Agronomy for canola quality *Brassica juncea* in modern cropping systems

Rob Norton[1], Wayne Burton[1,2] and Phil Salisbury[2,3]
[1] Joint Centre for Crop Innovation, The University of Melbourne, Horsham, Victoria, 3401. rob.norton@unimelb.edu.au
[2] Department of Primary Industries, Grains Innovation Park, Private Bag 260, Horsham Vic 3401, Australia, wayne.burton@nre.vic.gov.au
[3] Joint Centre for Crop Innovation, The University of Melbourne, Victoria, 3010, Australia, psalisbury@optushome.com.au

ABSTRACT

As canola quality *Brassica juncea* approaches commercialisation, there is a need to develop appropriate agronomic packages for the crop. The crop will be grown mainly in low rainfall (<350 mm average annual rainfall) with stubble retention and reduced tillage, in what is mainly a cereal based farming system, where it will confer a rotational benefit. There is a need to better define potential production regions and sowing times within those regions. Strategies for crop establishment including seeding rate, row width and seeding depth need to be tested in conservation farming systems along with crop nutritional demand for N, P, S and trace elements. Data on crop safety and residue limits are required to assist with registering crop protection chemicals, and crop protection strategies developed for a range of pests, weeds and diseases. The timing of harvest and its effect on crop quality is also important to achieve a low cost, reliable production system for juncea canola.

Key Words: nutrition, establishment, *Brassica juncea*.

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 “Juncea Canola” 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 potential benefits of developing canola quality *B. juncea* were recognised in Australia in the early 1980’s (Kirk and Oram 1981) and there has been interest in breeding programs in Australia as well as in Canada. Two juncea canola varieties were released in Canada 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 Australia, the performance of juncea canola has been reported by Burton *et al*. (2003) and Norton *et al*. (2004), where the crop was generally superior to *B. napus* canola where napus yields are less than 1.5 t/ha. This roughly corresponds to areas where average annual rainfall is less than 350 mm.

Low rainfall farming systems rely on low cost, reliable cereal crops but there is a need to diversify rotations by developing management systems for juncea canola that are low cost, resilient and provide acceptable gross margins compared with current cereal crops. Based on current rotations, if juncea canola could be grown on 10% of the total cereal growing area in the low rainfall winter cereal zones, the production area for Australia would be over 600,000 ha.

The current challenge is to place juncea canola in a modern "conservation" cropping system where soil cover is maintained in a diverse and profitable rotation. While there has been a lot of research on *B. juncea*, much of the agronomy may not be transferable because the newer types have shorter growing season, reduced height and different fatty acid composition when compared to the older types (*e.g.* Pusabold, CPI 81792 and CPI 81997). While some data on seeding rates, row spacings and herbicides are useful, strategies such as sowing times and nutrition may not be. Potter *et al.* (1997) has also investigated seeding rates and row spacings for canola in low rainfall environments and this work is also likely to be partially applicable to juncea canola. The partial applicability arises because *B. juncea* has smaller seeds, which may make it more difficult to establish than juncea canola under high stubble loads and with direct drilling.

The objective of this paper is to provide a brief situation statement on our current knowledge of juncea canola agronomy and to suggest areas where additional research may be needed.

RECENT AND CURRENT AGRONOMIC RESEARCH

We have a very good understanding of the reasons for the superior performance of *B. juncea* under water stress when compared to *B. napus* (Wright *et al*. 1996). In the Wimmera under relatively dry conditions over two years, *B. juncea* (JN004) produced seed yields of 2.35 t/ha, compared to 1.95 t/ha and 3.50 t/ha for canola (Monty) and wheat (Goldmark) respectively, with all three crops using similar amounts of water in each year. There is also a good understanding of the phenology of the crop (Robertson *et al.* 2002) and these data sets provide sufficient information to initiate some simulation modelling for risk management assessments with this crop.

Gunaserera *et al*. (2001) presented data from Western Australia which supported the general view that short stature early types of juncea canola are best adapted to low rainfall areas. How early these short season juncea canola should be is as yet unresolved, with germplasm available five days earlier than current types. While very early maturity (earlier than Monty/Outback) may appeal in terms of heat and drought avoidance, such a short growing season may mean that the crop does not accumulate adequate biomass to achieve good yields. Earlier types, however, do present growers with the option of delaying sowing to improve weed control, although yields still need to be acceptable. In the newer types, crop uniformity and height are both significantly improved over JN004. Therefore, crop maturity, especially with respect to earliness, needs to be considered in a farming systems context - both in the low rainfall regions as well as in high rainfall regions where it may be spring sown.

In 2003 and 2004 in Victoria, there were investigations on juncea canola agronomy in collaboration with the Birchip Cropping Group and Incitec-Pivot using JN004. The thrust of this work has been to look at herbicide tolerance (BCG) and crop nutrition in the Mallee. All three mustard lines (JN004, JO006, JP056) were quiet tolerant to trifluralin and chlorpyralid (Lontrel ®) at commercial rates. All lines showed symptoms to the Group C herbicides simazine and duron, however JN004 was significantly more tolerant to diuron than simazine. Brodal and dicamba caused severe symptoms in all lines (Bell and Van Rees 2003).

Early research on N indicated that juncea canola was not likely to be responsive to additional fertilizer N (Castleman 1995) although an experiment at Warracknabeal in 2003 showed that juncea canola was responsive to applied N where it was banded. In contrast, canola responded only where N was top-dressed on this site (Norton, *pers comm*.). A more extensive series of nutrition experiments in the central Mallee in 2004 failed due to drought.

Because juncea canola is destined to be grown in areas where high levels of subsoil abiotic limitations have been identified (Nuttall *et al*. 2003) it is important to define the varietal responses to B and salinity. Kaur *et al.* (2003) showed that there is quite a degree of variation for B tolerance in *B. juncea* and *B. rapa*, although the *B. napus* cultivar (Ag Outback) used as a check line in one experiment was quite tolerant. Additional research on salinity tolerance is important as the abiotic chemical constraints of high sodicity, high salinity, boron toxicity, bicarbonate toxicity and possibly aluminium toxicity occur together. There is very little known of the response of either the germplasm used or the lines approaching commercialisation to these abiotic stresses.

Beneficial rotational effects of high glucosinolate *Brassica* species are well known (Kirkegaard *et al*. 2000) and provided the root glucosinolate levels in juncea canola are not significantly reduced, this break-crop effect will be highly significant for Mallee farming systems. Those systems are dominated by cereals and a profitable break crop would add important biodiversity in creating disease breaks, as well as using a potentially deep rooted crop to exploit resources that may be beyond the root zone of cereals.

In terms of pathogens, there is a need to keep a watching brief on the response of juncea canola to blackleg, although the crop will be deployed place it in areas where blackleg is a low risk. There is additional research required on other pathogens such as white rust and *Pratylenchus* nematodes. It is expected that juncea canola would be susceptible to *Rhizoctonia* so care needs to be taken in how the crop is established in no-till farming systems. Other biotic factors to consider are the potential effects of insect pests such as diamondback moth, redlegged earth mite and aphids.

GAPS IN CURRENT AGRONOMIC KNOWLEDGE

The development of a reliable and low cost management system for juncea canola will require the following areas to be addressed. The focus here is in placing this crop in low rainfall areas using conservation farming systems where stubble cover is maintained. The issues below are taken from a review of the current crop check guide for canola and are presented in no particular order. Components of the guide were assesses to determine where more information is needed to develop a reliable growers guide for juncea canola.

1. Risk analysis and adaptation

There are some unresolved issues about the general adaptation of juncea canola, not just in the low rainfall regions of the Mallee, Western Australia (Northern, Eastern and Sand Plain), Upper Eyre Peninsula and NSW Central, but also as a spring-sown crop in southern and western high rainfall regions. Within those zones it is important to:

a) Define within production regions the drought and high temperature risks and the impact of stored soil moisture on these risks.
b) Better define sowing time, especially to define safe sowing windows while still achieving satisfactory grain yields.

There needs to be a good assessment of the response of juncea canola lines to abiotic stresses such as salinity, boron and sodicity, particularly as these soil constraints are coincident with the main areas where the crop will be grown. The impact of these stresses and potential value of tolerant lines can be incorporated into existing simulation models to improve risk assessments and indicate the commercial value of tolerance.

Quality stability in response to seasonal conditions also needs to be assessed, and we have done some similar analyses on fatty acid levels in canola.

2. Nutrition

There is limited information on this topic, and given that fertilizers are the largest single input cost, developing low cost nutrient management strategies is important. In terms of individual nutrients, the following should be considered

a) Nitrogen: need to define strategies for application including the ability of juncea canola to acquire nitrate from deeper in the profile than cereals. The dynamics of N nutrition throughout the rotation requires some attention, especially if deep N is present, under situations where lucerne is the prior land use.
b) P and S: requirements need some work, especially for S. If there are relatively high levels of S supply (*e.g*. following gypsum) this may increase the glucosinolate levels beyond the canola standard - especially for lines that are at the canola quality standard now.
c) Trace element s: requirements are probably similar to canola, which routinely requires Zn.

3. Establishment

The small seed size of juncea canola makes it more difficult to achieve good placement in a seedbed, especially where stubble is present. While this is essentially an engineering issue there is a need for some work on sowing using air-seeders and combines of commercial size. Strip trials to investigate issues such as seeding rates, row widths, press wheels and sowing

depths can be demonstrated using the initiatives of these farmer groups. The trend to wider drill rows to enable stubble loads is a particular issue for crops such as juncea canola, that have tap roots which have only limited ability to spread into the inter-row spaces to access resources. Plant density is also likely to be a critical issue, as well as ensuring evenness of density.

4. Crop protection chemicals

There are no crop protection chemicals registered for juncea canola and there is a need to get crop safety tolerances for herbicides as well as maximum residue limits for target chemicals. Registration data for pre-emergence herbicides, post-emergence grass and broad-leafed herbicides will all be needed. Similarly, assessments of insecticides need to be initiated. In the mean time, minor-use registrations for all chemicals (herbicides, insecticides and fungicides) should be investigated. Such registrations could be for juncea canola in its own right, or alternatively, there may be the option of applying for a generic registration extending from canola to "Brassica oilseed crops".

The competitiveness of juncea canola against weeds should also be investigated urgently. Initially there will not be any herbicide tolerance juncea canola, although IT and TT types are both being developed. Weed control, especially wild radish control, will be important both from a yield perspective and from a quality perspective (preventing glucosinolate levels rising through admixture contamination).

5. Harvest timing and quality

A significant practical issue for juncea canola is correct timing of windrowing or harvest. Although a significant advantage of juncea canola is that it can be direct headed avoiding the costs of windrowing, but there needs to be some clear guidelines developed in collaboration with growers on timing of harvest relative to crop yield, oil quality and maturity, and also defining the situations where windrowing may be advisable (*e.g.* where maturity is uneven). This would be similar to the work done to identify correct windrowing times for canola when it was first grown.

6. Disease and Pest Resistances

Juncea canola will continue to be routinely screened for blackleg resistance. The tolerance to *Pratylenchus* spp. is likely to be important, although it is not known if there is any variation within the germplasm for this character. Response to white rust is also important and in high rainfall areas *Sclerotina* may be an issue.

CONCLUSION

It is now 25 years since Kirk and Oram (1981) identified juncea canola as a potential crop for low rainfall regions in Australia. With breeding programs now producing varieties that meet the canola quality standards, there is a need to co-ordinate the development of agronomic packages appropriate for this crop. The practices for napus canola are useful, but there are significant differences in the agronomic practices in regions where juncea canola will be produced that requires consideration of a range of management options and germplasm responses.

There is now a need to develop strategies to meet these challenges, including strengthening links between existing researchers, farming systems groups and individual farmers.

REFERENCES

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

Burton WA, SJ Pymer, PA Salisbury, JTO Kirk and RN Oram (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, PA Salisbury and D Potts (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.

Castleman GH (1995). Effects of herbicides o mustard (*Brassica juncea*). Proceedings of the 10th Australian Research Assembly on Brassica's (Ed. T Potter). Struan, 26-28th September 1995 p 94-99.

Gunaserera CP, LD Martin, GH Walton and KHM Siddique (2001). Indian mustard (*Brassica juncea*) – a promising oilseed crop for low rainfall cropping regions of Western Australia. Proceedings of the 12th Australian Research Assembly on Brassica's (Ed. S Marcroft). Geelong, 2nd-5th October 2001. p 135-140

Kirkegaard JA, M Sarwar, PTW Wong, A Mead, G Howe and M Newell (2000). Field studies on the biofumigation of take-all by Brassica break crops. Aust. J. Agric. Res. 51, 445–56.

Kaur, S., R Norton, R Ford, P Taylor and W Burton (2003). Studies on the boron tolerance of Brassica species. Proceedings of the 13th Australian Research Assembly on Brassica's (Ed. Jan Edwards). Tamworth. 8th-12th September, 2003. p 99-102.

Kirk JTO and RN Oram (1981). Isolation of erucic acid-free lines of Brassica juncea: Indian mustard now a potential oilseed crop in Australia. J. Aust. Inst. Agric. Sci. 47: 51-2

Norton, RM, WA Burton and PA Salisbury (2004) Canola quality *Brassica juncea* for Australia. In "New directions for a diverse planet": Proceedings for the 4th International Crop Science Congress, Brisbane, Australia, 26 September – 1 October 2004. http://www.cropscience.org.au/icsc2004/poster/5/1/3/1275_norton.htm

Nuttall JG, Armstrong RD, Connor DJ and Matassa V (2003). Evaluating physiochemical constraints of calcarosols on wheat yields in the Victorian southern Mallee. Australian Journal of Agricultural Research 54, 487-497.

Potter TD, I Lidwig and JR Kay (1997). Brassica crops for low rainfall environments in South Australia. Proceedings of the 11th Australian Research Assembly on Brassica's (Ed. GH Walton). Perth. 6-10th October, 1997. p 128-132..

Robertson MJ, AR Watkinson, JA Kirkegaard, JF Holland, TD Potter, WA Burton, GH Walton, DJ Moot, N Wratten, I Farré and S Asseng (2002). Environmental and genotypic control of time to flowering in canola and Indian mustard. Aust. J. Agric. Res. 53, 793-809.

Wachsmann NG, RM Norton, D Jochinke and SE Knights (2003). The comparative growth, yield and water use of safflower, Linola™, mustard, canola and wheat in southern Australia. In "Solutions for a better environment": Proceedings of the 11th Australian Agronomy Conference Geelong, Victoria. http://www.regional.org.au/au/asa/2003/c/4/wachsmann.htm#TopOfPage

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

Wright PR, JM Morgan and RS Jessop (1996). Comparative adaptation of canola (Brassica napus) and Indian mustard (*B. juncea*) to soil water deficits: Plant water relations and growth. Field Crops Res. 49, 51-64.