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Project leader:	Dr Robert Saville East Malling Research
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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.

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GROWER SUMMARY

Objective 3 - Apple foliar diseases

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 3 deals with the surveillance of existing and potential new invasive pests and diseases.

Headline

- Alternatives to conventional fungicides are showing promise for in-season mildew control as part of a reduced fungicide programme.

Background and expected deliverables

Over-wintering control strategies

The uptake and use of Biological Control Agents (BCA's) has been limited for disease control in orchard crops despite their great potential to reduce conventional products as part of an integrated pest management programme. Barriers for the uptake of BCAs in orchard systems include the higher cost/ha and their reduced and variable efficacy relative to conventional products. Successful control can be difficult to achieve during the season when environmental conditions are optimum for development of the pathogen. This study aims to improve our understanding of interactions between potential antagonists and the pathogen (or pathogen substrate) to inform control strategies which target the overwintering phase.

Apple powdery mildew (*Podosphaera leucotricha*) mainly overwinters as mycelium in floral and vegetative buds. *Ampelomyces quisqualis* (AQ) is a mycoparasite of powdery mildew. AQ10 (a commercial preparation of AQ) was one of the best performing BCAs in trials conducted as part of SCEPTRE when applied throughout the season and in combination with fungicides in a managed programme. However the control achieved was not commercially acceptable. One of the disadvantages of using AQ10 is the slow growth rate of this parasite. This has led to our proposed strategy to target the overwintering phase of the disease, offering a long interaction period between parasite and powdery mildew.

Apple scab (*Venturia inaequalis*) overwinters in leaf litter. Leaf litter management is an important tool for the management of this disease. By disrupting the lifecycle, inoculum is reduced the following spring. The most widely used strategy for leaf litter management in integrated fruit production is the use of autumn applications of urea. Previous studies have demonstrated urea has several modes of action; (1) Direct fungistatic effect of urea on

perithecial development; (2) Increased abundance of microbial antagonists to *V. inaequalis*; (3) Accelerated leaf decomposition by (a) Increasing abundance and shift in microbial activity and (b) Increasing palatability of leaf litter to earthworms. New molecular tools are available to understand the microbial community shifts in environmental samples which offer the potential to develop more sustainable approaches to apple leaf litter management than urea.

Alternative treatments

In recent years there has been a reduction in available crop protection products for mildew control and an increase in the incidence of fungicide insensitivity. A number of alternative products are available on the market, which have plant health invigorating, plant defence eliciting or physical modes of action. This research will evaluate the efficacy of these products alone and as part of a programme for powdery mildew control, in order to reduce the reliance on a decreasing number of synthetic chemical based fungicide actives.

In Year 1, products which were evaluated included plant health invigorators, plant defence elicitors and products with a physical mode of action. The test products were evaluated in the field in programmes either with a reduced fungicide programme or alone. During the 2015 growing season powdery mildew disease pressure was high, particularly in the trial orchards which have very high levels of primary mildew due to carry over from previous seasons. This high disease pressure provided a demanding test for the programmes. The full fungicide programme performed best but even with a 7-10 spray interval, it was unable to keep the mildew epidemic below the 10% (commercial) threshold.

The test products alone did delay the epidemic relative to the untreated control but were unable to achieve commercially acceptable levels of control. Of the test products, SB Invigorator was the best performing product. Programmes in which test products were combined with reduced fungicides, performed better than test products alone but this improvement in performance was probably attributable to the fungicides.

The trial design for the 2016 trial season was amended to be more informative. The trial was conducted on a split plot design with half of the replicate blocks receiving a 7-day mildew programme based on fungicides and the other half receiving a 14-day mildew programme based on fungicides, with the test treatments being superimposed on these blocks. This provides two disease pressures ensuring test products are assessed under commercially relevant but sufficient disease pressure.

Summary of the project and main conclusions

Over-wintering control strategies

Trials were set up over the summer of 2016 to test whether the BCA is incorporated into the bud, whether the parasite can survive over winter and whether the stratergy is effective at reducing inoculum. The trial will compare AQ10 treatment with a winter treatment of conventional product + wetter and an untreated control. Spring assessments will be undertaken to determine the efficacy of these strategies and will be reported in next years' report.

We have used next generation sequencing technology to determine the early effects of urea on the microbial communities in leaf litter which could ultimately lead to the development of a biological product more sustainable than urea. Five Pseudomonad species have been identified which are early colonisers in response to urea application and which are likely to be responsible for accelerated leaf litter breakdown and subsequent microbial succession in response to urea treatment.

Alternative treatments

In a replicated split plot orchard trial on Gala, the main plots were sprayed with a standard fungicide programme at 7 or 14 day intervals to establish a high and low incidence of secondary mildew. Within these main plots nine test alternative treatments (B204, Spore kill, SB Invigorator, Wetcit, Garshield, Mantrac Pro, HDC F230, HDC F231 and HDC F232) were applied by air-assisted knapsack sprayer at 500 L/ha to small three tree plots. Sub plot treatments were applied eleven times at 7-10 day intervals, apart from B204 (three sprays at monthly intervals) and Mantrac Pro (nine sprays only). Untreated plots were included which were the 7 or 14 day fungicide only programmes. Secondary mildew was assessed weekly on extension growth. Plots were also assessed for phytotoxicity, fruit set, yield and fruit quality. The results obtained are summarised as follows

- The 7 and 14-day programmes used as the main block treatments successfully established high (<40% - almost 100% mildewed leaves) and low (10-30% mildewed leaves) mildew plots in which to evaluate the test products.
- Treatment 4 (SB Invigorator) was the most consistent in reducing mildew.
- Treatment 5 (Wetcit) and Treatment 8 (HDC F230) were the next most consistent products.
- HDC F232, Mantrac Pro and B204 were the least effective.

- B204 appeared to have little effect on mildew incidence at the start of the trial but by the time the third application was made B204 treated plots had a significantly lower mildew incidence than the fungicide only plots.
- There was no significant effect of treatments on yield, but the lowest yield was recorded in plots treated with Treatment 4 (SB Invigorator) and Treatment 9 (HDC F231).
- Phytotoxicity was recorded on Treatments 5 (Wetcit), 8 (HDC F230), 9 (HDC F231) and 10 (HDC F232) as necrotic spotting on leaves. Wetcit also significantly reduced fruit set. HDC F230 and HDC F231 also caused some premature leaf drop. HDC F230 also increased fruit russet.
- There were no significant effect of treatments on fruit size or fruit colour.

Financial benefits

Foliar diseases require a great number of treatments through the season which not only incur a high cost (product and application) but can also reduce the quality of the produce (residues vs disease). In a regulatory climate of reducing availability of actives, alternatives are desperately sought.

Action points for growers

- Monitoring mildew epidemic is an important component of mildew management as it can inform the choice of product that is selected. The Apple Best Practice Guide, available online, offers guidance to do this.
- Some promising alternative products have been evaluated to be used in conjunction with a reduced fungicide programme, some of which are already available to UK growers.