# The potential of winter canola types in the high rainfall zone of southern Australia

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## ABSTRACT

Field experiments were conducted at Hamilton in south west Victoria in 2005, 2006 and 2008 to identify canola traits better suited to the High Rainfall Zone (HRZ) of southern Australia so that the estimated yield potential of the region is realised. Nine cultivars with different reported maturities (winter and spring types) were sown at either two times of sowing and / or under different N fertiliser regimes. Dates of key phenological development were recorded and dry matter determined at bud, anthesis and harvest. Plant traits and climate data were assessed in relation to grain yield. Yields of the winter types were either significantly ($P$<0.05) higher or not significantly lower than the spring types in all three years, even though the winter types flowered later than the spring types (on average 35 days for the earlier sowing times) and spring rainfall was approximately half that of the long-term average. In general, the winter types had greater early vigour, higher dry matter production at the bud stage, anthesis and harvest and were taller than the spring types. This study indicates that winter types have the potential to provide significant improvements to the yield of canola in the HRZ either through the direct importation of cultivars from overseas or through the identification and incorporation of desired traits into existing material. It is recommended that a wider range of germplasm be assessed over a greater geographical area to identify traits relating to phenology and yield. This information can be used to help inform breeders on crop improvement priorities and assess the commercial potential of breeding cultivars specifically for the HRZ.

**Key words**: winter - spring - *Brassica napus* – phenology - yield

## INTRODUCTION

The canola industry began in Australia in the late 1960’s to provide an alternative crop to wheat following the introduction wheat quotas (Buzza 2007). Spring types are the most common rapeseeds grown in Australia whereas winter types (those requiring winter chilling to flower) are commonly grown in Europe, China, Eastern Canada and parts of the US (Kimber and McGregor 1995, Berry and Spink 2006). Early in the development of the rapeseed industry, winter types were considered poorly adapted to Australian conditions and therefore did not form the core of ancestral populations (Cowling 2007). However, there is interest in introducing European winter *B. napus* cultivars as a source of blackleg resistance, to increase yield and for tolerance to sub-optimal conditions (Light et al. 2005).

Recently, there has been a rapid expansion of cropping into the HRZ (annual rainfall >550 mm) of southern Australia with this region contributing significantly to National production (Walton and Barbetti 2005, Burton and Marcroft 2005). Average canola yields in the HRZ are 1.4 t/ha (ABS data 2001-2005), significantly lower than the predicted potential (> 4t/ha) based on growing season rainfall (GSR). It is proposed that winter types may have traits better able to exploit the resource-base of the HRZ, thus enabling the yield potential of the region to be realised.

## MATERIALS AND METHODS

Experiments were conducted at DPI, Hamilton Victoria (37$^{o}$49’S, 142$^{o}$04’E) in 2005, 2006 and 2008. A total of nine cultivars were tested to provide a wide range of growth and developmental patterns. Cultivars were commercial spring types including conventional ($^{AV}$Sapphire and Rivette), hybrid (Hyola 61 and 75), triazine tolerant (TT) types ($^{ATR}$Grace and $^{ATR}$Summitt), and winter types (Caracas and CBI206) from Europe. Cultivars were sown at two times of sowing; early (April 27 in 2006 and May 9 in 2008) and late (May 29 in 2005 and 2006 and July 4 in

2008). In 2005 and 2008 N fertiliser treatments were applied (high and low rates) whereas in 2006 N fertiliser was applied at the district practise.

Dates of bud appearance (initiation), flowering (50%) and maturity (40-60% change in seed colour) were recorded. At these key developmental stages, dry matter (DM) production was measured and at harvest, plant height, harvest index and grain yield were determined. Climate data was recorded using the DPI Hamilton weather station. Experimental designs were factorial designs with four replicates. Data was analysed by ANOVA using GenStat 9.1 (GenStat Committee 2003).

## RESULTS

### Rainfall

In all three years annual rainfall and GSR were well below the long-term averages (LTA) (Figure 1). The GSR (April to November) was only 73%, 67% and 80% of the LTA (534.5mm) for 2005, 2006 and 2008 respectively. The greatest reduction came in spring where rainfall was only 82% of the LTA (191.9 mm) in 2005 and nearly half that of the LTA for 2006 and 2008 (58% and 56% respectively).

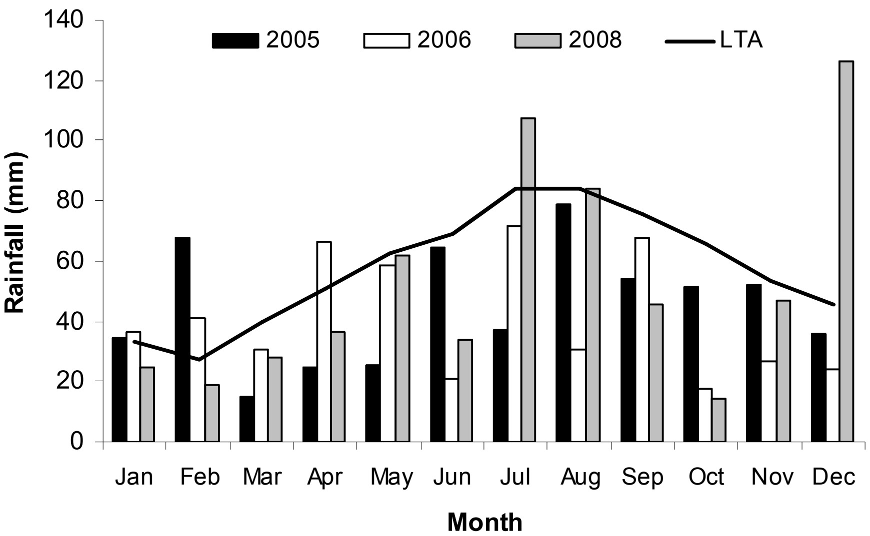


Fig. 1. Monthly rainfall (mm) for Hamilton in 2005, 2006 and 2008 (bars) and the long term average (line).

### Maximum temperatures from anthesis to maturity

In 2005 and 2008 all cultivars were exposed to a similar number of days above 30°C from anthesis to maturity (2 and 5 days respectively). In 2006 Caracas was exposed to more days above 30°C for both the first and second times of sowing. For the April sowing, Caracas experienced 4, Hyola75, 3 and [AV]Garnet and Rivette, 1 day above 30°C. For the May sowing, Caracas experienced 9 days with the other cultivars only exposed to 3 days above 30°C.

### Minimum temperatures from anthesis to maturity

In 2005, Hyola 61 and [AV]Sapphire were exposed to twice as many frosts (minimum temperatures less than 0°C) than Caracas and [ATR]Grace (two days below 0°C compared to one). There were more frosts in 2006 with [AV]Garnet and Rivette each exposed to twelve frosts after anthesis, Hyola 75, eleven and Caracas, ten. For the second time of sowing all cultivars were exposed to the same number of frosts (ten). In 2008, all cultivars for both sowing times were exposed to two frosts except [AV]Sapphire and [ATR]Summitt which were exposed to three frosts for the May sowing times.

**Phenology**
There was a distinct difference in maturity between the winter and spring types with the winter types flowering on average 35 days later than the spring types for the earlier sowing times (late April, early May) and 18 days later for the late sown treatments (late May and early July). All spring types within the same sowing time reached the bud visible stage on the same date with all cultivars flowering within a week of one another. In 2008 when the two winter types (Caracas and CBI206) were tested together, both displayed exactly the same duration to bud, flowering and physiological maturity. The duration from sowing to the bud visible phase for the early sown crops was longer for the winter types than the spring types by an average of 31 days (220 °C days), but this duration contracted to an average of 19 days (190 °C days) for the later sowing times. The period between bud visible to flowering was similar for both the winter and spring types irrespective of sowing time. The winter types were shorter from flowering to physiological maturity than the spring types (average of 7 days for both sowing times).

**Grain yields, dry matter production, plant height and harvest index**
Yields from early sown and N fertiliser treatments were higher than late sown crops or those that received no N fertiliser. However, there were no cultivar x N fertiliser or cultivar x time of sowing interactions and so this paper will only report on the means of the treatments for each cultivar.

Table 1. Yield, bud, anthesis and total dry matters, plant height and harvest indices of two winter (Caracas and CBI206) and seven spring ($^{ATR}$Grace, $^{ATR}$Summitt, Hyola 61, Hyola 75, $^{AV}$Sapphire, $^{AV}$Garnet and Rivette) canola types sown at Hamilton in 2005, 2006 and 2008. Values are means of treatments (2005, N fertiliser; 2006, time of sowing and 2008; N fertiliser and time of sowing).

| Cultivar | Yield (t/ha) | Bud DM (kg/ha) | Anthesis DM (kg/ha) | Total DM (kg/ha) | Plant Height (cm) | Harvest Index |
|---|---|---|---|---|---|---|
| **2005** | | | | | | |
| Caracas | 2.67 | 720 | 6500 | 10990 | 171.9 | 0.24 |
| $^{ATR}$Grace | 2.10 | 470 | 3420 | 8550 | 143.4 | 0.26 |
| Hyola 61 | 2.44 | 720 | 3730 | 8820 | 144.7 | 0.29 |
| $^{AV}$Sapphire | 2.66 | 660 | 3640 | 9870 | 141.8 | 0.27 |
| F Prob | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| LSD (P=0.05) | 0.244 | 112.2 | 522.9 | 1281.4 | 5.79 | 0.020 |
| **2006** | | | | | | |
| Caracas | 1.48 | 2930 | 5760 | 8540 | 142.1 | 0.17 |
| Hyola 75 | 1.60 | 1170 | 3740 | 7960 | 141.5 | 0.20 |
| Rivette | 1.26 | 820 | 2880 | 5500 | 129.8 | 0.23 |
| $^{AV}$Garnet | 1.63 | 1070 | 3870 | 6720 | 147.1 | 0.25 |
| F Prob | 0.004 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| LSD (P=0.05) | 0.209 | 335.3 | 699.0 | 1314.6 | 7.94 | 0.026 |
| **2008** | | | | | | |
| Caracas | 2.95 | 2990 | 6250 | 10420 | 101.0 | 0.27 |
| CBI206 | 3.48 | 2880 | 6990 | 11490 | 115.2 | 0.30 |
| $^{ATR}$Summitt | 2.17 | 400 | 3300 | 6830 | 99.0 | 0.31 |
| Rivette | 2.41 | 590 | 3680 | 7340 | 96.5 | 0.33 |
| $^{AV}$Sapphire | 2.48 | 660 | 4520 | 7830 | 96.3 | 0.32 |
| $^{AV}$Garnet | 2.94 | 750 | 4180 | 8560 | 103.5 | 0.35 |
| F Prob | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| LSD (P=0.05) | 0.401 | 356.9 | 1619.7 | 1324.6 | 6.78 | 0.016 |

Yields from the winter types were either significantly ($P<0.05$) higher or not significantly lower than the spring types (Table 1). In 2008, yields from the winter type CBI206 were 18% higher than the best performing spring type AVGarnet whilst CBI206 and Caracas were 40% and 19% higher respectively than the National Variety Trials control AVSapphire. Bud DM yields of the winter types were significantly ($P<0.001$) higher than the spring types with the exception of Hyola 61 in 2005. Anthesis DM was a minimum of 2770, 1890 and 2950 kg/ha greater than the spring types in 2005, 2006 and 2008 respectively. Total DM yields were 11-17% higher than the spring types although differences were not significant ($P<0.001$) for AVSapphire in 2005 and Hyola 75 in 2006. The winter types tended to be taller than the spring types with the exception of AVGarnet where plant height was similar. The harvest indices of the winter types were significantly ($P<0.001$) lower than the spring types with the exception of CBI206 and ATRSummitt in 2008 where CBI206 was slightly, but not significantly lower (Table 1).

## DISCUSSION

In all three years, the yields of the winter types were either commensurate with or significantly greater than the spring types. This was despite these cultivars experiencing stress during the flowering to maturity period as evidenced by observations of wilting, pod abortion, a shorter grain fill phase than the spring types and low harvest indices. The stress was due to late flowering relative to the spring types which coincided with hot, dry conditions in seasons where the GSR was approximately two thirds and spring rainfall approximately half that of the LTA. This suggests that yields could have been even higher if seasons were more typical. The reduced exposure to frosts due to delayed flowering may also have contributed to higher yields in the winter types. There was a large gap in the maturities between the spring and winter types. It may be that a maturity between the two groups would provide an optimum development to avoid climatic risks (frost, heat and drought) and to maximise assimilate production. Further work, including field experiments to test a more complete range of maturity types together with crop modelling will help identify the optimum phenology for this environment.

Higher yields from the winter types were most likely due to greater DM accumulation. In 2006 and 2008 DM accumulation by the bud visible stage was generally 2 to 3 times higher for the winter types than the spring types. Although higher DM values were in part due to late initiation, growth rate (kg/ha/day) was also greater for the winter types (data not shown). In the UK, Mendham and Scott (1975) showed that yield was proportional to the interval between sowing and initiation for winter cultivars with contrasting phasic development. These authors attributed this to late initiators being able to lay the foundation for a more substantial shoot and root system. It is therefore possible that the higher yields from the winter types were due to improved radiation capture through early vigour and plant height and greater soil water extraction through a well developed root system. Not only is this high DM beneficial for the production of grain yield but could also be of value for the livestock industries through grazing (Kirkegaard et al. 2008), and by providing an alternative use for the crop as hay or silage if the crop fails. This, together with the fact that the winter types appeared relatively robust even in poor seasons, suggests that the risk of introducing such germplasm into farming systems in this environment is low, providing problems such as blackleg and lodging are addressed.

Further yield gains may be achieved either through the direct importation of higher yielding cultivars from overseas or through the identification and incorporation of specific traits into existing Australian germplasm. The winter cultivars tested in these experiments were not brought into Australia to test specifically for yield advantages in the HRZ. Caracas was introduced for use in breeding programs to provide an alternative source of blackleg resistance (Wayne Burton *pers comm.*) whilst CBI206 was introduced to assess its' potential in grazing systems (Trent Potter *pers comm.*). To identify cultivars that may be better suited to the HRZ, a wider range of winter germplasm specifically targeting yield improvement needs to be screened over a wider geographical area than was covered in this study. This may identify cultivars that can be directly imported into the region or identify specific traits that can be incorporated into existing material. It should be noted that although having the maturity of the spring types, yields of AVGarnet were also high and that this cultivar does have a winter parent (Wayne Burton *pers comm.*). This cultivar displayed characteristics of the winter types in particular plant height and DM production and highlights the opportunity to identify specific traits relating to yield in this environment so that they can be used in breeding programs.

## CONCLUSION

This study indicates that winter types have the potential to provide significant improvements to the yield of canola in the HRZ either through the direct importation of cultivars from overseas or through the identification and incorporation of desired traits into existing material. Through a better understanding of canola growth and development in the HRZ, crop models can be improved to provide a better assessment of yield potential (t/ha) and production potential (area) of the HRZ. This will help breeders identify crop improvement priorities and assess the commercial potential of breeding cultivars specifically for the HRZ.

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