Modelling *Stemphylium vesicarium* on Pear: an Hourly-based Infection Model

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Abstract

In 2001 modelling of *Stemphylium vesicarium* on pear was started based on southern European research results. From these results an infection table was derived and an hourly-based infection model was developed. In 2002 and 2003 the model was evaluated in trials and practice. In 2003 the model was updated regarding the way infection points were calculated during interrupted wetness periods. The first results are promising, although the model still needs improvements.

INTRODUCTION

Brown spot on pear (*Pyrus communis* L.) is caused by *Stemphylium vesicarium* (Wallr.) E. Simmons [teleomorph *Pleospora allii* (Rabenh.) Ces. & De Not.]. The fungus can infect several crops like garlic, leek, onion, asparagus and pear (Johnson 1990; Montesinos et al., 1995a; Suheri and Price, 2001). On pear, the fungus infects leaves, fruits and to a lesser extent twigs. The resulting necrosis and fruit rot is caused by fungal penetration of stomata and lenticels and the production of a host-specific necrotoxin (Montesinos and Vilardell, 1992). Brown spot causes severe damage especially in southern Europe. However, the disease is also found in the Netherlands and to a lesser extent in Belgium in recent years and damage levels up to 70 % fruit incidence occurred. Conference, the predominant pear cultivar in the Netherlands and Belgium, is very susceptible (Montesinos et al., 1995a).

The influence of temperature and wetness duration on conidial infection by *S. vesicarium* on pear has been studied previously (Montesinos et al., 1995b). This led to the development of a brown spot forecasting system (Llorente et al., 2000).

Climatical conditions in the Netherlands and Belgium however, are quite different from the conditions in southern Europe. Especially rainy days with long leaf wetness periods at relatively low temperatures are not exceptional in a Dutch summer. It is obvious that the forecasting system should be revalidated or even adapted for use under different climatical conditions.

Dutch and Belgium fruit growers and their advisors are interested in using a brown spot model with the METY weather stations (Bodata, Dordrecht, The Netherlands), that are primarily used for apple scab warning and are installed in all the main fruit growing areas in the two countries. Hourly weather data are available and hourly model output is preferred. Therefore the aim is the development of an hourly-based model for *S. vesicarium* on pear, which is easily adaptable to new knowledge on the life cycle of the fungus in general and the infection process in particular.

MODEL DEVELOPMENT

Infection Model

The basic idea of the hourly-based infection model is to simulate the process of spore germination followed by penetration into the plant tissue. As soon as leaves become wet spores are assumed to start germination. The speed of spore germination mainly depends on temperature. At a given temperature a germinating spore is assumed to need a number of hours to penetrate into the plant tissue and infect the leaf. However, if the wet leaf dries before a spore has infected it, a spore will stop growing or start dying, thus depending on microclimatic conditions. If the leaf becomes wet again the spore will resume the penetration process unless it has dried out so much that it is no longer viable.

The data needed for the infection model are derived from a paper presented by E. Montesinos at the IOBC/WPRS meeting in 1999 in Fontevraud (Llorente et al., 2000). In this paper a formula[1] is given to calculate the daily infection risk. This formula is derived from earlier experiments (Montesinos et al., 1995b) where leaves of potted plants of pear cultivar Conference were inoculated with conidia of *S. vesicarium* at different temperature and leaf wetness conditions and disease severity was recorded. With the same formula a disease risk chart was developed. The starting-point of the model is the isopath in this disease risk chart that separates the categories of light and moderate infection risk and corresponds to a 0.4 relative disease potential index according to the formula.

The choice was made to transform the data into an infection table (Table 1) instead of a formula. Hourly infection points from the infection table are cumulated as long as leaf wetness continues. The cumulative infection points counter indicates the infection risk and is compared with the action threshold. An advantage of this approach is that the infection model could be developed quickly by modifying an existing apple scab program. A second advantage is that this model can handle leaf wetness periods of more than 24 hours.

The first version of the infection model was used in trials in 2002. New research results (Llorente et al., 2002) led to an update in 2003 in the way infection points were calculated during interrupted wetness periods. A leaf wetness period should be interrupted more than 8 hours to reset the cumulative infection points counter to zero in the first version of the infection model. Vapour pressure deficit is used to determine how many dry hours are necessary to interrupt a leaf wetness period long enough to reset the cumulative infection points counter to zero in the updated version of the model.

[1] $Log_{10}(S) = -1.70962 + 0.00289T + 0.04943W + 0.00868TW - 0.002362W^2 - 0.000238T^2W$

In the STREP browspot forecasting system the action threshold (SA) is calculated. This action threshold (SA) is calculated by totalling the daily infection risk (S) over the past 3 days. For the calculations a day is considered to start and finish at 8:00 hours GMT. Hourly weather data (leaf wetness and temperature) are measured to calculate daily wetness duration in hours (W) and mean air temperature in °C of wetness periods (T). With W and T the daily infection risk (S) is calculated according to the formula above.

Action Thresholds

When the hourly based infection model reaches 1000 points there is considered to be an infection risk. According to the origin this is a moderate risk. The actual amount of disease incidence this infection will cause, will be also determined by the actual quantity of spores in the orchard and the susceptibility of leaves and fruits to infection. It is not sure if fungicide treatments at an action threshold of 1000 points can prevent disease incidence in an orchard with a very high disease pressure. On the other hand in an orchard with a low disease pressure an action threshold of 1000 points could lead to unnecessary fungicide sprayings. Therefore adequate action thresholds should be determined.

Validation of the Model

Two trials were conducted, in 2002 and 2003, in a highly infected orchard. In 2002 the first version of the infection model was used with an action threshold of 1000 points (comparable to STREP threshold SA=0.4). In 2003 the updated version of the model was used with an action threshold of 1500 points. The action threshold was raised in order to standardise the threshold with other trials in the Netherlands and Belgium.

Because of the damage caused by brown spot in practice in 2001 and 2002 Dutch fruit growers were not sure how to deal with the disease. Since 2003 regional groups of growers, supported by the advisory service DLV, started to learn more about the fungus and to practically apply the results of the model. As no information on disease pressure in the different orchards was available in 2003, growers were advised to apply a fungicide treatment against *S. vesicarium* when the arbitrary action threshold of 1500 points was reached.

The results of the two trials with the model are encouraging and have been recently published (de Jong et al., ISHS pear symposium Stellenbosch 2004, submitted).

The percentage of diseased leaves and fruit were subjected to analysis of regression using Genstat 5 Release 4.1 and 6.1 statistical package (Lawes Agricultural Trust, Rothamsted Research, UK). T-probabilities were calculated for pair wise comparison of treatment means. Significant F-tests ($P < 0.05$) were followed by a Least Significance Difference (LSD)-test for pair wise comparisons of treatment means using LSD0.05 values.

No significant difference was found in leaf incidence between the treatments sprayed preventively and the treatments done according to the model in 2002. In 2002, a 44% reduction of applications was achieved with an action threshold of 1000 points (Table 2).

In 2003, the preventively sprayed treatments had a significant lower leaf and fruit incidence than the treatments sprayed following the model. In 2003, a 67% reduction of applications was achieved with a threshold of 1500 points. It appears that it was not possible to raise the action threshold in a highly infected orchard like the experimental orchard. In the next trial in 2004 both thresholds of 1000 and 1500 points will be evaluated.

The experiences with the practical application of the model were satisfactory in 2003. DLV monitored leaf and fruit incidence and in most cases this was negligible. However, on 3 parcels fruit incidence of 1 %, 1,5 % and 2,5 % was recorded. According to the growers fruit incidence in 2003 was lower in comparison with 2002. The analysis of the spraying and irrigation diaries of the growers indicated that in one case the use of overhead irrigation could have caused some incidence, while in the other two cases the 1500 points action threshold might have been too high. In 2004 the 1000 points action threshold will be evaluated on these 3 parcels.

The action thresholds were refined after the evaluation of the trials and the experiences in practice with the model in 2003. Growers whose orchards were without any symptoms in 2003 are advised to use an action threshold of 2500 points in 2004, growers who found less than 1 % fruit incidence at harvest in 2003 are advised to use an action threshold of 1500 points, while growers with more than 1 % fruit incidence in 2003 are advised an action threshold of 1000 points the following year.

DISCUSSION

The first experiences with the model in trials and by growers are promising. However, the model still needs improvements. Volumetric spore traps were placed in the orchard in 2003 and 2004. Spore catches of *S. vesicarium* from these traps will be counted and analysed. This analysis will form, together with the results of new trials, and together with the experiences with the model in practice in 2004 as well with supplementary literature, a basis to update the model in 2004/2005.

Although some parts of the life cycle of *S. vesicarium* on pear stay unclear yet, the authors hope to release the model for use by growers and advisors within a few years.

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Tables

Table 1. Infection table for *Stemphylium vesicarium* on pear.

Temperature from	Temperature until	Hours leaf wetness until infection	Points per hour (1000=infecton)
-30.0 °C	8.0 °C	--	0.0
8.0 °C	8.6 °C	35	28.5
8.6 °C	9.2 °C	30	33.3
9.2 °C	10.0 °C	25	40.0
10.0 °C	10.8 °C	19	52.6
10.8 °C	11.7 °C	17	58.8
11.7 °C	12.5 °C	16	62.5
12.5 °C	13.3 °C	15	66.6
13.3 °C	14.3 °C	14	71.4
14.3 °C	24.0 °C	13	76.9
24.0 °C	26.0 °C	14	71.4
26.0 °C	28.0 °C	16	62.5
28.0 °C	30.0 °C	27	37.0
30.0 °C	31.0 °C	47	21.2
31.0 °C	100.0 °C	64	15.6

Table 2. Efficacy of treatments against brown spot on leaves and fruit, 2002-2003. Values followed by different letters are significantly different according to regression analysis at P<0.05.

Treatment schedules	Number of applications	Leaf Incidence (%)	Fruit Incidence (%)
2002			
untreated	--	10.3 a	19.8 a
difenoconazole[1] (p[2])	16	1.8 b	16.6 a
difenoconazole[1] (WS[3])	9	2.0 b	16.2 a
F-probability		<0,001	0,001
2003			
untreated	--	4.6 a	15.1 a
difenoconazole[1] (p[2])	18	0.0 b	2.4 b
difenoconazole[1] (WS[3])	6	1.1 c	5.9 c
F-probability		<0,001	<0,001

[1]Sprayed together with thiram as a tank mix

[2]p: sprayed preventive from full bloom onwards

[3]WS: sprayed according to the warning system