National Brassica Germplasm Improvement Program

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ABSTRACT

The National Brassica Germplasm Improvement Program (NBGIP) is responsible for the development of germplasm incorporating new or enhanced traits for the Australian canola industry. NBGIP’s pre-breeding activities comprise two separate, but linked, GRDC projects being carried out by NSW DPI and Vic DPI. The purpose of NBGIP is to 'equally and fairly' provide advanced canola germplasm containing important new or improved traits to all the private breeding companies for incorporation into new open-pollinated or hybrid cultivars. Traits to be developed will be prioritized by a Canola Breeders Group (CBG). The aim is to ensure that Australian growers have cultivars that allow them to compete effectively on world markets.

Key Words: germplasm, NBGIP

INTRODUCTION

The National Brassica Germplasm Improvement Program (NBGIP) is responsible for the development of germplasm incorporating new or enhanced traits for the Australian canola industry. NBGIP’s pre-breeding activities comprise two separate, but linked, GRDC projects being carried out by NSW DPI and Vic DPI. The purpose of NBGIP is to 'equally and fairly' provide advanced canola germplasm containing important new or improved traits to all the private breeding companies for incorporation into new open-pollinated or hybrid cultivars. Traits to be developed will be prioritized by a Canola Breeders Group (CBG) that includes representatives from all Australian focused breeding organizations, NBGIP and GRDC. Input will also be sought from industry representatives as appropriate. The aim is to ensure that Australian growers have cultivars that allow them to compete effectively on world markets.

The success of NBGIP trait improvement will depend on the ready uptake of developed germplasm by private breeding companies. This will only occur if the traits being developed are considered a high priority for the breeding companies, as well as the industry

ROLE OF CANOLA BREEDERS GROUP

The overall role of the Canola Breeders Group is to oversee the development of the enhanced germplasm for each new priority trait. This would involve an agreed development plan for each key trait that includes decision points at key times to continue as is, modify the plan or stop. It is therefore considered essential that:

- all breeding companies and industry provide oversight and direction to prioritize trait development.
- there are effective linkages to industry committees to provide direction e.g. market and pathology needs
- the traits are made available to companies is a timely and cost-effective manner
- there are minimal encumbrances to IP access

DECISION MAKING PROCESS

For each trait of interest, decision making steps in germplasm development (Figure 2) will include:
- identification of, or development of, effective screening protocols for each priority trait
- identification of appropriate genetic variability for each key trait through use of screening protocols
- attempt to create variability if insufficient variability exists
- enhancement of trait expression through selection and breeding
- Incorporation of enhanced trait as required into appropriate adapted background(s).

**RESEARCH AND DEVELOPMENT METHODOLOGIES**

The proposed research and development will utilize a range of breeding methods depending on trait background. The methodology used will depend on the specific trait required, the inheritance of the trait, the availability of sufficient variability to allow the trait to be improved and the genetic background of the trait. Potential methodologies include doubled haploids, marker assisted selection, backcrossing, modified pedigree breeding, single seed descent, recurrent selection, mutation breeding, interspecific hybridisation and resynthesis. The approach needs to be flexible to allow change as more knowledge and experience is gained. This is particularly relevant for the challenging agronomic traits such as drought tolerance, shatter tolerance and frost tolerance. Molecular techniques such as tilling and incorporation of GM traits will also be utilized wherever possible and practical.

Germplasm identified with the nominated traits will be provided to the breeding crossed into adapted Australian backgrounds. Selected crosses will be used to develop segregating doubled haploid populations for use in the molecular marker project.

**KEY TRAITS FOR DEVELOPMENT**

An AOF/GRDC taskforce during 2006 identified a number of key agronomic and quality priorities. In addition, the current Canola Quality Objectives Group is also providing feedback on key quality parameters to ensure the continued success and competitiveness of the Australian oilseed industry. Potential agronomic priorities identified include alternative sources of blackleg resistance, drought tolerance, shatter resistance and frost tolerance during seed development. Potential quality priorities include high oil and protein content, low saturated fats and very low glucosinolate content. Figure 1 presents a large number of potential traits for canola improvement. They are divided into three classifications, namely key traits, preliminary traits and future traits. The majority of the germplasm development will target the key traits, but some initial research on the preliminary traits will be an additional component of the germplasm development. Such work might involve a preliminary screen of available variation for a specific trait.

**BRIEF METHODOLOGY**

**Alternative sources of blackleg resistance**

*Vic DPI* will screen new potential sources of winter resistance in a blackleg field nursery. Lines will be assessed for both survival percentage and internal infection. New sources of resistance (containing different Rlm resistance genes) from winter germplasm (e.g. French cultivars) will be identified. New winter sources of blackleg resistance will be crossed to adapted germplasm. Concurrently, development of DH populations based on new winter sources of resistance will be initiated. A further 1-2 generations of backcrossing may be required to restore the adapted Australian spring background. The further selection, crossing and development of Australian x Australian polygenic resistance will also continue to be undertaken in the Vic DPI program. Markers already developed for some spring and winter resistance genes by the *Brassica* Molecular Marker Project will be utilised in this development. There is also the option to combine polygenic resistance with new *sylvestris* genes. Vic DPI will also provide a back-up nursery for NSW trials.

*NSW DPI* will aim to identify new sources of resistance to improve polygene resistance. NSW DPI will request germplasm from the Australian Temperate Field Crops Collection (Horsham,
Australia), the University of Western Australia (Perth, Australia), the Department of Agriculture and Food (Perth, Australia), Agriculture & Agrifood Canada (Saskatoon, Canada), the University of Alberta (Edmonton, Canada), the USDA (Ames, USA), the *Brassica napus* Diversity Fixed Foundation Set (BnDFFS, Warwick, UK), the European *Brassica* core collection and any other source that is identified. Lines received will be evaluated in blackleg nurseries and any resistant material identified. A subset of resistant lines selected from 2007 introductions will be sown in nurseries in Victoria, South Australia and Western Australia to confirm the resistance in 2008.

NSW and Vic DPI will be actively involved in AAFC's new blackleg consortium. This consortium aims to identify QTLs controlling non-race specific resistance as well as develop a set of differential lines with known race-specific resistance genes. Most resistant Australian cultivars are believed to have non-race specific resistance (as well as race specific), but there is no knowledge of genetic variation amongst these cultivars for this type of resistance. This consortium will complement the existing work of the BMMP.

**Water Use Efficiency (Drought tolerance)**

*NSW DPI* will develop practical methodology to differentiate genetic variation in selected germplasm. Low rainfall environments will be used to field screen for drought tolerance. Possible sources of drought tolerance will be selected by examining results from trials in 2002 and 2006 (two years with severe end-season moisture stress at Wagga Wagga). Yield, oil content, seed weight, canopy temperature, flowering/podding imitation and harvest index will be used as possible indicators of improved tolerance. Any other sources of tolerance (e.g. the ACIAR project, interspecific material from various sources) will also be included, if available. The value of harvest index and practical methods to measure water status of both the soil and plants will be investigated. To provide more control over rainfall, *NSW DPI* has renovated an existing rainout shelter at Wagga Wagga. Control of in-crop rainfall will be necessary to screen for terminal drought conditions. A second approach will involve evaluating the role of deep rooting and the importance of tolerance to aluminum toxicity in acid soils.

*Vic DPI* will conduct a ‘back-up’ field nursery (20-40 lines) in a low rainfall, drought prone environment to screen a range of Australian adapted germplasm for differences in drought tolerance. This will support the screening trials of *NSW DPI*, the lead agency for this trait. Australian adapted lines previously selected as performing well under drought conditions will be screened, along with lines identified in ACIAR/GRDC project 'Oilseed *Brassica* Improvement in China, India and Australia' with drought tolerance and thermo tolerance.

**Shatter resistance**

*Vic DPI* will conduct a field screening nursery (30-50 Australian adapted lines) for shatter resistance based on delayed harvesting of standing plots. After maturity, lines will be assessed every 2-3 weeks for up to 3 months for degree of shattering. Trial entries will be selected on the basis of past performance or reputation under delayed harvest. A second approach for the development of shatter resistance involves interspecific hybridisation with *Brassicaceae* species with enhanced shatter resistance. Access to shatter resistant *B. napus* developed in India via intergeneric crosses with radish or *B. carinata* as part of the ACIAR/GRDC project, will be sought. When available, these lines will be backcrossed to Australian adapted germplasm. Several generations of backcrossing and selection will be required. A third approach being considered involves tilling. Allelic variation in *B. napus* at loci known to be associated with pod dehiscence in either *B. rapa* (from the Multinational *Brassica* Genome Project) or *Arabidopsis thaliana* will be targeted.

*NSW DPI* will establish ‘back-up’ trials to evaluate for shatter tolerance through delayed harvest (28 days post physiological maturity). Assuming that there are probably many genes involved in shatter resistance, a simplified recurrent selection procedure will be used to try to combine these genes.

**Frost tolerance during seed development**
**NSW DPI** has already developed methodology at Tamworth for frost tolerance screening, with -3°C identified as the appropriate temperature for screening *Brassica* species. A preliminary screening trial using 15 lines will be undertaken in 2007 using a wide range of germplasm. Linkages have been established with Indian and Canadian colleagues to standardize methods. Methods of creating variation e.g. mutation (particularly UV mutagenesis of microspores) will need to be explored.

**Oil Content stability/Increased protein**

One requirement of the Canola Quality Objectives Group is identification of lines with better stability of ‘oil plus protein’ across a range of environments. The joint NSW and Vic approach would use previously identified sources of high ‘oil plus protein’ in early and mid season lines, plus lines identified in 2007 field screening. The quality stability of selected high ‘oil plus protein’ lines will then be evaluated across a range of environments (4-6 sites).

In addition, quantum leaps in oil (3%) and protein (3%) content have also been targeted. It is likely that a GM approach would be required to make such significant improvements.

**Brassica Molecular Marker Program**

The BMMP program has been focused on the development of QTL markers for blackleg resistance in the different DH populations. Identified markers are being validated in 2007, with a view to making some markers available at the end of the project year (June 2008). The BMMP project is also seeking to identify the resistance genes in popular Australian cultivars.

The BMMP will also have the responsibility to develop molecular markers for some of the new key traits being developed by NBGIP.
Figure 1. Key traits, preliminary traits and future traits for germplasm enhancement.
Figure 2. Canola Germplasm Development Chart

Is there known, available genetic variation? (e.g. frost, zero saturated fats, low glucosinolates).

Yes (e.g. drought, shatter)

Is there an effective screening protocol?

Yes (e.g. b’leg)

Screen germplasm

Cross (selection)

DH populations

Screen DH’s for traits

marker/project companies

No (e.g. sclero)

Develop protocol?

Assess already available data for variation? (e.g. quality traits)

Create variation? (e.g. mutation, interspecific crosses, resynthesis)

Cross

DH populations

Screen germplasm

etc.

etc.

Screen germplasm

etc.

Develop protocol?