SELECTING CANOLA VARIETIES FOR WESTERN AUSTRALIA – FINAL GRDC PROJECT REPORT

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ABSTRACT

The National Brassica Improvement Program's (NBIP) aim is to produce a range of canola varieties adapted to diverse growing regions of Australia. To facilitate the development of canola cultivars specifically suited to the short season Mediterranean environment and soils with low pH, a five year project began in 1996 to take single plant selections at two locations in Western Australia. The source of material was early generation (F3, F4) crossbred lines originating from the two public plant breeding organisations within the NBIP. Plants were selected on the basis of early flowering, high pod number per plant, high oil and protein concentrations and lower glucosinolates than control varieties. Lines with the highest seed yields and oil quality parameters were promoted into a series of yield trials over the following years. The selected lines were also included in blackleg disease nurseries to provide data for lines to be culled from further promotion based on poor resistance to blackleg disease.

The project in Western Australia has provided the NBIP, with nearly 7000 early-, mid-maturing and triazine tolerant, high yielding lines with increased oil and protein concentrations, of which about 30 have been used as parents in crossings. Results in the preliminary yield trials show that for winter sowing in short season environments in W.A., lines should be selected which flower about 80 days after sowing. Early maturing progeny derived from WA selected plants are being evaluated for possible commercial release.

KEYWORDS

Selection, adaptation, evaluation, yield, oil, protein.

INTRODUCTION

The National Brassica Improvement Program's (NBIP) aim is to provide a range of maturities incorporating blackleg disease resistance, improved yield, oil and protein that will be adapted to the diverse growing regions in Australia. The NBIP consists of two public plant breeders located at Horsham, Victoria and at Wagga Wagga, New South Wales. Selections of crossbred material done at these two locations in environments with clay/loam soils having strong water-holding capacity, high fertility and cool, wet spring periods are best suited to produce varieties of medium to late maturity. Western Australia has a diverse agricultural environment, some of which is cool and wet, where varieties of medium to late maturity do well. However, about 60% of the crop-growing region receives low rainfall (320-500mm annually), temperature rises rapidly after flowering and has sandy soils with low pH, poor water holding capacity and low fertility. The domination in WA of the locally bred early maturing canola variety Narendra from 1994-1997 (cf 42% of canola area), illustrates the advantage of developing varieties for WA and other short season environments of southern Australia in situ.

Water stress imposed after the start of flowering, reduces seed yield in *Brassica napus* as a result of high pod abortion rates and reduces oil concentration and increases glucosinolate concentration (Mailer and Cornish, 1986, Jensen et al, 1996). High temperature (35^{o}C) for 7 days during flowering and pod fill, reduced *B. napus* dry matter yield and affected all reproductive organs to reduce seed yield. *B. napus* was less able to recover from heat stress after flowering than other Brassica species. (Angadi et al, 2000). Experiments using time of sowing treatment to simulate different lengths of growing periods show that with a reduction in season length, *Brassica* oilseed species reduce seed yield as a result of a reduction in pod numbers (Thurling, 1974, Richards and Thurling, 1978, Diepenbrock, 2000). The production of canola under such environmental conditions requires crop management to avoid moisture and heat stress after flowering. Sowing early in the growing season increases seed yields and provides the highest oil concentrations (Walton, 1998). Many experiments have shown a strong relationship in *B. napus* between early start to flowering and increased seed yield (Thurling, 1974, Thurling and Vijendra Das, 1979, Thurling and Kaveeta, 1992). Richards and Thurling (1978) concluded that earlier flowering *B. napus* cultivars are better suited to W.A. conditions and significant improvement in seed yield would come about through the simple selection of early flowering lines having the highest dry matter at flowering, with further selection based on harvest index.

In 1996, the Western Australian Department of Agriculture had no canola breeding program, so began a collaborative project with the NBIP and with financial support of the GRDC, to support the plant breeders in developing early maturity canola varieties by undertaking selection of plants in Western Australia.

MATERIAL AND METHODS

Under the agreement between the NBIP and the Western Australian Department of Agriculture, crossbred canola lines originating from Agriculture Victoria and the NSW Department of Agriculture oilseed breeding programs trials (F4 and F3 material respectively), were available for selection in W.A. The lines were those placed each year in the interstate early-, mid-maturity and triazine tolerant (TT) evaluation trials, plus additional crossbred lines available. The number of lines each year totalled between 100 and 200. The number of plants selected each year in W.A. was no more than 1500 in consideration of the analytical laboratory resources.

The crossbred lines were sown in widely spaced single rows at two locations, at Wongan Hills Research Station (30^{o} 50'S, 116^{o} 43'E) and at Merredin Research Station (31^{o}30'S, 118^{o}10'E). Two sites were chosen as insurance against crop failure at either location. Over the four years of the project (1997-2000), the two locations had similar maximum and minimum mean monthly temperature patterns. The annual rainfall at Wongan Hills averaged about 40 mm more than at Merredin (table 1). 1999 was a wet year in comparison with the other three years. The soil at Wongan Hills is described as grey sand overlying yellow sands with increasing clay, pH ($CaCl_2$) 4.3, Northcote; Uc 5.22. The soil varied at Merredin, predominantly brown sandy loam over sandy clay loam, pH ($CaCl_2$) 5-7, Northcote; KS-Uc 4.21, Dr 2.12, Dy 3.13. The selection rows were 5m length, with paired rows initially. From 1998 the rows were in three replicated blocks. The crossbred lines were also sown in small plot yield trials, with two replications at each location. The appearance of the crop growth in these plots was used to choose the lines to concentrate on for the selections. The sowing dates for the selection rows at both locations ranged from June 4 to June 24, depending on the season. Each line had the number of days after sowing of the start and end of flowering recorded. At maturity, the plant height (cm) was estimated and plants were selected on the basis of stem height (not too tall) and high number of branches and pods.

Table 1. Annual rainfall (mm) for each of the four years 1997-2000 for Wongan Hills and Merredin.

	Wongan Hills				**Merredin**			
	1997	**1998**	**1999**	**2000**	**1997**	**1998**	**1999**	**2000**
Annual	319.6	347.5	619.0	340.1	338.5	311.0	513.3	300.4

The seed from each plant was weighed and oil, protein and glucosinolate concentrations were analysed at the Canola Research Laboratories, Wagga Wagga. Plants with higher oil and protein and lower glucosinolates concentrations than control varieties (non-TT, Monty, and Dunkeld; TT, Karoo) were chosen for further evaluation.

After the initial selection, the chosen lines followed the following annual sequence of;
Preliminary yield trials, located at Wongan Hills and at Merredin. The plot size was five rows and 3m in length, with two replicate blocks. Each plot had the start of flowering, end of flowering, crop height recorded and seed harvested and weighed.

Stage 2 yield trials, consist of three categories, non-TT early-maturity, non-TT mid-maturity and TT. Each category had three trials in W.A. each season. The plots were eight rows and 15m in length.

Variety Testing Program, at an extensive number of locations throughout the WA agricultural regions.

Concurrent with the Stage 2 trials and Variety Testing Program, the lines were included in the blackleg disease screening nurseries at Wongan Hills and at Mount Barker for an estimate of their tolerance.

Weed and insect control was achieved through standard agronomic practice, the preliminary yield and Stage 2 TT trials had Atrazine applied post emergence at 2L/ha. Adequate Phosphorus and Sulphur was applied at seeding, with 70 units/ha of Nitrogen, in a split application.

RESULTS AND DISCUSSION

Over the five years of the project, a total of 6,992 plants were selected, the majority of which were triazine tolerant and 2,152 (30.7%) were promoted into the preliminary yield trials. The selection of these plants is an important outcome for the Project, as they contributed to the gene pool from which the plant breeders could draw on, especially for the early flowering character. The plant breeders used about 30 of the selections in numerous crosses within the NSW and Victorian programs. The canola interstate evaluation program at present and in the future should have many crossbred entries with W.A. selected lines in the pedigree.

Early flowering versus yield

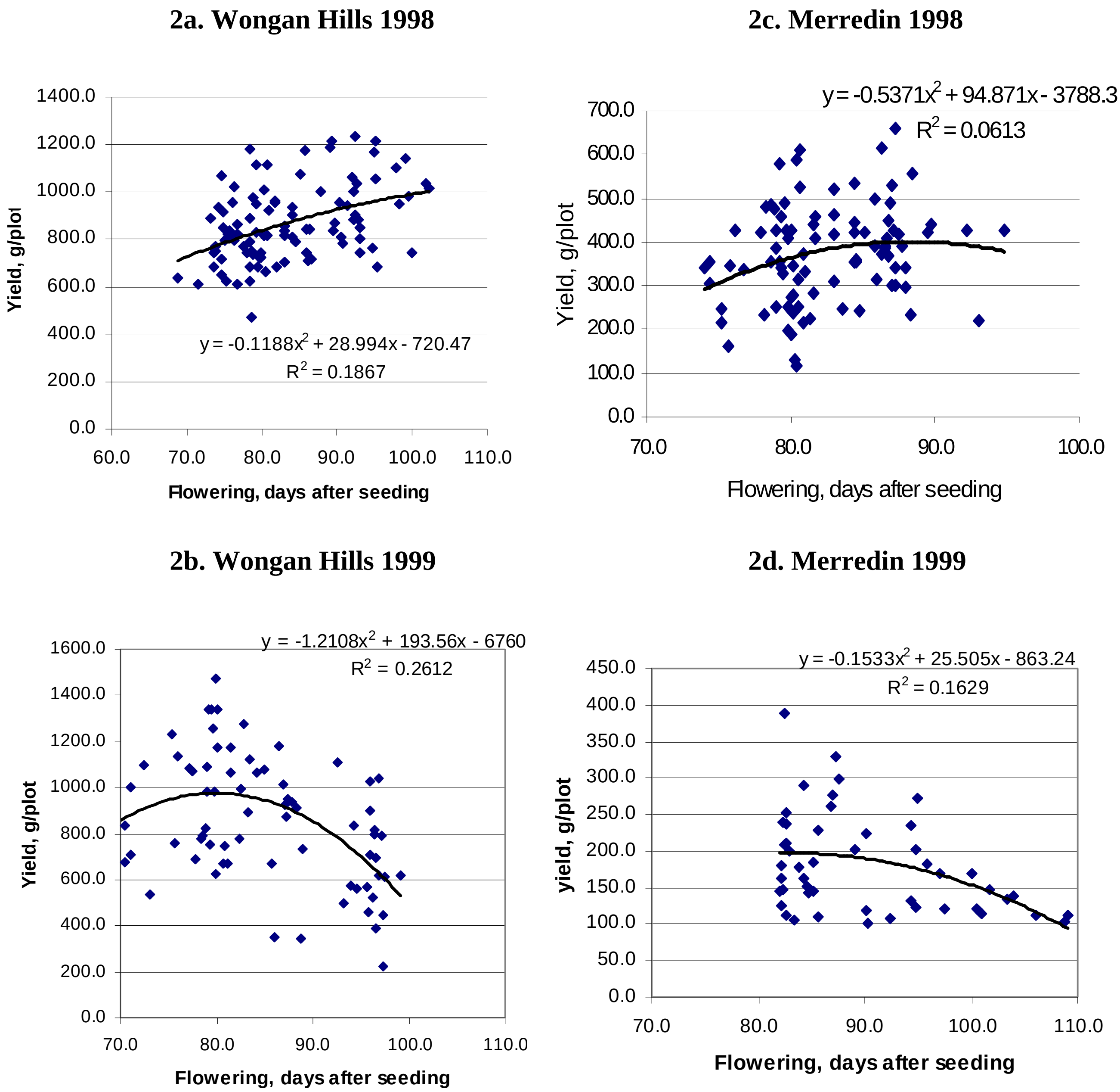
Correlations between the number of days after sowing when 50% of plants had commenced flowering and the seed yield obtained off the plot in the preliminary yield trials, were done for both sites in 1998, a low rainfall year and 1999, a high rainfall year. The correlations for the TT selections are presented in figures 2a to d. Similar correlations were found for the non-TT selections (not presented). The four correlations were curvilinear, with three of the four having yield peaking at start of flowering, 80-87 days after sowing. The days to flower at peak yield corresponds with the start of flowering for the TT variety Karoo. At Wongan Hills in 1998, the yield appears to respond to later flowering. This reflects the better moisture content held in the soil from April rainfall onwards which the later flowering lines responded to in yield. Looking at the highest yielding points in the correlation, the yield tends to flatten as the days to flower exceeds 80 days.

For the non-TT lines, the yield peaked when flowering started 75-85 days after sowing. This corresponds with the variety Monty. Early flowering avoided low moisture and high temperature stresses late in the reproductive stages. Flowering earlier, the plants are unable to provide sufficient pre-anthesis biomass to support a high yield. Flowering much later, the plants ran into environmental stresses post-anthesis. In an experiment at Minnipa, South Australia, Oram et al (1997) found a negative linear correlation between seed yield and days to flowering in canola, with the highest yield from the earliest flowering, 75 days after seeding.

Improving the germplasm through selection.

Direct comparison of selections made from control varieties gives one estimate of improvements made through the selection process in W.A. In 1998 Stage 2 evaluation, a selection from Mystic (RK7) was tested against Mystic, the selection gave 28% higher yield, 4 days earlier flowering, no improvement in oil, protein concentration and less blackleg tolerance. In 2000, ten selections from TT varieties (Karoo, Clancy, Hylite200TT and Pinnacle) were in comparison against their namesake. On average, the selections gave 15% higher yield, were 2 days earlier flowering and produced 0.4% higher oil and protein concentrations. The method of selection in the project is capable of significant yield improvement and earlier flowering, but quality characters seem less significant.

Figure 2. Correlations between plot yield and start of flowering of triazine tolerant selections in preliminary yield trials at Wongan hills and Merredin in 1998 and 1999.



Possible new varieties for Western Australia?

The best performing TT selections in the Stage 2 evaluations from 1998 to 2000, (table 2), gave on average up to 21% higher yield, 3.5% more oil and 2.1% more protein than Karoo. Selections from the NBIP, flowered later than Karoo, however, selections from WA bred material, flowered up to 13 days earlier than Karoo. Blackleg resistance was not improved in the TT lines, until after 1997, when the selections were made from within the disease nursery and achieved up to 30% greater survival.

The best early- and mid-maturity selections averaged 13% and 12% higher yield than Monty and Rainbow respectively. For early-maturity selections, the oil and protein concentrations averaged

1.7% and 2.3% higher than Monty respectively. The mid-maturity selections responded to the cooler, wetter trial locations with oil and protein increases of 2.6% and 2.8% respectively above Rainbow. Selections made within the disease nursery environment raised survival of the best lines early-maturity and mid-maturity lines by 30% and 10% respectively.

In the state-wide variety trials in 1999 and 2000, the selections did not yield better than the control varieties. This may reflect the use of trial seed instead of pure seed in these evaluations. Trial seed will have heterogeneity increased through outcrossing and harvester machinery admixture, giving potential for more variation. The flowering and blackleg responses were consistent with the Stage 2 trial performances. The first selection to be considered for commercial release was the early-maturity line, RK7-96W2, however, its yield was not significantly different to the variety Mystic (RK7) and it's level of resistance to blackleg was insufficient to warrant proceeding.

The TT selection, DBX2, is being considered for future release in W.A.. It has better blackleg tolerance than Karoo and similar yield performances and quality. It is currently in variety evaluation against more recent TT selections before a final decision is made.

Table 2. The range of average variation in yield (expressed as a percentage of control variety), days to start of flowering, %plant survival in blackleg disease nursery, oil% and protein% for the best five selections compared to the control variety, in the stage 2 trials over the years 1998 to 2000.

Category:	Yield %	Fl. (days)	Survival % *	Oil %	Protein %
TT vs Karoo	-4 to 21	-13 to 10	17 to 30	0.3 to 3.5	0.6 to 2.1
Early-maturity vs Monty	0 to 13	-3 to 9	-1 to 30	0 to 1.7	-0.4 to 2.3
Mid-maturity vs Rainbow	1.5 to 12	-1 to 1	-12 to 10	1.3 to 2.5	1.5 to 2.8

*Percentage of emerged plants surviving in disease nursery.

CONCLUSIONS

The support to the breeding and evaluation of NBIP crossbred material to provide new canola varieties for the low rainfall regions of Australia, has been a success, even though new varieties have yet to come from the project. The selection of plants from within the NBIP has produced new lines having improved yield, tolerance to blackleg disease, oil and protein concentrations over the control canola varieties. The improvement in yield seen in the early evaluation trials has not yet (up to 2000) held for the state-wide evaluation trial results, although the better blackleg resistance has been maintained. In future, seed of advanced lines for evaluation will come from pure seed increase plots so the initial gains found in the preliminary yield trials should be reflected in the state-wide evaluation trials. The more recent (1998-2000) selections which are being, or will be tested, will be used as parents in the crossing programs of the NBIP and some should warrant commercial release in the future.

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