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Project leader:	Dr Robert Saville East Malling Research
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Key staff:	Dr Robert Saville (EMR) Dr Michelle Fountain (EMR) Dr Angela Berrie (EMR) Mr Chris Nicholson (ADAS) Prof David Hall (NRI) Dr Rob Jackson (UoR)
Location of project:	NIAB EMR (Lead), RSK ADAS, Natural Resources Institute, University of Reading.
Industry Representative:	The programme management group (PMG) Nigel Kitney, Jeremy Linsell, Nigel Jenner and Tom Hulme
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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.

Robert Saville
Project leader, Plant Pathologist
NIAB EMR
Signature ..... Date .....

Michelle Fountain
Entomologist
NIAB EMR
Signature ..... Date .....

Report authorised by:
Rachel Lockley
Fruit Technical Manager
AHDB
Signature ..... Date .....

Signature ..... Date .....

GROWER SUMMARY

Objective 6 - Codling and tortrix moth

Project TF 223 is a five year project which was commissioned to tackle a number of current pests and diseases affecting tree fruit crops. Objective 6 deals with novel methods of controlling codling and tortrix moth species in apple orchards.

Headline

- The RAK3+4 mating disruption system can give comparable control of codling and tortrix moths to conventional spray programmes.

Background and expected deliverables

Codling moth is the most important pest of apples and is also an important pest of pears in the UK. Most insecticide sprays used on these crops are targeted specifically towards these moths. Control is usually good, but populations are not reduced to such low levels that spraying is reduced in subsequent years. Sex pheromone mating disruption technology offers a sustainable way of reducing damage and reducing local codling moth populations in the long term.

The original aim of this work was to demonstrate the efficacy of sex pheromone mating disruption. It would be assessed alone and in combination with granulosis viruses or nematodes, whilst also measuring the effects on other pests and natural enemy populations. The effects were examined over two growing seasons as the treatment with mating disruption pheromones is for long term control over a wide scale. The sex pheromone mating disruption formulation (RAK3+4) was kindly supplied by BASF.

Summary of the project and main conclusions

Mating Disruption

Two commercial farms, one in the South East and one in the West Midlands of England were used. In the second year, the West Midlands farm was mistakenly over sprayed with Coragen by the host grower, so this site was not used for monitoring in that year. An additional farm in the South East was monitored instead. This had been treated with the RAK3+4 mating disruption (MD) system for three years. Each farm was divided into two halves. The first half was treated with the RAK3+4 mating disruption (MD) system for control of codling moth (CM),

summer fruit tortrix (SFT) and fruit tree tortrix (FTT), whilst the other half received the grower's conventional spray programme. Over six hectares on each farm were subjected to mating disruption. The trial results could not be analysed statistically as there were only two replicates included.

In both years at each farm, the numbers of pests and natural enemies were assessed on three occasions; spring (pre-treatment); July (first generation codling damage) and harvest (second generation codling damage). All three pest moth species were monitored weekly in each orchard using sex pheromone traps. For codling and tortrix moth assessments, fruit that had dropped to the ground and fruits on whole trees were assessed. Other notable pest damage was also recorded.

Although few moths were captured in the pheromone monitoring traps on the MD side of the farms, the RAK3+4 system did not cause complete trap shut-down (no moths in traps) indicating that some males may have been able to locate and mate with female moths. Some minor moth damage was observed, but the results were comparable, like for like, with a conventional spray programme.

Some orchards on the mating disruption sides of the farm received an additional Coragen spray when trap moth catches were 4 or above per week or where early ripening varieties which are more vulnerable to codling moth were present. There was some concern over tortrix caterpillars in the young shoots in the spring at Site 1. These were reared through and found to be SFT. However over 50% of the caterpillars were parasitized by wasps. Two sprays of the granulovirus Capex, applied 10 days apart, killed the majority of remaining caterpillars in the affected orchards.

There were few observable differences in natural enemies between the RAK3+4 deployment and conventional spray programme over the trial period, including earwig numbers. However, as earwigs have a single generation each year, the study may not have been long enough to identify differences.

In the second year, there was more first generation CM damage in the early ripening varieties Early Windsor and Bramley. There was notable damage from two pests in the second year on the MD side of the farms. Blastobasis caused damage to fruit at harvest and woolly aphid was abundant in some orchards on the MD side of farms in orchards that had lower numbers of earwigs. These pests would normally be controlled with insecticide applications targeted at

CM and tortirx moths and in the past, would have been controlled by the use of broad-spectrum products applied soon after petal fall to control spring pests.

The damage to fruit caused by codling moth at harvest was fairly similar between the MD and conventional sides of the farms. Tortrix caterpillar damage to the fruits was noticeably higher on the MD side of one farm compared to the conventional side.

Nematodes

A series of laboratory and field microcosm tests were instigated to test the efficacy of nematode sprays to target diapausing codling moth larvae in July and August in apple orchards. This work was kindly funded by BASF.

Using the orchards in the MD trials (above) the scientists attached sentinel cages of codling moth larvae to the trunks of apple trees. Using the grower's spray equipment, these were treated with a mixture of the predatory nematodes *Steinernema carpocapsa* (Nemasys C) and *Steinernema feltiae* (750 million of each sp. per ha) in high water volumes applied to the cages. Good infection of the larvae was not achieved, probably because the cage mesh prevented droplets containing the nematodes reaching the larvae. As a result the scientists used a series of laboratory tests to give a 'best' chance for nematodes to locate and infect codling moth larvae and pupae. In the field, it was decided to employ a different approach. Using a Birchmeier B245 motorised mist blower, it was possible to infect codling moth larvae/pupae with nematodes, even when they were hidden within sentinel cages. Codling moth pupae were less susceptible to nematode infection than larvae. These experiments showed that there may be some efficacy of the nematode sprays when used against codling moth larvae in the field and the tests should now be repeated in the field with larvae in cardboard rolls without the mesh cages.

Main conclusions

The RAK3+4 mating disruption system gave comparable control of codling and tortrix moths to conventional spray programmes. However, certain apple varieties may be more vulnerable to damage and close monitoring of sporadic pests is essential. Growers may need to use supplementary spray applications to maintain commercially acceptable control.

In laboratory studies codling moth larvae were vulnerable to commercially available pathogenic nematodes.

Financial benefits

Codling moth control programmes typically cost growers more than £200/ha/annum. Even a low level of fruit damage (<0.3% fruits damaged) is economically unacceptable. Improving control and/or reducing spray use will be of financial benefit to growers. It may also enhance natural numbers of predators in the crop and benefit the wider environment.

Action points for growers

- The RAK3+4 mating disruption system can give comparable control of codling and tortrix moths to conventional spray programmes.
- It may be advantageous at farms with medium to high pressure of codling numbers to apply an additional Coragen to early ripening or vulnerable varieties where MD technologies are employed.
- Growers should closely monitor for other pests which may occur because of the limited availability of lepidopteran insecticides. In particular sporadic tortrix species and blastobasis caterpillars may be a risk.
- Growers and agronomists should consult the AHDB Apple Best Practice Guide online on how best to monitor for these pests.