Identifying canola varieties for dual-purpose use

John Kirkegaard[1], Susan Sprague[1], Steve Marcroft[2], Trent Potter[3], John Graham[1], Jim Virgona[4], Jeff McCormick[4]

[1]CSIRO Plant Industry, GPO Box 1600, Canberra, ACT 2601, Australia
[2]Marcroft Grains Pathology, 110 Natimuk Rd., Horsham, VIC. 3400, Australia
[3]SARDI, PO Box 618, Naracoorte, SA 5271
[4]School of Agriculture, Charles Sturt University, PO Box 588, Wagga Wagga, NSW 2678, Australia

Abstract

Canola has recently shown significant potential as a dual-purpose crop in the high rainfall areas of southern NSW/ACT, Australia. Further development of the concept in other environments will require identification of suitable germplasm. We screened a broad range of current varieties and elite germplasm in contrasting environments (Canberra ACT, Wagga Wagga NSW, Naracoorte SA) in 2007 to identify the most appropriate phenological types which combined good early biomass production, high blackleg resistance and grain yield not significantly reduced by winter defoliation. A range of 36 entries was sown on three sowing dates at each site and plots were defoliated mechanically (~10 cm) to simulate heavy sheep grazing in mid-winter. Hybrid varieties produced up to 50% more early biomass (6-8 leaf stage when grazing would likely commence) than conventional varieties and triazine tolerant varieties 50 % less. Blackleg severity was increased by defoliation but this was minimised in varieties with good genetic resistance (Australian Blackleg Rating >7.5). Yield loss associated with defoliation was minimal if the terminal buds were not removed in the defoliation process (i.e. elongated < 15 cm) but significant loss (up to 60%) could occur if plants were defoliated at later stages depending on seasonal conditions. At all sites, canola varieties were identified which could be sown early, have 2-4 t/ha of biomass removed in mid-winter, and recover with no yield loss compared to grain-only crops sown at the recommended time. The study has identified varieties which combine suitable phenology with other desirable dual-purpose traits for further evaluation in different regions.

Key Words

grazing crops, feed-gap, mixed farming, Brassica, forage rape

Introduction

Dual-purpose cereals have been an integral component of mixed farming systems in southern Australia for some time (Dann et al. 1983) and more recently the choice and area of oat, triticale and wheat varieties has expanded. The area of milling-quality, dual-purpose wheat varieties expanded rapidly following their release in 2000 (Virgona et al 2006) due to the higher value of the harvested grain compared with the other dual-purpose cereals. However early-sown winter wheat can be exposed to a greater risk of leaf and root diseases which host on pasture grasses and volunteer cereals, most recently demonstrated by outbreaks of wheat streak mosaic virus which has reduced safe early sowing opportunities for dual-purpose wheat. A dual-purpose, broadleaf crop with a high value grain such as canola would provide an excellent break crop for grass weed and disease control and increase the flexibility and profitability of mixed farming operations. Recent studies have demonstrated the potential for dual purpose canola in the cool, high rainfall zone of southern NSW/ACT (Kirkegaard et al. 2008), but were limited to outdated European varieties and two Australian varieties. To support further development of the concept we report studies aimed at identifying suitable germplasm for dual-purpose use across other zones of southern Australia. In particular we sought varieties with appropriate phenological adaptation for different regions which also combined good early biomass production, high blackleg resistance and yield not significantly reduced by winter defoliation.

Methods

A collection of 36 canola (*Brassica napus*) lines was screened at three sites in southern Australia; Canberra (ACT), Wagga Wagga (NSW) and Naracoorte (SA) in 2007. The germplasm included a range of maturity types (winter [lines 1-5], winter x spring [lines 6-16], spring [lines 17-33]) current commercial varieties and elite breeding lines, conventional, hybrid and triazine tolerant varieties as well as three mustard (*B. juncea* [lines 34-36]) and one forage rape cultivar (Winfred, line 3). We avoided entries known to have low resistance to blackleg, but lines varying in Australian Blackleg Ratings (ABR scale 0 to 9) from 5 to 9 were included. The canola lines were sown on three dates at each site 10-14 days apart, the latest representing the normal sowing window for grain-only canola (Canberra 21/3, 5/4, 12/5; Naracoorte 17/4, 1/5, 26/5; Wagga Wagga 4/4, 18/4, 3/5). All entries were sown at the second sowing date (S2) at each site, a subset of 10 entries at S1 and S3, with 6 entries common to all sites and sowing dates. The experiments were arranged as split-split-plot design in 3 blocks, with the entries randomised within the sowing time main plots. Individual plot size was 2 m x 10-12 m. Defoliation treatments were imposed on one half of each plot in mid-winter (Canberra 13/8, Naracoorte 23/7, Wagga Wagga 10/7) using a forage harvester to cut and remove green biomass to a height of ~10 cm. Measurements included plant establishment, early biomass production (6-8 leaf stage), biomass at, and removed by defoliation, timing of key phenological stages, and yield in defoliated and un-defoliated plots using bordered quadrat cuts (0.4 – 0.8 m^2). Blackleg severity was assessed at physiological maturity by measuring the % of plants lodged and the levels of internal stem infection in cross sections of the stem base. Lodged plants, or those with >80% internal stem infection were considered to be severely infected.

Results

Seasonal conditions

Dry autumn conditions meant that irrigation was required to establish the experiments at all sites, but average May rainfall provided good conditions for vegetative growth. Naracoorte received close to average rainfall for the remainder of the season, but further irrigation was required during very hot and dry spring conditions (September) at Canberra, and particularly at Wagga Wagga where severe water stress in late August and early September significantly restricted flowering duration in some lines.

Early biomass production

Biomass production at the 6-8 leaf stage, when plants were first judged sufficiently anchored to resist grazing varied from 0.5 to 3.0 t/ha among the varieties. Across the sites, the early biomass production was generally highest among hybrid varieties, intermediate in conventional varieties and lower in triazine varieties Several currently available commercial hybrid lines from Australia were among the best performers as illustrated by S2 data for Wagga Wagga (Figure 1). The amount of biomass removed in mid-winter varied from 9 t/ha for early sown (S1) varieties which had already flowered at the time of cutting, to <0.5 t/ha for many S3 varieties. Most varieties which were at vegetative to early bud elongation stage had between 2-4 t/ha of biomass removed by the winter defoliation (data not shown).

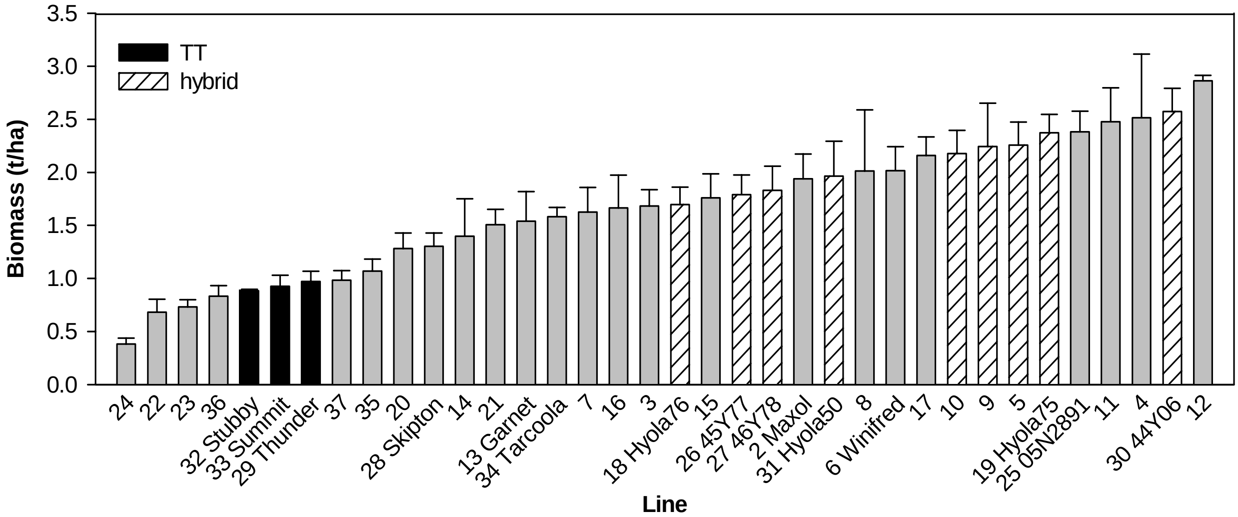

Figure1. Biomass production on June 6 for 36 entries sown at Wagga Wagga on 18 April 2007 (S2).

Impact of defoliation on Blackleg

Blackleg was not prevalent at the Canberra site, but significant infection was present at Naracoorte and Wagga Wagga. Defoliation increased the severity of blackleg infection severity in 20 % of the entries at Naracoorte and 37% at Wagga Wagga, with no significant change in the other varieties (2 of 40 at Naracoorte had reduced disease after defoliation). The mean increase in % of plants with severe infection was 11% at Naracoorte and 15% at Wagga Wagga, however blackleg infection tended to be increased more by defoliation in entries with lower blackleg ratings and shown for S2 at Wagga Wagga (Figure 2). These observations were consistent with other experiments in the area which were grazed by sheep for 2-3 weeks during winter (Sprague et al unpublished data).

Global Issues Paddock Action. Proceedings of the 14th Australian Agronomy Conference. September 2008, Adelaide South Australia.

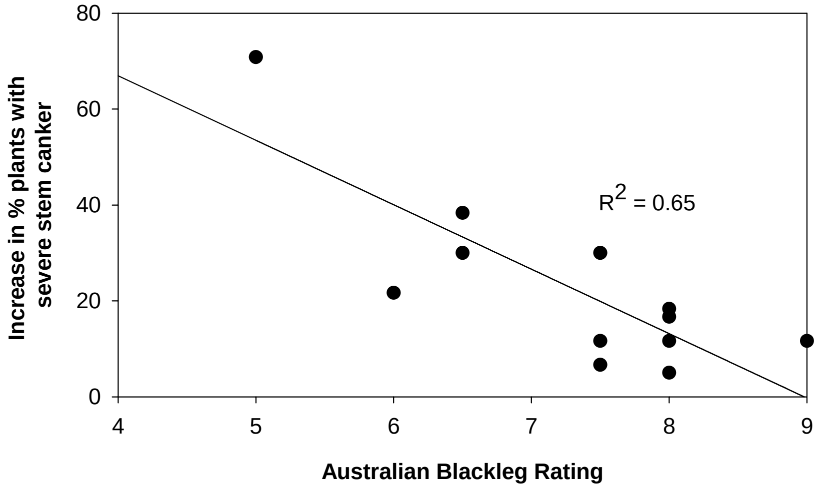

Figure 2. Relationship between level of blackleg resistance (ABR) and the increase in blackleg severity in response to defoliation for S2 at Wagga Wagga in 2007.

Impact of defoliation on phenological development

The range of sowing dates and the different maturity types included at each site combined with the single date of defoliation meant that there was significant variation in the developmental stage at which the entries were defoliated. Despite this variation, there was a relatively consistent impact of defoliation on the delay in phenological development across the sites (Figure 3). Irrespective of site and sowing date, entries defoliated during the vegetative stage or when the buds were visible but not elongated, had flowering delayed by an average of < 3 days. Those cut at later stages had increasing delays in flowering of up to 30 days or more if defoliation was delayed until flowering.

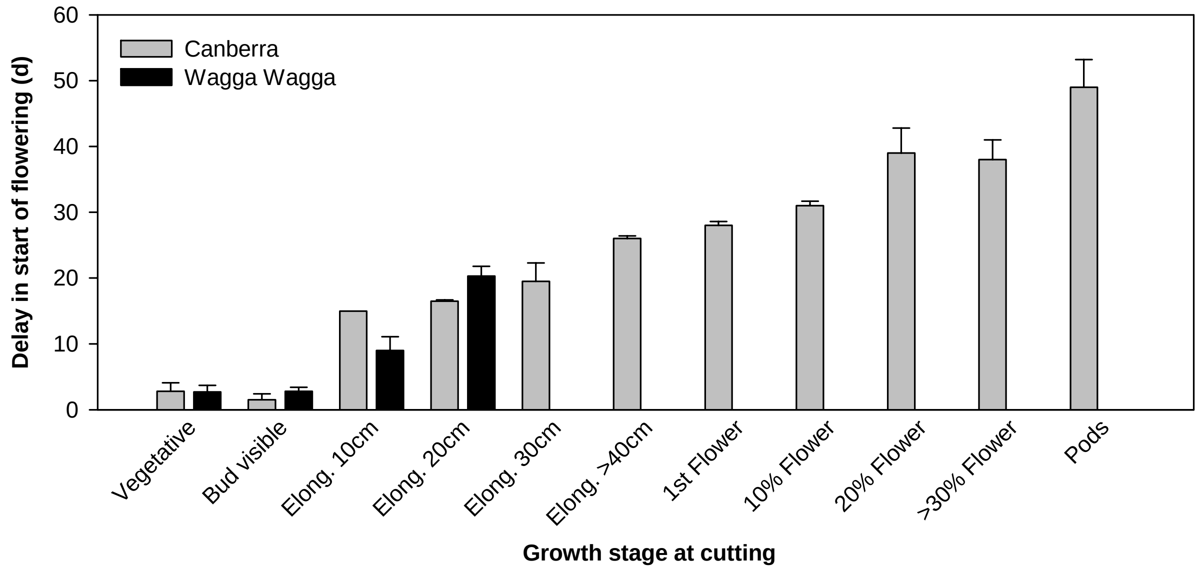

Figure 3. Delay in flowering in canola associated with defoliation at different growth stages. Data are means across sites and sowing dates.

Recovery and grain yield

The impact of defoliation on regrowth and grain yield was closely related to the growth stage at the time of defoliation, and the resulting delay in development (Figure 3). At all sites, entries in each sowing date which were defoliated prior to elongation of the buds suffered little yield penalty (<10%), while those which were defoliated at later stages suffered increasing yield reductions of up to 60% or more if defoliated at or after flowering. At each site, entries with an appropriate phenology, high early biomass production, good blackleg resistance and high yield after defoliation were identified for the early sowing dates (S1, S2) (Table 1). The data indicate that for early sown winter varieties at the higher rainfall sites (Canberra and Naracoorte), 3.5 to 5 t/ha of biomass could be removed in mid-winter with no impact on yield. At these sites, early-sown defoliated crops (S1, S2) significantly out-yielded the later sown grain-only crops (S3) despite the removal of 2-4 t/ha of biomass. In the shorter season areas with drier spring conditions (Wagga Wagga), currently available varieties performed well and yield of early sown crops was increased (S1) after defoliation presumably due to water savings during winter. In these areas opportunities for removal of winter biomass without yield penalty are more limited due to the shorter growing season.

Table 1. A summary of biomass removed in winter in defoliated plots, and the subsequent yield (compared to un-defoliated plots) for the best performing varieties at each site and sowing date.

Site	Sow	Variety/Line	Type	Biomass Removed (t/ha)	Yield Uncut (t/ha)	Yield Cut (t/ha)
Canberra *(cut 13/8)*	21/3	Line 1	Winter hybrid	3.9 ± 1.4	4.0 ± 0.2	4.0 ± 1.0
		Line 11	Winter/spring	6.7 ± 0.6	3.1 ± 0.2	3.1 ± 0.9
	5/4	Line 1	Winter hybrid	2.5 ± 1.0	3.0 ± 0.6	3.6 ± 0.5
		Line 5	Winter hybrid	3.4 ± 1.4	3.6 ± 0.2	3.5 ± 0.6
	12/5	AV-Garnet	Winter/spring	none	2.1 ± 0.8	na
		Hyola75	Late-spring	none	1.9 ± 0.1	na
Nara'cte* *(cut 23/7)*	17/4	Line 5	Winter hybrid	4.7 ± 0.4	2.6 ± 0.1	2.6 ± 0.3
		Line 11	Winter/spring	3.3 ± 0.6	3.0 ± 0.2	2.6 ± 0.3
	1/5	Line 11	Winter/spring	3.3 ± 0.2	3.0 ± 0.2	3.0 ± 0.2
		Line 13	Winter/spring	2.7 ± 0.3	3.7 ± 0.4	3.7 ± 0.2
	26/5*	Line 1	Winter hybrid	na	2.0 ± 0.3	1.4 ± 0.1
		46Y78	Mid-hybrid	na	3.0 ± 0.2	1.0 ± 0.1
Wagga *(cut 10/7)*	4/4	AV-Garnet	Late-spring	3.4 ± 0.5	0.6 ± 0.1	1.4 ± 0.3
		Skipton	Mid-spring	3.7 ± 0.5	0.6 ± 0.0	1.1 ± 0.1
	18/4	46Y78	Mid-hybrid	2.9 ± 0.2	1.7 ± 0.2	1.5 ± 0.3
		Hyola50	Mid-hybrid	3.4 ± 0.2	1.8 ± 0.5	1.3 ± 0.1
	3/5	AV-Garnet	Late-spring	0.7 ± 0.3	1.7 ± 0.2	2.1 ± 0.5
		Line 36	*B. juncea*	0.5 ± 0.3	2.2 ± 0.7	2.1 ± 0.9

*Sowing 3 at Naracoorte was cut on 3/9

Discussion and Conclusion

A number of outcomes from these experiments will assist the further development of dual-purpose canola in southern Australia. Early biomass production varied by a factor of 3 (1 to 3 t/ha) among the entries at recommended populations (70 pl/m^2) with hybrid varieties providing higher biomass, and triazine tolerant varieties less than current conventional varieties. Manipulating seeding rates, row spacing and N management may offer further opportunities to optimise winter forage production. Based on the results of these defoliation experiments, targeting the grazing period prior to significant bud elongation will minimize the delay in flowering and its associated impacts on yield while potentially providing 2-4 t/ha of high quality winter forage. The consistent impact of defoliation timing on developmental delays across sites, varieties and sowing dates (Figure 3), similar to those reported previously by Kirkegaard et al (2008), provide a useful rule of thumb to guide grazing management, although further evaluations under commercial grazing conditions are required. Blackleg severity was increased by defoliation in 20-40% of entries but could be minimised by selecting varieties with high resistance (>7.5 ABR). For each site and sowing date, varieties were identified which combined a suitable phenology with good early biomass production, high blackleg resistance and good recovery and yield after defoliation, even under the relatively unfavourable climatic conditions which prevailed at two of the sites during 2007. These results provide further optimism for wider application of dual-purpose canola and these elite lines are currently under further evaluation in larger scale experiments grazed by sheep at several sites in southern Australia.

References

Dann PR, Axelsen A, Dear BS, Williams ER, Edwards CBH (1983). Herbage, grain and animal production from winter-grazed cereal crops. Australian Journal of Agriculture and Animal Husbandry 127, 452-461.

Kirkegaard JA, Sprague SJ, Dove H, Kelman WM, Marcroft SJ, Lieschke A, Howe GN, Graham JM (2008). Dual-purpose canola – a new opportunity in mixed farming systems. Australian Journal of Agricultural Research 59, 291-302.

Virgona JM, Gummer FAJ, Angus JF (2006). Effects of grazing on wheat growth, yield, development, water use and nitrogen use. Australian Journal of Agricultural Research 57, 1307-1319.