Epidemiology and control of pear scab

AP218

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Epidemiology and control of pear scab

Final report

Horticultural Research and Development Corporation

Project No: AP 218

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1. Summaries

1.1 Industry summary

Pear scab, caused by the fungus *Venturia pirina* Ad. Aderh., is the most important field disease of pears in Australia. Significant losses, up to 10% of the entire crop in some seasons, occur in both Williams Bon Chretien (WBC) and Packham’s Triumph, the two varieties which make up most of the pear production in Australia. The project aimed to improve disease control and minimise fungicide usage through a better understanding of the epidemiology of the disease. This should enable growers to adopt more appropriate control measures, and improve the industries competitiveness on both local and overseas markets.

Studies over three years have shown that ascospores are the most important source of early season scab infections in the spring. Conidia produced from wood infections were not found to be important in the spring period in the orchards studied. Most ascospores were released after rainfall during daylight. Smaller numbers were found at night and usually within a few hours of dawn or dusk. Wet periods which begin during night time may be important in orchards with a high disease carryover, but in orchards with low disease carryover such periods are unlikely to cause much disease when compared with those that begin during daylight. Peak ascospore discharge usually coincides with the period from budburst to the petal fall or calyx stage. This emphasises the importance of control measures applied during this time (usually September-November).

Infection periods were monitored in orchards during this time and calculated according to the criteria for apple scab (Mills periods: periods of leaf wetness and temperature). Comparison between infection periods recorded by an electronic weather station (a Neogen Envirocaster), programmed for the prediction of scab infection periods, and those calculated from mechanical wetness and temperature recorders showed similar results.

Evaluation of hydrated lime as a replacement for some fungicide sprays during the spring and summer showed that such treatments give significant disease control. Under conditions of high disease pressure (as experienced in the first two years of this study) control is not as good as with a conventional fungicide. Slight phytotoxicity (fruit lenticel enlargement) was observed where many sprays were applied, but in two grower trials where only a few applications were made no difference was observed between fruit finish in hydrated sprayed or conventionally sprayed blocks. Such treatments may find application where there is a need to reduce the number of conventional fungicides.

1.2 Technical summary

Pear scab, caused by the fungus *Venturia pirina* Ad. Aderh., is the most important field disease of pears in Australia. Significant losses, up to 10% of the entire crop in some seasons, occur in both Williams Bon Chretien (WBC) and Packham’s Triumph, the two varieties which make up most of the pear production in Australia. The project aimed to improve disease control and minimise fungicide usage through a better understanding of the epidemiology of the disease.
This should enable growers to adopt more appropriate control measures, and improve the industries competitiveness on both local and overseas markets.

Studies using a Burkard spore trap at two locations (results for a total of four seasons) showed that ascospores were mature at or before the green tip stage. Peak discharges usually occurred following rain periods during September and October. A few spores were trapped after November, and (once) spores were trapped in January of the same growing season. Most ascospores were released during daylight hours. In one season at one trapping site, up to 10% of all ascospores trapped were caught during the night, although spores were mostly caught within a few hours of dawn or dusk. These results indicate that infection periods that begin at night may be important in orchards with a high disease carryover from the previous autumn, but in orchards with a low disease carryover such periods are unlikely to cause much disease when compared with those that begin during daylight. Wood infections occurred on the varieties WBC and Packham's during a season of high disease pressure. No conidia were detected on these lesions in the following spring, indicating that they are not the most important source of overwintering inoculum. In seasons of lower disease pressure no wood infections were observed.

Infection periods were monitored using mechanical temperature and leaf wetness recorders and compared with those recorded by an electronic weather station (a Neogen Envirocaster). Results showed that predictions by either system were similar, although predictions from the Envirocaster were slightly less conservative (ie predicted fewer infection periods) than predictions from mechanical recorders calculated by the criteria of Mills.

Hydrated lime when evaluated in replicated small plot trials as a possible replacement for conventional fungicide sprays during the growing season gave significant disease control. High volume sprays at 2% were more active than those at 1%. Under high disease pressure, these sprays were not as effective as a conventional protectant fungicide. Hydrated lime sprays did not affect the damage caused by insect pests including codling moth, light brown apple moth and pear and cherry slug. Slight phytotoxicity, which appeared as enlarged lenticels on fruit, sometimes occurred after 6-10 sprays. Such damage was never found after fewer sprays. Grower trials using airblast sprayers showed that hydrated lime sprays were practical when applied by commercial operators.

1.3 Publications


Epidemiology and control of pear scab


Talks/Field days

• Fourteen talks or presentations have been made to grower groups at AgVic, CFICA, NVFA meetings and to meetings of Tasmanian and Western Australian growers, and at a National Conference of Plant Pathologists.
• Three Field Days were held, two at ISIA Tatura and one on a grower property in Shepparton East, to demonstrate aspects of the project.
• Poster displays have been made at the AAPGA Conference, at Wandin/Silvan field days and at IHD displays.

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2. Introduction

Pear scab, also known as black spot, is caused by the fungus *Venturia pirina* Aderh. This disease is one of the most important diseases of pear throughout the world, and it occurs wherever pears are grown. It is most damaging in regions which have a high spring and summer rainfall. Flowers, fruits, leaves and shoots can be infected, but fruit infection (Figure 1) can result in downgrading and significant crop loss.

Symptoms of scab on fruit appear as black spots which may distort and crack the fruit. Late season infections are smaller and more superficial, while infections immediately before harvest only show up during or after storage as very small black spots. Leaf infections are circular, brown or black in colour, and can occur on both sides of the leaf. Twig or shoot infections appear as small oval shaped blisters.

The fungus can survive from one season to the next in fallen infected leaves under the trees, or as twig lesions. Ascospores are produced from the fallen leaves in spring and can cause new infections on the developing tree tissue. Some researchers consider that conidia produced from twig lesions can sometimes be the most important source of new infections in the spring. Temperature and moisture are important in the spread and development of the disease.

Control measures are based on timely application of protectant fungicides, supplemented by post-infection sprays. Protectant sprays are timed according to tree development stages and their timing is modified depending on the prevalence of wet weather favourable to further disease development. Post-infection sprays are applied to control scab infections which are initiated during periods of wet weather.

In Australia, pears are grown in all states which have a suitable temperate climate. However, the bulk of the crop (over 80% of Australian production) is produced in Victoria, mainly in the Goulburn Valley. In this region, rainfall is generally low and crops rely on irrigation for much of the growing season. Despite this, spring rainfall can provide suitable conditions in some seasons (about one in every five) for severe epidemics of pear scab to develop. As recently as 1989 up to 10% of the canning fruit crop was lost to scab infection.

As the industry strives to meet the demands of markets for crops produced with reduced pesticide input, there is greater pressure on growers to control scab with a minimum of fungicide applications. This project aims to improve scab control and minimise sprays by an improved understanding of the disease cycle, by comparing scab infection prediction systems and by evaluating an unconventional spray treatment for its efficacy against scab.

3. Sources of Primary Inoculum

3.1 Introduction

Scab is a major disease of pears in Australian orchards. Overseas reports indicate that the causal fungus can overwinter and cause new infections on developing pear trees in springtime via both
Figure 1. Symptoms of pear scab on fruit of cultivar WBC from the spray trial, Tatura 1992/93

Figure 2. Burkard 7 day recording spore trap operating in a pear orchard at Tatura in early spring.
ascospores and conidia. This study was undertaken to define the importance of ascospore and conidial inoculum in the overwintering of the disease under Australian conditions, and to define details of the release of this inoculum during spring in order to allow better timing of control measures.

3.2 General Materials and Methods

Studies to determine the significance of the two sources of primary inoculum were made at the two field sites established for spray trial studies (section 5). Ascospore trapping was carried out using a Burkard 7 day recording spore trap (Burkard Scientific (Sales) Limited, UK) (Figure 2). Trap tapes were changed weekly, and tapes cut into one day lengths, mounted on microscope slides, and examined by scanning under a compound microscope at hourly intervals across the long axis of each tape. Because of the time involved and constraints on labour during the growing season, when spray trials and other work was necessary, most tapes were examined after harvest, during autumn and winter. Shoots were examined for lesions of scab at both trial sites during the growing season and at harvest. Ten shoots per tree were cut and examined in the laboratory for twig lesions of the scab fungus. Detailed assessments of the incidence and severity of lesions on shoots were made, when they were detected.

3.3 Ascospores

Venturia pirina Aderh., the perfect state of the pear scab fungus, belongs to the class Ascomycotina. The fruiting body is a pseudothecium, globose in shape with a short neck, and which is immersed in dead, overwintered leaf tissue. Asci are cylindrical, bitunicate and contain 8 olive green two celled ascospores. Ascospores mature in late winter-early spring and are released and infect developing pear tissue during spring. Details of the release of ascospores under Australian conditions have not been determined. This work aimed to:

- Determine the discharge season of the perfect stage of the pear scab fungus in relation to host development
- Determine the relation between discharge and weather events
- Determine the relation between discharge and time of day

3.3.1 Ascospore trapping (2 locations and 3 seasons)

Ascospore trapping was carried out using a Burkard 7 day recording spore trap. Traps were operated from early September until the end of January (WBC trees at Tatura) or February (Packham trees at Strathewen). Traps were located within the tree line between two trees. Overwintered leaves (approximately 500-1000 leaves) were collected from under nearby pear trees known to have had scab in the previous season and scattered within a 1m radius of the trap. In 1992/93, one trap was located in a block of mature (40 year old) Packham pears at Strathewen. In 1993/94, two traps were operated, the first at Strathewen (as for 1992/93), and a second trap at

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Figure 3. Number of ascospores trapped in relation to infection periods, scab development and tree growth stage in Packham pear at Strathewen, 1992/93. Infection period severity 1= light, 2= moderate and 3= heavy. Date of first trapping = A. Green tip = GT, full bloom = FB and petal fall = PF. Leaf (+) and fruit (Φ) scab incidence in untreated trees. Numbers above the x axis indicate small ascospore catches.
Figure 4. Number of ascospores trapped in relation to infection periods, scab development and tree growth stage in Packham pear at Strathewen, 1993/94. Infection period severity 1= light, 2=moderate and 3= heavy. Date of first trapping = A. Green tip =GT, full bloom = FB and petal fall = PF. Leaf (+) and fruit (♦) scab incidence in untreated trees. Numbers above the x axis indicate small ascospore catches.
Figure 5. Number of ascospores trapped in relation to infection periods, scab development and tree growth stage in WBC pear at Tatura, 1993/94. Infection period severity 1= light, 2=moderate and 3= heavy. Date of first trapping = A. Green tip = GT, full bloom = FB and petal fall = PF. Leaf (+) and fruit (♦) scab incidence in untreated trees. Numbers above the x axis indicate small ascospore catches.
Figure 6. Number of ascospores trapped in relation to infection periods, scab development and tree growth stage in WBC pear at Tatura, 1994/95. Infection period severity 1= light, 2=moderate and 3= heavy. Date of first trapping = A. Green tip = GT, full bloom = FB and petal fall = PF. Leaf (+) and fruit (●) scab incidence in untreated trees. Numbers above the x axis indicate small ascospore catches.
Tatura, within the tree line in the block of WBC trees used in the replicated spray trial. In 1994/95 one trap was operated, at the Tatura site.

3.3.1.1 Length of trapping season

The daily ascospore catches during the growing season in relation to tree growth stages, infection periods, and disease development on fruit in untreated trees in the spray trials are shown in Figures 3 and 4 (Packham, Strathewen) and Figures 5 and 6 (WBC, Tatura). For each trapping season (except 1992/93 when the spore trap was set up a little after the green tip stage of tree development) the first ascospores were trapped at or before green tip. Generally, most spores were trapped in the 4-5 week period from green tip to petal fall (September to early October). In the very dry spring of 1994/95 at Tatura, spore discharge, although at a low level, was delayed and a significant discharge was recorded at calyx, in late October. Low spore numbers were usually trapped from mid October through to mid November. Beyond this time, only occasional spores were trapped into December, and, once, in January.

3.3.1.2 Release in relation to rain and dew

Table 1 summarises ascospore releases in relation to rain, dew, irrigation or dry periods. Results show that most release events (from 51-73%) occurred during or after rain. A smaller proportion of events, from about 22-49% of all events recorded, occurred during or following dew. In one season, ascospore release occurred once following a period of irrigation. The relation between the total number of ascospores trapped and rain was even more pronounced; over 90% were associated with rain, and less than 8% were associated with dew or irrigation. Many release events occurred at times when no infection period was recorded.

Figure 7 summarises hourly releases from the 7th to the 15th September 1993 at Tatura. Ascospores were trapped on every day during this period, although the largest numbers of spores were trapped during or after rain (on the 8th, 9th, 12th, 13th, 14th and 15th), and only small numbers after dew (on the 7th, 10th and 11th). When rain began at night, significant spore numbers were trapped only during daylight following the onset of rain (12th-15th).
### Table 1. Ascospore releases during periods of rain, dew or no detectable moisture, for four trapping seasons.

<table>
<thead>
<tr>
<th>Year and site</th>
<th>Moisture conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rain</td>
</tr>
<tr>
<td><strong>Strathewen 1992/93</strong></td>
<td></td>
</tr>
<tr>
<td>Number of release events</td>
<td>21</td>
</tr>
<tr>
<td>Release duration (h)</td>
<td>95</td>
</tr>
<tr>
<td>Total spores trapped</td>
<td>829</td>
</tr>
<tr>
<td>Average number spores/ha</td>
<td>8.7</td>
</tr>
<tr>
<td>Infection periods during releases</td>
<td>12</td>
</tr>
<tr>
<td><strong>Strathewen 1993/94</strong></td>
<td></td>
</tr>
<tr>
<td>Number of release events</td>
<td>35</td>
</tr>
<tr>
<td>Release duration (h)</td>
<td>244</td>
</tr>
<tr>
<td>Total spores trapped</td>
<td>9649</td>
</tr>
<tr>
<td>Average number spores/ha</td>
<td>39.5</td>
</tr>
<tr>
<td>Infection periods during releases</td>
<td>11</td>
</tr>
<tr>
<td><strong>Tatura 1993/94</strong></td>
<td></td>
</tr>
<tr>
<td>Number of release events</td>
<td>19</td>
</tr>
<tr>
<td>Release duration (h)</td>
<td>130</td>
</tr>
<tr>
<td>Total spores trapped</td>
<td>1845</td>
</tr>
<tr>
<td>Average number spores/ha</td>
<td>14.2</td>
</tr>
<tr>
<td>Infection periods during releases</td>
<td>8</td>
</tr>
<tr>
<td><strong>Tatura 1994/95</strong></td>
<td></td>
</tr>
<tr>
<td>Number of release events</td>
<td>8</td>
</tr>
<tr>
<td>Release duration (h)</td>
<td>25</td>
</tr>
<tr>
<td>Total spores trapped</td>
<td>136</td>
</tr>
<tr>
<td>Average number spores/ha</td>
<td>5.4</td>
</tr>
<tr>
<td>Infection periods during releases</td>
<td>3</td>
</tr>
</tbody>
</table>

### 3.3.1.3 Diurnal periodicity of release

When ascospores trapped per season were plotted on an hourly basis, it can be seen that there is a strong diurnal periodicity of trapping (eg Figure 8, Tatura 1993). Most ascospores were trapped during daylight hours. At the Strathewen site 98 and 99% of ascospores were trapped during daylight in 1992/93 and 1993/94, respectively. By contrast, at Tatura, 90 and 93% of ascospores were trapped during daylight in 1993/94 and 1994/95, respectively. During the dry 1994/95 season, many very small catches were made in darkness during the early morning, possibly associated with dew formation.
Figure 7. Hourly trap counts of ascospores and duration of leaf wetness due to rain (R) or dew (D) over a 9 day period in early spring at Tatura, 1993
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3.4 Conidia and twig lesions

Fusicladium pyrorum (Lib.) Fuckel, is the imperfect stage of the pear scab fungus. It occurs on leaves, flowers, fruits and shoots of pear. Overseas reports indicate that shoot or twig infections which occur during one season can overwinter and produce inoculum which can cause the initial or primary infections in the following season. Some reports indicate that this conidial inoculum is more important than ascospore inoculum which comes from infected dead leaves under trees. In Australia, studies to determine the relative importance of conidia or ascospores in overwintering and establishing new infections in the spring have not been made.

This work aimed to:
• Determine if twig infections occur on pears in commercial plantings
• Determine if such infections could overwinter and produce conidia in the following spring.

Trees in the two trial sites were examined for shoot infections throughout the course of the study, and detailed assessments were made at harvest on 10 shoots per tree.

3.4.1 Results

Twig or shoot infections were observed on from 40-100% of extension shoots of both Packham and WBC trees in the hydrated lime trials in 1992/93, a season of very high disease pressure (Tables 2 and 3, section 5). On Packham shoots from the untreated trees, an average of about 25 lesions per shoot occurred. Lesions were usually raised and blister like, and were often elliptical or circular in shape, and ranged from 1-2 mm to 1 cm in length. Almost 100% of shoots had scab lesions in the middle section of each shoot, while about 60% of shoots examined showed lesions on the basal (oldest part of shoot) and distal (newest growth) ends.

Sections were made from twig lesions in late winter and examined for conidia. Fungal stromatic tissue was apparent in all sections but no conidia of pear scab were detected.
In 1993/94 only a few shoot lesions were observed (mainly in untreated trees at both trial sites) while in 1994/95 no shoot lesions were observed on any trees in the replicated trial at Tatura.

4. Infection periods

4.1 Envirocaster vs conventional recorders

4.1.1 Introduction

Pear scab can be controlled by protective fungicide applications timed according to tree development stages and weather conditions. Post-infection spray schedules are an alternative to, or a supplement for, protective schedules. Such schedules depend on monitoring temperature and duration of wet periods, using either mechanical recorders or electronic weather recording equipment which have been developed to automatically record potential infection periods.

This study aimed to evaluate the Neogen Envirocaster\(^\text{a}\), a self contained, computer driven environmental monitoring instrument, and compare its predictions with those calculated by conventional weather recorders. As evaluated, the Envirocaster\(^\text{a}\) was equipped to record potential apple or pear scab infection periods and to recommend spray timing. The equipment was loaned by Mr Brian Gaffney of Horticultural Monitoring and Control Pty. Ltd., Bacchus Marsh, to Agriculture Victoria. It was installed in a pear block at the Institute for Sustainable and Irrigated Agriculture at Tatura, in Northern Victoria from August 1992 to July 1995.

4.1.2 Methods

The Envirocaster\(^\text{a}\) was installed between trees within a row of 45 year old Williams Bon Chretian pears, in a block of trees in the Institute for Sustainable and Irrigated Agriculture at Tatura (Figure 9). As originally installed in August 1992, the Envirocaster\(^\text{a}\) contained the Neogen apple scab prediction model. From the beginning of the second season, in August 1993, a pear scab model was installed and operated in addition to the apple scab model. Sensors included air temperature, relative humidity, leaf wetness and a tipping bucket rain gauge. A De Witt leaf wetness recorder and a seven day recording thermohygrograph were operated in close proximity to the Envirocaster\(^\text{a}\) at the same site.

The equipment was checked weekly and historical advisory, historical data and daily weather summaries were downloaded using a laptop computer. At least every two weeks, the hourly weather summaries were also downloaded.

In the third season (1994/95) a replicated spray trial was carried out in the same block of pear trees. One aim of this trial was to attempt to validate the recommended spray dates from the Envirocaster\(^\text{a}\). One treatment in this trial was the use of post-infection sprays at times as recommended by the Envirocaster\(^\text{a}\). Crop disease levels from this treatment were compared with those from another treatment, which consisted of a protectant spray program, with sprays applied according to tree growth stage and weather conditions. The trial sprays were applied until late December, after which all trees in all treatments were sprayed as required.
Figure 9. Downloading data from the Neogen Envirocaster, a computerized environmental monitoring instrument, in an orchard at Tatura
4.1.3 Results

1992/93

The Envirocaster® operated satisfactorily throughout the first season (1992/93) recording 16 infection periods from September to January. These comprised eight low, three medium and five high levels of infection (based on the apple scab model). During this season the mechanical leaf wetness recorder failed to operate satisfactorily. As a result no comparisons could be made.

1993/94

In year two (1993/94) the Envirocaster® recorded 10 infection periods. The mechanical recorders predicted three more infection periods, based on the Mills table for apple scab infection. (Note that the model has an optional requirement for rain to initiate an infection period, which we chose to leave switched on for both 1993/94 and 1994/95. Because of this requirement and the fact that the rain gauge was unexpectedly inoperative for the first month of the season, we calculated the infection predictions for this period from the hourly weather summaries. The cause of this problem was unknown, but was possibly due to an error in installation of the gauge at the beginning of the season).

Of the three infection periods recorded by the mechanical recorder but not by the Envirocaster®, two of these were marginal infection periods, close to the point where the leaf wetness and temperature period is insufficient to register as an infection period. Slight differences in leaf wetness and/or temperature recorded by the different sensors during this period could account for the different predictions.

The third infection period recorded by mechanical recorders but which was not predicted by the Envirocaster® could be explained by the requirement of the model for rain to initiate an infection period. For the infection period in question, no rain was recorded and therefore no infection was predicted. If rain had been recorded or if the rain requirement had been switched off, then the wetness and temperature recorded in the hourly weather summaries would have been sufficient, according to Mills table criteria for apple scab, for an infection period. In addition, the apple scab model did predict an infection for this period (in the historical advisory summaries), as did the mechanical recorders (based on Mills criteria). Surprisingly, the pear scab model did not record the hours of leaf wetness which occurred for that period in the historical data summary.

An infection period recorded by the Envirocaster® on the 27/12/93 was not included in the comparison as the mechanical recorder malfunctioned during that period.
In year three (1994/95) the Envirocaster® predicted six infection periods, while the mechanical recorders predicted two more. One of these two periods predicted by the mechanical recorders was again a marginal infection period and the different prediction could reflect the slight differences in the leaf wetness and/or temperature recorded by the different sensors during this period (as for 1993/94). The second of these periods, which occurred late in the season, was associated with an apparent blockage of the tipping bucket rain gauge with mud, in the middle of a split wetness period. This failure to record an infection period could be explained by the model's requirement for rain to initiate an infection period (as in 1993/94). However, the apple scab model did not record any infection period and only recorded the first part of the split wetness period in the historical advisory or the historical data summaries, unlike in 1993/94. Data from the daily and hourly weather summaries indicated that this period would have been an infection period based on Mills criteria.

The results from the spray trial in year three were inconclusive as disease levels were very low (less than 1% in the control trees). A single post-infection spray was applied at late calyx to the trees treated according to the Envirocaster® recommendations, between two predicted infections. An early infection period at around green tip was ignored as all trees in the spray trial were sprayed at bud movement, and this spray was presumed to provide adequate protection to account for the predicted infection. Disease levels at harvest in trees treated according to the Envirocaster® were no different than levels from trees in the unsprayed control.

A generally good correlation existed between the infection indexes (the product of temperature and hours of wetness) calculated from mechanical recorders and from the Envirocaster® hourly weather summaries (figure 10).

**Figure 10.** Infection indexes recorded by mechanical recorders and the Neogen Envirocaster at Tatura, 1994/95.

### 4.1.4 Discussion

In summary, the Envirocaster® operated reliably for the three seasons of the evaluation. In season one it predicted 16 infection periods (operating the apple scab model). In season two it predicted 10 infection periods (11 if the rain requirement was ignored) operating the pear scab...
model. In the third season six infection periods were predicted (seven if the rain requirement was ignored), again operating the pear scab model.

Over two seasons, the Envirocaster® pear scab model predicted 16 (76%) (or 18 (86%) if the rain requirement had been ignored) out of the 21 infection periods predicted using the Mills table and mechanical recorders.

Particular care is needed with the rain gauge, as the Envirocaster® model for scab has an optional requirement for rain to occur before it predicts an infection period (unless this requirement is switched off). We experienced such a problem at a crucial time in the second season, when the rain gauge was inoperative for the first month of the season. The cause of this was unknown, but was possibly due to incorrect installation of the rain gauge at the beginning of the season. As a result no predictions were made despite the occurrence of significant wet periods, and rain showers. (Note that infection periods predicted for this time period were calculated subsequently from the hourly weather data and included in the predictions listed in the results for 1993/94). The second time the Envirocaster® failed to record an infection period when the rain requirement was met was late in the third season. The problem occurred with an apparent blockage of the rain gauge with mud, in the middle of a split wetness period. This may have resulted from mud being slung from tractor tyres and lodging in the gauge. It is recommended that for the period that the rain requirement is switched on, the gauge is checked daily.

4.2 Disease progress in relation to infection periods

4.2.1 Introduction

Conditions for infection by the apple scab fungus, Venturia inaequalis Cke. (Wint.), have been extensively studied. Periods of leaf wetness at certain temperatures, known as infection periods, which occur during the spring and summer, are required for scab spores to germinate and infect host tissue. Fewer studies have been made of such conditions for pear scab, however, generally they are presumed to be the same or similar to those required for apple scab. The aim of these studies was to observe disease progress in relation to the occurrence of infection periods as calculated for apple scab.

4.2.2 Methods

Infection periods were recorded at the two trial sites (see 4.1.2), and disease progress was monitored by assessing infection on leaves and fruit in unsprayed trees at intervals during the season.

4.2.3 Results and Discussion

The number of infection periods, their severity and their relation to disease development, are shown in figures 3-6 (section 3). The number of infection periods varied between sites and seasons, with Strathewen recording a consistently higher number of infection periods than Tatura. A high number of infection periods between green tip and petal fall was associated with a rapid development of fruit scab infection at Strathewen in 1992 (figure 3). By contrast,
a low number of infection periods during the same period in the following season was associated with a much lower and slower disease development at Strathewen in 1993 (figure 4). Many infection periods later in the season lead to a late increase in fruit disease to a high level (figure 4). In the driest season which occurred during the experimental work, at Tatura in 1994, only a trace of infection occurred by harvest. In this season, only one infection period occurred between green tip and petal fall (figure 6).

5. Hydrated lime sprays for scab control

5.1 Introduction

Five replicated field trials were conducted during the project, along with two grower demonstration trials (unreplicated) with the aim of evaluating hydrated lime sprays as a treatment for scab control.

The aims of these trials were to determine:

- whether hydrated lime sprays applied on a protectant schedule could give control of scab
- whether such sprays were comparable to conventional fungicide sprays
- whether such sprays affected fruit yield and quality
- whether such sprays affected other insect pests
- whether growers found such treatments practical using commercial spray equipment

5.2 General Materials and Methods

5.2.1 Trial sites:

Two sites were used for replicated trials, one in a block of trees at the Institute for Sustainable and Irrigated Agriculture at Tatura in Northern Victoria, and the other in a commercial block at Strathewen in Southern Victoria. The Tatura site was in a block of 45 year old Williams Bon Chretien (WBC) trees planted at 5.5x5.5 m spacings, in rows of 10 trees with two Buere Bosc pollinators planted in every three rows. Trees were irrigated by under tree sprinklers. A grass and clover sward covered the entire area under the trees. The Strathewen site was in two rows of 5 year old Packham's Triumph pears planted at 3x5m spacings. Howell and Winter Nelis pollinators comprised every third row of trees. All trees were drip irrigated, and a herbicide strip was maintained along each tree line.

5.2.2 Disease and yield assessments

Trees were examined regularly and growth stages were recorded. After disease was first recorded in the unsprayed trees, several (up to five per season) assessments of fruit and leaf scab were made in the field by recording the incidence of scab infected leaves on 100 fruit and 100 leaves on each tree in the trial. At harvest, all fruit were picked and the yield per tree recorded by weighing on field scales. Samples of 100 fruits and 10 shoots per tree were taken back to the laboratory and assessed for scab incidence and severity, and symptoms of insect damage was also recorded. In some seasons, fruit from some treatments was stored in...
polyethylene liners within cardboard fruit boxes at 1°C for up to 60 days and then assessed for
firmness using a penetrometer, and fungal rots. In some trials a simulated marketing period of
5 days at 20°C was also applied before assessment.

5.2.3 Trial design

Trials were usually randomised complete blocks with treatments replicated six times using
single tree units. In 1994/95 the design was two Latin squares with missing plots, with 8 or 9
replicates. All results were analysed by Anova using Genstat 5, release 3.1 (Rothamstead
Experimental Station). Grower demonstration trials were not replicated.

5.2.4 Spray treatments

In the replicated trials sprays were applied to the point of runoff by a hand gun at 170-180 psi. Spray
timing was based on protectant sprays from green tip in relation to tree growth stage and
was adjusted according to the intensity of infection periods during the spring period. Hydrated
lime (as Limil R), thiram (as Thiram 800 g/kg DF) and flusilazole (Nustar 10 g/kg DF) were
the treatments applied. Grower trials were sprayed using commercial airblast sprayers.

5.2.5 Infection periods

Leaf wetness and temperature were monitored at each site with a De Witt leaf wetness recorder
and a thermohygrograph. A Neogen Envirocaster was located at the Tatura site for the three
seasons of the project. (See section 4).

5.3 Replicated field trials

5.3.1 Trials 1 (Strathewen, Packham) and 2 (Tatura, WBC) 1992/93

These trials aimed to compare protectant schedules of hydrated lime sprays at two rates (2 and
1 kg/100L) with mixed schedules including the conventional fungicides thiram and flusilazole
and with schedules of conventional fungicides alone. A maximum of 8 (Strathewen) or 6
(Tatura) sprays of hydrated lime were applied in a season of very high disease pressure. Details
of treatments and application times are shown in Tables 1 and 2.

5.3.1.1 Results

Disease pressure was intense this season and reports indicated that some commercial growers
in the Goulburn Valley had 80-100% fruit infection on WBC pears at harvest.

Disease pressure was so great at both trial sites that even conventional fungicides failed to
control scab. Figure 1 shows the severity of fruit infection at harvest on unsprayed WBC pears
from the Tatura trial. Given that the number of sprays were too few, and were spread too far
apart, to counter the intense disease pressure which occurred during this season, it is not
surprising that hydrated lime treatments failed to reduce the fruit scab incidence when
compared with untreated levels at harvest. Thiram sprays gave the best control of fruit scab.
Hydrated lime alone did reduce the severity of fruit scab infection although not as much as when in schedules with other conventional fungicides or when compared with conventional fungicides on their own (Tables 2 and 3). The high rate of hydrated lime tended to give better disease control than the lower rate. Shoot scab occurred at a very high level (90-100% in untreated trees) and few treatments gave significant reductions when compared with untreated trees. The Strathewen trial had very intense early season scab pressure as indicated by the very high incidence of fruit with large scab lesions.

Table 2. Effect of sprays on incidence and severity of scab at Strathewen 1992/93, cv Packham

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Scab incidence</th>
<th>Scab severity</th>
<th>Incidence of fruit with primary scab</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fruit</td>
<td>Leaf</td>
<td>Shoot</td>
</tr>
<tr>
<td>1. untreated</td>
<td>100</td>
<td>31.5</td>
<td>100</td>
</tr>
<tr>
<td>2. hydrated lime</td>
<td>99.8</td>
<td>18.7</td>
<td>95.0</td>
</tr>
<tr>
<td>3. 1/2 hydrated lime</td>
<td>100</td>
<td>21.8</td>
<td>100</td>
</tr>
<tr>
<td>4. hydrated lime/thiram</td>
<td>99.5</td>
<td>20.3</td>
<td>95.0</td>
</tr>
<tr>
<td>5. hydrated lime/flusilazole</td>
<td>98.8</td>
<td>9.0</td>
<td>81.7</td>
</tr>
<tr>
<td>6. thiram</td>
<td>77.7</td>
<td>6.5</td>
<td>73.3</td>
</tr>
<tr>
<td>7. flusilazole</td>
<td>93</td>
<td>3.0</td>
<td>65.0</td>
</tr>
<tr>
<td>LSD P=(0.05)</td>
<td>5.7</td>
<td>11.1</td>
<td>15.5</td>
</tr>
</tbody>
</table>

Insect damage was low at Strathewen, while at Tatura levels of Tortricid pests (light brown apple moth and codling moth) and mealy bug were much higher. Pear blister mite damage on leaves was significant at Strathewen but was not observed at Tatura. There were no clear treatment effects at Strathewen, while at Tatura hydrated lime trees tended to have lower levels of codling moth than untreated trees. Hydrated lime treated trees had significantly less codling moth levels than flusilazole treated trees. Thiram treatments resulted in highly significant increases in fruit infested with mealy bug at Tatura. Flusilazole treatments appeared to increase levels of LBAM and pear and cherry slug when compared with untreated trees in this trial.
All treatments significantly increased fruit weight and fruit yield (except hydrated lime at 1% for fruit yield) at Strathewen. Thiram treated trees produced the greatest yield and fruit weight increases. At Tatura thiram and flusilazole treatments resulted in significantly heavier fruit than that from untreated trees. No other treatments were significantly different from the untreated control.

### Table 3. Effect of sprays on incidence and severity of scab at Tatura, 1992/93, cv Williams Bon Chretien

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Scab incidence</th>
<th></th>
<th>Scab severity</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fruit</td>
<td>Leaf</td>
<td>Shoot</td>
<td>Fruit</td>
</tr>
<tr>
<td>1. untreated</td>
<td>100</td>
<td>62.8</td>
<td>91.7</td>
<td>3.9</td>
</tr>
<tr>
<td>2. hydrated lime</td>
<td>98.5</td>
<td>35.5</td>
<td>80.0</td>
<td>2.1</td>
</tr>
<tr>
<td>3. 1/2 hydrated lime</td>
<td>99.0</td>
<td>44.2</td>
<td>91.7</td>
<td>2.1</td>
</tr>
<tr>
<td>4. hydrated lime/thiram</td>
<td>96.0</td>
<td>28.5</td>
<td>75.0</td>
<td>1.9</td>
</tr>
<tr>
<td>5. hydrated lime/flusilazole</td>
<td>93.7</td>
<td>23.2</td>
<td>85.0</td>
<td>1.5</td>
</tr>
<tr>
<td>6. thiram</td>
<td>75.8</td>
<td>15.7</td>
<td>43.3</td>
<td>1.3</td>
</tr>
<tr>
<td>7. flusilazole</td>
<td>100.0</td>
<td>15.0</td>
<td>71.7</td>
<td>2.0</td>
</tr>
<tr>
<td>LSD P=(0.05)</td>
<td>5.6</td>
<td>9.7</td>
<td>21.5</td>
<td>0.4</td>
</tr>
</tbody>
</table>

5.3.2 Trials 3 (Strathewen, Packham) and 4 (Tatura, WBC) 1993/94

These trials aimed to further test protectant schedules of all treatments, including conventional fungicides in combination with hydrated lime. One aim was to test whether conventional fungicides over the early part of the season followed by hydrated lime was better than conventional fungicides during the early season only. Only the higher rate of hydrated lime was used as results from the first season showed that the 1% rate was less effective than the 2% rate. A maximum of 10 (Strathewen) or 6 (Tatura) sprays of hydrated lime were applied in these trials, in a season of high disease pressure.
5.3.2.1 Results

This season, scab infection pressure, although high, was less than in the previous year. Hydrated lime alone gave significant control of scab on fruit and leaf (Tables 4 and 5), as did all other treatments. Thiram alone, and in combination with flusilazole, gave the best scab control, significantly better than hydrated lime alone. The high (by commercial standards) incidence of scab at harvest was due to a high incidence of summer spot -late season infections. These levels were also favoured by the minimal spray program applied after the end of December, which gave poor protection against secondary spread of disease. No shoot infections were observed in any trees in this season, a marked contrast with the high levels recorded in the previous year. Although there was a trend towards lower scab levels in treatment 6 compared with treatment 5 (where hydrated lime was omitted in late season sprays) these differences were not significant.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Scab incidence</th>
<th>Scab severity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fruit</td>
<td>Leaf</td>
</tr>
<tr>
<td>1. untreated</td>
<td>77.7</td>
<td>16.3</td>
</tr>
<tr>
<td>2. hydrated lime</td>
<td>50.2</td>
<td>2.8</td>
</tr>
<tr>
<td>3. thiram</td>
<td>17.7</td>
<td>2.5</td>
</tr>
<tr>
<td>4. thiram/flusilazole/thiram</td>
<td>15.0</td>
<td>0.5</td>
</tr>
<tr>
<td>5. thiram/flusilazole</td>
<td>30.7</td>
<td>4.6</td>
</tr>
<tr>
<td>6. thiram/flusilazole/hydrated lime</td>
<td>26.0</td>
<td>2.0</td>
</tr>
<tr>
<td>7. hydrated lime/flusilazole/hydrated lime</td>
<td>38.0</td>
<td>1.6</td>
</tr>
</tbody>
</table>

LSD P=(0.05) 16.6  6.1  0.5  NS

Insect levels were very low at Strathewen, with the exception of moderate levels of pear and cherry slug on leaves. All spray treatments gave significant reductions in leaf damage. Similarly, levels of pests were low at Tatura with the exception of pear and cherry slug, which
reached very high levels late in the season, necessitating a specific insecticide spray to restrict damage levels.

Table 5. Effect of sprays on incidence and severity of scab at Tatura 1993/94, cv Williams Bon Chretien

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Scab incidence</th>
<th></th>
<th>Scab severity</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fruit</td>
<td>Leaf</td>
<td>Fruit</td>
<td>Leaf</td>
</tr>
<tr>
<td>1. untreated</td>
<td>87.3</td>
<td>13.0</td>
<td>2.8</td>
<td>0.3</td>
</tr>
<tr>
<td>2. hydrated lime</td>
<td>51.2</td>
<td>7.5</td>
<td>1.6</td>
<td>0.1</td>
</tr>
<tr>
<td>3. thiram</td>
<td>31.8</td>
<td>8.6</td>
<td>0.8</td>
<td>0.1</td>
</tr>
<tr>
<td>4 thiram/flusilazole/thiram</td>
<td>37.0</td>
<td>5.8</td>
<td>0.8</td>
<td>0.1</td>
</tr>
<tr>
<td>5. thiram/flusilazole</td>
<td>43.0</td>
<td>8.6</td>
<td>0.9</td>
<td>0</td>
</tr>
<tr>
<td>6. thiram/flusilazole/hydrated lime</td>
<td>30.3</td>
<td>4.5</td>
<td>0.9</td>
<td>0</td>
</tr>
<tr>
<td>7. hydrated lime/flusilazole/hydrated lime</td>
<td>53.8</td>
<td>6.5</td>
<td>1.2</td>
<td>0.1</td>
</tr>
<tr>
<td>LSD P=(0.05)</td>
<td>15.5</td>
<td>NS</td>
<td>0.7</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Hydrated lime treatments appeared to have no effect on pest levels. Thiram treatments significantly reduced pear and cherry slug levels. LABM levels were significantly higher in the only treatment which had no spraying after petal fall, indicating that the absence of spraying after petal fall was an important factor in the build up of this pest.

There were no treatment effects with respect to tree fruit yield and average fruit size at either site. Yields per tree at the Strathewen site increased dramatically from the previous season as trees reached a greater size and cropping potential. By contrast yields per tree at Tatura decreased by comparison with the previous season. A significant increase in lenticel size on fruit was observed at both sites on fruit treated with the full schedule of 10 hydrated lime sprays when compared with fruit from thiram sprayed or untreated trees.

Differences in fruit calcium levels were not found in fruit treated with 10 hydrated lime sprays when compared with fruit from trees sprayed with thiram only. Storage trials indicated that fruit from trees sprayed with 10 hydrated lime sprays was firmer (as measured by penetrometer) than fruit from trees treated with thiram sprays only. Low levels of fungal rots,
mainly caused by *Botrytis* and *Penicillium* spp, occurred at a similar level in fruit from trees treated with hydrated lime only or thiram. However, in the Packham fruit from Strathewen, significantly more storage scab developed on fruit treated with hydrated lime than on fruit treated with thiram.

### 5.3.3 Trial 5 (Tatura, WBC) 1994/95

This trial aimed to test hydrated lime spray schedules, again applied as protectant sprays, in a season of lower disease pressure than the previous two seasons. A maximum of seven hydrated lime sprays were applied in what proved to be a very low disease pressure year.

#### 5.3.3.1 Results

Disease pressure was so low that at harvest only a trace of scab was detected with no difference between treated or the untreated trees. After 50 days storage, a little more disease developed but still at an insignificant level. Insect levels were low except for pear and cherry slug, but there were no differences between treatments. Lenticel enlargement was again observed on trees treated with hydrated lime with the greatest effect seen on trees treated with seven sprays. Fruit calcium levels were not different between trees treated with hydrated lime or a conventional fungicides. There were no differences between treatments with respect to fruit yields and fruit weight.

Fruit firmness did not differ between treatments after 60 days storage, although after an additional 5 days at 20°C fruit treated with hydrated lime sprays were softer than fruit treated with conventional fungicides, but were not different from fruit from untreated trees. After storage fruit from trees treated with seven hydrated lime sprays (treatment 2) had significantly more rots caused by *Botrytis* than fruit from trees treated with seven thiram sprays (treatment 3).

### 5.4 Grower demonstration trials

Three grower trials were established with the aim of getting grower feedback on the use of hydrated lime in commercial sprayers. Only two growers applied any hydrated lime sprays (2 or 3 sprays), in a season of very low disease pressure.

#### 5.4.1 Results

Observations were made on scab, lenticel enlargement, calcium levels in fruit, fruit weights and fruit firmness after storage. No conclusions can be reached from these unreplicated observations. Growers considered that hydrated lime was suitable for routine treatment with commercial sprayers provided that good agitation was maintained in the vat and that entire bags of hydrated lime were applied to the vat rather than attempting to add portions of a bag.
5.5 *Leaf surface pH levels in relation to hydrated lime treatments*

Previous reports on apples have indicated that high pH on the leaf surface is a likely factor in the efficacy of hydrated lime sprays against apple scab. Studies were therefore carried out to examine pH changes on leaves of pear trees in the field after spraying with hydrated lime. A portable pH meter fitted with a flat probe was used. Leaves were moistened by spraying with distilled water before pH was determined.

Figure 11 shows the changes in pH on leaves of WBC pear trees in the field. They show that pH changes from about 12 immediately after spraying with hydrated lime to around 9.5 after 7 days.

![Figure 11. pH levels on the surface of pear leaves sprayed with 2% calcium hydroxide. Measurements were taken over a period of 15 days on WBC trees at Tatura in 1994.](image)

6. **Conclusions**

This study has shown that:
1. ascospores (from overwintered dead leaves) are the most important source of early season infections in spring
2. most ascospore release occurs after rainfall
3. most ascospores are released during daylight
4. the small numbers of ascospores released during darkness are usually within a few hours of dawn or dusk
5. these night releases of ascospores may be important in orchards with very high disease carryover, but are unlikely to be important in orchards with low disease carryover

HRDC project AP 218
6. peak ascospore discharge usually occurs between the tree growth stages of green tip to petal fall or calyx
7. unusual seasonal conditions can alter this pattern eg. in a dry spring the peak ascospore discharge was delayed
8. conidia from twig infections are not important as a major source of early season infection
9. twig infections can occur on both Packham's Triumph and WBC pears, under high disease pressure
10. comparison between scab infection periods predicted by an electronic weather station (Neogen Envirocaster) and mechanical weather recorders were similar
11. hydrated lime sprays do give some control of pear scab infection, however such treatments are less effective than conventional fungicides under high disease pressure
12. such sprays did not affect the level of damage caused by common insect pests, but occasionally slight phytotoxicity was observed in the form of enlarged fruit lenticels
13. hydrated lime sprays were found to be practical when applied by growers using commercial airblast sprayers

7. References


8. Recommendations

Scab infection requires all of the following:

1. Susceptible host tissue (from green tip stage onwards). Trees can't be infected when they are dormant as no susceptible tissue such as young leaves or flowers are present.

HRDC project AP 218
2. **Mature spores** of the scab fungus in a condition which allows them to infect tree parts. Significant numbers of ascospores are mature usually from pre-green tip to at least the calyx stage.

3. **Suitable weather conditions** (infection periods comprising periods of leaf wetness and temperature) which allow spores to germinate and infect the pear tissue. These are best monitored using weather equipment designed to record scab infection conditions (the minimum requirements being a leaf wetness sensor and a temperature sensor.)

This project has shown that:

1. The critical time for application of control treatments is the early spring from green tip to petal fall or calyx stage. This coincides with a period of highly susceptible new growth of the tree, and with the period when significant numbers of mature ascospores are ready to be discharged.

2. The use of protectant treatments (supplemented by post-infection treatments where necessary) is favoured during this period as a lower risk strategy than one relying only on curative or post-infection sprays.

3. After calyx stage, a combination of protectant and post-infection treatments may be used. If good control of the early season infections is achieved (see 1.) then control at this stage is less critical. If disease pressure is low and no disease is observed then post-infection treatments, used only when infection periods are recorded, may be sufficient.

4. From research to date, the use of apple scab infection criteria appears to be acceptable for the prediction of pear scab infections.

5. The most important source of spores for new infections in spring is in dead leaves under trees, which contain ascospores. Conidia on twig lesions which survive the winter and release in the spring were not found to be important in this study.

Future work needs to address the issue of effect of the amount of overwintering disease in the form of ascospores on the development of infections and the level of control measures necessary in the following spring. In addition further work is required to relate spray timing to ascospore release, and to determine the length of and variability of the ascospore discharge. These areas will be studied in the new project AP 521.

In addition, further extension of the results of this project to growers, scouts and chemical resellers is necessary to ensure that the industry are as well informed as possible about the importance of timing of control measures in relation to ascospore release and weather conditions. The use of Agnotes, grower association newsletters and specific project newsletters, in addition to talks and field days, all contribute to the adoption of findings of this research by the pear industry. Extension of this work will continue as part of the new project on pear scab monitoring AP521.

9. **Acknowledgements**
This project was funded by the Horticultural Research and Development Corporation, the Australian Apple and Pear Growers Association and the Canned Fruit Industry Council of Australia. This work was supported by Mr B. Gaffney of Horticultural Monitoring and Control Pty Ltd, Bacchus Marsh, through the loan of the Neogen Envirocaster for the duration of the project, and provision of ready back-up support and advice. The authors gratefully acknowledge the technical assistance of Mr M. Appleby and Ms E. Whitten in the first year of the project; the assistance of staff of the Institute of Sustainable and Irrigated Agriculture, Tatura, in particular Mr L. Issel, Ms V. Bates, Dr T. Lim and Ms J. Vigliaturo; the willing assistance of grower co-operators including Mr B. Apted, Mr A. McNab, Mr P. McCamish and Mr G. Themilis; the staff of the NVFA including Mr P. Jobling; and the statistical advice of Mr G. Hepworth.
10. Appendix 1 Publications


Welcome to the first issue of the pear scab newsletter!!

This newsletter will present information from research on pear scab and other issues which are relevant to the pear industry. It is hoped that this newsletter will help us to keep pear growers up to date with the projects. If there are any other issues that growers would like more information on, or that they would like published in this newsletter, please contact us. It is anticipated that the newsletter will be published frequently, at least 3 times a year for the duration of the projects.

This first edition of the pear scab newsletter contains results from the project ‘Epidemiology and control of pear scab’. These results are a summary of the main observations from the field trials. Full results will be available in the next issues. This edition also provides a summary and plans of trials of the new project ‘Disease monitoring and control of pear scab’. Preliminary results of this new project will be available in the autumn edition.

IN THIS EDITION...

Project ‘Epidemiology and control of pear scab’
- Background and trials
- Infection periods study
- Spore overwintering studies
- Hydrated lime trial

New project ‘Disease monitoring and control of pear scab’
- Background
- Work this season

Project ‘Pear scab screening’
- Background and work this season

By Oscar Villalta and Bill Washington
Institute for Horticultural Development, Private Bag 15 South Eastern Mail Centre, Vic 3176, Australia
Telephone (03) 9210 9222 Facsimile (03) 9800 3521
PROJECT ‘EPIDEMIOLOGY AND CONTROL OF PEAR SCAB’

PROJECT BACKGROUND
This research project was funded for three years (1992-1995) by the Canned Fruit Industry Council of Australia (CFICA), the Apple and Pear Industry (AAPGA) and the Horticultural Research and Development Corporation (HRDC). This project was part of the Apple and Pear Industry’s National program to reduce pesticide usage in pome fruit.

Aims of research were:
The aims of this project were to improve pear scab control (Venturia pirina) and to minimise fungicide usage through a better understanding of the epidemiology of the disease. Results from this project should enable growers to adopt more appropriate disease control measures.

INFECTION PERIODS STUDY

Results summary
At the Tatura site, infection periods were monitored using mechanical temperature and leaf wetness recorders and compared with those recorded by an electronic weather station (a Neogen Enviromaster®). Infection periods were calculated according to the criteria for apple scab (Mills periods of leaf wetness and temperature). Results showed that predictions by either system were similar, although predictions from the Enviromaster® fitted with a scab prediction program (pear model) were slightly less conservative (i.e., predicted fewer infection periods) than those predictions from mechanical recorders based on Mills periods.

SPORE OVERWINTERING STUDIES

Summary of field observations
Studies using a Burkard spore trap at the two locations (results for a total of two growing seasons in each location) showed that ascospores (primary inoculum) were mature at or before the green tip stage. Peak ascospore discharges occurred mainly between green tip and petal fall or calyx stages, during September and October following rain periods (for example fig. 1). Most ascospores were trapped during daylight hours after rainfall. In one season in one trapping site, up to 10% of all ascospores trapped were caught during the night, although ascospores were mostly caught within a few hours of dawn or dusk. Wood infections (conidia) occurred in the varieties WBC and Packham in the orchards studied during a season of high disease pressure. No conidia were detected in these lesions in the following spring. In seasons of lower disease pressure no wood infections were observed.
Implications of spore studies results

(i) Studies over the three years have shown that ascospores are the most important source of early season scab infection in the spring. Conidia produced from wood infections were not important during spring in the orchards studied.

(ii) Most ascospores are released during the daylight hours after rainfall. Results from the small number of ascospores caught within a few hours of dawn or dusk, indicate that infection periods that begin at night may be important in orchards with a high disease carryover from the previous autumn.

(iii) Peak ascospore discharge usually coincides with the period from budburst to the petal fall or calyx stages. This emphasises the importance of control measures applied during this time (usually from September to November).

HYDRATED LIME (Limil®) TRIALS

Field trials summary
Hydrated lime (Limil®) was evaluated in replicated small plot trials as a possible replacement for conventional fungicide sprays at the two locations and in three grower demonstration trials (non-replicated). In replicated trials, sprays were concentrated from budburst to petal fall or calyx stages in a protectant schedule and then applied less frequently from November to January.

Replicated trials results
Hydrated lime (Limil®) sprays gave significant disease control when applied in replicated small plots. Results showed that under high disease pressure (high carry over of disease from previous year and wet spring weather) control is not as good as with conventional protectant fungicide (for example Fig. 2). Slight phytotoxicity, which appears as enlarged lenticels on fruit was observed after six to ten sprays but not with fewer sprays. Hydrated lime sprays did not affect the damage caused by insect pests including codling moth, light brown apple moth and pear and cherry slug.

![Graph showing ascospore discharge](image)

Fig. 1 Number of ascospores trapped in 1993/94 season at Tatura in Northern Victoria.
Grower demonstration hydrated lime results
Between 2-3 hydrated lime (Limil®) sprays were applied by grower co-operators to blocks of WBC trees (non-replicated) between petal fall stage and December, using airblast sprayers.

No phytotoxicity was observed on fruit skin. In this season disease pressure was low, and very little disease developed even in unsprayed trees.

Hydrated lime work conclusion
(i) The trial results for the replicated small plots suggest hydrated lime offers scope for scab control in situations of low disease pressure. Such treatments may find application where there is a need to reduce the number of conventional fungicides. For example after the end of the primary infection period where disease pressure is low and scab has been well controlled.

(ii) Grower trials using air blast sprayers showed that hydrated lime sprays are practical when applied by commercial operators. Nozzles must be flushed clean after each application. Hydrated lime should not be used with piston pumps.

A NEW PROJECT!! ‘DISEASE MONITORING AND CONTROL OF PEAR SCAB’

BACKGROUND
Pear growers, through the Canned Fruit Industry Council of Australia (CFICA), have requested more research to improve pear scab control and reduce fungicide usage. They provided funds to support another three year project supervised by Bill Washington. These funds are being matched by the government via the Horticultural Research and Development Corporation (HRDC) and enabled the appointment of Oscar Villalta as a scientist at IHD Knoxfield for another three years. The project commenced in July 1995.

The project approaches for control of disease are:
(i) To develop a monitoring method (usable by commercial scouts) to assess disease potential from one season to the next and enable the adjustment of spray timing. This will relate seasonal disease carryover (ascospores) to control measures required during the spring.

(ii) To develop a warning system to highlight periods of primary (ascospore) discharge, enabling sprays to be targeted at the highest risk period when ascospores are mature. This may enable adjustment of sprays in the second half of the growing season.

(iii) To assess the potential of post-harvest treatments, including urea, to reduce overwintering inoculum.
Work this season...

New project field trials
Six field trials have been established in the Goulburn Valley (five on grower properties) in the current 1995/96 season. We need more grower co-operators for next season’s work!! These trials are designed to evaluate different strategies to reduce fungicides applications. These strategies will be determined by:

- Occurrence of infection periods, disease incidence and severity will be monitored at these sites during the growing season. This work should identify orchards in which scab fungicides can safely be omitted during the second half of the season when disease pressure is low. Grower co-operators will apply these sprays in small replicated trial blocks.

- A network of mechanical weather recorders installed in these sites will provide information on the occurrence of infection periods. It is expected that an electronic weather recorder fitted with a scab prediction model will be added to the network in 1996/97 season.

- Monitoring procedures to quantify the overwintering inoculum of scab will be evaluated. These sites will be monitored for disease incidence and severity after harvest and survival of overwintered inoculum estimated in early spring next year. Replicated trials will be established in 1996 season to validate these procedures.

- Ascospore trapping at ISIA Tatura using a Burkard spore trap will continue to examine the seasonal variation in the timing of ascospore discharge.

Laboratory experiments
* Post-harvest leaf treatments of urea and other materials will be examined to assess ascospore productivity in spring.

* Methods of measuring early season ascospore maturity will be assessed to enable the development of a spore (primary inoculum) warning system for growers.

What do we do in our spare time?

CONDUCTING SCREENING
FOR PEAR SCAB RESISTANCE

Background
A national project to breed improved varieties of pears for the Australian pear industry began in 1993. A major aim of this program is to develop varieties which are resistant to pear scab. A protocol has been developed at IHD Knoxfield to screen young pear seedlings for their reaction to pear scab. Crosses are made in Western Australia, New South Wales and South Australia and seedlings resulting from these crosses are challenged by the fungus under controlled conditions. The screened seedlings are moved to nurseries at IHD Knoxfield and ISIA Tatura. 1995 is the second year we have screened the national pear breeding material. This season we also will be evaluating a range of commercial pear varieties (young grafted pear plants) for their reaction to several pear scab isolates under controlled conditions. This work will help to determine potential sources of resistance to scab and the host-specific reactions to infection. We need to continue collecting scab specimens for this work so please let us know of any outbreaks of scab or send us a sample by mail.

Pear scab screening 1995 is well under way!!
We have taken over the new glasshouse complex at IHD Knoxfield with more than 15,000 seedlings to be screened this year. The scab screening team are groaning under the weight!! For more information on pear scab screening contact us. Results of the 1995 screening will be available in the next edition of the pear scab newsletter.

Acknowledgments
Horticultural Research and Development Corporation (HRDC)
Canned Fruit Industry Council of Australia (CFICA)
Apple and Pear Industry (AAPGA)
Growers co-operators
Brian Gaffney Horticultural Monitoring and Control Pty. Ltd.
Epidemiology & control of Pear Scab

(HRDC project AP 218)

Researchers: W.S. Washington and O. Villalta, Institute for Horticultural Development, Knoxfield,

1993/94 is the second year of a three year project which aims to improve the control of pear scab by achieving a better understanding of: 1) The overwintering of the scab fungus (under the tree in dead leaves as ascospores, or in the tree on twigs as conidia); 2) disease development in relation to infection periods and tree phenology; and 3) by evaluating hydrated lime (calcium hydroxide) as an alternative to conventional fungicides for scab control.

Results to date:

a) Spore trapping/overwintering studies

* In year one, ascospore discharge was detected from 21/9/92 to 24/1/93 (most between 21/9-20/10) in Southern Victoria (SV). The significance of the very low levels detected as late as January is not yet understood, but apparently the fungus has the ability to survive into mid summer.

* Extensive twig infections were found on the current seasons growth of both WBC and Packhams pears during the season.

* In year two, ascospore discharge was mostly between 3/9/94 and the 10/10/94 in Northern Victoria (NV). Discharges appeared to occur even during periods when a significant proportion of the orchard floor was flooded.

* Twig infections from the previous year failed to produce conidia. No new twig infections were observed on the current seasons growth during this season.

b) Infection conditions and disease development

* In year one both trial sites had very high disease pressure. The first infections were found on 13/10/93 (SV) at full bloom or 20/10/93 (Northern Victoria or NV) at petal fall. Disease increased very rapidly early in the season in unsprayed trees. Summer infections were significant, causing high levels of summer spot.

* 20 (SV) or 16 (NV) infection periods were monitored during the growing season.

* In year two the first infections were found on 8/10 (NV) or 18/10 (SV). Disease increased at a slower rate than year one, although summer spot (late season infections) were again significant.

* 23 (SV) or 17 (NV) infection periods were monitored during the growing season.

* Envirotaster® scab infection monitoring has operated at the Tatura site for two seasons, with infection predictions being similar to those recorded and calculated from conventional leaf wetness and temperature recorders.

c) Hydrated lime sprays

* Hydrated lime has activity against scab and gives significant disease control. It is more active at 2% than 1%. Hydrated lime was not as effective against scab as a conventional protectant fungicide (thiram) (Table 1).

* Several spray programs including conventional fungicides early in the season followed by hydrated lime were tested, however none were significantly better than a full program of a protectant fungicide (Table 1).

* Hydrated lime did not affect insect pest levels or cause any phytotoxicity to the tree or crop in year one. In year two, similar results were obtained, but superficial fruit skin damage in the form of enlarged lenticels was observed with 10, but not 5 or 6, sprays of hydrated lime (Table 1). This damage is only slight but may be important on fresh market fruit. No effects of hydrated lime on insect pests were observed in year two.
The calcium content of hydrated lime treated fruit was not different from fruit treated with thiram (Table 2). However, fruit firmness after storage, tested using a penetrometer, appears to be greater for hydrated lime treated fruit of both varieties tested.

pH (a measure of acidity) was measured on trees sprayed with hydrated lime. Results indicate that pH on unsprayed leaves is about 7, but rises to about 12 immediately after spraying, declining to about 9.5 at seven days and 7 after 14 days. Levels above pH 9 are likely to be the minimum required for protection against new infection.

Preliminary conclusions

Most ascospore release occurs between green up and petal fall. This confirms the importance of sprays during September and October for effective disease control. Indications are that other sources of overwintering (twigs) are of little importance in the overwintering of the disease and initiation of new infections in spring.

The Environcaster® infection period monitoring has predicted infection periods similar to those from conventional leaf wetness and temperature recorders.

Hydrated lime sprays give significant disease control. Under high disease pressure (high carryover of disease from the previous year, and wet spring weather) control is not as good as with a conventional protectant fungicide.

Hydrated lime sprays do not appear to affect insect pests. Slight skin blemishing occurred after 10 (but not 6 or 8) sprays.

FUTURE WORK 1994/95

1) Continue ascospore trapping work and monitor for twig (conidial) infections
2) Continue infection period monitoring with Environcaster® and other instruments in relation to disease development.
3) Small plot trials
   a) continue hydrated lime work at Tatura
   b) conduct comparison of Environcaster® based sprays vs conventional protectant sprays
4) Grower supervised trials using hydrated lime in commercial equipment (5-6 growers?)

Acknowledgments: This project is funded by CFICA, AAPGA and the HRDC

Table 1. Effect of hydrated lime and other sprays on scab severity and lenticel enlargement at harvest, 1993/94.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Scab severity (fruit)</th>
<th>% lenticel enlargement</th>
<th>Scab severity (fruit)</th>
<th>% lenticel enlargement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. control</td>
<td>2.3</td>
<td>-</td>
<td>2.1</td>
<td>32</td>
</tr>
<tr>
<td>2. Hydrated lime(L)</td>
<td>1.6</td>
<td>20</td>
<td>1.3</td>
<td>49</td>
</tr>
<tr>
<td>3. Thiram (T)</td>
<td>0.8</td>
<td>7</td>
<td>0.6</td>
<td>29</td>
</tr>
<tr>
<td>4. T/Nustar®N/T</td>
<td>0.8</td>
<td>-</td>
<td>0.3</td>
<td>23</td>
</tr>
<tr>
<td>5. T/N</td>
<td>0.9</td>
<td>-</td>
<td>0.6</td>
<td>24</td>
</tr>
<tr>
<td>5. T/N/L</td>
<td>0.9</td>
<td>-</td>
<td>0.5</td>
<td>27</td>
</tr>
<tr>
<td>7. L/N/L</td>
<td>1.2</td>
<td>-</td>
<td>0.8</td>
<td>30</td>
</tr>
</tbody>
</table>

Rated on a scale of 0-7 where 0 = no disease and 7 = 5% or more of fruit scabbed.

continued next page
SOIL ACIDITY SURVEY

Growers who took part in last year's Soil Acidity Survey have just attended the third round of discussion group meetings. The main topic was: Liming soils - How to and what to use. The main points raised included:

- Lime applied to the surface of very acidic soil is generally ineffective, as the lime is not able to naturally incorporate into the soil. Surface applied lime is really only useful when used to maintain correct pH levels, not when used to correct major problems. To fix pH problems at depth, lime must be fully incorporated into the soil.

- The best time to use lime is at re-planting time. Growers must ensure optimal pH levels are obtained before planting, as it is very difficult to change pH levels once the trees are established.

- Not all Limes are equal and growers need to work out which lime will be the most effective, for the best price. Growers should ask suppliers of lime for details of the product, especially the Effective Neutralising Value of the lime, which will give growers a guide to the quality of the lime on offer.

The fourth round of the discussion group meetings will detail suggested fertiliser programs, especially in relation to the type, rates and timing of Nitrogen applications.

The NVTA and ISIA Tatura are currently evaluating the potential to hold a second Soil Acidity Survey program, so that more growers can have the opportunity to learn how fertiliser and irrigation practices influence soil acidity in orchards.

Again, thanks to HRDC and PIVOT for their continuing support of this valuable soil acidity survey project.

BATLOW SEMINAR - Aug 2nd

The program for the annual Batlow Co-op seminar @ the Batlow R.S.L. Club, has been released. Again it promises to be an interesting day. The main speakers on the day include:

- Silverio Sansevini - will talk on two topics
  1) high density plantings, orchard layout, training systems and rootstocks.
  2) research & breeding programs to improve apple, pear, cherry and plum selection for Scab resistance and use of biotechnology for variety identification.

- Hans Kunnen - Chief economist NSW State Bank - will update economic projections.

- Keith Jones - Tas DPI, will discuss Apple thinning

- James Wong - Tas DPI - will discuss Apple Core Rot and Black Spot

- Phil Woodward - AHC - will discuss the markets' need for new varieties

- Mary Jo Fisher - NSW Farmer - will talk on the impact on fruit growing of the new Industrial Relations Legislation.

- Martin Ferguson (to be confirmed) - ACTU - will talk on the importance of the Rural Industry to the National Economy.

The cost of the seminar is still only $30 which is great value. Bookings are essential and can be made by phoning Lucy @ Batlow fruit Co-op office, phone (069) 191 408 or fax (069) 191 286.

Table 2. Effect of hydrated lime or other sprays on the calcium content of fruit at harvest, 1993/94.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>WBC</th>
<th>Packham</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Peel and flesh</td>
<td>Peel</td>
</tr>
<tr>
<td>Thiram</td>
<td>53</td>
<td>40</td>
</tr>
<tr>
<td>Hydrated lime</td>
<td>52</td>
<td>43</td>
</tr>
<tr>
<td>Commercial</td>
<td>65</td>
<td>29</td>
</tr>
</tbody>
</table>
IMPLEMENTATION OF IPM IN THE MURRAY GOULBURN VALLEY
(pome & stone fruits)

Researcher: Vicki Bates

Funding: Dept of Ag, NVFA, VPAGA & HRDC

ACTIVITIES:

1) A survey of fruitgrowers designed to assess the level of use of IPM techniques, as well as attitudes towards these techniques was carried out during 1991/92 and 1993/94.

More growers are monitoring pests
According to the 93/94 survey, growers indicated the following increases in monitoring over the past two years:
26% codling moth, 24% LBAM, 39% OFM and 20% twospotted mite.

2) Training courses and seminars have been devised, conducted and evaluated
60% of Goulburn Valley growers have completed the Farm Chemical Users Course.
7 FCUC were run in the Shepparton East area prior to Christmas, 90 growers participated.

3) A Codling Moth pheromone management study is under way. 3 Shepp East orchards that are using codling moth pheromones in apples & pears are being monitored, so that we can examine not only the control of codling moth but also the effect that the change in management has on other pests in the orchard. So far this season the codling moth pheromone is performing well.

4) Occurrence and levels of chemical residues in pears have been studied for a number of different management situations.

5) A number of reports, posters and videos have been prepared on EPM and growers are encouraged to contact Vicki for further information.
(phone: 058 335 222)

CHANGE IN IPM TECHNIQUES
(MURRAY GOULBURN VALLEY)

EPIDEMIOLOGY & CONTROL OF PEAR SCAB

Researcher: Bill Washington, IHD Knoxfield

Funding: CFICA, AAPGA and HRDC

1. Field Studies 1993/94 season

Two field sites were established, one at ISIA tatura on WBC pears and one at Strathewen on Packham pears.

Spore trapping using Burkard 7 day recording traps, to determine details of primary inoculum (spore) release, started in early spring at both sites.

Field spray trials to evaluate Limil® treatments compared with a standard protective fungicide (Thiram '), or incorporated in schedules with other fungicides, were commenced at green tip.

The acidity (or pH) on leaf surfaces was monitored to establish the decline rates. Preliminary results show that pH on unsprayed leaves is close to 7 but rises to around 12 immediately after spraying with Limil and then declines to around 9.5 at seven days and to 7 after 14 days. (a pH greater than 9 is likely to be the minimum for protection against new infection.

Trees were examined for twig infections during the growing season. Little or no infection was observed, by contrast with last season when high levels of twig infection were found.

' Thiram was chosen as a representative protective fungicide for the following reasons: it is registered for use on pears for pear scab control, it is not a member of the ethylene-bisdithiocarbamate group of fungicides which have been under recent scrutiny and a number of which have been withdrawn from use, it is an easy to use dry-flowable formulation, it is safe on predatory mites.

More detailed results will be available following the harvest and assessment of the trials in February. This will be printed in the Technical Bulletin.
Pear scab, or black spot is caused by the fungus *Venturia pirina*. It attacks leaves, shoots, blossoms and can cause serious crop loss especially in wet seasons when control measures are inadequate. The disease is found world-wide, wherever pears are grown. The fungus is closely related to apple scab, but although many similarities exist, cross-infection from one host to the other cannot occur.

**Symptoms**
The symptoms of pear scab are very similar to those of apple scab. Fruit infections appear as olive-green to black spots (figure 1). Early infections cause large spots that distort the fruit while later infections cause smaller, more superficial spotting. As with apple scab, infections immediately before harvest may produce storage scab—very small black spots that develop on fruit during storage. Leaf infections, which are less common than in apple scab, frequently occur on the underside of leaves (figure 2). Twig infections, by contrast are more common than those on apple, and appear as small oval blisters on the affected shoot.

**Figure 1. Winter Nelis fruit infected with pear scab, showing spotting and fruit distortion**

**Economic importance**
Pear scab is the most serious and widespread fungal disease of pears. Losses from the disease are similar to those caused by apple scab on apples, and control depends mainly on costly spraying programs.

**Disease cycle**
The disease cycle of pear scab is also similar to that described for apple scab. The main difference is that under Victorian conditions shoot infections on pears are more common than on apples. These shoot infections can provide the fungus with another means of overwintering, although overwintering as ascospores in dead leaves under trees is still the most important source of primary inoculum. Shoot infections are common on Winter Nelis and Buerre Bosc, but are less common on Williams' Bon Chretien and Packham's Triumph.

Infection periods (the time that leaves or fruit must remain wet for infection to occur) of pear scab are presumed to be similar to those described for apple scab, although detailed studies have not been carried out to confirm this.
Control measures
Principles of control are very similar to those for apple scab. Control is based on a protectant spray program, supplemented by post-infection and autumn eradicant sprays.

The period from delayed green tip to petal fall is most important in preventing infection. This corresponds with the period of greatest discharge of ascospores. Apply the first spray when one-third of buds reach the stage of delayed green tip. Apply the second spray about five to seven days later, and the third spray about 10 to 14 days after the first. A fourth spray should be applied at petal fall. Growing plant tissues could become exposed during infection periods in showery weather, and a fifth spray may be needed between delayed green tip and petal fall. Alternatively a post-infection spray may be needed.

Cover sprays applied at 10-14 day intervals after petal fall may be necessary if primary infection has occurred, and if wet weather favourable to infection persists. During dry summer weather no further sprays are necessary. However, if an infection period does occur, the use of an appropriate protectant spray before the wet period, or a post-infection spray shortly after it should prevent development of summer scab.

Similarly, infection periods immediately before harvest may make sprays necessary in order to prevent the development of scab in storage.

Note that post-infection sprays must be applied within several days of an infection period. For maximum effect they should be applied as soon as the weather clears after such a period.

When scab has been difficult to control, then apply autumn eradicant sprays after harvest to reduce the carryover of the fungus into the next season.

When planning your scab spray program, it is wise to include at least two fungicides with different modes of action. This minimises the risk of development of tolerance to fungicide. Consult with Agriculture Victoria for the fungicides and spray timing that is most appropriate in your situation.

For effective pest and disease control, correct diagnosis is essential. A commercial diagnostic service is available at the Institute for Horticultural Development. For further information, contact the Diagnostic Service. ph: (03) 210-9222 or fax (03) 800 3521.
Biological Control of Fruit Diseases

A Three-Day Workshop on Research, Regulation and Registration of Biological Control Agents for Use Against Fruit Pathogens

Program and Abstracts

13-15 September, 1994

CSIRO
Cunningham Lab.
St Lucia,
Queensland
Australia

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Australian Centre for International Agricultural Research (ACIAR)
Pear scab control using field sprays of calcium hydroxide


Pear scab, caused by *Venturia pirina*, is the most important field disease of pears in Australia. In most seasons, control is achieved with 5-11 applications of fungicides during the spring and summer. Trials to test calcium hydroxide (Ca(OH)2) sprays for the control of pear scab were carried out over two seasons on pear trees of the cultivar Packham (in southern Victoria) and Williams Bon Chretien (in northern Victoria). Four trials under high disease pressure showed that Ca(OH)2 sprays gave significant disease reduction when compared with disease on untreated trees, but were not as effective as a program of a conventional protectant fungicide. Programs including conventional fungicides early in the season followed by hydrated lime were tested but none were significantly better than a full program of a conventional fungicide. Ca(OH)2 sprays did not affect insect pests (including codling moth, LBA and mealy bug) as measured by fruit damage at harvest. Ten sprays of Ca(OH)2 appeared to increase lenticel spotting, however no damage was observed with fewer sprays. The calcium content of Ca(OH)2 treated fruit was not different from fruit treated with a conventional fungicide. However, fruit firmness after storage appeared to be higher for fruit treated with 10 sprays of Ca(OH)2.

Related work aims to improve pear scab control through a better understanding of the disease cycle (spore trapping) and infection conditions (weather conditions in relation to disease development).

High Ph on leaf and fruit surfaces as a control strategy for apple scab.

J.A.L. Wong, J. O'Loughlan, J.K. Schupp and W. Williams
Department of Primary Industries, St. John's Avenue, New Town, Tasmania, 7008

The concept of modifying the leaf and fruit surface pH to a highly alkaline level was tested to control apple scab (*Venturia inaequalis*). High pH materials tested included hydrated lime (calcium hydroxide), water glass (sodium silicate), washing soda (sodium carbonate) and borax (sodium tetraborate). Where appropriate these materials were used alone or as part of an integrated approach with other substances including synthetic fungicides. High pH modification of leaf and fruit surfaces is aimed at preventing infection by spores by creating a highly alkaline phylloplane barrier. Laboratory studies demonstrated that spore germination and infection hyphae formation are severely inhibited at about pH 9 and 8 respectively. Allowing for variance in spore isolates, total inhibition of infection hyphae formation occurs at a pH of 8.5 to 9. Hydrated lime proved to be the most suitable material. Disease control with hydrated lime alone varied from about 50% control to highly effective control, depending on disease pressure. Hydrated lime with 2 or 3 systemic fungicides incorporated in the spray program provided more reliable results, giving satisfactory to excellent scab control. The degree of effectiveness of scab control correlated with thoroughness of spray coverage.
CALCIUM HYDROXIDE FOR CONTROL OF PEAR SCAB

W.S. Washington
Institute for Horticultural Development, Knoxfield

As part of the Apple and Pear Industry's aim to reduce pesticide usage in pome fruit, a national program to meet the goals of reduced fungicide usage in apple and pear production is currently being developed. A component of this program is the project "Epidemiology and control of pear scab" funded for 1993/94 by the Canned Fruit Industry Council of Australia, the Apple and Pear Industry and the Horticultural Research and Development Corporation.

Aims

The aims of this project are to achieve effective disease control and to minimise the use of conventional fungicides by:

1) disease cycle studies,
2) infection period studies and
3) calcium hydroxide (hydrated lime, Limil™) spray studies.

1) Disease cycle studies aim to give a better understanding of how the disease operates, with a view to improving the timing of control measures. The pear scab fungus, Venturia pirina is related to, but distinct from the apple scab fungus, Venturia inaequalis. However many aspects of the life cycle and biology of the pear scab fungus have been presumed to be the same as those of the apple scab fungus, and in many cases detailed research has not been carried out to test these presumptions. Aspects such as overwintering via twig lesions, which occur more commonly on pear than on apple, may be more significant than previously thought. If this is confirmed, then the existing control practices which are based on the protection of new growth from primary infection from ascospores (which develop in overwintered dead leaves under the trees) may require modification.

2) Similarly, infection period studies aim to test the presumption that the requirements for pear scab infection (hours of leaf wetness and temperature) are the same as those for apple scab infection, as found in the Mills Table, or modifications thereof.

3) Recent work by Dr J.Wong in Tasmania has demonstrated the potential of calcium hydroxide as an alternative to conventional fungicides for the control of apple scab. Therefore, as part of the pear scab project, the efficacy of calcium hydroxide sprays against pear scab will be tested.

Methods and Results

In 1992/93, two field sites were established, one at Tatura in northern Victoria in a block of 45 year-old WBC pear trees, and the other at Strathewen in southern Victoria in a block of five-year-old Packham pears.

Ascospore discharge is being monitored in the orchard over the duration of the project. The use of a Burkhardt 7-day recording spore trap enables the timing of ascospore release from overwintered leaves to be monitored on an hourly basis throughout the growing
season. Observations of the occurrence of twig lesions is also being monitored during this time. (Note that partial funding of the project in 92/93 has restricted some parts of the proposed work.)

At Strathewen, ascospore trapping began at green tip (late September) and discharges of spores were detected from then until first cover (early November). Most ascospores were trapped between green tip and petal fall, and discharges were associated with periods of wetness. Twig infections were found during the growing season on new shoots of unsprayed trees at both sites.

Infection periods are being monitored using both mechanical and electronic recorders. A Neogen Envirocaster, a self contained computerised environmental monitoring station which provides management information on the control of apple scab, has been loaned by Horticultural Monitoring and Control Pty. Ltd. of Bacchus Marsh for the duration of the project. This equipment was installed in August and has operated continually since then. The weather conditions favoured severe infection at both sites, and between green tip in late September and the end of January, a total of 20 or 16 infection periods (according to apple scab criteria) were recorded at Strathewen or Tatura, respectively.

Replicated spray trials were established at both sites, and the following treatments were evaluated:

1. unsprayed control
2. calcium hydroxide 2%
3. " 1%
4. " 2% except two sprays of thiram over flowering
5. " 2% except two sprays of flusilazole over flowering
6. thiram 0.12%
7. flusilazole 0.002%

All trees were sprayed with copper hydroxide at green tip, and subsequently 8 or 6 sprays were applied at Strathewen or Tatura, respectively. Sprays were concentrated over the flowering period and then applied less frequently from November to January. Timing was based on tree growth stages.

At Strathewen on Packham pears the potential for severe scab infection was great, with very wet conditions occurring especially during flowering, susceptible and vigorous young trees and a plentiful source of primary inoculum. The first disease was observed in unsprayed trees at full bloom, when approximately 1% of blossoms were infected. One month after bloom almost 98% of fruitlets in unsprayed trees were infected and many severely affected fruitlets had already fallen, a result of infection periods at finger and white bud stage.

By harvest most treatments had a very high proportion of fruit infected with scab, and only thiram (78%) or flusilazole (93%) were significantly better than the untreated control (100%). However, when scab severity (a measure of the amount of scab on each fruit) was examined fruit from all treatments except the half rate of calcium hydroxide were less severely scabbed than those in the untreated control (figure 1.). Similarly fruit yields from all treatments except the half rate of calcium hydroxide were significantly greater
than the untreated control. Calcium hydroxide and several other treatments resulted in yield increases of between 90-140% when compared with the control. This effect is probably due to the increased crop load resulting from the prevention of blossom and fruitlet drop due to severe scab infections, and due to increased fruit size resulting from the better growth of less severely scabbed fruit in all treatments. Shoot infections were common, ranging from 65% of shoots infected in the flusilazole treated trees to 100% in the untreated control trees. Leaf scab was less common, ranging from 35% in the flusilazole treatment to 32% in the controls. All sprays delayed disease development, but were relatively ineffective by commercial standards under the heavy disease pressure and the relatively light spray program.

At Tatura on WBC pears the first disease was observed at petal fall and two months later (mid December) approximately 90% of fruit in the unsprayed trees was infected. By harvest most treatments had a very high proportion of fruit infected with scab, and only thiram (76%) and calcium hydroxide/flusilazole (94%) were significantly better than the untreated control (100%). However, when scab severity was examined fruit from all treatments were less severely scabbed than those from the control (figure 1.). There was no significant difference between scab severity in fruit from the calcium hydroxide treatment and that from the flusilazole treatment. Leaf infections ranged from 15% in the flusilazole treated trees to 63% in the control. Shoot infections were again common, ranging from 43% infection in the thiram treatment to 92% in the untreated control. All treatments resulted in fruit yields higher than from the untreated controls, although only flusilazole and calcium hydroxide at the high rate were significantly higher, with a yield increase of about 30%.

A third trial was established in a block of Red Delicious apples at Tatura, where the same treatments (with the exception of numbers 5. and 7.) were tested. Trees were sprayed at the same time as those in the WBC pear trial. Disease pressure was much lower than in the WBC trial and by harvest only 39% of fruit in the untreated controls were scabbed. All treatments resulted in significant reductions in fruit scab (both incidence and severity) when compared with the untreated controls. Fruit or leaf scab infections in the calcium hydroxide and thiram treatments were not significantly different.

In all trials, calcium hydroxide sprays resulted in no significant effect on the incidence of the insect pests codling moth, light brown apple moth, mealy bug, pear blister mite and pear and cherry slug when compared with their levels in the untreated controls. There was a trend towards a reduction in codling moth damage at one site, and a trend towards an increase in pear and cherry slug damage at the other pear trial site.

Where calcium hydroxide was sprayed, a white deposit was left on the fruit, leaf and stem surface of the treated trees. This persisted for several weeks, and a reduced deposit was still present on fruit from calcium hydroxide treatments at harvest. However no harmful effects were observed on any part of the tree.

Preliminary conclusions

Indications are that calcium hydroxide sprays have the potential to give control of pear scab approaching that obtained by conventional fungicides. Under the conditions of these trials, where disease pressure was extremely high and the spray schedule tested was more
suited to average conditions of a drier spring and summer, both calcium hydroxide and conventional fungicides were relatively ineffective. Where disease pressure was low (in the apple trial), scab control using either rate of calcium hydroxide was equivalent to that obtained by a conventional protectant fungicide.

Severe epidemics of scab are well known for their potential to cause serious crop losses. The most common loss is due to the downgrading of scabbed fruit. However results from these trials demonstrate the potential for crop loss due to reduced fruit yield, which results from severe infections over the flowering period causing fruitlet drop, and stunted fruit growth of severely infected fruit which remain on the tree.

In conclusion, work in 1992/93 has shown that:

* Calcium hydroxide is active against pear scab.

* Calcium hydroxide can give a level of scab control approaching that from conventional fungicides.

* Calcium hydroxide at 2% is more effective than at 1%.

* Calcium hydroxide showed no effect on the levels of insect pests.

* Calcium hydroxide caused no harmful effects to the fruit or the tree.

Further studies will investigate factors such as the control obtained by reduced spray intervals, and the integration of calcium hydroxide sprays with other fungicides. Ongoing work on pear scab will also continue to clarify aspects of the disease cycle and the conditions favouring pear scab infection.

Acknowledgments

In 1992/93 this project was supported financially by The Canned Fruit Industry Council of Australia and the Horticultural Research and Development Corporation.

The assistance of the following is gratefully acknowledged: Mr B.Gaffney of Horticultural Monitoring and Control Pty. Ltd. in the loan of and installation of the Neogen Envirocaster; David Mitchell Ltd. for the donation of Limil; Messrs L., B. and R.Apted for the provision of a trial site; Ms Vicki Bates, Mr L.Issel and other staff of the Institute for Sustainable Agriculture, Tatura, for help with the maintenance of the trials at Tatura and Mr M. Appleby and Ms E. Whitten for help with the treatment and assessment of the trials.
9TH BIENNIAL CONFERENCE
AUSTRALASIAN
PLANT PATHOLOGY SOCIETY

APPS

WREST POINT CONVENTION CENTRE
4TH - 8TH JULY 1993

CONFERENCE PROGRAM
AND ABSTRACTS
**122. High pH on leaf and fruit surfaces as a control strategy for apple scab.**

J.A.L. Wong, J. O'Loughlin, J.K. Schupp and W. Williams

Department of Primary Industry, St John's Avenue, New Town, Tasmania, 7008

The concept of modifying the leaf and fruit surface pH to a highly alkaline level was tested to control apple scab (Venturia inaequalis). High pH materials tested included hydrated lime (calcium hydroxide), water glass (sodium silicate), washing soda (sodium carbonate) and borax (sodium tetraborate). Where appropriate these materials were used alone or as part of an integrated approach with other substances, including synthetic fungicides. High pH modification of leaf and fruit surfaces is aimed at preventing infection by spores by creating a highly alkaline phylloxera barrier. Laboratory studies demonstrated that spore germination and infection hyphae formation are severely inhibited at about pH 9 and 8 respectively. Allowing for variance in spore isolates, total inhibition of infection hyphae formation occurs at a pH of 8.5 to 9. Hydrated lime proved to be the most suitable material. Disease control with hydrated lime alone varied from about 50% control to highly effective control, depending on disease pressure. Hydrated lime with 2 or 3 systemic fungicides incorporated in the spray program provided more reliable results, giving satisfactory to excellent scab control. The degree of effectiveness of scab control correlated with thoroughness of spray coverage.

Key Words: pH, apple scab, hydrated lime, fungicide reduction.

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**123. Calcium hydroxide for the control of pear scab.**

W.S. Washington and M. Appleby

J.H.D. Knoxfield, Department of Agriculture, Victoria.

Pear scab, caused by Venturia pirina, is the most important field disease of pear in Australia. In 1992 the project "Epidemiology and control of pear scab" began with the aim of improving disease control and minimising the use of conventional fungicides. Recent work by Dr J. Wong in Tasmania has shown that Ca(OH)2 sprays can control the related disease apple scab. Therefore, as part of the above project, tests of these sprays against pear scab were conducted.

A replicated trial at Tatura on cv. WBC tested the following treatments: 1) an untreated control, 2) six sprays of 2% Ca(OH)2, 3) six sprays of 1% Ca(OH)2, 4) four sprays of 2% Ca(OH)2 and two of thiram, 5) four sprays of 2% Ca(OH)2 and two of flusilazole, 6) six sprays of thiram, and 7) six sprays of flusilazole. High volume sprays were applied on a protectant schedule. Weather conditions favoured disease, and 16 infection periods were recorded.

The disease was first observed at petal fall and by mid-December 90% of fruit in untreated trees were infected. By harvest the incidence of disease in the thiram and the Ca(OH)2/flusilazole treated fruit was significantly less than that in the untreated fruit; all other treatments including flusilazole and Ca(OH)2 were not different from the control. However, when disease severity on fruit was examined, all treatments were significantly better than the untreated control. Thiram alone, and Ca(OH)2, flusilazole gave best control; there was no difference between Ca(OH)2 at either rate and flusilazole alone. In another trial on cv. Packham at Strathewen, results were similar, although flusilazole alone tended to give better control than at Tatura.

Key Words: Fungicide reduction, disease control, pear scab.

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**124. Transposon Mutagenesis of a Race Specific Plant Resistance Gene.**

E.A.B. Aitken, J.A.Callow and H.J. Newbury

Homologous transposons in both Antirrhinum majus and maize have been utilised by other workers to isolate and clone pigment and homeotic genes by insertional mutagenesis. This work describes the use of the transposons in A. majus to isolate a plant resistance gene. A. majus plants resistant to Puccinia antirrhini race a (Aitken et al. 1989) were crossed with a line of A. majus which showed a high frequency of resistance to the disease. Plants which were homozygous for resistance and which showed a high frequency of transposition were selected from the F2 (RRHTrans). These RRHTrans plants were held at 15°C to promote the movement of the transposons (particularly Tam3) and therefore increase the chance of a transposon inserting into the targeted R gene. They were crossed with homozygous recessive (rr) individuals and the progeny was screened with race a. From 11,167 F1s, six candidates showed a novel susceptible phenotype where powdery white mould was formed all over the leaves but were smaller than in the rr plants and were associated with an intense halo of chlorosis not previously seen. No susceptibles were found in the control crosses which were between non-high transposing lines. The candidates showed some genetic and somatic reversion to full resistance, evidence for transposon mutagenesis. The mutation associated with this novel phenotype mapped closely to the pigment gene Eosina which had previously been shown to be closely linked to the R gene. Southern analysis of the DNA from these plants using the known transposons as probes reveals many hybridising bands because of the multiple copies of the transposons in the Antirrhinum genome. However, a band has been identified which is only associated with the DNA of plants which carry the mutation and not with those of their progeny which have reverted to full resistance (i.e. where the transposon has excised from the target R gene).

Key Words: resistance genes, molecular rust, mutagenesis.
10th Biennial Australasian Plant Pathology Society Conference

Scientific Programme and Abstracts

Lincoln University
(near Christchurch)
NEW ZEALAND

28 - 30 August 1995
(Workshops 23 - 26 Aug & 31 Aug - 2 Sept)
280. Epidemiology and control of pear scab
Washington, W.S., and Villalta, O.N.
IHD, Knoxfield, Agriculture Victoria, PB 15, SEMC, Victoria 3176, Australia

Pear scab, caused by the fungus *Venturia pirina* AdEh., is a major disease of pears worldwide. In the Goulburn Valley, where over 80% of Australia's pears are produced, losses to scab can be as high as 10% of the total crop. This study aimed to improve disease control through a better understanding of the disease cycle, to compare different systems for predicting scab infection and to test hydrated lime as an alternative to conventional sprays.

Ascospores from overwintered infected leaves, rather than conidia from overwintered twig infections, were the most important source of primary inoculum. Spore trapping with a Burkard trap showed that ascospore release occurred mainly between green tip and petal fall stages. Most ascospores were trapped during daylight hours (90-99% of all spores trapped). Of those spores released in darkness most were trapped within a few hours of sunrise or sunset. Infection periods predicted by electronic (a Neogen Envirocaster®) or conventional weather recording equipment were similar. Hydrated lime sprays gave significant but weak protection against scab when applied to trees during the growing season. They were sometimes associated with slight phytotoxicity.

These results emphasise the importance of control measures during September and October, and indicate that infection periods which begin at night may be important especially in orchards with high carryover of ascospore inoculum.

281. Fire reduces levels of *Cryptodiaporthe melanocraspeda* inoculum in *Banksia coccinea* stands
Bathgate, J.A., and Shearer, B.L.
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2 Department of Conservation and Land Management, Como, WA 6152, Australia

*Cryptodiaporthe melanocraspeda* causes a serious canker disease of *Banksia coccinea*. The fungus sporulates on cankered sticks and branches. Studies were conducted to determine whether (i) burning reduces levels of infectious plant material, thereby reducing the inoculum level at seedling germination and (ii) unburnt *B. coccinea* which escaped the most recent fire act as infection foci in regenerating stands. Inoculum survival in cankers above the charred zone was assessed 10 months after a low-intensity fire. Ascospore viability was only 2.8%, compared with 26% in similar unburnt vegetation, indicating a large reduction in inoculum had occurred after burning. Canker incidence was assessed at distance intervals from 15-23 year old remnants in 6-10 year old *B. coccinea* regrowth in four stands. Cankers incidence was greatest (13-55%) 0-25m from the remnants and declined to 0-6.5% at >100 m, indicating a focal pattern of disease development about the unburnt remnants. Inoculum which survives on living vegetation which escapes burning is therefore likely to be a more important source of inoculum for the reinfection of stands than unburnt parts of plants which are killed by fire. In terms of inoculum control, fire regimes which create large patches of burnt vegetation are preferable to those which create mosaics of small patches of burnt and unburnt vegetation.

282. Use of molecular biology techniques to identify wood-rotting fungi
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1 Dept of Applied Biology & Biotechnology RMIT Melbourne, Victoria 3000, Australia
2 CSIRO, Division of Forest Products, Clayton, Victoria 3168, Australia

The identification of wood-rotting fungi is important as these cause destruction of trees and timber. The current identification methods are based on morphological features of hyphae and fruiting bodies. However, these methods are limited because fruiting bodies appear late in the life cycle and are extremely difficult to form in vitro. The polymerase chain reaction using arbitrary primers (RAPD-PCR) can be used to differentiate wood-rotting fungi from hyphae in cultures and potentially from wood in situ. Forty-six isolates of four important genera (*Phellinus, Coltricia, Inonotus* and *Stereum*) were studied. The consistency and reproducibility of the banding patterns authenticated the use of the technique. Each isolate produced a specific banding profile with each primer. Different isolates of the same morphological species did not show 100% similarity, but intraspecific similarity was generally greater than interspecific similarity, meaning that isolates of the same species tended to group together. Within genera, groupings of species on the basis of banding patterns did not correspond with groupings on the basis of morphological features. Future work involves obtaining diagnostic profiles of all known species to compare with the profiles of unknown fungal pathogens from the field obtained using the same primers. This technique offers potential for rapid identification of many wood-rotting fungi not only from trees and timber,
Evaluation of the Neogen Envirocaster™ for prediction of pear scab infection periods at Tatura, in Northern Victoria, Australia.

Report to Mr B. Gaffney, Director, Horticultural Monitoring and Control Pty. Ltd., PO Box 532, Bacchus Marsh, Victoria 3340, Australia

W.S. Washington and O.N. Villalta
Institute for Horticultural Development, Knoxfield
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South Eastern Mail Centre
Victoria 3176
Australia

July 1995
Summary

Pear scab, caused by the fungus *Venturia pirina* Aderh., is the most important field disease of pears in Australia. The disease can be controlled by protective or post-infection fungicide sprays, or a combination of the two. Both post-infection and, to a lesser extent, protective schedules depend on monitoring temperature and duration of wet periods, using either mechanical recorders or electronic weather recording equipment.

The Neogen Envirocaster® is an electronic weather recorder which can be fitted with various models to predict disease or pest outbreaks. As evaluated, the Envirocaster® was equipped to record potential apple and pear scab infections and recommend spray timing. In an evaluation over three seasons, between 1992-1995, the Envirocaster® operated reliably and predicted 76% (or 86% if the rain requirement for infection was ignored) of infection periods predicted by mechanical recorders using the Mills table.

In the first season, the Envirocaster® only operated the apple scab model, and predicted 16 infection periods. No comparison was made with conventional mechanical recorders in this season. In the following two seasons it operated a pear scab model in addition to the apple scab model. The Envirocaster® predicted 10 (or 11 if the rain requirement was ignored) out of the 13, and 6 (or 7 if the rain requirement was ignored) out of the 8 infection periods predicted by mechanical recorders in the second and third seasons respectively.

Provided that all sensors are operating correctly, and in particular the rain gauge (as the pear scab model has an optional requirement for rain to be recorded before an infection period will be recognised) the Envirocaster® appears to operate reliably and accurately predict scab infection periods in the field. Further validation of the model should be carried out by a spray trial to test the validity of the spray advisories.
Introduction

Pear scab, caused by the fungus *Venturia pirina* Aderh., is the most important field disease of pears in Australia. Significant losses can occur in both Williams Bon Chretian (Bartlett) and Packham's Triumph pears, the two varieties which make up the majority of pear production in Australia.

The disease can be controlled by protective fungicide applications timed according to tree development stages and weather conditions. Post-infection spray schedules are an alternative to, or a supplement for, protective schedules. Such schedules depend on monitoring temperature and duration of wet periods, using either mechanical recorders or electronic weather recording equipment which have been developed to automatically record potential infection periods.

This report presents the results of an evaluation of the Neogen Envirocaster®, a self contained, computer driven environmental monitoring instrument. As evaluated, the Envirocaster® was equipped to record potential apple or pear scab infection periods and to recommend spray timing. The equipment was loaned by Mr Brian Gaffney of Horticultural Monitoring and Control Pty. Ltd., Bacchus Marsh, to Agriculture Victoria. It was installed in a pear block at the Institute for Sustainable and Irrigated Agriculture at Tatura, in Northern Victoria from August 1992 to July 1995. This evaluation was carried out as part of a three year project funded by the Horticultural Research and Development Corporation to study the epidemiology and control of pear scab, caused by *Venturia pirina*. The project was led by Mr W.S. Washington of the Institute for Horticultural Development, Knoxfield, part of Agriculture Victoria.

Methods

The Envirocaster® was installed between trees within a row of 45 year old Williams Bon Chretian pears, in a block of trees in the Institute for Sustainable and Irrigated Agriculture at Tatura. As originally installed in August 1992, the Envirocaster® contained the Neogen apple scab prediction model. From the beginning of the second season, in August 1993, a pear scab model was installed and operated in addition to the apple scab model. Sensors included air temperature, relative humidity, leaf wetness and a tipping bucket rain gauge. A De Witt leaf wetness recorder and a seven day recording thermohygrometer were operated in close proximity to the Envirocaster® at the same site.

The equipment was checked weekly and historical advisory, historical data and daily weather summaries were downloaded using a laptop computer. At least every two weeks, the hourly weather summaries were also downloaded.
In the third season (1994/95) a replicated spray trial was carried out in the same block of pear trees. One aim of this trial was to attempt to validate the recommended spray dates from the Envirocaster®. One treatment in this trial was the use of post-infection sprays at times as recommended by the Envirocaster®. Crop disease levels from this treatment were compared with those from another treatment, which consisted of a protectant spray program, with sprays applied according to tree growth stage and weather conditions. The trial sprays were applied until late December, after which all trees in all treatments were sprayed as required.

Results

1992/93

The Envirocaster® operated satisfactorily throughout the first season (1992/93) recording 16 infection periods from September to January (figure 1). These comprised eight low, three medium and five high levels of infection (based on the apple scab model). During this season the mechanical leaf wetness recorder failed to operate satisfactorily. As a result no comparisons could be made.

1993/94

In year two (1993/94) the Envirocaster® recorded 10 infection periods (table 1, see footnote). The mechanical recorders predicted three more infection periods, based on the Mills table for apple scab infection. (Note that the model has an optional requirement for rain to initiate an infection period, which we chose to leave switched on for both 1993/94 and 1994/95. Because of this requirement and the fact that the rain gauge was unexpectedly inoperative for the first month of the season, we calculated the infection predictions for this period from the hourly weather summaries. The cause of this problem was unknown, but was possibly due to an error in installation of the gauge at the beginning of the season).

Of the three infection periods recorded by the mechanical recorder but not by the Envirocaster®, two of these were marginal infection periods, close to the point where the leaf wetness and temperature period is insufficient to register as an infection period. Slight differences in leaf wetness and/or temperature recorded by the different sensors during this period could account for the different predictions.

The third infection period recorded by mechanical recorders but which was not predicted by the Envirocaster® could be explained by the requirement of the model for rain to initiate an infection period. For the infection period in question, no rain was recorded and therefore no infection was predicted. If rain had been recorded or if the rain requirement had been switched off, then the wetness and temperature recorded in the hourly weather summaries would have been sufficient, according to Mills criteria for apple scab, for an infection period. In addition, the apple scab model did predict an infection for this period (in the historical advisory summaries), as did the mechanical recorders (based on Mills criteria). Surprisingly, the pear scab model did not record the hours of leaf wetness which occurred for that period in the historical data summary.
An infection period recorded by the Envirocaster\textsuperscript{R} on the 27/12/93 was not included in the comparison as the mechanical recorder malfunctioned during that period.

1994/95

In year three (1994/95) the Envirocaster\textsuperscript{R} predicted six infection periods, while the mechanical recorders predicted two more (table 2). One of these two periods predicted by the mechanical recorders was again a marginal infection period and the different prediction could reflect the slight differences in the leaf wetness and/or temperature recorded by the different sensors during this period (as for 1993/94). The second of these periods, which occurred late in the season, was associated with an apparent blockage of the tipping bucket rain gauge with mud, in the middle of a split wetness period. This failure to record an infection period could be explained by the model's requirement for rain to initiate an infection period (as in 1993/94). However, the apple scab model did not record any infection period and only recorded the first part of the split wetness period in the historical advisory or the historical data summaries, unlike in 1993/94. Data from the daily and hourly weather summaries indicated that this period would have been an infection period based on Mills criteria.

The results from the spray trial in year three were inconclusive as disease levels were very low (less than 1% in the control trees). A single post-infection spray was applied at late calyx to the trees treated according to the Envirocaster\textsuperscript{R} recommendations, between two predicted infections (table 2). An early infection period at around green tip was ignored as all trees in the spray trial were sprayed at bud movement, and this spray was presumed to provide adequate protection to account for the predicted infection. Disease levels at harvest in trees treated according to the Envirocaster\textsuperscript{R} were no different than levels from trees in the unsprayed control.

A generally good correlation existed between the infection indexes (the product of temperature and hours of wetness) calculated from mechanical recorders and from the Envirocaster\textsuperscript{R} hourly weather summaries (figures 2 and 3).

Discussion

In summary, the Envirocaster\textsuperscript{R} operated reliably for the three seasons of the evaluation. In season one it predicted 16 infection periods (operating the apple scab model). In season two it predicted 10 infection periods (11 if the rain requirement was ignored) operating the pear scab model. In the third season six infection periods were predicted (seven if the rain requirement was ignored), again operating the pear scab model.

Over two seasons, the Envirocaster\textsuperscript{R} pear scab model predicted 16 (76%) (or 18 (86%) if the rain requirement had been ignored) out of the 21 infection periods predicted using the Mills table and mechanical recorders.

Particular care is needed with the rain gauge, as the Envirocaster\textsuperscript{R} model for scab has an optional requirement for rain to occur before it predicts an infection period (unless this requirement is switched off). We experienced such a problem at a crucial time in the second season, when the rain gauge was inoperative for the first month of the season. The cause of this was unknown, but was possibly due to incorrect installation.
of the rain gauge at the beginning of the season. As a result no predictions were made despite the occurrence of significant wet periods, and rain showers. (Note that infection periods predicted for this time period were calculated subsequently from the hourly weather data and included in the predictions listed in the results for 1993/94). The second time the Envirocaster\textsuperscript{R} failed to record an infection period when the rain requirement was met was late in the third season. The problem occurred with an apparent blockage of the rain gauge with mud, in the middle of a split wetness period. This may have resulted from mud being slung from tractor tyres and lodging in the gauge. It is recommended that for the period that the rain requirement is switched on, the gauge is checked daily.

Acknowledgments

This work was supported by Mr B. Gaffney of Horticultural Monitoring and Control Pty Ltd, Bacchus Marsh, through the loan of the Neogen Envirocaster\textsuperscript{R} for the duration of this work, and provision of ready back-up support and advice. The study was part of a larger project “The epidemiology and control of pear scab” funded by the Horticultural Research and Development Corporation, the Australian Apple and Pear Growers Association and the Canned Fruit Industry Council of Australia. The assistance of staff of the Institute of Sustainable and Irrigated Agriculture, Tatura, in particular Ms V.Bates, Dr T.Lim and Ms J.Vigliaturo, is also acknowledged.
Fig. 1. Infection periods predicted by the Neogen Enviroscent at Falta, 1992/93.
Table 1. Pear scab infection periods recorded by mechanical recorder and the Neogen Envirocaster® at Tatura, 1993/94.

<table>
<thead>
<tr>
<th>Date</th>
<th>Infection index Mechanical (°C x hrs wetness)</th>
<th>Infection period Mechanical (Mills table)*</th>
<th>Critical period</th>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>08.09</td>
<td>240</td>
<td>yes*</td>
<td>Petal fall</td>
</tr>
<tr>
<td>13.09</td>
<td>315</td>
<td>yes*</td>
<td>Shoot growth</td>
</tr>
<tr>
<td>18.09</td>
<td>208</td>
<td>yes*</td>
<td>Shoot growth</td>
</tr>
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<td>Shoot growth</td>
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<tr>
<td>16.01</td>
<td>262</td>
<td>yes</td>
<td>Petal fall</td>
</tr>
</tbody>
</table>

A Leaf wetness data from nearby site
B Rain gauge not working, hourly data used
C No rain recorded, no infection period recorded (rain requirement on), hourly data used
* Mills table used to calculate infection period, Mills and Laplante (1954)

Table 2. Pear scab infection periods recorded by mechanical recorder and the Neogen Envirocaster® at Tatura, 1994/95.

<table>
<thead>
<tr>
<th>Date</th>
<th>Infection index Mechanical (°C x hrs wetness)</th>
<th>Infection period Mechanical (Mills)*</th>
<th>Critical period</th>
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<tr>
<td>04.09</td>
<td>238</td>
<td>yes</td>
<td>Finger opening</td>
</tr>
<tr>
<td>29.09</td>
<td>144</td>
<td>yes</td>
<td>Finger opening</td>
</tr>
<tr>
<td>26.10</td>
<td>187</td>
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<td>Finger opening</td>
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<tr>
<td>01.11</td>
<td>189</td>
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<td>Finger opening</td>
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<tr>
<td>05.01</td>
<td>430</td>
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<td>17.01</td>
<td>230</td>
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<tr>
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<td>378</td>
<td>yes</td>
<td>Finger opening</td>
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</table>

A Rain gauge blocked but infection period would have been recorded, hourly data used
* Mills table used to calculate infection period, Mills and Laplante (1954)
Infection index (Deg C x Hrs)

Fig 2. Comparison of Infection indexes recorded by mechanical recorder and the Neogen Envirocaster at Tatura, 1993/94.

- Mechanical Envirocaster
Fig 3. Comparison of infection indexes recorded by mechanical recorder and the Neogen Envirocaster at Tatura, 1994/95