Evaluating the potential for dual-purpose (graze/grain) canola in the mixed farming systems of southern Australia

Risk and Opportunity Assessment Report
GRDC Project CSP00085

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January 2007
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Executive Summary

Dual-purpose canola, like dual-purpose wheat, describes the process of using a canola crop for forage, and then growing the crop on for seed. We combined the outcomes of a 3-year CSIRO pilot study near Canberra (2004-2006), extensive Industry consultation and some initial climatic risk assessments to compile a preliminary risk and opportunity assessment to assist us in further research on the dual-purpose canola concept in southern Australia. The encouraging results from the Canberra pilot study were met with interest and support by most of those consulted, revealing a wider range of potential regions and farming systems applications of the concept than originally conceived.

Potential applications were suggested in all current canola growing areas as well as new areas in the high rainfall zone (including WA). In all cases, dual-purpose use would rely on early sowing opportunities, careful varietal selection to ensure that crop development, both before and after grazing remains within an acceptable physiological window, and careful grazing management to balance any trade-offs between the value of the forage and that of the seed. Our experimental observations, consultations and climatic analysis to date indicate there is considerable scope to achieve these goals.

We have demonstrated that from April sowings, canola can produce 2.5 to 4.0 t/ha of high-quality forage for grazing in winter, which is readily eaten by sheep, and that good live-weight gain can be achieved (210 g/day for Merino lambs). We observed no animal health issues associated with grazing canola and believe potential problems are manageable by observing current recommendations for grazing fodder brassicas. A challenge for the project will be to consider appropriate grazing management for dual-purpose canola in relation to whole-farm feed supply and stock availability, issues which will be considered in close collaboration with other current projects focussed on this issue.

The canola can recover well from heavy grazing, although flowering delays associated with grazing ranged from 0 to 4 days when grazed before the buds were visible and elongating, to 28 days if the crop was already flowering when grazed. Significant delays in flowering caused yield reductions particularly if the spring conditions were unfavourable, although no yield reductions were observed when cool and wet spring conditions allowed compensatory growth. In the cooler, higher rainfall areas, there appears to be significant scope to capture value from grazing during the vegetative period without significant impacts on yield. The trade-off between continued grazing at the possible expense of seed yield is one which could be managed by individual enterprises once clear guidelines to predict these trade-offs are established. Hay-cutting and silage are other viable options providing further flexibility for canola within mixed farming systems.

The major risks identified are the pest and diseases associated with early sowing (principally insects and viral diseases) and those which may be exacerbated by grazing (e.g. blackleg). Our planned strategy for the on-going project combines varietal screening in different site/sowing date/season scenarios to assess the suitability of germplasm for dual-purpose use, with grazing management and agronomic studies to provide robust management guidelines. Investigation of the pest and disease risks and other risks raised during our consultation will be carefully monitored during the project.
Background and Introduction

The aim of this project is to evaluate the potential for dual-purpose canola in the mixed farming systems of southern Australia, and to develop robust management guidelines to maximise the economic and environmental benefits from this option. A CSIRO Plant Industry pilot study conducted at Ginninderra Research Station ACT (2004 to 2006) has shown that winter or long-season spring canola can be sown early (March/April), produce significant high-quality forage for grazing in mid-winter (August) and recover from grazing to produce high grain yield (4 t/ha) with good oil content (47%) (Kirkegaard et al 2006).

GRDC have funded a 3-year project to test the feasibility of the concept across a wider range of environments in southern Australia, identify suitable varieties and develop robust management guidelines for this option in different regions. As a first step, we have conducted a ‘risk and opportunity assessment’ by consulting widely among growers, consultants, breeders, agronomists, other scientists and Industry specialists across southern and western Australia as well as scientists in USA, Canada, Europe and South Africa. Together with the outcomes from the CSIRO Pilot Study, this has provided valuable background information to direct the experimental program to ensure the most critical knowledge gaps can be filled.

This report summarises the outcomes of these activities and represents the current state of knowledge on the dual-purpose use of canola at the commencement of the Experimental Phase in 2007.
A summary of presentations and consultations to date

2005
March - Pre-season meeting of Chandlers Landmark at Young, NSW: presentation to 170 growers and consultants from across the region.
“Dual-purpose (grazing) canola – a new opportunity for farming systems”

September - GRDC Southern Panel visited Ginninderra Experiment Station (GES) and inspected the field experiment immediately following grazing.

October 3 to 7 – 14th Australian Research Assembly on Brassicas (Port Lincoln, SA): presentation to the audience of Brassica agronomists, pathologists and breeders from throughout Australia.
“Dual-purpose (grazing) canola – a new opportunity for farming systems”

October 26 - Visit to the GES Experimental Site by the CBWA/NPZ Technical Advisory Committee organised by Dr Wallace Cowling.

2006
February 14 to 16 – NSW DPI Broad-acre Cropping Unit Technical Update, Orange Agricultural Research Institute 14-16 February: Dr Hugh Dove made a presentation.
“Dual Purpose Canola”

February 17 - National Canola Pathology Meeting, Melbourne: presentation to an audience of breeders, pathologists and GRDC representatives from throughout Australia.
“Dual-purpose (grazing) canola – a new opportunity for farming systems”


April 11 – Dr Steve Marcroft (Marcroft Grains Pathology), Dr Jim Virgona (CSU) and Mr Jeff McCormick (CSU) visited the GES experiment site to discuss potential collaborative studies.

April 20 - Pre-season meeting of Delta Agriculture at Young, NSW: presentation to 200 growers and consultants from across the region.
“Dual-purpose (grazing) canola – a new opportunity”

July 6 to 11 – Presentation by Dr Hugh Dove at 26th Biennial Conference of the Australian Society of Animal Production, Perth WA of a paper entitled:
“The potential dual-purpose use of canola for grazing and oil production”

August 24 – Presentation to a visiting delegation of Argentine farmers at CSIRO Plant Industry.

August 28 – Sept 1 - Tour and meetings in Victoria and South Australia

Dr Steve Marcroft organised a 5-day tour of canola-growing areas and arranged meetings with potential collaborators and key Industry personnel in Victoria and SA. Drs Kirkegaard, Dove, Marcroft and Sprague visited the following groups. A short
A presentation on the dual-purpose idea and results to date was given, followed by discussion of the potential opportunities and limitations of the idea and possible collaborative work.

August 28 am – Meeting at Melbourne University with Dr Phil Salisbury.

August 28 pm – Meeting at Southern Farming Systems, Geelong: Mr Col Hacking, Mr Rohan Wardle, Mr Cam Nicholson, Dr Tim Reeves.

August 29 – Meeting at SARDI, Naracoorte - Mr Trent Potter.

August 30 - Meeting at Victorian DPI, Hamilton: Dr Penny Rifkin, Dr Ralph Behrendt, Dr Steve Holden, Dr Pedro Evans.

August 31 - Meeting at VIDA, Horsham: Dr Keith White, Dr David Pike, Mr Denis Ballinger.

September 1 - Meeting at VIDA, Horsham: Dr Rob Norton, and final discussions of project team.

September 10 to 14 - 13th Australian Agronomy Conference, Perth: Dr Susan Sprague presented a paper summarising results from the CSIRO pilot study. “Dual-purpose canola – a new opportunity in mixed farming systems”

October 5 – Presentation to scientists from AgResearch, New Zealand at CSIRO Plant Industry.

October 26 - Visit to the GES Experiment Site by Geoff Wray’s consultant group from Forbes, NSW, with 25 farmers.

November 1 – Dr Jim Virgona organised a meeting at CSU School of Agriculture to discuss the grazing canola concept with CSU, NSWDPI, FarmLink and consultants from NSW. Attended by Mr Nigel Phillips, Mr Geoff Pitson, Mr Neil Wratten, Dr Alison Bowman, Dr Jim Virgona, Mr Jeff McCormick, Dr Hugh Dove.

November 12 to 16 – Dr Kirkegaard attended USA Canola Association Meeting, Indianapolis, Indiana USA: Met with USA scientists from Kansas and Oklahoma State Universities working on grazing canola. A poster presented by these scientists was entitled “Grazing winter canola in the southern Great Plains – things to consider” Authors: Dr William Heer, Dr Mike Stamm, Dr Charlie Rife.

2007

February - GRDC Updates at Bendigo – Steve Marcroft to make presentation

February 16 - National Canola Pathology Meeting, Perth: presentation by Dr. Sprague to an audience of breeders, pathologists and GRDC representatives from throughout Australia. “Disease implications for dual-purpose canola”
Publications and Industry newsletters

“Canola another ‘graze and grain’ option?”, *Grain Business*

“Dual-purpose canola – a new opportunity”, *The Link* March 2005 Vol. 10 pp 4. (Distributed to members of FarmLink Research in southern NSW)


“Dual-purpose canola?” *The Land* June 22.


“Dual purpose canola – a new opportunity”, *Canola News*, July 2006. pp 9-10. (Published by The Canola Association of Australia Inc.)


“Grazing and crop yield”, *South East Coastal Leader*, September 6 2006.


“Canola for grain and grazing”, CSIRO Plant Industry e-Newsletter

“Dual-purpose canola in the mix”, CSIRO web-based Fact Sheet
http://www.csiro.au/csiro/content/file/pffl.html
Outcomes of the CSIRO Pilot Study at Ginninderra Experiment Station, Canberra 2004 to 2006 (For full details see Appendix)

Overview
● Winter or long-season spring varieties can be sown early (late March/April), grazed in winter (mid-August) and recover from grazing to produce high yield (4 t/ha) and good oil content (47%). Early sowing (prior to early-April) suits winter types which require a cold period (vernalisation) to initiate flowering and so do not bolt too early. Later grazing (September) increased forage production but reduced grain yield, although the value of the additional forage can offset yield reduction in some cases.

Biomass (forage) production
● Winter types sown in March produced similar early biomass as conventional spring types (2.5 – 3.5 t/ha of biomass in 8 weeks) and provided 1 t/ha of grazed forage in early May.
● Winter and long-season spring canola varieties sown in mid-April can provide 2 to 4 t/ha of winter forage for grazing by mid-August.

Grazing by sheep
● Animals readily ate canola at growth stages ranging from early vegetative to flowering/early pod stage and showed no preference for a commercial fodder hybrid when offered a choice between the hybrid and canola.
● Canola forage (in winter) was of high quality - around 20% protein and 80% digestible.
● Under heavy grazing in winter the animals removed 60% of the available biomass.
● No animal health issues were observed from grazing periods of 2 days up to 3 weeks, but established guidelines for grazing brassicas should be observed.
● Young Merino lambs gained 210 g/day grazing canola at first flower stage for 3 weeks in September 2006. Mean animal intake was 1980 g OM/d, comprising 75% canola leaf and 18.5% sub-clover (alkane technique – unpub. data, A. Lieschke, H. Dove, M. Friend).

Impact of grazing on growth and development
● Grazing delayed flowering and reduced plant height depending on the intensity of grazing and the plant stage at the time of grazing. In Canberra, under intensive mid-August grazing (i.e. 2/3 of available biomass removed), the delays in flowering and impacts on plant height according to plant stage when grazed were as follows;

<table>
<thead>
<tr>
<th>Plant stage when grazed</th>
<th>Delay in flowering</th>
<th>Height reduction (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-vegetative stage before buds are visible</td>
<td>0 to 3 days</td>
<td>None (2004)</td>
</tr>
<tr>
<td>-plants with buds visible but not elongated</td>
<td>4 days</td>
<td>up to 10 (2006)</td>
</tr>
<tr>
<td>-buds elongated (20 - 30 cm) no flowers</td>
<td>7 - 15 days</td>
<td>10 to 20 (2006)</td>
</tr>
<tr>
<td>-first flowers to open</td>
<td>26 to 30 days</td>
<td>30 to 40 (2005, 2006)</td>
</tr>
</tbody>
</table>

● In a pot study (Jeff McCormick - PhD student at CSU), plants which had all leaf lamina removed by hand in winter prior to bud appearance (6 leaf stage) had flowering delayed by around 3 to 4 days (winter types), but by 9 days in a spring canola variety (Skipton).
Impacts of grazing on yield

- The effect of grazing on yield depended on both the magnitude of the growth and development changes (above) and on seasonal conditions. The delays in flowering and the need for vegetative re-growth can reduce leaf area development, shorten the flowering and pod-filling period and increase the risk of heat and water stress during pod-fill. These can all contribute to yield and oil reduction, although the impact depends on seasonal conditions. Yield penalties are reduced in cool, wet spring conditions as crops can compensate for later flowering. A summary of yield impacts;

2004 (Sown 14 April) No yield penalty for winter and late-spring types grazed in mid-August, with a favourable spring finish.

2005 (Sown 8 April) A yield penalty of 0.5 t/ha due to mid-September grazing which provided insufficient time for compensation, even under excellent spring conditions.

2006 (Sown 8 March) Winter types – no yield penalty grazed in mid-August during bud-visible to bud elongating stage (yield 0.7 t/ha due to spring drought). Spring type – total yield loss (0.8 t/ha in un-grazed) as plants were at full flower when grazed in mid-August and did not recover.

- Yield penalties caused by grazing can be offset by the value of the grazing, hay or silage in some seasons depending on the type of enterprise mix on the farm. The data below are for a winter canola grown at GES near Canberra.

<table>
<thead>
<tr>
<th>Year</th>
<th>Crop option</th>
<th>Fodder (t/ha)</th>
<th>Grain (t/ha)</th>
<th>Oil (%)</th>
<th>Gross margin*</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>Grain only</td>
<td>0</td>
<td>4.1</td>
<td>48</td>
<td>982</td>
</tr>
<tr>
<td></td>
<td>Graze/grain</td>
<td>2.5</td>
<td>4.3</td>
<td>46</td>
<td>1248</td>
</tr>
<tr>
<td>2005</td>
<td>Grain only</td>
<td>0</td>
<td>2.6</td>
<td>46</td>
<td>495</td>
</tr>
<tr>
<td></td>
<td>Graze/grain</td>
<td>4.3</td>
<td>2.1</td>
<td>49</td>
<td>693</td>
</tr>
<tr>
<td>2006</td>
<td>Grain only</td>
<td>0</td>
<td>0.8</td>
<td>-</td>
<td>-30</td>
</tr>
<tr>
<td></td>
<td>Graze/grain</td>
<td>0.6</td>
<td>1.0</td>
<td>-</td>
<td>100</td>
</tr>
</tbody>
</table>

*We valued forage conservatively at $84/t from these crash-grazed experiments; $325/t for seed yield in 2004/5, $400/t in 2006 and $350/ha fixed production cost (see Kirkegaard et al. 2006). Growers should apply their own cost and price estimates to the data above.

- In the 2006 drought, the option to cut the standing biomass for hay or silage in October rather than to grow the crop on for seed yield would have been a good option, as feed was low and hay prices good. The biomass was around 5 to 6 t/ha.

Disease and pest incidence

- Grazing did not significantly increase blackleg incidence or severity in the winter canola in this study as levels were generally low during these dry years and the winter types had good blackleg resistance. In the spring canola in 2006, blackleg was absent from the un-grazed treatments but stem infection severity of 10 to 50% was observed in the grazed treatments.

- Early sown crops in 2006 (March) suffered some early insect damage although grazing in May removed most of the damaged leaf material.

In summary, the choice of variety for specific sowing dates, regions and grazing management will be the key to maximising the dual-purpose value of canola.
In 2004, the effect of mid-August grazing on delayed flowering was obvious on 13 September (above), but the grazed crop re-grew and there was no impact on yield (4.2 t/ha). Left - light graze; centre - heavy graze; right - ungrazed.

In 2005, later grazing (mid-September) provided more forage than in 2004, but resulted in a yield penalty (2.6 to 2.1 t/ha) even in an excellent finish. The delayed flowering and reduced plant height caused by grazing is clear. In each picture above, the grazed treatment is on the left.

In 2006 (8 March sowing), the spring canola grazed at full flower in mid-August (on left) provided 4.0 t/ha of forage but did not recover from grazing (ie no seed yield), while the winter canola produced 0.6 t/ha forage and 1.0 t/ha seed yield. Left picture - before grazing; right picture - after grazing.
Risk and Opportunity Assessment

Potential areas and farming systems for adoption – are they significant?

Key outcome. There are a wider range of potential regions and farming systems applications of this concept than originally conceived. Applications were suggested in all current canola growing areas as well as new areas in the high rainfall zone (including WA). While the potential area for adoption therefore may be substantial, early sowing opportunities will limit the frequency of adoption.

Discussion

Grazing winter canola (Scenario 1). The CSIRO pilot study focussed on the use of winter and/or long-season spring canola sown early (March-April), grazed during winter (August) with large stock numbers prior to bolting, and then the crop locked up. The concept targeted the cooler, high-rainfall Tablelands and slopes where dual-purpose winter wheat is currently (or potentially) grown (Figure 1, Scenario 1). Significant forage for grazing can be produced by sowing these winter types early, without compromising yield, in the same way as has been demonstrated for dual-purpose wheat. This approach will be limited by the frequency of early sowing opportunities and availability of stored water or follow-up rainfall to ensure crop survival and good forage production.

Graze/grain trade-off (Scenario 2). The consensus among the groups surveyed was that while early sowing (March) may be an option in some areas and seasons, the areas where this is feasible are small and the opportunities for early sowing infrequent. In seasons with good early rain, pasture growth will also reduce the need for additional early feed. The more likely scenario would be to sow in mid to late-April, 1 to 3 weeks earlier than normal for canola, to provide vigorous early growth using long-season spring varieties or hybrids, and to utilise the grazing to delay flowering back into the usual window so that pod filling occurs at the usual time (Scenario 2, Figure 1). In higher-rainfall cooler areas, the longer cool spring conditions may accommodate later flowering windows caused by grazing in many seasons, reducing the trade-off with yield. In these areas, grazing of canola sown up until the normal sowing window in mid-May is likely to be feasible without significant yield penalties. Later flowering will reduce yield and oil content and may increase insect pests, so the trade-off with seed yield vs grazing value will be an important consideration.

In Victoria/SA, this type of management would be applicable to areas in the Western District around Hamilton/Penshurst (100,000ha), NE Victoria (30,000 ha) and Southeast SA (20,000), and in the high- to medium-rainfall areas of southern NSW (200,000 ha). We also received significant feedback from WA breeders, consultants and producers who considered that significant areas of the high-rainfall zones in WA could also be suitable areas for adoption although longer season spring types, rather than winter types would presumably be more suitable as the warmer winters may not satisfy vernalisation requirements. We will focus a major part of the project on determining the interaction between variety, sowing date, region, grazing management and the resultant trade-offs between the value of grazing and grain production within this Scenario, which represents the most likely and widespread Scenario for adoption within Australia.

Clip-grazing (Scenario 3). The NSW meeting also proposed a less intensive “clip-grazing” strategy where fewer sheep are grazed on larger (100 - 200ha) paddocks earlier and for
longer periods, on crops which could be sown more or less within the current sowing window for canola. This type of approach would be more suited to crop-focused farmers in areas such as those west of Wagga Wagga. The idea of this approach is to minimise the impact of any grazing on canola yield which is a greater focus and profit driver of these largely crop-focused farmers who tend to carry fewer stock. This would mean trying to avoid delays in flowering and ensuring that flowering ends around mid October. This approach is in contrast to “managing the trade-off” as in the case discussed above. Advantages may also arise from management such as wider rows sown into trash for easier access and less spoilage by sheep. The types of enterprises which may utilise this approach would be lambing or lactating ewes in winter, and finishing lambs or steers in autumn. The feed would be most valuable during the month of July. This approach may be suitable for large areas of traditional canola growing regions in medium-rainfall environments with a somewhat shorter growing season.

We met one grower from Grenfell (Mr Maurice Batkin) who has been grazing canola in this way for many years. He uses an opportunistic approach when sowing opportunities arise in mid-April, grazes when full ground cover is achieved but before bolting (June/July). He grazes lambing ewes on the canola, has never lost a lamb and sees no obvious impact on canola yield (average 2.5 t/ha).

The graze-only option. Canola is often grazed or cut for hay during drought years such as 2006. Although this was not planned, a graze-only option was discussed as a low-input, low-risk strategy for mixed farms in lower-rainfall areas where producing canola seed is more risky. The canola would be used as a forage crop and to clean up paddocks of weeds or diseases such as take-all and Rhizoctonia in the following year. For example, on the Eyre Peninsula, canola is one of the only effective break crops for Rhizoctonia and yield increases of up to 40% have been seen in subsequent wheat and barley crops. One strategy would be to sow canola with the intention of using it only for forage, which would reduce input, windrowing and harvesting costs accordingly, as grain production is not the aim. The crop would generally receive sufficient rainfall to provide winter forage to rest pastures and if spring rainfall was good could be either re-grazed out or cut for hay. The economics of such a strategy are worthy of investigation.

Spring-sown canola. Some growers in south-eastern SA sow canola in spring and it may be possible to sow earlier and use grazing to delay flowering (Naracoorte). In other areas, winter types sown in spring could be grazed over summer and autumn and then produce seed in the following season (e.g. around Hamilton). Unpredictable flowering and seed glucosinolate contents in winter types grown in this way are potential issues with this risky option which would require significant testing.

Planned strategy within the project

The range of options discussed above indicates that there may be many different opportunities to utilise canola as a grazing option in different farming systems, each requiring a specific combination of variety and management to maximise the graze/grain trade-off within different business structures. The choice of sites at GES, Wagga and Hamilton/Naracoorte will allow activities relevant to all of these scenarios, but we will focus our resources on the strategies for managing canola sown within Scenario 2, where those surveyed felt the most immediate and widespread potential for the concept existed.
and where significant knowledge gaps remained. Some of the more fundamental issues we will address are relevant to all regions.
Scenario 1: Early sowing with winter cultivars (as per CSIRO Pilot Study Canberra)
Vernalisation requirement & long spring finish decrease risk of yield reduction

Scenario 2: Sowing with late spring or hybrid type (1 to 3 weeks early; considered most likely widespread approach)
Trade-off between value of grazing and grain yield

Scenario 3: Conventional sowing window (current cultivars) with “clip grazing” (practiced by grower at Grenfell, NSW)
Light grazing & locked up to maximise yield

Useful notes:
• Canola sown in mid-March can produce 2.5 t/ha biomass in 8 weeks.
• Canola sown in mid-April can produce 3.5 t/ha biomass for grazing in August.
• Grazing canola prior to bud elongation appears to have little effect on flowering or yield irrespective of season.
• Grazing canola during bud elongation can delay flowering by 7 to 15 days and may reduce yield (season dependant).
• Grazing canola at flowering can delay re-flowering by up to 28 days and significantly reduce yield.

Figure 1: Potential scenarios proposed for dual-purpose use of canola in mixed farming systems.
Varietal choice and germplasm collection for screening

Key outcome. Existing commercial varieties may be suitable in many cases, although breeding lines previously unsuitable for grain-only production have also been provided by most breeding companies. A range of new material, including longer-season spring types, hybrid varieties (including triazine–tolerant (TT)), winter and winter/spring crosses and B. juncea have also been made available for evaluation.

Discussion

Extensive discussions were held throughout 2006 with canola breeders from Australia, USA, Canada and Europe. Most breeders were able to suggest material which may be suitable for dual-purpose use (Table 1) and have provided seed for evaluation. The key varietal characteristics for dual-purpose use common to most potential areas are:

(1) High and robust blackleg resistance and, if possible, novel sources of resistance to reduce selection pressure
(2) Vigorous early growth to produce maximum forage for grazing
(3) High-quality forage, with low risk of animal health issues
(4) An ability to tolerate and recover from grazing
(5) Option to produce hay or forage in a dry finish
(6) High yield potential and good oil quality after grazing

Depending on the particular strategy for specific farming systems and regions (outlined previously), a wide range of conventional, TT, hybrid, winter, winter/spring canola (B. napus) or B. juncea types may adequately meet these requirements. Therefore a wide range of types will be included in the initial evaluations. We will only include lines with good blackleg resistance. Herbicide tolerance was raised as an issue by some as an advantage for early-sown crops, although others considered that it was not essential as weeds could be controlled with good management. Breeders from both Pacific Seeds and NPZ indicated that the development of TT Hybrids was technically feasible within a relatively short period of time.

Winter types may not vernalise in warmer seasons in some areas. This may result in variable flowering patterns which would be undesirable. In addition some winter types may develop higher levels of seed glucosinolates (a seed-quality issue) when grown under the higher temperature and water-stress conditions in Australia. Winter/spring crosses or longer-season spring types will most likely be the best option in all but the coldest of Australian environments. Several people indicated that a “Hyola60 type” would be ideal for the dual-purpose use and this cultivar performed very well in the 2004 season at GES (mid-April sowing) where no yield penalty was observed from grazing during advanced bud elongation, despite a 3-week delay in flowering. A data set obtained from South Africa in 2005 involving 20 cultivars of canola sown early (12 April) showed that after being grazed or cut, the average yield was 2.3 t/ha (± 0.3 t/ha) compared to 2.4 t/ha (± 0.3 t/ha) for uncut. The impact of cutting varied from 0.4 t/ha yield gain to a 1.2 t/ha yield loss clearly demonstrating the interaction of variety and the impacts of grazing.

Planned strategy within the project

We will initially screen a wide range of material (Table 1) to consider all of the potential farming system scenarios identified in Figure 1.
### Table 1 - Varietal Evaluations for grazing canola – Genotype list and contacts

<table>
<thead>
<tr>
<th>Phenotype</th>
<th>Variety</th>
<th>Characteristic</th>
<th>Supplier/s</th>
<th>Seed procured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter types (5)</td>
<td>Capitol</td>
<td>Used in GES Study</td>
<td>Monsanto</td>
<td>Yes</td>
</tr>
<tr>
<td>- different blackleg genes</td>
<td>Caracas</td>
<td>Early</td>
<td>Monsanto</td>
<td>Yes</td>
</tr>
<tr>
<td>- different phenotype</td>
<td>CBI1</td>
<td>Early</td>
<td>RAPS/GBR</td>
<td>Yes</td>
</tr>
<tr>
<td>- different morphology</td>
<td>CBI2</td>
<td>Late</td>
<td>RAPS/GBR</td>
<td>Yes</td>
</tr>
<tr>
<td>- Capitol evaluated previously</td>
<td>CBI3</td>
<td>Late</td>
<td>RAPS/GBR</td>
<td>Yes</td>
</tr>
<tr>
<td>Winter x Spring (5)</td>
<td>RT125</td>
<td>Mid-late, parent Capitol</td>
<td>NBIP</td>
<td>Yes</td>
</tr>
<tr>
<td>- different phenology</td>
<td>NPZ1</td>
<td>Late</td>
<td>NPZ</td>
<td>Yes</td>
</tr>
<tr>
<td>- different morphology</td>
<td>NBIP2</td>
<td>Late/tall, parent Columbus</td>
<td>NBIP</td>
<td>Yes</td>
</tr>
<tr>
<td>- different morphology</td>
<td>NBIP3</td>
<td>Late/tall, parent Capitol</td>
<td>NBIP</td>
<td>Yes</td>
</tr>
<tr>
<td>Hybrid (10)</td>
<td>Hyola50</td>
<td>Early Conventional</td>
<td>Pacific</td>
<td>Yes</td>
</tr>
<tr>
<td>- different phenology</td>
<td>44Y06</td>
<td>Early Conventional</td>
<td>Pioneer</td>
<td>Yes</td>
</tr>
<tr>
<td>- different vigour</td>
<td>45Y77</td>
<td>Mid Imi</td>
<td>Pioneer</td>
<td>Yes</td>
</tr>
<tr>
<td>- different morphology</td>
<td>Hyola75</td>
<td>Late Conventional</td>
<td>Pacific</td>
<td>Yes</td>
</tr>
<tr>
<td>- different morphology</td>
<td>05N289I</td>
<td>Mid-late Imi</td>
<td>Pioneer</td>
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</tr>
<tr>
<td>Late flowering spring (6)</td>
<td>NBIP4</td>
<td>Winter hybrid</td>
<td>RAPS/GBR</td>
<td>Yes</td>
</tr>
<tr>
<td>- different backgrounds</td>
<td>NBIP5</td>
<td>Late/tall</td>
<td>NBIP</td>
<td>Yes</td>
</tr>
<tr>
<td>- different backgrounds</td>
<td>NBIP6</td>
<td>Late/tall</td>
<td>NBIP</td>
<td>Yes</td>
</tr>
<tr>
<td>Mid-season (4)</td>
<td>NBIP7</td>
<td>Mid/late</td>
<td>NBIP</td>
<td>Yes</td>
</tr>
<tr>
<td>- different backgrounds</td>
<td>NuSeed1</td>
<td>Late/tall</td>
<td>NuSeed</td>
<td>Yes</td>
</tr>
<tr>
<td>Early season (2)</td>
<td>Tarcoola</td>
<td>Conventional</td>
<td>NuSeed</td>
<td>Yes</td>
</tr>
<tr>
<td>- B. juncea (3)</td>
<td>JR55</td>
<td>Vigorous</td>
<td>NBIP</td>
<td>Yes</td>
</tr>
<tr>
<td>- Fodder rape (B napus)</td>
<td>JC05006</td>
<td>New release (early)</td>
<td>NBIP</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>JC06019</td>
<td></td>
<td>NBIP</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Winfred/Maxima</td>
<td></td>
<td>Wrightsons</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Critical threats and constraints

Diseases and pests

Pests. Early sowing into warmer conditions may reduce the risk of damage by some pests but increase the risk of others. Damage caused by red-legged earth mite and blue oat mite may be reduced as these mites cause damage to crops establishing in cooler autumn temperatures when mites become active. However, mites can be effectively controlled by management in the previous spring or by insecticide applied to seed pre-or post-sowing. Damage by false wireworm may be reduced by more vigorous early crop growth. *Bryobia* and *Balaustium* mites are active in warmer temperatures and early sowing may increase the risk of damage. Transmission of viral diseases by aphids and damage by caterpillar larvae of white cabbage butterfly, cutworm and brown pasture loopers may be increased. The delay in flowering, and subsequently pod-filling, due to grazing could increase the risk of some insect pests as the period at which crops are susceptible and insect pests active may increase in duration. Such pests which are problems in late spring and early summer include aphids (turnip aphid, cabbage aphid, green peach aphid and cowpea aphid), Rutherglen bugs and caterpillars (native budworm and diamond-back moth). Insect pests in early-sown canola acting as a reservoir for the invasion of more susceptible later-sown canola crops may also pose a risk.

**Blackleg** (*Leptosphaeria maculans*): Ascospores can be released throughout the canola growing season with the peak period of release dependent on environmental conditions during the preceding summer months. Earlier sowing, leading to more developed plants at the time of first ascospore showers, would generally reduce the impact of blackleg in ungrazed crops. Tissue damage caused by grazing may cause an increase in blackleg as exposed stems and petioles could provide a point of entry for the fungus. On the other hand, grazing could also have the potential to reduce blackleg severity as infected leaves and petioles may be removed before the fungus penetrates to the stem. There may also be an interaction between the type of blackleg resistance in the host and grazing. Resistance active at the leaf surface which inhibits the penetration of the fungus into the plant may not be effective after damage by grazing. However resistance that inhibits fungal growth at the petiole/stem junction or at the base of the stem may be effective against blackleg entering the plant through wounds caused by grazing. In addition, novel types of blackleg resistance could be introduced into the farming system if new types of *B. napus/B. juncea* suitable for grazing, but which have not previously been released as commercial cultivars, are identified in this study. This could provide significant benefits for the control of blackleg in crops grown solely for grain as different types of host resistance can be rotated in space and time.

**Sclerotinia stem rot** (*Sclerotinia sclerotiorum*): Sclerotinia infection is influenced by flowering time and the size of the crop canopy which affects canopy moisture. Both flowering time and canopy density can be manipulated by grazing. Grazing generally delays flowering time, but may also reduce crop biomass, thereby reducing canopy moisture and hence the severity of infection.
Other diseases: Damping-off fungi (Rhizoctonia, Pythium, Fusarium) and downy mildew (Peronospora parasitica) may be less prevalent in earlier sowings where plants are growing more rapidly in warmer soils.

Clubroot, caused by *Plasmodiophora brassicae* is favoured by warm, wet, acid soils. Although clubroot is not seedborne it can occur as a dust contaminant on the outside of seed but seed purchased from a reputable source is generally low risk. The resting spores of *P. brassicae* can be transmitted by anything that carries contaminated soil. Whether this includes grazing stock is not known. The increased production of fodder brassicas grown over the warmer months may act as a *Brassica* host to build up levels of inoculum which could be an issue for early- sown grazing canola crops. Clubroot resistance is present in *B. napus*, *B. campestris* and *B. oleracea*.

Early-sown canola crops may have an increased risk of transfer of viruses (beet western yellows virus, turnip mosaic virus and cauliflower mosaic virus) by aphids. Summer and early-autumn rainfall provides conditions for wild radish and other weeds which are hosts to aphids and viruses. It is possible that these could build up in these early-sown canola crops, resulting in increased spread of viruses to later-sown crops.

**Planned strategy within the project**

We have screened all varieties for inclusion in the evaluation for a high degree of blackleg resistance (Table 1). Investigations of the impacts of early sowing and grazing on the incidence and severity of major pests and diseases including blackleg will be assessed by monitoring at all of the field sites, and by additional glasshouse and laboratory experiments carried out by Dr Susan Sprague to specifically investigate the impacts of defoliation and stem damage on disease incidence and severity.

**Early sowing**

*Late breaks*. The opportunities for early sowing will differ across regions but our consultations with experienced consultants in most areas suggest there will be significant opportunities for sowing 1-3 weeks earlier than normal (i.e. from early April) in most higher rainfall regions. Earlier sowing opportunities (March) are less likely and “false-breaks” with a return to hot conditions may cause crop failure if there is no stored water. We investigated the opportunities for early sowing using the *MetAccess* climate database for a range of sites in southern NSW/ACT and in Victoria/SA (Figure 2a and b) (runs by Dr Hugh Dove). The analysis showed that the probability of receiving a sowing opportunity (defined as 25 mm in any 5 day period) was 1 year in 3 from late March and 1 year in 2 by early April at Canberra and Wagga, while at the drier site (Condobolin) which is near the margin of current canola areas, the opportunities for earlier sowing were clearly reduced (Figure 2a). At the Victorian/SA sites with a more marked winter-rainfall pattern, the sowing opportunity moved later with a 1 in 3 chance by early April and 1 in 2 by late April (Figure 2b). The drier site at Horsham also had limited early sowing opportunities. Opportunities for dual-purpose use become limited after May sowing due to reduced biomass production, unless the grazing value exceeds the seed yield values, because yield reductions become increasingly likely in all but the very long season environments.
Figure 2a. The probability of sowing opportunities at selected NSW sites
Figure 2b. The probability of sowing opportunities at selected Vic/SA sites
Weed management. All groups indicated that weed management for early-sown crops will be an issue and many wanted to know if there was a suitable TT variety for grazing. Other groups indicated that with good weed management there will be significant opportunities for conventional varieties, especially if they are very vigorous and the grazing by sheep assists in reducing weeds. We have observed that sheep preferentially graze all available grass weeds within the canola stands before starting to feed on the canola.

Establishing canola into cereal stubble. Canola can suffer a severe growth penalty if sown directly into heavy wheat stubbles. Restrictions to burning in late summer/early autumn means that stubble will need to be well-managed to avoid this issue. At GES in 2006, there were significant impacts on crops sown into wheat stubble in comparison to short fallow after pasture.

Bird damage. Crops (particularly early sown) can be badly damaged by ducks or other birds especially if sown close to dams or other nesting areas.

Delayed flowering and maturity

Delayed flowering will reduce the risk of frost during the early water-filled pod stage when canola is most sensitive. Analysis using MetAccess showed the risk of frost (screen temperature < 0°C) on any day at the NSW sites from mid-September to mid-October fell from around 20% to less than 4% in Canberra, from 8% to rare in Wagga and there was no risk at Condobolin (data not shown). At the Victorian sites, there was a relatively constant but low level of frost risk at Hamilton (4 to 6%) until late October, and less than 3% risk at both Naracoorte and Horsham for the same period.

A greater threat posed by the effect of grazing on delayed flowering and later maturity is the risk high temperatures during flowering and pod-fill, which will reduce yield potential. Canola pollen is damaged directly by temperatures above 29°C causing sterility and failure of seed set, while hotter temperatures generally will increase the level of water stress on the plant during the flowering and pod-filling stage. In general, the consultants and agronomists suggested that to avoid significant yield loss, delayed flowering and maturity outside the current window for canola should be avoided or minimised where possible, although in higher rainfall areas with cooler spring temperatures the impacts of delayed flowering are likely to be less significant.

We used the Metaccess climate database software to investigate the probability of temperatures exceeding 29°C on any particular day throughout the anticipated flowering and pod-filling period (see Figure 1 above) at selected sites throughout NSW/ACT (Figure 3a) and Victoria/SA (Figure 3b) (runs by Dr Hugh Dove). In Canberra, the risk of high temperatures remains low (<10%) until mid-November but rises from 10 to 20% at Wagga from early to mid-October (Fig 3a). At Condobolin significant risk exists from mid-September and rises sharply in October. In Vic/SA, the risk also remains low (< 10%) at the higher rainfall site at Hamilton until mid-November, from late October at Naracoorte and Horsham, although there is a steep rise in the risk at Horsham to 20% from late October (Fig 3b). These Figures demonstrate the increasing risk of higher temperature and water stress on grazed crops where flowering and pod-filling is delayed from the usual window (mid-September to late October), into a delayed window of 2 to 3 weeks. The risks are clearly increased in the lower-rainfall inland sites in both NSW and Vic/SA.
Canberra: Probability of daily maximum temperature > 29°C

Wagga Wagga: Probability of daily maximum temperature > 29°C

Condobolin: Probability of daily maximum temperature > 29°C

Figure 3a. Probability of high temperature stress at selected NSW sites
Hamilton: Probability of daily maximum temperature > 29°C

Naracoorte: Probability of daily maximum temperature > 29°C

Horsham: Probability of daily maximum temperature > 29°C

Figure 3b. Probability of high temperature stress at selected Vic/SA sites
**Chemical withholding periods**

Canola production can involve significant use of a range of agrichemicals including herbicides, pesticides and fungicides applied to the soil, the seed or onto established crops during the vegetative stage. Agrichemicals have withholding periods (WHP) which indicate the time which must be observed between application and grazing by animals. The dual-purpose canola concept involves grazing canola crops at a much earlier stage than would normally occur in drought, or for cut hay or silage. From the majority of discussions, the proposed timing of grazing would be mid-June to late August from an early to mid April sowing. Some of the common chemicals used on canola and their withholding periods are shown below.

<table>
<thead>
<tr>
<th>Product</th>
<th>Withholding period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simazine</td>
<td>15 weeks</td>
</tr>
<tr>
<td>Atrazine</td>
<td>15 weeks pre-sowing; 6 -10 weeks post sowing</td>
</tr>
<tr>
<td>Lontrel</td>
<td>12 weeks</td>
</tr>
<tr>
<td>Onduty</td>
<td>6 weeks (applied at 2 to 6 leaf stage)</td>
</tr>
<tr>
<td>Verdict</td>
<td>4 weeks</td>
</tr>
<tr>
<td>Select</td>
<td>3 weeks</td>
</tr>
<tr>
<td>Treflan, Stomp</td>
<td>None</td>
</tr>
<tr>
<td>Impact</td>
<td>4 weeks</td>
</tr>
<tr>
<td>Jockey</td>
<td>8 weeks</td>
</tr>
<tr>
<td>Gaucho (Imidacloprid)</td>
<td>Do not graze or cut for stockfeed within 6 weeks of sowing</td>
</tr>
<tr>
<td>Fastac</td>
<td>3 weeks</td>
</tr>
<tr>
<td>Dimethoate</td>
<td>1 day</td>
</tr>
</tbody>
</table>


Given the range of products and formulations which may have different amounts of active ingredient, it would be wise to consult the labels, your local agronomist or these websites for the most up-to-date information about withholding periods for any chemicals used on canola crops which are to be grazed.

**Planned strategy for the project**

At this stage we will focus on evaluating the range of material for dual-purpose use without a focus on these issues, most of which would seem manageable within most systems. However we will document any obvious limitations to implementation of dual-purpose use as a result of prohibitive chemical withholding periods within specific systems and consider options to minimise their occurrence.
Grazing management

Animal health issues. Management guidelines for canola as a dual-purpose crop are limited at this time. Most of the discussion about potential animal health issues is derived from the well-documented problems of some of the forage brassicas (fodder rapes, kales, turnips, etc.) for which guidelines have been developed (NSW Agfact P2.1.13 Ayres and Clements, 2002), or from the grazing of failed canola crops during drought (“Managing failed canola crops”; Paul Parker NSWDPI, Young 2006). Neither of these situations adequately reflects the risks for dual-purpose canola grazed during the vegetative stage in winter. Generally, livestock health problems from grazing are sporadic and can be avoided by good agronomic and grazing management. Many of the health issues (e.g. neonatal goitre, reproductive problems, digestive irritation problems, rumen statis syndrome, polioencephalomalacia) are caused by glucosinolates in the tissues. Canola is bred for low seed glucosinolates and levels in vegetative tissues also tend to be lower during vegetative growth than in traditional fodder brassicas. If anything, these issues would be less likely in canola grazed in winter.

Haemolytic anaemia is another Brassica-related problem caused by compounds known as SMCOs (cysteine-like amino acids), but these tend to be low in forage rapes and canola, and are mainly a problem in kale. Some Brassica issues which may arise in dual-purpose canola include:

● Photosensitisation – Swelling, blistering and scabbing on exposed face and ears. Caused by grazing stock, especially young lambs, on young Brassica crops.

● Bloat – avoided by ensuring animals are not starved before putting them on canola.

● Nitrate poisoning – Hungry livestock with empty rumens suddenly introduced to high-nitrate plants are at risk, especially in cool, overcast conditions and high N-fertiliser application.

The general recommendations for managing fodder rapes and grazed canola crops are our best recommendation for dual-purpose canola at present:

● Do not let hungry stock with low levels of gut-fill graze on brassicas
● Introduce animals to the crop slowly to allow rumen microbial populations to adjust
● Monitor animals during the first days of grazing
● Ensure stock have plentiful water
● Tainting of meat can occur – remove stock 3-7 days before slaughter.

There were no health issues in the CSIRO pilot study (2004-2006) and a grower who have been grazing lambing ewes on canola in winter for many years have reported no health issues.
Utilising the available feed. The consensus was that the feed would be most valuable to fill the winter feed gap from mid-June to mid-August, although this depended on the location and the types of grazing enterprise of individual businesses. Groups at Naracoorte and Geelong nominated July-August as most valuable period while the Hamilton and NSW groups nominated June/July. A key issue discussed was how dual-purpose canola would fit into the management of the whole-farm feed supply. The idea of moving sheep from winter wheat onto winter canola and then to pasture was raised as a possibility.

An aspect which is already an issue in the utilisation of dual-purpose cereals is whether individual producers will have or be able to get sufficient stock to graze large areas of canola at high grazing pressures. Whilst these might favour the “clip-grazing” concept (Scenario 3, above), such light grazing pressures could generate patchiness in the crop and cause unevenness of flowering and maturity which will cause difficulty in windrowing. Losses caused by trampling and fouling in grazed canola have also been observed, but there are few quantitative data. This aspect warrants further study.

One aspect which has not been studied with dual-purpose canola, but which Drs Hugh Dove and Andrew Moore have examined in simulation studies with forage brassicas, is whether the availability of this novel winter feed supply could allow a shift in the timing of major livestock operations. For example, although autumn lambing seems to offer the advantage of finishing lambs on spring pasture growth, it involves the major disadvantage of having ewes in full lactation during the winter feed gap. The possible use of dual-purpose canola to fill the winter feed gap and allow a reconsideration of autumn lambing, is worthy of investigation.

Planned strategy for the project

Grazing management is clearly a key issue for the success of the dual-purpose canola concept and we will be seeking close collaboration with existing and new projects focussed on dual-purpose crops such as those within the Grain and Graze initiative. We have close involvement through Dr Hugh Dove and his work on winter wheat and will integrate grazing studies on dual-purpose canola into his on-going work on dual-purpose cereals. In addition we will locate our Wagga Wagga site on a shared paddock with Dr Jim Virgona who is also investigating aspects of grazing on dual-purpose crops. There are significant opportunities to build further links within Victoria through the DPI group at Hamilton and their projects such as Evergraze and Sheep/Wheat Initiative during the course of this project.

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 (*Leptosphaeria 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 m²) 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.

<table>
<thead>
<tr>
<th>Month</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
<th>Tot</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>48</td>
<td>21</td>
<td>3</td>
<td>3(24)</td>
<td>12(40)</td>
<td>25</td>
<td>18(25)</td>
<td>89</td>
<td>44</td>
<td>66</td>
<td>81</td>
<td>82</td>
<td>581</td>
</tr>
<tr>
<td>2005</td>
<td>53</td>
<td>68</td>
<td>36</td>
<td>7(16)</td>
<td>2(33)</td>
<td>126</td>
<td>109</td>
<td>71</td>
<td>125</td>
<td>86</td>
<td>93</td>
<td>20</td>
<td>845</td>
</tr>
<tr>
<td>2006</td>
<td>58</td>
<td>14(50)</td>
<td>30(25)</td>
<td>11(40)</td>
<td>0(20)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>LTM</td>
<td>60</td>
<td>56</td>
<td>51</td>
<td>47</td>
<td>46</td>
<td>40</td>
<td>42</td>
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<td>54</td>
<td>64</td>
<td>64</td>
<td>53</td>
<td>623</td>
</tr>
</tbody>
</table>

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 and branched from lower buds following removal of the main stem.

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.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Biomass (t/ha) 23 August</th>
<th>Yield (t/ha)</th>
<th>Oil (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ungrazed</td>
<td>Grazed</td>
<td>Removed</td>
</tr>
<tr>
<td>Hyola 60</td>
<td>4.6a</td>
<td>2.1a</td>
<td>2.5a</td>
</tr>
<tr>
<td>Winter1</td>
<td>4.7a</td>
<td>2.1a</td>
<td>2.6a</td>
</tr>
<tr>
<td>Winter2</td>
<td>2.8b</td>
<td>2.5a</td>
<td>0.3b</td>
</tr>
</tbody>
</table>

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).

<table>
<thead>
<tr>
<th>Variety</th>
<th>Biomass (t/ha) 23 September</th>
<th>Yield (t/ha)</th>
<th>Oil (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ungrazed</td>
<td>Grazed</td>
<td>Removed</td>
</tr>
<tr>
<td>Winter1</td>
<td>8.11</td>
<td>3.80</td>
<td>4.30</td>
</tr>
<tr>
<td>Winter2</td>
<td>6.56</td>
<td>3.51</td>
<td>3.05</td>
</tr>
<tr>
<td>Winter3</td>
<td>6.42</td>
<td>3.08</td>
<td>3.36</td>
</tr>
</tbody>
</table>

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 Ginninderra Experiment Station in 2004. Significant effects in 2004: blackleg severity (Variety); Sclerotinia incidence (Graze, Variety); 2005: blackleg incidence (Variety).

<table>
<thead>
<tr>
<th>Year</th>
<th>Variety</th>
<th>Blackleg stem infection</th>
<th>Sclerotinia stem rot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Incidence (%)</td>
<td>Severity (%)</td>
</tr>
<tr>
<td>2004</td>
<td>Hyola 60</td>
<td>23</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Winter1</td>
<td>45</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Winter2</td>
<td>35</td>
<td>75</td>
</tr>
<tr>
<td>2005</td>
<td>Winter1</td>
<td>36</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Winter2</td>
<td>63</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>Winter3</td>
<td>18</td>
<td>50</td>
</tr>
</tbody>
</table>

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.

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

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 sclerotinia 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.

**Acknowledgements**

We thank staff of Ginninderra Experiment Station for managing the crops and livestock for this experiment and Mr Geoff Howe and John Graham for technical support.

**References**

