Management of fungal diseases of canola for a sustainable canola industry in Western Australia

Summary

The rapid expansion of area under canola in Western Australia (WA) has increased the impact of fungal diseases, particularly blackleg. In WA alone, losses in 1998 and 1999 from blackleg were estimated to be in the order of $20 and $50 million, respectively. The research in the current project focused on identifying improved host resistance to blackleg, improved cultural practices and more effective chemical strategies needed for minimising losses from blackleg and to ensure sustainability of the WA canola industry. The research also focused on clearly defining the threat posed by various other fungal diseases to canola crops in WA.

During the project, approximately 4,000 canola genotypes were evaluated for their resistance to blackleg under extreme disease pressure. About 600 entries were found to have superior resistance than the resistance of current commercial varieties. This research has helped the National Brassica Improvement Program (NBIP) to release canola varieties most adapted to the WA environment with improved resistance to blackleg. Four blackleg management packages were developed to help growers to assess their risk and apply appropriate management strategies to minimise losses from blackleg. These packages were widely adopted by growers and enhanced their confidence in considering canola as a profitable crop in their cropping system.
Conclusions

During its five year tenure, the project has produced four blackleg management packages and produced data in the development of the Blackleg Sporacle model. The blackleg management packages have been widely adopted and used by growers not only in WA but also in eastern Australia. The scientific merit of work done towards epidemiology of blackleg and Blackleg Sporacle model has been internationally recognised. The following conclusions were drawn from the research conducted in the project.

Blackleg in canola

1. Monitoring: A shift towards growing highly resistant varieties and good management practices has helped to lower overall blackleg levels. However, high blackleg levels found in varieties with sylvestris resistance highlight the need for growers to reassess their risk from blackleg and consider the overall management strategies including avoiding residues and use of fungicides especially if growing these varieties in order to minimise the risk of resistance breakdown.

2. Resistant varieties: Growing resistant varieties is the most economical means of managing blackleg. Blackleg resistance rating on canola varieties is updated based upon their performance under extreme blackleg pressure. A Farmnote is prepared each year to help growers to choose the most resistant canola varieties suitable for their area.

3. Fungicides: Impact® as in-furrow treatment and Jockey® as seed dressing were the best fungicide treatments to reduce losses from blackleg. However, other fungicides such as prochloraz® and flusilazole® have the potential to control blackleg and improve yield of canola if used either as spray applications or in a combination of seed dressing with Jockey.

4. Stubble management: Raking and burning of canola stubble reduce the amount of stubble by more than 80%. This is a good option for growers in areas not prone to wind erosion. Another means of reducing the blackleg inoculum is by applying some chemicals to the residues. There is a potential for some chemical treatments such as Impact, glyphosate® and copper sulphate® to suppress the production of fruiting bodies and ascospores of the blackleg fungus when applied directly to the residues.

5. Epidemiology and Blackleg Sporacle: The blackleg spore showers commence early in the southern high rainfall region due to cooler and wetter summer and autumn conditions. In comparison, maturation of fruiting bodies is delayed by about two months in the northern agricultural region and consequently the ascospore showers commence late in the season. This provides an opportunity for growers in the Northern Agricultural Region of WA to sow crops earlier in order to considerably
reduce the risk of blackleg.

Hypocotyl rot caused by *Rhizoctonia* spp.
1. Current commercial canola varieties are very susceptible (VS) to hypocotyl rot and damping-off caused by *Rhizoctonia* spp. Therefore, seed dressing with Rovral® is the only option for growers, particularly in high damping-off risk situations.
2. In case of complete stand failure to hypocotyl rot/damping-off, resowing either to canola or cereals is the best option. Delaying sowing canola by three weeks reduces the risk of hypocotyl rot and damping-off.

Downy mildew
There is very little resistance to downy mildew in the existing canola varieties. Preliminary experiments under controlled conditions have shown the potential for Axiom® MZ 720 to control downy mildew if sprayed before onset of the disease.

**Recommendations**

**Blackleg**
- Choose the right paddock. Avoid paddocks with recent canola residues (1-2 years).
- Choose the best adapted variety with the highest level of blackleg resistance.
- Maximise the distance between last year’s residue and this year’s crop; upwind is better.
- Crop protection fungicides are important tools for managing blackleg. These should be used wisely and where appropriate, as these are only a part of the overall risk management strategy against this disease.

Economic benefit from applying fungicides depends upon:
- varietal resistance
- disease pressure
- yield potential.

Using Impact®
Impact (active ingredient flutriafol®) can give useful protection against blackleg, especially during crop establishment. Yield responses to Impact have been assessed for most varieties based on several years of trial data. The yield loss guidelines in the package should help find out the economics of using or not using Impact in a given situation.

To achieve an economic return from canola in terms of fungicide application:
Use Impact when growing a variety with moderate canker resistance (4-6) and it is under moderate to high disease pressure; Avoid applying Impact where a variety has either high canker resistance (7) together with good yield potential and low disease pressure, or low canker resistance (3) together with very high disease pressure. Impact is not required for varieties with very high canker resistance (8+).

Minimising the risk of blackleg spore showers
Extensive research has been conducted on the timing of maturation of fruiting bodies and patterns of spore release of blackleg in different agroclimatic regions of WA. A model (Blackleg Sporacle) has been developed to predict the timing of spore release in different regions. Using daily temperature and rainfall inputs over summer and autumn, the model can provide a seasonal estimate on the arrival of the first ascospore showers. The model can provide growers with an early warning to avoid the spore showers at the critical stage of susceptibility by manipulating the time of sowing the crops if possible. A forecast on the likelihood of first spore showers is made available to growers either through Pestfax or the Department of Agriculture’s website and is updated regularly at fortnightly intervals.

Hypocotyl rot and damping-off caused by *Rhizoctonia* spp.
Avoid sowing at the opening rains especially in sandy soils when *Rhizoctonia* activity is at its maximum.
Use Rovral® as seed dressing to provide control of damping-off.
In case of stand failure due to rhizoctonia, the best option is to resow the crop.

**Outcomes**

Economic outcomes

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# Refer to ‘Report Disclaimer’
Canola growers are attaining economic benefits by applying Impact® to their canola crops under various blackleg risk situations. The effectiveness of Impact is largely dependent on the amount of disease pressure and the level of varietal resistance. The cost-benefit scenario (gross margin) varies in different canola growing regions of Western Australia under different disease pressures. An example would be the variety Surpass 300TT (WA blackleg canker rating 4) grown in the Great Southern Region under moderate disease pressure. With a yield potential of 1.2t/ha and an on-farm price of $350 per tonne, the use of Impact may provide a gross margin of $59/ha compared with a gross margin of $5 if Impact is not used. This is a great benefit for growers who have to grow their crops under this scenario.

On the other hand, canola growers in the Northern Agricultural Region are gaining economic benefits from this project following the recommendations of the Blackleg Management package. They are sowing canola early in the season, therefore, avoiding blackleg disease and the necessity to use Impact in-furrow.

Environmental outcomes

Integrated disease management (IDM) strategies will reduce the amount of fungicide used in canola crops. With the help of forecasting blackleg spore showers, growers are able to assess the likelihood of occurrence of spore showers in their crops and can decide if they need to apply fungicides. This will reduce the need for unnecessary fungicide use and improve the profitability of canola crops.

Social outcomes

This project is helping to sustain the canola industry in WA by minimising disease impacts on canola yields. To avoid the high risk growers perceive to be associated with the production of this crop, there has been a tendency towards reducing the area sown to canola. The major concerns for growers in terms of canola production are price volatility, high cost of production relative to cereals and high management input for disease control impacting on their family and social engagements. Improved integrated disease management (IDM) will help growers to maintain their income and boost their confidence in sustained canola production. More recently, breakdown of blackleg resistance in highly resistant varieties caused concern and anxiety in farming communities. This project has helped to deliver timely resistance management strategies to minimise the likelihood and impact of breakdown of resistance and, therefore, has been helpful in minimising anxiety.

Achievements/Benefits

The rapid expansion of area under canola in Western Australia has increased the impact of fungal diseases, particularly blackleg. In WA alone, losses in 1998 and 1999 from blackleg were estimated to be in the order of $20 and $50 million, respectively. Research in the current project focused on identifying improved host resistance to blackleg, improved cultural practices and more effective chemical strategies needed for minimising losses from blackleg and to ensure sustainability of the WA canola industry. The research also focused on clearly defining the threat posed by various other fungal diseases to canola crops in WA.

This project commenced in July 1998. Since then a substantial amount of germplasm has been screened for resistance to blackleg from the national and international brassica breeding programs (NBIP).

Following achievements have been made;

Evaluation of Brassica germplasm for resistance to blackleg

During 1998-2003, approximately 4,000 lines including commercial varieties, alternative sources of resistance from the NBIP, and specialty oil canola lines from the international breeding programs (Dr Roy, Cornell University and Dr Paul Raymer, University of Georgia, USA) were evaluated for their resistance to blackleg under severe disease pressure each at Mt. Barker and Wongan Hills, respectively. About six hundred lines were found to have superior resistance than the resistance in the current available commercial varieties (e.g. Oscar and Dunkeld).

The results from all these trials were reported to the respective breeders to further incorporate the best resistance in their canola breeding programs. The data on levels of resistance found in commercial varieties were incorporated with data in eastern states' nurseries and a varietal list of blackleg resistance ratings was produced by the Canola Association of Australia (CAA). This research has contributed to the development of new Australian varieties with improved blackleg resistance.

Monitoring blackleg and other canola diseases

During 1998-2003, canola crops were monitored for incidence and severity of blackleg and other diseases throughout WA.
The mean statewide incidence and severity of blackleg varied over years due to management practices and fluctuating weather conditions during the growing seasons. There was a significant increase in both the incidence and severity of blackleg in varieties with sylvestris resistance in the 2003 growing season. This research had provided timely feedback to growers about the distribution and impact of new strains that had the ability to overcome sylvestris resistance. Other diseases such as downy mildew, hypocotyl rot caused by *Rhizoctonia*, sclerotinia stem rot and white leaf spot were significant in terms of reducing canola yields in some worst cases but did not appear to be an immediate threat to the canola industry.

Effectiveness of host resistance under severe blackleg pressure

In 2001, trials were conducted at two different locations to investigate the effectiveness of host resistance under three different disease pressures. Due to atypical seasonal conditions, the disease development was not sufficient in the trials to evaluate resistance. The treatment of maximum protection with fungicides significantly reduced the disease severity in susceptible to moderately resistant (MR) varieties but not in the highly resistant variety Surpass 501TT. However, this treatment increased the seed yield only on six and 30 month old residues at Merredin and Wongan Hills, respectively. The results suggest that the best effective chemical application may be with varieties with moderate levels of blackleg resistance.

Evaluation of fungicides for the control of blackleg

Trials were conducted to evaluate the efficacy of different fungicides as ‘in-furrow’ treatments, foliar treatments and as a combination of seed and foliar treatments in separate trials at different locations across WA. Impact® as in-furrow was the most effective fungicide in reducing blackleg severity and improving yield of canola compared with seven other fungicides tested as in-furrow treatment. However, among fungicides tested either as seed dressing alone or a combination of seed dressing and foliar application, seed treatment with Jockey® either alone or in combination with prochloraz® were equally effective as Impact in-furrow. These results suggest the potential for other fungicide treatments to manage blackleg in order to provide growers with some flexibility in choosing the best and most economical fungicide regime.

Effect of position of fungicide treated fertiliser placement

An additional trial was conducted at Wongan Hills to investigate various means of placing Impact treated double super fertiliser at various positions in relation to the seed to more effectively control blackleg and improve yield in canola. Placing Impact treated double super fertiliser 2cm below the seed or banding sideways at 2cm or drilling with the seed were equally effective treatments for control of blackleg and improving yield in canola. However, the treatment of top dressing with or without Impact was not effective in reducing blackleg.

Cultural practices to reduce the spore load on residues

Trials were conducted to evaluate various treatments to increase the rate of stubble breakdown in order to reduce the amount of blackleg inoculum at Avondale. The treatment of raking and burning significantly reduced the amount of stubble. However, the treatment of scarifying the stubble was ineffective. Likewise, various seeding techniques (knife point, narrow point, full cut point and disc) had no significant effect on stubble breakdown on their own. This research has potential for growers to reduce the blackleg inoculum by raking and burning.

Chemical suppression of blackleg on canola residues

Various chemical treatments, including Impact, Benlate®, Roundup®, urea, copper sulphate® and calcium compounds were evaluated for the suppression of blackleg spore production on canola residues under natural conditions. The visual effect of spore release clearly demonstrated the efficacy of Impact. Roundup and copper sulphate in suppressing spore production on the residues. This research has identified the potential for some chemical treatments in controlling the sexual stage of the fungus by direct application of chemicals to the residues to reduce the spore load while maintaining the benefits of retaining stubble on the soil surface.

Effect of time of sowing on severity of blackleg

This was additional research conducted to explore the effect of time of sowing on incidence and severity of blackleg disease in canola. Delaying sowing until July reduced blackleg severity at most locations, however, the late sowing resulted in yield penalties due to a shortened growing season. Results of studies conducted in the project suggest two possible scenarios for minimising losses from blackleg. First, the crops should be sown as early as possible before the onset of maturation of pseudothecia in order to escape major ascospore showers at the most susceptible seedling phase. This could be possible only if there is an opportunity to sow early with the early start of the season. Secondly, in case of a late start to the season, fungicide protection may be necessary, particularly for crops that are sown after mid June as yield losses from blackleg on late sown crops are very high.
Epidemiology of blackleg
Research has been conducted on the timing of maturation of fruiting bodies (pseudothecia) and discharge of ascospores of blackleg since 1998. The fruiting bodies of blackleg are produced earlier in high rainfall areas and late in low rainfall areas. Likewise, the discharge of ascospores starts earlier in high rainfall areas and late in low rainfall areas. The ascospores continue to discharge over longer periods in high rainfall areas, whereas, the discharge window is fairly narrow in low rainfall areas. The results of this research were used by project DAW621 to develop a computer model to predict the timing of major ascospore showers so that growers could alter the time of sowing to avoid major ascospore showers coinciding with the seeding susceptible stage.

Rhizoctonia hypocotyl rot
Rhizoctonia hypocotyl rot is associated with poor stand establishment of canola and emerged as a significant problem, especially in the Great Southern Region of WA during 2000 and 2001. A total of 50 isolates were collected from the affected crops and characterised using pectic enzyme electrophoresis. A strain of *Rhizoctonia solani* (ZG5) was found to be most predominantly associated with hypocotyl rot. Trials were conducted to investigate the effect of time of sowing on severity of hypocotyl rot and damping-off caused by *Rhizoctonia solani* (ZG5). The results indicated that the disease is particularly severe if sown earlier and delayed sowing significantly reduces the disease severity.

Downy mildew
*Downy mildew, caused by Peronospora parasitica* is a serious disease affecting young canola seedlings early in the season in WA. Systemic infection at the seedling stage causes stunting of the plants and occasionally kills the plants if the infection is very severe. Eleven commercial varieties of canola were evaluated in a growth chamber experiment for their resistance to downy mildew. The varieties with comparatively high resistance were Surpass 501TT, Hyden, Surpass 400, with severity scores ranging between 5.3-6.2, followed by Surpass 300TT, Outback and Beacon, with severity scores in the range of 6.3-6.8. Current commercial varieties of canola are very susceptible (VS) to downy mildew. Therefore, efficacy of various fungicides was tested for the control of downy mildew in a growth chamber. Four fungicides, Jockey, Aliette®, Coppox® and Benlate (a.i. 500g/kg benomyl) were evaluated as seed dressings. In another experiment, Axiom® MZ 720 was tested either as a seed dressing or as a combination of seed dressing and foliar spray applied at five, seven and 15 days after inoculation or one day before inoculation. None of the fungicides except Jockey tested in the first experiment were effective as a seed dressing to provide protection against downy mildew. However, Axiom MZ 720 as a seed dressing provided protection for only one week. The foliar spray of Axiom MZ 720 was not effective in providing protection if sprayed after inoculation. However, when it was applied as a foliar spray a day before the inoculation, it provided excellent control of downy mildew by completely inhibiting disease development. Therefore, control of downy mildew by foliar application of Axiom MZ 720 before the onset of the infection seems promising under growth chamber conditions and needs to be further tested under field conditions.

Extension
The findings of this project have been published at three international and two national conferences, talks and posters at Crop Updates and field days. Other publications include seven scientific papers, four blackleg management packages, four Farmnotes, one technical bulletin, AgMemo articles and Pestfax articles. The research was also extended through a radio interview, press releases and talks to advisers.

Benefits to the industry
The canola industry in WA has benefited from this project by monitoring fungal diseases of canola, particularly blackleg disease and its management. The findings of blackleg monitoring have indicated that levels of this disease are continuously rising and growers have been given advice to apply appropriate management strategies in order to reduce losses from blackleg. The major benefit is from the disease management strategies defined from this project. The disease management trials using the fungicide Impact in-furrow and Jockey as a seed dressing have shown a yield increase of 200kg/ha in moderately resistant (MR) to susceptible varieties when crops are grown under moderate disease pressure. These practices have been widely adopted by growers. Given the fact that the breakdown of resistance in highly resistant varieties has forced growers to grow MR varieties, the net return using Impact or Jockey is expected to be $14-$30/ha, which in turn across the order of 200,000 hectares of canola will result in large returns to the industry (estimated to be $3-$6 million).

Furthermore, the development of the Blackleg Sporacle model that can be used by growers to decide if they need to apply the fungicides based upon the synchronisation of spore showers with the susceptibility stage of the crop is likely to reduce the cost of canola production.
Other research

Other research and development (R&D) opportunities identified during this project have been incorporated into the current GRDC funded project, DAW00106 ‘Managing disease constraints in Western Region farming systems’. There is considerable potential for further epidemiological research to fine-tune Blackleg Sporacle. There is great scope for evaluating foliar fungicides for control of blackleg in order to provide growers with the flexibility of choosing the best fungicide regime suitable to their farming practices. The option for foliar fungicide application will also have a great place in forecasting blackleg spore showers in situations where growers missed the opportunity to apply in-furrow or seed dressing fungicides while seeding can have the option of foliar fungicide applications if Blackleg Sporacle forecasts the risk of spore showers coinciding with the susceptible stage of their crop.

The project already has a close collaboration with the modelling project DAW00018 to develop epidemiological models. Blackleg Sporacle was regarded as having great potential to be used in Victoria, New South Wales and South Australia at the National Canola Pathology Meeting held at the University of Melbourne on 26 February 2002. There is a good opportunity to further strengthen this collaboration with the eastern states through project DAW00018. Furthermore, there is also an opportunity for international collaboration on blackleg epidemiology and modelling with European researchers.

Breakdown of the sylvestris resistance gene in previously highly blackleg resistant varieties caused a great concern in terms of sustainability of the canola industry. Opportunities exist for interstate collaboration in understanding the virulence of resistance breaking strains.

During the current and past growing seasons, white leaf spot caused by *Pseudocercosporella capsellae* has emerged as a significant problem throughout the northern and southern agricultural regions of Western Australia. There is very little understanding of the epidemiology and management of this disease as it has been of relatively minor economic significance in the past. An opportunity exists to develop best management strategies to control this disease.

**Intellectual property summary**

The data obtained on the timing of maturation of blackleg pseudothecia and discharge of ascospores have been used to develop the Blackleg Sporacle model in the project DAW00018 supervised by Dr Art Diggle. Therefore, intellectual property (IP) management issues relating to blackleg modelling will be addressed in DAW00018. Some resistance sources screened were owned by third parties. The Australian adapted germplasm is owned by the Western Australian, Victorian and New South Wales governments, mostly in collaboration with the GRDC through the NBIP.

**Additional information**
