VG203

Early identification of onion diseases - the key to their strategic management

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HAL

Know-how for Horticulture™

VG203

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1. SUMMARY

(a) INDUSTRY SUMMARY

Information Videos
Two videotapes entitled 'Onion Quality and Hygiene Standards' and 'Onion Diseases - What they look like and hints on their management' were released to industry in 1993 and 1994 respectively. They describe the Tasmanian Onion Industry Standards for quality and hygiene and provide a handy reference for the identification of common onion diseases. Both were designed to be easily understood and are recommended as an education and discussion tool.

Forecasting for Downy Mildew
This section of the project successfully led to a better understanding by the onion industry of downy mildew disease under Tasmanian conditions, including the important role of paddock selection and crop management on disease development.

The Canadian DOWNCAST system of forecasting outbreaks of onion mildew was applied to weather data collected by remote sensing equipment placed in two onion crops or in the same crop, within the canopy and outside it. Conditions which favoured spore formation were relatively frequent through the monitoring period of October to February in both seasons. Infection periods were not but occurred often enough, (at two to three week intervals), to cause major disease outbreaks had fungicides not been applied.

It was recommended that fungicides be applied to crops on the day before irrigation was to start because high humidity in the crop canopy for 24 hours after watering proved the greatest infection risk period in the absence of wet weather. Although the fungicide cover was eroded by the irrigation, it was important that leaves received maximum protection at that time. It was also clear, as a result of logging weather data, that cloudy or misty mornings which persisted until 10.00 am promoted infection. Rainfall from 3.00 am to 7.00 am prevented spore production in spite of high humidities as a result of damage to emerging spores. High day time temperatures (+24° C daily maximum) prevented disease developing even after sporulation.

In the first year of the project it became clear that unless good coverage of leaf surfaces with fungicides was achieved disease was not controlled adequately. As a result an industry standard for application of fungicides was developed. Recommendations addressed nozzle size and shape, boom height, droplet size, application rate and the use of wetting agents. The use of wetters did not compensate for poor leaf coverage with spray droplets.

Information from the weather loggers was broadcast to growers on a daily basis by way of the local Devonport commercial radio station. Feedback from industry suggested that the sponsored broadcast reminded growers of the need to be vigilant and monitor crops for disease. It was also a novel way of involving families and the community in disease awareness. Crop advisors reported better and more timely application of fungicides for mildew control as a result of the broadcasts.

Disease Photo Pocketbook
This part of the project is yet to be completed as a result of staff changes. Text of the booklet has been prepared but publication is awaiting collection of suitable photographs to accompany text. The proposed booklet is still an essential resource to onion growers and their advisers and will be completed as soon as possible.

(b) TECHNICAL SUMMARY

Information Videos

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(c) PUBLICATION SCHEDULE

Material linked with the project has been released to:

Onions Australia
Local papers
Crops Branch, Annual Report, DPIF
Vegielink and District Newsletters, DPIF
ABC and local radio

Videos have been distributed to industry for use as extension and education tools for growers and their own staff. Both have also been used to train staff from a local onion export enterprise in disease identification, as part of Certification Assurance requirements through the Australian Quarantine and Inspection Service (AQIS) Quality Assurance initiative.

Further formal publication of results and the project is not anticipated because of staff movements from the district.

2. RECOMMENDATIONS

(a) Extension/adoption by industry

Acceptance of videos as an extension tool in Tasmanian rural industries will need to be evaluated in the near future to assess their value. Little feedback has been gained to date on the onion videos, although they have been a useful resource during Quality Assurance Certification training courses.

The downy mildew forecasting project has been widely accepted by the Tasmanian onion industry. To maintain results achieved to date, ie. no severe outbreaks of downy mildew for three seasons, the operation of the weather stations in onions should continue. This has been discussed by industry and a request has been made of the Department of Primary Industry and Fisheries, Tasmania, to continue operating the system at the former level.

To extend the benefits already achieved by the project it is appropriate to broaden the forecasting beyond downy mildew in onions. Opportunities exist for development of community based forecasters for potato blights and apple black spot. The achievements of the current two year project, if applied to the larger potato and apple industries could impact positively on cost effective production. Increased awareness by growers of conditions favouring disease, timely pesticide applications and effective spray application methods could result in gains of better yields and product quality, while also demonstrating a commitment to strategic use of pesticides in food production. Forecasting lends itself to any crop/pest combination that can be managed strategically with cultural or chemical control options.

(b) Directions for future research

To become a reliable and accurate (yet affordable) forecasting system, the onion mildew forecaster would require substantial research input over a number of years, correlating weather and crop data with DOWNCAST and disease outbreaks. Systems are available commercially which provide a comprehensive forecast with spray recommendations. However, these are very expensive and given the topography in Tasmania would be needed in almost every onion paddock to be fully effective.

Throughout the project, cooperation has been sought and received from the Mr Rob O'Brien (QDPI) in Queensland who has been undertaking parallel studies. Similarly, interest in the project has been registered from Government and private organisations in New South Wales, South Australia and Victoria.

Increased benefits to rural Australia from disease and pest forecasting with remote sensing technology could be achieved by coordinating the research and development activities in this area which are being supported by HRDC and other funding bodies. Linking technology, data bases and experiences by way of conferences, discussion groups or coordination of projects would be of value to researchers and avoid duplication. Similar activities on different commodities which would fall under the umbrella of the Horticulture include remote sensing and disease forecasting for downy and powdery mildews in grapes (AUSVIT), rust in plums (Q), downy mildew in onions (TAS), target spot and blight in potatoes (TAS, SA), black spot in apples (general).

(c) Financial/commercial benefits

Financial benefits from the project are difficult to determine. In many cases it has cost onion growers more to produce clean crops because of the rigorous protectant fungicide schedules they have maintained. However from weather data collected and identification of infection periods, it is likely that mildew would have occurred in some districts during the last three seasons, resulting in crop losses for some growers and quality problems for the export industry.

It is likely that there have been flow-on benefits to other broad acre vegetable commodities from increased grower awareness of the need for better crop coverage with sprays. True benefits could be captured with an extension campaign linking this project with others currently supported by HRDC including the management of potato blights.

3. TECHNICAL REPORT

(a) Information Videos

Introduction

Two videotapes entitled 'Onion Quality and Hygiene Standards' and 'Onion Diseases - What they look like and hints on their management' were proposed as extension tools to support the industry standards and a ready reference for early identification of common onion diseases respectively. They were designed to be easily understood and to provide an alternative extension resource for industry and government trainers. The disease identification tape could be kept on farm as a reference to the diseases covered.

Materials and Methods

Scripts for the two videos were prepared in advance of obtaining footage of relevant activities. Filming, script editing and tape production was undertaken on behalf of the Southern Cross Television Network in Devonport by Messrs. Derryn McArthur (cameraman) and Matthew Sullivan (journalist). Filming occurred over an 18 month period prior to final compilation of the two tapes.

The first video was based on the Onion Hygiene and Quality Standards formulated by the Tasmanian Onion Panel in consultation with the industry. The second tape was based on the common, damaging diseases found in Tasmanian onion crops.

Results

The video tapes were completed and released to industry and HRDC in January 1994.

Discussion

Using videos as a basis for discussion or education with individuals or with groups is relatively new to Tasmanian agriculture although it has been used in Queensland. Making a video is a long process in onions because of the extended growing period of the crop. It is essential that a script or script outline is prepared before filming to ensure that all appropriate footage is collected for final compilation. The use of a professional cameraman and journalist meant this part of the project was completed with few problems.

Costs associated with video production can be high. In this project we were fortunate to produce the master videos and 25 copies of each for about $5,000. It remains to be seen whether the benefits of videos outweigh their production costs.

(b) Forecasting for Downy Mildew

Introduction

A survey of onion crop advisors in 1989/90, following the severe outbreak of downy mildew disease, identified time and method of application, misuse of protectant and eradicant fungicides and deficiencies in application as the major contributing causes of poor disease control. It also identified the need for more education of growers in disease epidemiology and control given that downy mildew is likely to occur in Tasmania every year if not checked. Survey results were incorporated into a discussion paper on the disease in Tasmania. This paper is appended as a suitable introduction to the current project (Appendix 1).

A pilot project in 1990/91 investigated a mildew forecasting system for onions called DOWNCAST, after which application was made to HRDC for funds to purchase two remote weather stations to develop DOWNCAST in Tasmania. It was thought that a forecaster could help growers improve disease control by linking spray applications with conditions favouring the pathogen, and could also help them become more familiar with the disease and how to avoid or better manage outbreaks. The project was managed in close consultation with the onion industry with annual reviews of the outcomes of the project by a management committee.

Materials and Methods

Weather data loggers were set up in onion paddocks in early spring when crops were at the three to four leaf stage. In the first year sites were at Moriarty, about 20 km East of Devonport and at the Forthside Vegetable Research Station, 15 km Southwest of Devonport. In the second year data was collected at Moriarty only. In the both years, the station used in the crop at Moriarty collected data within and outside the crop canopy. Whenever possible, data was downloaded on a daily basis using a modem and computer at the Stoney Rise Centre of the DPIF at Devonport. When not available, data was unloaded manually via lap top computer in the paddock.

Daily assessments of mildew status were made from the downloaded data and the appropriate mildew message was broadcast on the local Devonport commercial radio station the same day after the 11.00 am news bulletin. A set of instructions on how to use the radio mildew warnings was distributed to growers by onion companies at the beginning of the forecasting experiment. The information for growers and the text of one season's radio messages is appended (Appendix 2). DOWNCAST parameters for sporulation and infection were relative humidity at or more than 95% between 2.00 am and 6.00 am EST (one hour later for daylight saving time), with little or no rain in that period for spore production. Infection occurred in the three hours after 6.00 am if humidity continued to be above 94%. Highest activity occurred at temperatures between 10° and 13° C. Solar radiation limited spore survival as did daily maximum temperatures of more than 24°C.

Notification of positive infection periods was faxed to onion companies and agribusiness for information of crop advisors, and through them to growers. Using the Microsoft® Excel spreadsheet program, graphs were prepared to compare data collected from within and without the canopy and results analysed.

Results

It became clear by correlating DOWNCAST parameters with weather data that conditions favouring mildew were closely related to microclimate both in the paddock and within the canopy. Because infection can occur over such a short space of time, local factors such as wind direction and frequency, sunshine, rainfall and crop management factors such as plant density, irrigation and spray application can have a major impact on disease development within individual paddocks and cropping districts.

Conditions favourable for sporulation were relatively frequent through the monitoring period of October to February in both seasons. A summary of sporulation warnings and infection periods in the two years of the project is presented in Table 1. Infection periods were not common but occurred often enough, (at two to three week intervals), to cause a disease outbreak had fungicides not been applied. In the first year of the project it became clear that unless good coverage of leaf surfaces with fungicides was achieved, disease was not adequately controlled. At the Moriarty site in year 1, disease became established in the crop in sheltered headlands which enabled some testing of DOWNCAST against visible infection. The crop was densely sown (over 100 onions per square metre) and had a westerly aspect which favoured disease. In spite of a regular protectant program and strategic use of an eradicant fungicide disease was not eradicated. This was attributed to difficulties in achieving total leaf coverage within the dense crop canopy. An industry standard for application of fungicides was developed following trials with fluorescent dyes by the onion industry to address these difficulties. Recommendations for better coverage included nozzle size and shape, boom height, droplet size, application rate and the use of wetting agents. The use of wetters did not compensate for poor leaf coverage by droplets. A copy of the standard is appended. (Appendix 3).

It also became clear from constant monitoring that irrigating crops during summer had a bigger impact on disease potential than the weather (low summer rainfall). Recently irrigated crops had higher humidity levels within the canopy for the 24 hours after watering than dry crops, regardless of the weather. It was recommended that fungicides be applied to crops in the day before irrigation was to start. In this way the greatest infection risk period was managed even though fungicide cover was eroded by the irrigation. It was evident through logging that cloudy or misty morning conditions which persisted until 10.00 am would promote infection. Rainfall from 3.00 am to 7.00 am prevented spore production in spite of high humidities. High day time temperatures (24° C plus daily maximum) prevented disease developing even after sporulation.

- Additional recommendations based on the first year of the forecasting included:

- Limiting the use of eradicant fungicides to four per season when disease pressure was highest but visible disease was not.

- Increasing reliance on regular protectant fungicide application given the potential for the disease to occur and develop rapidly.

- Infection occurred over a short period, but a latent period of 14 days between infection and sporulation was consistent in crops monitored.

- Disease was more likely to develop in sheltered areas of a crop, behind trees and hedges and in headlands planted at 90° to prevailing winds (ie. wind blew across the row rather than along it).

- Crops needed to be checked regularly on foot for first signs of disease, particularly after infection warnings.

Table 1. Summary of numbers of days sporulation and infection days recorded by the downy mildew forecaster, 1992/94

Month	Conditions for sporulation (No. days per month)		True infection periods (Date infection recorded)	
1992/93	**Forthside**	**Moriarty**	**Forthside**	**Moriarty**
October	12	15	16	30
November	13	18	Nil	15 & 16
December	6	9	19	11
January	4	n/r	Nil	Nil
TOTAL	35	42	2	4
1993/94	**Moriarty**		**Moriarty**	
October	5		15	
November	5		Nil	
December	11		26	
January	6		7, 20, 29	
February (to 8/2/94)	2		1	
TOTAL	28		6	

Data collected from within and without the canopy provided an insight into the effect that the crop had on ambient conditions, and subsequently on conditions affecting the pathogen. Findings are summarised in Table 2. Temperatures were generally cooler than ambient in the canopy and relative humidity was higher within the crop for up to 2 hours longer in the morning. Light intensity reached a maximum of half that outside the crop after canopy closure but ,there were no real differences in surface moisture measures. The differences recorded indicate that modification of the environment inside the canopy causes the crop to remain susceptible to mildew infection for longer than ambient weather readings would suggest. Data from the month of December 1992 have been graphed to demonstrate differences between ambient and crop canopy readings. (Appendix 4)

Table 2. Differences in weather data recorded inside the onion crop canopy and outside the crop (ambient), October to December.

	Recordings within the canopy compared with ambient				
	Temperature °C		Relative	Leaf	Solar
Month	**Maximum**	**Minimum**	**Humidity %**	**Wetness**	**Radiation**
October	- 1 - 2	- 5 - 7	Same	Same	Lower
November	-1 - 2	- 3 - 5	+ 1 - 2 hr night and morning	Same	Lower
December	+1 - 2	- 4 - 5	+ 1 - 2 hr night and morning	Same	Lower Half ambient maximum

Information from the weather loggers was broadcast to growers on a daily basis by way of the local Devonport radio station. Feedback suggested that the sponsored broadcast reminded growers of the need to be vigilant and monitor crops for disease. It was also a novel way of involving families and the community in disease awareness. Crop advisors reported better and more timely application of fungicides for mildew control as a result of the broadcasts. A summary of industry comments on the program from the pilot project through the two years of this project is appended. (Appendix 5) In the final year of the project, the Northwest regional daily newspaper (The Advocate) also published some reports on the status of the disease. Articles generally went to press immediately after an infection period was detected. Several of these articles are also appended. (Appendix 6)

A number of articles were prepared for the press and general presentation during the project. Where available these are appended. (Appendix 7)

Discussion

The initial impact of this project following closely on some significant crop losses was large. It was also of interest to many growers and industry because of its novelty. As a result of the positive attitude to the project and the perceived need that something had to be done, a steady change in practices and attitudes to disease control in onions has occurred in the last three years. Realistically, whether these changes continue will depend a lot on weather patterns in the near future and the pressure on crops from mildew. An attempt to evaluate the project by way of a postage paid card (Appendix 8) to all onion growers was not successful with only three cards returned. Feedback from respondents suggested that they were all aware of the forecaster but were unsure how it could benefit them. In future programs, evaluation procedures should to be addressed in extension planning and adoption strategies.

The mildew forecasting project generally lead to a better understanding of onion downy mildew by growers and crop consultants including the important role of paddock selection and crop management on disease development. Improved chemical management of downy mildew in onions was also achieved as a result of the project. This was through better timing of applications, particularly when crops were being irrigated, more rigorous preventative fungicide schedules and better use of application technology. Some of the innovations were formalised in an onion industry standard for spray application. The project increased knowledge of disease epidemiology and options for better management of it in the onion industry. As a result of daily radio broadcasts informing the community of the current mildew status, growers were given a regular reminder to be vigilant in disease management and began to get a better 'feel' for conditions likely to promote downy mildew. Early reminders also allowed growers to buy in fungicides before disease pressure became great and supplies became scarce.

(c) Disease Photo Pocketbook

The text for this booklet has been prepared and publication is awaiting collection of photographs to illustrate text. The booklet will be released as soon as possible.

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The project could not have been completed to the present stage without the assistance of Messrs. Matthew Sullivan and Derryn McArthur (Southern Cross Television), onion growers Neville and Paul Badcock, Colin and David Chaplin, John Smink and the Forthside Vegetable Research Station. The cooperation of onion packer/exporters; Vecon Pty Ltd, Roberts Vegetables, Clements and Marshall Pty Ltd and Perfecta Produce is also acknowledged.

The technical support of Leon Hingston and Craig Palmer is acknowledged with thanks, as is the onion industry itself through the Downy Mildew Subcommittee of the Tasmanian Onion Industry Panel.

APPENDICES

Appendix 1	Downy Mildew in Onions - Discussion Paper: A summary of epidemiology, management and the Tasmanian experience.
Appendix 2	How to Use the Onion Mildew Forecaster Commercial Radio Mildew Warning Text - 1993/94
Appendix 3	Onion Industry Standard - Effective fungicide use in onions.
Appendix 4	Differences between ambient and crop canopy weather data readings, December 1992, Moriarty site. Graphs.
Appendix 5	Industry evaluation and recommendations of the onion mildew project.
Appendix 6	Onion mildew infection warnings, The Advocate Newspaper.
Appendix 7	Press and general extension articles related to onion mildew management and forecasting.
Appendix 8	Project evaluation postage paid survey card.

Appendix 1

Downy Mildew in Onions - Discussion Paper: A summary of epidemiology, management and the Tasmanian experience.

DOWNY MILDEW IN ONIONS - DISCUSSION PAPER
A summary of epidemiology, management and the Tasmanian Experience
Compiled by Lois Ransom, Plant Pathologist, DPI, Tasmania

INTRODUCTION

Onion downy mildew is caused by the fungus *Peronospora destructor* (Berk.) Caspary. Outbreaks of disease are often difficult to manage and have a devastating effect on crop foliage and resultant yield. The volume of fungicide applied annually to crops worldwide indicates the general concern of growers to keep mildew under control. Past experiences have shown that epidemics can develop very quickly under favourable weather patterns without forewarning.

The purpose of this paper is to outline the life cycle of *P. destructor*, its interaction with its onion host and environment, management options for disease control and a summary of factors that may have contributed to the mildew outbreaks in Tasmania during the 1990-91 season.

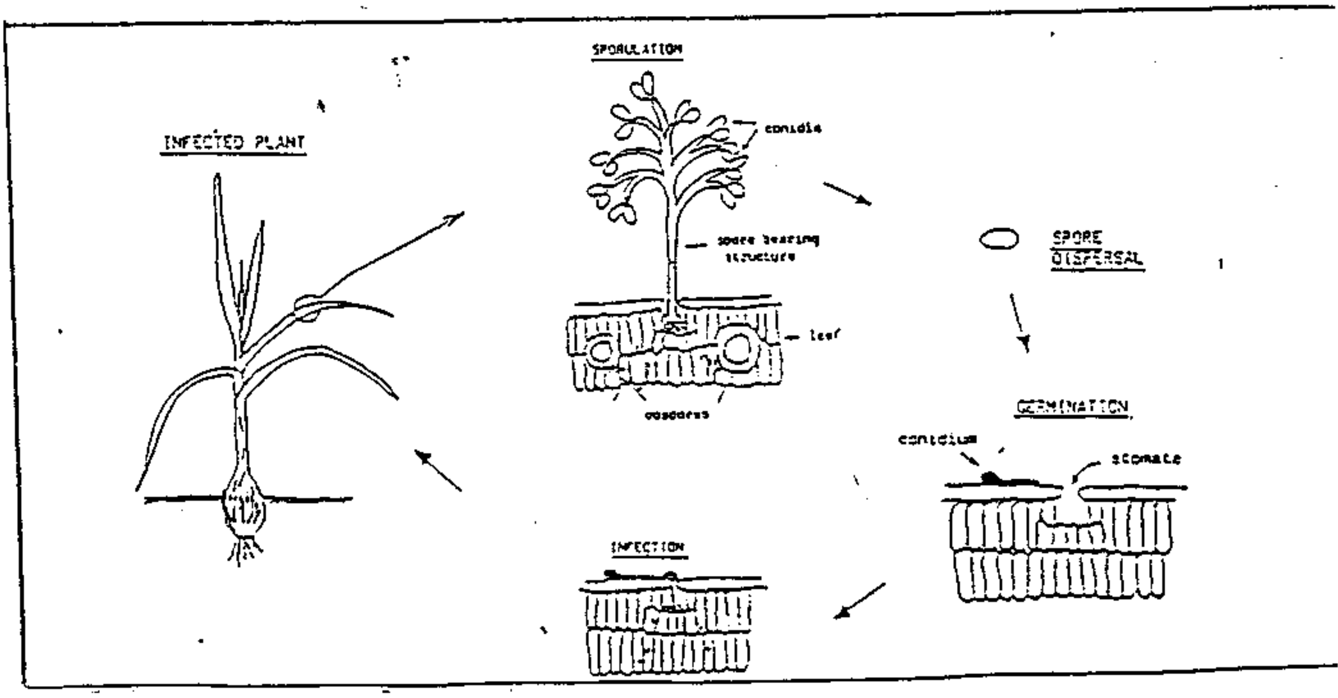
THE FUNGUS (Adapted from QDPI Technical Feature, Queensland Fruit and Vegetable News, June 29 1989)

Onion mildew is one of the most destructive diseases of onions. It produces two types of spores: thin-walled conidia, which act as the means of infection during the growing season, and thick-walled oospores, which may allow survival between seasons (although this has not been fully investigated).

Conidia develop on microscopic, branching spore-bearing structures which grow through leaf stomata. Oospores develop in infected leaves and are incorporated into the soil with plant trash.

The life cycle of the onion downy mildew pathogen is shown in Figure 1. There are four major phases: sporulation (spore production), dispersal, germination and infection. Sporulation, germination and infection usually take place overnight or in the early morning while the dispersal of spores occurs during daylight. All phases of the life cycle are influenced by the environment and it is only when conditions favour the pathogen that severe outbreaks develop.

Figure 1. Life cycle of downy mildew on onions



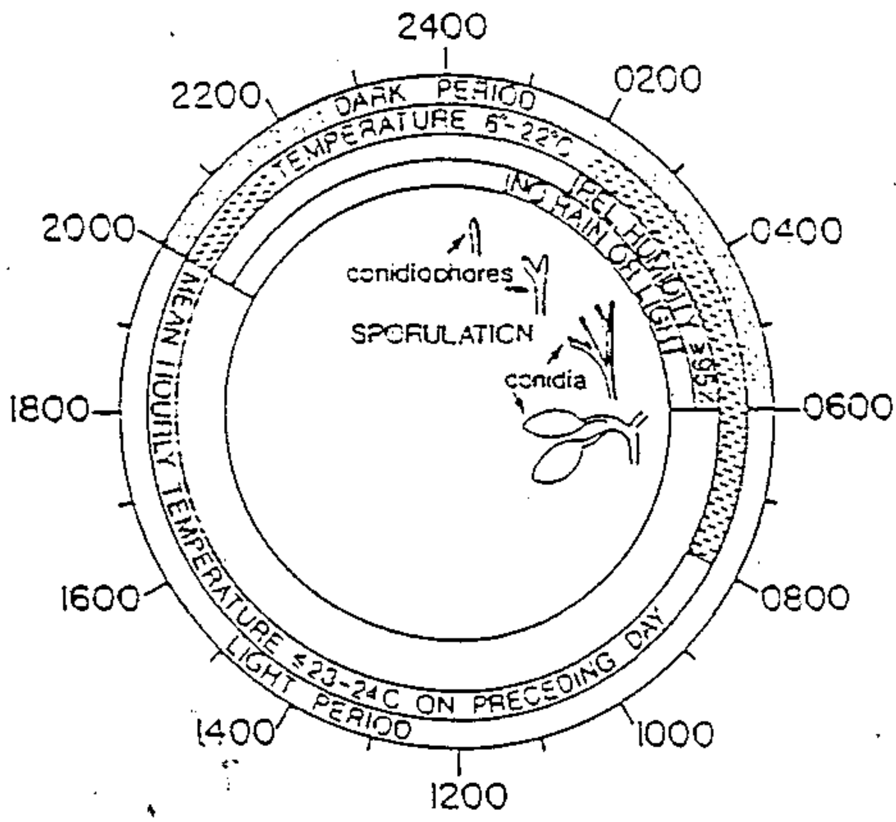
Sporulation

Overseas work has demonstrated that sporulation only occurs under certain specific conditions

- A relative humidity greater than 95 percent between 2 am and 6 am.
- No or light rain after 1 am.
- Mean hourly night temperature between 6 to 22° C (optimum 10 to 13° C)
- Mean hourly temperature during the preceding day of less than 24° C.

A schematic diagram of the environmental requirements for sporulation of *P. destructor* on onion leaves is shown in Figure 2. (Palti, 1989)

Figure 2. Environmental requirements for sporulation of *P. destructor*.



Dispersal

Spores may be released and spread soon after sporulation or may remain on the leaf surface for up to two days before being disseminated. Cool conditions with light winds favour the spread of spores, with a peak of activity between 10 am and 12 noon.

Germination and infection

Spores can only germinate in a layer of water on the leaves. Germination occurs over a wide temperature range 1 to 28° C) with 10 to 13° C being ideal. Under these temperatures germination takes place within four hours and leaf penetration occurs within three hours of germination if water remains on the leaf surface. Spores can remain viable for up to three days.

Incubation period

After infection, there is a considerable delay before sporulation occurs on the invaded leaf. This is usually nine to 16 days, depending on temperature. In general terms, weather conditions favourable for disease outbreak are cloudy, mild days, with cool, still, dewy nights. Light winds during the day help to disperse the conidia.

Weather conditions unfavourable for disease are hot days and warm nights with dry winds.

Because of the influence of weather conditions on disease severity, some seasons will be worse for downy mildew than others. This is especially true of the cooler temperate growing areas where conditions are favourable for disease for much of the growing season.

Other variables in disease development are sunlight (most conidia are killed after 8 hours of light), rate of dew deposition (slow deposition can result in drying of spores and germination tubes resulting in spore death), rainfall (heavy falls wash spores from leaves) and cultivar differences (waxy leaves are more difficult to infect than weathered leaves with less wax).

THE DISEASE

Symptoms

Infected autumn-sown crops develop leaf symptoms in spring. Infected leaves may curl outwards and lesions, when they develop, are long and pale yellow with a glazed appearance. Spores are produced under humid conditions and develop as a thick grey-purple felt. Occasionally under dry conditions sporulation is confined to the inside of the leaf cylinder and is not apparent on the outer surface. Under dry conditions the only signs of disease may be non-sporulating white spots on foliage.

Because of a dependence on humidity for most stages of its life cycle, downy mildew is often first seen in crops in damp hollows or in other areas where humidity or leaf wetness occurs for prolonged periods. A field infection can often be traced back to the original source of disease with the source being generally up-wind.

The infection cycle of *P. destructor* is characterised by long latent periods (9 - 16 days) and sporulation, infection and dispersal periods of 1 - 2 days. This leads to a stepwise increase in disease which, if not checked, may destroy onion foliage almost completely during four infection periods.

Disease may systemically invade necks of maturing bulbs and infection can be carried over into potential seed crops by this means.

MANAGEMENT

Downy mildew will never be eradicated and some form of control will always be necessary.

Cultural Management

Cultural management involves all options pre-and post-sowing which encourage crop vigour and reduce the likelihood of disease development by manipulation of the environment within the crop to make it less favourable for the pathogen.

The following options are easily accomodated by growers if adequate planning is encouraged:

- Volunteer plants and onion refuse should be destroyed and farm hygiene standards maintained to prevent buildup of crop residues.

- 4 - 5 year rotations between onion crops should be pursued by packer/exporters.

- Spring sown-crops should not be sown adjacent to autumn-sown crops.

- Crops sown adjacent to last season's paddock are at risk from inoculum carried over in crop debris.

- Sites where prolonged high relative humidities occur through the growing season should either be avoided or recognised as a likely site of disease. High humidity within crops can be restricted by avoiding western facing slopes (East and Northeastern slops remain free of moisture longer), hollows, shaded areas from hedges and buildings.

- Well drained paddocks do not hold moisture so crops could be less prone to other diseases and humidity levels are reduced.

- Crops should be sown parallel to the prevailing wind to encourage air movement within the crop canopy.

- Crop density is directly correlated with the likelihood of disease.

- Do not over fertilise. Dense foliage restricts airflow, encourages maintenance of high humidity and shading, and spore survival, reduces efficiency of fungicide coverage and provides a greater surface area on which to sporulate.

- Irrigation should not be applied in the morning before dew has dried as this prolongs the period of spore germination and infection.

- Overhead irrigation increases the risk of mildew so crops should be watered at night when leaves would be wet anyway.

- Onion cultivars show differences in resistance. Breeding to increase resistance could be of value.

Chemical Management

Prior to the development of systemic fungicides with eradicant activity, control of downy mildew relied on regular applications of the protectant fungicides, mancozeb, copper compounds and chlorothalonil. With the new systemic fungicides, which include Ridomil MZ (R) and Galben M (R), applications can be made at wider intervals with the level of disease control maintained. However the four most important factors determining the level of control gained from fungicide applications are still applicable:

- Timing - Fungicides whether protectant or eradicant in activity must be applied at or preferably before the first signs of disease are observed. Late applications of protectant chemicals will not stop disease after it is sighted and while conditions are conducive for development. Late applications of eradicant materials greatly increase the risks of control failure and the likelihood of disease resistance to the fungicide. Systemic chemicals should be reserved for periods when there is a high risk of infection and the disease populations is small.

- Coverage - All registered fungicides have been shown through the registration process to control the diseases on hosts cited on the product label. However control relies on the deposition of fungicide on susceptible plant parts in sufficient concentrations to restrict fungus development.

- Crop nutrition and the desire for lush, green tops and maximum yields.

- Regular irrigation.

- Any herbicide, wind damage.

- Late recognition of disease in the field.

- Too late change to use of eradicant fungicides.

- Too much reliance on Bravo, at too long intervals between spray applications.

- Irregularity in application of protectants.

- Poor crop coverage with fungicides.

- Buildup of infection to large levels which put pressure on all fungicides.

- Reliance on Superstand Phos (R) to contribute to disease control when this function has not been recognised with registration for the purpose.

WHERE DO WE GO FROM HERE ?

I believe the time has come for the industry to unite in its approach to disease control. There is sufficient knowledge from experience within the onion industry to determine the best and most ecomonical approach to mildew control for the whole industry. A united approach also overcomes problems with grower confusion from conflicting recommendations and resultant tardiness in applying fungicides. Unity will also help in emphasising important factors in good disease control such as cultural management aspects and the need for good spray coverage and the use of wetter/stickers.

My thoughts on better control of mildew include:

- Uniting of all industry groups to the common good.

- Developing a standardised approach to mildew control and publicise this well through the media.

- Reduction in the use of Bravo on onion crops for mildew control.

- Use of ground rigs only for mildew fungicide application.

- Exclusive use of eradicant fungicides with the first confirmed diagnosis of downy mildew in autumn and spring sown crops. Each use of eradicant to be in blocks of two sprays with a 10 - 14 day interval between.

- Development of an early warning system, based either on the Canadian DOWNCAST system (Jesperson and Sutton, 1987) or by detection in highly susceptible areas ie. Moriarty, Sassafras.

- Incentive schemes for best mildew control or demonstrated measures to prevent occurrence of buildup.

- **Frequency and interval** - Protectant fungicides should be applied every 7 - 10 days. Systemic fungicides can be sprayed at longer intervals, especially where proprietary mixes of protectant/eradicant chemicals are used.

- **Residual activity** - This refers to the half-life of the chemical layer on the plant in the face of weathering factors, such as wind abrasion, water wash, ultraviolet degradation. Residual activity is best determined under local conditions when disease pressure is high.

Overseas and interstate experimentation and experience related to chemical control of mildew has determined differences in efficacy between commonly used and registered fungicides.

The effects of chlorothalonil and mancozeb on germination and protection of leaves from infection by *P. destructor* were studied by Smith *et al.* (1985). They found an interaction between surface wax thickness and infection. Natural weathering of leaves outdoors allowed the fungus to infect more easily. They also found that both fungicides inhibited germination of sporangia. However there were substantial differences in the residual properties of both chemicals. Complete protection with chlorothalonil began to dissipate 2 days after fungicide application and after 7 - 10 days provided little control. Mancozeb provided complete protection from infection up to 4 days after application and maintained good control up to 10 days after application. It was also more effective in depressing sporulation, thereby reducing inoculum potential. Stofella and Stonoda (1982) also found that regular applications of Bravo 500 (R) reduced onion yield.

This difference in efficacy between recognised protectant treatments was also recorded last season in field trials undertaken by the Queensland Department of Primary Industries (R G O'Brien, pers. comm). With reference to Table 1 it is obvious that treatments of Kocide (R), Bravo (R), Ridomil 25 (R), Aliette (R), Previcur (R) and Aliette + Bordeaux did little to control mildew when compared with the control treatments and those containing mancozeb. It should be noted that resistance to metalaxyl by the fungus has been verified in the Lockyer Valley hence the lack of efficacy shown by this chemical. Such a result would not be expected in Tasmania.

The Queensland workers stressed the need for a wetter/sticker to increase the performance of protectants, especially wettable powder formulations. In further sensitivity tests they found that Previcur and Aliette had no effect on the development of disease.

Further studies undertaken in Canada by Jesperson and Sutton (1987) determined that Ridomil applied during the 8 days before or 4 days after infection provided effective control. Similarly the fungicide used in a program initiated near the end of the first infection cycle managed the disease effectively. The fungicide applied 6 - 8 days after the first sporulation/infection period was too late to prevent sporulation and killing of some foliage but timed to manage subsequent infection and disease.

TASMANIAN SURVEY RESULTS

A number of survey forms were received back and any interpretation of them should not be construed as criticism of any approach to disease management or of any person or company. Rather I intended the survey to be a way of constructively evaluating the 1990-91 season to develop new and more effective approaches to mildew control.

Probable contributions to the epidemic came from:

- Weather conditions conducive to sporulation and infection.

- Crop nutrition and the desire for lush, green tops and maximum yields.
- Regular irrigation.
- Any herbicide, wind damage
- Late recognition of disease in the field.
- Too much reliance on Bravo, at too long intervals between spray applications.
- Irregularity in application of protectants.
- Buildup of infection to large levels which put pressure on all fungicides.
- Reliance on Superstand Phos® to contribute to disease control when this function has not been recognised with regestration for the purpose.

WHERE DO WE GO FROM HERE?

I believe the time has come for the industry to unite in its approach to disease control. There is sufficient knowledge from experience within the onion industry to determine the best and most economical approach to mildew control for the whole industry. A united approach also overcomes problems with grower confusion from conflicting recommendations and resultant tardiness in applying fungicides. Unity will also help in emphasising important factors in good disease control such as cultural management aspects and the need for good spray coverage and the use of wetter/stickers.

<u>My</u> thoughts on better control of mildew include:

- Uniting of all industry groups to the common good.
- Developing a standardised approach to mildew control and publicise this well through the media.
- Reduction in the use of Bravo on onion crops for mildew control.
- Use of ground rigs only for mildew fungicide application.
- Exclusive use of eradicant fungicides with the first confirmed diagnosis of downy mildew in autumn and spring sown crops. Each use of eradicant to be in blocks of two sprays with a 10 to 14 day interval between.
- Development of an early warning system, based on the Canadian DOWNCAST system (Jesperson and Sutton, 1987) or by detection in highly susceptible areas ie. Moriarty, Sassafras.
- Incentive schemes for best mildew control or demonstrated measures to prevent occurrence of buildup.

REFERENCES

Jesperson, G D and Sutton, J C. 1987. Evaluation of a forecaster for downy mildew of onion (*Allium cepa* L.). *Crop Protection* 6 (2): 95 - 103.

Palti, J. 1989. Epidemiology, prediction and control of onion downy mildew caused by *Peronospora destructor*. *Phytoparasitica* 17 (1): 31 - 48.

Smith, R W, Loorbeer, J W and Abd-Elrazik, A A. 1985. Reappearance and control of onion downy mildew epidemics in New York. *Plant Disease* 69: 703 - 706.

Stoffella, P J and Sonoda, R J. 1982. Reduction of onion yields by chlorothalonil. *Hort Science* 17 (4): 628 - 629.

Table 1. The effect of different fungicidal treatments on the severity of onion downy mildew 18 and 21 weeks after sowing, yield and quality of harvested onions. (From Queensland Department of Primary Industries, R G O'Brien, pers. comm)

Treatment	Disease Severity		Plot Yields (kg)			
	18 Weeks	21 Weeks	No. 1 Large	No. 1	Small	Total Yield
Kocide (540 g/kg copper hydroxide) 2 g/L	3.37	5.6	0.45	10.15	13.63	24.24
Dithane M 45 (800 g/kg mancozeb) 2 g/L	1.17	2.15	7.73	28.74	11.17	47.64
Bravo (500 g/L chlorothalonil) 3 ml/L	2.72	5.38	0.5	13.51	12.87	26.76
Ridomil 25 WP (250 g/kg metalaxyl) 0.8 g/L	2.55	5.22	0.65	14.86	14.1	29.59
Aliette (740 g/kg fosetyl-Al) 3 g/L	2.62	5.13	0.68	13.66	13.69	28.04
Ridomil MZ 720 (80 g/kg metalaxyl + 640 g/kg mancozeb) 2.5 g/L	1.4	2.32	6.67	27.16	11.71	45.55
2022D (fosetyl-Al + Bordeaux) 4.5 g/L	2.42	5.13	0.58	14.02	13.26	27.72
Previcur (600 g/L propamocarb) 5 ml/L	2.5	5.42	0.76	14.41	13.23	28.21
Control (water + wetter)	2.85	5.67	0.95	15.48	12.69	29.12
LSD P = 0.01	1.04	0.64	3.97	8.23	NS	9.59

Appendix 2

How to Use the Onion Mildew Forecaster

Commercial Radio Mildew Warning Text - 1993/94

DEPARTMENT OF
PRIMARY INDUSTRY
TASMANIA

FORECASTING OUTBREAKS OF ONION DOWNY MILDEW

A regular protectant spray program should be in place in autumn-sown onion crops NOW. The forecasting program soon to function in the Devonport area will advise growers of conditions that favour the development of mildew spores and infection by them. Information received will relate specifically to land in the immediate vicinity of the logging equipment, but it can be used as a guide by growers in surrounding areas, who closely monitor their crops for mildew, to help in scheduling eradicant spray applications. However you should consult your field officer prior to making any changes to your recommended spray program.

To assist in spreading the word on potential disease outbreaks, Ciba-Geigy Australia Ltd, the manufacturers of Ridomil MZ 720, have agreed to sponsor a daily report immediately after the 11.00 am newsbreak on Radio 7AD (900 KHz). Broadcasting is scheduled to begin on Tuesday 29 October. This will announce whether or not an infection period has occurred in the last 24 hours at either of two monitoring sites at Moriarty and Kindred. A daily report is needed because the mildew can produce spores and infect new leaves in one night.

HOW TO USE THE FORECAST

The announcement will state that there has or has not been an infection period in the last 24 hours.

Warnings of infection periods should be **IGNORED** on the day of the announcement if:

- a protectant fungicide (ie. mancozeb) has been applied within 6 days, or,

- an eradicant fungicide (ie. Ridomil MZ 720(R), Recoil(R), Fruvit(R), Galben M(R)) has been applied within 8 days.

If no further infection warnings are announced in the following three days, a protectant schedule with applications at 7 - 10 day intervals can be maintained.

An **eradicant** fungicide should be applied **when**:

- an infection period is announced 10 - 14 days after the last protectant application, or,

- one eradicant application has been made and the second is needed to make up the block of two eradicants.

Eradicant sprays must be applied within 4 days of an infection period.

To avoid the build up of mildew resistant to eradicant fungicides, manufacturers instructions on the label **MUST** be followed accurately. Eradicants should always be applied in blocks of two sprays 10 - 14 days apart, with blocks slotted into a regular protectant spray schedule **when weather conditions favour the disease.**

IF YOU HAVE QUESTIONS CONCERNING THE FORECASTING OF ONION MILDEW CONTACT EITHER YOUR FIELD OFFICER OR THIS OFFICE

Lois Ransom
Plant Pathologist

PO BOX 303 DEVONPORT TASMANIA 7310 ● TELEPHONE (004) 240201 EXTENSION.........
FAX (004) 240238

OPTION 1A

Voice A	The following onion mildew forecast is sponsored by Ciba-Geigy Australia, manufacturers of RIDOMIL MZ 720.
Voice B	The Department of Primary Industry and Fisheries reports that:
	conditions at moriarty overnight did not favour onion mildew and no infection period was recorded.
Voice A	Ciba-Geigy integrated disease management hint: to reduce the potential for downy mildew to infect your onion crop always destroy volunteer onion plants and onion refuse.

OPTION 1B

Voice A	The following onion mildew forecast is sponsored by Ciba-Geigy Australia, manufacturers of RIDOMIL MZ 720.
Voice B	The Department of Primary Industry and Fisheries reports that:
	conditions at moriarty overnight did not favour onion mildew and no infection period was recorded.
Voice A	Ciba-Geigy integrated disease management hint: good drainage in your onion paddock will reduce humidity in the crop and lessen the chance for downy mildew to develop.

OPTION 1E

Voice A	The following onion mildew forecast is sponsored by Ciba-Geigy Australia, manufacturers of RIDOMIL MZ 720.
Voice B	The Department of Primary Industry and Fisheries reports that: conditions at moriarty overnight did not favour onion mildew and no infection period was recorded.
Voice A	Ciba-Geigy integrated disease management hint: avoid dense onion plantings which prevent air movement in the crop.

OPTION 1F

Voice A	The following onion mildew forecast is sponsored by Ciba-Geigy Australia, manufacturers of RIDOMIL MZ 720.
Voice B	The Department of Primary Industry and Fisheries reports that: conditions at moriarty overnight did not favour onion mildew and no infection period was recorded.
Voice A	Ciba-Geigy integrated disease management hint: do not over fertilise as dense crop canopies prevent air movement and prevent good spray coverage.

OPTION 2

Voice A	The following onion mildew forecast is sponsored by Ciba-Geigy Australia, manufacturers of RIDOMIL MZ 720.
Voice B	The Department of Primary Industry and Fisheries reports that: an onion mildew infection period was recorded overnight at Moriarty.
Voice A	For effective control of downy mildew in Onions use RIDOMIL MZ 720. Double strength power that fights downy mildew in both the inside and outside of the plant. RIDOMIL MZ 720 from Ciba-Geigy.

OPTION 3

Voice A	The following onion mildew forecast is sponsored by Ciba-Geigy Australia, manufacturers of RIDOMIL MZ 720.
Voice B	The Department of Primary Industry and Fisheries reports that: Conditions overnight favoured the production of spores at Moriarty. If you have irrigated your crop in the last 24 hours, an infection period may have occurred.
Voice A	Ciba-Geigy recommend you check your crop today for signs of the disease and consider use of RIDOMIL MZ to fight downy mildew in both the inside and outside of the plant. RIDOMIL MZ 720 from Ciba-Geigy.

Appendix 3

Onion Industry Standard - Effective fungicide use in onions.

Effective fungicide use in onions

"Effective control of leaf diseases by fungicides in onions is absolutely dependent on best possible coverage of leaves with fungicides."

This means that droplet size is critical. In the following 'recipes' we have tried to achieve a droplet size of 150 - 200 microns. If you cannot achieve the necessary pressures or do not have the correct nozzles you should adjust your spraying 'recipe' to get average droplet sizes as close to 150 microns as possible.

The general information that follows should help you to achieve the best possible crop coverage and so optimise chemical disease control. Of course other factors such as timeliness of spraying and seasonal conditions will influence the potential for disease to spread.

Boom height: Should be set 550 - 600 mm above the top of the crop when at full canopy to avoid striping. This will be influenced by nozzle spacing, particularly for fan jets, so should be checked in the field. A metre rule in the cab could be handy.

Hint: Removal of nozzle filters when using mancozeb (Dithane etc.) will help to prevent nozzle blockage. But remember to check filters further up the line regularly to remove other rubbish.

Wetters/spreaders: No hard and fast rules. Be aware that use of a spreader will not compensate for poor coverage of leaves with droplets of fungicide. Note also that some wetters can make onions vulnerable to the effects of herbicides if applied too soon after fungicides.

Hint: Avoid 'misses' in coverage where spray runs begin by overlapping sprays on the headlands. Disease can begin in under- or non sprayed areas.

Triple jet assemblies: make changing jets more convenient and quicker.

Weather conditions: cool, dry weather with a little wind will aid good coverage.

Hint: Consider the cost of fungicides you have to apply against the small cost of maintaining your spray equipment and the large capital cost of replacement.

Maintenance: Calibrate sprayers regularly, change nozzles before they become too worn (keep spares on hand where you can find them - like taped onto the rig somewhere), use the correct ones for the job, use the right spray pressures and water volumes. With a little bit of time your equipment will be capable of applying the sprays when and where they are needed to best control any diseases.

Crop damage: Try to avoid crop damage with tractor wheels as this can open up plants to other diseases.

Regular scheduling: When crops are threatened every year with disease (such as Downy mildew) a regular schedule with a ground rig is essential. If your interval between protectant sprays is more than **10 days** when disease is about, **you are in trouble!**

The use of cone jets is recommended for application of fungicides. The following 'recipes'should be used as a guide to successful coverage of onion leaves with fungicides.

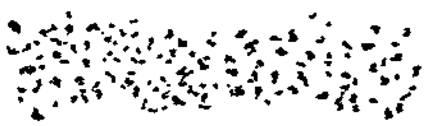
	Cone Jets	Fan Jets*
Water rate	250 l/ha	300 l/ha
Pressure	8 - 10 bar (800 - 1000 KPa or 112 - 140 psi)	8 - 10 bar (800 - 1000 KPa or 112 - 140 psi)
Nozzles	1553/12 - 1553/14 (Hardi) or TX10 or TX12 (Spraying systems) [Stainless steel nozzles wear less than brass]	4110/14 (Hardi) or 02 Series (Spraying systems)*
Swirl plates	Grey (Hardi) or No. 25 core (Spraying systems)	
Nozzle spacing	500 mm (standard)	see note*
Ground speed	7 km/hr (approx.)	7 km/hr (approx.)
Nozzle output	1.5 - 1.75 l/min	1.5 - 1.75 l/min

*Note: fan angle and nozzle spacing will determine boom height above crop canopy.

Examples:

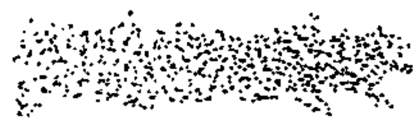
1. **1553/12** cone nozzles with **9.5 bar @ 7 km/hr** applies **250 l/ha** - droplet size 150 microns
2. **1553/14** cone nozzles with **8.5 bar @ 7 km/hr** applies **300 l/ha** - droplet size 200 microns
3. 4110/**14** fan nozzles with **11 bar @ 7 km/hr** applies **300 l/ha** - droplet size 200 microns

*** must be consistent over all leaf surfaces**



Suitable for herbicides and insecticides

*** must be consistent over all leaf surfaces**



Coverage desirable for fungicides

Calibration of sprayer:

$$\text{Water rate (l/ha)} = \frac{600 \times \text{nozzle output (l/minute)}}{\text{nozzle spacing (m)} \times \text{groundspeed (km/hr)}}$$

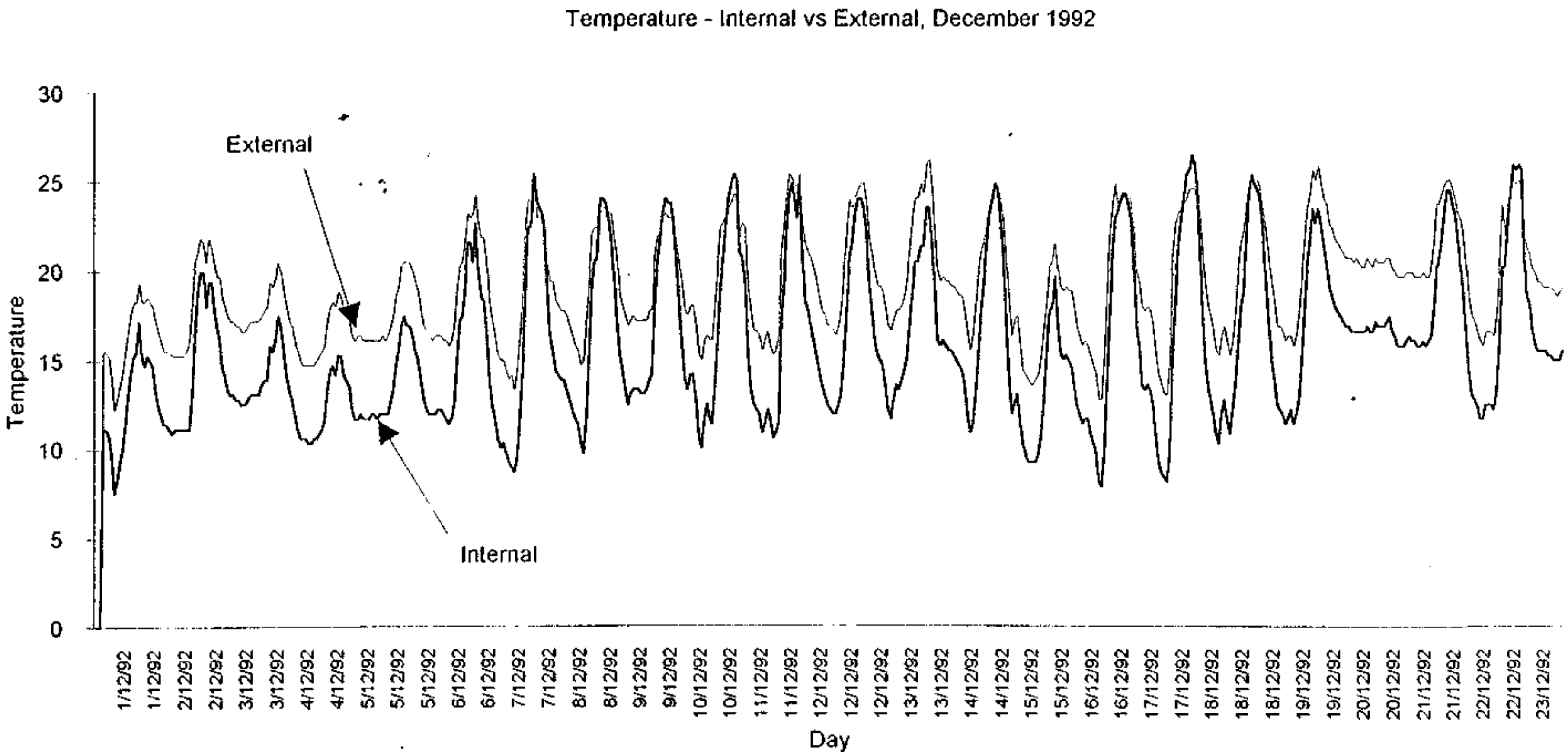
If you need help with calibration of your equipment or on the use of fungicides in general, contact your local field officer, chemical company representative, the Department of Primary Industry and Fisheries or your spray equipment supplier.

Remember: handle chemicals with care and always read the label before use.

Prepared by Lois Ransom for the Downy Mildew Subcommittee of the Onion Industry Panel. August 1993

Appendix 4

Differences between ambient and crop canopy weather data readings, December 1992, Moriarty site. Graphs


Temperature - Internal vs External, December 1992
External
Internal
Temperature
30
25
20
15
10
5
0
1/12/92
1/12/92
2/12/92
2/12/92
3/12/92
3/12/92
4/12/92
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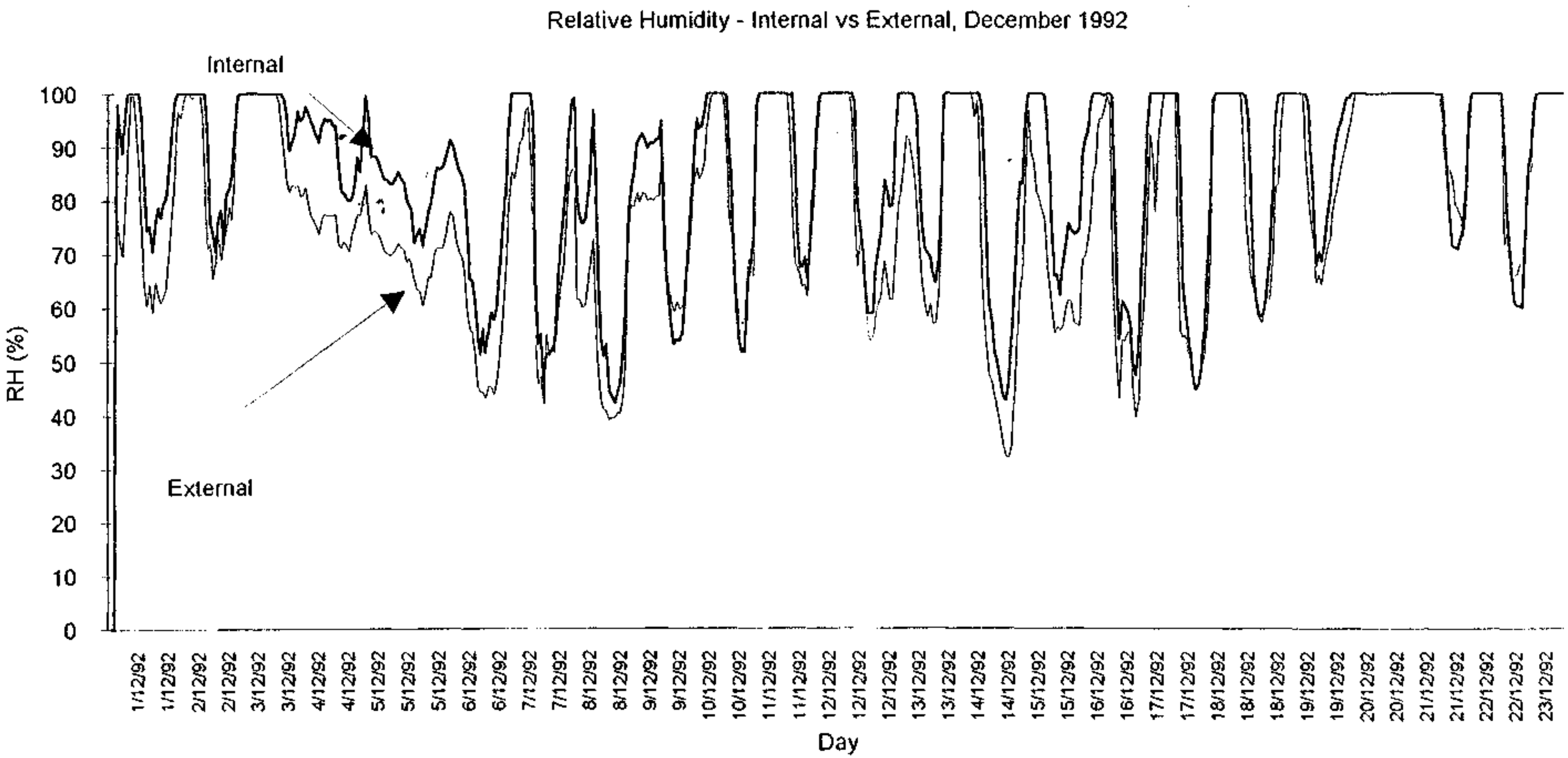
21/12/92
21/12/92
22/12/92
22/12/92
23/12/92
Day


Relative Humidity - Internal vs External, December 1992
Internal
External
RH (%)
100
90
80
70
60
50
40
30
20
10
0
Day
1/12/92
1/12/92
2/12/92
2/12/92
3/12/92
3/12/92
4/12/92
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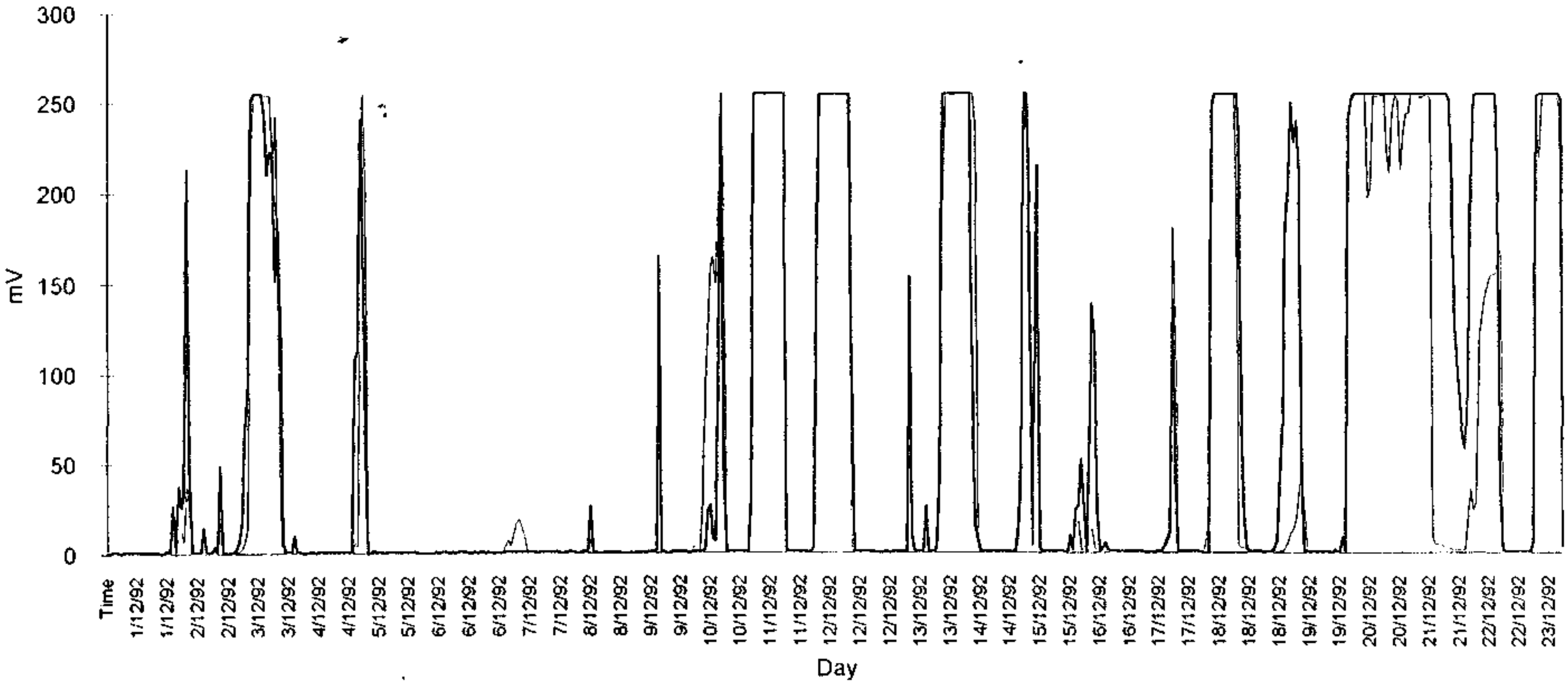
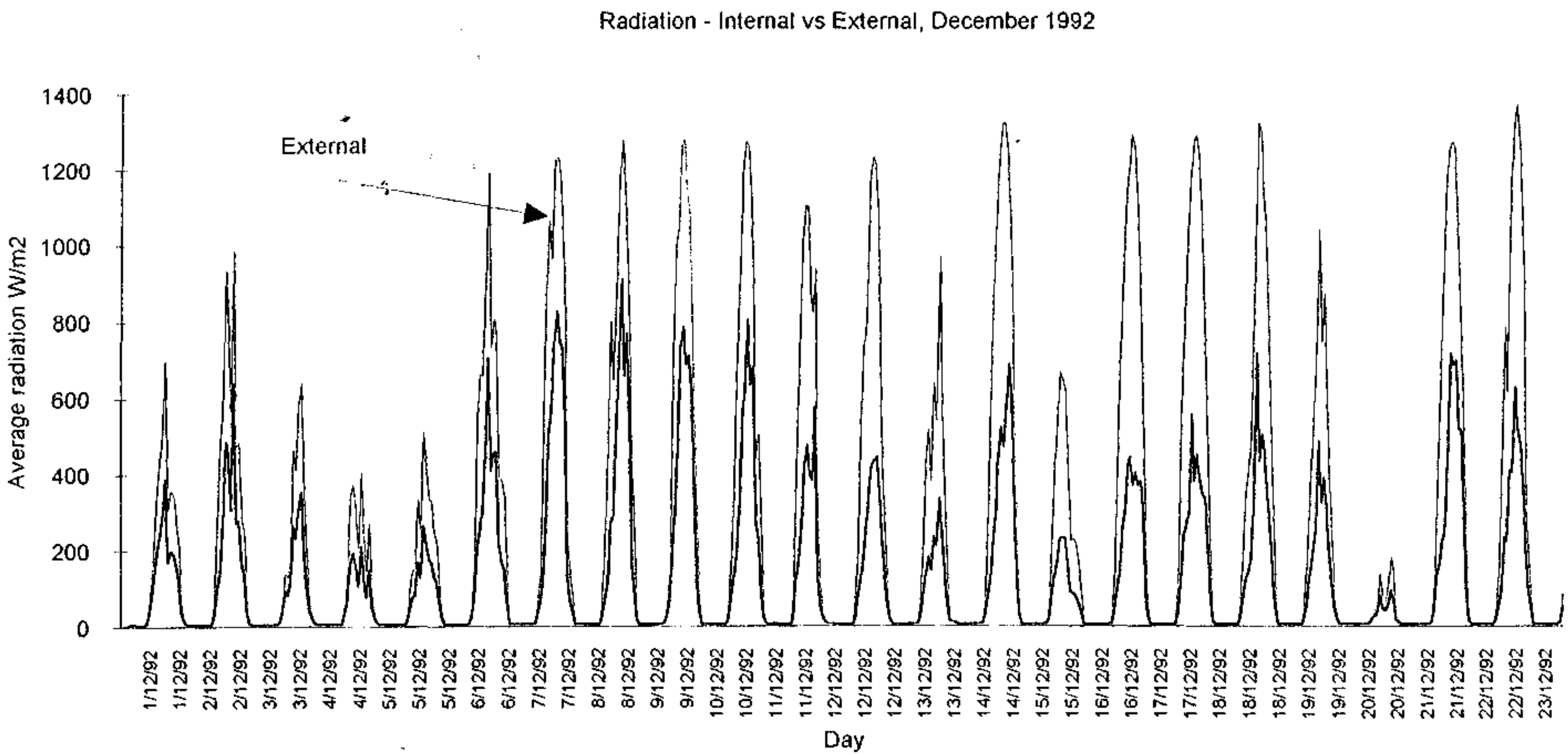
23/12/92

Average Moisture - Internal vs External, December 1992




Radiation - Internal vs External, December 1992
External
Average radiation W/m2
1400
1200
1000
800
600
400
200
0
1/12/92
1/12/92
2/12/92
2/12/92
3/12/92
3/12/92
4/12/92
4/12/92
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18/12/92
18/12/92
18/12/92
19/12/92
19/12/92
20/12/92
20/12/92
21/12/92
21/12/92
22/12/92
22/12/92
23/12/92
Day

Appendix 5

Industry evaluation and recommendations of the onion mildew project.

SUMMARY OF INDUSTRY COMMENTS - RE ONION MILDEW MANAGEMENT

Pilot Year

Observations and Comments:

Following feedback from the survey and after crop losses the year before, there was more emphasis on the use of the protectant fungicide mancozeb in a regular schedule from the 5 -6 leaf growth stage. Full schedules were in place by early bulbing. Eradicant applications were scheduled either at first indications of infection periods or when crop growth stage and weather conditions indicated a risk of infection. Little grower apathy to application of fungicides was encountered following widespread damage from disease in the previous season.

There was widespread awareness of the need to block spray with phenylamide fungicides to prevent further resistance development.

Attention was paid to the need for good crop coverage with fungicides. It was noted that addition of the widely used wetter Pulse® improved droplet dispersal but did not compensate for poor coverage of the leaf surface.

Mildew failed to develop in usually susceptible districts such as Moriarty and this may have reduced the levels of disease in all areas. Reductions in plant densities by several packers were also likely to have reduced disease previously associated with dense crops. Some reported outbreaks of mildew in late crops following cessation of fungicide sprays in early February indicated the need to continue preventative fungicide applications until tops began to fall over.

The forecaster was seen to provide options for future crop management and was seen as a tool for educating onion growers in conditions favourable to mildew development. Could be of value as a source of strategic information for future disease control. Could have potential in more affordable disease control schedules in the future.

Recommendations:

That DOWNCAST criteria should be refined for Tasmanian conditions to further separate sporulation and infection periods. Crop advisors were reluctant to allow growers to use the unproven forecasting system with most still relying on own experiences or a regular spray program to manage disease.

That data received should be collected in an information base to increase epidemiological knowledge of the disease in the State.

That forecasting should begin as soon as practicable after crop establishment and early warnings given through faxes to advisors as soon as they are recorded.

A study of application technology be undertaken with respect to pressure, water rates, nozzle type, boom height and the growing crop to mprove fungicide coverage of onions.

Spray schedules should begin with a block of two eradicant sprays followed by regular protectant applications when experience dictates that the crop growth stage and weather conditions are most likely to favour disease. Maximum protection to be targeted at the bulbing stages when most severe disease occurs.

Daily updates of mildew forecasts be broadcast on Radio 7AD in Devonport to increase awareness.

Year 1

Observations and Comments:

Forecasting commenced at the beginning of October. Some technical hitches occurred but were overcome. Readings of sporulation and infection periods were made according to DOWNCAST. A number of warnings were issued based on conditions that allowed spore production. Infection periods for each month correlated well with outbreaks of disease observed by field staff 14 days later. Outbreaks were reported in early October, late October, late November, Christmas and early New Year and late January.

Addition of wetters in crop sprays (particularly with grass killers) appeared to increase crop susceptibility to disease.

Concern was expressed over the number of warnings given. However it was agreed that there was value in operating the radio broadcasts as a reminder to growers of timely and regular fungicide applications for disease management.

Continued reluctance by industry to rely totally on the forecaster for scheduling fungicide applications.

Recommendations:

There was a need to further tighten definition of infection and sporulation periods.

A 'Richter Scale' approach was favoured to quantify crop risk from disease as the season progressed.

Absolute infection periods when they occurred should be transmitted immediately to industry for immediate action.

Continue to develop the forecaster under Tasmanian conditions as the potential is there for more accurate prediction of disease.

Continue radio broadcasts, subject to sponsorship.

Overlap predictions with forecasting in other crops (ie. potato blights)

Increase grower and crop advisor eduction on the link between irrigation, fungicide schedules, crop growth stage and disease.

Identify weather patterns that favour mildew and educate growers to recognise these in advance (ie. from TV and newspaper weather maps)

Year 2

Observations and Comments:

As previously. Disease management maintained as a result of strategies put in place the previous season. No major outbreaks of disease detected.

Recommendations:

That the DPIF be requested to continue to operate the onion forecaster at the current level of input under the management of the Plant Pathologist based in Devonport.

That technical expertise in setting up the system in August-September 1994 be linked with the HRDC potato blight project.

That interpretation of infection and sporulation events be made form weather records according to protocols in place.

That notification of events be continued in the same form, by faxed messages to packers and by commercial radio messages.

Appendix 6

Onion mildew infection warnings, The Advocate Newspaper.

Onion monitoring system

RADIO warnings that spore production was likely to occur in the Moriarty onion crop were reported on Saturday and Sunday mornings by the DPIF. The warnings resulted from high humidity in the crop between 3-7 a.m. both mornings.

Warm and sunny days were followed by cool nights which allowed dew to form on the leaves and increase the humidity to a level where spores were likely to develop.

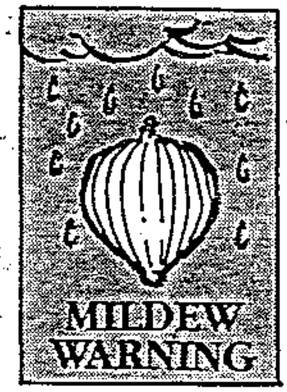
Growers with crops at or near bulbing, or with crops where air movement along the rows is slowing because of a dense canopy, should check onions for signs of disease. It is best to check in plenty of time to apply a spray before irrigation because overhead water from rain or irrigation can result in an increase in the likelihood of disease.

There was no mildew warning reported on Monday, despite overnight rain.

The Advocate, Saturday 20 November

Humidity prompts disease warning

AN ONION mildew infection warning was issued by the Department of Primary Industry and Fisheries on Thursday morning.



The warning followed overnight recording of conditions favourable for disease.

Heavy overnight rain stopped at Moriarty shortly after 3 a.m. and humidity levels remained high till after 10 a.m.

The weather experienced on Thursday morning was common to the North of the State, so all onion growers should consider that infection was likely to have occurred in their crop and should take appropriate action.

A warning that spore production was likely to occur in the monitored crop was issued yesterday morning following high humidity in the crop between 3 a.m. and 7 a.m.

Growers with crops at or near bulbing who have recently irrigated their crops should check them for signs of disease. Sheltered and thickly sown areas in the crop will show signs of disease earliest.

Growers should continue their crop protection schedule, paying particular attention to achieving best possible leaf coverage with fungicides. It is essential to check that sprays are covering both sides of the leaf.

Appendix 7

Press and general extension articles related to onion mildew management and forecasting.

Downy mildew forecasting in onions

Advocate Newspaper Article.

What use is the onion mildew forecaster to you?

Check your risk levels against the list below.

Do you have:

- [ ] a crop now at bulbing stage
- [ ] an irrigation schedule in place
- [ ] dense crop
- [ ] a sheltered crop or sheltered areas in your crop
- [ ] a previous crop which had mildew last year close to the current crop

If you have ticked 4 or more you are at risk from mildew this year. You will need to recheck this list each week because the risk of disease increases as your crop grows.

Weather conditions you need to recognise which favour mildew

1. Rain or drizzle before midnight
   Cool overnight temperatures (10 - 14°C)
   Crop stays wet but no further rain until after 10.00 am (daylight saving time)

2. Overnight fog which does not clear early enough to allow leaves to dry before 10.00 am or weather becomes hazy drizzle (common in easterly weather patterns)

3. Cool night temperatures (10 - 14°C) causing dew on crops irrigated within 24 hours.

Two types of warnings are given, based on those broadcast daily after the 11.00 am news on Radio 7AD.

1. Spore production:

   Conditions have been favourable overnight for production of mildew spores. Therefore growers with crops at 5 - 7 leaf stage who have been irrigating in the last 24 to 48 hours must check crops for signs of the purplish-grey felty patches of spores on leaves. Check particularly in sheltered areas such as behind hedges and in densely sown patches. Mildew most often begins on the base of leaves near the necks rather than at the tips.

2. Infection period:

   Conditions have allowed spores to be produced and for infection of the leaves to have occurred. Growers in the vicinity of the weather loggers should check crops as above and consider including a block of two eradicant type fungicide sprays (ie. Ridomil MZ, Galben M, Fruvit, Recoil) into their protectant spray schedule. Growers outside the monitored areas should check crops for signs of disease as above.

What you need to know about sprays:

You should ignore an infection warning if:

you have used a protectant fungicide (ie. mancozeb) within 6 days , or,
you have used an eradicant fungicide within 8 days.

If no further warnings are announced in the following 3 days, the routine protectant schedule of 7 - 10 days can be maintained.

Apply an eradicant fungicide when:

an infection period is announced 10 - 14 days after the last protectant chemical spray, or,
one eradicant spray has been applied and you need to apply the second in the block of two.

An eradicant must be sprayed no later than 4 days after an infection period and not when disease is severe as resistance will occur and the entire chemical group will become ineffective. No more than four sprays are allowable by the manufacturers for the season per onion crop and these should only be applied in groups of two sprays, not singly, when weather conditions favour the disease.

Managing Onion Downy Mildew in Australia

Len Tesoriero and John Salvestrin are with NSW Agriculture. Rob O'Brien is with Queensland Department of Primary Industry. Vic Gales and Gerry MacManus are with the University of Queensland. Lois Ransom and Leon Hingston are with the Tasmanian Department of Primary Industries and Fisheries and Anabel Fulton is with the University of Tasmania.

In New South Wales, Queensland and Tasmania, Downy Mildew forecasting systems are being evaluated and ways to manage this important disease are being explored. In this article, researchers from the three states give an account of their work to date.

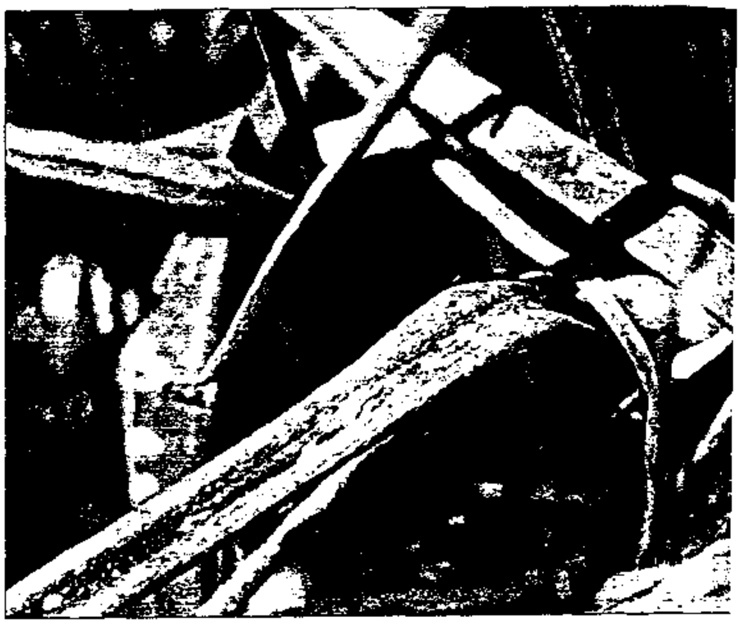
Onion production in Australia extends from the warm subtropical and Mediterranean climates through to cool temperate regions. Downy Mildew (DM) of onions is caused by the fungus *Peronospora destructor* and is a major yield-limiting disease in all of these production areas. It is widespread and damaging mainly during cool damp conditions but is much reduced by hot dry weather.

Early infections in crops appear as discrete patches of lighter and slightly wilted foliage. Upon closer inspection, the surface of infected leaves has elongated lesions that are first noticeable as light green areas that develop blue-grey velvety growth as the fungus produces spores. Leaf tips wilt, dry out and are frequently colonised by the dark mould *Stemphilium botryosom*. Bulbs from affected plants have a lower market value since they are smaller and predisposed to storage rots.

CANADIANS LEAD THE WAY

Research carried out in Canada over the last decade has given us a clear understanding of the life cycle of the onion DM and the environmental conditions it requires for infection and spread. An article in the 1991 issue of Onions Australia (Volume 8) contained a summary table of the DM life cycle. It is reproduced here to refresh your memory.

The Canadians developed a model, called *Downcast*, that could scan weather records from the previous 24 hours and give an alert if an infection period was likely to have occurred. Chemicals could then be applied to control the disease providing they had curative (also called *kick-back* or eradicant) properties. The phenylamide group fits this category and has an effective *kick-back* period of about 4 days.



Severe infestation of Downy Mildew.

RESISTANCE PROBLEMS

Unfortunately, the development of resistance by DM to these fungicides has meant that infected plants cannot be cured. Furthermore, the Downcast model cannot be used effectively to control DM where the fungicide has no *kick-back* activity.

Protective chemicals can only limit further spread of the disease by preventing further infections.

Any resistance to the phenylamide fungicides is of particular concern for three reasons. Firstly, these chemicals are the only group currently registered for DM of onions with any curative of *kick-back* activity. Secondly, there is cross-resistance to other members of this group of chemicals. That is, if metalaxyl is used and the fungus develops resistance to it, then the fungus will also be reisistant to products containing the related chemicals, benalaxyl and oxadixyl. Thirdly, once resistance appears in the DM population it will not go away even after these chemicals are no longer used. The resistance problem has hastened an evaluation of new chemicals for DM control and a national survey to determine the fungicide resistance status of DM isolates. Progress on these projects is reported later in the article.

DISEASE CYCLE OF DOWNY MILDEW	
SPORULATION	Production of spores (Night)
DISPERSAL	Spread of spores (Day)
GERMINATION	Spores germinate (Night)
INFECTION	Fungus penetrates leaf tissue (Night/Early Morning) Little or no visible damage (9-16 days)
SPORULATION	Visible damage

New South Wales 75 Tonne Club

Major onion growers in the Griffith district are supporting a project aiming to increase yields and quality whilst reducing production costs. Crop monitoring, disease control and comparative analysis are all important aspects of the program.

These 75 Tonne Club growers account for roughly two thirds of the production in NSW. A levy based on the areas sown by each grower is collected via the Irrigation Research and Extension Committee and attracts further financial assistance from the Horticultural Research and Development Corporation. The research is conducted by NSW Agriculture.

MONITORING CROPS FOR DISEASE

Initial research during the 1992 season centred on monitoring crops and identifying problems. Early detection and management of DM has been a central focus of this project. It soon became apparent that growers needed some basic disease diagnostic skills since they had difficulty distinguishing DM from other diseases, herbicide damage and malnutrition. Workshops were organised where the critical steps required for a correct diagnosis were demonstrated. These sessions also provided a forum for discussion of a broad range of management options such as the destruction of potential disease reservoirs in volunteer onions from the previous season and fungicide use strategies to minimise the risk of resistance problems.

Monitoring crops by regular inspections (weekly to fortnightly) was successful in detecting early outbreaks of DM on four properties during the 1992 season. This considerably reduced the number of chemical sprays applied as some growers had no disease. Growers with DM were able to target infected areas to prevent the disease spreading.

FORECASTING FOR DISEASE

The DM forecasting system, *Envirocaster*, was assessed on one grower's property. This unit was loaned to the project by Brian Gaffney of Horticultural Monitoring and Control Pty. Ltd. A computer model in the *Envirocaster* (based on the *Downcast* model) gave a daily update for weather conditions required for DM to occur. Four clusters of days favourable to DM were identified over the 1992 season. The first period occurred in late August when plants had not formed much of a canopy. No DM infections were found at this time except on a maturing seed crop in the district. The second period lasted 12 days in the middle of October. DM was found in four crops from different parts of the district in the week following this period. Spray applications with phenylamide and mancozeb mixtures appeared to arrest the development of the disease. Samples of infected plants have been kept and the mildew will be tested for resistance to phenylamide.

CURRENT RESEARCH

The *Envirocaster* model will be evaluated further this season. Growers agreed to purchase an *Envirocaster* unit which is now located at the Horticultural Research and Advisory Station, Griffith. Weather from different parts of the district will be compared to determine how many units are required to cover the production area. There have already been two high DM risk periods in the current season. DM has been detected in two small crops of early onions and a seed crop in the district. This result reinforces a pattern that emerged last year when the disease only appeared in crops that were nearing maturity.

The Queensland Experience

Most of Queensland's onion crop is produced in the Lockyer Valley, 100km west of Brisbane. About 900 ha are grown each winter. DM occurs each season but severity depends on weather patterns during the July to mid-September danger period.

For most of the season, winds are predominantly from the west. They are dry and create conditions unfavourable for DM. Overcast showery conditions favourable for DM are usually the result of a temporary change to SE - NE winds. These conditions generally last only a few days before returning to the usual westerly weather. Because of the difference in the types of weather in this area, disease forecasting looks promising as a means to minimise fungicide use and improve the efficiency of disease control.

FORECASTING TEST RUN

In 1989 the *Downcast* system was evaluated in an unsprayed section of an onion crop. Observations were made over an 113 day period while fungal sporulation and infection were predicted to occur on only 20 days. In most cases sporulation-infection periods were grouped, in fact, 14 of the 20 sporulation-infection events occurred during 4 weeks in July-August.

To determine whether the predicted infections were actually occurring, each week 5 pots of onion plants (trap plants) were placed in amongst the plants in the field. At the end of each week the trap plants would be removed to a glasshouse and observed to see whether the disease developed. There was a very high correlation between infection of the trap plants and predicted sporulation-infection periods during the week that they were in the field. **But perhaps of even more significance was the finding that during weeks when there were no predicted infection periods, no disease occurred in the trap plants. This was in spite of the fact that the disease had been present in the field for several weeks.**

Left to right: Len Tesoriero (Pathologist), Tony Valeri (grower), Frank Violi (grower) and Andrew Watson (Acting Pathologist) discuss the control strategy of Downy Mildew.

According to the *Downcast* system, five spray applications would have covered all the sporulation-infection events in the 1989 season.

CURRENT FORECASTING EXPERIMENT (1993)

At Gatton Research Station an observation plot has been established and monitored by an electronic weather station and a trap that constantly samples the air for spores of the fungus. Trap plants are inserted in the crop twice per week to measure the probability of infection taking place. Field disease is calculated every week. At time of writing, DM is rampant in the observation plot and careful attention is being paid to the epidemic development.

FORECASTING SYSTEM

The data being collected from the weather station, trap plants, spore trap and observation plots will be carefully examined and analysed with the objective of developing a disease forecasting program based on the *Downcast* model.

Growers in the area around the Gatton Research Station will use this information as an additional tool to help them manage DM in their crops.

FUNGICIDE RESEARCH

For a forecasting system to be successful, there must be a fungicide with effective 'kick-back' activity. Since forecasts are made following the detection of a sporulation-infection event, systemic fungicides with the ability to halt the progress of young infections are needed. Other fungicides are being examined which could be in rotation with or as alternatives to phenylamides. A fungicide with good activity against DM fungi, dimethomorph, is now under test to determine its effective length of kick-back activity.

The problem of fungicide resistant strains of DM is a danger when systemic fungicides are used intensively. There is evidence that phenylamide resistant strains are present in some areas. Rotation of fungicides and the combination of systemic fungicides with protective products are strategies which should be used.

Each season is different and before we can ask growers to rely on a forecasting system we would like to test it for at least 3 years. We must also measure how variable weather conditions are through the district, since this will determine whether one or more recording stations will be required.

Forecasting in Tasmania

The cool and wet growing season of 1990 favoured DM infection and caused major crop losses to some growers. Losses were worse where eradicant fungicides were applied late, poorly or were the sole means of control.

Two automatic weather recorders were used in 1991 to identify days that were favourable for DM. Forecasting was based on the *Downcast* model. Growers were informed by commercial radio broadcasts in the Devonport district.

The forecaster was not sensitive enough over a wide range of crop maturity and micoclimates to accurately predict disease.

Four significant factors influenced DM occurrence:

(i) Daily maximum temperatures over 23° or 24° C appeared to nullify any sporulation from the previous 24 hours.
(ii) Conditions were favourable for DM for a 24 hour period after irrigation of crops that had a closed canopy. This contrasted with the warm and dry prevailing weather.
(iii) Sheltered areas of dense crops were more severely affected by DM.
(iv) Tanks mixtures of wetters and fungicides did not compensate for poor leaf coverage.

A NUMBER OF RECOMMENDATIONS FROM THE 1991 SEASON INCLUDED:

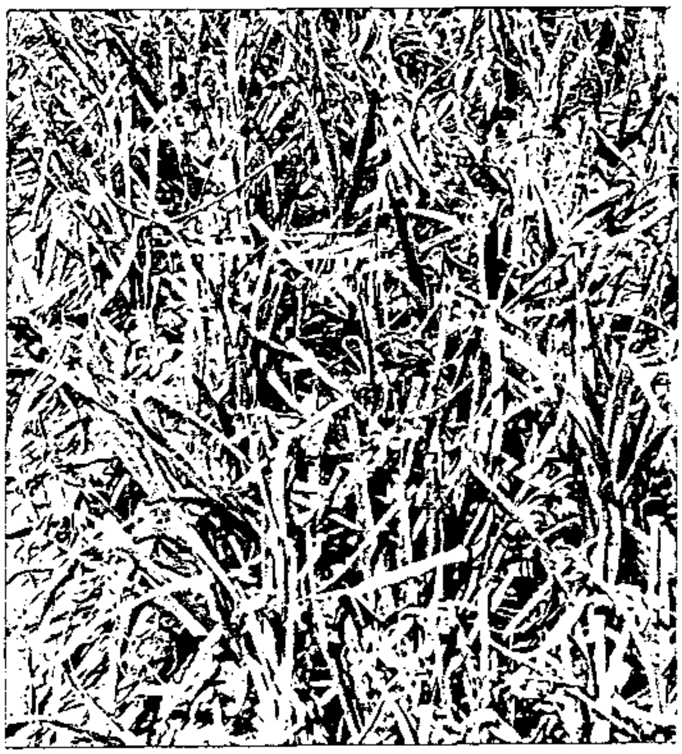
- Radio broadcasts were invaluable in increasing district awareness of DM and the need to be prepared to spray.
- Limit the use of eradicant fungicides to four per season when conditions are favourable for disease but there is no visible disease.
- Use regular protectant fungicide applications given that there is always the potential for disease to occur and multiply very rapidly.
- Obtain the best possible crop coverage with sprays for maximum disease control.
- Time sprays to the irrigation schedule when risks of infection are higher.

In 1992 a study was undertaken to monitor the way the crop canopy affected those weather conditions important for DM.

Weather recorders were placed inside and outside a crop. Temperatures inside the canopy were generally cooler than those outside. Relative humidity was higher for up to 2 hours longer in the morning within the crop. Maximum light intensity was only half of that of the outside environment while there was no difference in leaf moisture. In short, these differences confirmed that the environment within the crop was more favourable to DM for longer periods than outside.

Research in the current season aims to tighten up the forecasting model with the knowledge gained from the last two seasons. Radio broadcasts continue to be a useful prod for growers to be prepared to spray eradicant fungicides when they are most valuable.

In the meantime, the keys to mildew control are a better understainding of the disease, regular monitoring of crops, use of a regular and tight protective spray schedule and the best possible coverage of crops with fungicides.



Bad infestation of Downy Mildew which is more of a problem in high density crops.

Appendix 8

Project evaluation postage paid survey card.

(1)

Reply Paid No. 101

Attention: Lois Ransom
PO Box 303
DEVONPORT 7310

Department of Primary Industry and Fisheries Tasmania

Onion Downy Mildew Forecaster - Survey

Please circle response

Did you:

Yes	No	know a mildew forecaster operated in your district last season?
Yes	No	hear any radio warnings on 7AD?
Yes	No	change your spray routine as a result of warnings?
Yes	No	benefit from heeding mildew warnings?
Yes	No	read the mildew forecaster article in Vegie Link?

Is the forecaster of practical use to you: Yes No

What needs to be done to make the forecaster and warnings more useful ....