Oilseed Brassica improvement in China, India and Australia – ACIAR/GRDC project

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ABSTRACT

This paper reports on outcomes of the 5 year collaborative research project "Oilseed Brassica Improvement in China, India and Australia", which was co-funded by the Australian Centre for International Agricultural Research (ACIAR) and the Grains Research and Development Corporation (GRDC). The aims of the project were to increase *B. napus* and *B. juncea* production and quality in each country through the exchange of germplasm with improved yield, quality, disease resistance and agronomic characters. It included the development of breeding populations for key traits and the enhancement of skills and knowledge. The project involved major *Brassica* oilseed research organisations in each of the three countries, including six organisations in Australia (University of Melbourne, University of Western Australia, Department of Agriculture and Food Western Australia, Department of Primary Industries Victoria, South Australia Research and Development Institute and NSW Department of Primary Industry and Investment), five organisations in India (Indian Council of Agricultural Research, New Delhi; National Research Council on Rapeseed-Mustard, Bharatpur; The Energy and Resources Institute, New Delhi; Punjab Agricultural University and Haryana Agricultural University) and three organisations in China (Huazhong Agricultural University, Wuhan; Oil Crops Research Institute, Chinese Academy of Agricultural Sciences, Wuhan and Institute of Industrial Crops, Xinjiang Academy of Agricultural Sciences, Urumqi).

A major outcome of the project has been the successful exchange of germplasm between Australia, China and India. In 2004/05 48 *B. napus* and 44 *B. juncea* lines were exchanged and in 2006/07 58 *B. napus* and 60 *B. juncea* lines were exchanged. This has enabled all three countries to benefit from access to germplasm which was not previously accessible. The germplasm was assessed for agronomic traits (including yield, drought and thermo tolerance and shatter resistance), oil quantity and quality and resistance to diseases (*Sclerotinia*, white rust and blackleg). Promising lines containing these traits have been incorporated into breeding programs in each country to produce populations with enhanced expression of the key traits. The germplasm has also been used in studies of genetic distance and multi-environment F_1 hybrid field trials in the three countries.

Key words: Brassica – Disease – Agronomy – Hybrid – Training

INTRODUCTION

Oilseed Brassicas are the dominant oilseed crop in China and Australia and the second most important oilseed crop after peanuts in India. The predominant oilseed Brassica species in Australia and China is *B. napus*, while in India *B. juncea* predominates, with only small areas of *B. napus* grown. Combined, the three countries represent approximately 60% of the world's oilseed Brassica area. Despite considerable progress in breeding programs in each country a number of limitations to yield and quality still need to be addressed. The overall aim of this trilateral project was to utilise germplasm from China, India and Australia to enhance productivity of canola quality *B. napus* and *B. juncea* in all three countries. The project is in line with ACIAR's objective of assisting developing countries in improving their own skills and resources, whilst working towards resolving Australia's own agricultural problems.

The focus of the project was on germplasm screening and enhancement for six key characters which were breeding priorities for the partner countries (Table 1). In addition, standard agronomic and quality characters were also assessed. Institutes in each country were responsible for project objectives related to the specific key characters relevant to their skills and resources. The list of institutes and their specific responsibilities is presented in Table 2.

The project objectives were:

1. Identification and/or development of effective screening/evaluation protocols for each key character.
2. Identification of appropriate variability for key characters through use of screening protocols.
3. Enhancement of germplasm in all countries for key characters through selection and breeding.
4. Identification of heritability of key traits, genetic distance and, heterotic pools.
5. Development/provision of appropriate information on improved germplasm and diseases for incorporation into existing technology transfer protocols.
6. Increase the scientific skills of Chinese and Indian scientists through scientific exchanges, study tours and training.

Table 1. Key characters of interest.

Character	**Species**	**Country**
Canola quality ('00')	*B. juncea*	India, Australia, China
Drought tolerance and thermotolerance	*B. napus*	Australia, India
	B. juncea	India, Australia
Sclerotinia	*B. napus*	China, Australia
	B. juncea	India, Australia, China
White rust	*B. juncea*	Australia, (India)[1], (China)[1]
Shatter resistance	*B. napus*	Australia, India, (China)[1]

[1]Indicates country not involved in trait development, but would still utilise the developed lines.

Table 2. Organisations involved in the project and their key responsibilities.

Country	**Institute**	**Key responsibility**
China	Huazhong Agricultural University	Sclerotinia, Genetic distance, Hybrid vigour
	Institute of Oil Crops Research, Chinese Academy of Agricultural Sciences	Sclerotinia, Agronomy & Quality, Hybrid vigour
	Institute of Economic Crops, Xinjiang Academy of Agricultural Sciences	Agronomy & Quality (B. juncea)
	National Research Centre on Rapeseed - Mustard	Sclerotinia, Drought tolerance, Thermotolerance, Agronomy & Quality
India	Punjab Agricultural University	Thermotolerance, Agronomy& Quality, Introgression of traits from B. carinata
	CCS Haryana Agricultural University	Sclerotinia, Drought tolerance, Thermotolerance, Agronomy & Quality
	The Energy and Resources Institute	Shatter resistance, Agronomy & Quality
Australia	The University of Melbourne	White rust
	The University of Western Australia (Barbetti)	Sclerotinia, White rust
	The University of Western Australia (Cowling)	Genetic distance, Hybrid vigour
	Victorian Department of Primary Industries	Agronomy & Quality, Canola quality B. juncea
	NSW Department of Industry and Investment	Agronomy & Quality
	South Australia Research and Development Institute	Agronomy & Quality
	Department of Agriculture and Food WA	Agronomy & Quality

MATERIALS AND METHODS

In 2004/05 and 2006/07, each country contributed *B. napus* and *B. juncea* lines with variation for the key characters of interest (Table 3). The material introduced into Australia has been provided to the Australian Temperate Field Crops Collection, Victoria. Field testing of these lines occurred for two years in each country. Replicated plot trials were sown to measure yield, quality and agronomic characters, while specific disease nurseries and screening trials for drought tolerance and shatter tolerance were also established. Existing standard protocols for evaluating traits were used where available and appropriate. However, for some traits including Sclerotinia and white rust protocol assessment and/or development was undertaken (Li et al. 2007a,b).

Table 3. Series I and Series II germplasm exchange.

Country	Series I lines exchanged (2004/05)		Series II lines exchanged (2006/07)	
	B. napus	***B. juncea***	***B. napus***	***B. juncea***
China	20	10	25	20
India	3	22	2	23
Australia	25	12	31	17
TOTAL	48	44	58	60

Following germplasm screening, enhancement of germplasm was initiated through selection and breeding. Each breeding organisation in the project was responsible for the development of one or more germplasm pools, targeting improvements in specific key characters. Exchange of these populations is currently being organised and they will be available to all breeding organisations involved in the project.

Genetic distance analyses of the germplasm from the three countries were carried out in Australia, India and China using the SSR technique (and also SRAP technique in China). An F_1 hybrid vigour trial was carried out across the three countries in 2007/08 and 2008/09. Seven agronomic traits were measured (vegetative vigour, date of 50% flowering, height of first branch, height of first pod, mature height, seed yield and 1000-seed weight) and a multi-environment trials analysis was conducted across the six trial sites in the three countries from these data. The last of the field trials were harvested mid 2009, so the data is now being analysed to determine the relationship between molecular genetic distance and heterosis.

Scientific exchanges, study tours and training were also organised to increase the scientific skills of scientists from the collaborating countries.

RESULTS AND DISCUSSION

Screening of *B. juncea* and *B. napus* over four seasons for the key characters has been completed in Australia, India and China. There was significant genetic variation among lines for all of the traits. Useful trait variation in at least one of the three countries was observed in thermotolerance, Sclerotinia resistance, white rust resistance, blackleg resistance, shatter resistance and *B. juncea* glucosinolate content.

For example, Chinese *B. napus* lines were identified which were significantly more resistant to Sclerotinia infection under Australian field conditions than the most susceptible lines (Li et al. 2009). These genotypes will be useful sources of resistance for breeding programs in Australia. Canola quality *B. napus* and *B. juncea* lines from Australia will be valuable to Chinese and Indian breeding programs. Blackleg resistance from Australian *B. napus* lines will also be useful to China and India for pre-emptive breeding (Li et al. 2008). Variation for drought and thermotolerance was observed in the B. juncea lines in India, and this has been used for population development. Shatter resistance population development has also been undertaken in India, using Australian and Indian lines and significant differences in shatter resistance among the progeny of the crosses has been observed.

Genetic distance analyses of the *B. napus* and B. *juncea* germplasm showed abundant genetic diversity among the lines of both species (Chen et al. 2008). This will assist breeders in all countries in their selection of the most diverse lines to widen their gene pools. Results of the multilocation F_1 hybrid field trials will also provide breeders with valuable information on heterosis and combining ability.

Additional outputs from the project have included advanced training of Indian and Chinese scientists and increased interaction among collaborators from the participating countries. During 2004-2007, Chinese and Indian scientists visited Australia for advanced training in areas including methods for assessing drought tolerance, NIR spectroscopy for oil quality analysis and molecular techniques. In addition, the 2007 progress meeting in Wuhan, China and the 2008 progress meeting in India have enhanced collaboration between Australian, Chinese and Indian scientists.

In addition to the work described above, many collaborations established as part of the project will continue into the future, bringing further benefits to those involved. In Australia, additional evaluation of selected lines and the breeding populations will occur as part of the National Brassica Germplasm Improvement Program (NBGIP).

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