October	Overwintering codling & Tortrix	Nematodes	Nemasys C (Steinernema carpocapse) 1.5 billion/hectare
Post harvest 10% leaf fall	Canker	Cuprokylt FL	5.0L/1000L
Post harvest 50% leaf fall	Canker	Cuprokylt FL	5.0L/1000L
Winter pruning	Canker	Removal during pruning	-

Notes:

- Dithianon WG at 0.75kg/ha is an alternative to Captan
- Timing of the aphid spray will vary according to season and region. Jerry Cross to advise on best timing
- Nematode treatment will reduce overwintering caterpillars. Use where these pests were a problem in 2007. Apply as a high volume spray to the surface of trunk and lower branches in October in wet conditions. Product is supplied by Becker Underwood (contact Andy Brown Tel 01903 732323 or 07974662951)
- Apply Cuprokylt spray to orchards with a canker problem. Note that there is a maximum spray concentration on product label. Apply at 1000L/ha to ensure thorough wetting of wood and leaf scars. Where leaf fall is prolonged Folicur at 0.6L/ha may also be used to ensure leaf scar protection
- Nutrients are applied as normal practice to both plots
- Weed control/herbicide use as normal practice to both plots

Results

Diseases

Weather conditions were wet and favourable for scab infection around bud burst on 23 March, but during April and early May the conditions were warm and very dry and did not favour apple scab infection (Table 4). May, June and July were exceptionally wet and favourable for scab infection. Apple scab was not recorded on shoots or fruit at Mount Ephraim until the end of July/August, where scab was recorded on shoots in the conventional plot and on fruit in both plots, but only at a very low incidence. Similarly, at Broadwater farm no scab was recorded until August when it was noted on the youngest leaves on the extension growth in both plots (Table 5). At harvest in September, the scab incidence on fruit was negligible at Mount Ephraim. At Broadwater around 2% scabby fruit were present in the ZRMS plots and none recorded in the conventional plot. Less than 0.1% storage scab was recorded on stored fruit from both plots during grading in December. Late scab was recorded on sampled leaves from both plots at both sites in October but only at a low incidence.

No primary blossom mildew was recorded at either site when assessed in April (Table 6) and primary vegetative mildew recorded in May was only present at Mount Ephraim and at similar incidence in both plots. Despite this low incidence of primary mildew, secondary mildew on extension growth rapidly built up in the summer to around 40-100 % infected shoots. At Broadwater, at the final assessment in July the incidence of mildewed shoots was about 50% lower in the conventional plot compared to the ZRMS plot (Table 6), but still above the acceptable incidence of secondary mildew on extension growth of 30% mildewed shoots. At Mount Ephraim at the final assessment in July the incidence of mildewed shoots was similar in both plots and well above commercially acceptable levels (Table 6).

Only fruit from Broadwater Farm were stored and only short term until December. Total losses due to rots were very low - 0.4-0.5% (Table 7). Nectria rot (*Nectria galligena*) and brown rot (*Monilinia fructigena*) were the predominant rots present. The incidence of nectria rot was highest in the conventional plots and corresponded to a higher incidence of nectria eye rot recorded in the conventional plots at harvest (1.1% compared to 0.6%). The incidence of brown rot was highest in the ZRMS plot and this also corresponded to a higher incidence of this rot in ZRMS plots at harvest compared to conventional plots (1.5% compared to 0.5%). The incidence of both rots in store was however, very low (Table 7). The grade out of the fruit was >90% Class 1 for both plots.

Table 4. Apple growth stages, monthly rainfall (mm) and number of days on which rain fell recorded at EMR in March to September in 2007, compared to 50 year average

Month	Apple growth stage (date)	Rainfall mm	Number of rain days	50 year average
March	Bud burst (23 March)	51.0	21	44.3
April	Mouse ear (2 April) Green cluster/pink bud (13 April) Full bloom (23 April) Petal fall (30 April)	0.8	3	44.5
May		85.0	19	45.8
June		67.4	20	49.7
July		117.8	18	46.4
August		40.8		52.0
September	Harvest (5-10 September)	25.4		63.7

Table 5. Apple scab incidence as % infected shoots or fruit 2007 at 2 commercial trial sites

Scab assessment	Broadwater Gala		Mount Ephraim Gala	
	ZRMS	Conventional	ZRMS	Conventional
April/ May	0	0	0	0
7 June	0	0		
11 June				
26 June			0	0 (fruit scab)
2 July	0	0		
31 July			0	1.0
24 August	21.7	2.5	0 (2 scabby fruit)	5.0 (2 scabby fruit)
Harvest September	2.4	0	0.1	0.8
Late leaf scab (% infected leaves) October	16.0	11.0	8.0	4.0

Pests

The incidence of pests recorded at Broadwater in both plots pre- and post-blossom was very low. Pheromone trap catches for both plots are shown in Table 8. Neither codling nor tortrix catches in the traps reached threshold in the ZRMS plots and therefore did not require treatment. Runner (methoxyfenozide) was applied for tortrix control in the conventional plot post-blossom. Pest damage recorded on the fruit at harvest is shown in Table 9. Total pest damage recorded on the fruit from ZRMS plots was low (3.3%) but double that recorded in the conventional plot. Most of the difference was accounted for by increased incidence of tortrix and codling moth damage to fruit in the ZRMS plots, but actual losses were very low and acceptable commercially.

Table 6. Powdery mildew incidence as % infected blossoms or shoots 2007 at three commercial trial sites

Mildew assessment	Broadwater Gala		Mount Ephraim Gala	
	ZRMS	Conventional	ZRMS	Conventional
Primary blossom April	0	0	0	0
Primary veg May	0	0	0.3	0.3
7 June	62.5	66.7		
11 June				
26 June			92.5	98.3
2 July	91.0	42.0		
31 July			100	94.0
24 August	81.7	55.8	97.5	86.7

Table 7. Incidence as % infected fruit of post harvest rots in cv. Gala stored until December 2007

Storage rot	Broadwater Gala December 2007	
	ZRMS	Conventional
Brown rot	0.12	0.05
Phytophthora	0.02	0.01
Nectria	0.16	0.39
Botrytis	0.03	0.02
Penicillium	0.04	0.01
Gloeosporium	0.02	0.01
Storage scab	0.04	0.02
Other	0	0
Total losses due to rots	0.4	0.5

The incidence of pests recorded at Mount Ephraim in both plots pre and post blossom was in general low. Pheromone trap catches (Table 8) for codling moth reached threshold in the ZRMS plots and CyD-x (codling moth granulosis virus) was applied on three occasions for control. Runner (methoxyfenozide) was applied for tortrix and codling moth control in the conventional plot. As in previous years woolly aphid (*Eriosoma lanigerum*) developed on trees in both plots. Magnesium sulphate was applied on several occasions and prevented build-up of the pest to damaging levels. In August, the incidence of fruit tree red spider mite (*Panonychus ulmi*) increased rapidly in both plots, causing leaf bronzing, and requiring intervention with the acaricide Sequel (fenpyroximate). The orchard predatory mite (*Typhlodromus pyri*) was present in the plots but not in sufficient numbers to effect rapid control of the red spider mite before leaf damage occurred. Pest damage recorded on the fruit at harvest is shown in Table 9. Total pest damage recorded on the fruit from ZRMS plots was low (2.4%) and approximately half of that recorded in the conventional plot. Most of the difference was accounted for by increased incidence of tortrix and codling moth damage to fruit in the conventional plots, but actual losses were very low and acceptable commercially.

Table 8. Moth catches in pheromone traps sited in ZRMS and conventional plots in No. 1 Gala orchard at Broadwater Farm, West Malling, in 2007

Date	ZRMS				Conventional			
	Codling moth	Summer fruit tortrix	Fruit tree tortrix	Light brown apple moth	Codling moth	Summer fruit tortrix	Fruit tree tortrix	Light brown apple moth
10 May	0	0	0	6	1	3	0	5
18 May	1	0	0	10	1	1	0	18
25 May	4	4	0	12	3	8	0	3
1 June	0	10	1	2	0	11	1	5
8 June	1	4	13	7	0	2	7	4
15 June	0	9	23	0	1	10	8	0
22 June	0	6	8	2	2	1	4	0
29 June	0	1	3	0	0	0	0	1
6 July	0	0	4	6	2	0	5	1
16 July	9	0	8	7	9	0	11	10
20 July	3	0	6	5	2	0	5	6
27 July	0	0	3	10	0	0	3	11
6 August	0	2	3	25	5	2	7	39

Table 9. Pest damage to fruit recorded as % damaged fruit at harvest 2007 at two commercial trial sites

Pest	Broadwater Gala		Mount Ephraim Gala	
	ZRMS	Conventional	ZRMS	Conventional
Rosy apple aphid	0.3	0	0	1.2
Sawfly	0	0	0	0
Tortrix	1.7	0.9	0.1	0.6
Early caterpillar	0.2	0.3	0.4	0.1
Codling moth	0.6	0.3	1.7	2.4
Earwig	0.5	0	0.2	0.3
Rhynchites	0	0	0	0.1
Capsid	0	0	0	0
Blastobasis	0	0	0	0
Mussel scale	0	0	0	0
Total Pest damage	3.3	1.5	2.4	4.7

Pesticide residues

The results of the pesticide residue analysis conducted on fruit collected at harvest is shown in Table 10. Most of the pesticide applications to both ZRMS and conventional plots did not result in a detectable residues. In conventional plots, residues were detected for products applied near harvest (penconazole, boscalid, pyraclostrobin and fenpyroximate). No residues were detected in apples sampled from the ZRMS plots at Broadwater. Myclobutanil was detected in apples sampled from ZRMS plots at Mount Ephraim.

Discussion

Despite the wet conditions in May and June, the incidence of scab in the ZRMS plot at Mount Ephraim was negligible indicating that the scab control in this plot was as good as that in the conventional plot. At Broadwater the incidence of scab in the ZRMS and conventional was negligible and similar until the final assessment pre-harvest in August when scab was recorded on the youngest leaves on around 20% of the shoots compared to 2.5% of shots in the conventional. The incidence of scab on fruit at harvest was also higher in the ZRMS plot (2%) but still acceptable commercially. The presence of the late scab on the extension growth indicated the possibility of late scab infection of fruit which, although not visible on the fruit at harvest, could develop in store as storage scab. Short-term storage of the fruit until December ensured minimum risk of storage scab which develops at a slow rate at the temperature of 2ºC at which the fruit was stored. Although the scab incidence in the ZRMS plot was low treatments applied post-harvest to minimise overwintering scab were critical for scab control in 2008.

As in previous years the control of powdery mildew in ZRMS plots was poor at both sites despite the low incidence of primary mildew recorded in spring. However, the high incidence of secondary mildew appears to have little effect on yield and fruit quality in Gala.

At Mount Ephraim use of the granulosis virus (cyD-x) resulted in better control of codling moth than the insecticide used to treat the conventional plot. So far, codling moth has not reached threshold level at Broadwater.

It is difficult to explain the high incidence of fruit tree red spider mite recorded in August in both plots at Mount Ephraim, especially as the wet summer should not have been favourable to this pest. Intervention with an acaricide to control the problem was unavoidable in order to prevent loss of crop. The residue of the acaricide applied (fenpyroximate) was detected in the fruit from the conventional plot but not in those from the ZRMS plot.

Conclusions

- Control of apple scab in ZRMS plots was as good as that in conventional plots
- The incidence of secondary mildew in the ZRMS plots was high but similar to that in conventional plots
- The high incidence of secondary mildew did not appear to affect yield or fruit quality
- Losses due to rots was very low in fruit from both conventional and ZRMS plots at Broadwater, but the fruit was only stored until December
- The treatments applied in ZRMS plots gave satisfactory control of pests

Technology transfer

- The results from the first year of the project were presented to the HDC Top Fruit Panel in December 2007
- Results from the project were also presented at the EMRA Zero residues day at EMR in December 2007

Objectives 2 and 3 – Evaluation of ZRMS in commercial orchards outside Kent and in Bramley and Braeburn

In September 2007, trial sites for Bramley and Braeburn were established at Foxbury Farm, Stone Street, Ightham (12 Acres Bramley) and at Rodmersham Court, Rodmersham (Jazeels Braeburn). The orchards were divided into ZRMS and conventional plots and the post harvest programme (Table) applied.

In March 2008, a trial site was established in a Gala orchard at Castle Fruit Farm, Newent, Gloucestershire.

Table 10. Chemical residues (mg/kg) detected in apple samples taken at harvest

Site	Chemical	Residue detected mg/kg		Reporting level	MRL mg/kg
		ZRMS	Conventional		
Broadwater	penconazole	Not detected	0.01	0.01	0.2
Mount Ephraim	myclobutanil	0.01	Not detected	0.01	0.5
	boscalid	Not detected	0.11	0.01	1.0
	pyraclostrobin	Not detected	0.02	0.01	0.3
	fenpyroximate	Not detected	0.05	0.05	Not set

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Acknowledgements

Thanks to Mr Peter Checkley (Broadwater Farm), Mr Sandys Dawes (Mount Ephraim), Mr Robert Mitchell (Foxbury Farm), Dr Oliver Doubleday (Rodmersham Court) and Mr Michael Bentley (Castle Fruit Farm) for hosting the trials.

