Dual-purpose canola – a new opportunity in mixed-farming systems?

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Abstract

We conducted field studies near Canberra from 2004 to 2006 to investigate the feasibility of utilising canola as a dual-purpose (grazing and grain) crop. Dual purpose canola would provide an excellent break crop for winter cereals in the high rainfall zone, and potentially improve the profitability and flexibility of mixed farming operations. Winter and long-season spring canola varieties with good blackleg resistance sown in mid-April 2004, provided up to 2.5 t/ha of high quality forage in mid-August and recovered from grazing to produce high yield (4 t/ha) and oil content (47%) with no yield penalty associated with grazing. In 2005, delayed grazing (mid September) of similarly established crops caused some yield reduction (~0.5 t/ha) but this was more than offset by the value of the additional feed (up to 4.3 t/ha). In 2006, sowing in early March provided an early grazing opportunity with up to 3.5 t/ha of standing biomass produced within 8 weeks. Further work is underway to test the feasibility of this concept across a wider range of environments and to identify varieties with suitable characteristics for dual-purpose use.

Key Words

Break-crop, feed gap, *Brassica,* blackleg

Introduction

Dual-purpose cereals have been an integral component of mixed farming operations in the medium to high rainfall zones for some time and more recently the varietal choice and area sown has expanded (McRae *et al* 2006). Dual-purpose wheat can be exposed to a high risk of root disease (e.g. take-all) due to early sowing into recently removed pastures which contained grass hosts of the disease. A long-season, dual-purpose canola would provide an excellent break-crop in this situation, as well as increased flexibility and income.

Winter types of *Brassica napus* are currently used as spring-sown forage crops in Australia (fodder rapes), and produce large amounts of high quality biomass for grazing (Ayres and Clements 2002). In Europe and North America, winter *B. napus* is grown as an oilseed crop and is adapted to long cold winters in which the vernalisation requirement delays the reproductive stage until spring. We were interested in the possibility of using these winter canola varieties as dual-purpose (grain/graze) crops in the medium to high rainfall zones of Australia in much the same way as the dual purpose wheat is grown – sown early in autumn, grazed in the winter, and allowed to re-grow to produce an oilseed crop. The zones in which this could be feasible depend on opportunities for early sowing, and on varieties with suitable phenology and re-growth capacity.

A significant barrier to this opportunity has been the general susceptibility of most imported canola varieties to Australian isolates of the blackleg fungus (*Leptosphearia maculans*), the most significant pathogen of canola in Australia. Recently, winter canola lines from Europe with good resistance to Australian blackleg isolates have been identified (Steve Marcroft *pers comm.*), and this material provided an opportunity to test the feasibility of using canola as a dual-purpose crop.

We conducted a pilot study in the cool, high rainfall area near Canberra, ACT, to investigate the feasibility of dual-purpose canola. Several questions were addressed by the study: 1) how much forage could be produced by winter canola? 2) will sheep consume canola forage, would they prefer fodder *Brassica*, and what is the nutritive value of canola forage? 3) will the canola recover from grazing? 4) would grazing result in reduced seed yield and oil content? 5) does grazing influence the levels of key diseases such as blackleg and sclerotinia stem rot?.

Methods

The study was conducted at Ginninderra Experiment Station near Canberra from 2004 to 2006. In 2004, the Australian spring canola Hyola 60, and two blackleg resistant French winter canola varieties (Winter1 and 2), were sown on 14 April at 5kg/ha. A hybrid fodder Brassica (cv. Hunter) was sown around the experimental area for comparison. The experiment was a split plot design with two blocks containing each of the 3 canola varieties arranged randomly in plots 6 m x 30 m. In mid-August the experimental area was fenced to provide main plots of grazed and un-grazed treatments in each block. Ten sheep were initially allowed access to the canola varieties and to an adjacent 6 m strip of the fodder Brassica to determine if they preferred this to canola forage. Animals were then confined to the canola areas only (6 m x 30 m) for a period of 48 hrs. Biomass cuts (0.8 m^2) in grazed and un-grazed areas were taken after the sheep were removed to determine the amount of forage removed, and the in vitro digestibility and protein content of the canola forage was measured. The final biomass and yield of the canola in the grazed and un-grazed areas was measured from two hand harvested quadrats (1.08 m x 0.4 m) taken at physiological maturity in each plot and oil content measured using NMR. The incidence and severity of blackleg and sclerotinia stem rot was recorded at physiological maturity using the methods described in Kirkegaard et al. (2006). In 2005, the experiment was established and managed in a similar way, except Hyola 60 was replaced with a 3rd winter variety (Winter 3), and grazing was delayed until mid-September to allow more biomass to accumulate and to determine the impact of later grazing on seed yield. In 2006 (experiment in progress at the time of writing), the experiment was sown earlier on the 8 March and included the same 3 winter varieties as used in 2005 as well as the Australian spring canola variety Thunder, but arranged in 4 blocks containing each of the 4 varieties in 30 m x 2 m plots. The earlier sowing in 2006 was used to investigate the potential for earlier and multiple grazing.

In each year, all plots were sown with starter fertiliser (20 kg/ha; N 18 kg/ha; P 18 kg/ha S) and top-dressed with 50 kg/ha N as urea following grazing. Irrigation was used when necessary to establish the experiments at the desired time (2005, 2006) and otherwise was only applied when the crops were showing symptoms of severe stress. Gross margin analyses were conducted assuming fixed production costs of $350/ha and a price of $325/t for canola seed. Canola forage was difficult to value from crash-grazed small plots, but we estimated a conservative value of $84/t assuming 50% wastage, and feed conversion rates of 8:1 in a sheep meat enterprise @$1.65/kg live weight.

Results

Seasonal conditions

The years 2004 to 2006 experienced dry autumn conditions and irrigation was required to establish the experiments (Table 1). Winter and spring rainfall was close to average in 2004, but well above average in 2005.

Table 1. Monthly rainfall and irrigation (brackets) for 2004 to 2006 and long-term mean (LTM) for Canberra.

Month	J	F	M	A	M	J	J	A	S	O	N	D	Tot
2004	48	21	3	3(24)	12(40)	25	18(25)	89	44	66	81	82	581
2005	53	68	36	7(16)	2(33)	126	109	71	125	86	93	20	845

2006	58	14(50)	30(25)	11(40)	0(20)								-
LTM	60	56	51	47	46	40	42	47	54	64	64	53	623

Biomass grazed and yield 2004

In 2004, the sheep showed no preference for the Hunter fodder *Brassica* over the canola forage and grazed normally when confined to the latter**.** At the start of grazing on 18 August, the Hyola 60 mainstems had elongated, Winter1 had visible buds beginning to elongate while Winter2 remained vegetative. The estimated biomass removed at grazing reflected these differences (Table 2). The *in vitro* digestibility and crude protein content did not differ significantly between canola varieties; mean values (% of DM) were 80.0 and 20.4%, respectively. Grazing delayed flowering by up to 2 weeks for Hyola 60 as grazed plants regrew

Table 2. Biomass removed by grazing, and the impact of grazing on yield and oil for three canola varieties at Ginninderra Experiment Station, 2004. Numbers with the same letter within columns (Variety main effect) are not significantly different (P=0.05). There was no significant impact of grazing on yield or oil for any variety.

Variety	Biomass (t/ha) 23 August			Yield (t/ha)		Oil (%)	
	Ungrazed	Grazed	Removed	Ungrazed	Grazed	Ungrazed	Grazed
Hyola 60	4.6a	2.1a	2.5a	4.8a	4.6a	50.5a	50.5a
Winter1	4.7a	2.1a	2.6a	4.1b	4.3b	47.9b	46.1b
Winter2	2.8b	2.5a	0.3b	4.1b	4.0b	48.4b	47.6b

and branched from lower buds following removal of the main stem. Winter 1 was delayed to a similar extent while there was no delay in Winter 2. Despite the delay, there was no significant difference in the yield or oil content of the canola varieties. The earlier flowering of the spring canola Hyola 60 may have explained the generally higher yield as the spring was rather dry (Table 2).

Biomass grazed and yield 2005

Grazing commenced on 5 September at a higher biomass than 2005 and more biomass was removed by grazing during the 8 day grazing period (Table 3) than in 2004. All varieties had commenced stem elongation at the time of grazing, and grazing delayed flowering by around 16 days. Grazing reduced seed yield by around 13% in all varieties, but had no significant effect on oil content (Table 3).

Table 3. Biomass removed by grazing, and the impact of grazing on yield and oil for three canola varieties at Ginninderra Experiment Station, 2005. There was no effect of variety on any of the parameters measured. Significant effect of grazing on biomass and yield (P=0.05).

Variety	Biomass (t/ha) 23 September	Yield (t/ha)	Oil (%)

	Ungrazed	Grazed	Removed	Ungrazed	Grazed	Ungrazed	Grazed
Winter1	8.11	3.80	4.30	2.63	2.10	45.9	48.8
Winter2	6.56	3.51	3.05	2.67	2.07	47.6	46.8
Winter3	6.42	3.08	3.36	2.82	2.27	43.5	45.3

Biomass production in 2006

In 2006, the early sowing on 2 March resulted in accumulation of around 3.5 t/ha of biomass in all varieties by 3 May, of which 0.9 t/ha was removed by an early grazing during 3 to 5 May. The grazed crops had begun to re-shoot from axial buds and visible regrowth had occurred within 2 weeks of grazing, providing the possibility of further grazing in mid-winter before the crop enters the reproductive stage.

Impact of grazing on disease incidence and severity

There was no blackleg lodging observed in either year at the site, and the severity of infection was generally low, however, an average of around 50% of plants were infected in both years (Table 4). There were significant effects of variety on blackleg severity in 2004, and blackleg incidence in 2005 with Winter2 clearly more susceptible than either Winter1 or Winter3. There was no significant effect of grazing or interaction with grazing on blackleg levels in either year, although more replicates may be required to detect differences between main plots. The incidence of sclerotinia stem rot was generally low, however incidence was lower in Winter1 and reduced by grazing in 2004, but there were no effects evident in 2005.

Table 4. Impact of grazing on the incidence of blackleg and sclerotinia stem rot (% plants infected), and severity of blackleg (% of stem cross section affected) at Ginnindera Experiment Station in 2004. Significant effects in 2004: blackleg severity (Variety); Sclerotinia incidence (Graze, Variety); 2005: blackleg incidence (Variety).

Year	Variety	Blackleg stem infection				Sclerotinia stem rot	
		Incidence (%)		Severity (%)		Incidence (%)	
		Ungrazed	Grazed	Ungrazed	Grazed	Ungrazed	Grazed
2004	Hyola 60	23	35	2	4	6	2
	Winter1	45	60	6	9	0	0
	Winter2	35	75	9	25	7	4
2005	Winter1	36	35	5	4	1	6

Winter2	63	63	17	5	4	4
Winter3	18	50	2	4	7	1

Economics of dual-purpose use

In 2004, where grazing had no effect on yield or oil content, the additional income from grazing provided a clear gross margin increase of $210. In 2005, the later grazing reduced yield by 0.5 t/ha at a cost of $162/ha, which was more than offset by the estimated value of the grazed forage ($360/ha).

Table 5 Gross margin estimates from grain only and dual-purpose Winter1 canola at Ginninderra Experiment Station in 2004 and 2005.

Year	Crop option	Fodder (t/ha)	Grain (t/ha)	Oil (%)	Gross margin $/ha
2004	Winter1 grain only	0	4.1	48	$982
	Winter1 graze/grain	2.5	4.3	46	$1248 ($210 + $1048)
2005	Winter1 grain only	0	2.6	46	$495
	Winter1 graze/grain	4.3	2.1	49	$693 ($360 + $333)

Discussion

The study has confirmed that winter or long-season spring varieties sown in early to mid autumn can produce significant quantities of high quality forage which is readily eaten by sheep. The winter canolas, and more surprisingly the spring type Hyola 60, recovered well from grazing, which had either no impact on seed yield and quality (2004) or caused a yield reduction worth considerably less than the value of the grazing itself (2005). The excellent recovery of the spring variety Hyola 60 was surprising because it was at an advanced stage of stem elongation when grazed in August 2004 and had the elongating main stem completely removed by the sheep. This indicates that canola can recover from grazing during the early flowering stage provided there is sufficient time and suitable conditions for recovery. Such conditions are likely to be readily satisfied in the cooler, long-season areas of the high rainfall zone where dual-purpose wheat is currently grown. The delayed development caused by later grazing of the winter varieties in 2005 resulted in a yield penalty despite the cool, wet spring conditions which provided maximum opportunity for grain growth and recovery. The data available from 2006 suggests that earlier and/or multiple grazing may be possible from sowing canola earlier in autumn to capitalise on vegetative growth during warmer early autumn growing conditions. Winter varieties may be more suitable in this case as the spring types will bolt to flowering before winter and the impact on seed yield may be significant. Although the economic trade-off between yield reduction and forage production in 2005 favoured the later grazing, more severe yield penalties are likely if average or below average spring conditions occur. The interaction between sowing date, grazing time and the specific varietal phenology will dictate the most appropriate management strategy to achieve maximum biomass for grazing, but still leave sufficient time for regrowth and grain formation. If the prospect of good seed yield seems unlikely in very poor spring seasons, the canola could be cut for hay, as it has been shown in recent drought years to make hay of good quality.

There was no consistent evidence that grazing influenced the levels of disease in these experiments, although the levels of both blackleg and sclerotinia were possibly too low, and the replicates too few for significant effects to emerge. There are interesting potential interactions between winter varieties and blackleg. Firstly, they offer the prospect of introducing new sources of blackleg resistance from European winter germplasm into the farming system. In addition, the early sown winter canola will be at a more advanced stage of development during the peak period for blackleg spore showers during May – July, potentially reducing the earliness and hence the severity of infection. However, the tissue damage caused by sheep grazing in mid-winter may expose the crops to late infection, and the effects of this are uncertain. The reduction in canopy size, and delayed flowering caused by grazing are also likely to influence the interaction with sclerotinia stem rot which infects crops later in the season and is favoured by dense vigorous canopies. Grazing may provide an option for canopy management of early-sown vigorous varieties which have high yield potential, but which often suffer significant penalties in seasons when sclerotonia incidence is high.

Conclusion

This study has demonstrated that there is potential to develop canola varieties with suitable phenology as dual-purpose crops in longer season, high rainfall environments. Further research is underway to investigate the suitability of a wider range of germplasm for dual-purpose use in this and other environments, and to develop grazing management strategies which maximise the economic benefits within mixed farming systems.

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