Dual-purpose crops – roles, impact and performance in the medium rainfall farming systems

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Take home messages

- Dual-purpose (DP) crops can increase farm profit in the medium rainfall areas of southern NSW
- True winter cereal and canola varieties have a better fit in the eastern slopes, while fast winter and slow spring varieties are safer dual-purpose options in the lower rainfall western areas
- At the paddock-scale, high profit relies on attention to detail with crop and livestock management. Establish the right crop early, and correct lock-up times are key to increase profit and reduce risk
- Recent variable seasons (very dry and very wet) demonstrate the many flexible 'exit' options for dual-purpose crops (graze out, graze-silage, graze-hay, graze-grain, grain only)
- Ongoing refinement to deal with new and emerging issues with DP systems are discussed.

Introduction

The medium rainfall area between the Olympic Way and Newell Highway in southern NSW has been the area of the earliest and longest adoption of dual-purpose (DP) cropping and the associated research activities of GRDC and other agencies (Grain'n'Graze, DP wheat and DP canola research). Outputs from experimental research and grower experience over two decades has firmly established dual-purpose crops (both cereals and canola) into mixed farming systems. Experienced growers have undoubtedly increased profit, flexibility and reduced risks in their businesses with appropriate integration of dual-purpose crops. Numerous previous papers have reported on that success and readers are urged to revisit these for more of the finer detail (see reference list).

A range of both winter and spring cereal and canola varieties provide potential grazing opportunities across this zone. The opportunity to sow 'true winter types' in March still presents across this region, but especially in the eastern slopes (Cootamundra, Harden, Greenethorpe) the season is long enough for early March sowing, an extended grazing period (May-July) and successful grain harvests (2 - 3 t/ha) with true winter types.

As you move west to the Newell highway, the frequency of early March sowing opportunities declines, and while excellent grazing opportunities still exist in some seasons, flowering and grain filling for true winter types often falls outside the optimum period, limiting grain yield recovery. In these areas, the fast winter wheat types and slow developing spring canola types tend to provide more frequent and reliable dual-purpose options. In this area farms often have a greater focus on grain than livestock, but autumn and winter feed gaps in the livestock enterprise can still limit whole-farm profit.

Most of the research on dual-purpose crops reflect the potential performance in individual paddocks compared to grain-only crops, assuming highly efficient forage utilisation. Flow-on benefits at the

farm-scale (e.g., benefits for earlier sowing, reduced supplementary feeding) have been observed, but the impact on profit at the farm-scale depends on many enterprise-level factors which are the focus of subsequent papers.

Background to current use of winter and long-season spring varieties

DP winter cereals have been part of the system in this region for decades with breeding programs devoted to them since the 1960s. During the 1990s the profitability of crops exceeded livestock. As a result, farms intensified cropping, with livestock numbers and interest in DP crops waning. The large impetus to further adoption of DP crops, came with the development of higher protein milling wheat varieties in the late 1990s – early 2000s (e.g., Whistler, Wylah and EGA Wedgetail(b)). The combined value of the early-sown grazing forage and higher protein grain revitalised interest and increased adoption significantly, with research outlining grazing strategies to avoid grain yield penalties.

DP canola was developed as an option in the late-2000s and was timely as wheat streak mosaic virus temporarily discouraged early sowing of DP wheat, and early-sown hybrid canola varieties could provide high value grazing potential similar to wheat. By 2010, DP canola had become an established part of the feed base and along with grazing cereals, provided the opportunity to increase winter livestock carrying capacity, while maintaining or increasing crop production. New varieties of wheat and canola suitable for DP use have been released in recent years. A significant gap remains in canola where no intermediate winter-spring types with 'fast-winter' - 'slow-spring' phenology are currently available. These would be better suited to sow in late March - early April to increase grazing potential, but mature earlier than current winter types to maintain grain yield.

Research outcomes establish the profit potential

The research results represent what is possible when the forage produced is grazed carefully and very efficiently, and the value is often estimated assuming high-value (meat) livestock enterprise. Establishing that aspiration potential of dual-purpose crops, and the management factors to achieve it, remains a useful benchmark for improvement - even though many seasonal, economic or enterprise-level factors will determine what can be achieved on different farms.

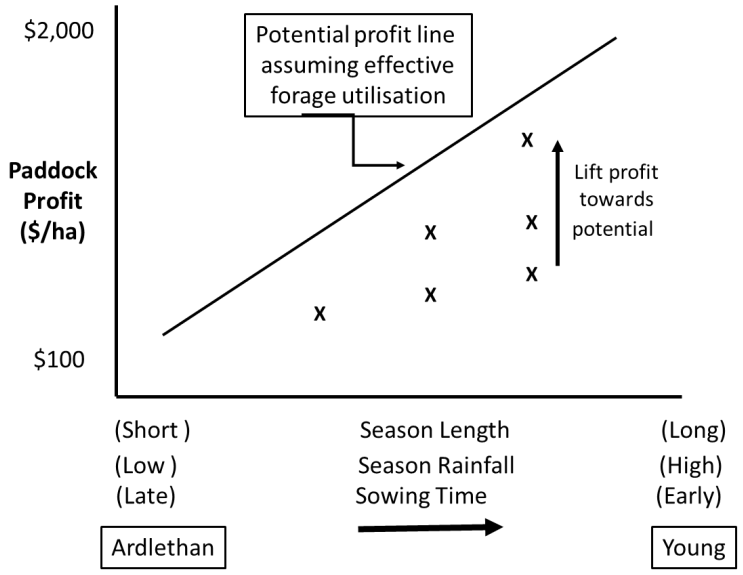

Figure 1. The potential paddock-scale profit from dual-purpose crops assuming effective forage utilisation (solid line) increases with longer seasons, more rain and early sowing. Improved crop and livestock management can improve profit at any potential level (crosses).

Getting it right at the paddock scale - a few universal guidelines

Early establishment with the right variety is the key to success.

Successful establishment in the earliest window with the right variety to flower at the optimum time provides maximum grazing potential. Grazing potential **declines by 200-250 dry sheep equivalent (DSE).days/ha for every week's delay after March 1.**

Lock-up time and residual biomass are crucial decisions to maximise profit

Grain yield penalties occur when grazing too late (i.e., removing reproductive parts) and too hard (leaving insufficient biomass to reach target yield). Rules of thumb have been published widely previously (see reading list). The decision is significantly influenced by the crop yield outlook and the relative prices for livestock and grain. These different 'exit options' (graze out, graze-hay, graze-silage, graze-grain) depend on specific circumstances and can provide significant management flexibility in response to variable seasonal or price outlooks.

Direct and indirect impacts on profit

In general, in these medium rainfall areas, dual-purpose crops are likely to be replacing grain-only crops on farms that are more crop-focussed. A summary of over 10 years of experiments, simulation studies and collaborative on-farm validation has demonstrated an increase in net crop returns at the paddock scale in the range of $300 to $1000/ha (Table 1). In general, the potential profit/ha is higher with earlier-sown winter types in the higher rainfall, longer-season areas and decreases as rainfall, season length and early-sowing opportunities decline moving west (Figure 1, Table 1). This is because the period for forage production, the time for crop recovery, and the grain-yield potential all decline with later sowing – but opportunistic grazing is still possible.

At farm scale, DP crops provide a range of other benefits such as widening the sowing window, filling critical feed gaps for earlier turn-off at higher weight or price, reduced supplementary feeding, spelling pastures and providing flexible options in dry years. The recent move to strict summer weed control and earlier sowing in cropping programs means early-sown DP crops provide indirect benefits to the whole farm by moving the whole sowing program earlier. This effect, together with buoyant livestock prices has meant that dual-purpose crops have become an important adaptation to increasingly unreliable autumn and spring rainfall and increasing spring temperatures.

Table 1. Typical examples of forage, grain yield and gross margins achieved from well-managed dual-purpose crops by collaborating growers in southern NSW

Crop type	Grazing achieved (DSE.days/ha)	Grain yield (t/ha)	Paddock gross margin (GM) $ increase above grain only
Winter wheat	1600 - 2700	4.5 – 6.5	+$600 - $1000
Spring wheat	400 - 800	3.0 - 5.0	+$300 - $500
Winter canola	750 - 2500	2.0 – 4.0	+$600 - $1000
Spring canola	300 - 700	1.5 – 2.5	+$300 - $500

Recent performance of winter types across the medium rainfall zone

Recent farming systems experiments have investigated the performance and profitability of grazing early-sown (March) winter canola and wheat systems at Greenethorpe and Wagga Wagga which span the medium rainfall zone. The economic performance of grazed canola-wheat systems has been compared with later-sown, grain-only spring wheat and canola systems (both systems managed with optimal agronomy). The grazing value was estimated by measuring the biomass removed by the livestock (usually heavily grazed for short periods), assuming 70% use efficiency and using feed conversion ratio and average long-term meat prices to establish the potential value of the

grazing (see summary at end). The annual and average 3-year profit (earnings before interest and taxes (EBIT)) was calculated and compared using real input and production costs for the years 2018-2020 (Table 2).

Profit was higher at Greenethorpe than at Wagga for both the dual-purpose system and the grain-only systems as a result of higher forage and grain yields in most years. But at both sites, the dual-purpose systems were significantly more profitable in all years (except 2018 at Wagga where the winter canola crop failed to recover from grazing in the drought). In the consecutive dry years of 2018 and 2019 at both sites, the grazed forage was an important part of the increased profitability as grain yields were relatively low. In the wet year of 2020 the un-grazed spring crops outyielded the grazed winter crops, but this was more than compensated by the value of the grazed forage.

Table 2. Annual and 3-Year profit (EBIT) at Greenethorpe and Wagga Wagga for early-sown (March) dual- purpose canola-wheat systems compared with timely sown (April) canola-wheat grain-hay systems in 2018 and 2019. Systems were phased (both crops were grown in each year).

Site/Crop	Dual-purpose system				Grain only system		
	Variety (date sown)	Graze (t/ha)	Grain/ (hay) (t/ha)	EBIT ($/ha)	Variety(date sown)	Grain/ (hay) (t/ha)	EBIT ($/ha)
Greenethorpe							
2018 Wheat	Kittyhawk(ф) (5/4)	1.6	1.8	$799	Coolah(ф) (7/5)	2.5	$619
2019 Canola	Hyola970 (23/3)	4.9	0	$1,419	HyTTec® TT (1/5)	(3.1)	$96
2020 Wheat	Bennett(ф) (18/3)	2.1	6.2	$1699	Coolah(ф) (5/5)	7.8	$1269
Ave 3-Yr EBIT				*$1305*			*$661*
2018 Canola	Hyola970 (3/4)	3.2	0.7	$1,251	HyTTec TT (7/5)	1.1	$79
2019 Wheat	Bennett(ф) (26/3)	3.4	0	$960	Coolah(ф) (1/5)	(4.8)	$538
2020 Canola	Hyola970 (17/3)	3.5	3.9	$2759	HyTTec TT (5/5)	4.6	$1958
Ave 3-Yr EBIT				$1536			$859
Average 3-Yr System EBIT				$1420			$760
Wagga Wagga							
2018 Wheat	Kittyhawk(ф) (3/4)	0.7	2.4	$649	Beckom(ф) (2/5)	2.2	$323
2019 Canola	Hyola970 (8/4)	4.5	(1.7)	$996	43Y92 (26/4)	1.4	$113
2020 Wheat	Bennett(ф) (10/3)	2.5	6.0	$1370	Beckom(ф) (12/5)	6.9	$917
Ave 3-Yr EBIT				*$1005*			*$451*
2018 Canola	Hyola970 (3/4)	1.8	0	-$79	43Y92 (3/4)	1.3	$93
2019 Wheat	Kittyhawk(ф) (8/4)	0.8	(3.0)	$229	Beckom(ф) (6/5)	(3.8)	$50
2020 Canola	Hyola970 (10/3)	2.4	2.8	$1505	43Y92 (23/4)	4.0	$1440
Ave 3-Yr EBIT				*$552*			*$528*
Average 3-Yr System EBIT				$778			$489

Our expectation was that successive seasons of early-sown winter crops at Wagga would generate legacies of dry soils that would reduce yield and profit compared with later sown grain-only crops. While the relative advantage of the grazed crops at Wagga was lower (59%) compared to Greenethorpe (85%) it remained significant, and in only 1 case out of 6, was the profit lower than the grain only option.

In almost all cases, grazing reduced grain yield compared to grain only crops (except wheat at Wagga in 2018), which means the value ascribed to the grazed forage is an important driver of the profits reported. The biomass removed in grazed winter crops averaged 3.1 t/ha (1.6 to 4.9 t/ha) at Greenethorpe and 2.1 t/ha (0.7 to 4.5 t/ha) at Wagga Wagga. The value of this forage will differ

depending on how effectively it is utilised and the value of the livestock enterprise. Our assumptions are detailed at the end of this article and can be modified to suit each enterprise.

Performance of spring types for grazing

A long-term experiment at Temora from 2009-2017 investigated the effect of grazing sheep on no-till, controlled-traffic, spring wheat and canola crops sown from mid-April to early May (Table 3). The crops were managed to **maximise grain yield** in no-till, interrow sowing systems on 30cm row spacing, and were **grazed opportunistically** with animals removed prior to Z31. The data reflect the potential for the opportunistic grazing of spring crops and the impacts on grain recovery.

The amount of biomass available for grazing is significantly less than for winter crops due to later sowing and more rapid development to Z30 and bud visible. The total biomass available at the start of grazing averaged 0.8 t/ha for canola (0.3 to 1.3 t/ha) and 0.8 t/ha (0.3-1.7 t/ha) for wheat. A maximum of ~1 t/ha was removed by livestock. In most cases the effects on grain yield were relatively small, (<0.2 t/ha), but tended to be higher with heavy (e.g., canola 2014) or late (e.g., wheat 2015) grazing.

Table 3. Effect of winter grazing on yield of canola and wheat varieties grown in C-W-W system at Temora between 2009 and 2016. Crops were crash grazed by sheep prior to stem elongation. Long-term average growing season rainfall (GSR) is 300 mm

Crop/year	Cultivar type & sowing date	GSR (April-October) (mm)	Grazing			Yield (t/ha)	
			Period	Start graze dry matter (t/ha)	Biomass removed (t/ha)	Ungrazed	Grazed
Canola							
2010	Tawriffic TT – 15/4	318	29-30/6	0.3	0.2	4.2	4.0
2011	45Y82CL – 15/4	198	24-25/6	0.8	0.5	3.3	3.1
2013	Hyola575CL – 1/5	230	2-4/8	1.3	1.0	1.0*	0.7*
2014	Stingray◊ TT – 1/5	313	8-9/7	0.5	n/a	2.1	1.6
2016	Hyola650TT - 27/4	590	14-16/7	1.1	0.7	3.3	3.2
Wheat							
2009	Gregory◊ – 30/4	225	18/6-7/7	0.4	0.4	1.7	1.3
2010	Bolac◊ – 15/4	318	25/6	0.3	0.1	7.0	7.5
2011	Bolac◊ – 15/4	198	22-26/6	0.8	0.6	4.3	4.8
2012	Wedgetail◊ – 18/4	186	20-21/6	0.3	-	4.8	4.8
2013	Gauntlet◊ – 1/5	230	24-25/7	0.8	-	3.8	3.0*
2014	Lancer◊ – 1/5	313	-	-	-	4.0	3.9
2015	Lancer◊ - 24/4	279	13-20/7	1.3	0.7	5.3	3.8
2015	Lancer◊ – 24/4	279	18-19/7	1.7	0.9	5.7	3.8
2016	Lancer◊ - 28/4	590	18-19/7	-	-	5.7	5.1

*****Severely affected by frost.

Emerging issues and farm-level considerations

Exceptional performance in drought but legacies must be managed

Early-sown DP wheat and canola options have been highly profitable at GRDC farming systems sites at Greenethorpe and Wagga in two recent decile 1 seasons in comparison with timely-sown grain only crops (Table 2). However, the success largely depended on deep stored water from either summer rainfall and good fallow management, or sequences with legumes which left legacies of

water and N. At Greenethorpe, consecutive early-sown dual-purpose crops (phased canola and wheat) were able to capitalise on higher amounts of stored water to produce twice the profit achieved by a grain-only (or hay) system across the 3-year sequence **($1420/ha *vs* $760/ha)**. At Wagga Wagga under drier conditions, income for the same DP crops declined in the second year in 2019 due to the legacy of drier soil from 2018, but the DP system still had higher profit than the grain-hay system **($778/ha *vs* $489/ha**). In medium rainfall areas, selecting the paddocks and seasons in which to use early-sown winter options can maximise profits.

Companions and forages

Some new options are being used on farms in the area including companion mixes which include a mix of cereal, oilseed and legume options, where after grazing the companions are terminated and the main crop harvested, or all may be grazed out. The mixture can increase the amount and quality of the forage while some benefits (soil improvements, pest or insect repellence, weed competition, N-fixation) are sought. In other cases, winter and summer crops may be sown exclusively for forage.

Managing N budgets in DP crops

Early-sown grazing crops require robust N levels at or near sowing to maximise biomass production (100-150 kg N /ha available in soil or fertiliser). But the uncertain fate of N in the consumed forage that is recycled onto the soil makes top-dressing decisions difficult. Though sheep remove very little N from the paddock (~5%), the timing and availability of the grazed and recycled N is uncertain – our best estimates suggest only 50% of the N taken up by the crop will be recycled and available to current crops, so adjusting topdressing accordingly to yield potential on this basis is advised.

Utilising the feed in good seasons

The large amount of feed made available in autumn especially in seasons like 2020 and 2021 (following prolonged drought) meant that thought must be given to effective and profitable utilisation of this feed. How to match the stock with the opportunity? Join more ewes for early autumn lamb? Retain more lambs from previous spring to target export weights? Trade sheep? These all carry risks for overstocking if dry conditions persist.

Farm-level impacts

Capitalising on the potential forage generated by dual-purpose crops at the farm-scale to lift profit towards the **potential profit** as predicted from forage production in plot-scale research requires careful planning of the livestock enterprise at the whole-farm scale. Dual-purpose crops will generally comprise only a portion of the cropping program, and numerous farm-scale considerations are required to determine how the grazing enterprise can be adjusted to make the most of the additional forage. These considerations are discussed in the paper by John Francis: 'Practicalities and economics of integrating dual purpose crops into the whole of farming operation in the medium rainfall zone'

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Further reading

https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/past-update-proceedings/2019/grdc-grains-research-update-coolah-2019

https://www.grdc.com.au/uploads/documents/GRDC_Dual-PurposeCrops.pdf

Appendix 1: Determining earnings before interest and tax (EBIT)

To calculate the annual EBIT for all treatments, we have initially used the following assumptions/prices.

A. Expenditure

1. All herbicides/fungicides/insecticides, seed dressings, fertilisers, GRDC levies and crop insurance costs were obtained from the annual NSW winter cropping guide or the annual SAGIT farm gross margin and enterprise planning guides with links at:
    i. https://www.dpi.nsw.gov.au/agriculture/broadacre-crops/guides/publications/weed-control-winter-crops
    ii. https://grdc.com.au/resources-and-publications/all-publications/publications/2019/farm-gross-margin-and-enterprise-planning-guide
2. All seed was priced according to purchasing as pure treated seed from seed companies. i.e. In 2019, prices used were wheat seed at $1/kg, faba bean seed at $1.20/kg, chickpea seed at $1.80/kg and canola seed ranging between $23-30/kg
3. All operations costs (sowing, spraying, spreading, haymaking, harvest) were based on the principal that a contractor performed the task. These costs were extracted from the yearly SAGIT Farm gross margin and enterprise planning guides. i.e. In 2019 prices used included sowing at $50/ha, ground spraying at $10/ha, cereal harvest at $70-85/ha, cut/rake/bale hay at $115/ha, with links at: https://grdc.com.au/resources-and-publications/all-publications/publications/2019/farm-gross-margin-and-enterprise-planning-guide
4. All variety levies for all crops and varieties were determined from the variety central website at: (e.g. for pulses) http://www.varietycentral.com.au/varieties-and-rates/201920-harvest/pulse/

B. Income

1. Wheat, barley and canola grain prices were obtained on the day of harvest from the AWB daily contract sheet for specific regions relating to trial location at: https://www.awb.com.au/daily-grain-prices
2. Pulse grain prices were obtained on the day of harvest from Del AGT Horsham and confirmed with local seed merchants.
3. Hay prices were obtained in the week of baling from a combination of sources including The Land newspaper and local sellers.

Appendix 2: Determining grazing value

To determine the estimated value of grazing the early sown crops, we have used the following formulae:

Winter grazing value ($/ha) = Plant dry matter (kg) removed x Liveweight dressed weight (c/kg) x Feed conversion efficiency (0.12) x Dressing % (lambs) x Feed utilisation efficiency (0.75)

Dressed weight and value:

- Lambs = 22.9kg (3-year average of light, heavy and trade lambs)

- Dressed weight = $6.25/kg (3-year average NSW)
- Dressing percentage = 50%

An example of 45kg lambs grazing winter Hyola 970 canola:

3800kg plant DM removed x $6.25 x 0.12 x 50% x 0.75 = $1069/ha

Note:

• These calculations assume a “trading margin” of zero – i.e. animals are bought and sold for the same price/kg

• We have not deducted a cost associated with the grazing livestock – this must be estimated and deducted for relevant enterprises (breeding, trading, etc)

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