# *BRASSICA NAPUS* BREEDING

***P. Salisbury and N. Wratten***

**SUMMARY**

- The availability of high yielding, good quality blackleg resistant *B. napus* varieties has been a major factor in the resurgence of the Australian canola industry.
- To date, Australian production has predominantly been based on open-pollinated varieties from the public breeding programs. The impact of the private breeding programs, and potentially hybrids, is expected to increase over the next few years.
- Triazine tolerant varieties have had a major share of the Australian production in recent years. Newer forms of herbicide tolerance, both non-GMO and GMO, are becoming available, with the first GMO varieties expected to be available in 2001-2002.

## PUBLIC BREEDING PROGRAMS

The first public rapeseed breeding program in Australia was initiated in Victoria (Buzza) in 1970, followed by programs in New South Wales (Wratten) and Western Australia (Roy) in 1973. Initially, the two species *B. napus* and *B. rapa* were developed for Australia, with the early maturing *B. rapa* targeted specifically at lower rainfall environments. The initial objectives of the programs were to develop open-pollinated varieties that were high yielding and blackleg resistant, with improved quality. Work on *B. rapa* stopped in the mid 1980s. Breeding programs for an additional *Brassica* species, *B. juncea* (Indian mustard) commenced in Canberra (Oram, Kirk), Victoria (Salisbury) and Western Australia (Roy) in the late 1970s and early 1980s. The programs aimed at producing canola quality *B. juncea* for lower rainfall environments. Although all public programs were funded separately, there was good collaboration between them.

The Agriculture Western Australia breeding program was officially closed in 1989, although a selection program utilising lines from New South Wales and Victoria has continued in recent years. Breeding activities in Western Australia have recommenced in 1999 through the University of Western Australia (Cowling). In 1992, the public breeding programs were officially combined into one co-ordinated National *Brassica* Improvement Program. To date, Australian production has been predominantly based (>90%) on open-pollinated varieties from the public breeding programs.

## PRIVATE BREEDING PROGRAMS

The first private *B. napus* breeding program was initiated by Pacific Seeds (Buzza, Easton) in 1980, followed by AgSeed Research (White, Kadkol) in 1988. More recently, Pioneer (Wilson) and AgrEvo (Pike) have also commenced breeding programs in Australia. A major focus on hybrids is evident in several of the private programs. Hyola 30 and Hyola 40, the first of several *B. napus* hybrids from the Pacific Seeds program, were released in 1988. AgSeed Research released their first open-pollinated variety in 1996, with the first releases from Pioneer available in 1999.

## BREEDING PROGRESS

### Yield

Average commercial yields in Australia have risen substantially over the years, with current yields close to treble those obtained with the earlier varieties. Australian average yields rose from 0.6 t/ha in the 1970s to 1.8 t/ha in 1993. A major component of this yield increase was associated with enhanced blackleg resistance. Increased canola production in low rainfall environments in recent years has reduced national average yields to around 1.6 t/ha.

### Oil and meal quality

The early Canadian varieties grown in Australia were of poor quality, with oil high in erucic acid (20-40%) and meal high in glucosinolates (70-120 micromoles per gram of oil free meal). High levels of erucic acid were considered nutritionally undesirable, while meals containing high levels of glucosinolates were goitrogenic, causing both palatability and nutritional problems in non-ruminant animals.

Canadian breeders led the world in the development of improved quality in rapeseed, with the first low erucic acid variety released in 1968 and the first double low (low erucic acid and low glucosinolates) variety released in 1974. These varieties were used by Australian breeders as a source of improved quality. Subsequently, the first low erucic acid *B. napus* (Wesreo from Western Australia) and *B. rapa* (Jumbuck from New South Wales) varieties were released in 1978 and 1982 respectively. The first Australian canola quality *B. napus* varieties, Marnoo (Victoria) and Wesroona (Western Australia) were released in 1980.

More recent canola varieties (Table 4) have shown continued improvements in quality, especially through further reductions in glucosinolate levels. Maluka and Shiralee, released from New South Wales in 1987, were the first varieties with very low and more stable glucosinolate contents. Recently released varieties have glucosinolate levels less than half the maximum value for canola quality.

Since the introduction of canola quality, the oleic acid content of Australian canola varieties has remained relatively constant at around 60%. It has an ideal fatty acid composition for many of its current uses. However, further improvements to canola oil quality are also underway. Selection to further enhance oleic acid levels and reduce linolenic acid will provide enhanced oil stability for specific applications. Further reductions in saturated fatty acid content are also being sought.

In addition, a number of different specialty *Brassica* varieties targeted at specific end-uses have been developed through a joint venture between Agriculture Victoria and AgSeed Research. High erucic acid types, condiment mustards and biofumigation mustards have been developed.

The ability to develop improved canola quality and other specialty *Brassica* varieties has been greatly enhanced by recent advances in the development of rapid, non-destructive quality analysis using NIR. NIR technology has enabled a more than ten-fold increase in the number of quality samples analysed each year.

**Oil and protein content**

With the initial focus on combining blackleg resistance with canola quality and high yield, little emphasis was given to selection for improved oil and protein content. Consequently, oil and protein contents of new varieties remained static or decreased slightly for about 10 years. However, as the Australian industry has become more export oriented, there has been an emerging need for high oil and protein content varieties to allow Australia to become competitive with Canada. Increased selection pressure resulted in a number of high oil and protein content mid-season varieties (e.g. Dunkeld and Grouse). The most recent releases continue to show further improvement (e.g. Charlton). Similar improvements are also occurring in early varieties targeted at low rainfall environments (e.g. Mystic).

**Blackleg resistance**

Following the blackleg epidemic of the early 1970s, it was clear that resistant varieties were required for the successful re-establishment of the industry. Wesreo, released in 1978 from the Western Australian program, was the first blackleg resistant *B. napus* variety. Other early releases, Marnoo and Jumbuck, had moderate levels of resistance. Wesroona, the first blackleg resistant *B. napus* variety with canola quality, was released in Western Australia in 1980. Continued improvements in the level of *B. napus* resistance have been made in the open-pollinated varieties. The latest mid-season varieties from breeding programs in New South Wales and Victoria have higher levels of blackleg resistance than any previously released Australian varieties. Current Australian mid-season varieties have the highest levels of blackleg resistance of any spring canola varieties in the world and when these are grown with appropriate crop rotation, losses to blackleg are negligible. Further improvements in the levels of blackleg resistance in early maturing and triazine tolerant canola are being sought.

*Selection methods*

As adult plant resistance to stem canker is the major component of resistance required in Australia, selection for resistance is primarily based on field screening of adult plants in blackleg nurseries against the prevalent race mixture. Higher levels of seedling resistance are also being sought as insurance against the increased disease pressure associated with a major increase in canola area.

In Australian public plant breeding programs, parents for crossing are generally selected from field blackleg nurseries. Single plant selections are crossed together to combine different sources of resistance and to improve overall levels of resistance. Segregating material is screened in the blackleg nursery in the $F_2$ generation, allowing a high proportion of material to be immediately rejected on the basis of insufficient

resistance. After one or two generations of single plant selection for resistance in blackleg nurseries, lines are evaluated as bulks that are regularly screened for resistance in subsequent generations. In addition, single plant selections for blackleg resistance are often taken from later generation bulks and evaluated as potential new lines.

*Sources of resistance*
The blackleg resistance in current Australian varieties is incomplete, allowing the fungus to survive and reproduce saprophytically even on the most resistant lines. This does not place undue pressure on the pathogen to overcome current resistance. This form of resistance is believed to be under polygenic control.

The major sources of blackleg resistance used in the Australian *B. napus* breeding programs to date have been Japanese spring material and French winter material. The Japanese variety Norin 20 is a parent in many Australian varieties (Table 4).

Alternative sources of blackleg resistance continue to be sought by breeders and researchers throughout Australia. Marcroft is evaluating cultivated *Brassica* species containing the B genome (*B. nigra, B. juncea, B. carinata*). Field and glasshouse trials have shown *B. carinata* to be more resistant to blackleg than *B. nigra*, *B. juncea* or *B. napus*. Attempts are being made to transfer these resistance genes to *B. napus*, as part of a collaborative project with Canada (Good). Attempts by Salisbury and Hyett to introduce resistance genes from a range of wild crucifer species into *B. napus* have been unsuccessful to date, due to a lack of introgression of the resistance genes into the *B. napus* genome. New transgenic sources of resistance are also being evaluated. None of these resistance genes are available in commercial varieties at this stage.

*Molecular markers*
Molecular markers are being sought for different sources of blackleg resistance. Ash, Wratten and Raman are developing markers for two sources of resistance, a French winter line (Amazon) and a current Australian line (Grouse). Pang, Taylor and Ponnampalam are developing markers for the *B. juncea* resistance in *B. napus*, initially transferred by Roy.

**Range of maturity types**

When the first Australian bred varieties were released, the area of canola was very small and was based in the medium to higher rainfall wheatbelt areas. This meant that only a small number of mid-season varieties were required. However, in recent years, as the industry has expanded into a wider range of environments, the breeding programs have developed varieties with early, mid and late maturity types. The availability of early maturing varieties has been a major factor in this expansion. With the most recent expansion of the industry into the very low rainfall environments (e.g. 280-350 mm annual rainfall areas of Western Australia and South Australia), a very early maturity class may be required.

**Herbicide resistance**

Control of broadleaf weeds, especially crucifer weeds, has been a major problem with conventional canola varieties. The availability of triazine tolerant (TT) varieties has significantly enhanced weed control options for canola growers. The first TT variety, Siren, was released in 1993. Despite a significant yield (15-20%) and oil content penalty relative to conventional varieties, TT varieties have been widely accepted. In 1999, approximately 45-50% of the Australian canola area was sown to early and mid-season TT varieties, with 85% of the Western Australian crop being TT.

There is a significant opportunity for alternative forms of herbicide resistance, especially those with no yield or oil penalty. Alternatives likely to become available in the next few years include imidazolinone resistance (non GMO) and Roundup Ready®, Liberty Link® and bromoxynil resistance (GMO'S).

**Agronomic traits**

Recent varieties are shorter and more resistant to lodging and shattering than the earlier varieties. Reduced height lessens the risk of lodging in crops, particularly in years when crops can be sown early, and also make windrowing easier. Significant progress has been made for shattering resistance, especially in programs where breeding plots are direct headed (e.g. New South Wales). However, further shatter resistance is required before all crops can be safely direct headed.

**FUTURE DIRECTIONS**

The availability of improved varieties has been one major factor in the resurgence of the canola industry in Australia. Open-pollinated *B. napus* varieties (both conventional and triazine tolerant) have been the basis of the industry to date, with hybrid varieties not yet having significant impact on the market. However, the availability of improved hybrid systems is likely to see the impact of hybrids increase over time.

Effective strategies for the control of blackleg remain vital to the long term viability of the industry, with breeding for resistance a key component of these strategies. Australian canola varieties are the most blackleg-resistant spring varieties in the world and this resistance will be further enhanced through the identification and utilisation of alternative sources of resistance.

The majority of new characteristics for improvement of canola over the next ten years will be the result of gene technology. These new developments can be divided into those involving modified crop production characteristics and those modifying product quality characteristics. To remain internationally competitive, Australian public breeding programs are forming appropriate research and commercial linkages with owners of key technologies. A number of collaborative projects between public and major international private organisations are currently underway in Australia.

Within the next ten years, Australian canola production is likely to come predominantly from GMO varieties. The first GMO canola varieties available in Australia will be the herbicide resistant types Liberty Link® and Roundup Ready®. They are expected to be available by 2001-2002.

## FURTHER READING

Hyett, J.H., Brown, J.S., Salisbury, P.A. and Ballinger, D.J. (1995) Introducing wild genes for blackleg resistance into canola. *10th Australian Research Assembly on Brassicas*, Struan, pp. 36-37.

Potter, T.D. and Salisbury, P.A. (1993) Triazine resistant canola in southern Australia. *7th Australian Agronomy Conference*, Adelaide, pp 80-82.

Potter, T.D., Salisbury, P.A., Ballinger, D.J., Wratten, N. and Mailer, R.J. (1995) Comparison of historical varieties of rapeseed and canola in Australia. *9th International Rapeseed Congress*, Cambridge, UK, pp 365-367.

Roy, N.N (1984) Interspecific transfer of *Brassica juncea*-type high blackleg resistance to *Brassica napus*. *Euphytica* **33**, 295-303.

Salisbury, P.A., Ballinger, D.J., Wratten, N., Plummer, K.M. and Howlett, B.J. (1995) Blackleg disease on oilseed Brassica in Australia: a review. *Australian Journal of Experimental Agriculture* **35**, 665-672.