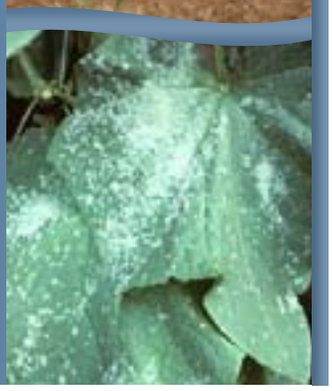

Managing Downy and Powdery Mildew, Anthracnose and White Blister

Vegetable Disease Program IPM

Efficacy and economic benefit of control options

KEY MESSAGES

- Plant resistant varieties.
- Irrigate crops in the morning to reduce leaf wetness and infection.
- Manage nutrients as they impact on disease.
- Use disease forecasting models when cropping susceptible varieties.

Victoria The Place To Be

DEPARTMENT OF PRIMARY INDUSTRIES | biosciences research

Efficacy and economic benefit of control options: variety, nutrition, predictive models and management of irrigation for white blister, downy mildew and anthracnose.

Resistance to Downy Mildew and Anthracnose in Lettuce

In glasshouse trials on lettuce seedlings only 4 of the 21 lettuce varieties tested, were susceptible to a South Australian isolate of downy mildew (*Bremia lactucae*). These were 'Fortune' (DMR none); 'Sureshot' (DMR 1-4); 'Winter Select' (DMR none) and 'Constanza' (DMR 1-16, 19, 21, 23). In similar experiments none of the 20 lettuce varieties tested, were resistant to anthracnose (*Microdochium panattonianum*) but three varieties, 'Tekero', 'Fortune' and 'Bernadinas' had some tolerance to the disease (Fig 1) .

Figure 1. Anthracnose on lettuce.

Resistance to White Blister

Brassica rapa (Chinese cabbage and pak choi)
Seedlings of only one of four pak choi varieties 'Seven Gates', showed some level of resistance to white blister (Fig 2). Blisters were small and surrounded by brown margins.

Brassica oleracea (broccoli, cauliflower, Brussels sprouts and cabbage, Fig 3).

- In glasshouse trials seedlings of Brussels sprouts 'Abacus' and 'Romulus' and cauliflower 'Avalanche' were resistant to white blister.
- In field trials cauliflowers 'Discovery' and 'Skywalker' were susceptible, but no blisters formed on heads. Broccoli 'Booster' and 'Tyson' had resistance, 'Belstar' and 'Rhumba' had some resistance but 'Profit', 'Ironman', 'Grevillea' and 'Agassi' were susceptible. Commercial varieties of cabbage are still resistant to the Australian white blister.
- Australian strains of *Albugo candida* differ from European strains so continuous screening for resistance is necessary in case new strains appear.

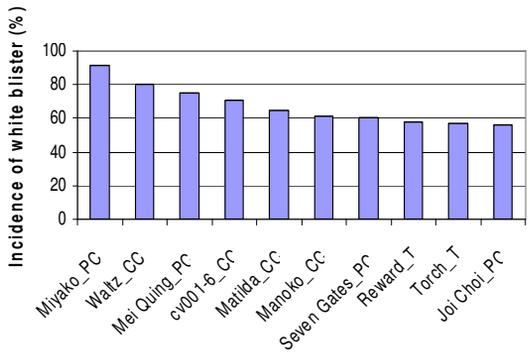

Figure 2. Incidence of white blister on commercial varieties *B. rapa* (PC, pak choi; CC, chinese cabbage; T, turnip).

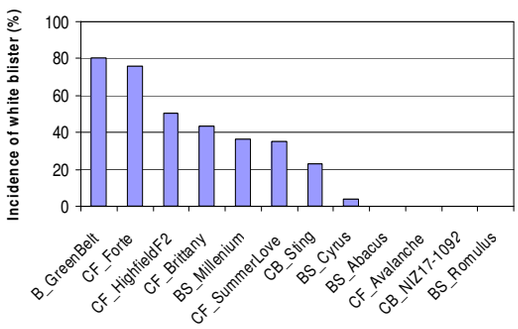

Figure 3. Incidence of white blister on seedlings of commercial *B. oleracea* varieties (B, broccoli; BS, Brussel sprout; CF, cauliflower; CB, cabbage).

Management of White Blister with Variety and Time of Irrigation

Variety:

Growing broccoli varieties resistant to white blister can reduce the levels of the disease on heads by 97% or more (Figs 4 & 5).

Irrigation:

Irrigating broccoli crops in the morning (~4.00 am) instead of the evening (~8.00pm) reduced the incidence of white blister on the heads of a susceptible broccoli variety by 50% (Fig 4).

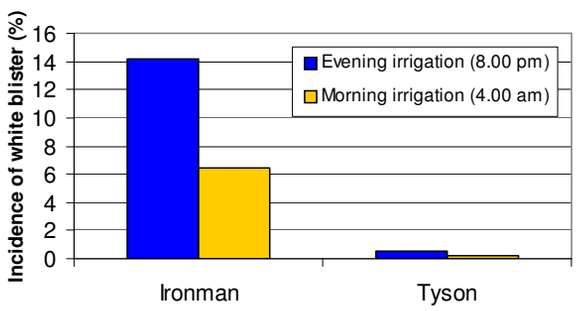

Figure 4. Effect of variety and irrigation timing on incidence of white blister on a susceptible and tolerant variety of broccoli.

Figure 5. Blisters and systemic infection on a very susceptible broccoli variety.

Disease Predictive Models

Figure 6. Weather station.

Disease predictive models forecast the future appearance of a disease in a crop based on microclimate conditions in the crop and the biology of the causal organism. Microclimate conditions are measured by a weather station that records temperature, leaf wetness, relative humidity, solar radiation and rainfall (Fig 6). Data is collected from the weather station either by a modem or by wireless download. Models predict fungal spore release or infection, rarely both. They predict when to spray, which is when the fungus will be active; and when not to spray, which is when the fungus will not be active. Models have their greatest benefit when there is a highly susceptible crop grown under microclimate conditions conducive to disease. Disease predictive models evaluated in this project were DownCast, BremCast and Brassica$_{spot}$™. A model is being developed for powdery mildew on cucurbits.

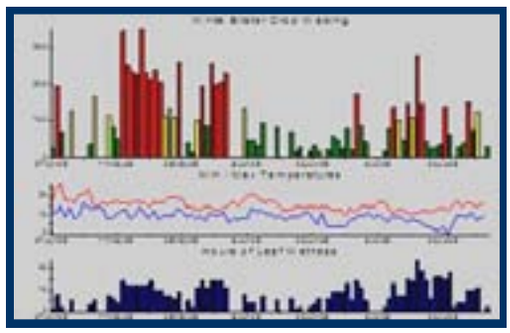

Figure 7. The Brassica$_{spot}$™ model output.
No bars- no risk,
Green bars- low risk,
Yellow bars- moderate risk,
Red bars- high risk of white blister
appearing in the crop in 7, 14 or 21 days.

White blister disease risk predictive model Brassica$_{spot}$™

Broccoli

- The Brassica$_{spot}$™ is a disease risk predictive model, which forecasts when white blister will appear in crops, based on temperature and leaf wetness conditions in the crop (Fig 7).
- The model is most effective in timing sprays on broccoli varieties susceptible to white blister, but not those tolerant to it.
- There are two versions of the model. Spraying according to both versions give the same level of white blister control and equivalent yield as Weekly spray programs (Fig 8).
- Brassica$_{spot}$™ can reduce up to 90% of Weekly sprays on broccoli whilst producing the same level of control as routine spray programs.

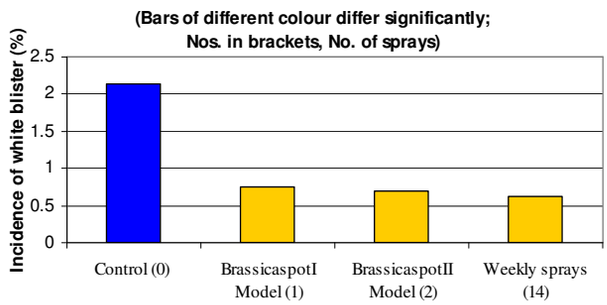

Figure 8. Comparison of Brassica$_{spot}$ models and weekly sprays to control white blister on broccoli heads.

Chinese cabbage

In a Victorian field trial a single spray of a registered systemic fungicide 14 days before harvest reduced the incidence of white blister by 52% on the 4 wrap leaves around the head, which is probably the best phenological time to protect the wrap leaves from white blister. No blister developed on the heads in the trial.

Lettuce downy mildew predictive models BremCast and DownCast

- Currently both DownCast and BremCast disease predictive models generally forecast the reduction of one fungicide spray or the same number of sprays as Weekly sprays or Farm Best Practice spray programs (Figs 11 & 12). Both models can over-predict by one spray in summer.
- Fungicides applied on the basis of the model predictions generally produced the same, or better control of downy mildew than Weekly sprays or Farm Best Practice spray programs (Figs 11 & 12).
- BremCast appears to give better control of lettuce downy mildew compared with DownCast, but is not as user friendly as DownCast. Consequently useful aspects of both models are currently being combined.

In-field Spore Test Kit for White Blister

A spore test kit is being developed in collaboration with UK scientists (Fig 9). It is designed for use in conjunction with the white blister disease risk predictive model (Fig 7). The model predicts microclimate conditions conducive for infection (red bars) and the spore test kit will confirm the presence of spores for infection. The spore trap (Fig 10) collects air samples above a broccoli field, which are then tested for the presence of *A. candida* in the spore test kit (Fig 9). The specificity of the spore test to Australian white blister races was recently confirmed.

Figure 9. In-field spore test kit.

Figure 10. Spore trap for use with the in-field test kit.

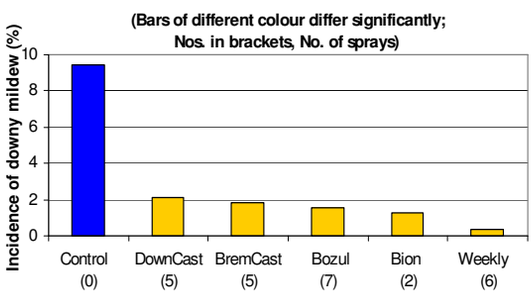

Figure 11. Efficacy of treatments to control downy mildew on cos lettuce.

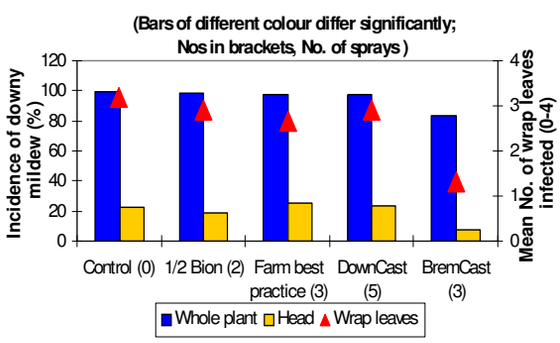

Figure 12. Efficacy of treatments to control downy mildew on iceberg lettuce.

Fungicide Alternatives

Lettuce

- Some fungicide alternatives, such as Bion and Bozyl had a similar efficacy to control downy mildew on cos lettuce as Weekly sprays or sprays applied based on DownCast and BremCast models (Fig 11). Bion was variable, if rates and timing are inappropriate it can cause phytotoxicity or have no efficacy.
- Under high disease pressure 10 weekly sprays of either *B. subtilis* or a fungicide only reduced downy mildew on wrap leaves but not on heads.
- It appears that under low disease pressure some of the fungicide alternatives have efficacy.

Brassicas

Seedlings

- On broccoli seedlings Bion and *B. subtilis* reduced white blister by 40-60% and 72%, respectively, but Vapor Gard and Nu-Film had no efficacy (Fig 13).
- On seedlings of Chinese cabbage and Pak Choi neither Du-wet, Nu-film nor *Bacillus subtilis* had efficacy to reduce white blister, and Bion was phytotoxic (Fig 14).

Foliage

In field trials on foliage of broccoli 'Grevillea', neither sodium lauryl sulphate nor *Streptomyces lydicus*, applied as weekly sprays, controlled white blister. Neither Bion nor *B. subtilis* controlled it on 'Rhumba'. Either Agral, Du-Wett or Designer mixed with a copper fungicide reduced the severity but not the incidence of white blister on foliage of broccoli 'Shamrock' in Tasmania(Fig 15).

Heads

In field trials white blister was reduced on heads of broccoli 'Grevillea' by 40% with sodium lauryl sulphate and by 60% with *S. lydicus.* None of these treatments were as effective as weekly copper sprays which reduced white blister on heads by 96% (Fig 16).

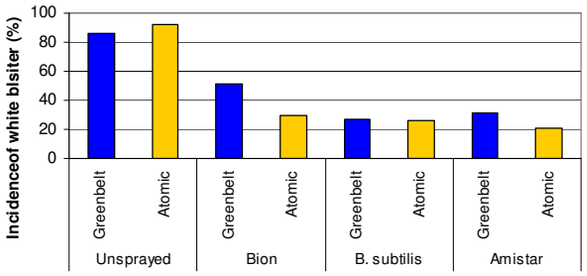

Figure 13. Efficacy of fungicide alternatives to control white blister on susceptible and tolerant brocoli varieties.

Figure 14. Phytotoxicity of Bion on *B.rapa* seedlings.

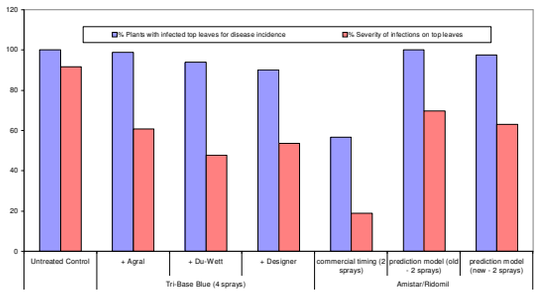

Figure 15. White blister severity on broccoli foliage – comparing prediction models and potential adjuvants for improved efficacy.

Effects of Nitrogen Sources on Lettuce Downy Mildew and Anthracnose

Glasshouse experiments on the effects of three different nitrogen compounds, found interactions between nitrogen source (calcium nitrate, ammonium nitrate and potassium nitrate), variety susceptibility and rate of nitrogen applied. These factors affected the development of downy mildew and anthracnose on lettuce seedlings:

- A high rate of potassium nitrate (KNO_3) promoted downy mildew but had no effect on Anthracnose.
- High rates of calcium nitrate $Ca(NO_3)_2$ resulted in a reduced incidence of Anthracnose.
- Ammonium nitrate (NH_4NO_3) was associated with high levels of both downy mildew and anthracnose.
- A strong varietal response in disease susceptibility and response to nitrogen indicates that balanced nitrogen schedules need to be tailored to the different lettuce varieties.

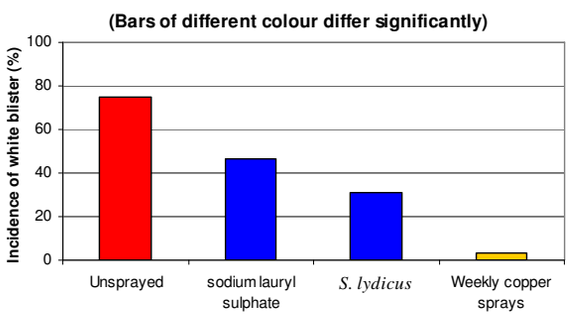

Figure 16. Efficacy of fungicide alternatives to control white blister on broccoli heads in the field.

Economics

- Growing a white blister resistant broccoli variety increases profits by 22%.
- Irrigating in the morning (4.00 am) rather than the evening (8.00 pm) increases profits by 5%.
- The Brassica$_{spot}$ models for white blister can increase profits by 25%, especially on white blister susceptible varieties.
- The BremCast model for downy mildew on lettuce is as good as, or better than, Farm Best Practice or Weekly sprays for contribution to farm profit. It can achieve a 6% increase in profit.
- Bion, if effective has the biggest contribution to farm profit, but is currently not available for vegetable production.