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| **Project title** | Sensitivity of apple powdery mildew (*Podosphaera leucotricha*) populations to triazole and strobylurin fungicides |
| **Project number:** | TF 195 |
| **Project leader:** | Dr Angela Berrie |
| **Report:** | Year 1 |
| **Previous report** | None |
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| **Location of project:** | East Malling Research<br>New Road, East Malling<br>Kent, ME19 6BJ |
| **Project coordinator:** | Nigel Kitney |
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## AUTHENTICATION

I declare that this work was done under my 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

Exact protocols for conducting experimental work have been established for determining the sensitivity of apple powdery mildew to fungicides in Year 2.

## Background and expected deliverables

Apple powdery mildew can reduce yield and fruit quality and levels as low as 8% mildewed leaves can reduce yield and quality on sensitive varieties such as Cox. On other varieties, high levels of mildew have been recorded in many commercial orchards but the effect on yield and quality is not as well understood as on Cox.

All growers and advisers are agreed that powdery mildew control is becoming difficult with some badly affected farms in East Kent having orchards with 50-100% mildew-infected shoots on average. There are many possible reasons for the poor mildew control including: limited range of effective fungicides, reduced efficacy of triazole or strobilurin fungicides due to changes in the sensitivity of the mildew population, change in shoot growth pattern due to climate change, poor spray cover or insufficient monitoring of mildew development.

Good control of powdery mildew during the growing season is the top priority. Triazoles are the most effective fungicides against apple powdery mildew and consequently are used intensively in apple orchards as there are few alternative products. This leads to repeated use of fungicides from the same chemical group resulting in a high risk of mildew isolates being selected with reduced sensitivity.

Alternative products for mildew control, including potassium bicarbonate, potassium phosphite, Milsana (knotweed extract) and a biocontrol agent *Ampelomyces quisqualis,* were evaluated as part of a Defra project (HH2502STF). Most had limited efficacy. A new Hort LINK project on chemical control in horticultural crops (Sceptre) started in 2011; one of its objectives is to find new fungicides and/or alternative products for controlling powdery mildew on apple. Information on whether triazole (myclobutanil, penconazole) or strobilurin (kresoxim-methyl, pyraclostrobin) fungicides are less effective due to reduced sensitivity of mildew populations in orchards is important for selecting appropriate fungicides to achieve good control and minimise the risk of insensitivity development.

### *Expected deliverables and benefits*

The information on the sensitivity of apple powdery mildew to triazole and strobilurin fungicides and its possible contribution to the current poor mildew control will benefit the industry in the following aspects:

（1） The information generated will complement that generated in the HortLINK project (Sceptre) in which new fungicides and/or alternative products for controlling powdery mildew will be investigated.

（2） It should provide the industry with a clearer understanding on fungicide control of apple powdery mildew.

（3） It will enable growers to select appropriate products in order to improve control as well as to reduce the risk of development of fungal resistance/insensitivity to fungicides.

## Summary of the project and main conclusions

In Year 1,protocols have been developed to study the response of apple powdery mildew to different fungicides at a range of concentrations using rootstocks. In Year 2, treated rootstocks and seedlings will be exposed to powdery mildew spores in a number of orchards where powdery mildew control has been difficult. Thus, by the end of Year 2, tentative conclusions on the (in)sensitivities of powdery mildew to selected fungicides may be drawn.

## Financial benefits

Growers can benefit from the project results in the following ways:

1) Correct selection of fungicide products in spray programmes to control powdery mildew and minimise the establishment and subsequent spread of mildew strains that are insensitive to fungicides.
2) Maintaining a good range of effective fungicides against powdery mildew to achieve effective control.

## Action points for growers

- There are no action points for growers at present as the project is at an early stage.

# SCIENCE SECTION

## Introduction

Apple mildew is probably, after scab and canker, the most important disease of apples in the UK. The disease can reduce yield and fruit quality. Levels as low as 8% mildewed leaves can reduce yield and quality on sensitive cultivars such as Cox. On other cultivars high levels of mildew have been recorded in many commercial orchards but the effect on yield and quality is not as well understood as on Cox.

UK growers and advisers generally agree that powdery mildew control is becoming difficult, with some badly affected farms in East Kent having on average orchards with 50-100% mildew-infected shoots. All apple cultivars appear to be affected, but the worst are Cox, Bramley, Gala, Jonagold and Braeburn. There are many possible reasons for the poor mildew control including:

- Limited range of effective fungicides – sulphur, myclobutanil, penconazole, pyraclostrobin, bupirimate and potassium bicarbonate
- Reduced efficacy of triazole or strobilurin fungicides due to a change in the sensitivity of the mildew population – a previous HDC-funded project at EMR indicated some reduced sensitivity to myclobutanil
- Change in the shoot growth pattern due to climate change – shoot growth continuing after harvest when spraying has stopped may lead to high incidence of primary vegetative mildew the following season
- Milder winters leading to improved survival of overwintering mildew
- Very favourable spring and summer weather – warm wet weather promoting shoot growth and mildew development and spread
- Growers being more concerned with scab control
- Poor spray cover or insufficient monitoring of mildew development

HDC project TF 156 at EMR showed that the application of some surfactant products during the winter may significantly reduce the level of overwintering mildew in the buds. However, the rate necessary for achieving this exceeded the maximum concentration permitted. Thus, good control of powdery mildew during the growing season is the top priority.

Triazoles are the most effective fungicides against apple powdery mildew and consequently are used intensively in apple orchards as there are few alternative products. This leads to

repeated use of fungicides from the same chemical group resulting in a high risk of mildew isolates being selected with reduced sensitivity.

Alternative products for mildew control, including potassium bicarbonate, potassium phosphite, Milsana (knotweed extract) and a biocontrol agent *Ampelomyces quisqualis,* were evaluated as part of a Defra project (HH2502STF). Most had limited efficacy. A new HortLINK project on chemical control in horticultural crops (HDC project CP 77 / HL01109 - SCEPTRE) started in 2011; one of its objectives is to find new fungicides and/or alternative products for controlling powdery mildew on apple. Information on whether triazole (myclobutanil, penconazole) or strobilurin (kresoxim-methyl, pyraclostrobin) fungicides are less effective due to reduced sensitivity of the mildew populations in orchards is important for selecting appropriate fungicides to achieve good control and minimise the risk of insensitivity development.

Chemical companies routinely monitor fungicide resistance for the major fungicide chemical groups and the major fungal pathogens including apple scab as part of FRAC (Fungicide Resistance Action Committee). No monitoring of sensitivity of apple powdery mildew to triazoles has been conducted in recent years and there are no standard methods for monitoring apple powdery mildew sensitivity to fungicides published by FRAC. Reduced sensitivity of powdery mildews to triazoles and more recently to strobilurins has been reported in other crops, including grape.

### *Project aim*

To develop a sustainable, cost effective system for control of apple powdery mildew (*Podosphaera leucotricha*)

### Project objectives:

1) To develop a practical method for monitoring the sensitivity of populations of *P. leucotricha* to triazole, strobilurin and other fungicides
2) To use the method to monitor the sensitivity of mildew populations to triazoles, strobilurin and other fungicides in apple orchards

## Materials and methods

Because powdery mildew is an obligate pathogen, meaning that it can only survive on live plant tissues, *in vitro* testing for fungicide insensitivity as used for most pathogens is not suitable. Therefore, in the first year fungicide concentration and orchard exposure time were examined in order to develop a protocol for monitoring mildew sensitivity. Initially, it was planned to include apple seedlings as a comparison to the use of rootstocks. Unfortunately, difficulty was experienced in sourcing the *Malus bittenfelder* seeds and so it was not possible to use them in the first year of the project. Apple seeds have now been now been obtained and will be used in year 2.

Potted rootstocks of MM.106 plants were raised in a mildew-free glasshouse. They were treated with a range of fungicide concentrations of Systhane (myclobutanil), Vivid (pyraclostrobin) and Luna Privilege (fluopyram). Four levels of concentration for each fungicide (Table 1) were used; these levels were determined on the assumption of 1000 L per ha for spray volume. On the day of the treatment, the first fully unrolled leaf on each shoot was labelled; on each plant, up to five shoots were selected.

Treated plants were then exposed to one of several sources of powdery mildew (these plants were physically placed next to trees/plants with mildew) for 24 h before being moved back to a contained glasshouse compartment. There were four or five plants for each combination of fungicide, concentration and inoculum source. In addition, for each inoculum source there were also six plants that did not receive any fungicides. The number of powdery mildew lesions was counted on the tagged leaf and three leaves immediately below (i.e. fully unrolled at the time of fungicide application and hence covered with fungicide).

This exposure treatment was conducted twice, once in July 2011 and once in August 2011. In the July exposure, three orchard sources of inoculum were used: TL161, CW121 and EE190 at EMR. In the August exposure trial, two sources of inoculum were used: CW121 and P1 (tunnel).

**Table 1.** Concentration of each fungicide product used

| Product | a.i. [single a.i. product] | Mode of action | Concentration (g or ml in 1 L water) | | | |
|---|---|---|---|---|---|---|
| | | | C1 | C2 | C3 | C4 |
| Systhane | myclobutanil (20%) | DMI | 0.0045 | 0.045 | 0.225 | 0.45 |
| Vivid | pyraclostrobin (23.6%) | QoI | 0.0044 | 0.044 | 0.22 | 0.44 |
| Luna Privilege | fluopyram (50%) | SDHI | 0.003 | 0.030 | 0.15 | 0.30 |

## Results

In the first exposure experiment the rootstocks were not exposed to mildew in the orchard for the full 24 hour period planned and were removed early due to a thunderstorm. Nevertheless, the air was quite humid during the exposure period and it was possible that dew might have formed on leaves during this time. Mildew lesions were not observed on these exposed plants.

The number of mildew lesions varied greatly with fungicides and their concentrations in the second exposure experiment (Figure 1). Overall, the number of mildew lesions on rootstock plants exposed to P1 was about three times as much as those exposed to CW121.

For Systhane and Vivid, the level of mildew at the C1 concentration was similar to the untreated (0.113 and 1.083 for the CW121 and P1, respectively); for Luna Privilege, it was less than the untreated at the C1 concentration. The profile of mildew development in relation to the fungicide concentration indicated that the range of concentration chosen for each fungicide is appropriate for monitoring sensitivity of mildew to each fungicide. Thus, for Luna Privilege and Systhane, the effective dose is between C1 and C2 (Table 1, Figure 1) whereas for Vivid it is between C2 and C3 (Table 1, Figure 1).

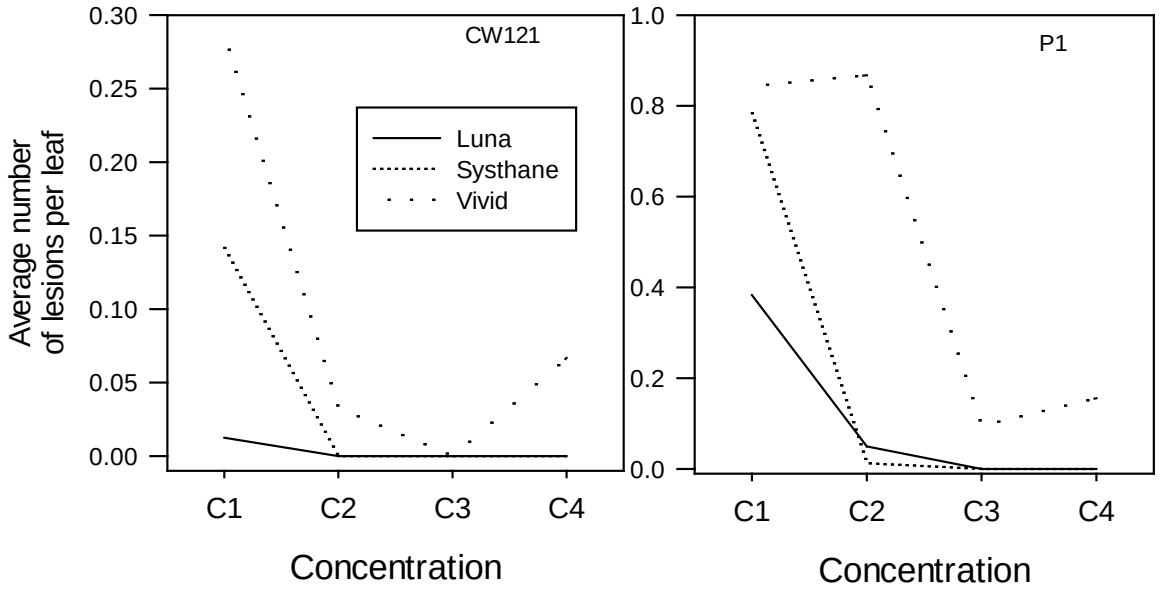


**Figure 1.** Average number of lesions per leaf on MM. 106 rootstock plants exposed to powdery mildew spores for 24 h at two sites (CW121 & P1) in August 2011. The exact concentration for each fungicide was given in Table 1

## Discussion

The main task of the year 1 work was to establish a protocol, especially the range of fungicide concentration, for subsequent experiments in Year 2. Through the exposure experiment, the effective range of concentration for each fungicide has been determined and these ranges will serve as a basis to compare (in)sensitivity of powdery mildew to each fungicide at each site. Any significant difference would indicate significant variation in mildew (in)sensitivity to each fungicide at each site. However, it should be noted that it is not possible to draw conclusions as to whether this variability is inherent or is because of the intensive use of the fungicides concerned since the baseline sensitivity of powdery mildew at these sites before the fungicides were introduced are not available.

In Year 2, both rootstock plants and seedlings will be used in the exposure experiments.

## Conclusions

- A protocol has been established for experiments in Year 2
- The effective range of concentration for the three fungicides to control powdery mildew has been determined

## Technology transfer

- The project work has been discussed with several consultants and presented during the HDC agronomy day at East Malling Research in 2012