Transformational impacts of dual-purpose canola in mixed farming systems

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Abstract

Mixed crop-livestock farming systems provide economic and biological resilience, but intense grass-cereal systems increase biotic and economic risk in the farming system. Dual-purpose canola (*Brassica napus*), developed since 2004, has become a highly profitable component of southern mixed farming systems in Australia. The enterprise is highly profitable at an individual paddock scale because grazing either comes at no cost to grain production, or the graze-grain income exceeds that of grain-only crops. The inclusion of dual-purpose canola also provides wider system benefits to underpin weed and disease control in dual-purpose cereal crops, and for perennial pasture establishment. High biomass production of canola in the traditional autumn feed gap (70 kg/ha/day) generates rapid weight gain in livestock for earlier selling and/or trading opportunities, and its timing complements dual-purpose cereals grazed in sequence to extend the winter spelling of pasture. At farm-scale, the integration of dual-purpose wheat and canola can transform traditional grazing systems when included on 10-20% of farm area, lifting farm profits by $100 to $200 per farm hectare.

Keywords

Grazing crops, feed gaps, farming system, live-weight gain, dual-purpose wheat, pasture

Introduction

The term dual-purpose (DP) refers to crops that are grazed during the vegetative stage in winter and later harvested for grain. Traditionally cereals such as oats (*Avena sativus*) and wheat (*Triticum aestivum*) were used for dual purpose, and the evolution of dual-purpose cereals has been reviewed (Harrison et al., 2011; Bell et al., 2014; Dove and Kirkegaard, 2014). Other crop types including grain legumes and oilseeds such as canola (*Brassica napus*) were also tested for dual-purpose use in the 1970's but canola was dismissed due to limitations of the varieties and agronomy used at that time (Dann et al., 1977). Kirkegaard et al., (2008) revisited the idea of grazing canola in the mid-2000s prompted by two drivers in different rainfall zones. In the high rainfall zone (HRZ), the success and intensity of use of dual-purpose winter wheat had led to intractable problems with diseases and grass weeds, so that a broad-leaf winter break-crop that could be grazed would be invaluable. In the medium and low rainfall zones, the canola area was declining during the Millennium Drought, and grazing income from spring canola offered a way to reduce risk and maintain canola and its critical role in the farming system (Kirkegaard et al., 2012). From 2004, a series of consecutive multidisciplinary research projects investigated the feasibility and best-bet management strategies for DP canola, and its integration and impacts at the whole-farm scale. From the outset, growers and consultants were embedded in the research teams to ensure relevant outcomes and rapid adoption. We review the interdisciplinary and participatory research that underpinned the rapid adoption of the innovation and consider its impact at farm scale, with a focus on hybrid winter canola in the HRZ.

Initial investigations

Experiments near Canberra during 2004 to 2006 (Kirkegaard et al., 2008) confirmed that early-sown (March to mid-April) spring and winter canola varieties could produce up to 3.5 t/ha of high-quality forage readily grazed by sheep with liveweight gain of 250g/d, and could recover to produce up to 4.0 t/ha grain yield. Key observations for subsequent research were, (i) spring types were unsuited to early (March) sowing due to early flowering, (ii) grazing could delay flowering by up to 30 days (iii) yield penalties occurred from grazing after stem elongation and/or when spring conditions were not conducive to recovery (iv) the economic loss from reduced yield could be compensated by the value of the grazed forage. Consultants visiting these preliminary experiments were excited by the potential and maintained interactions during the subsequent research.

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Blackleg management in grazed canola – a critical consideration
A critical first step to assess the feasibility of DP canola was to understand the impact of grazing on blackleg (*Leptosphaeria maculans*), the most significant disease of canola. Blackleg spreads via aerial spores in autumn and winter and infects plants via stomates or damaged tissues, so grazing was predicted to increase the risk and severity of infection. Kirkegaard et al., (2008) found grazing did not increase blackleg incidence or severity in winter varieties, but in 2006 grazing a spring variety increased severity from 0 to 10-60% prompting further investigation. Subsequent field experiments showed grazing could increase disease severity, but the effect was eliminated or minimised in varieties with high blackleg resistance and by ceasing grazing prior to stem elongation (Sprague et al., 2013). Withholding periods for seed applied fungicides generally don't impact on graze timings and the delayed flowering in grazed crops reduced the risk of upper canopy infection later in the season.

Biomass production and recovery after grazing
Biomass production
Experiments, simulation and on-farm experience over the last 15 years have generated a clearer picture of the key management factors driving the early forage production of DP canola (Lilley et al., 2015; Sprague et al., 2015). In approximate order of importance these factors are;
(1) Sowing date: assuming variety phenology is matched to the optimal flowering period, earlier sown winter varieties will generate much more biomass for grazing than later-sown spring types.
(2) N supply: Adequate N supply (150 kg N/ha for Feb-March sown winter types and 100 kg N/ha for April-sown spring types) is required at or soon after sowing to maximise early biomass production.
(3) Variety type: Despite some overlap, hybrid canola can produce more early biomass than conventional OP canola, while triazine tolerant varieties produce least biomass (growth lag associated with TT genetics). Hybrid-TT varieties produce more biomass than OP-TT varieties.
(4) Plant density: For optimum early biomass production the recommended plant population is 30-40 plant/m^2 (similar to un-grazed crops) as grazing generally does not commence before the 6-leaf stage and early-sown crops grow quickly under warm conditions.

Seasonal conditions clearly play a role, and in recent experiments the autumn growth rates for early-sown hybrid canola can be as high as 70 to 100 kg/ha/day and significantly exceed that of DP wheat (40-50 kg/ha/day) or pasture 10-20 kg/ha/day during that period, while in winter, winter canola growth rates are lower than those of wheat (Sprague et al., 2015; Kirkegaard et al., 2020; McGrath et al., 2021).

Recovery after grazing
The initial investigations suggested grazing canola prior to stem elongation reduced yield penalties but relied on good seasonal conditions for recovery. Subsequent physiological studies monitored regrowth and yield recovery in crops grazed at different stages and confirmed that crops grazed after stem elongation had yields reduce by up to 1 t/ha due to both delayed flowering and insufficient time for regrowth (Kirkegaard et al., 2012). Seasonal conditions play a significant role – if spring conditions were poor and the yield potential of un-grazed crops was low, grazed crops matched or exceeded the yield of un-grazed crops due to spared moisture in winter (Kirkegaard et al., 2008). Thus the potential yield reductions are related to yield potential, and current recommendations focus on adjusting both the timing and level of residual biomass at lock up to reach a target yield in different regions (Kirkegaard et al., 2020). Understanding the trade-off between extending grazing and yield penalties assists in lock-up decisions although ultimately the relative value of forage and oilseed will dictate the most profitable commercial decision for specific enterprises.

Table 1. A summary of published and unpublished grazing and crop yield achieved for dual-purpose canola across a range of sites and seasons in southern Australia from 2004 to 2020.

Canola type	Sowing time	Grazing			Grain Yield (t/ha)
		Feed at start (t/ha)	Period	DSE day/ha	
Winter (HRZ)	Feb - March	3 to 6	April-Aug	1500 - 3500	2 to 5
Spring (MRZ)	Early April	2 to 3	June-July	400 - 1000	2 to 4

Data sources: Dove and Kirkegaard (2014); Sprague et al., (2015); Kirkegaard et al., (2020)

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Grazing management and animal nutrition

Grazing canola can commence when plants are well anchored (~ 6 leaf stage) and chemical withholding periods observed, which usually means ~ 3 t/ha of biomass and full ground cover. Stocking rates can be adjusted to the available biomass and predicted grazing duration, but 25-30 DSE/ha for a 6 to 12-week grazing period (1000 to 3500 DSE.days/ha) is typical in the HRZ. The quality of canola forage can be considered similar to that of forage brassicas and grazing cereals with high digestibility (>80%), crude protein (>20%) and metabolizable energy (12-14 MJ/kg) (Kirkegaard et al., 2008; McGrath et al., 2021). Growth rates of sheep are commonly 200-350 g/d and animal health issues are rare provided the usual precautions for grazing brassicas are observed. There is a 10 to 14-day lag in animal growth rates when moving from cereal or pasture onto canola, so longer periods of grazing on canola are advised. The rapid autumn growth rate and slower winter growth rate of canola compared to wheat means canola is often grazed first and in sequence with wheat, providing a longer period of pasture spelling in winter (Bell et al., 2015).

Quantifying value at the farm scale

Establishing a whole-farm value for DP canola is difficult – it depends upon the type of grazing enterprise utilising the forage, the type of land-use the dual-purpose crop replaces (e.g. pasture, dual-purpose cereal or grain-only canola), the frequency of early-sowing opportunities and relative profitability of grain and forage in the longer-term. The most transformational impacts in recent years have been where long-season winter canola and wheat have been integrated into grazing-only enterprises in the HRZ. At the farm scale, field experiments (McGrath et al., 2021), simulation (Bell et al., 2015) and recent commercial experience have shown the integration of DP wheat and canola into traditional grazing systems at 10-20% of farm area can lift farm profits by $100 to $200 per farm hectare. In experiments with self-replacing merino flocks with fixed stocking rates, the benefits arose through increased winter grazing and reduced supplementary feeding costs, as well as the income from grain. Commercially, more value from DP canola comes from meat enterprises either trading livestock or selling weaners as prime stock rather than stores.

A case study near Goulburn

The transformational impacts of DP canola at farm scale are exemplified using an example modelled on farms in the Goulburn region on the southern Tablelands of NSW. We consider a 900 ha and former 100% grazing-only enterprise with 600 ha of native pasture and 300 ha improved pasture which has transitioned over the last decade to include 300ha of grazed winter wheat and canola (Table 2). The crop phase is pivotal to pasture improvement as its profitability (especially canola) can pay for lime, seed and fertiliser to underpin the establishment of the perennial grass-legume based pasture, and the formerly intractable serrated tussock grass can be controlled in the crop phase. The canola also provides grass weed and disease control for wheat in the cropping phase improving both forage yield and grain yield by ~1 t/ha compared to continuous wheat. To capitalise on the higher levels of autumn and winter forage produced by the crops, meat enterprises and livestock trading often augment self-replacing flocks. Rather than sell weaners as store animals they could be value-added to grow out to prime stock. Trading lambs on the dual-purpose crops (as in Table 2) is highly profitable and together with grain income, creates a significant increase in the gross margin from the grazing enterprise. Growers have also observed other benefits including ewe-hoggets cutting up to 1kg extra wool; joining rates of maiden ewes increased; pasture improvements from increased fertility after crops; reduced risk and flexible exit strategies of the crops in drought (graze-out, hay, silage).

Table 2. Transformation of a grazing enterprise (self-replacing 21-micron fleece, 25% joined to terminals) with integration of DP crops (traded lambs) over a decade in southern NSW.

Enterprise	Stock rate	Duration	Graze $GM/ha	Grain $GM/ha	Enterprise/Farm $GM
2010: 600 ha native pasture and 300 ha improved pasture					
600 ha Native Pasture[1]	5 DSE/ha	12 mths	$320	$0	$192,000
300 ha Improved Pasture[1]	12 DSE/ha	12 mths	$768	$0	$230,000
TOTAL Farm GM before DP crops					**$422,000**
2020: Integration of dual-purpose crops for trading					
300 ha Native Pasture[1]	5 DSE/ha	12 mths	$320	$0	$96,000
300 ha Improved Pasture[1]	12 DSE/ha	12 mths	$768	$0	$230,000
150 ha DP Winter Canola[2]	20 DSE/ha	2 mths	$1,036	$600	$245,400
150 ha DP Winter Wheat[2]	20 DSE/ha	2 mths	$1,036	$480	$227,400
TOTAL Farm GM after DP crops					**$798,800**

[1]Sheep on pasture $GM/DSE=$64; [2]Traded lambs gaining 250g/day @ $3.70/kg live-weight;
[2]Wheat grain yield 4 t/ha @$250/t and canola grain yield 2.2 t/ha @500/t.

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Conclusion

The integration of DP canola has been a catalyst for the incremental transformation of some mixed farming enterprises in southern Australia. It was underpinned by interdisciplinary research in close collaboration with growers and consultants. Farms that a decade ago produced only wool, now produce a range of cereals, oilseeds, hay and silage as well as cattle or sheep enterprises for meat and wool and have a level of diversity and flexibility that has improved business resilience.

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