BRASSICA JUNCEA BREEDING

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SUMMARY

- *Brassica juncea* genotypes with low erucic acid in their seed oil were first discovered in Australia in 1980.
- Early maturing, high yielding Australian canola quality *B. juncea* lines have been developed and are currently being crossed with higher oleic acid sources. Commercial canola quality varieties are expected to be available in the next few years.
- A number of specialty *B. juncea* varieties for oil production, condiment production and soil biofumigation have also been developed in Australia.

INTRODUCTION

A search for profitable alternatives to cereal crops lead to the agronomic testing of accessions of *Brassica juncea* (Indian, oriental or brown mustard) in southern Australia at several localities in the 1970s and 1980s. *B. juncea* had a number of potential advantages over *B. napus*, including enhanced seedling vigour, blackleg resistance and shatter resistance, plus higher tolerance to drought and high temperature stresses. *B. juncea* accessions were obtained from all mustard-producing countries of the world, including both the China-Eastern European and India/Pakistan geographic groups. The former group is characterised by brown or yellow seeds containing predominantly propenyl (allyl) glucosinolate. The plants require long days for flowering and are resistant to leaf blight caused by *Pseudomonas syringae* pv. *maculicola* (Figure 10). The India/Pakistan group has brown seeds containing mostly propenyl and butenyl glucosinolates, and plants which are daylength neutral and susceptible to leaf blight.

Breeding programs for the development of canola quality *Brassica juncea* commenced in Canberra (Oram, Kirk), Victoria (Salisbury) and Western Australia (Roy) in the late 1970s and early 1980s, targeted especially at low rainfall environments. The Western Australian program was closed in 1989 and the Canberra program has also recently been concluded, with advanced breeding material being incorporated into the Victorian program (Burton), as part of the National *Brassica* Improvement Program. In conjunction with the breeding program, agronomic work by Castleman has provided essential information for the successful production of mustard in low rainfall environments.

BREEDING PROGRESS

Canola quality

Low erucic acid

Kirk and Oram found low erucic acid *B. juncea* in a mixture of high and low erucic acid types in two commercial mustard samples. The zero erucic/low eicosenoic acid components of these two samples were designated Zem 1 and Zem 2, and were widely distributed to mustard breeders around the world, including those in Canada, China, India, USSR, and UK.

Kirk and Hurlstone found that the two geographic groups differed appreciably in the erucic acid content of the seed oil: the China-Eastern European group contained an average of 25% and the India/Pakistan group averaged 49%. In the F_2 of crosses of several representatives of these two groups to the zero erucic lines, Zem 1 and Zem 2, the proportions of low erucic acid plants were 25% and 6.25%, strongly suggesting that the groups are homozygous for dominant alleles controlling the synthesis of erucic acid at one and two loci, respectively. Subsequent breeding behaviour confirmed this hypothesis.

Working independently, Roy developed low erucic acid, hexaploid *B. juncea*-like plants from an interspecific hybrid between *B. juncea* and *B. rapa*. While it was possible to transfer the low erucic acid trait to other *B. juncea* varieties by crossing, this source of low erucic acid was not widely used in later breeding programs.

Zem lines were backcrossed to a range of lines in both geographic groups. It was evident that Australian adapted *B. juncea* would need to combine the early flowering and reduced height of the Indian germplasm with the superior disease resistance and quality attributes of the European germplasm.

Glucosinolates

Palmer identified a somaclonal variant of an Indian *B. juncea* accession that had 22% less glucosinolates in the seed. This variant was utilised in Australian breeding programs as a first step in reducing seed glucosinolates, in conjunction with other lower glucosinolate sources, including induced mutations and the interspecific lines developed in Canada by Love. Intensive crossing and selection over many generations eventually reduced the glucosinolate levels in Australian lines to canola quality standards.

The development of rapid methods for determination of total seed glucosinolate content has been an important step in breeding for low glucosinolate *B. juncea*, with both X-ray fluorescence and NIRS technology being used in Australia.

Fatty acid composition

In order for canola quality *B. juncea* to be used interchangeably with *B. napus* in the market place, it has been important to increase oleic acid levels to match the *B. napus* level of 60%. Most of the early Australian canola quality breeding *B. juncea* lines had oleic acid levels in the 40-52% range. In addition to further selection to exploit existing variation in the Australian lines, additional sources of high oleic acid have been sought. High oleic (60-65%) *B. juncea* lines developed by Potts and Males from Canada have been used in Australian crosses as part of a collaborative venture. Using gene silencing techniques, Stoutjesdijk has achieved substantial increases in oleic acid content (up to 73%) in Australian canola quality *B. juncea* lines.

Other quality types

The late maturing, low erucic acid, high propenyl glucosinolate CSIRO variety Siromo, derived from a cross between Zem and Domo, was used to establish a cold-pressed mustard seed oil industry by the Yandilla Mustard Oil Enterprise at Wallendbeen, New South Wales in 1989. Three further CSIRO varieties have since been released for this enterprise: Line 352 (mid-season), and VSYZE 11 and 99Y1-1 (early). Several hundred tonnes of seed are now processed annually, and the oil is distributed widely in Australia, and to small but growing overseas markets. Most of the meal, which contains about 18% oil after cold-pressing, is sold as a high protein/high energy feed for beef cattle. In addition, the meal is also marketed as an ingredient for the manufacture of table mustard and pickles, and as a natural snail bait. Yandilla now makes a pungent oil containing propenyl isothiocyanate by moistening the meal and re-pressing it at a higher pressure and temperature. The Yandilla meal is also utilised by others to distil off propenyl isothiocyanate for sale as a food preservative and flavouring compound in Japan and elsewhere.

A collaborative venture between Agriculture Victoria and AgSeed Research Pty Ltd has developed a number of condiment and biofumigation mustards. A yellow-seeded condiment variety, Muscon M-973, and two low erucic acid, high glucosinolate biofumigant varieties, Fumus F-E75 (early) and Fumus F-L71 (late), have recently been released. As green manure crops, biofumigant varieties control certain soil borne insects, nematodes and fungal and bacterial diseases in various crops, including potatoes, sugarcane and cereals.

Disease resistance

Blackleg
B. juncea has proved to be much more resistant than *B. napus* to the blackleg fungus, *Leptosphaeria maculans.* Although Ballinger and Salisbury have recently identified Australian field isolates which can attack *B. juncea*, this species remains significantly more resistant than *B. napus* to the mixture of blackleg races in the field.

Pseudomonas leaf blight
Many China-Eastern European accessions are resistant to the leaf blight caused by *Pseudomonas syringae* pv. *maculicola.* This resistance has been shown by Oram, Halsall and Edlington to be controlled by a single dominant gene with low expressivity. In *B. juncea*, the bacterium enters leaf tissue when moisture remains on the surface for one or more days, especially after frosts. The organism invades the vascular system and moves into the stem, branches and flowers. It may be transmitted through seeds, but these can be disinfected by hot water treatment. The severity of the disease on susceptible genotypes declines markedly after about five or six years of mustard cultivation in any locality. It seems possible that the pathogenic bacteria are

gradually out-competed on the leaf surfaces by related, free-living, non-pathogenic pseudomonads and xanthomonads.

Yield and agronomic performance

A number of early maturing, shorter stature, high yielding Australian canola quality *B. juncea* lines have been developed. These lines show significant yield advantages over *B. napus* in some low rainfall environments, especially under conditions of water stress and high temperatures during seed fill. These lines are currently being crossed with higher oleic acid sources. Commercial canola quality varieties are expected to be available in the next few years.

FUTURE DIRECTIONS

Canola quality *B. juncea* varieties are expected to be available in Australia in the next few years. Their release will be dependent on obtaining regulatory approval for *B. juncea* as a food product. The incorporation of herbicide resistances, especially those with no inherent yield penalty, into new Australian varieties will be important to enable *B. juncea* to succeed in the low rainfall environments.

Access to other new GMO characteristics will also be important to ensure the long term competitiveness of Australian canola quality *B. juncea*.

FURTHER READING

Kirk, J. T. O., and Hurlstone, C. J. (1983) Variation and inheritance of erucic acid content in *Brassica juncea*. *Zeitschrift für Pflanzenzüchtung* **90**, 331-338.

Kirk, J. T. O., and Oram, R. N. (1981) Isolation of erucic acid-free lines of *Brassica juncea*: Indian mustard now a potential oilseed crop in Australia. *Journal of the Australian Institute of Agricultural Science* **47,** 51-52.