Breeding Research on New Oilseed Species for Production in Canada

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Introduction

Annual production of canola in Canada averaged 4.24 million tonnes on 3.3 million ha over the 10 year period 1985-1994 (Anonymous 1995). Most of this production (98%) occurred in the prairie provinces Manitoba, Saskatchewan, and Alberta. Canada exports approximately 50% of this production as seed, with 90% of all exports going to Japan. Canada is the largest exporter of canola seed in the world. The two species grown are *Brassica napus* and *B. rapa* occupying 60% and 40%, respectively, of this acreage. World population growth will result in further increased demands for high quality vegetable oil and high protein animal feed. Canola production in Canada is restricted to the cooler northern areas of the prairies, the so-called canola belt, because of the requirement for low temperature and low evaporation rates for these species for optimum growth. To increase production, the growing area for canola must be expanded into the drier and warmer regions of the southern prairies. It is unlikely that *B. napus* and *B. rapa* can be successfully grown in these drier areas of the prairies, and research was therefore undertaken to explore the potential of other species that are better heat and drought tolerant, for their potential as oilseeds on the dry prairie.

Brassica juncea

The mustard species *B. juncea* is grown as a condiment on some 50,000 ha annually in the prairie provinces of Canada, with 80% of total production in Saskatchewan. This production is concentrated in the drier areas of the prairies because of the better seed quality obtained under drier conditions. Studies by Woods et al. (1991) indicated that *B. juncea* is higher yielding than *B. napus*, is early maturing and resistant to seed shattering. It is also known to be better heat and drought tolerant than *B. napus*. A requirement for *B. juncea* to become an oilseed crop for Canada was the development of zero erucic acid, low glucosinolate germplasm. This was achieved through crosses between zero erucic acid *B. juncea* from Australia (Kirk and Oram 1981) and low glucosinolate *B. juncea* of the Saskatoon Research Centre (Love et al. 1990). Crosses were then made between the F_1 generation of this cross and the Canadian oriental condiment mustard cultivar Cutlass, followed by a cross to zero erucic acid, high oil content *B. juncea* derived from crosses between zero erucic acid lines and the Russian high oil content cultivar Donskaja. Selections in segregating generations of these crosses produced canola quality *B. juncea* of acceptable agronomic type that was field tested in 1990 (Love et al. 1991).

The breeding work to develop canola quality *B. juncea* was continued, and in 1993, replicated yield tests were grown at 9 locations in western Canada that demonstrated the yield advantage of *B. juncea* canola over *B. napus* canola (Rakow et al. 1995) (Table 1).

Table 1: Average agronomic performance and seed quality of selected canola quality *Brassica juncea* and *B. napus*, grown at 9 locations in western Canada, 1993 (after Rakow et al.1995).

	Yield		Mat.	Height	Oil	Glucosinolates[1]
Entry	kg/ha	%Legacy	(days)	(cm)	(%)	(μ moles/g meal)
B. juncea						
J92-78	2226	117	112	169	44.5	21.4
J92-223	2338	122	112	163	44.5	19.2
J92-650	2104	110	111	161	45.0	18.8
B. napus						
Cyclone	2061	108	109	130	46.1	4.4
AC Elect	1899	99	107	130	47.2	6.6
Legacy	1910	100	108	130	46.6	6.3

[1]Glucosinolates from Saskatoon location only

The average yield of the three *B. juncea* lines was 16% higher than that of the *B. napus* check variety Legacy. *Brassica juncea* matured a few days later and was 35cm taller than *B. napus*. The oil content of *B. juncea* was 1 to 2% lower, and total glucosinolate contents were higher than *B. napus*.

Table 2: Palmitic, stearic, oleic, linoleic and linolenic acid contents of zero erucic acid *Brassica juncea* line J92-223, *B. napus* low linolenic acid line C92-0226, and of interspecific derived BC_1F_2 and BC_1F_3 *B. juncea* plants (after Rakow 1995)

	Fatty acids (% of total)				
Entry	Palmitic	Stearic	Oleic	Linoleic	Linolenic
B. juncea					
J92-223	3.8	2.2	<u>42.5</u>	<u>36.5</u>	12.7
B. napus					
C92-0226	4.0	1.9	<u>69.3</u>	<u>20.7</u>	1.8
Backcross[1]					
BC_1F_2(n=29)	4.3	3.2	53.0	31.9	<u>5.5</u>
BC_1F_3(n=13)	5.1	4.3	<u>61.0</u>	<u>21.6</u>	<u>4.7</u>

[1]Backcross: (*B. juncea* x *B. napus*) x *B. juncea*

The fatty acid composition of zero erucic acid *B. juncea* is different from that of *B. napus* in that oleic acid is lower and linoleic acid is higher (Table 2). This is unacceptable for a vegetable oil in Canada, unacceptable for a vegetable oil in Canada, and a minimum of 55% oleic acid is required before a *B. juncea* canola variety will be considered for registration. We attempted to correct this deficiency through an interspecific cross with low linolenic acid *B. napus* followed by a backcross to *B. juncea*. Backcross F_2 and F_3 selections for high oleic/low linoleic acid concentrations produced the desired *B. napus* like fatty acid composition (Table 2). Further backcrosses to *B. juncea* will be required to develop canola quality *B. juncea* with the desired fatty acid composition. It will also be necessary to further reduce glucosinolate contents in canola *B. juncea* to levels in *B. napus*. High oil content is available in *B. juncea* germplasm and is being used in the breeding program to increase seed oil contents of *B. juncea* canola (Rakow et al. 1995).

Brassica carinata

Brassica carinata (Ethiopian mustard) is the most productive oilseed crop in the highlands of Ethiopia (Seedeler 1983). We evaluated eleven *B. carinata* introductions from the Plant Gene Resources Centre in Ethiopia for two years in field tests at Saskatoon (Getinet et al. 1996). Seed yields of *B. carinata* were not different from those of *B. napus* in one year, but were lower than *B. napus* in the second year. There was a large variation among the *B. carinata* introductions for days to maturity ranging from being equal in maturity to early maturing Canadian *B. napus* varieties to 15 days later than *B. napus*. *Brassica carinata* introductions were large seeded with on average of 1.0g per 1000 seed higher seed weight than *B. napus*. Oil contents of *B. carinata* were 6 to 8% lower than *B. napus* while meal protein contents were higher. Yellow seeded forms of *B. carinata* had higher seed oil and meal protein and lower meal fibre levels than brown seeded forms.

It was concluded, from the results of this study, that *B. carinata* could be a potential oilseed crop for the Canadian prairies. *B. carinata* has high levels of blackleg resistance and seems to be adapted to dryland production (Knowles et al. 1981, Ferreres et al. 1983, Alonso et al. 1991). Its large seed size would be beneficial for stand establishment under dry conditions. However, early maturing lines must be developed that are adapted to the short season growing areas of western Canada, and seed oil contents must be increased to make *B. carinata* competitive with *B. napus*. A further requirement for *B. carinata* to become an oilseed crop is the development of zero erucic acid, low glucosinolate genotypes. We have developed zero erucic acid *B. carinata* from interspecific crosses with *B. juncea* (Getinet et al. 1994) and investigated the inheritance of this trait (Getinet et al. 1997a). The low oleic acid content of approximately 20% and high concentrations of linoleic (38%) and linolenic acid (34%) in zero erucic acid *B. carianta* are of concern and breeding efforts have been initiated to increase oleic acid contents in zero erucic acid *B. carinata* (Raney et al. 1995a). Also, the development of low glucosinolate *B. carinata* has been initiated through interspecific crosses of *B. carinata* with low glucosinolate *B. juncea* and *B. napus* (Getinet et al. 1997b.) In summary it is concluded that *B. carinata* could be developed into a productive, high quality canola species for production on the Canadian prairies.

Sinapis alba

The species *S. alba* is well adapted to dryland production because of its tolerance to high temperatures and drought stress. It is highly resistant to diseases and many insect pests and the pods are highly shatter resistant. It is lower yielding than *Brassica* species and the seed has an oil content of only 25 to 28% which are the major limiting factors for *S. alba* oilseed development.

We are interested in *S. alba* as an oilseed crop because of its adaptation to dryland agriculture. Therefore, selections for low erucic acid *S. alba* were initiated in the early 1970's at Saskatoon which resulted in the identification of the desired zero erucic acid forms. Krzymanski et al. (1991) reported the isolation of low glucosinolate *S. alba* , and we utilized these two germplasm sources to develop canola quality *S. alba* (Raney et al. 1995b). Research was also initiated to increase seed oil content of *S. alba* utilizing high oil content (36-38% oil) germplasm from Sweden (Olsson 1974). This research is at an early stage, but we believe that it should be possible to develop *S. alba* into a productive oilseed crop for the Canadian prairie.

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