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SID 4

Annual/Interim Project Report for Period

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Project details

1. Defra Project code: HH3122STF
2. Project title: Producing apples free from pesticide residues
3. Defra Project Manager: Dr Emma Hennessey
4. Name and address of contractor:
   East Malling Research
   New Road
   East Malling
   Kent

   Postcode Kent
5. Contractor's Project Manager: Dr Angela M Berrie
6. Project: start date ..... 1 April 2004
   end date ..... 31 March 2007

Scientific objectives

7. Please list the scientific objectives as set out in the contract. If necessary these can be expressed in an abbreviated form. Indicate where amendments have been agreed with the Defra Project Manager, giving the date of amendment.

The overall objective is to develop a management strategy that produces apples free of pesticide residues without loss in fruit quality.

Specific objectives are:

1. To (a) test and demonstrate the zero residue strategy under a range of conditions on commercial farms to identify any problems and to ensure uptake of the system by fruit growers and (b) to undertake a desk study to produce guidelines for use of fungicides and insecticides post bloom to ensure that fruit at harvest are free of pestcide residues.

2. To identify the long term effects of the zero pesticide residue strategy on pest and disease incidence and on pest and disease control.

3. To develop effective alternative methods for control of powdery mildew.

4. To evaluate two entomopathogenic fungi as biocontrol agents of rosy apple aphid in the orchard in spring and autumn, identifying any factors which limit efficacy.

5. To identify methods that eliminate apple scab on overwintering leaf litter in Bramley orchards.

6. To evaluate the longer term effects of the zero pesticide residue strategy on (a) arthropod populations in apple trees compared to those of a broadspectrum routine programme and untreated and (b)on microbial populations in apple trees compared to those of a broadspectrum routine programme or untreated.

7. To demonstrate to fruit growers the feasibility of the zero residue strategy and to encourage uptake by providing advice through the Apple Best Practice Guide and HDC Fact Sheets

Summary of Progress

8. Please summarise, in layperson's terms, scientific progress since the last report/start of the project and how this relates to the objectives. Please provide information on actual results where possible rather than merely a description of activities.

Objective 1
In collaboration with World Wide Fruit trials were continued at the orchard sites established in two Cox orchards and two Gala orchards on commercial farms in Kent. In each orchard the Zero Residue Management System (ZRMS) was applied to half the orchard and compared to the grower's standard programme in the other half. Dormant season treatments were applied to the ZRMS plots in autumn 2004. Pest and disease levels were mainly low and similar in ZRMS and grower plots. Scab incidence on fruit at harvest at all sites was <1% and similar in ZRMS and grower plots.The main disease problem was powdery mildew. The incidence of secondary mildew was high at sites 2-4 due to a high incidence of primary mildew in these orchards. Use of sulphur post bloom was only partially effective in controlling the mildew. In a non trial situation mildew control in such orchards would be re-established by a season of intensive fungicide use before resuming ZRMS. The incidence of codling moth was above threshold at site 3 but was well controlled post bloom by the use of codling moth granulosis virus.Woolly aphid incidence increased post bloom in orchards at site 4 and site 3 and this pest could pose problems for control in ZRMS. However, at site 3 frequent use of sprays of magnesium sulphate appeared to suppress development of the pest. The incidence of rots in Gala stored from sites 1 and 3 until December or January and in Cox from site 2 stored until January was <1% and similar in fruit from ZRMS and grower plots. The results from the second year of evaluation of ZRMS on commercial farms continue to look promising. No residues were detected in fruit from ZRMS plots.

Objective 1b
Data on residue decline in pesticides commonly used in apples have been sought from pesticide companies concerned. Obtaining the necessary information to give guidance on harvest intervals likely to give zero residues has been slow. Once all relevant information has been obtained the guidance document for growers will be finalised.

Objective 2
The trial established at East Malling in 2001, in which the ZRMS was developed, has been continued for a fifth year in order to study the long term effects of ZRMS in comparison to untreated and conventionally managed plots. 2005 was a moderate risk scab year with 30-60% scabbed fruit in untreated plots at harvest. Scab incidence on fruit at harvest was <1% in ZRMS plots compared to 0.3-1.2% in conventional plots. Similarly, <1% storage scab was recorded on Gala from ZRMS plots stored until mid March 2006, compared to 2% and 70% recorded on stored Gala from conventional and untreated plots respectively. This result demonstrates that the incidence of scab inoculum in ZRMS plots is very low, compared to conventional plots where late sprays were applied for scab control. Powdery mildew incidence was also low and similar in both treatments. Carbendazim applied at late bloom to ZRMS plots reduced the incidence of Nectria rot in store compared to the other treatments and this combined with the other strategies for control of storage rots in ZRMS were effective, with losses due to rots in Cox fruit from ZRMS plots stored until March lower than losses in fruit from conventional and untreated plots. So far, after five seasons the ZRMS has not resulted in a build up of disease, specifically scab and powdery mildew. *Phoma* leaf spot and sooty blotch are present but so far only at a low incidence.

The main pest problem recorded were Tortrix caterpillars and Rhynchites weevils (8% and 25% damaged fruit respectively in untreated plots). The pre bloom pesticide treatments applied in ZRMS plots, which included a post harvest aphicide in 2004, gave effective control of pests with around 4% damaged fruit at harvest compared to 5% damage in conventional plots and 50% damage on average in untreated plots. So far no new pest problems have started to build up in the ZRMS plots. No residues were detected in fruit from ZRMS plots.

Objective 3
A large plot trial was established on cv. Cox to evaluate efficacy of potassium bicarbonate or potassium phosphite compared to sulphur for control of powdery mildew. Untreated plots were included as controls. The incidence of secondary mildew in the orchard was very high and none of the treatments were effective in reducing mildew incidence to commercially acceptable levels. Potassium phosphite gave some reduction in mildew incidence, which is in contrast to results in trials elsewhere. In 2006 this trial will be repeated.

Objective 4
Three experiments, the last still in progress, examining the efficacy of foliar sprays of commercially available formulations of entomopathogenic fungi for control of rosy apple aphid have been done. In the first in spring 2004, sprays of *Beauvaria bassiana* and *Paecilomyces fumosoroseus* were applied in the spring. The effect of exclusion of ants was also investigated. Intensive application of sprays with a hand lance into individual colonies caused considerable mortality of aphids by physical means but no mycosis was observed in the field. Culturing in the laboratory showed that fungal spores were present on dead aphid bodies but this did not provide evidence that aphid mortality was caused by the entomopathogenic fungi applied. No quantitative effects of exclusion of ants were observed. The second experiment evaluated foliar sprays of two commercially available formulations of *Beauvaria bassiana* in the field for

control of rosy apple aphid in the autumn. The effect of an oil base adjuvant on the efficacy of the fungus is being studied. Populations of aphids that developed in May 2005 were very small but no affects of the treatments were apparent. A third experiment repeating the second is currently in progress. The effects of the treatments are to be assessed in May 2006. A fourth experiment examining the efficacy of spring sprays is being started in May 2006.

Objective 5
Scabby Bramley leaves were collected in autumn 2005, placed in net bags and dipped in various fungicides, including urea, myclobutanil, fenbuconazole, pyrimethanil, tebuconazole and untreated. Treated leaves were laid out on the orchard floor over winter in net bags in plastic trays, to protect them from earthworms. In spring the treated leaves were collected and assessed for scab pseudothecia and ascospores. Assessments are currently in progress. Results from a similar trial from 2004/2005 indicated that all the chemical treatments reduced ascospore incidence.

Objective 6a
The long-term effects of different intensities of pesticide management on the biodiversity of arthropods in the orchard ecosystem are being studied in the IPM orchard at East Malling. The arthropod biodiversity in each of the 12 plots of the IPM trial is being quantified over a 6-year period comparing the effects of the different treatments on biodiversity. In 2005, identification to species of the samples collected in 2004 was completed. Data sets for 2001, 2002 and 2004 are completed. The same range of arthropod groups representing phytophagous, predatory and benign guilds have been quantified using the same regular structured sampling regimen with four sampling methods (beat sampling, sweep netting, sticky traps from and pitfall traps) has been followed each year from April to September. For 2004, 38,555 individuals were collected and sorted into taxa, identified to species and counted. The data have been collated in full in excel data bases ready for statistical analysis. Sampling for the last year of the study is now in progress.

Objective 6b
The five different pesticide programmes applied to the trial plots at East Malling were used to study the long term effects of such programmes on microbial biodiversity on the leaf and fruit surfaces on the apple trees. In 2005 the study initiated in 2001 was continued. Rosette leaves or fruit of cv. Discovery were sampled on three occasions at petal fall, fruitlet stage in June and pre-harvest in August / September using the techniques and protocols established in project HH2502STF. Development of the molecular method for characterisation of the microflora has continued during the project. Initially Denaturing Gradient Gel Electrophoresis (DGGE) was chosen as the most suitable method for discriminating PCR products, but this system proved to be impractical, unreliable and gave poor resolution of PCR products. Similarly agarose gels also proved to be unsuitable. A method for analysis of the DNA extracted from leaf or fruit washings was therefore developed using a high resolution, high throughput DNA sequencer (ABI 3100 sequencer) and this method will be used to finally analyse the DNA extracts. Data from this will be analysed using GENESCAN and GENOTYPER. The 2006 programme will concentrate on completion of the DNA analysis and data interpretation with one or two further orchard samplings if needed.

Objective 7
Visits were made to the plots at East Malling by various grower groups. Growers met with a technologist from Marks & Spencer in the commercial trial at site 3 in August 2005 to discuss progress. The results of the first three years of the trial (HH2502STF) and year 1 of the current trial were presented to growers at several meetings. Events are listed in Section 12a.

Amendments to project

9. Are the current scientific objectives appropriate for the remainder of the project? ..... **YES** ☒ **NO** ☐

If **NO**, explain the reasons for any change giving the financial, staff and time implications.
Contractors cannot alter scientific objectives without the agreement of the Defra Project Manager.

Progress in relation to targets

10. (a) List the agreed milestones for the year/period under report as set out in the contract or any agreed contract variation.

It is the responsibility of the contractor to **check fully that all milestones have been met** and to provide a detailed explanation when they have not been achieved.

Milestone		Target date	Milestones met	
Number	Title		In full	On time
1/02	Desk study on pesticide residues	31/05/05	YES	YES
5/01	Effectiveness of DMI fungicides in scab sexual state suppression	31/03/06	YES	YES
6/01	Second years sampling of arthropod populations and microflora from plots complete	31/03/06	YES	YES
7/01	Grower visits to plots	31/12/05	YES	YES

(b) Do the remaining milestones look realistic?..... **YES** ☒ **NO** ☐

If you have answered **NO**, please provide an explanation.

Publications and other outputs

11. (a) Please give details of any outputs, e.g. published papers/presentations, meetings attended during this reporting period.

Publications

CROSS J.V. & BERRIE, A. M. (2005). Producing apples free of pesticide residues. Proceedings of 2005 BCPC International Congress, pp 775-782

BERRIE, A.M. & CROSS, J.V. (2005). Development of an Integrated Pest and Disease management system for apples to produce fruit free from pesticide residues. Proceedings of IOBC conference Baselga di Pine 2004. IOBCwprs Bulletin 28(7), pp. 22-32

BERRIE, A.M. & CROSS J.V. (2006). Development of an integrated pest and disease management system for apples to produce fruit free from pesticide residues – Aspects of disease control. Proceedings IOBC conference, Piacenza, Italy September 2005. IOBCwprs Bulletin (in press)

Presentations

April 2005 – Talk given at Cider growers conference on zero residue apple production

September 2005 – Talk given on disease control in Zero residue apple production at IOBC orchard diseases workshop

Marks & Spencer post-harvest chain improvement: Back to Basics workshop, 30 September 2005. Talk given Insect control in zero residue IPM systems

Marks & Spencer post-harvest chain improvement: Back to Basics workshop, 30 September 2005. Talk given post-harvest control of apple rots in zero residue systems

British Crop Protection Conference, Glasgow 31 Oct-2 Nov 2005. Paper given on zero residue apple production.

8 February 2006 – Two-hour lecture and training given by J Cross to Hutchinsons Ag Chem reps, including progress report on zero residue apple production

14 March 2006 – Talk given to West Sussex Fruit Group on coping with zero residues in apple production

Meetings attended

28 April 2005 – Discussion with grower and technologist from the Coop Group on zero residue production in apples and pears

12 May 2005 – Talk on Zero residue apple production at Tesco's Grower of the Year event

Marks & Spencer conference – 20 May 2005, participated

19 July 2005 – Visit growers and Marks& Spencer technologist to Zero Residue commercial trials

26 July and 2 August 2005 – HDC workshops on rot risk assessment conducted by A Berrie to train growers as part of alternative strategy for rot control, part of zero residue production

22 September 2005 – Exhibit on zero residue trial at East Malling Trade open day

Project HH3122STF – Growers steering committee meeting – 21 February 2006

(b) Have opportunities for exploiting Intellectual Property arising out of this work been identified? ..... **YES** ☐ **NO** ☒

If **YES**, please give details.

(c) Has any other action been taken to initiate Knowledge Transfer?..... **YES** ☒ **NO** ☐

If **YES**, please give details.

The results of the first four years of the project have been presented at many grower meetings. Discussions have also taken place with individual growers and their customers on possible implementation of the system in part on their farm in order to satisfy the growing demand for residue-free fruit. Collaboration with World Wide Fruit in establishing the trial sites on commercial farms ensures the project is well publicised. World Wide Fruit are already keen on encouraging their growers to adopt some of the practices in the system. Other aspects are listed above.

Future work

12. Please comment briefly on any new scientific opportunities which may arise from the project.

Biodiversity studies

Further work on arthropods could concentrate on groups not already studied or be extended to other apple management systems such as organic production.

The techniques developed in this project to study microbial biodiversity could be used to look at microbial diversity in other apple management systems such as organic production or other perennial crops such as raspberries. It can also be used to study biocontrol of plant pathogens.

Zero pesticide residue management strategy

The work so far has concentrated on Cox and Gala. There is a need to extend the commercial trials to other areas where disease control may be more challenging due to higher rainfall and to cover other apple varieties such as Bramley and late picked varieties such as Braeburn and Cameo.

The strategy developed in this project to produce residue-free fruit could be extended to other fruit crops such as raspberries.

Declaration

13. I declare that the information I have given is correct to the best of my knowledge and belief.

Name	Dr Michael G Solomon	Date	28 April 2006
Position held	Science Director, East Malling Research		