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Technology Transfer of Integrated Control of Downy Mildew on Nursery Seedlings

Final Report

Horticultural Research and Development Corporation Project NY97011

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Technology transfer of integrated control of downy mildew in nurseries..

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CONTENTS

1. INDUSTRY SUMMARY

Downy mildew is a major disease of seedlings in nurseries, especially of pansy, brassicas, stock, alyssum, lettuce and poppy and of the shrubs, hebes and roses. Integrated management strategies, including fungicide treatments, were developed through two recently completed Horticultural Research and Development Projects (NY97011 and NY406). The aim of the work reported here was to facilitate the adoption of the research by the nursery industry through a series of seminars, workshops, conferences, nursery visits and various published media. A second part of this project generated data on a phosphonate fungicide, to assist Agrichem Pty Ltd in obtaining registration of the fungicide for use in the nursery industry. The earlier project (NY406) identified the fungicide as giving good control of downy mildew on cauliflower and stock seedlings.

Six seminars on management of downy mildews in nurseries were delivered at workshops, Annual General Meetings or Conferences, to nurserymen in Western Australia, Tasmania, South Australia, New South Wales (Sydney), New South Wales (Northern Rivers) and Victoria. Several nurseries in each state were visited during the seminar program. Discussions were held with either management or the leading hands on downy mildews in their nurseries and control strategies for the disease. The booklet 'Downy mildew on nursery plants' and the seminar handout 'Downy mildew management in nurseries' were given to each of the 23 nurseries visited.

There was a wide range in the level of downy mildew on nursery seedlings within a state. Some nurseries had major downy mildew problems, some had moderate problems whilst others had no downy mildew diseases. The latter were already using integrated management strategies (environmental management with fungicide protocols) to control the disease. One nurseryman reported that he had changed his watering times and no longer had a downy mildew problem on his seedlings. Another, who grew hebes, improved his hygiene practices, adopted the integrated management strategies and reported that he had controlled the disease on hebes.

Downy mildew on lisianthus was identified as an emerging problem in the nursery and cutflower industries. Downy mildew was not detected on pansies in South Australia. The South Australian Research and Development Institute do not have pansies recorded as a host of downy mildew. Consequently, importation of pansy seedlings into South Australia from other states should be viewed with concern for fear of introducing the pansy downy mildew disease into the state.

A systemic phosphonate fungicide was trialed as a fortnightly drench treatment on cauliflower, pansy and stock seedlings and on potted roses against the standard mancozeb treatment applied weekly. The phosphonate treatment was as effective or better than the mancozeb treatment depending on disease pressure. When disease pressure was high a combination of both phosphonate and mancozeb gave better control than either treatment alone. The phosphonate treatment was phytotoxic when applied as a drench to the potted roses but not when applied as a spray to rose cuttings. The data from these trials is being used by Agrichem Pty. Ltd. to obtain registration of the fungicide as a downy mildew control through the National Registration Authority. A review of blue igloo film cover, indicates that in some parts of Australia, it may have potential to reduce the impact of downy mildew diseases.

2. RECOMMENDATIONS

1. Nurserymen should be encourage to implement the integrated management strategies to control downy mildew on nursery plants, especially once the systemic fungicide is registered.

2. There is a need to educate nurserymen and their staff on fungicides, fungicide groupings, spray application and calibration of spray equipment. It is strongly suggested that all nurseries should have the AVCARE brochure on fungicide groupings and a member of staff familiar with its interpretation.

3. Operators in some nurseries may benefit from courses in business management as they expand from a family business to a small business operation. It was noticeable that some nurseries were better organised than others and that some staff were better trained than others.

4. Basic hygiene practices in nurseries, which applies to all planting material, could do with a periodical revision for all nursery staff.

5. The usefulness of blue igloo film covers for reduction in the incidence of downy mildew needs to be resolved.

6. The Northern Rivers Branch of the NIANSW appeared to be very well organised and the group as a whole appeared to readily exchange information. They had produced a nice glossy booklet of nurseries in the region, which would make location very easy for wholesalers, retailers and the public. This approach could perhaps be used as a model for other regions.

3. INFORMING THE INDUSTRY ON DOWNY MILDEW CONTROL 3.1

Introduction

The downy mildew disease, caused by fungi in the family Peronosporaceae, occurs on a wide range of plants in nurseries, on annuals such as pansies and on perennials such as hebes. The disease is caused by a different fungus on each host plant genera. Although the downy mildews were reviewed by Spencer (1981), their occurrence on ornamentals was given very little coverage. Many of the downy mildews occurring on ornamentals attack mostly young tissue or seedlings grown in crowded conditions (Spencer, 1981). Those commonly reported during project NY406 were downy mildews on brassicas, pansies, stocks, alyssum, *Hebe,* poppy and rose. Many of these plants are important nursery lines which are grown year round. Downy mildew causes losses estimated at 10-12% or $4 million annually.

Project NY406 (Minchinton *et ai,* 1998) developed control strategies for downy mildew on *Brassica* seedlings by the integration of a phosphonate fungicide spray program with modified cultural practices. This has dramatically reduced the disease in some nurseries by 80% to 100%. The phosphonate fungicided was effective, economical and safe, but unregistered for control of downy mildew on seedlings. The chemical company, however, was unwilling to register the product. This study aimed to find a new phosphonate product that could be registered.

This project (NY97011) proposed to obtain efficacy data for a systemic fungicide on pansies, stocks, potted roses and brassicas. Data collected from the trials were collated and presented to Agrichem Pty. Ltd. for submission to the National Registration Authority for a 'Category 39 extension of label' registration for control of downy mildew on ornamentals and vegetable seedlings. In addition, refinement of control strategies to reduce the sporulation of downy mildew on pansies was to be carried out by the evaluation of blue igloo covers

Brassica downy mildew
Downy mildew on *Brassica* seedlings has been widely studied. It is caused by the fungus *Peronosporaparasitica* (Pers.ex Fr.) Fr.. In South Africa the seed borne nature of the fungus was responsible for its spread in nurseries (Achar, 1995). Evidence collected by project NY406 (Minchinton *et al,* 1998), however, indicated that epidemics of the disease on nursery seedlings in Australia probably resulted form airborne spores rather than seed borne contamination. *Brassica* weed species may also act as alternative hosts for the fungus, producing enough spores to infect *brassica* seedlings in the nursery (McMeekin, 1969).

Spores of the fungus will only germinate in water, thus requiring wet leaf surfaces on plants for infection. Most leaf infection takes place within 3 hours of spores landing on wet leaf surfaces (Channon and Hampson, 1968). It takes 5 to 7 days for symptoms to be produced after inoculation (Brophy and Laing, 1992). Spores are produced overnight in the dark, taking 7 hours to reach maturity (Davidson, 1968 and Chou, 1970). The optimum temperature for sporulation is 8°C to 16°C (Feltonand Walker, 1946). Project NY406 has confirmed that spores are released in the morning as the air dries out (Pinkard, 1942). Cohen (1976) reported that white light inhibited sporulation of cucurbit downy mildew. Project NY406 (Minchinton *et al,* 1998) has confirmed that white light has a similar effect on the *Brassica* downy mildew. It is, however, the blue wavelengths which are the most active (Cohen and Eyal, 1977; Lukens, 1965).

Fungicide trials conducted in the UK (Davis and Wafford, 1987; Whitwell and Griffin, 1967) and in South Africa (Brophy and Laing, 1992) demonstrated that the best control of the disease was obtained where a systemic and contact fungicide were used together. The metalaxyl fungicide, once an excellent control for downy mildew on brassicas, has by over use, led to the development of fungicide resistant *P. parasitica* in the UK (Crute and Gordon, 1986). Breeding and screening brassicas for resistance to downy mildew is taking place in Europe (Crute and Holub, 1996; Astleyef a/., 1996).

Pansy downy mildew

Downy mildew on pansy *{Viola)* is caused by *Peronosporaviolae* de Barry in Europe, Asia and Australia. In America the disease is caused by *Bremia megasperma* (Berlese) Wilson, G. W. (Constantinescu, 1979). Spores which are produced on the under surface of leaves are mauve on the former and white-yellowish or white-greyish on the latter. Screening of fungicides to control *P. violae* and evaluation of cultivars for susceptibility to the fungus were carried out in France (Boudier, 1987). The clear white, yellow and blue flowering forms were more susceptible to the disease than variegated ones (Boudier, 1987). Project NY406 (Minchinton *et at,* 1998) established that sporulation by the fungus occurs in the early morning, similar to that of *P. parasitica.*

Alyssum downy mildew

The fungus *Peronospora parasitica* (Pers.ex Fr.) Fr. causes downy mildew on alyssum *(Lobularia maritima).* Symptoms are gall-like blisters, which are atypical for downy mildews (Spencer, 1981). The fungus may be a host specialized form of *P. parasitica.*

Rose downy mildew

Rose downy mildew is caused by the fungus *Peronospora sparsa.* The fungus can survive as dormant mycelium in plant parts (Bertus, 1977). The optimum conditions for disease development are relative humidities above 90% and low temperatures. Spores will only germinate over a temperature range of 4°C to 27°C with an optimum of 18°C. Some control of the disease is obtained by ventilating glasshouses to reduce humidities below 90% and by raising temperatures above 27°C (Gill, 1977). Varietal difference in susceptibility to *P. sparsa* has been reported (Baker, 1953, and O'Neill, 1994). Fungicides were evaluated for control of the disease by O'Neill (1994).

Stock downy mildew

Downy mildew on stock *(Matthiola)* seedlings is caused by the fungus *P. parasitica* (Pers.ex Fr.) Fr., but it is a different physiological race to the *P. parasitica* causing downy mildew on *Brassica* seedlings. The fungus on brassicas will not infect stocks and vice versa (Jafar, 1963). The optimum temperature for infection and sporulationis 15.5°C to 21°C with a range of 4.5°C to 27°C. Symptoms develop in 5 to 6 days at the optimum temperature (Jafar, 1963). Furalaxyl (Fongarid) was evaluated as a control for the disease on stocks (Trimboli, 1978) and is currently registered for control of downy mildew on ornamentals.

Hebe downy mildew

Downy mildew on *Hebe* (shrubby veronica) is caused by the fungus *P. grisea.* Densely planted cuttings are very susceptible to the disease. Variation in susceptibility of cultivars to the disease, has been observed by the senior author.

Integrated management strategies for downy mildews in nurseries

The integrated management strategies developed by Project NY406 (Minchinton *et al*, 1998) were based on a combination of fungicide treatments of seedlings and the management of the nursery environment.

These strategies included;

1. *Controlled watering:* Where possible avoid watering seedlings in the morning, especially after the dew has evaporated, because this is the time when spores are released and spread by air currents around the nursery. Spores need water to germinate and infection occurs within 3 hours on wet leaf surfaces. A short, heavy watering is preferable to a long light watering.

2. *Ventilation:* Always maintain a well ventilated environment to lower humidity and to dry leaf surfaces off quickly in order to reduce spore production and infection. This means adequately spacing trays and planting fewer seedlings per tray.

3. *Nutrition:* Maintain a balanced program of nutrition, as a potash (K) deficiency has been shown to increase the susceptibility of seedlings to downy mildew.

4. *Hygiene:* Remove sources of spores in the nursery, such as heavily infected seedlings and old infected seedlings past their use-by-date. In severe, persistent infestations, completely remove the host from the nursery and bury any dumped infected plant material during the time of the year when sales of the host are low, in order to break the cycle of infection in the nursery. Eradicate cruciferous weeds as they are a source of downy mildew infection for *Brassica* seedlings. Seed does not appear to be a source of infection for the disease in Australia.

5. *Fungicides:* Apply registered fungicides as preventative sprays, especially when the disease is expected from autumn through winter. Apply a registered contact fungicide such as Mancozeb® as a spray once a week and a soon to be registered systemic phosphonate fungicide, as a drench once a fortnight.

3.2 Materials and Methods

A seminar or workshop was presented in each state with the assistance of the state nursery industry association. Visits to seedling nurseries were accommodated when required on the interstate trips. A booklet which reviewed downy mildew diseases, 'Downy mildews on nursery plants', was distributed to interested nurserymen at meetings, workshops and nursery visits.

Seminars

Seminars were presented to the nursery industry on control and management of downy mildew in nurseries in Western Australia, Tasmania, New South Wales, South Australia and Victoria. Queensland was also approached (Appendix 1). The seminars were specifically modified where appropriate to cater for the requirements of each audience (Table 1). They focused on delivering the integrated management strategies to control downy mildews in nurseries, developed in Projects NY406 and NY97011, to the nursery industry. A seminar handout was distributed at each meeting, conference or workshop (Appendix 2). A booklet which reviewed downy

mildew diseases, 'Downy mildews on nursery plants', was distributed to interested nurserymen at meetings and workshops. See Appendix 3 for presenter's seminar notes, see Appendix 4 for photocopies of slide presentations and see Appendix 5 for Conference abstract and publications list.

Table 1 Summary of seminar presentations to the NIAA.

Date	State	Conference/Meeting	Seminar Title
28/10/97	WA	$Profits Workshop	Plant disease and the effect on profit
14/07/98	Tas	AGM NIAT	Managing downy mildews in nurseries
24/07/99	SA	Nursery Technical Conference	Managing downy mildews in nurseries
5/08/98	NSW	AGM Tree & Shrub Growers, Tubegrowers	Managing downy mildews in nurseries
11/08/98	NSW	AGM Northern Rivers Branch of NIA of NSW	Managing downy mildews in nurseries
16/10/98	Vic	4th ASHS Conference	Integrated management of downy mildews in nurseries

Nursery visits

Wholesale nurseries were visited in each state during the course of the interstate seminar programs. Nursery visit itineraries were made in consultation with the state IDO's, State secretary, the National Training Officer, Branch Presidents and Crop consultants. The seminar handout 'Downy mildew management in nurseries' and the booklet 'Downy mildew on nursery plants' were distributed during the nursery visits. See Appendix 6 for a list of nurseries visited and see Appendix 7 for photographs of nursery visits. During the nursery visits a small list of questions were asked in the course of discussion on downy mildew. The questions were:

1. Do you have a downy mildew problem on seedlings?
2. With which plant genera do you have problems?
3. Which plant genera have you seen downy mildew on in the past?
4. What control strategies are you currently using ?
5. Are your control strategies working?
6. When are seedlings in the nursery watered?

Western A ustralia

A seminar on 'Control of downy mildew in nurseries' was presented to nurserymen and staff at the '$Profits Workshop' on 28 October 1997 at Dundebar Nurseries, 88 Damian Road, Wannaroo, WA. Five nurseries were visited, two in Manjimup, two in the southern Perth suburbs and one in the northern Perth suburbs. The nurseries visited were Five Acre Nursery, Springall Nursery, Sunnyvale Plants, Riverton Nurseries and G & S Seedlings (Appendix 6). The workshop and nursery visits were organised through Mr Sandy Pate, IDO, NIAWA.

Tasmania

A seminar on 'Management of downy mildew in nurseries' was presented to the Annual General Meeting of the Nursery Industry Association of Tasmania Inc. at the Mount Pleasant Laboratories of the Department of Primary Industries and Fisheries, Launceston, Tasmania 7250, on the 14th of July 1998 (Appendix 2). Three nurseries were visited in the north of the island, J. & A Bradnsema, Riverside Nursery, Cloverlea Nursery and Alans Nursery (Appendix 6). Visits to nurseries in the south of the island were curtailed due to illness of the senior author. The agenda for the AGM and nursery visits were organised by Mr Colin Fleming, Secretary of the NIA of Tasmania.

South Australia

A seminar was presented to the South Australian Nursery Industry Technical Conference on the 24th of July 1998 at the Charles Hawker Conference Centre, Waite Research Precinct, Waite Road, Umbrae, SA 5064. The seminar day (Appendix 1) and the itinerary for nursery visits were organised by Ann Frodsham, SA Nursery IDO. She also kindly provided photocopies of the one page seminar handout for the audience at the conference.

On the first day Topline Plants Co. Pty. Ltd. and Flag Nurseries were visited in the Adelaide Hills and two professional meetings were conducted, one with Dr Prue McMichael, Plant Pathologist, Scholefield Robinson Horticultural Services Pty. Ltd. and the other with Ms Barbara Hall SARDI Horticultural Pathology, SARDI Plant Research Institute. On the second day nursery visits were made to the north Adelaide plains region with Mr Greg McPhee, Training Officer NIAA and with the assistance of Mr Domenic Cavallaro, IPM Consultant. The nurseries visited were Cavco Flowers, Virgina Nursery and Living Colour Plants (Appendix 6).

New South Wales

The two seminars presentations in NSW and the nursery visits (Appendix 6) were organised with the assistance of the NIAA Training Officer, Mr Greg McPhee, the NIA of NSW IDO Mr Richard Stephens and by Mr Denis Cook, secretary of the Northern Rivers Branch of the NIA of NSW and by Mr and Mrs Vedler. The first NSW seminar on 'Downy mildew control in nurseries' was presented to a combined meeting of the Tubestock Growers Association and the Tree and Shrub Growers Group of NIA of NSW on the 5th of August 1998 at Annangrove Rd, Rouse Hill, NSW 2156. The seminar presentation was organised through Mr Chris Douglas of the Tree and Shrub Growers Group of the NIA of NSW and Mr Des Leeke of the Tubestock Growers Group of the NIA of NSW. The second NSW seminar on 'Downy mildew control in nurseries' was presented on the 11th of August 1998 to the Annual General Meeting and dinner of the Northern Rivers Branch of the NSW NIA.

Queensland

Cancelled due to lack of interest. See Appendix 1 for correspondence.

Victoria

A seminar was presented at the 4th Australian Society of Horticultural Science (14-17th October 1998) on the 16th of October 1998 at the Carlton Crest Hotel, Melbourne, Victoria 3004. A poster presentation was also made for the Conference. See Appendix 1 for Conference itinerary. During Project NY406 and NY97011, four nurseries were visited (Appendix 6).

3.3 Results

Western A ustralia

The $Profits Workshop attracted 30 people. A nursery walk followed the workshop. Nursery management kindly provided a buffet dinner. Downy mildews were discussed with several nurserymen during the course of the evening.

Downy mildew was very severe on *Brassica* seedlings in the cooler wetter region of southern Western Australia, Manjimup. Disease incidence was moderate in the southern Perth suburbs and none was found at a vegetable seedling nursery north of Perth. It is interesting to note that the vegetable seedling nursery, without any signs of downy mildew, watered plants prior to dawn but not in the morning hours following. Their seedlings were also well spaced which encouraged good ventilation (Fig 1, Appendix 7). On ornamentals, downy mildew was only observed on displays of mature pansies which were growing in a sheltered position at one nursery, whilst the other nursery had not seen downy mildew on pansy. Downy mildew was observed only occasionally on stocks by Western Australian nurserymen. Nurserymen reported that downy mildew was not a problem on their *Brasscia* seedlings during summer, which is not surprising given the hot dry summer conditions of Western Australia.

Tasmania

There were 7 nurserymen present at the AGM who were each presented with a one page seminar handout 'Downy mildew management in nurseries' and copy of the booklet 'Downy mildews in nurseries'. Downy mildew occurred at low levels on older *Brassica* seedlings in one nursery, whilst in other nurseries it was not observed. No downy mildew was observed on pansy (Fig 2, Appendix 7) or stock seedlings in any of the nurseries during the field trip, however, nurserymen reported they had seen it in the past on these plants.

South Australia

About 150 nurserymen were present at the conference seminar. Five nurseries were visited (Appendix 6) and two professional meetings were conducted.

The levels of downy mildew on *Brassica* seedlings varied enormously from nursery to nursery. One nursery had no downy mildew on their *Brassica* seedlings, which were grown under cover in a heated glasshouse with trays of seedlings spaced and raised off the floor (Fig 3, Appendix 7). In another nursery there was close to 100% incidence of downy mildew on *Brassica* seedlings and none on pansy seedlings but it had been observed on stock seedlings in the past. At this nursery the *Brassica* seedlings were grown outside in a relatively high rainfall region which would normally make control difficult. Another nursery had seedlings grown on raised benches but house venting was very poor (low roof line) and sides of the house were not open to the elements (wind). There was a 100% disease incidence of downy mildew on these seedlings and the disease was also observed on lettuce seedlings at the same nursery. Fortunately the nurseryman was in the process of constructing a modern greenhouse complex to replace the out-dated greenhouse technology. The last nursery visited had some downy mildew on their *Brassica* seedlings, which were grown in the open and no downy mildew on their pansy seedlings (Fig 4, Appendix 7). A lapse in the spray program may have contributed to the low level outbreak of the disease in the nursery

Discussions with scientists and the crop consultant in SA highlighted the presence of downy mildew *{Peronospora chlorae)* on *Eustoma grandifloria* (lisianthus). Plants are grown under cover for the cut flower industry. The disease causes major problems for growers and producers of planting material, to such an extent that a court case is pending. Symptoms of downy mildew on lisianthus are a terminal shoot dieback extending down the stem which causes a light browning of stems and leaves. Stems and basal leaves may rot. The fungus sporulates on both the upper and lower leaf surfaces (P. McMichael, pers. comm.).

A list of downy mildews on plants in South Australia was obtained from scientists at SARDI. The disease is found on *Allium, Brassica, Capsella, Coronopus didymus* (lesser swine cress), *Eustoma* (lisianthus), *Geum, Lobularia* (alyssum), *Matthiola* (stock), *Papaver* (poppy) and *Rheum,* but interestingly not on pansies. Downy mildew *(Bremia latuca)* is a major problem on lettuce in the state and it is thought that cultivars are losing their resistance to the fungus and that the fungus may have developed resistance to some fungicides (B. Hall pers. comm.).

New ***South Wales***

There were about 27 people present at the seminar given to the combined meeting of the Tree and Shrub Growers Group and the Tubstock Growers Group. Copies of the seminar handout (Appendix 2) and several copies of the booklet 'Downy mildews in nurseries' were distributed to interested nurserymen. Further copies were sent to Mr Des Leeke for distribution to members of the Tubergrowers Association. See Appendix 1 for meeting itinerary. About 30 people attended the AGM of the Northern Rivers Branch of the NIA of NSW. They were given copies of the seminar handout (Appendix 2) and several copies of the booklet 'Downy mildews in nurseries' was also distributed.

The nurseries visited in the Sydney region were Newports Nursery, Windmill Nursery and Craigie's Nursery (Appendix 6). All these nurseries appeared to be situated in high rainfall areas. Nurserymen had observed downy mildew on brassicas, lettuces, stocks, pansies and hebes. The biggest problem appeared to be on pansies and it was much worse in some nurseries than in others. One nursery had a small problem with their pansies but had a diverse arsenal of fungicides and were very prompt at rouging out heavily infected trays of seedlings. Only a little inspection of one nursery took place due to torrential rainfall but they did not consider that the disease was a problem at the time. Another nursery had major problems with downy mildew on pansies. This nursery had started to address the problem by improving fungicide applications of Dithane(R), with the use of a 'cold fogger', which had shown successful control of the disease on a batch of pansy seedlings. Other management measures of controlling the disease were also discussed, such as hygiene, i.e. burial of dumped infected plants rather than leaving them in exposed heaps. Avoidance of watering seedlings in the morning where possible and maintaining a balanced program of nutrition was also discussed. The nursery also decided to avoid growing pansy and *Brassica* seedlings for a month a year in order to break the presence of the host in the nursery which should translate to a break in the presence of inoculum and the disease on the site.

Nursery visits in the Northern Rivers region of NSW were to Parker's Place, Bau Farms and Weslor Flowers Nursery (Appendix 6). A workshop was held at Parker's Place (Fig 5, Appendix 7). Pete's Plants Nursery was not visited, as, at the last minute he reported that since he had changed his watering time, downy mildew was no longer a problem on his seedlings. The Northern Rivers Branch of the NSW NIA appeared to be a very active group of nurserymen and had produced a booklet containing maps of all the nurseries in the area.

There were 7 nurserymen present at the workshop held at Ray Parkers Nursery. An abridged version of the downy mildew seminar was presented followed by a nursery walk. Nurserymen present were mainly shrub growers and reported problems with downy mildew on *Hebe.* Copies of the handout and the booklet were distributed. The group discussed possible control measures for downy mildew on hebes, such as surface sterilising cutting material; avoiding the use of sale plants for propagating material, growing the mother plants in a different and drier area of the nursery; ventilation, nutrition and fungicides. Varying watering times to avoid watering in the morning didn't appear to be a practical solution for shrub growers in this region.

Victoria

There were about 20 people present at the seminar given to the 4th Australian Society for Horticultural Science Conference held in Melbourne. During project NY406 research was conducted at two Victorian seedling nurseries and another seedling nursery and two shrub nurseries were visited. The nurseries involved were Floriana Pty. Ltd., Woodlyns Nurseries Ply. Ltd., Woods Nursery Pty. Ltd., Southern Advanced Plants Pty. Ltd. and Haar's Nursery. During the current proj ect research was conducted at Karinga Nursery Pty. Ltd.

The three seedling nurseries had problems with downy mildew on brassicas, stocks and pansies and some had problems with it on poppies and alyssum. Largely as a result of the research project, the downy mildew problems on seedlings have disappeared, however, downy mildew on pansies still causes some problems. The foliage of pansies is very dense and a good spray application is required to obtain an adequate coverage of fungicide. Control failures appear to arise when fungicide protocols are not commenced as soon as the seedlings emerge from the germination chambers, or as a result of irregular spray programs.

One rose propagator reported downy mildew causing leaf drop on cuttings and another had problems on potted miniature roses. The downy mildew problems in the former were controlled with modifications to environmental and fungicide management practices. The downy mildew problem in the latter were brought under control with changes to fungicide applications.

Downy mildew on *Hebe* caused a major problem in propagating houses and tubestock. The disease probably originated on infected mother plants which were grown in a sheltered position on the southern side of a building. Suggested management practices were relocation of mother plants to a more open area, fungicides applications to mother plants, surface sterilisations of cuttings with a mild hypochlorite solution, changes in fungicide spray applications to propagating beds and tubestock and better ventilation of tubestock. Nursery management later reported that they had implemented many of these changes and brought the problem under control. The nursery policy was to reduce fungicide usage and as summer was approaching, they would reduce and eventually discontinue fungicide applications as conditions would be unsuitable for downy mildew development.

3.4 Discussion

During the project 6 seminars were presented and 23 nurseries were visited. The distribution of downy mildew diseases in parts of Australia is interesting, bearing in mind that only a few nurseries were visited, though these were probably the leading nurseries in each state. Downy mildews were generally more of a problem where nurseries were located in high rainfall areas. Those which had good control of the disease were using environmental management strategies. Generally, once nurserymen had some understanding of the fungus life cycle and infection prerequisites they often came up with suggestions to reduce the problem. During the project downy mildews were observed on seedlings of pansies (Fig 6 Appendix 7), brassicas (Fig 7 Appendix 7) and lettuces (Fig 8 Appendix 7) and on foliage of potted hebes (Fig 9 Appendix 7).

Downy mildew on pansies was rare in Western Australia and not detected in either South Australia or Tasmania, although, nurserymen in the latter reported its presence. Its apparent absence from South Australia could have implications for the importation of pansy seedlings from outside the state. It is not known, however, if there is any movement of pansy seedlings into South Australia. It is possible that the growing of this host throughout the year in the nurseries, may be contributing to the disease's endemic nature and difficulty in control, as there is no break in the host on many sites, whereas years ago the growing of pansy seedlings was seasonal.

It was also found that downy mildew on lisianthus was a big problem both in planting material and cut flowers. It appears very difficult to control, especially on planting material destined for cutflower growers. It is suspected that neither environmental nor fungicidal management practices are commenced early enough, or are sufficiently consistent to control the disease.

Follow up phone calls to nurseries with downy mildew problems or to crop consultants, has indicated that there has been a major improvement in control of the disease. These improvements have been attributable to modifications in environment, changes in management practices and variations in fungicide programs.

Problems identified during the course of the nursery visits

Interestingly, in some nurseries, only the proprietor was present at the meeting but at other nurseries middle management staff were also present. There were a number of concerns raised by nurserymen during the course of the nursery visits such as:

- Complaints about staff problems.
- Complaints about the state of sales.
- There were difficulties in understanding of fungicide groupings and the need to rotate fungicides from different chemical groups to avoid the possibility of fungi developing resistance to fungicides
- Spray application.

4. EFFICACY TRIALS WITH PHOSPHONATE FUNGICIDE

A report was presented to Agrichem Pty Ltd on the efficacy of their phosphonate fungicide to control downy mildew in nursery seedlings, see separate confidential attachment. The following is a summary of that report.

Fungicide efficacy trials were conducted with phosphonate fungicide for the control of downy mildew on seedlings of cauliflower, pansy and stock, on potted roses and rose cuttings. Under conditions of low disease pressure the phosphonate fungicide, applied as a drench at the recommended rate of 2.5ml/L, significantly reduced the incidence of the downy mildew disease on cauliflower, pansy and stock seedlings. When disease pressure was extremely high it significantly reduced the incidence of the disease at the label rate and at twice the label rate when applied in combination with Mancozeb^{R}. The combination of fungicides out-preformed a Mancozeb spray. There was no evidence of phytotoxicityon any of the seedlings.

The phosphonate fungicide, when applied at the rate of 2.5ml/L and 5ml/L as a drench of 300ml per 200mm diameter pot, was phytotoxic to the potted roses. No downy mildew developed on the rose trials and none was located to inoculate the trial plants. Trials established at a commercial nursery (Karinga Nursery Pty. Ltd.), which had reported a recent outbreak of downy mildew also failed to develop downy mildew on any of the plants, including the controls (untreated with chemicals).

5. TRIAL OF BLUE IGLOO FILM FOR DOWNY MILDEW CONTROL

5.1 Introduction

It is generally accepted that there are two photoreceptors in plants, phytochrome which absorbs in the 600-800nm band and a blue absorbing photoreceptor which absorbs in the 300nm to 500nm band (Raviv and Reuveni, 1995). The inhibitory effect of blue light on fungal sporulation is well documented and has been found to cover a number of diverse fungal genera. Blue light had an inhibitory effect in sporangial production by *Pseudoperonosporacubensis,* on cucumber leaves (Cohen and Eyal, 1977). Blue wavelengths of light were also found to inhibit sporangial formation by *Phytophthora infestans* on potato leaves (Cohen *et ah,* 1975), *Peronospora tabacina* on tabacco (Cohen, 1976) and *Botrytis* (Tan and Epton, 1973). The blue light did not prevent emergence of *P. cubensis* sporangiophores through stomata on the cucumber leaves but emerged sporangiosphores were abnormal (Cohen and Eyal, 1977). The inhibitory effect of the blue light was very temperature dependant. At 20°C it strongly inhibited sporangiophore formation, at 15°C it had little effect, whilst at 10°C it stimulated production (Cohen and Eyal, 1977).

UV-B radiation (280-320nm) had the opposite effect to blue light, especially on *Botrytis cinerea,* and enhanced sporulation (Tan and Epton, 1973), though there are no reports of it affecting sporulation in the downy mildews. *Botrytis,* however, is a ubiquitous problem in any enclosed greenhouse (igloo). Commercially available polyethylene films with UV stabilisers were transparent to UV (Raviv and Reuveni, 1995). Their ratio of the transmitted light, Blue:UV was measured at 4:1 in the mid 1980's. Certain UV-Absorbing plastics were found to absorb light up to 340nm, which just covers the range where UV-B radiation stimulates sporulation of many fungi. Raising the ratio of Blue:UV to 40:1 remarkably slowed epidemic development of *Botrytis* on tomatoes (Reuveni and Raviv, 1992) and reduced disease development of downy mildew on curcubits but it did not increase yields (Reuveni and Raviv, 1997).

Blue:UV film covers have potential as an Integrated Pest Management tool even though they may not increase yields. Their benefit is in decreasing the cost of production, as fewer sprays of fungicides are required. They may reduce a reliance on chemical controls in a monoculture (single crop) system, by lowering the selection pressure for fungicide resistant strains of pathogens (Raviv and Reuveni, 1995). This would be very useful for Peronosporaceae (downy mildews) and *Botrytis,* as races of these fungi have developed resistance to fungicides (O'Brien, 1992; Katan, 1982, respectively). The blue igloo film covers containing protection against UV radiation were designed to be used on unheated greenhouses and have been available for a number of years overseas (Ginegar Plastic Products, Israel).

Blue igloo film was obtained to assess its ability to slow disease incidence on white flowering pansy seedlings.

5.2 Materials and Methods

Tunnel frames of dimensions 1.2m x 1.0m x 1.4m high were constructed out of PVC. Blue igloo film was obtained curtesy of Andy Sadler (The Ringfab Group, 3 Cobalt Way Maddington, WA 6109) to cover 3 frames, while the other 3 were to be covered with standard clear film. Each frame was designed to hold six trays of seedlings of a white pansy cultivar.

The treatments to be applied to one tray in each frame were control (drench and spray with water), drench of the phosphonate fungicide (2.5/ml/L), drench of the phosphonate fungicide (5ml/L), and each of these treatments combined with a spray of Mancozeb (800g/Kg at 1.5g/L), making 3x2 = 6 treatments in all. Drenches were scheduled for application once a fortnight with a watering can and sprays were scheduled for application once a week with a hollow cone nozzle at 250 KPa (36 psi) by a LPG pressurised sprayer.

5.3 Discussion

Trial. The experiment was to be set up during spring of 1997 but was not because Melbourne was experiencing a drought (El Nino) and it was considered that seedlings in such a small and enclosed environment would suffer heat stress. Then the Technical Officer on the project was away for 2 months on sick leave. In addition a staff member on another project run by the senior author left. Consequently, there was neither the time nor resources to run the trial.

Observations of blue igloo covers. In Western Australia two *Brassica* seedling nurseries were visited and management was questioned about the efficacy of the covers. Neither nursery had the blue film covers completely covering the houses (Fig 10 Appendix 7). Management at one nursery was unsure if there were any benefits from the blue cover. The management at the other nursery did not think there were any benefits in disease suppression and suspected that the light quality at that latitude was to poor to obtain benefit from the blue film. He had also noted that the fertiliser program in the nursery had to be changed with the blue cover and was doubtful of again replacing the film.

It is possible that the incomplete covering of the houses may be contributing to the suspected lack of suppression of downy mildew on *Brassica* seedlings. White light which contains all wave lengths would be entering the houses from the incompletely covered areas. This light would contain both UV-B and blue wave lengths, so one may be cancelling any beneficial effects of the other (Reuven and Raviv, 1997). The incomplete covering of the houses was apparently largely due to the need for ventilation. The blue film covers were designed for use on igloos, unheated at night (Raviv and Reuveni, 1995). Cohen and Eyal (1977), though, demonstrated that the effect of light on inhibition of sporulation was temperature dependant. It is also possible that the lack of temperature controls in some of the Western Australian greenhouses may be contributing to the perceived lack of efficacy of the blue film covers. Environmentally controlled greenhouses would be expected to render conditions unsuitable for the disease.

Neither of the Western Australian nurseries avoided watering seedlings in the mornings, at the time, which is conducive to disease development. If non-chemical means are to be employed to reduce the incidence of the disease, then it is imperative to integrate these management strategies to maximise their benefits rather than to rely solely on only one. Spraying of fungicides is still necessary with the blue film covers though the number of applications is fewer (Reuven and Raviv, 1997).

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