Project title	Epidemiology and prediction of rose downy mildew
Project number:	HNS 173
Project leader:	Dr Xiangming Xu East Malling Research
Report:	Year 1
Key staff:	Dr Xiangming Xu Joyce Robinson
Location of project:	East Malling Research New Road East Malling Kent ME19 6BJ
Project coordinator:	
Date project commenced:	1 April 2009
Date project completed (or expected completion date):	31 March 2012
Key words:	Scab, insensitivity, cross-resistance, fungicides

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.

Dr Xiangming Xu
East Malling Research

Signature .... Date 18 March 2010

Report authorised by:

Dr Christopher Atkinson
Head of Science
East Malling Research

Signature .... Date 31 March 2010

CONTENTS

Grower Summary

Headline

A prototype computer model to assist with the integrated control of rose downy mildew is currently being developed.

Background and expected deliverables

Downy mildew (*Peronospora sparsa*) is a highly destructive disease on roses, causing severe and rapid defoliation. Infection is generally restricted to young plant growth. Severe leaf abscission may occur. Intensive fungicide usage, which can result in unjustified applications and environmental pollution, does not always control the disease satisfactorily due to poor timing or choice of fungicides, and may accelerate the selection of fungal strains that are resistant to fungicides.

Infected plants, particularly those with severe leaf abscission, are usually discarded because of possible infection of stems and hence the risk of diseased growth the following year. This not only results in production losses but also leads to additional waste. Severe disease is known to occur under humid conditions but published information has not been adequately synthesised. All rose cultivars are considered to be susceptible to this pathogen although they can greatly differ in their sensitivity.

Research has demonstrated a disease control approach utilising computer models to be successful on several crops, although operating such a system may place some extra demand on producers. EMR has already obtained some quantitative data on rose downy mildew development from an un-replicated experiment; another similar set of data were recently obtained in California. In a preliminary study at EMR, conidia were shown to have a very high potency for infecting leaflets: only 25-40 conidia per leaflet resulted in the near maximum incidence of disease. EMR has also developed and validated a prediction model for rose powdery mildew with HDC funding (HNS 165). In this work, we shall combine the prediction models for powdery and downy mildews on rose.

Expected deliverables and benefits

- This project will produce a system (computer software) to predict development of rose downy mildew that will improve disease control efficacy, which will be integrated with the forecasting system for rose powdery mildew that has recently been developed at EMR with HDC funding (HNS165)

- The system can be used by growers to develop cultural methods that avoid creating favourable microclimate conditions for downy mildews, to time fungicide applications, and to select appropriate fungicides and dose
- How to use the model predictions for practical disease management may depend on individual circumstances. It may include:

  - programming irrigation schemes to reduce the risk of disease development, particularly in the glasshouse, based on the joint effects of temperature and duration of wetness on disease development
  - using protectant products in the initial epidemic phase (i.e. early season) with the timing of application determined by model predictions as well as weather forecasts
  - using products that have high efficacy as an anti-sporulant when disease has already established in the crop, with the timing of application determined by model predictions as well as current disease level and weather forecasts

Summary of the project and main conclusions

- This is the first year of a three-year project, focusing on developing experimental protocols and developing a prototype forecasting model
- We have developed an initial prototype forecasting model and incorporated this model with the powdery mildew model as a computer software package. We will now collect more experimental data to improve and validate this model
- We failed to obtain viable downy mildew isolates from many samples sent to us last year. However, we have arranged for two downy mildew isolates to be sent to us from a German research institute in March 2010 for experimentation this year

Financial benefits

It is too early to claim any financial benefits of this project to growers

Action points for growers

- As the success of this project relies on information on current rose production systems, please take time to get involved in the work when the opportunities arise.

Science Section

Introduction

Downy mildew (*Peronospora sparsa*) can be very destructive but tends to be sporadic in its occurrence (Horst, 1983). Although not as common as powdery mildew, downy mildew is considered in the UK to rank in the 'top four' most important foliar diseases of cultivated roses along with rust, powdery mildew and black spot. Infection is generally restricted to young, apical plant growth although it can infect leaves, stems, peduncles, calyces and petals. The main effect of the disease is short-term disfigurement caused by foliar lesions and extensive premature leaf abscission or 'leaf drop'.

Under humid, cool conditions, conidia and conidiophores appear copiously on the lower surfaces of leaves but, under less favourable conditions, spore production is sparse and difficult to detect (Wheeler, 1981). Sporangia germinate within four hours in water and germination was favoured under cool conditions (< 18°C) (Breese *et al.*, 1994). Field observations indicated that as little as four hour wetness may be sufficient for infection to take place (Baker, 1953). Using detached leaves, it was shown that infection could take place after only two hour leaf wetness at an optimum temperature and disease severity increased with increasing length of leaf wetness (Aegerter *et al.*, 2003). Latent period ranged from four to seven days, depending on temperature (Aegerter *et al.*, 2003). In the same study, an empirical model was developed to describe the effects of weather conditions on development of rose downy mildew.

The fungus is believed to overwinter as dormant mycelium in cuttings and plants. However, the role of oospores in overwintering and initiating infections is less certain. Mycelium of *P. sparsa* may survive the winter in the cortex of rose stems (Wheeler, 1981). Systemic infections appeared to be important in rose rootstocks in the downy mildew epidemics seen in California (Aegerter *et al.*, 2002). Recent studies indicated that systemic infection in U.K. bush roses was not important and that oospores may have played an important role in overwintering (Xu and Pettitt, 2004).

Current knowledge on the biology and epidemiology of the rose downy mildew fungus is very limited. As a result, current control of downy mildew in roses relies almost totally on routine fungicide applications, especially in crops grown outdoors. Successful control with fungicides usually only results from the implementation of routine programmes with 10-14 day intervals between applications. In U.K. container-grown crops this can mean 10-15 sprays applied over the period from leaf emergence in spring to the onset of dormancy in autumn. Recent work has shown that compounds for control of potato blight that are effective against

Peronospora species infecting other host species can give good control of rose downy mildew (O'Neill *et al.*, 2002). However, resistance to these compounds is widely seen in the oomycetes and especially in other downy mildews (e.g. *P. parasitica*). Recently HDC has funded work on evaluating alternative products for controlling rose downy mildew (HNS 135). Correct timing of fungicidal products is important, which is partially determined by the risk if fungal infections.

Materials and methods

Development of prediction models

We have developed a prototype model that predicts potential infection periods by downy mildew, mainly based on results from two published results (Breese *et al.*, 1994; Aegerter *et al.*, 2003) and unpublished results we collected at EMR. Rainfall triggers the model to start a potential infection period, i.e. release conidia from overwintering lesions or from lesions on plants. This model assumes that all spores are viable and land on leaf surface immediately following a rainfall event. The rate of infection by each spore is independent of cultivar and inoculum density. If wet leaves become dry, the model halts any current infection process; any infecting spores are liable to die during the dry period with the rate of spore mortality depends upon the relative humidity and temperature during the dry period. Further experiments are necessary to obtain data on spore mortality during dry periods. When a leaf is re-wetted by rain, dew or overhead irrigation, the surviving spores continue to infect. An infection period ends when all spores landed following a rainfall event have infected the leaf or are dead. The progress of infection is measured as infection efficiency (IE), defined as the accumulated percentage of spores which have successfully infected plants. The final IE of each infection period quantifies the favourability of weather conditions for infection.

Weather variables needed to run the model include total rainfall, state of leaf surface (dry/wet), and ambient humidity and temperature at an interval of $\leq$ 30 min. The model calculates, if necessary, values of these variables at 3-min intervals to run the model. Flat sensors are often used to indicate the wet or dry state of unrolled leaves. However, the drying characteristics of these sensors can be expected to differ from those of the leaves. To provide a more reliable indication of the wet/dry state of leave surface, the model assumes surface wetness when any of the following two criteria are met: (1) conventional surface wetness sensor(s) indicate surface wetness; (2) vapour pressure deficits derived by the model from humidity and temperature are < 60 Pa, and (3) there is any measurable amount of rainfall.

Epidemiology of rose downy mildew

Due to difficulties in obtaining viable downy mildew isolates, experimental work has yet to commence.

Results

Model development

A prediction model has been developed for rose downy mildew and implemented as a computer programme (Figure 1), which has been incorporated with the rose powdery mildew model (HNS 165). This program structure can be used to house pest/disease models of other crops and utilities for handling climatic data for day-to-day management activities in nurseries.

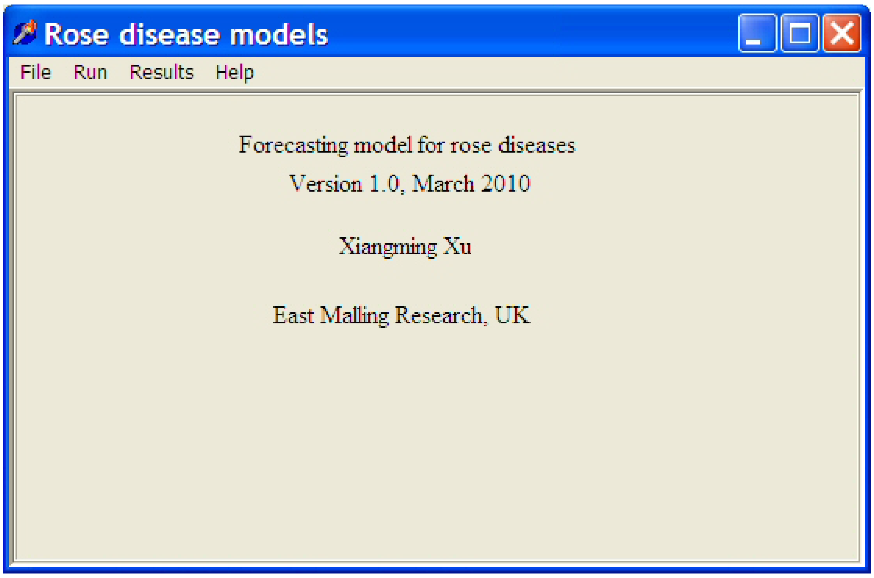

Figure 1. A screen shot of the main window of the rose mildew prediction model

This model uses ASCII text files as input files (i.e. containing weather data). All weather data loggers should be able to produce ASCII text files. The programme provides a very flexible data format definition facility to define the exact data format for each specific data file (Figure 2). This is essential for the model to read weather data accurately. The program also provides a help file that gives detailed explanations on how to define data format. The data format definition and subsequent data handling by the model have been tested for data files from several different types of weather data loggers used in the UK.

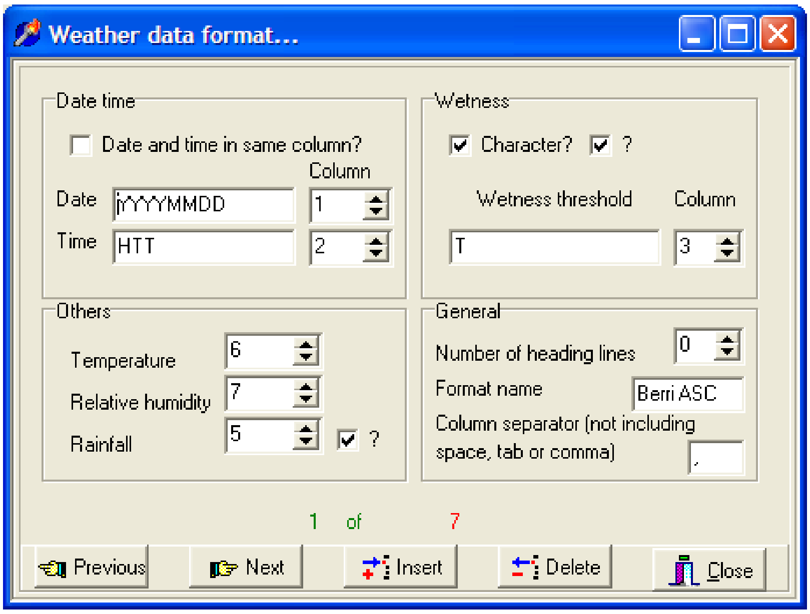

Figure 2. A screen shot of the window used for defining weather data format

Users can run the model for any specified period of time using a particular set of weather data (Figure 3).

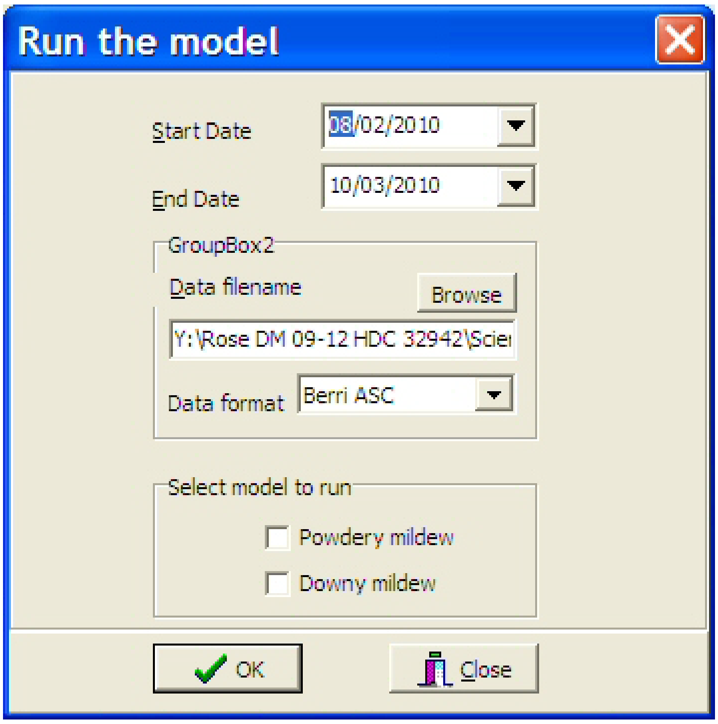

Figure 3. A screen shot of the window used for initiating the predictive model

The model will display the estimated IE values for each potential infection period as shown in Figure 4 (for illustrative purpose only). In this example, there were three potential infection periods: the last and the first one was most and least severe, respectively.

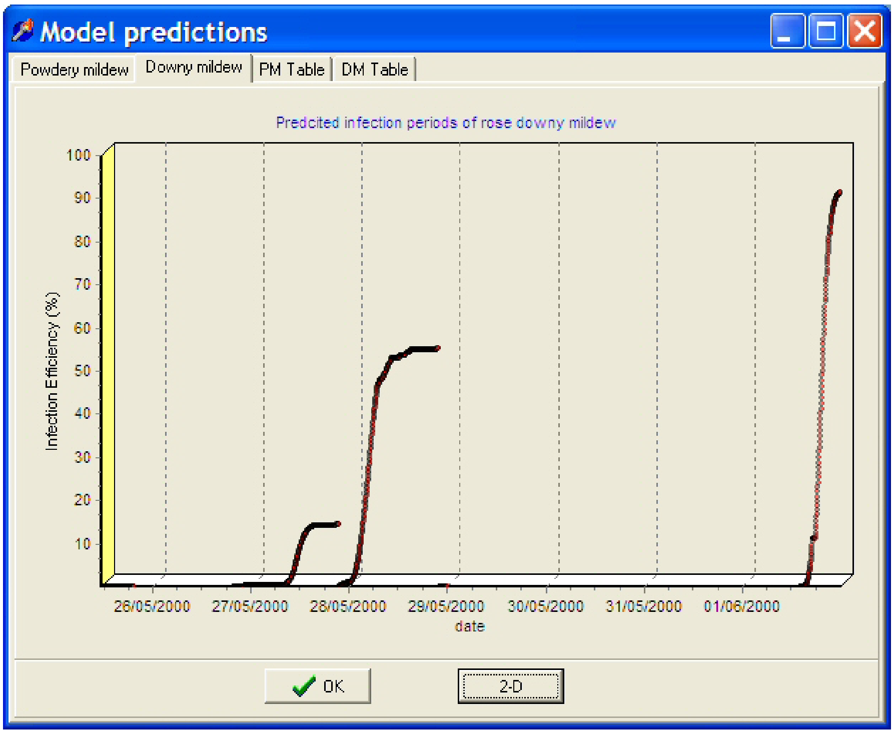

Figure 4. A screen shot of model predictions for illustration purpose only

The program also provides a context-sensitive help system. Thus whenever users press F1 key, a help screen will be displayed with relevant information.

In the coming year, we shall conduct experimental studies to collect new data to improve/validate the model, this will include face-to-face discussions with rose growers. We also plan to organise a workshop to demonstrate and train growers to use the system. The workshop is currently scheduled for 2011.

Experimental work

Many rose leaf samples that were suspected to have downy mildew symptoms were sent to EMR. Unfortunately, most of those symptoms were not caused by the downy mildew fungus but by the black spot fungus. This was also confirmed by Dr Tim O'Neil of ADAS, Cambridge.

Of the few samples with typical downy mildew symptoms, we failed to obtain any viable fungal spores to inoculate new leaves; the most likely reason for this was that these leaves were treated with fungicides, which may have killed the fungus although the symptoms were still present. As for powdery mildew, it is not possible maintain rose downy mildew isolates on artificial media. We have contacted a German researcher (Dr Dietmar Schulz, Inst. f. Pflanzengenetik, Abt. Molekulare Pflanzenzüchtung, Hannover) who is currently involved in rose downy mildew research for fungal isolates. It has been agreed that he will send us isolates in this spring 2010. Thus, we should be able to complete all the necessary experimental work as planned.

Discussion

This is Year 1 of a three-year research project. There are no experimental data that currently need to be discussed. New experimental work will be initiated in 2010.

Conclusions

- We have developed a preliminary prototype predictive model for rose downy mildew

Technology transfer

- We discussed this work and related work at EMR with Chris Warner (a rose breeder) when he visited EMR in August 2009.

References

Aegerter BJ, Nunez JJ, Davis RM, 2002. Detection and management of downy mildew in rose rootstock. *Plant Disease* **86**, 1363-1368.

Aegerter BJ, Nunez JJ, Davis RM, 2003. Environmental factors affecting rose downy mildew and development of a forecasting model for a nursery production system. *Plant Disease* **87**, 732-738.

Baker KF, 1953. Recent epidemics of downy mildew of rose. *Plant Disease Reporter* **37**, 331-339.

Breese WA, Shattock RC, Williamson B, Hackett C, 1994. *In vitro* spore germination and infection of cultivars of *Rubus* and *Rosa* by downy mildew fromboth hosts. *Annals of Applied Biology* **125**, 73-85.

Horst RK, ed 1983. *Compendium of rose diseases*. St. Paul, Minnesota, USA: American Phytopathological Society, 64.

O'Neill TM, Pye D, Locke T, 2002. The effect of fungicides, irrigation and plant density on the development of Peronospora sparsa, the cause of downy mildew in rose and blackberry. *Annals of Applied Biology* **140**, 207-214.

Wheeler BEJ, 1981. Downy mildew of ornamentals. 473-485 *in*: Spencer DM, ed. *The downy mildews.* Academic Press, London.

Xu X-M, Pettitt T, 2004. Overwintering of rose downy mildew (*Peronospora sparsa*). *in*: Spencer-Phillips PTN and Jeger MJ, eds. *Advances in downy mildew research*. Kluwer, The Netherlands