Identifying traits for canola in a new cropping environment in Australia

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Abstract
A field experiment was conducted in 2010 to identify canola traits suited to the new and expanding high rainfall cropping region of south-eastern Australia. Winter and spring cultivars from Europe were assessed to test the hypothesis that cultivars from other high rainfall regions of the world would make better use of the longer growing season and therefore produce greater yields than cultivars currently available to farmers. The grain yield, yield components and level of blackleg infection of four canola cultivars from Europe (3 winter types and 1 spring type) were compared to a high yielding Australian spring type. Crops were grown +/- spring irrigation and +/- plant growth regulator (PGR). The European types produced approximately 20% more grain than the Australian control with grain yields as high as 8.0 t ha^{-1} under irrigation. The application of 45 mm of irrigation in spring resulted in approximately 1 t ha^{-1} more grain than the rain fed treatment. The PGR caused a significant height reduction but did not improve grain yield or harvest index. Results indicate that this region has a high yield potential and that European germplasm may have traits that will enable this potential to be realised. However, water stress during flowering and grain fill is likely to limit yields under rain fed conditions. Important traits are likely to include high seed numbers per pod, drought tolerance during flowering and seed development and good blackleg resistance. Further testing of germplasm under a wider range of conditions will be needed to verify findings and develop cultivars adapted to the region.

Keywords: winter, spring, yield, yield components, phenology

Introduction

Agriculture in the High Rainfall Zone (HRZ) of southern Australia has traditionally been dominated by the livestock industries (DPI 2010a). More recently, the area sown to crop has increased with this region now making a significant contribution to national grain production. However, there has been little breeding specifically for the HRZ and farmers rely on cultivars from the traditional hotter, drier cropping regions of Australia. As a result cultivars are not well adapted to the environment and thus production is limited. Canola types grown in Australia have a spring maturity and have been shown to have a narrow genetic base (Cowling 2007). Winter types are grown in many HRZ of the world but are considered unsuitable for the traditional shorter season cropping regions in Australia. However, the longer growing season in the HRZ of southern Australia may enable the later maturing winter types to better exploit the resource-base and increase yields under rain fed conditions. Recent experiments showed unexpected high grain yields in the HRZ of Victoria from winter canola types imported from Europe (Riffkin 2009). At Hamilton in 2008, a winter canola type yielded nearly 20% more than the highest yielding spring type despite spring rainfall being approximately half the long term average and the winter type flowering 4 weeks later. The aim of the field experiment conducted in 2010 was to identify factors contributing to and limiting canola yields in the HRZ of southern Australia to identify traits to incorporate into breeding programs. Irrigation was used to determine the effects of spring drought on yield, particularly for the long season winter cultivars. Plant growth regulators were used to determine if we could reduce plant height and improve harvest indices to produce more efficient crops.

Materials and Methods

A field experiment was conducted on the Department of Primary Industries (DPI) Research Farm at Hamilton in south-eastern Australia in 2010 (long/lat 37°45’S, 142°03’E). Five cultivars were sown in autumn (April 30) onto raised beds (1.7 m mid furrow to mid furrow) to control winter waterlogging, with +/- spring irrigation (i.e irrigation and rain fed) and +/- plant growth regulator (PGR) treatments. The experimental design was a split-plot design with irrigation as the main block and cultivar x PGR randomised within each irrigation block with three replicates giving a total of 60 plots. Plot size was 16 m long x 4 beds giving a total plot area of 109 m^2 (including furrows). Treatments were applied to all four beds in the plot but only the inner two beds were sampled. Yield, yield components and level of blackleg infection were determined from 2 x 1 m^2 quadrat cuts per plot at harvest. The experiment was analysed through ANOVA using GenStat 12th Edition (GenStat Committee 2003).

Cultivars included three European winter types, CBI206, Taurus and CBW03, one spring European type, CBI8802 and one Australian spring type, Hyola50. Hyola50 was selected as a high yielding cultivar for the region based upon long term cultivar evaluation experiments (DPI 2010b). All cultivars were conventional hybrids. Soil moisture was monitored from one plot in each of the irrigation replicates using gypsum blocks. Irrigation was applied to the irrigation + plots when the readily available water readings were between 30 and 50 kPa at a depth of 30 cm. The total amount of irrigation applied was 44.8 mm with 7.5 mm applied on 26 Oct and 2 Dec and 14.9 mm applied on 28 Oct and 19 Nov. An experimental growth regulator was applied when the bud had extended to between 30 and 50 cm (Aug 9 and Sep 17 for the spring and winter types respectively). Daily minimum and maximum screen temperatures (°C) and rainfall (mm) data was collected from the DPI weather station approximately 500 m from the site.

Results

Climatic conditions were ideal as the crop reached flowering, pod formation and seed development with a cool, wet finish to the season. Annual and growing season rainfall (GSR: April to November) was higher than the long term average mainly due to high August and December rainfall. The crop was not exposed to frost (temperatures <0°C) or extreme, high temperatures during flowering and grain fill (Figure 1).

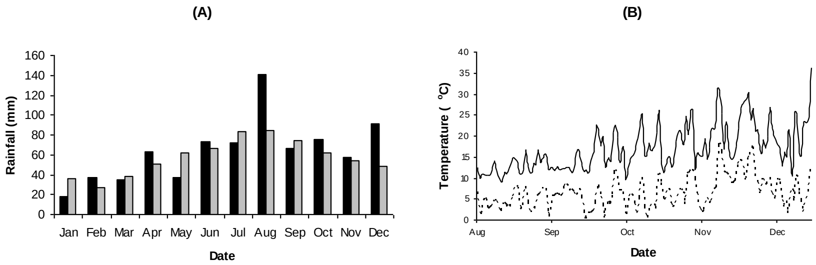

Figure 1: (A) long-term average (grey bars) and 2010 (black bars) rainfall and (B) minimum (dotted line) and maximum (solid line) temperature data in 2010 at Hamilton.

The winter canola types reached the bud and flowering stages of development approximately 4 weeks later than the spring types. The European cultivars matured approximately 10 (spring type) and 16 (winter types) days later than the Australian spring type (Table 1).

Table 1: Dates of phenological development for the Australian spring type (Hyola50), the European spring type (CBI8802) and 3 European winter types (CBI206, Taurus and CBW03) at Hamilton in 2010.

	Hyola50	CBI8802	CBI206	Taurus	CBW03
Bud	21-Jul	21-Jul	23-Aug	23-Aug	23-Aug
First Flower	30-Aug	30-Aug	30-Sep	2-Oct	30-Sep
Harvest (Rain fed)	30-Nov	9-Dec	15-Dec	15-Dec	15-Dec
Harvest (Irrigated)	30-Nov	10-Dec	16-Dec	16-Dec	16-Dec

Grain yields were significantly (P<0.001) greater from the European cultivars than the Australian cultivar and significantly greater under irrigation than the rain fed treatments. The PGR significantly reduced plant height (P<0.001) but had no effect on grain yield or harvest index. There were no significant interactions between treatments. Yields ranged from 5.7 t ha^{-1} for rain fed Hyola50 to 8.0 t ha^{-1} for the winter type CBI206 under irrigation (data not shown). The European cultivars produced up to 6.8 t ha^{-1} under rain fed conditions with yields more than 1 t ha^{-1} greater than Hyola50 regardless of irrigation treatment. The grain yields of both European types were not significantly different from each other. Higher grain yields from the European types were the result of more seeds pod^{-1}. Greater grain yield from the irrigation treatment was the result of more pods m^{-2} and heavier seeds (Table 2). Blackleg was not detected in any of the cultivars and therefore did not impact on the results.

Table 2: Yield and yield components for cultivar and irrigation treatments at Hamilton in 2010. Cultivar variables are the mean of the +/- irrigation and +/- plant growth regulator (PGR) treatments. The Australian spring control was Hyola50, the European spring type was CBI8802 and European winter

types were CBI206, CBW03 and Taurus. Irrigation variables are the mean of the cultivar and PGR treatments. A total of 45 mm of irrigation was applied in 4 applications between Oct 26 and Dec 2. There were no significant interactions between the treatments.

	Grain Yield DM (t ha^{-1})	**Pods m^{-2}**	**Seeds pod^{-1}**	**Seed Wt (mg)**	**HI**	**Plant height (cm)**
Cultivar (mean of Irrigation and PGR treatments)						
Hyola50	6.06	11151	12.3	4.29	0.341	163.6
CBI8802	7.26	9526	17.7	4.22	0.356	192.1
CBI206	7.36	8980	19.9	4.10	0.373	180.7
CBW03	7.20	8521	22.5	3.69	0.366	172.8
Taurus	7.12	8985	23.2	3.45	0.370	174.4
F Prob	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
LSD	0.588	927.9	0.99	0.128	0.0131	4.91
Irrigation (mean of Cultivar and PGR treatments)						
+ irrigation	7.48	9898	19.3	4.04	0.367	178.0
Rain fed	6.51	8967	19.0	3.86	0.356	175.4
F Prob	<0.001	<0.001	ns	0.046	0.022	ns
LSD	0.045	78.2		0.172	0.0076	

Discussion

Significantly (P<0.001) greater yields from the European germplasm compared to the high yielding Australian cultivar support the hypothesis that the cultivars currently available to farmers are not able to fully exploit resources in the HRZ. These results support findings from previous experiments at the same location (Riffkin 2009) and indicate that greater productivity may be achieved in the HRZ of southern Australia by introducing new genetic material. Grain yields in excess of 6.5 t ha^{-1} under rain fed conditions show that the HRZ of south-eastern Australia has a high yield potential. However, the greater yields achieved under irrigation suggest that soil moisture stress in spring will have a major impact on grain yield through fewer pod numbers and lower seed weights. Given the high rainfall in 2010, it is possible that in a year with rainfall closer to the long term average, moisture stress in spring will reduce grain yields particularly for the later maturing winter types. However, most of the additional rain in 2010 fell during periods unlikely to benefit the crop; either increasing the risk of waterlogging (August) or occurring after grain fill (December). To assess the potential and limitations of the European cultivars and to identify important traits for the region, a better understanding of the effects of environment on grain yield will be needed. This will require further testing of European and Australian cultivars over a wider range of seasons and locations. Although not present in this experiment, blackleg is the most important disease of canola in Australia and has the greatest impact on yield in the higher rainfall, more intensive canola growing areas. It is therefore critical that imported or newly developed germplasm has good resistance to blackleg.

Conclusion

The HRZ of south-eastern Australia has a high yield potential but for this potential to be realised, new traits will need to be introduced. Important traits are likely to include high seed numbers per pod, drought tolerance during flowering and seed development and good blackleg resistance. Further testing of germplasm under a wider range of conditions will be needed to verify findings and develop cultivars adapted to the region.

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References

Cowling, W. A., 2007: Genetic diversity in Australian canola and implications for crop breeding for changing environments. Field Crops Research, 104, 103-111.

DPI (2010a) Livestock Farm Monitor Project Results 2009/10 (Eds Jonathan Tocker and Tony Berrisford). Department of Primary Industries, Victoria. pp.119.

DPI (2010b). Victorian Winter Crop Summary 2010. (Eds Geoff Stratford and Ashley Wallace). Department of Primary Industries, Victoria. pp.78.

GenStat Committee 2003: 'GenStat® Release 7.1.'(VSN International Ltd: Oxford).

Riffkin, P. A. 2009: The potential of winter canola types in the high rainfall zone of southern Australia. In 'Changing Foods, Changing Climate, Changing canola'. Proceedings of the 16th Australian Research Assembly on Brassicas Conference,14-16 September 2009, Ballarat, Victoria, pp 32-36.