GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

UM00020

Strategies to ensure longevity of blackleg disease resistance genes in canola

PROJECT DETAILS

PROJECT CODE:	UM00020
PROJECT TITLE:	STRATEGIES TO ENSURE LONGEVITY OF BLACKLEG DISEASE RESISTANCE GENES IN CANOLA
START DATE:	01.03.2004
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Summary

This project investigated whether rotation of canola varieties derived from different blackleg resistance sources can increase the durability of blackleg resistance as well as reduce yield loss caused by blackleg.

Key findings include:
1. The blackleg fungus responds to changes in sources of variety resistance.
2. Blackleg severity remains low when canola is sown into canola stubble, provided that the new canola variety is based on a different source of resistance.
3. Isolates from a particular resistance source were more virulent when screened back on the same resistance source.
4. Stubble and canola of the same resistance source should be separated by 500 metres.

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Old or Archival Reports (Projects that concluded in 2007 or earlier)

The information contained in these older reports is now several years old, and may have been wholly or partially superseded or built upon in subsequent work funded by GRDC or others. Readers should be aware that more recent research may be more useful for their needs. Findings related to agricultural chemical use are also potentially out of date and are not to be taken as a recommendation for their use.

Conclusions

There are two main conclusions from this project:

1. Blackleg isolates are specific to particular sources of canola blackleg resistance. It is possible to obtain isolates with multiple virulences but they do not appear to increase in frequency within the total blackleg population. Therefore, blackleg will generally become more virulent on a source of resistance if that resistance is sown in consecutive years. If sources of resistance are switched each season, the proportion of blackleg isolates able to attack any given resistance should remain low.

2. It is possible to protect a source of blackleg resistance by avoiding stubble of the same type. A distance of at least 500m is required from the previous year's stubble of the same stubble type.

Given the main findings from this project, it is highly probable that more sophisticated blackleg management strategies can be developed. If growers separate the same resistance sources in space and time, blackleg severity will be reduced and the longevity of resistance sources will be increased.

Field monitoring showed that the population structure of the blackleg fungus was directly determined by which varieties growers sowed. Growers therefore had direct control on the virulence of the blackleg population. Monitoring also showed that previously overcome resistance sources could be restored by not sowing them for a period of time. It is now up to the industry to use this to their advantage and to avoid a repeat of the 2003 blackleg wipe-out that occurred on the Eyre Peninsula in South Australia (SA).

Recommendations

The main recommendation is to use this knowledge to produce a durable blackleg management strategy for the canola industry. This recommendation has already been acted on by the GRDC through funding of the current project 'Pilot scale implementation strategy to maximise durability of blackleg resistance in canola'.

Further recommendations are to the breeding, germplasm enhancement and seed production industries. This work has shown that simply screening canola lines on polygenic stubble will not provide total blackleg resistance. In preliminary discussions with breeding companies, there is a recognition of the importance to screen National Variety Trial (NVT) lines on stubbles from polygenic, sylvestris derived, *Brassica juncea* and winter-type canola. This screening is already being completed for some commercial varieties through the current GRDC project and could easily be extended to include all commercial varieties and NVT lines.

Outcomes

The project outcome is expected to be reduced blackleg severity and increased durability of blackleg resistance sources within Australian canola varieties. As blackleg is the main disease of canola in Australia and can typically cause 10 to 20% yield loss, the key findings from this project will have significant economic benefits to the Australian canola industry. The key output from this project is a potentially entirely new blackleg management strategy for the industry.

Over the past 35 years, Australian canola breeders have successfully developed highly blackleg resistant varieties which have been widely adopted by growers. However, in recent years, the blackleg fungus has overcome a number of different resistance sources. Initial field observations showed that where one source of blackleg resistance was severely infected, other sources in the same location often had little disease. This project supports this initial observation. Blackleg isolates that are virulent on a particular source of resistance increase in frequency when exposed to that resistance and decline in frequency when not exposed to the same resistance source.

This knowledge has led to the following proposed blackleg management strategy. The industry 'backbone' will continue to be polygenic blackleg resistant varieties. Growers will be able to use other sources of blackleg resistance but they must separate them in space and time from stubble of the same resistance source. This will result in lower disease severity in the polygenic varieties and a lower probability of isolates of the fungus overcoming any particular source of resistance.

To implement the proposed management strategy, growers will require considerable support. This is being addressed in the current project ‘Pilot scale implementation to maximise durability of blackleg resistance in canola’.

The following information will be made available to growers;
1. Warnings on individual varieties that may be becoming more susceptible to blackleg.
2. All commercial varieties will be divided into their different blackleg resistance groups.
3. Pathogen monitoring to inform the industry how the system is working, and to provide warnings prior to any major events such as the complete resistance breakdown seen on the Eyre Peninsula in 2003.
4. A detailed blackleg management plan. The plan will be in a similar format as the current ‘Australian blackleg management guide'.

Growers, advisers, breeders, pathologists and the seed industry will be involved together in the development of the blackleg management plan to ensure that it is logistically feasible and adopted by industry.

Scientific knowledge required to develop an entirely new disease management strategy for Australian growers has been acquired. The challenge is to use this knowledge to create a logistically workable management strategy that can be readily adopted by the Australian canola industry.

Achievements/Benefits

Blackleg caused by *Leptosphaeria maculans* is the major disease of *Brassica napus* (canola) worldwide. Monogenic resistance, derived from *Brassica rapa* ssp. *sylvestris* has been overcome in Australia, causing severe yield losses in canola varieties reliant on this resistance source. In addition, polygenic resistance in some varieties has been eroded with time. This loss of resistance is due to the increased frequency of aggressive isolates in fungal populations under selection pressure from resistance genes in the host. Experience in other crops suggests that rotation of different resistance genes in space and time may reduce the frequency that resistance genes are rendered ineffective by changes in fungal populations.

This project aimed to determine if rotation of canola varieties derived from different blackleg resistance sources could increase the durability of the resistance sources in canola varieties and thus reduce yield loss caused by blackleg.

Key findings
1. Populations of the blackleg fungus respond very quickly to changes in sources of blackleg resistance in canola. For instance, on Eyre Peninsula in 2002 canola varieties containing sylvestris-derived resistance were immune to blackleg, while in 2003 and 2004, crops were totally susceptible. At trial sites in 2005 and 2006, these varieties had lower levels of blackleg severity, as local growers had not grown these sylvestris-derived varieties since 2003.
2. Blackleg severity remained low over the three years of this project (2004-06) when canola was sown into canola stubble from the previous year, provided that the new canola variety was based on a different resistance source to the stubble into which it was sown.
3. Blackleg isolates display host specificity. Isolates collected from a particular resistance source were more virulent against

the source that they were collected from, but less virulent against different sources of resistance.
4. The isolation distance required between stubble and canola of the same resistance source is approximately 500 metres. This was consistent even where the sylvestris resistance had been overcome. The time required between crops of the same resistance source was 30 months.
5. Climate, environment and canola production intensity have a major influence on blackleg severity enabling a risk based blackleg management plan to be developed.
- High risk - continuous cropping, high rainfall.
- Medium risk - long rotations, medium rainfall.
- Low risk - opportunistic canola planting, low rainfall.

Canola varieties reliant on the same resistance genes could be separated in space and time. Therefore, growers could be encouraged to:
- Grow polygenic varieties, where possible.
- Grow varieties with different sources of blackleg resistance but never in successive years.
- Keep a minimum of 500 metres between the current crop and previous stubble of the same resistance source.

These results suggest that rotating canola varieties that use different blackleg resistance sources may reduce blackleg severity. In view of the experience in other crops, this could also reduce the risk of blackleg resistance being overcome by the blackleg fungus.

Given that the blackleg fungus responds so quickly to new sources of blackleg resistance, the Australian canola industry must develop production systems that do not expose the same resistance sources to the blackleg fungus for consecutive years. Rotation of resistance may reduce the frequency of blackleg strains that are capable of overcoming particular sources of resistance. This strategy thereby would prolong the life of varieties.

Other research

Future work

Monitoring blackleg severity on different sources of host resistance.
Data collected from the field are crucial to support any management plan for durable blackleg resistance. Monitoring advanced yield trials will be an early warning system to growers to advise if a source of blackleg resistance has been overcome by the fungus. It will also show if the durable blackleg management plan is working in the field. The following activities will be pursued:
1. NVT field surveys - to determine areas where resistance is being overcome.
2. Replicated sites - for destructive sampling in yield and blackleg nurseries. Regions of high blackleg severity will be targeted.
3. Screen new isolates for multiple virulence - aggressive isolates will be collected from field surveys and replicated sites, they will be screened for virulence across different sources of resistance.
4. Resistance erosion alerts - blackleg rating data and the data collected in the above points will be used to place alerts on varieties with possible erosion of blackleg resistance.
5. Monitor populations of fungi for changes in virulence via markers. This is being carried out by Barbara Howlett and Angela Van der Wouw via a new GRDC project.

Pilot scale implementation
A pilot scale program will be undertaken for three years before a durability plan is released to growers in 2010.
1. Available sources of blackleg resistance
- Polygenic (most commercial varieties).
- Winter/polygenic group (commercially available).
- Sylvestris/polygenic (commercially available).
- Brassica juncea - (commercial release in 2007 - Dune⁽ᶦ⁾).
2. Classify varieties into four groups - using pedigree information, molecular markers if available, and screening commercial varieties against known blackleg isolates.
3. Working Group (pathologists, breeders, growers, advisers) - to determine best practical management guide, that utilises the results from project UM020.
4. Potential grower package

- Australian Blackleg Ratings with resistance erosion alerts.
- Variety resistance groups guide.
- Durable blackleg resistance management guide; could be produced as a management practice within the existing guide.

Intellectual property summary

This projects contains no intellectual property. All information in relation to the durability of blackleg resistance will be freely available to the canola industry.

Additional information

Papers in internationally refereed journals

Balesdent, M.H., Barbetti, M.J. Hua Li, Sivasithamparam, K., Gout, L. and Rouxel, T. (2005). Analysis of Leptosphaeria maculans race structure in a world-wide collection of isolates. Phytopathology 95: 1061-1071.

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Fitt, B.D.L., Brun, H., Barbetti, M.J. and Rimmer, S.R. (2006). World-wide importance of phoma stem canker (Leptosphaeria maculans and L. biglobosa) on oilseed rape (Brassica napus). European Journal of Plant Pathology 114: 3-15.

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