Canola quality *Brassica juncea* for Australia.

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Abstract

Brassica juncea has been bred to produce seed with a fatty acid profile similar to canola quality *B napus*. Advanced breeding lines evaluated in 19 regions across southern Australia in 2003 produced yields approaching the well-adapted *B. napus* cultivar AG-Outback. At locations where the yield of AG-Outback was less than 1.5 t/ha, the better lines of canola quality *B. juncea* were higher yielding than the *B. napus* control, which supports the initial concept of developing a reliable non-cereal crop for use in low rainfall areas. The main focus of the breeding program has been to improve the oil and meal quality to canola standards, with a fatty acid composition similar to commercial *B. napus* cultivars. Across six sites, *B. juncea* breeding lines had oil contents around 40% and glucosinolate contents within canola standards, although oleic acid levels were somewhat lower than similarly adapted *B. napus*. Newer breeding lines are now available that combine good yields with canola quality and oleic acid levels similar to *B. napus*.

Media summary

Canola quality *Brassica juncea* is approaching commercialization as a crop for low rainfall regions in Australia, where it should become a reliable and profitable break crop.

Key Words

Brassica juncea, breakcrop, oilseeds, fatty acid composition.

Introduction

Oilseeds and pulses comprise 15% of the 10 Mha of winter grain production in Victoria, New South Wales and South Australia, but in regions with less than 350 mm average annual rainfall, less than 1% of the 2.5 Mha crops grown is currently sown to oilseeds and only 7% sown to pulses. Canola quality *Brassica juncea* has been developed for growers in these low rainfall areas of Australia through the National Brassica Improvement Program in association with the Saskatchewan Wheat Pool. This crop is different to condiment (high glucosinolate) mustard in both end-use and agronomy, and the term <u>Juncea Canola</u> is being used to recognise these differences. Juncea Canola has low erucic acid levels, moderate oleic acid levels and low glucosinolate levels so that it can be considered to produce a product equivalent to conventional canola produced from *B. napus*.

The advantages of *B. juncea* over *B. napus* include more vigorous seedling growth, quicker ground covering ability, greater tolerance to heat and drought and enhanced resistance to the blackleg fungus, *Leptosphaeria maculans* (Woods *et al.* 1991, Burton *et al.* 1999). *B. juncea* seed pods shatter less readily and seeds potentially contain a higher percentage of oil plus protein because the yellow seed coat is thinner. The oil of both species is low in saturated fats. The potential benefits of developing canola quality *B. juncea* are recognised by a number of northern hemisphere countries, particularly Canada, where there are major breeding programs focused on its development. Canada released two Juncea Canola varieties in 2002 that have yielded around 6% more than the best *B. napus* types in the short growing season areas of Alberta and Saskatchewan. In 2003, there were almost 4000 ha of Juncea Canola in the prairie provinces of Canada.

Burton *et al*. (2003) reported data from 17 multi-location trials in 2001 and 2002 and showed that across all sites the best near-canola quality Juncea Canola yielded slightly less than the *B. napus* canola (1.0 versus 1.2 t/ha). However at the 10 lower yielding sites where the *B. napus* controls yielded less than 1.5 t/ha, the Juncea Canola lines were equal to or higher. The research reported here provides an update of the performance of current Australian lines across a range of environments during 2003, as well as discussing issues concerning the future development of the crop.

Methods

Multi-location Trials

B. juncea lines nearing canola quality were evaluated across Australia in multi-location trials in 2003. The 19 sites selected were in the low and medium rainfall zones within Victoria (6 sites), New South Wales (8 sites), Western Australia (3 sites) and South Australia (2 sites) in order to select lines with wide adaptation and also collect results on species potential in these areas. Yield, agronomic and quality data were collected from the trial sites. Quality analyses were undertaken on lines using standard testing procedures (McFadden *et al.* 2003). Lines designated with the prefix JN, JO and JQ represented the most recent of breeding lines promoted into the multi-location trials. AG-Outback, Rainbow and Hyola43 were early *B. napus* controls. Only yield results from 5 selected lines (JN004, JN028, JO006, JQ035 and JQ036) have been included in this paper, although 15 lines were included in the trials. In all cases, trials were managed using standard agronomic practice for conventional canola production in each region. Plots were 0.9-1.2m wide and 7 – 20m long.

Early Generation Breeding Lines

A larger data set from the 2003 early generation testing (JR-lines) plus some controls was used to investigate the relationship between yield and fatty acid composition. There were six sites used in this experiment, 3 in Victoria (Horsham, Beulah and Culgoa), 2 in South Australia (Lamaroo and Minnipa) and Tamworth in New South Wales. Plot management and quality analyses used were similar to the methods described in the multi-location trials above.

Results and discussion

Multi-location Trials

Figure 1 provides a summary of the performance in 2003 of 5 lines of canola quality *B. juncea* compared to AG-Outback across the 19 sites. Yield data has been analysed using multiplicative models described by Smith *et al*. (2001) to provide an overall mean (BLUP – best linear combined prediction of yield) across these environments. This provides an indication of where *B. juncea* may be best adapted, with the yields of a selection of lines from the multi-location trials compared to the yield of one of the *B..napus* controls. These results show that on sites where AG-Outback yielded less than about 1.5 t/ha, the yields of some of the more recent lines of *B. juncea* are generally higher yielding than the *B. napus* control. Where AG-Outback yields are higher than 1.5 t/ha, the *B. juncea* lines yielded less than 1.5 t/ha except at one site. On this site at Tamworth in northern New South Wales, *B. juncea* has produced yields significantly higher than *B. napus* control lines, although it is uncertain as to why this difference occurs. These results are similar to those reported by Burton *et al*. (2003) for a set of lines evaluated in 2001, with superior yields of *B. juncea* where site means were lower than 1.5 t/ha.

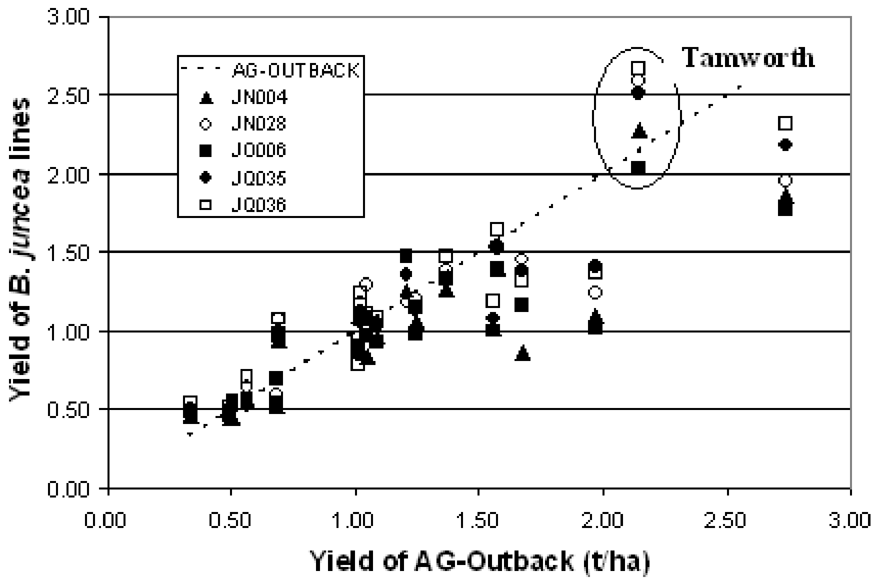

Figure 1 Yield (BLUP) of high yielding breeding lines of canola quality *Brassica juncea* compared to the yield of AG-Outback across 19 sites in 2003. Yields at the Tamworth site are indicated.

Early Generation Breeding Lines

Yield and oil quality data for a sub-set of the highest yielding lines plus some of the controls are presented in Table 1. Similar to the multi-location trials, yield data has been analysed using multiplicative models described by Smith *et al*. (2001). The yields presented are expressed as the best linear combined prediction of yield is provided from the sites used. There has been steady progress in both the yield and the quality of Juncea Canola, with zero erucic acid in the oil and meal glucosinolate levels below the current required canola quality standard. Oleic acid levels of some of the Juncea Canola lines are comparable to *B. napus* lines such as AG-Outback and Hyola43. The mean yields presented in Table 1 show that the newer lines are approaching canola yields, with oil contents similar to *B. napus*.

Table 1. 2003 across site summary for yield, quality and agronomic traits for early generation canola quality *Brassica juncea* breeding lines from six sites in Victoria and New South Wales.

Line	Yield (t/ha)	Maturity (days)	Height (cm)	Oil Content (%)	Glucosinolate Content	Oleic Acid % fatty acids	Canola quality*
AG-Outback	1.26	101	108	40.0	9.6	63.7	00
Hyola43	1.33	98	123	41.8	8.8	61.9	00
Rainbow	1.22	107	118	39.7	6.7	59.8	00
JN004	1.17	96	136	39.8	32.1	46.5	00

JN028	1.38	97	148	38.1	69.3	48.2	0+
JR033	0.95	100	NR**	40.5	14.5	59.4	00
JR042	1.66	103	131	39.1	10.8	46.9	00
JR046	0.92	99	NR**	42.3	11.1	61.3	00
JR048	1.21	100	118	41.1	18.0	57.4	00
JR049	1.47	92	150	40.5	13.8	44.9	00
JR050	1.17	94	153	40.9	18.1	56.5	00
JR055	0.99	104	168	40.2	14.4	60.0	00
JR136	1.06	98	NR**	40.9	17.3	56.5	00

*Canola quality : 00 = erucic acid free, low in glucosinolates; 0+ = erucic acid free, high in glucosinolates.
**NR - Height not recorded

In terms of oil quality, the current high yielding lines in the breeding program have a somewhat lower level of the desirable oleic acid (C18:1). The results show a negative relationship between yield and oleic acid content (Figure 2). In general, lines with yields over 1.4 t/ha have oleic acid levels less than 50% of the total fatty acid concentrations. This correlation reflects the history of the breeding program, with all selection for yield in the early years of the program was carried out in lines with less than 50% oleic acid. Germplasm with 60% oleic acid has only recently become available to the breeding program. Lines such as JR136 represent the newer germplasm where good yields and high oleic acid levels are combined.(Figure 2). As expected, based on oil biosynthesis pathways, higher oleic acid levels were generally associated with lower levels of linolenic (C18:2) acid (r^2 = 0.98).

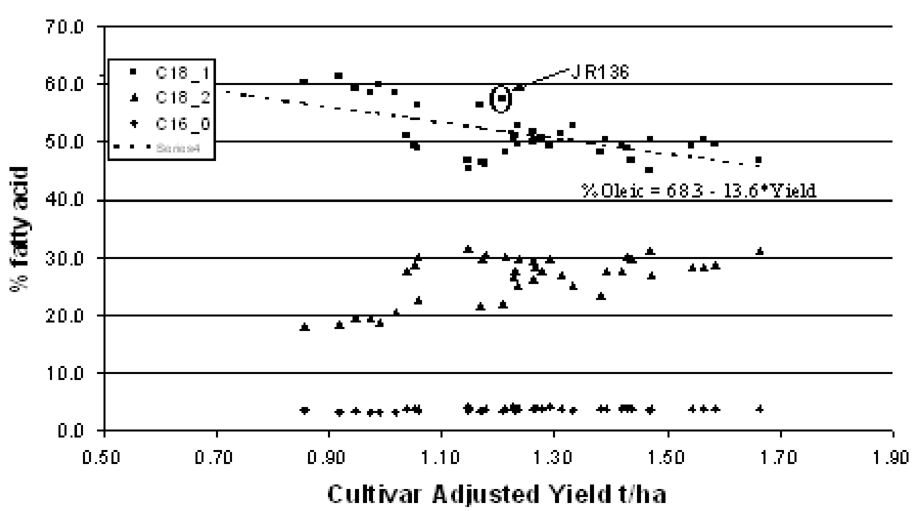

Figure 2 Fatty acid composition of a range of recent breeding lines versus adjusted yields. The relationship between 18:1 and yield is shown on the figure (r^2=0.48).

Based on the performance of Juncea Canola reported here, growers will have access to a profitable and reliable non-cereal crop in low rainfall areas, in particular where *B. napus* canola yields are less than 1.5 t/ha. In collaboration with various industry groups, our research is now seeking to identify appropriate agronomic practices for these new cultivars. In 2003 and 2004 we have investigated the fertilizer requirements of the crop in collaboration with Incitec Pivot especially N, P, S and Zn response. In 2002 and 2003, the Birchip Cropping Group (Bell and Van Rees 2003) reported herbicide sensitivity of three lines of canola quality *B. juncea*, including JN004 and JO006. This information, along with work from Walpeup, Minnipa and Tamworth will assist in developing reliable and low cost production systems for this new crop.

Conclusion

These results indicate that canola quality standards are being consistently met with breeding lines of *Brassica juncea*. It is over 20 years since the identification of low erucic acid genes in the species by Oram and Kirk (1981), highlighting the long term nature of investment into crop improvement. The current lines have quality essentially equivalent to *B. napus* canola, with similar maturity and superior yields in regions where canola will yield less than around 1.5 t/ha.

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References

Bell C and Van Rees H (2003). Birchip Cropping Group – an update from 2003. Victorian Grains Research Update, Bendigo, February 2004. p 129-133.

Burton WA, Pymer SJ, Salisbury PA, Kirk JTO and Oram RN (1999). Performance of Australian canola quality Indian mustard breeding lines. Proc. 10th Int. Rapeseed Congr., Canberra, Australia. http://www.regional.org.au/au/gcirc/4/51.htm#TopOfPage

Burton WA, Salisbury P and Potts D (2003). The potential of canola quality *Brassica juncea* as an oilseed crop for Australia. Proc. 13th Biennial Australian Research Assembly on Brassicas, Tamworth, N.S.W. p 62-64.

Kirk JTO and Oram RN (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: 51-2

McFadden A, Mailer RJ and Parker P (2003). Quality of Australian canola 2002/2003, Vol 9. Australian Oilseeds Federation.

Potter T, Marcroft S, Walton G and Parker P (1999). Climate and Soils In: P.A.Salisbury, T.D. Potter, G. McDonald and A.G. Green (eds.), Canola in Australia: The first thirty years, pp. 5-8. Organising Committee of the 10th International Rapeseed Congress, Canberra, Australia.

Smith AB, Cullis BR and Thompson R (2001). Analyzing variety by environment data using multiplicative mixed models and adjustments for spatial field trend. Biometrics, 57, 1138-1147.

Woods DL, Capcara JJ and Downey RK (1991). The potential of mustard (*Brassica juncea* (L.) Coss) as an edible oil crop on the Canadian Prairies. Canadian Journal of Plant Science, 71, 195 – 198.