



Developing alternate fungicides to control white blister disease in brassica crops

HAL Project VG04061

Final Report

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MEDIA SUMMARY

White blister (*Albugo candida*) is the most important foliar disease of brassica crops in Australia. The disease can affect all stages of plant growth, but its greatest impact is on infected flower heads, resulting in substantial losses to yield and higher costs in sorting. This Horticulture Australia project aimed to evaluate fungicides for white blister control (*Albugo candida*) and to expedite the registration of suitable fungicides in Australia for white blister control on brassica and leafy brassica crops.

- In these studies, Ridomil Gold MZ and Ridomil Gold Plus at 2.5 kg/ha and 2.2 kg/ha, respectively, were effective for white blister control. The systemic fungicides, Amistar and BAS 500 or Cabrio, were also effective ; however, Penncozeb, Bravo, Filan and phosphorous acid had no effect on the disease.
- Amistar SC at 0.25 and 0.5 L/ha appeared to be adequate for effective disease control, when disease pressure was low and/or when field conditions were not favourable for the disease. Higher rates of Amistar SC at 1.0 and 2.0 L/ha gave better disease control, when the disease pressure was high and field conditions were favourable to the disease.
- Amistar SC or Ridomil MZ must be applied early, at the first sign of infection, for effective disease control. Less effective control by Amistar SC or Ridomil MZ was noted when they were applied later, long after the onset of the disease.
- Copper fungicides based on copper hydroxide or copper oxychloride tend to be less effective than the systemic fungicides in preventing leaf infection, but are effective in reducing head infections. They should be considered for use on crops that are approaching maturity in order to prevent head infections, following early systemic fungicide applications.
- In Tasmania and Victoria, favourable field conditions, consecutive plantings and multiple plantings combine to create a constant disease pressure over a prolonged period of time, as well as prolonged exposure of fungal populations to a fungicide. The systemic fungicides, Amistar, Cabrio, Ridomil Gold MZ and Ridomil Gold Plus have a high risk of resistance development if they are exposed to constant disease pressure. Failure to follow resistance management guidelines carefully will likely result in the loss of these new fungicides as effective control measures. Growers should adopt an integrated disease management strategy that incorporates the use of fungicides, along with other management practices such as resistance cultivars, crop rotations and reducing multiple plantings, for long-term and sustainable disease control.

Fungicide efficacies

White blister (*Albugo candida*) is the most important foliar disease of brassica crops in Australia. The disease can affect all stages of plant growth, but its greatest impact is on infected flower heads, resulting in substantial losses to yield and higher costs in sorting. This Horticulture Australia project aimed to evaluate fungicides for white blister control (*Albugo candida*) and to expedite the registration of suitable fungicides in Australia for white blister control on brassica and leafy brassica crops.

Six efficacy trials were conducted to evaluate azoxystrobin (Amistar SC), chlorothalonil (Bravo Weather Stik), metalaxyl-M + mancozeb (Ridomil Gold MZ) and metalaxyl-M + copper hydroxide (Ridomil Gold Plus) and to determine suitable rates, application timing and programs for white blister control. Another two field trials were conducted to evaluate the alternative fungicides pyraclostrobin (BAS 500 or Cabrio), boscalid (BAS 510 or Filan), BAS 516 (pyraclostrobin + boscalid), BAS 536 (pyraclostrobin + dimethomorph), copper hydroxide (Flo-Bordo) and phosphorous acid (Agri-Fos), for white blister control.

- In these studies, Amistar SC, Ridomil Gold MZ and Ridomil Gold Plus were found to be effective in protecting leaves and heads from white blister.
- Amistar SC was evaluated at rates of 0.25, 0.5, 1.0 and 2.0 L/ha for white blister control. Under high disease pressure, Amistar SC at 1.0 and 2.0 L/ha gave the best disease control. It also gave relatively effective disease control at 0.25 and 0.5 L/ha, which indicates that the lower rates may provide adequate control in situations where disease pressure is low and/or when field conditions are not favourable for the disease
- Ridomil Gold MZ and Ridomil Gold Plus at 2.5 kg/ha and 2.2 kg/ha, respectively, are effective for white blister control. The efficacy of Ridomil Gold MZ was found to be dependent on its history of previous use, locations and farm practices.
- BAS 500 was also found to be effective against white blister. Disease control by the combinational fungicide mixtures BAS 516 and BAS 536 appeared to be due to pyraclostrobin alone. Penncozeb, Bravo, Filan and phosphorous acid had no effect on white blister.
- The contact fungicides based on copper hydroxide or copper oxychloride tended to be less effective than the systemic fungicides in preventing leaf infection under high disease pressure. They were, however, effective in preventing head infections.

Fungicide use

AUSVEG applied for emergency and temporary permits for the use of chlorothalonil, mancozeb, boscalid and phosphorous acid for white blister control in 2003 to 2005. However, in this project, all of these fungicides were found to have no effect against the disease, and growers have since stopped using them for white blister control.

- The temporary permit use of Ridomil Gold MZ, copper oxychloride and Amistar SC expires in March 2008. Ridomil Gold MZ and Amistar SC must be registered with the APVMA for long-term use in brassica crops. In this project, Syngenta Crop Protection Pty Ltd funded a series of residue and efficacy studies in order to generate the data required for the registration of Ridomil Gold MZ and Amistar SC for use on brassica and leafy brassica vegetable crops.
- Copper fungicides based on copper hydroxide or copper oxychloride are alternatives to the systemic fungicides, Amistar and Ridomil Gold MZ, and are already registered for use in Australia for the control of other brassica diseases. They should be considered for use on crops that are approaching maturity in order to prevent head infections, following early systemic fungicide applications. Amistar SC or Ridomil MZ must be applied early, at the first sign of infection in the crop at the pre-button stage, for effective disease control. In this project, Amistar SC or Ridomil MZ sprays were less effective when applied later, long after the onset of the disease.
- In Tasmania and Victoria, favourable field conditions, consecutive plantings and multiple plantings combine to create a constant disease pressure over a prolonged period of time, as well as prolonged exposure of fungal populations to a fungicide. The systemic fungicides, Amistar, BAS 500 and Ridomil Gold MZ have a high risk of resistance development, if they are exposed to the constant disease pressure. Failure to follow resistance management guidelines carefully will likely result in the loss of these new fungicides as effective control measures. Growers should adopt an integrated disease management strategy that incorporates the use of fungicides with other management practices, such as resistance cultivars, crop rotations and reducing multiple planting, for long-term and sustainable disease control.

RECOMMENDATIONS

- For long-term and sustainable white blister control growers should adopt an integrated disease management strategy that incorporates the use of fungicides along with other management practices such as using disease tolerant cultivars, crop rotations, management of crop debris, avoid consecutive brassica crops and reducing multiple planting.
- Currently, the most effective fungicides for white blister control are phenylamide (metalaxyl-M) and strobilurin (azoxystrobin and pyraclostrobin). These fungicides have a high risk of resistance development. It is essential to use a management program to prevent or delay the build-up of resistant fungal populations, in order to maintain and prolong the useful life of the most effective fungicides. Attempting to manage resistance after it has developed is far more difficult than prevention.
- Systemic fungicides should be used early in the epidemic when the pathogen population is low. High-risk fungicides should be used at the manufacturer's recommended full rate and application interval. Therefore, Amistar, Cabrio, Ridomil Gold MZ and Ridomil Gold Plus should be used early; when infections are first noted or when field conditions are conducive to infections.
- A spray mixture of Amistar or Cabrio with copper fungicide should also be considered for fungicide resistance management.
- It is best to limit high-risk fungicide to no more than two consecutive sprays during the crop or as recommended by their manufacturers.
- Copper fungicides applications should be considered, following the early systemic fungicide applications, in order to prevent head infections.
- The number of spray applications will depend on locations, disease pressure, climatic conditions, cultivar susceptibility and crop growth. The disease risk prediction model that was developed in UK based on the temperature and duration of leaf wetness has been shown to have the potential to improve fungicide application timing for white blister control in Australia.
- In commercial practice, it is typical to apply up to two systemic fungicide applications in each planting at the initial flower head formation. Therefore, in order to reduce long-term exposure of the pathogen to a fungicide and hence reduce the risk of fungicide resistance, a block of two spray applications of a systemic fungicide should be considered. For example, apply two applications of Ridomil Gold MZ in one planting, followed by two applications of Amistar SC in the next planting.

Background

White blister (*Albugo candida*) is a fungal disease that became commercially important in Australia in 2002 when the disease became widespread in many broccoli crops in Victoria. The disease can affect all stages of plant growth and can result in substantial losses to yield. Generally, the tolerance level for broccoli head infections in a fresh market broccoli crop is 10%, with increased costs in sorting during and after harvest, and potential losses if the disease develops on heads in storage and in transit to their market. *A. candida* belongs to the same group of fungi, classified as *Oomycetes*, as other fungal pathogens such as *Peronospora*, *Pythium* and *Phytophthora*. Fungicides that are active against the latter pathogens may also have activity against *A. candida*.

When white blister first became widespread in Victoria in 2002, quarantine restrictions were implemented on the interstate movement of broccoli and cauliflower plant material, in order to prevent its spread to other states in Australia. However, these attempts to prevent and eradicate the disease in early 2003 were unsuccessful due to the rapid spread of the disease. The disease is now present in all major brassica production regions throughout Australia. White blister is now considered to be the most important foliar disease on brassicas, namely broccoli, cauliflowers and brussels sprouts. White blister also affects leafy brassica vegetables. The disease is most widespread and severe in Werribee South, Victoria, and in northern Tasmania. Therefore, all fungicide evaluation studies in this project were conducted in these two regions.

Azoxystrobin and metalaxyl-M + mancozeb are systemic fungicides that were identified as being highly effective against *A. candida* on broccoli in Victorian trials in 2003/04, in HAL project VG02118, as well as in a field efficacy trial conducted in 2004 by H. Pung, Peracto Pty Ltd. Growers in Tasmania regularly used chlorothalonil for white blister control in 2003 and 2004, even though no efficacy study has been conducted to establish that chlorothalonil is effective against white blister. No fungicides are currently registered for control of white blister on these crops. Initially, emergency permits were issued by the Australian Pesticides & Veterinary Medicines Authority (APVMA) for copper oxychloride, chlorothalonil and metalaxyl + mancozeb use in Australia, on broccoli and cauliflower, in 2003. These permits have been renewed and are scheduled to expire in March 2008, subject to an understanding that in the interim period, the product manufacturers must make progress in generating the scientific data necessary to support full product registrations for their continued and long-term use in Australia. Brassica is considered to be a major crop and only registered products can be used, and only for the approved purposes that are specific on the fungicide label. This project was, therefore, carried out with voluntary funding and in-kind support from Syngenta Crop Protection Pty Ltd, in order to expedite the product registrations of suitable fungicides in Australia for white blister control on brassica crops. Alternative fungicides, which may also have been effective for white blister control from Nufarm Australia Ltd and Agrichem Industries Pty Ltd, were also examined in initial studies in 2005.

Currently, the lack of choices in fungicides, as well as lack of an informed and proven use of fungicide products, poses a serious threat of their misuse and/or overuse, which could jeopardise their long-term availability and effectiveness. Therefore, regulated and proper use of these products, with full support from the manufacturers, is seen as a vital step in ensuring the long-term efficacy of these products in integration with other non-chemical measures identified in other studies in project VG02118.

Aims

The first aim of this project was to evaluate fungicides for their effectiveness for white blister control on broccoli. If proven to be effective and if considered by the product manufacturer to be feasible for full product registration, further trial studies were conducted to generate all necessary efficacy and residue data required for registering the fungicides with the APVMA.

This project consisted of three main areas:

- Section A: Evaluation and development of effective fungicides from Syngenta Crop Protection for white blister control on brassica crops in Australia. Field trials were conducted to evaluate Amistar, Bravo, Ridomil Gold MZ and Ridomil Gold Plus, and to determine suitable rates, application timing and programs for white blister control. Data generated from the trial studies are also being used to support product registrations and to develop recommendations for label use by Syngenta Crop Protection.
- Section B: Preliminary evaluations of alternative fungicides for white blister control. This study aimed to identify fungicides from other chemical groups that may be effective against white blister and that could be used for fungicide resistance management programs with fungicides identified in Section A.
- Section C: Studies on residues of azoxystrobin, metalaxyl-M and mancozeb in brassica vegetables. This study included residue trials and analysis conducted under GLP (Good Laboratory Practice), and data generated will be used to register Amistar SC, Ridomil Gold MZ and Ridomil Gold Plus for use on brassicas for white blister control in Australia.

GENERAL DISCUSSION

Efficacy of azoxystrobin, chlorothalonil, metalaxyl-M + mancozeb and metalaxyl-M + copper hydroxide

- Six efficacy trials were conducted to evaluate azoxystrobin (Amistar SC), chlorothalonil (Bravo Weather Stik), metalaxyl-M + mancozeb (Ridomil Gold MZ) and metalaxyl-M + copper hydroxide (Ridomil Gold Plus) and to determine suitable rates, application timing and programs for white blister control.
- Amistar SC, Ridomil Gold MZ and Ridomil Gold Plus were found to be effective in protecting leaves and heads from white blister. The efficacy of Ridomil Gold MZ may be dependent on its previous use, locations and farm practices.
- Amistar SC was evaluated at different rates of 0.25, 0.5, 1.0 and 2.0 L/ha for white blister control. Under high disease pressure, Amistar SC applied at the highest rate of 1.0 and 2.0 L/ha gave the best disease control. At the lower rates of 0.25 and 0.5 L/ha, it also gave relatively effective disease control. Therefore, in situations where disease pressure is low and/or when field conditions are not favourable for the disease, low rates of Amistar SC at 0.25 and 0.5 L/ha may be adequate for effective disease control. Whereas, if disease pressure is very high and field conditions are favourable to the disease, higher rates of Amistar SC at 1.0 and 2.0 L/ha should be considered.
- Ridomil Gold MZ and Ridomil Gold Plus at 2.5 kg/ha and 2.2 kg/ha respectively, are effective for white blister control.
- Amistar SC or Ridomil MZ must be applied early, at the first sign of infection in the crop, at about initial button stage, for effective disease control. Less effective control by Amistar SC or Ridomil MZ was noted when they were applied later, long after the onset of the disease.
- Penncozeb applied at 2.2 kg/ha Bravo Weather Stik applied at 1.8 L/ha did not control white blister.

Alternative fungicides for white blister control

- Two field trials were conducted at Forth, Tasmania, and Werribee South, Victoria, to evaluate alternative fungicides for white blister control. The alternative fungicides were pyraclostrobin (BAS 500 or Cabrio), boscalid (BAS 510 or Filan), BAS 516 (pyraclostrobin + boscalid), BAS 536 (pyraclostrobin + dimethomorph), copper hydroxide (Flo-Bordo) and phosphorous acid (Agri-Fos).
- BAS 500 and BAS 536 were effective against white blister. BAS 510 has no effect on white blister. There was no synergistic or additive effect in disease control by the combinational mixture of BAS 516, indicating that only its pyraclostrobin active ingredient was effective against white blister.
- Phosphorous acid did not control white blister on broccoli leaves or heads. It also did not improve white blister control, when applied in a mixture of copper hydroxide + phosphorous acid, when compared to copper hydroxide alone.
- The systemic fungicides, BAS 500 and BAS 536, are suitable alternative fungicides for white blister control. There was no difference in the performance of BAS 500 at 0.25 L/ha and BAS 536 at 1.0 kg/ha. However, the combinational mixtures of BAS 536 may offer advantages in reducing the risk of fungicide resistance.
- Copper fungicides based on copper hydroxide or copper oxychloride are suitable additions to the systemic fungicides, Amistar and Ridomil Gold MZ. When the disease pressure is very high, copper fungicides tend to be less effective than the systemic fungicides in preventing leaf infection. They are, however, very effective in preventing head infections. Therefore, copper fungicides should be considered for use on crops that are approaching maturity in order to prevent head infections, following early systemic fungicide applications to reduce disease pressure to a level that can be readily controlled.

GENERAL DISCUSSION (Cont.)

Permit use and fungicide registrations

- AUSVEG applied for emergency and temporary permits for the use of chlorothalonil, mancozeb, boscalid and phosphorous acid for white blister control in 2003 to 2005. However, in this project, all of these fungicides were found to have no effect against the disease, and growers have since stopped using them for white blister control.
- The temporary permit use of Ridomil Gold MZ, copper oxychloride and Amistar SC expires in March 2008. Ridomil Gold MZ and Amistar SC must be registered by the APVMA for long-term use in brassica crops. In this project, Syngenta Crop Protection Pty Ltd has funded a series of residue and efficacy studies in order to generate the essential data for the registration of Ridomil Gold MZ and Amistar SC for use on brassica and leafy brassica vegetable crops.
- The alternative fungicide, pyraclostrobin or BAS 500 belongs to the same strobilurin chemical group as azoxystrobin (Amistar), and therefore is not a suitable alternative to Amistar. As a result, the product manufacturer and distributor decided not to register it for use on brassicas against white blister in Australia.
- Copper fungicides based on copper hydroxide or copper oxychloride are alternatives to the systemic fungicides, Amistar and Ridomil Gold MZ. Copper fungicides are already registered for use on brassicas for disease control in Australia. They should be considered for use on crops that are approaching maturity in order to prevent head infections, following early systemic fungicide applications.

Fungicide resistance management

- White blister is most common and severe in northern Tasmania and Werribee South, Victoria, due to field conditions that are highly favourable to the spread of the disease. In northern Tasmania, broccoli is typically planted once a year and in 3-4 year rotations with non-brassica crops, and disease pressure ranged from low to moderate. In contrast, at Werribee South, Victoria, broccoli is typically planted throughout the year with or without a short break with a lettuce crop, and disease pressure is usually high.
- In both northern Tasmania and Werribee South, it is a common practice to have consecutive plantings of several broccoli crops adjacent to one another. Under favourable field conditions, the disease incidence and severity can increase in the later plantings as disease pressure increases with each crop. Consecutive plantings and multiple plantings help create a constant disease pressure over a prolonged period of time, as well as prolonged exposure of fungal populations to a fungicide.
- When the disease first became widespread in both regions, growers initially relied solely on Ridomil Gold MZ for disease control. Ridomil Gold MZ is also often used as a curative fungicide, after the disease has become widespread and severe. These practices have resulted in substantial variations in the efficacy of Ridomil Gold MZ, depending on the locations, disease pressure and history of fungicide use.
- The link between leaf infections and head infections is unclear and may be related to environmental conditions and cultivar susceptibility. High levels of leaf infections do not always result in high levels of head infections, and vice versa. However, if leaf infections are not controlled and the pathogen populations become very high, resistance to fungicides can develop quickly because higher numbers of the pathogen are available for selection.
- Currently, the most effective fungicides for white blister control are phenylamide (metalaxyl-M) and strobilurin (azoxystrobin and pyraclostrobin) fungicides. Phenylamides are very systemic compared with other fungicides but most of this mobility is in the xylem. As a result, most of the movement is upwards and outwards in plant tissue. Strobilurin fungicides are strongly held by the waxy layer of leaves and tend to be released gradually over a period of time resulting in useful product redistribution on plant surfaces not directly sprayed. Some strobilurins redistribute internally via the xylem and others externally. Unfortunately, both of these fungicide groups have a high risk of resistance development because they have very specific modes of action. Failure to follow resistance management guidelines carefully will likely result in the loss of these new fungicides as effective control measures.

GENERAL DISCUSSION (Cont.)

- It is essential to use a management program to prevent or delay the buildup of resistant strains, in order to maintain and prolong the useful life of the most effective fungicides. Attempting to manage resistance after it has developed is far more difficult than prevention.
- Phenylamide and strobilurin are “single site” fungicides, because they interfere with a single metabolic pathway in the pathogen. In this case, only a single mutation in the pathogen population is needed for resistance to develop. The development of resistance to this type of fungicide can be extremely rapid.
- Copper fungicides are “multi site” fungicides because they interfere with multiple metabolic sites in the pathogen. Several mutations must occur simultaneously before resistance to fungicides of this type can develop. The resistance results from the modification of several genes, and develops somewhat gradually over time. Increasing the fungicide application rate or the frequency of application improves performance, but continued use could eventually result in complete loss of control.
- It is best to limit high-risk fungicides to no more than two consecutive sprays during the crop or as recommended by their manufacturers.
- High-risk fungicides should be used early in the epidemic when the pathogen population is low. The tactic of using high-risk fungicides as curatives (eradicator) is inconsistent with good resistance management. Resistance can develop quickly when fungicides are used curatively because far higher numbers of the pathogen are available for selection and survival, and intermediate resistance can more easily be selected.
- High-risk fungicides should be used at the manufacturer’s recommended full rate and application interval. Reduced rates could increase the populations of pathogen strains that are of intermediate resistance.

Fungicide use and timing

- Systemic fungicides such as Amistar, Cabrio, Ridomil Gold MZ and Ridomil Gold Plus should be used early, when infections are first noted, usually at the initial flower head formation or initial button stage. A spray mixture of Amistar or Cabrio with copper fungicide should also be considered for fungicide resistance management.
- The number of spray applications will depend on locations, disease pressure, climatic conditions, cultivar susceptibility and crop growth.
- Under low disease pressure and conditions that are not favourable to the disease, one to two systemic fungicide applications applied at the initial button stage appear to be sufficient for white blister control. Under high disease pressure and favourable conditions, at least four fungicide applications may be required for effective control of leaf and head infections.
- In commercial practice, it is typical to apply up to two systemic fungicide applications in each planting at the initial flower head formation. Therefore, in order to reduce long-term exposure of the pathogen to a fungicide and hence reduce the risk of fungicide resistance, a block of two spray applications of a systemic fungicide should be considered. For example, apply two applications of Ridomil Gold MZ in one planting, followed by two applications of Amistar SC in the next planting.
- Copper fungicides should be considered on crops that are approaching maturity in order to prevent head infections, following the early systemic fungicide applications.
- Apart from fungicide control methods, growers should also adopt an integrated disease management strategy that incorporates the use of fungicides along with other management practices such as resistance cultivars, crop rotations and reducing multiple planting for long-term and sustainable disease control.

TECHNOLOGY TRANSFER

- Detailed efficacy trial reports were sent to the appropriate agricultural chemical companies in 2005, 2006 and 2007.
- Workshop meeting held with Dr. Elizabeth Minchinton at Werribee on 6 May 2005 to review and extend project studies and exchange information.
- Project outcomes were presented at a Tasmanian vegetable extension day held at Devonport on 27 July 2005.
- Project outcomes were presented at the Brassica Disease Workshop on 10 November 2005 at Forth, Tasmania.
- A flyer on white blister - fungicide resistance management that was prepared in consultations with Syngenta Crop Protection Pty Ltd and Nufarm Australia Limited, was distributed to growers and consultants in 2005 and 2006.
- Progress of the project studies was presented and discussed at the Brassica Review Meeting with HAL and industry representatives on 13th March 2006 at Coogee, NSW.
- Project outcomes presented at a Tasmanian vegetable extension day held at Ulverstone on 25 July 2006.