  

GRAZING CROPPED LAND

June 2016

Grain & Graze
Profit through knowledge

A summary of the latest information on grazing winter crops from the Grain & Graze Program

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Intent of this grazing crop guide

This guide updates the latest information from the Grain & Graze 2 Program (2010 - 2013) on grazing winter crops. It builds on the *Free Food for Thought* workshop notes published in March 2008, providing close to a decade of grazing crop experiences. Importantly it captures favourable and challenging seasonal conditions.

Experimental results, farmer information and observations are combined to paint a picture around grazing crops in Southern Australia. The guide identifies common principles for grazing crops as well as providing local insights into different responses and management approaches required in different parts of the country.

The guide is not intended to report on all the information that exist on grazing winter crops but rather to support the extension events being conducted in the Grain & Graze 3 program (2014 to 2016).

Grazing winter crops can provide feed, but only if the advantages gained from grazing are not outweighed by the impact grazing has on silage or hay production, crop grain yields and quality and the longer term effects on weeds and the soil.

The circumstances on every farm will be different which means there is a vast range of possible grazing approaches. There is no recipe to grazing winter crops. Instead there are some general rules-of-thumb that help farmers and advisors to appreciate the impacts and benefits from grazing different crops, at different times and for different durations and intensities. Each individual will need to consider these pros and cons and determine the best fit for their situation.

To assist with these deliberations, information is presented to show ranges in results and not only the average. The range can be used to appreciate the volatility in outcomes which may occur. There are three broad types of ranges presented:

- The average with the 50% range. Half the recorded values fall within this range.
- The average, 50% range and the extreme values. This includes all values measured so the extreme outcomes can also be shown. They are often called 'box & whisker' graphs – see page 6 for an explanation.
- The number of times a certain result occur. They are represented as bar graphs.

The guide is structured to answer the questions farmers commonly ask about grazing winter crops. It has been compiled by Cam Nicholson, Alison Frischke and Phil Barrett-Lennard, with contributions from people in the following Grain & Graze 2 regions;

- Eyre Peninsula (Roy Latta, Jessica Crettendon, Naomi Scholz)
- East South Australia (Jeff Braun, Mick Faulkner, Bill Long)
- Southern Victoria (Simon Falkiner, Gina Kreek)
- Northern Victoria (Danielle McMillan, Damian Jones, Rob Fisher)

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Contents

1 The opportunities and potential downsides of grazing winter crops (why do it?)

Grazing winter crops is practiced across 19,000 mixed farms in Southern and Western Australia. In 2013 more than 2.7 million hectares of crop were grazed, representing 12% of the total area of crop grown[1]. However the area grazed fluctuates from year to year, suggesting that grazing crops are often used as an opportunistic feed source rather than an annual feed supply.

Suitable winter crops have commonly been referenced as 'dual purpose' because they can be used successfully for grazing and grain. Yet just because a crop variety may not have the tag 'dual purpose' does not mean it cannot be used for both purposes (refer to side story 1).

1.1 Balancing the benefits and the costs

The decision to graze winter crops requires weighing up the potential benefits to the farming system against the potential losses. The most obvious opportunity in a mixed farming system is to graze the crop when it is tillering, eating the leaves at the time of year when other feed is often in short supply. The greatest potential downside is the reduction in grain yield as a result of this grazing.

Examination of trial data from 193 comparisons in the high rainfall and medium to low rainfall environments shows a big range in dry matter production and impact on grain yield from grazing compared to no grazing (figures 1 & 2). These results are sourced from a range of years, cereal types, varieties, sowing dates and grazing approaches, so present both 'good' and 'poor' practice. Importantly it shows the opportunity for valuable dry matter production with minimal or no impact on grain yield if certain management choices and environmental conditions are met. It also highlights the potential losses when circumstances are unfavourable.

Side story 1: What's the difference between dual purpose crops, winter and spring types?

As the name suggests, dual purpose crops can be used for more than one activity, usually grazing over winter, followed by hay, silage or grain production. The dual purpose tag comes from the ability of the crop to recover after grazing.

Oats have traditionally been recognized as dual purpose, but recently some wheat and canola cultivars have been bred to remain vegetative (leafy) for a long period after sowing, enabling significant periods of grazing and then grain production. The long period of vegetative growth is determined by a gene bred into the plant that requires exposure to cold conditions to trigger commencement of head development. This requirement for a cold trigger gives rise to the term 'winter habit'.

Varieties with winter habit often grow slower than non-winter habit cultivars early in the season, but the dry matter difference at the end of winter can be reduced if crops are sown early - in March or early April. The time when the plant changes from vegetative growth is also more predictable with winter habit varieties because of the need for exposure to cold temperatures.

Just because a plant does not have winter habit does not mean it cannot be grazed and then recover successfully. However the opportunity to graze is reduced and the time when the plant changes from vegetative growth is less predictable.

1 GRDC Impact report for Grain and Graze 2 – Roberts Evaluation.

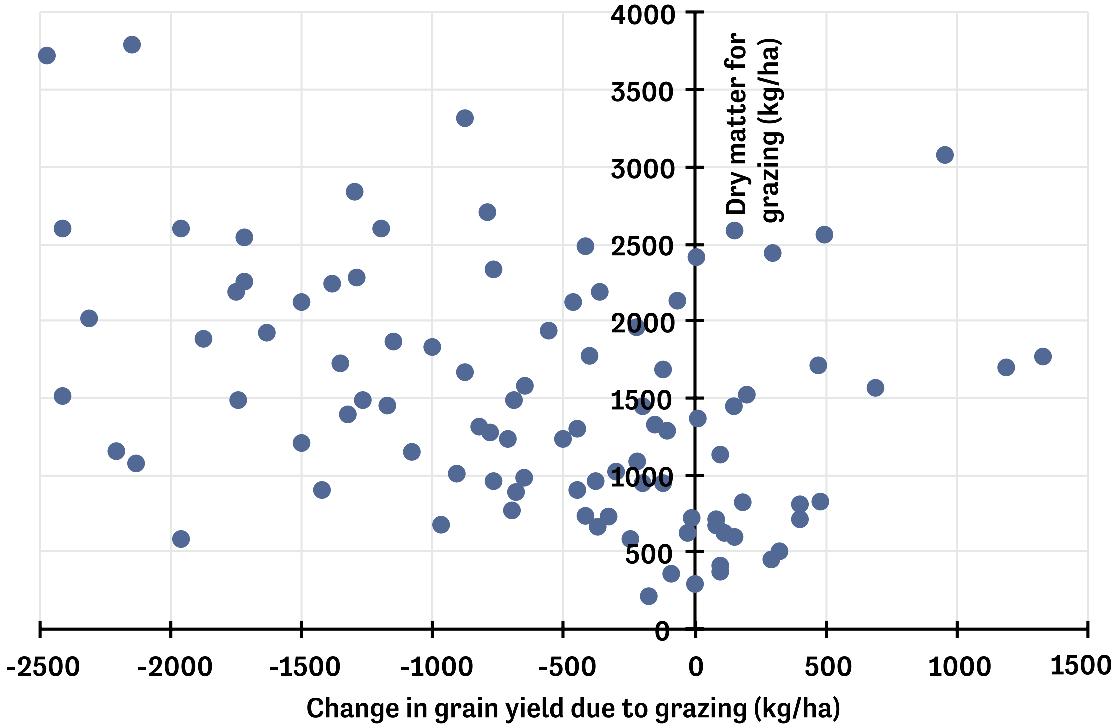


Figure 1: Dry matter produced at grazing and associated effect to cereal grain yield compared to no grazing in the 'high' rainfall zone (109 observations from 2004 to 2013).

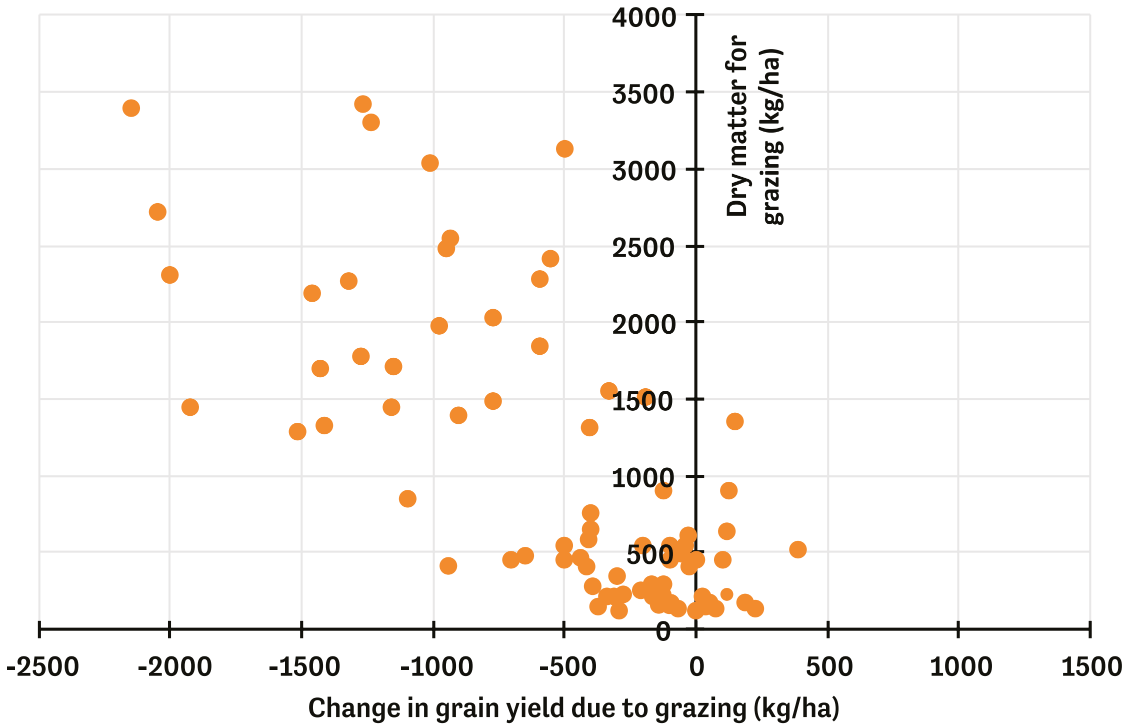


Figure 2: Dry matter produced at grazing and associated effect to cereal grain yield compared to no grazing in the 'medium' and 'low' rainfall zone (84 observations from 2006, 2008 to 2013).

However the decision to grow and graze winter crops is more complex than just comparing dry matter against grain yield. Each individual farmer needs to evaluate the full range of potential benefits and costs associated with grazing winter crops to help decide if the opportunities outweigh the risks. The possible benefits and costs identified by farmers who have experience in grazing crops are summarised below. Greater discussion of these topics are provided later in this guide.

Value to the livestock operation

- Provides high quality feed when fodder is often in short supply or replaces supplementary feeding
- Allows pastures to be rested to build a wedge of feed for use later in the year or for new pastures to establish
- Provides a worm free grazing environment
- Provides a place for animals to be 'parked' while pastures are treated with herbicides.

Costs to the livestock operation

- Grazing wheat crops for extended periods will require mineral supplementation
- May result in increased metabolic disorders, particularly with ewes in late pregnancy
- May require temporary fencing to ensure appropriate grazing
- Mobs may need to be 'boxed' to get adequate grazing pressure across a short time frame.

Value to the cropping operation

- Enables excessive crop canopies to be managed, reducing possible lodging, incidence of leaf diseases and future stubble loads
- Conserves soil moisture that can be used by the crop later in the year
- Delays maturity which may avoid late frosts
- Can improve the efficacy of some herbicide treatments e.g. broadleaf weed control and weed control e.g. selective grazing of grasses from oilseed or legume crops.

Costs to the cropping operation

- May reduce grain yield and grain quality
- Uneven grazing may lead to variable crop maturity
- May increase weed populations
- Delays maturity which may expose the crop to heat stress
- Will reduce stubble remaining after harvest.

Value to the whole farm

- Combination of grazing and grain production may increase overall farm profitability
- Potential to increase the area sown to crop without having to buy or lease more land
- Stocking rates can be increased, although extra livestock may need to be purchased.

1.2 Regional considerations

Climatic conditions have a major influence on the value and possible risks that can be encountered from grazing winter crops. These regional considerations influence the type of crops to sow, when they can be sown, how rapidly they will grow material for grazing and when the grazing 'window' closes. Figures 3 and 4 summarise some of these regional considerations. ***It is critical to appreciate these differences so the opportunities and risks of grazing winter crops are understood before grazing decisions are made.***

1.2.1 Flexibility in management

While grazing and then taking the crop through to harvest is the most common approach with grazing crops, other opportunities also present. Once grazing is completed, there may be opportunities to use the crop for silage, hay and straw. Winter crops can also be considered as an alternative forage source to traditional pasture as variability in climate becomes more challenging. Their rapid growth and high quality makes winter crops a feasible alternative to other annual fodder sources.

Time of sowing	April (canola), late April to late May (spring cereals).
Grazing	2-4 weeks but complete by mid July. Graze once well before GS30. Clip graze to minimise the risk of incurring a yield penalty.
Recovery after grazing	Good, but dependent upon the timing and intensity of grazing.

Time of sowing	April (canola), late April to late May (spring cereals).
Grazing	2-4 weeks but complete by mid July. Graze once well before GS30. Clip graze to minimise the risk of incurring a yield penalty.
Recovery after grazing	Good, but dependent upon the timing and intensity of grazing.

Time of sowing	March to April (winter cereals), April (canola), late April to late May (spring cereals)
Grazing	4-8 weeks, but complete by late July. Graze once or twice well before GS30. Clip graze to minimise the risk of incurring a yield penalty.
Recovery after grazing	Good but dependent upon the timing and intensity of grazing.

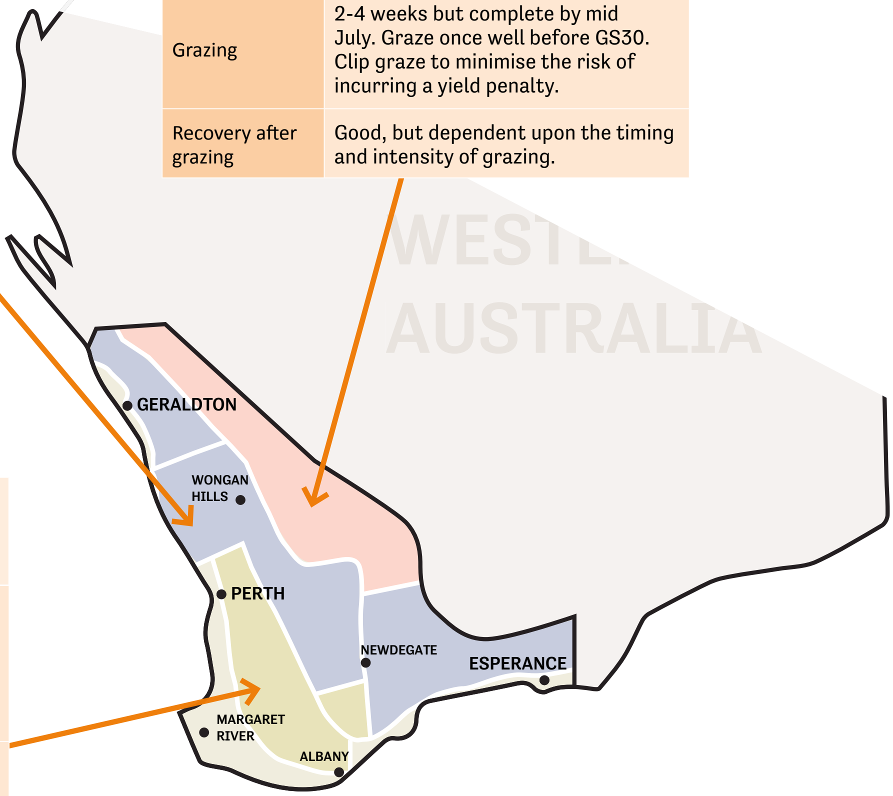
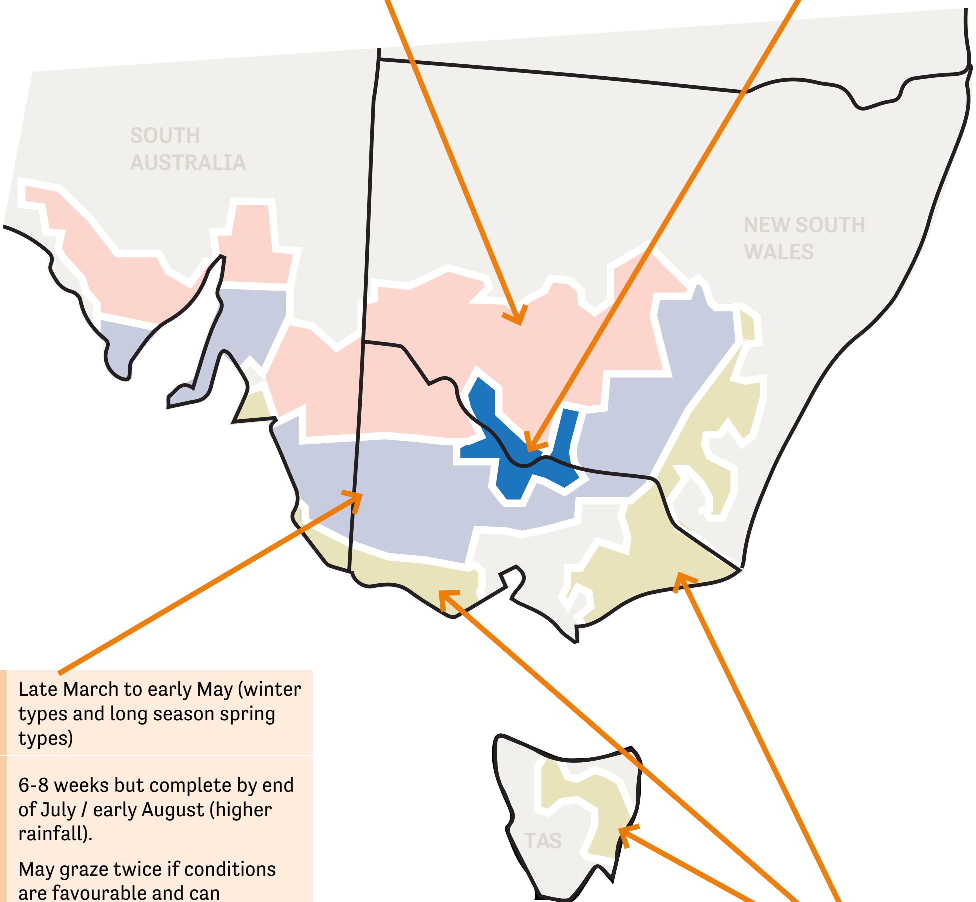


Figure 3: Regional considerations for Western Australia.

Time of sowing	April (winter types), April to early May (long season spring types).
Grazing	4-6 weeks but complete by mid July. Graze once, well before GS 30. Leave green leaf to provide greater chance of avoiding yield penalty.
Recovery after grazing	Grain yield usually affected, unless spring is favourable

Time of sowing	March (red wheat), April (winter types).
Grazing	Up to 12 weeks but completed by mid August. Can graze twice up to GS 30-32, three times if conditions are good. Can graze to the white line.
Recovery after grazing	Very good. Grain yield is usually maintained.



Time of sowing	Late March to early May (winter types and long season spring types)
Grazing	6-8 weeks but complete by end of July / early August (higher rainfall). May graze twice if conditions are favourable and can continuously graze. Can graze to the white line.
Recovery after grazing	Grain yield generally recovers, unless spring is unfavourable. Early sown barley yields are usually higher with grazing (if N is replaced).

Time of sowing	Late March (if early break) but usually mid April to mid May (winter types and long season spring types)
Grazing	6-10 weeks but complete by mid September (later in Tasmania). Usually only one grazing because of slow crop recovery after grazing (2 in Tasmania). Can graze to the white line.
Recovery after grazing	Grain yield generally recovers, unless spring is unfavourable.

Figure 4: Regional considerations for Southern Australia.

1.3 More on the possible benefits (the upside)

1.3.1 Extra feed for grazing

The greatest upside with grazing crops is the additional high quality feed that is available in the winter period. The most common uses of this extra feed is to:

- Fill a winter feed deficit, avoiding underfeeding, reducing the need for supplementation or the need to sell stock at low prices
- Provide the opportunity to 'punt' and trade stock, by purchasing at times of low prices
- To 'spell' pastures from grazing, enabling them to 'get away' and reach pasture benchmarks for lambing or calving.

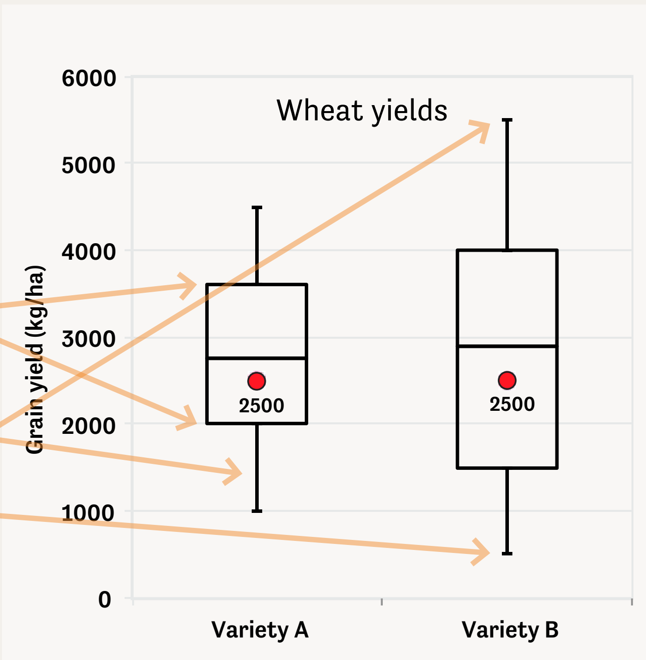
Examination of more than 500 measurements from 80 grazing crops trials conducted through Grain and Graze program over the past decade show a wide range in dry matter production. This variability is influenced by climatic conditions, type of crop, sowing rate, time from sowing to grazing and use of fertiliser, especially nitrogen.

To convey the variability in dry matter production, 'box and whisker' graphs and percentiles are used to summarise the information (see side story 2 on interpreting box and whisker graphs). Results for wheat, barley and canola are grouped around vegetative growth in low and high rainfall zones and for the start of stem elongation (high rainfall zone only) (figures 5 to 7).

Side story 2: Interpreting 'box and whisker' graphs

Box and whisker graphs present information about the variability around the average result and can be useful in appreciating risk. There are four critical pieces of information in a box and whisker graph.

1. The average. These are represented by the red dot.
2. The **ends** of the box represents the range where half the results occur. The smaller the height of the box the less range in values.
3. The **whiskers** represent the highest and lowest 25% of results.
4. The **end of the whisker** represent the maximum or minimum value. Long whiskers means there are some extreme values that are included in the average.



Consider an example (right) comparing the yields of two wheat varieties. They both have the same average yield but the yields of variety B are more variable than variety A.

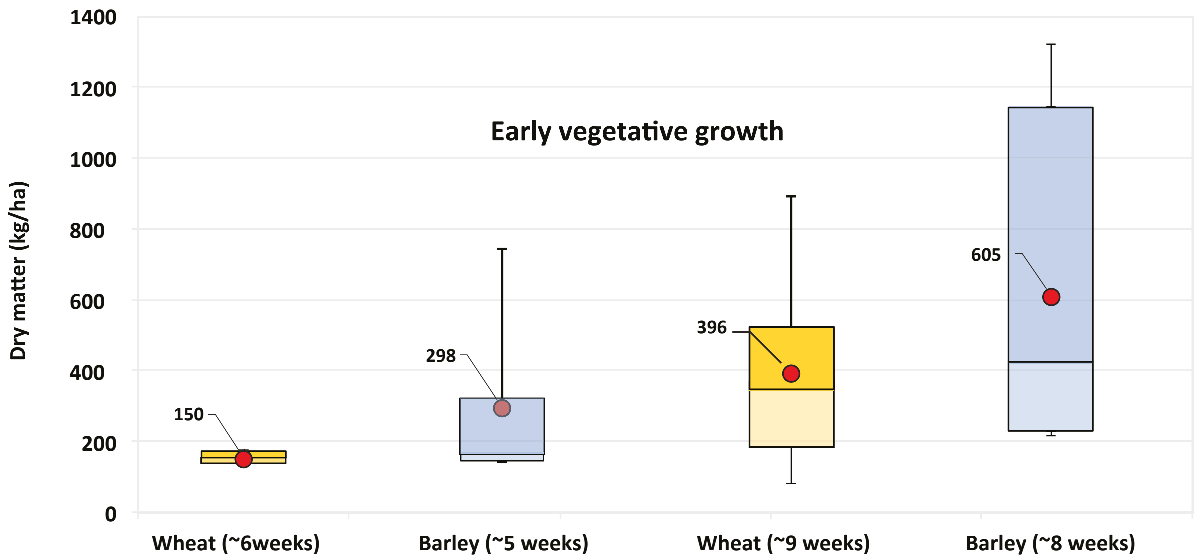


Figure 5: Range in recorded dry matter in vegetative growth (5 to 8 weeks from sowing) for wheat and barley in the low rainfall zone.

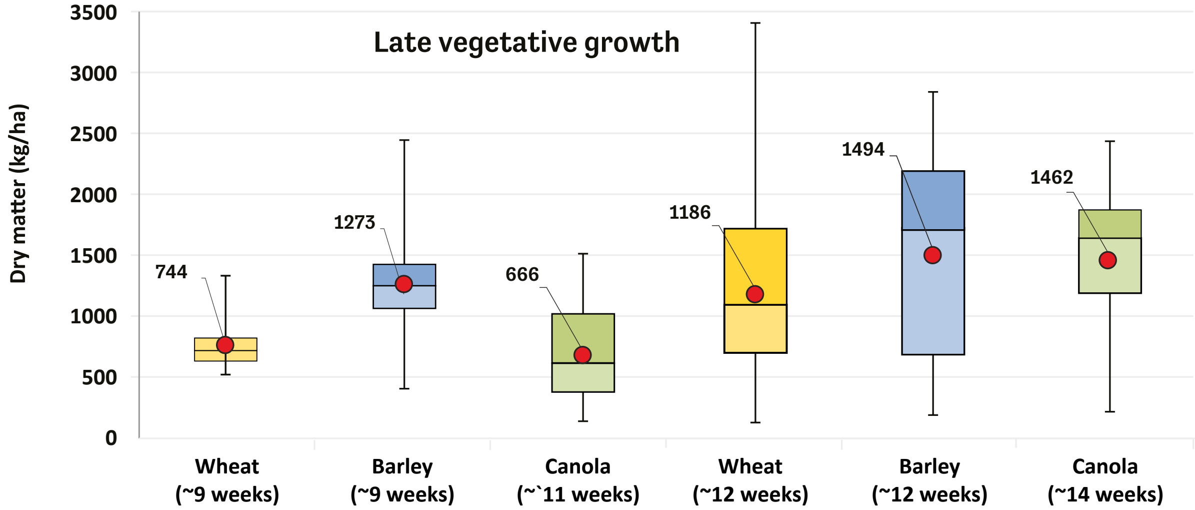


Figure 6: Range in recorded dry matter in vegetative growth (9 to 14 weeks from sowing) for wheat, barley and canola in the high rainfall zone.

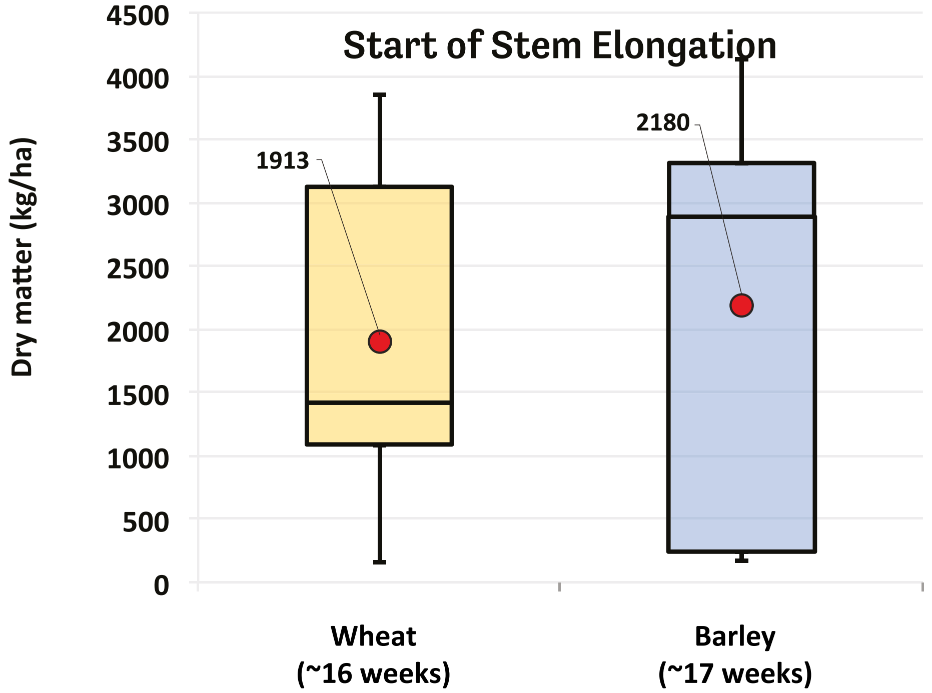


Figure 7: Range in recorded dry matter around stem elongation (16 to 17 weeks from sowing) for wheat and barley in the high rainfall zone.

The dry matter values are also presented in percentile tables (appendix 1).

Figures 5, 6 and 7 highlight a number of general, if not predictable, observations:

- Dry matter production is much greater in the high rainfall zone than the low rainfall zone for similar days from sowing. Rainfall, sowing rate and row spacing has a large influence on the measured difference.
- Barley provides more rapid early growth than spring or winter wheats or canola.
- Varieties within spring wheats, winter wheats or barley have much lesser influence on total dry matter when compared at the same sowing time, sowing rate and climatic conditions. This is not so canola, where hybrid varieties grow more rapidly under the same conditions.
- As the days from sowing increases so does the average dry matter production, however the range in dry matter production widens (seen by the taller boxes and longer whiskers).

1.3.2 High feed quality

Winter crops offer high quality feed which is equivalent or higher than typical pastures at the same time of year. Canola is slightly higher than the cereals in digestibility and metabolisable energy (figures 8 & 9). Digestibility and energy in the cereals appear to peak in the late vegetative stage and declines once stem elongation commences.

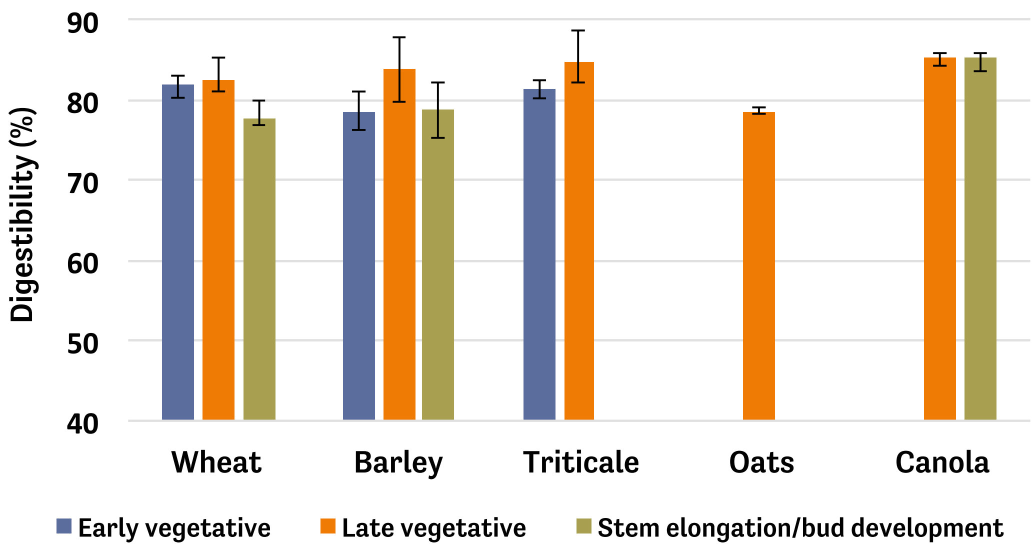


Figure 8: Average digestibility (%) for wheat, barley, triticale, oats and canola in the vegetative and early stem elongation phases (167 observations). Error bars represent the 50% range.

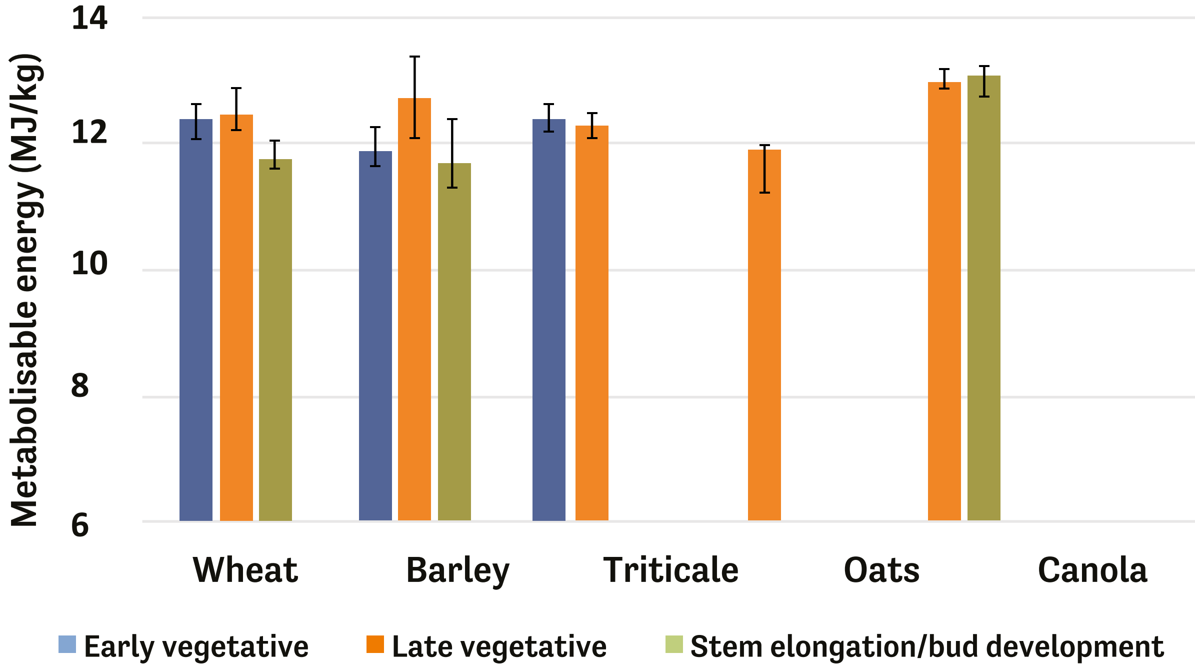


Figure 9: Average metabolisable energy (MJ ME/kg) for wheat, barley, triticale, oats and canola in the vegetative and early stem elongation phases (167 observations). Error bars represent the 50% range.

The protein content of all winter crops is very high in early vegetative growth, but declines as the crop matures, although the minimum protein levels remain well above the requirements of any class of livestock (figure 10). Maximum protein requirements for lactating or growing animal is around 14% to 16%. Animals are unable to store excess dietary protein, so any surplus protein is excreted by the animal in urine.

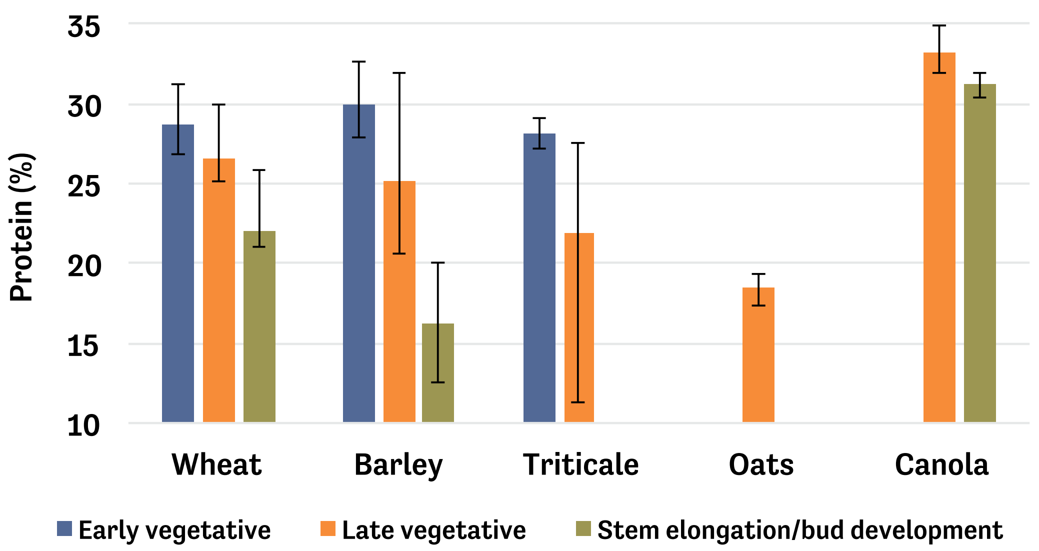


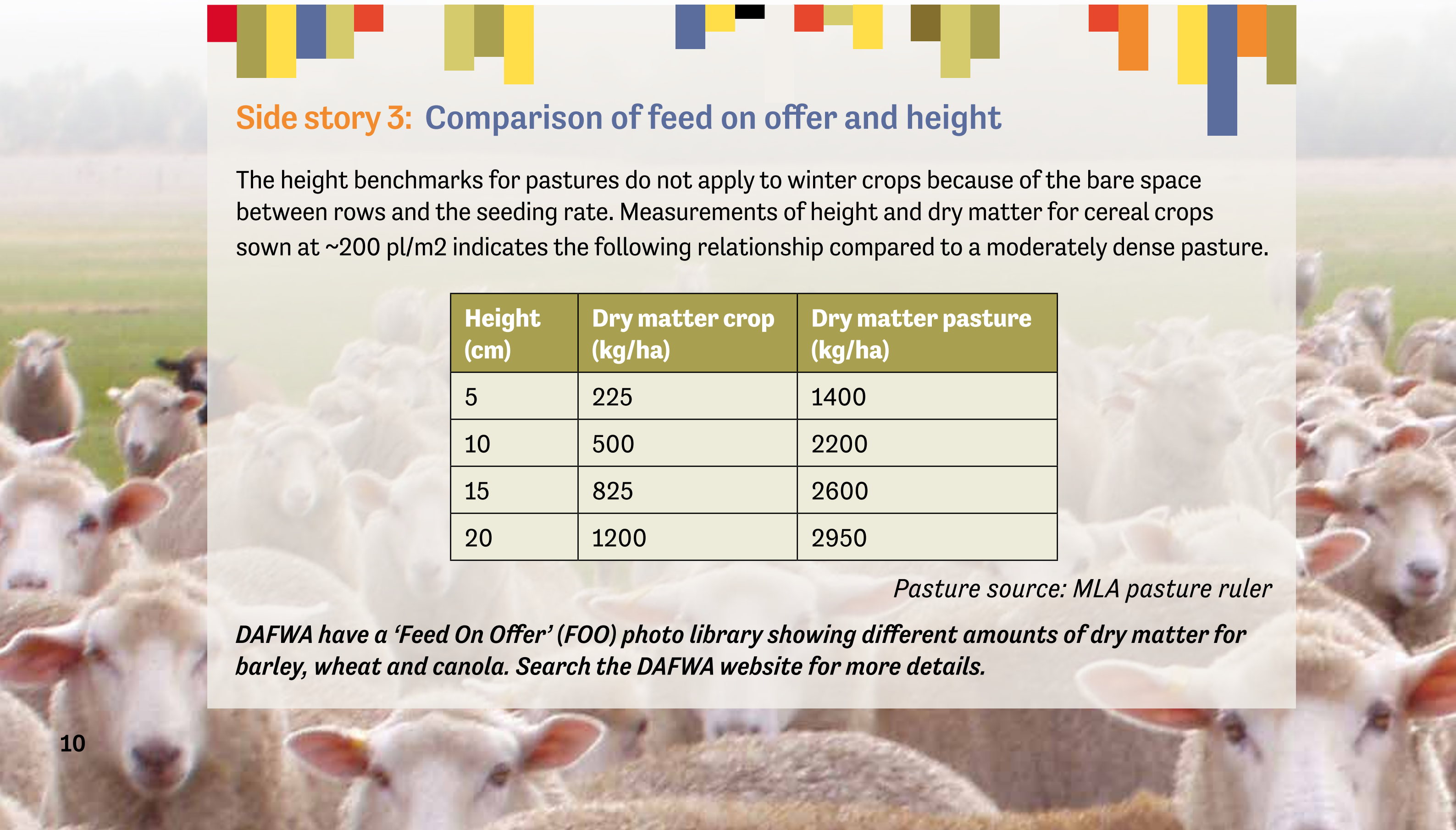
Figure 10: Average protein (%) for wheat, barley, triticale, oats and canola in the vegetative and early stem elongation phases (167 observations). Error bars represent the 50% range.

1.3.3 Potentially high animal growth rates

The performance of animals grazing winter crops (or pasture) is influenced by the quality of feed eaten and the amount available for grazing.

Cereals and canola tend to be less dense and grow more upright than pasture. This means it is much easier for a grazing animal to consume a greater quantity of feed for each bite with a winter crop than with a pasture, even though the total feed on offer (if cut to ground level) is the same or less (see side story 3 on comparison of feed on offer and height).

The difference in grazing height and the high quality of the winter crop has a considerable impact on intake and animal performance. If no animal health issues are present, the following animal growth rates could be anticipated from winter crops (table 1).



Side story 3: Comparison of feed on offer and height

The height benchmarks for pastures do not apply to winter crops because of the bare space between rows and the seeding rate. Measurements of height and dry matter for cereal crops sown at ~200 pl/m2 indicates the following relationship compared to a moderately dense pasture.

Height (cm)	Dry matter crop (kg/ha)	Dry matter pasture (kg/ha)
5	225	1400
10	500	2200
15	825	2600
20	1200	2950

Pasture source: MLA pasture ruler

DAFWA have a 'Feed On Offer' (FOO) photo library showing different amounts of dry matter for barley, wheat and canola. Search the DAFWA website for more details.

Table 1: Indicative liveweight gains for different classes of stock (based on Grazfeed)

Livestock	Description	Feed on offer (kg/ha)	Liveweight gain^ (kg/hd/day)
Lambs	Mixed sex, 10 mths old, 42 - 45 kg liveweight	~300	0.14 – 0.16
Hoggets	Mixed sex, 12 mths old, 45 - 48 kg liveweight	~300	0.13 – 0.15
Merino ewes	Late pregnancy (120 days), single lambs	~500	0.15 (ewe + foetus) 0.07 (ewe only)
	At lambing (15 days), single lambs	~800	0.22 (lamb)
First cross ewes	Late pregnancy (120 days)	~500	0.17 (ewe + single foetus) 0.20 (ewe + twin foetus) 0.07 (ewe only)
	At lambing (15 days)	~800	0.27 (single lamb) 0.18 (twin lamb)
Steers	Spring drop (10 mths old), 300kg liveweight	~500	1.06
	Autumn drop from previous year (14 months) 400 kg liveweight	~600	0.75

^ To achieve approximately 85% of maximum growth.

Graphs to predict liveweight gain from the dry matter on offer is provided in appendix 2.

1.4 More on the possible costs (the downside)

The greatest downside risk is the potential reduction in grain production and value due to grazing. Results from Grain and Graze and other experiments show a wide range of yield and quality responses to grazing, from large reductions in grain yield to no yield losses or even increases in yield.

1.4.1 Reduction in grain yield

Grain yield data from 2004 to 2013 was collected across 53 cereal trials and 246 measurements in Western Australia, South Australia and Victoria where a grazed and ungrazed comparison could be measured (figure 11). This included wheat, barley, triticale and oats. The results also include treatments where grazing was less than ideal, including grazing after stem elongation and when crops were under stress. These extreme treatments were imposed to appreciate the size of the yield and quality loss under adverse conditions.

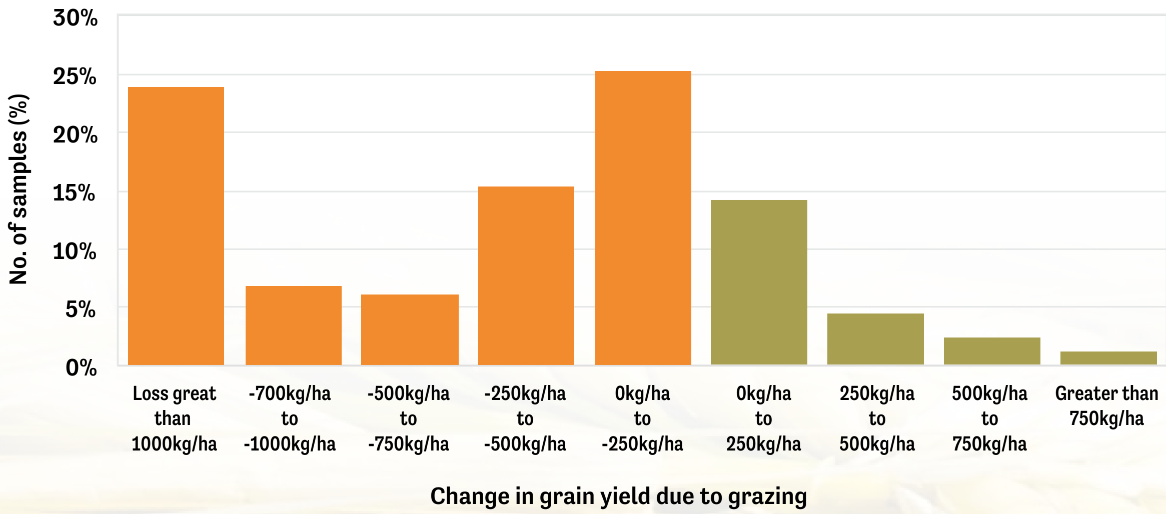


Figure 11: Change in cereal grain yield due to grazing.

Figure 11 highlights several key points:

- Cereal grain yield declined under grazing most of the time crops were grazed (78%), although the severity of the decline varied. The most common result was a yield decline of less than 250 kg/ha (25% of cases), with yield loss of between 250 kg/ha and 500 kg/ha occurring a further 15% of the time.
- Increases in grain yield were recorded in 22% of cases. The most common increase was up to 250 kg/ha although some larger gains were also recorded. The main reasons for the gains were attributed to reductions in lodging and less leaf disease, both a consequence of the removal of early growth by grazing.
- Large losses in grain yield were recorded (24% of cases). Four factors are believed to contribute to the large yield decline (table 2).

Table 2: Important factors observed to adversely affect grain yield

Factor	Effect
Growth stage of crop at end of grazing (refer to section 3.4.1)	Grazing after growth stage 30 may remove elongating grain ears and leave insufficient time for recovery before flowering.
Stressful environmental conditions after grazing and before flowering (refer to section 3.4.2)	Heat, moisture stress or waterlogging can hamper crop recovery and result in a loss of tillers and grains per ear.
Intensity and duration of grazing (refer to section 3.5)	Grazing that removes too much leaf may hamper adequate crop recovery reducing the potential for complete grain fill.
Variety maturity pattern too long for the growing environment (refer to section 3.4.3)	Grazing will delay maturity and may expose ripening crop to heat and moisture stress.

Canola

Grain data for grazed canola was limited. Most of the information was collected from Southern Victoria when the crop was sown at the conventional sowing time (late April to early May). Dry matter production was generally lower than cereals sown at the same time and the crop was slower to recover from grazing. This resulted in severe yield penalties.

Best practice sowing guidelines for canola are to sow in Late March to early April, but this may be difficult to achieve in some areas because of stubble burning restrictions and weed control. However the availability of new canola varieties with strong winter habit provides the opportunity to sow by taking advantage of out of season rainfall (October through to February), where the crop is treated like a brassica fodder for grazing before being locked up and taken through for grain.

1.4.2 Changes to grain quality

Grazing resulted in a variable response to cereal grain quality. In some trials grazing improved grain quality characteristics, in other trials grain quality declined. The general conclusions from the spread in results are discussed.

Protein

Grazing did not affect the average grain protein in wheat but did with barley. Of the 64 wheat results examined, the average change in wheat protein from grazing was -0.1%, with a similar number of increases in protein recorded as decreases (figure 12).

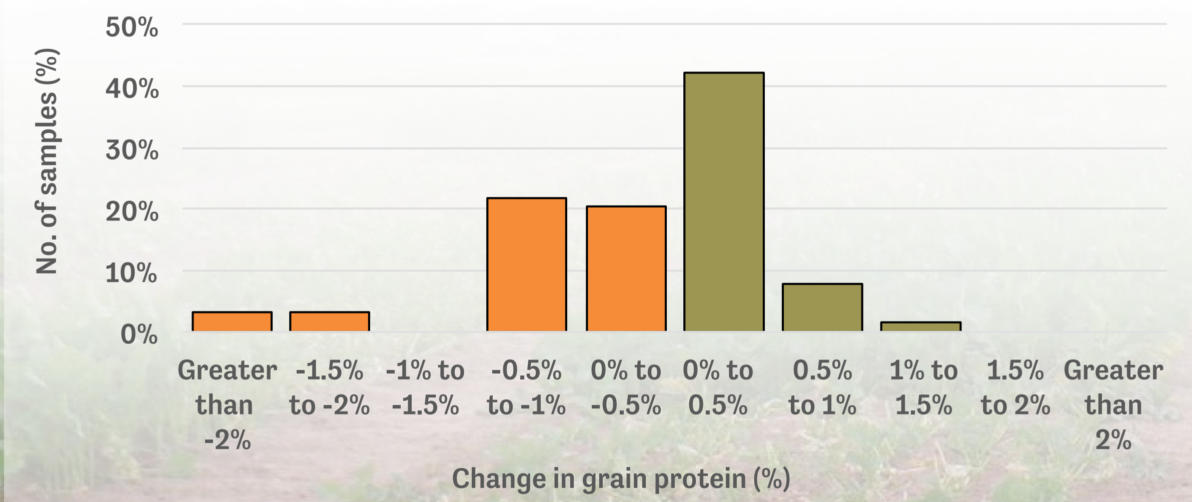


Figure 12: Change in grain protein for grazed wheat compared to ungrazed wheat (data from 64 comparisons).

The grain protein response to grazing for barley was different, with grazing more commonly resulting in a decline in grain protein (65% of the time). The average decrease across all trials for barley was 0.3% (figure 13).

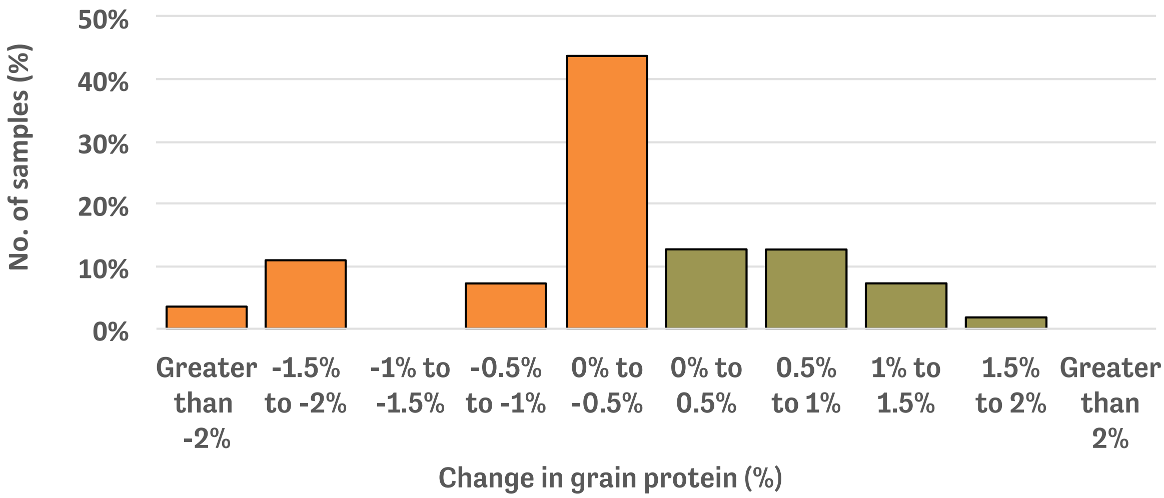


Figure 13: Change in grain protein for grazed barley compared to ungrazed barley (data from 55 comparisons).

The reasons for the decline in grain protein with grazed barley is not obvious. The results used in the analysis were collected across many years, using different varieties, nitrogen applications and time of grazing. This makes it difficult to identifying the possible reasons for changes in grain protein. The only loose association from the information is between grain yield and protein. It appears if grain yield is increased because of grazing, which happened in 40% of all the barley trials, then grain protein decreased (i.e. was diluted).

Grain size

Grain size in wheat and barley was generally not affected by grazing. Of the 54 comparisons with wheat and 42 comparisons with barley, slightly more than half the observations showed a reduction in grain size due to grazing. The average reduction in wheat was 1% and 2% for barley. The limited (less than 10) observations of grain size for triticale and oats showed similar responses to grazing as wheat.

Screenings

Screenings increased slightly for both wheat and barley as a result of grazing. More than 73% of wheat and 68% of barley comparisons showed an increase in screening compared to no grazing (figures 14 & 15). The average increase in screenings for wheat was 0.9% and 1.4% for barley. There was a slight correlation between increasing screenings and a reduction in yield after grazing.

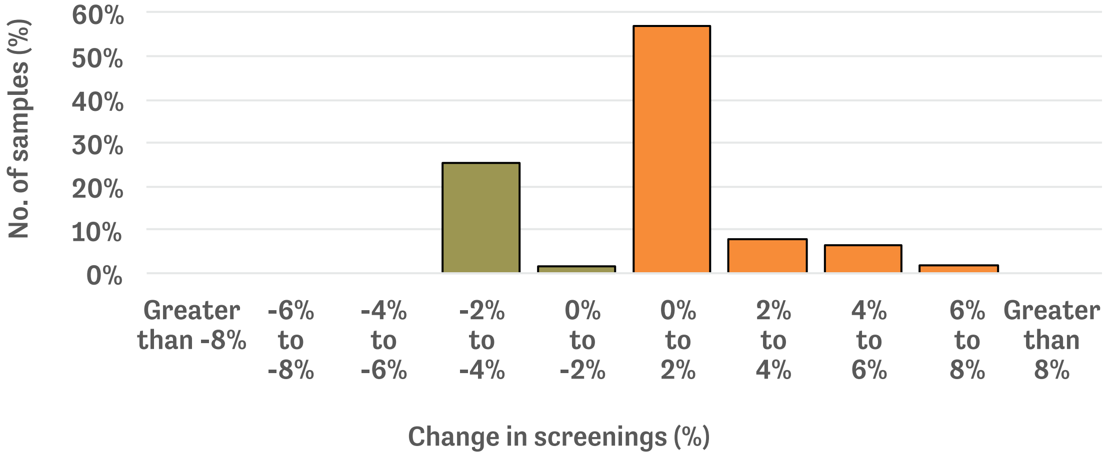


Figure 14: Change in screenings for wheat due to grazing (63 comparisons).

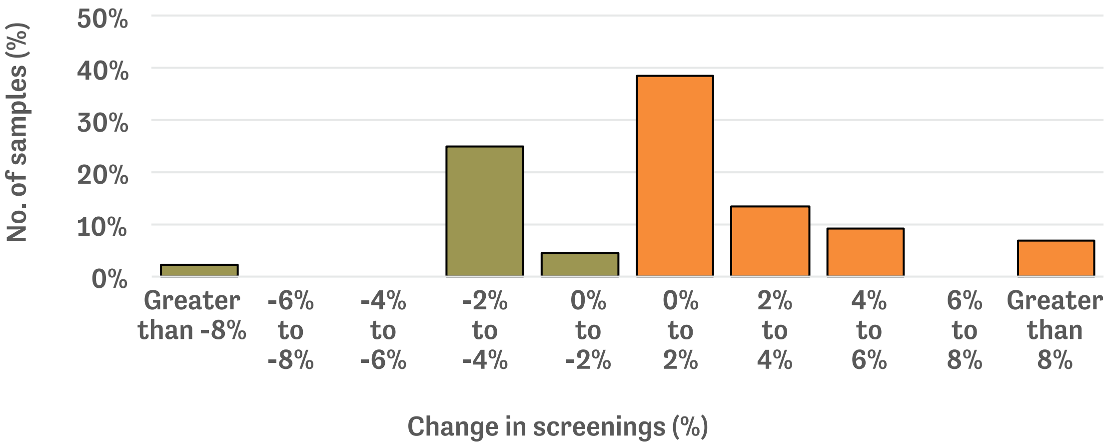


Figure 15: Change in screenings for barley due to grazing (44 comparisons).

1.5 Calculating the value of grazing crops

Calculating the value from grazing winter crops can be challenging because while there are immediate benefits through feed for livestock, the flow on effects are often more difficult to quantify. These flow on effects may include potential grain yield loss from grazing, building a 'feed wedge' because pastures can be spelled and making different livestock management decisions. The gains are realised within the farming system and not simply by comparing the potential loss of grain yield with the livestock gain when the crop is grazed.

Modelling undertaken by the CSIRO[2] would suggest the potential benefits to whole farm profitability are very significant, in the order of $100/ha to $200/ha. Attention to variety selection, early sowing, adopting best grazing practice and increasing stocking rate are all required to achieve this potential.

Individual farm considerations such as weed and disease issues, chances of favourable climatic conditions to enable early sowing, adequate farm infrastructure and cash flow to run more livestock and the manager's position on risk may temper these potential benefits.

A collection of farmer stories from around Australia are presented to convey the diversity of thinking and approaches used to graze crops. These stories highlight farmer's experiences in trying to make grazing crops work successfully in their farming system.

- *Lifting lambing with grazing crops* - Tim and Jodie Demeo, Raywood Victoria
- *Lifting whole farm profits at Howick* - The Fowler family, East Esperance, Western Australia
- *Sheep and grazing crops manage risk* - Matt Curtis, Wargan Victoria
- *Grazing cereals: The farmer experience* - Gus Glover with Jessica Crettenden, Lock SA. http://youtube/YOiFlObsS3k
- *Cereal Grazing for Improved Grain Yield* – Jeff Braun, Mid North, SA http://agex.org.au/media/cereal-grazing-for-grain-yield/
- *Grazing Cereal Crops* – Mick Falkiner and Ben Przibilla, Riverton, SA http://agex.org.au/media/grazing-cereal-crops/

2 Dr John Kirkegaard (2013) - Optimising the integration of dual-purpose crops in the high-rainfall zone. Report to the GRDC.

Lifting whole farm profits at Howick

The Fowler family from East Esperance in Western Australia started grazing crops in 2008 as a trial before fully incorporating into their farming system in 2010.

In 2011 they cropped 10,000 ha of wheat, barley and canola, of which more than half of that was grazed.

Andrew Fowler said grazing crops had delivered a major lift in the profit of their operation and that it was one of the best innovations they had implemented on the farm.

“We first tried it to make the pasture phase of our rotation more profitable and comparable with the cropping phase,” Andrew said.

“Previously we were looking at about $200/ha gross profit for livestock which wasn’t much when we compared it to cropping, which was about $500/ha.

“We needed to lift our stocking rate to increase our return per hectare to make grazing worthwhile, as well as to help recover some of the fixed costs associated with livestock and maintaining pasture paddocks.”

By using grazing crops, the Fowlers have now managed to lift the pasture phase to $350/ha gross profit and nearly double their stocking rate from 10 DSE (dry sheep equivalent) to 18 DSE.

In 2010 they increased their net profit by $500,000 by growing an extra 1,000ha of crop and retaining their livestock numbers.

“Grazing crops is a really important tool in matching the supply of feed to livestock demand, and it has helped the farming business to harness the synergies between livestock and crops” Andrew said.

“As a result we have had some great benefits with liveweight gains, higher stocking rates, cost savings, crop management advantages and more: all with little impact on crop yields at harvest”.

Benefits of grazing crops

Andrew has observed that grazing crops significantly reduces the levels of disease in barley (especially powdery mildew)

when compared with ungrazed crops, which eliminates the need for an early fungicide spray.

Grazing also reduces the height of canola crops by up to 30 cm, which makes swathing and harvesting a lot easier.

Yield and quality have not been compromised as a result of grazing. In 2010 the Fowlers' highest yielding paddocks were grazed, a wheat heat paddock went 4.7 t/ha and a grazed canola paddock yielded 2.1 t/ha. The quality was excellent with 45% oil and 0.6% admixture.

Andrew said an additional benefit is less grain is required for supplementary feeding.

"We wouldn't be able to maintain our livestock numbers if we didn't graze our crops".

"We would have to feedlot the sheep and cattle, or decrease our numbers which would reduce the profitability of our pasture phase and this was the main reason for heading down this path in the first place".

The Fowlers have had excellent live weight gains from grazing crops. For sheep, they average about 300 grams/head/day and 1.8 kilograms/head/day for cattle.

Challenges

Andrew said at the start, the hardest part was to open the gate and let the stock into a good looking crop, but he was amazed how quickly the crop recovered.

Other challenges the Fowlers have faced and, that Andrew stressed, were very important for the system to work, include

- the early seeding of crops
- good weed control
- a good rotation.
- providing ad-lib straw for livestock, and
- not over-grazing the crops, with the best results achieved if there is some biomass left after grazing.

Post grazing management

Livestock are removed from crops at the first hollow stem (around GS 30) in cereals and when buds are about 10cm high and there are a few leaves left in canola.

After livestock are removed, the Fowlers immediately apply nitrogen.

Once a new leaf has fully emerged, barley crops are sprayed with a broadleaf and powdery mildew spray, and Roundup Ready canola is sprayed (being careful to manage withholding periods if crops are to be grazed post-spraying).

Pasture tips

The Fowlers continue to strategically rest and graze their pasture paddocks while grazing crops.

"We don't lock up our pasture paddocks otherwise the cape weed gets away on us," Andrew said.

"If we continue to use our pastures, we find that it increases the quality and quantity of feed for August when we start full time grazing."

Original story by Julia Ashby, South East premium Wheat Grower's Association

Lifting lambing with grazing crops

Tim and Jodie Demeo at Raywood in Victoria have been grazing their pregnant ewes on cereal crops since 2007. They are convinced the practice has helped them increase their lambing percentages and provided them with an opportunity to expand their farm business.

The Demoes run 1500 crossbred ewes for second cross lamb production and grow wheat, barley, oats, lucerne and vetch with an average annual rainfall of 450 mm.

Tim, who has taken part in the Grain & Graze program almost since its inception, said grazing crops stands out as one of the most profitable he has made on his farm since he began to work the land in 1997.

The cropping system follows a seven year rotation of wheat, barley, canola, wheat, barley, vetch (hay), oats (hay) and vetch under-sown with lucerne and sub-clover.

Typically, sowing begins on April 20 (vetch and canola) and finishes on May 20. Barley is the first cereal sown because it produces more biomass for pregnant ewes to graze after shearing in mid-June. By then, crops are usually well established and the sheep are hungry.

The benefits

Winter cereal crops provide his pregnant ewes with the nutrition they need prior to, and following, lambing. In addition, there are benefits for his cropping enterprise; the lower biomass of grazed crops means that trash management is less of an issue.

"It gives you a good feeling to see the sheep on lush green paddocks in winter," Tim said.

Since implementing this practice, Tim's lambing percentages have risen by about 10 per cent. At the same time, he said his cropping enterprise had not suffered, with no significant change to yields or quality.

"We have never not harvested a crop that has been grazed," Tim said.

"I guess we're trying to have two bites at the cherry, but it's dollars for jam."

Livestock grazing

In conjunction with grazing crops, Tim operates a drift lambing system. Ewes that have lambed in the last 24 hours are left in the paddock while the rest of the mob (pregnant ewes yet to lamb) is moved onto a fresh cereal crop.

This process continues for the duration of lambing, with ewes moved from paddock to paddock until they lamb. "It helps limit mis-mothering," Tim said.

Drift lambing ensures smaller mob sizes and Tim said grouping animals according to when they gave birth, made record keeping simpler.

And it's not particularly arduous in terms of labour, according to Tim.

"We'd still be checking the lambing ewes every day. They're not hard to shift. We just open the gate and they go into the next paddock. If it was too hard we wouldn't do it."

On average cereal paddocks are grazed for only 10-14 days. When crops reach GS 30 (stem elongation) sheep are removed and crops left to mature. They generally just take the top 10cm – about half the biomass.

Tim believes drift lambing complements the system because it allows cereal paddocks to be rotationally grazed, minimising any potential soil compaction or pugging.

Challenges

While Tim and Jodie endeavour to keep their system as “simple as possible”, they concede that grazing crops can complicate some things.

“Top dressing can be a struggle, because we have to wait until we remove our sheep,” Tim said.

Spraying is also more complicated with withholding periods (WHP) for grazing livestock a consideration. In fact, it is for this reason that Tim is yet to attempt grazing canola.

“We plan to graze our TT canola but haven’t yet worked out how to juggle the WHPs,” he said.

Tim said weed control was a priority and, if need be, some paddocks are not grazed.

“We try to be flexible and have a ‘plan B’. We deal with our weeds if they become a problem and, likewise, if paddocks become dusty or sheep are losing condition, we take them out.”

The future

Perhaps the most exciting thing to come out of the Grain and Graze system is the opportunity it has given Tim and Jodie to expand.

“If we can get our efficiencies right, we could expand by up to one third. Of course with livestock it depends on how much you want to work,” Tim said.

Sheep and grazing crops manage risk

At Wargan in Victoria's far north west, mixed farmer Matt Curtis is meeting the unique challenges faced by primary producers in the Millewa with the inclusion of saltbush and dual-purpose wheat varieties on his dryland farm.

Seeing the value of livestock for cash flow and risk management, Matt has bucked the local trend of focusing purely on cropping.

With research and the adoption of some innovative farm practices, he has found that despite an average annual rainfall of just 250mm, there are ways and means to ensure both enterprises are productive and profitable.

The farm supports a 400 head self replacing Merino flock plus 300 Merino ewes that are crossed with White Suffolk rams for prime lamb production.

Matt said his grazing wheat crops, combined with an expanded Old Man saltbush plantation on some of his non-productive land, has given him scope to meet the feed demands of his sheep, with significantly less hand feeding.

Grazing crops

While cropping remains the predominant enterprise on the Curtis farm (accounting for 2800ha of the 4000ha property), Wedgetail wheat crops are primarily grown to feed sheep.

"Getting a crop off them is a bonus," Matt said.

Wedgetail was first trialled on the farm in 2011 after a very wet summer and Matt found it did very well.

"In 2011 we sowed it early and it went 12 bags, which was the same yield as our conventional wheat crops," he said.

"We grew it because we had the moisture. It went well so we kept going."

Being a long season wheat variety, Wedgetail is sown first and as early as possible if the opportunity is there.

"If we get an early break we can start sowing as early as late March," Matt said. "This helps with sowing logistics."

Sheep – generally pregnant ewes – are permitted to graze the wheat once it reaches about 150 mm (six inches) tall.

Once the crop tillers the sheep are usually removed and put onto salt bush or oats. However, taking a "feed first, harvest second" approach, if necessary, stock can be left to graze the wheat beyond tillering until other feed sources become available.

"The system is a bit versatile. That's the beauty of it," Matt said.

"We still run the header over crops that have been grazed beyond the optimum stage, although yields are usually reduced."

Challenges

Matt admits he had to get his head around the whole concept of feeding sheep crops so he started small. Encouraged by the early outcomes of grazing crops, he conceded the system still needed refining and, in his region, success hinged largely on the season. "I'm still working out when to take sheep out and how to manage spraying, although so far I don't think I've suffered any weed issues as a result of adopting the system," he said.

Uneven grazing has been a concern for Matt, particularly in his region where overgrazing can easily lead to soil degradation and erosion.

To combat this he has been experimenting with Rappa portable electric fencing which will make 'rotational grazing' a more feasible option and hopefully eliminate the problems with sheep preferring to stay in one area of the paddock.

Matt said lambing management also needed refining with ewes often lambing down right when, according to crop growth stage, they should be removed.

"It can be hard to juggle," he said. "It's something we're trying to fine tune."

1.5.1 Quantifying the whole farm benefits from grazing crops

Many farmers have commented that the greatest benefit from grazing their winter crops has been the additional pasture grown which can then be used by livestock at a later stage. This deferment requires the additional pasture production and better livestock condition from grazing the crop to be valued.

The GrassGro model was used to calculate the whole farm benefits from grazing crops for a prime lamb/cropping enterprise in South West Victoria. Ewes were stocked at 9/ha, lambed on August 1, with lambs sold on March 15. The modelling used 48 years of historic climatic data (from 1961 to 2006) and was able to capture the obvious benefits such as increased pasture production as well as the subtle benefits of increased reproductive performance and better lamb growth in spring because of the extra feed available.

The grazing period was 4 weeks. All livestock were 'grazed' on crops while the pasture was spelled[3]. At the end of the crop grazing period, all animals returned to the pasture. It was assumed there was no loss in grain yield due to grazing.

The key findings were:

- Grazing for a month in June resulted in an extra 200 kg/ha of pasture by August 1 compared to no grazing
- Deferring the start of grazing until July but then grazing for a month resulted in an extra 260 kg/ha of pasture by August 1
- The probability of lambs reaching the target weight of 45 kg liveweight by March 15 increased by 11%
- The economic benefit was $16/ha for the June deferment and $53/ha for the July deferment.

To enable full deferment for a month in July, it is estimated that half the farm would need to be in crop and be used for grazing. More crop would be required with a June grazing.

Further MIDAS computer modelling the Central Wheatbelt and South Coast of Western Australia showed that grazing crops also has the potential to improve farm profit by providing additional feed in mid-winter, but achieving the potential benefits relied on increasing stocking rates and supplementary feeding at times to levels that might be considered extreme by some farmers. The analysis also showed higher levels of crop dry matter substantially increases the profitability of grazing crops, whilst small yield penalties of around 10% as a result of grazing rapidly eroded most of the benefits.[4]

3 GrassGro does not include crops so grazing was substituted for high quality supplement representing crop quality and fed in a containment area.

4 Andrew Bathgate & John Young. The economics of grazing crops in the Central Wheatbelt and South Coast Regions of WA. Report to GRDC.

2 What and how to do it (agronomy at the paddock scale)

Successful grazing of crops requires the production of useful amounts of dry matter soon after sowing, with the ability for the plants to recover dry matter quickly after grazing. To maximise the chances of realising this, the following needs to be considered.

2.1 Paddock selection

Choose paddocks that provide early sowing opportunities.

These are likely to be paddocks that:

- Are **low in weeds**. Paddocks with low weed densities can be sown earlier because there is no need to wait for a germination and kill before sowing. Heavy weed burdens compete with the crop for moisture, reducing early dry matter production and compete against the crops as it recovers from grazing. Furthermore, grazing will open up the crop canopy letting light between rows and favouring weed growth after grazing.
- **Wet up sufficiently after early rain** to allow for an even germination of the crop and for subsoil moisture to be retained. Stored soil moisture is often vital to maintain crop survival if adequate follow up rains fail to occur.
- Have **good soil fertility**. Adequate phosphorus and nitrogen will provide opportunity for rapid leaf growth. Paddocks that are likely to have favourable mineralised nitrogen from a previous season are desirable. A crop with adequate nutrition will also recover faster after grazing.
- **Low disease status**. Early sowing in warmer conditions can often exacerbate underlying disease problems.

2.2 What to sow

Dual purpose or winter wheats immediately come to mind when thinking about crops suitable for grazing. Yet both spring and winter type crops can be grazed, it is just their development and therefore management decisions such as when they are sown and grazed need to be slightly different (see side story 4).

There is a lot of information available about crop varieties. They are commonly grouped into winter or spring types, by the length of growing season and by their maturity pattern (early, mid, late etc). Behind these grouping is the cold period (vernalisation) and day length (photoperiod) requirements of each variety.

Varieties are constantly entering the market and it is recommended you consult with your local agronomist to ensure the variety chosen suits the time of sowing and optimum flowering time. However to help gain a broad understanding of the different classifications, some common wheat and barley varieties have been listed (table 3).

Side story 4: Photoperiod, vernalisation and crop selection

The early growth of cereals and canola is primarily linked to temperature and soil moisture. The 'trigger' that takes the plant from vegetative growth to running to head is moderated by two additional factors, photoperiod and vernalisation. Spring type crops respond to photoperiod, winter type crops respond to vernalisation.

Photoperiod refers to day length. A photoperiod responsive plant exposed to short days in early vegetative growth responds by producing more leaves on the main stem. If the day length is too long in the vegetative stage, the plant thinks it is coming into spring and responds by turning reproductive (GS 30) earlier.

The most common type of cereals and canola grown in Southern and Western Australia are photoperiod responsive. This mean they cannot be planted too early because the day length tells the plant it is spring and should run to head. Therefore spring types are commonly sown in May and June. However the length of photoperiod exposure to initiate reproductive development varies greatly between cultivars.

Vernalisation refers to the need for a plant to experience a cold period to trigger reproduction. For winter crops theses are temperatures around 4 to 18°C for four to six weeks. If this cold is not experienced by the plant it will remain vegetative.

Winter type crops, mainly wheats such as Wedgetail, Wylah, Whistler and Revenue and emerging varieties of canola (e.g. Taurus) have a vernalisation requirement. This means they can be sown earlier and in warmer conditions without the 'trigger' to become reproductive.

Table 3: Classification of common wheat and barley varieties

<table>
<tr><th>Species</th><th>Common varieties</th><th>Type</th><th>Length of growing season</th><th>Reproduction triggered by</th></tr>
<tr><td rowspan="5">Wheat</td><td>Manning, Naparoo, Revenue</td><td rowspan="2">Winter</td><td>Long</td><td>Strong day length and strong cold period</td></tr>
<tr><td>Wedgetail, Currawong</td><td>Mid</td><td>Moderate day length, strong cold period</td></tr>
<tr><td>Amarok, Beaufort</td><td rowspan="3">Spring</td><td>Long</td><td rowspan="3">Moderate day length</td></tr>
<tr><td>Calingiri, Chara, Estoc, Magenta, Trojan, Yitpi</td><td>Mid</td></tr>
<tr><td>Cobra, Mace, Wyalkatchem</td><td>Short</td></tr>
<tr><td rowspan="3">Barley</td><td>Urambie</td><td>Winter</td><td>Mid</td><td>Moderate day length, strong cold period</td></tr>
<tr><td>Oxford</td><td rowspan="2">Spring</td><td>Mid / long</td><td rowspan="2">Moderate day length</td></tr>
<tr><td>Bass, Commander, Compass, Fathom, Hindmarsh, Moby, Scope</td><td>Short</td></tr>
</table>

While seasonal conditions have a strong influence on the amount of dry matter grown, in general barley will produce feed earlier than winter or spring wheats when sown at the same time. Spring wheats are generally faster growing than winter wheats. The amount of dry matter that triticale crops produce falls between barley and wheat.

Because all crops can be grazed, the choice variety within the broad classification becomes less important. Deciding what to sow should be primarily determined by the existing crop rotation, feed requirements and other paddock considerations rather than the variety.

2.3 When to sow (time of sowing)

Cereals crops and canola with strong winter habit can be sown early in the year (March to mid-April) because they need a period of cold and short days before they will run to head. Earlier sowing combined with favourable weather conditions can result in large amounts of dry matter for grazing.

Spring varieties sown early, even including long season types, will flower too early leaving the crop vulnerable to frost damage. For these varieties a mid to late April sowing is recommended. Short season spring varieties need to be sown even later, at the more conventional May sowing time.

Moisture for successful establishment

Successful early sowing obviously requires good establishment and subsequent growth. A recent study by the CSIRO[5] examined the probability of successfully establishing winter habit crops early in the season (1 March to 15 April) and earlier sown spring habit crops (15 April to 15 May) in the higher rainfall zones across Southern and Western Australia. As expected the chances of successful establishment varied considerably across the country and improved with later sowing (table 4).

5 Dr John Kirkegaard (2013) - Optimising the integration of dual-purpose crops in the high-rainfall zone. Report to the GRDC.

Table 4: Opportunity to sow early and achieve successful establishment of the crop

Location	Favourable sowing opportunity (% of years)	
	Winter wheats (sown 1 Mar to 15 Apr)	Spring wheats (sown 15 Apr to 15 May)
Kojonup (WA)	30% - 40%	50% - 60%
Esperance (WA)	30% - 40%	50% - 60%
Cummins (SA)	<30%	60% - 70%
Naracoorte (SA)	<30%	60% - 70%
Hamilton (Vic)	40% - 50%	>70%
Inverleigh (Vic)	60% - 70%	>70%
Bairnsdale (Vic)	60% - 70%	>70%
Cressy (Tas)	60% - 70%	>70%
Delegate (NSW)	>70%	>70%
Young (NSW)	60% - 70%	>70%

Growth after establishment

The amount of dry matter produced from early sowing, even with successful establishment, is dependent on adequate stored soil moisture or follow up rain. Figures 16 and 17 present dry matter production from early sown trials over a range of years. Results have been adjusted to indicate the average dry matter produced at the start of June and the start of July.

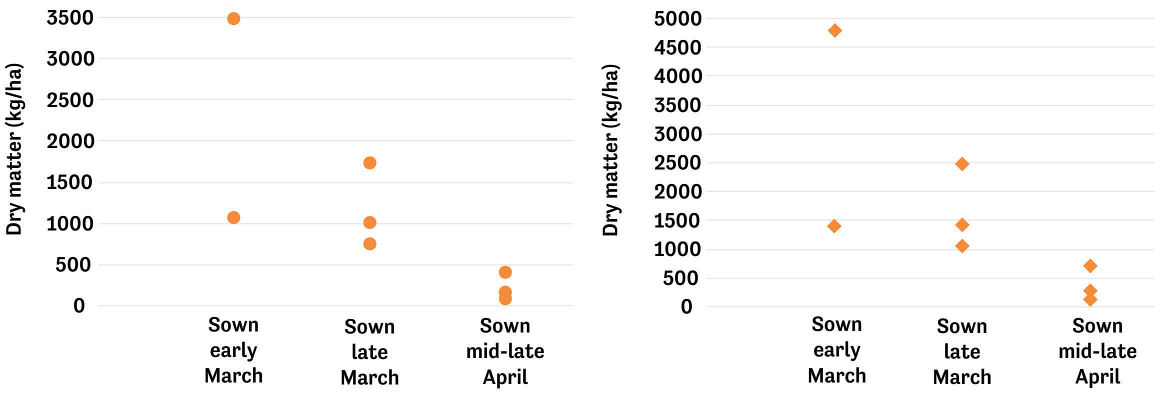


Figure 16: Calculated average dry matter available on June 1 (left, orange circles) and July 1 (right, orange diamonds) from early sown trials in the high rainfall zone (73 observations from trials conducted in 2004 to 2009). Each mark represents the average for all trials in that year.

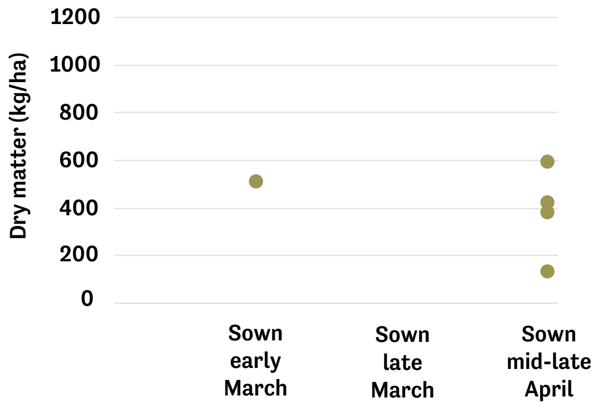


Figure 17: Calculated average dry matter available on June 1 (left, green circles) and July 1 (right, green diamonds) from early sown trials in the low rainfall zone (37 observations from trials conducted in 2008, 2011 to 2013). Each mark represents the average for all trials in that year.

Additional factors beyond time of sowing and variety selection also need to be considered when deciding on when to sow. These include issues around weed control and potential for increased crop disease.

2.4 Options for increasing dry matter production up to growth stage 30

Apart from early sowing, the most common approach to increase dry matter production for grazing is by increasing sowing rate (see side story 5). Trials from both high and low rainfall zones illustrates the potential benefit from higher sowing rates if seasonal conditions are favourable (table 5). If conditions are unfavourable, higher seeding rates have limited value.

Side story 5: Higher sowing rates to lift winter production

Ian Radford from Spalding in mid north of South Australia sowed Wedgetail winter wheat on May 5th into a lupin stubble following 250mm rain earlier in the year. He sowed at 150 kg/ha with 100 kg/ha of 18:20:0, seeding rates well above the district average.

Ian started grazing the crop 46 days later in mid-June and grazed until early September with ewes, hoggets and mixed sex cattle. He estimated the crop carried 25 dse/ha from mid-June to early September, when the paddock was closed to grazing. Importantly during the critical feed shortage period from mid-June to end July the paddock carried 30 dse/ha.

Growth stage 30 was reached at the end of July, but Ian continued grazing until first heads emerged, and the paddock still yielded 1.6 t/ha of ASW wheat. He would have suffered a yield penalty as the paddock was grazed later than ideal, but Ian was prepared to accept this penalty as a tradeoff for the extra grazing. Nevertheless he achieved a grain return of $600/ha.

Table 5: Additional dry matter produced from increased seeding rates

Location	Variety	Sowing date	Sowing rate (kg/ha)	DM at grazing (kg/ha)	Cost per extra tonne of DM ($/t)
Edillilie SA	Wheat	18/05/2006	60	127	No extra feed grown
			120	119	
	Barley		60	242	$ 205
			120	321	
Waikerie SA	Barley	18/04/2007	60	1917	$ 99
			120	2080	
Inverleigh Vic	Barley	16/05/2007	100	1780	$ 75 to $150
			150	1960	
			200	2050	

There are several considerations that need to be made when devising a grazing approach.

3.1 Estimating how much dry matter is available

There are two methods to estimate the amount of dry matter available in a crop. The first method uses a simple relationship between crop height and dry matter (see side story 6). This approach is applicable in high rainfall regions where seeding rates of 80 to 100 kg/ha and narrow row spacing (15 to 20 cm) are used.

In regions where row spacing is wider that 20 cm, seeding rates are lower and plant establishment is more variable, then the second method should be used, where crop cuts need to be taken (see side story 8).

Side story 6: Estimating the amount of dry matter from crop height

Measure the average height of the crop. Then refer to the following relationships (see table).

Relationship between crop height and available DM (kg/ha)

Cereal crop height (cm)	Dry matter (kg/ha)
2	75
4	175
6	275
8	375
10	500
12	625
14	750
16	900
18	1050
20	1200
22	1375
24	1575

Canola crop height (cm)	Dry matter (kg/ha)
2	100
4	225
6	325
8	425
10	550
12	650
14	750
16	850
18	975
20	1075
22	1175
24	1300

These relationships are based on a 20 cm (8') row spacing cereals estab ~200 pl/m², canola estab ~60 pl/m². Subtract or add 10 % to the estimate for every 2.5 cm (1') increase or decrease in row spacing. For barley crops add 10% to the estimated value.

Side story 7: Estimating the amount of dry matter by cutting

This method relies on access to scales with measurements in grams.

Measure a length of 2 m along the crop row. Cut the selected row to ground level and collect the sample. Repeat a further four times at random locations across the paddock. Combine all cut samples and weigh.

Compare the weight of the sample collected with the table.

Relationship between collected sample, row spacing and available dry matter (kg/ha) for cereals

Weight of green sample collected (gm/10 m row)	Row spacing (m)		
	0.2	**0.25**	**0.3**
250	225	180	150
500	450	360	300
750	675	540	450
1000	900	720	600
1500	1350	1080	900
2000	1800	1440	1200

These relationships are based on dry matter of 18 %.

Relationship between collected sample, row spacing and available dry matter (kg/ha) for canola

Weight of green sample collected (gm/10 m row)	Row spacing (m)		
	0.2	**0.25**	**0.3**
250	125	100	85
500	250	200	165
750	375	300	250
1000	500	400	335
1500	750	600	500
2000	1000	800	665

These relationships are based on dry matter of 10 %.

3.2 When to start grazing

Deciding when to start grazing is the first consideration. Once the plants are anchored and have grown secondary roots the crops can be grazed. This usually occurs around the three leaf stage for cereals but may not if dry conditions are encountered after germination. To ensure adequate anchorage, apply the 'pinch and twist test' (side story 8).

For canola it is recommended to commence grazing at the six to eight leaf stage when plants are well anchored but before the buds elongate more than 10 cm.

Ideally there should be 500 kg/ha to 800 kg/ha of dry matter per hectare for sheep (1000 kg/ha for cattle) to achieve high levels of animal performance. However in reality most crops may not have reached this amount of growth before grazing commences (refer to section 1). Postponing grazing until this benchmark is reached will limit the grazing opportunity for those who wish to minimise the impact on subsequent grain yield.

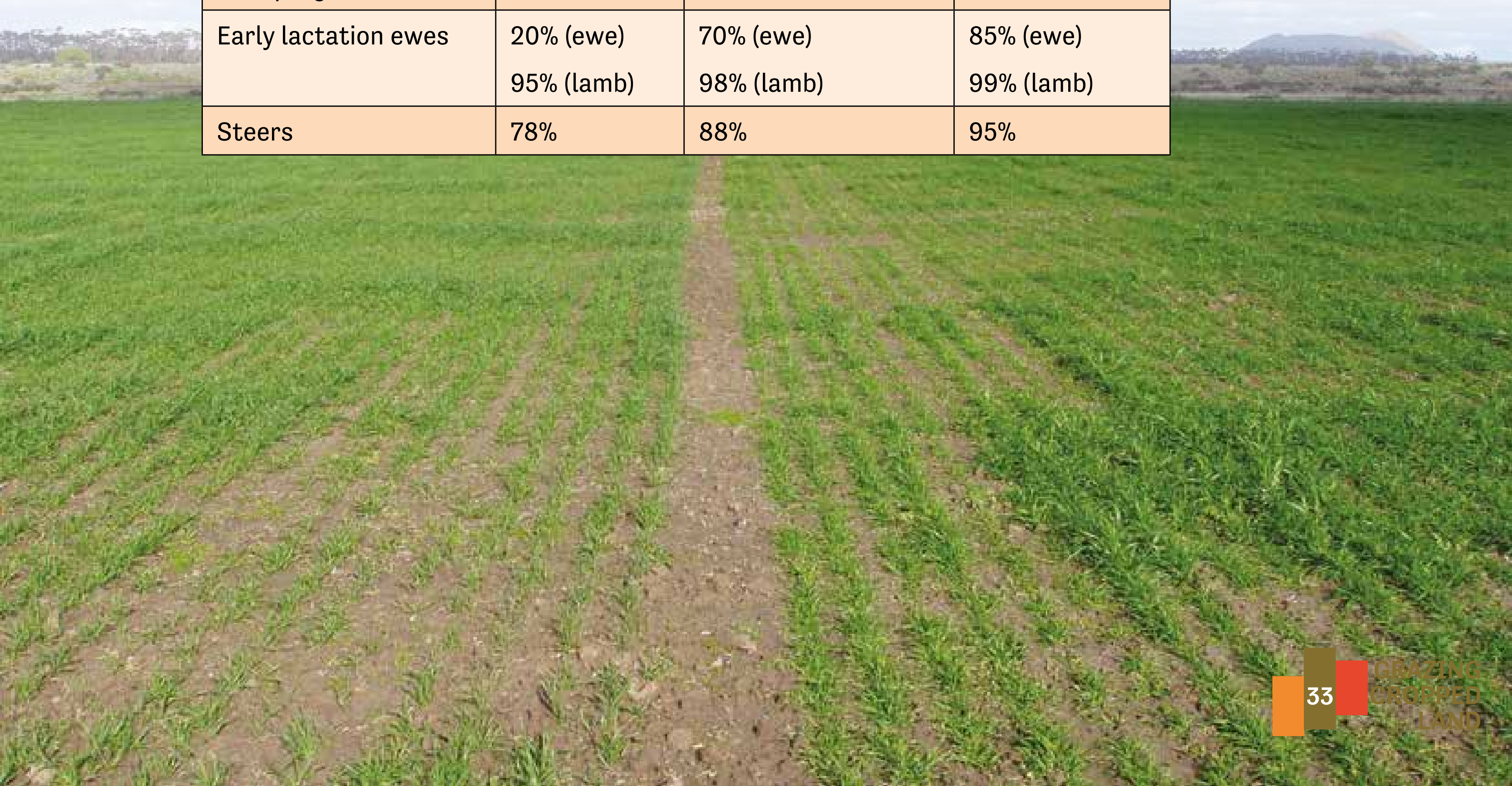
Side story 8: The 'pinch and twist test' to determine if a new crop can be grazed

- Pinch the top leaves between the thumb and forefinger
- Pull the leaves upwards while twisting your wrist
- If the leaves break off and the plant does not pull out of the ground, the crop can be grazed.

Grazing before these benchmarks is feasible although there will be a decrease in animal performance (table 6).

Table 6: Level of animal performance (% of maximum) at lower dry matter than ideal

Livestock	Dry matter on offer at grazing (kg/ha)		
	300	500	800
Trade lambs	85%	94%	97%
Late pregnant ewes	72%	88%	93%
Early lactation ewes	20% (ewe) 95% (lamb)	70% (ewe) 98% (lamb)	85% (ewe) 99% (lamb)
Steers	78%	88%	95%



3.2.1 Withholding periods with herbicide

Some pre and most post emergent herbicides, seed treatments and many insecticides and fungicides have a withholding period from grazing after application. These can be as long as 15 weeks which can severely limit the grazing opportunity. Therefore the timing of grazing and spraying operations need to be considered together (refer to side story 9).

A range of common herbicides used in crops for seed treatments, pre and post emergent weed control, fungicides and insecticides and their withholding periods is provided (appendix 3).

Grazing may improve the efficiency of weed control. For example, the use of grazing may enable certain broadleaf weeds to be controlled using a combination of a lower rate of herbicide with grazing (spraygraze technique).

A recent note posted on the Department of Agriculture and Food website in Western Australia reinforces the need to follow grazing withholding periods:

- The grazing withholding period (GWP) is the minimum time between chemical application and harvest for stockfeed or grazing to ensure the maximum reside limit (MRL) and/or export grazing interval (EGI) are not exceeded
- GWP are not about avoiding poisoning grazing animals, but ensuring animals are free of violative residues at slaughter
- It is a legal requirement to observe the GWP
- It is a requirement of ChemCert accreditation and Livestock Production Assurance (LPA) programs that chemical records are kept of when crops and pastures are treated, and of when grazing withholding periods expire.

Side story 9: Balancing grazing with grazing withholding periods

David Watson, a crop consultant serving farmers in South West Victoria has made the following comments around the challenges in using chemical treatments and grazing.

"Comprehensive pre-emergent strategies are generally employed in Southern Victoria to combat widespread rye grass herbicide resistance. Depending on products chosen, there will be a grazing withholding period of between 6 and 15 weeks. Additional in-crop herbicide applications for other grasses and broadleaf weeds is likely add another 2 to 6 weeks on top of the pre-emergent herbicides. By the time these withholding periods expire, it is likely the crop will be nearing or into early stem elongation at which time yield penalties from grazing can occur."

"The grazing window for most cereal paddocks in long term crop production will be very limited because of the necessary focus on robust weed control. My advice is to undertake grazing of cereals on paddocks with very low weed numbers or those paddocks that are coming out of rotation where the entry of weed seeds into the bank is not a major concern. The other exception would be those paddocks that are sown early to long season winter wheat varieties where pre-emergent herbicide withholding periods can expire and allow grazing prior to stem elongation. Again though these paddocks need to be fairly free of weeds since under this situation the effectiveness of the early knockdown is reduced."

3.3 How hard to graze

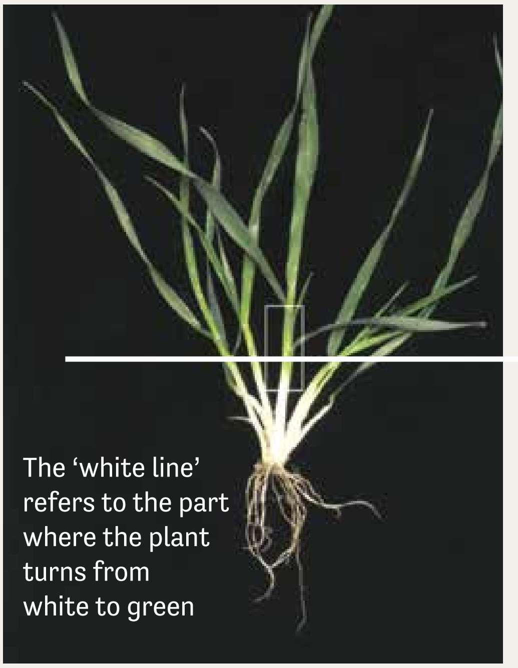
Deciding how much crop to leave behind can be contentious because it is a trade-off between maximising the feed on offer against the potential harm to grain ear formation and crop recovery.

Earlier recommendations have been to graze the crop 'to the white line' (see side story 10) but subsequent work has shown this increases the risk of encountering a grain yield penalty, especially if conditions after grazing are not favourable. Under favourable recovery conditions, which is more likely in the higher rainfall areas, heavy grazing is less risky.

The current approach used in lower rainfall areas is 'clip' grazing.

Side story 10: Grazing to the 'white line'

This refers to the location on the plant where the stems of the tillers change colour from white to green.



The 'white line' refers to the part where the plant turns from white to green

Clip grazing

This method involves a light grazing of the crop, with just the top few centimetres of the crop canopy removed. This is in contrast to the more traditional 'crash' grazing where a crop is heavily grazed, with the vast majority of the crop canopy eaten.

Clip grazing can reduce the risk of incurring costly grain yield penalties in dry seasons and lower rainfall areas. This is achieved by leaving more leaf area for recovery after grazing, enabling the crop to produce more biomass by flowering. Biomass at flowering is a key determinant of eventual grain yield.

Clip grazing also enables a crop to better compete with weeds post-grazing.

3.4 When to stop grazing

When to stop grazing is the third important decision. There are two parts to consider, firstly knowing when the plants commence stem elongation (GS 30) and secondly allowing sufficient time for plant recovery to ensure grain fill.

3.4.1 Growth stage 30

It is currently recommended that grazing with sheep is completed by GS 30 if the aim is to minimise the risk of grain yield loss (see side story 11). For cattle, grazing needs to be completed before GS 32 is reached because they do not graze as low.

Side story 11: Hints on how to pick when GS 30 is approaching

When a cereal is grazed, it delays the transition from tillering to stem elongation by a few days. Also the main stem of a cereal plant is usually more advanced in its development than the neighbouring tillers.

To gain an indication that GS 30 is approaching, monitor the main stem on plants that have not been grazed. When these plants begin stem elongation, the rest of the grazed crop will not be far behind.

Establishing an exclusion area in a paddock with weldmesh or portable sheep yard panels can provide a point to monitor crop development.

Grazing can continue after these benchmark growth stages, but the chances and magnitude of the loss in grain yield increases dramatically (figure 18). For regions where crops are sown purely to provide dry matter (DM) for grazing, there is no need to worry about damaging the embryonic ear of the plant.

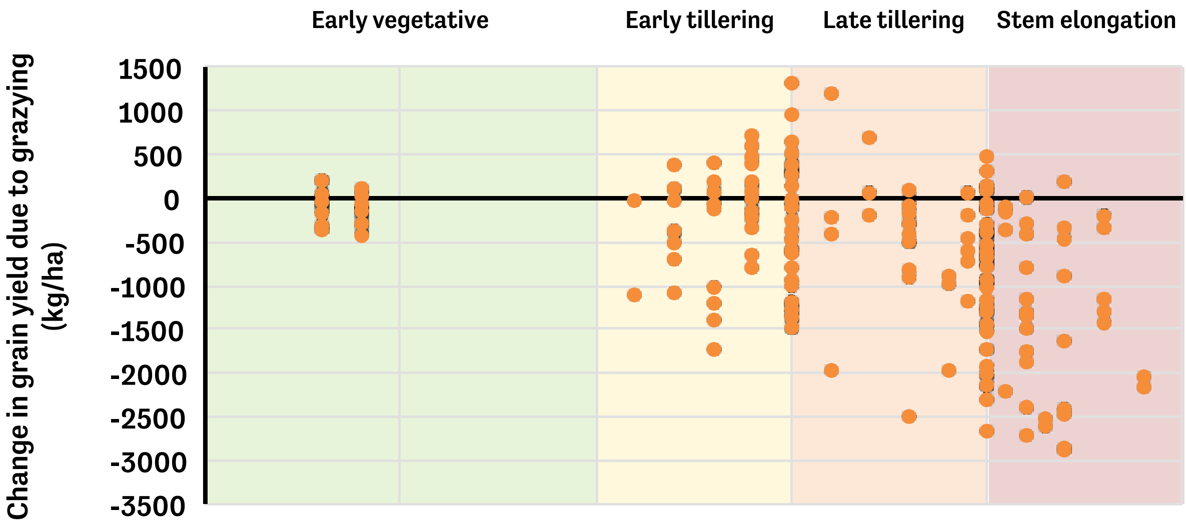


Figure 18: Change in grain yield for cereal crops grazed at different growth stages compared to ungrazed crops (246 observations for wheat, barley, triticale and oats from 2004 to 2013).

Figure 18 clearly shows the increased chances of grain yield loss if grazing occurs after the start of stem elongation (reproductive growth). Grazing after the plant begins stem elongation risks damaging the ear.

Unfortunately, predicting the changes in crop development cannot be determined by a date on the calendar (although crops with a winter habit are more predictable). Visual observation of the emerging embryo ear is the only way to accurately assign this growth stage of a crop.

There is a common referencing system that helps describe the development of a cereal plant from germination through to ripening. It consists of ten (10) development phases from zero to nine (0 to 9). Within each development phase there are up to ten (10) individual growth stages. This gives a two number code and is prefaced with the letters GS for growth stage.

When making decisions about grazing winter crops, the change from GS 2 to GS 3 is critical. GS 2 refers to the development phase when the plant is tillering or producing stems at each crown. GS 3 refers to the development phase when the plant stops tillering and the embryo ear which has formed in the base of each tiller begins to move up the tiller. This phase is also characterised by each tiller beginning to thicken into stems, and nodes forming low down on each tiller. The key growth stage observations to accurately determine a growth stage are described (table 7 and side story 12).

Table 7: Description of critical growth stages when grazing winter crops

Development phase	Code number	Growth stage observations	Code number
Tillering (vegetative growth)	2	Count the number of tillers **excluding the main stem** on each plant. Each tiller is valued at one	1 to 9#
Stem elongation (reproductive growth)	3	The base of the **main stem** needs to be cut in half and the distance between the base of main stem and the ear measured. If the ear is at 1 cm, the value is 0 If the ear is at 2 cm, there is a node forming about 1 cm above the base and the stem is hollow, the value is 1	1 to 9

In Australia cereal plants rarely produce nine tillers before stem elongation commences.

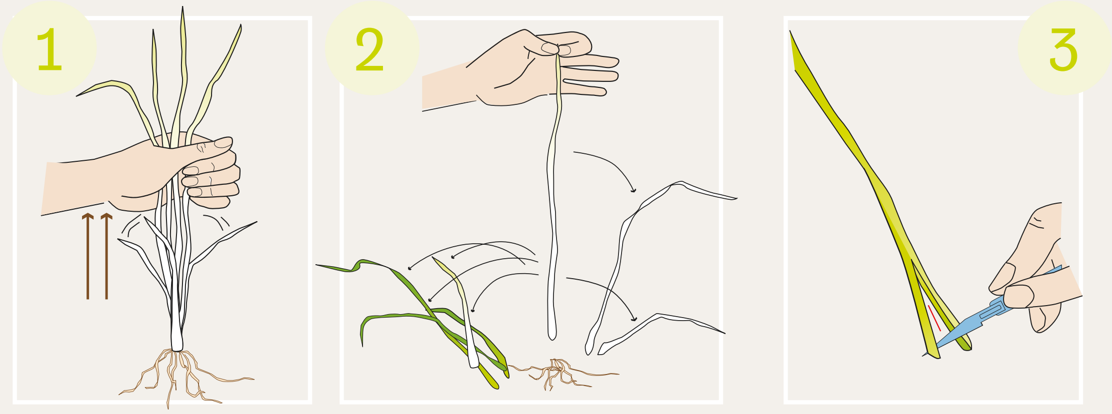
A plant in vegetative growth with a main stem and four tillers would be described as GS 24. The same plant would be described as GS 31 when the ear is about 2 cm above the base of the plant, a hollow is forming beneath the ear and a ring or node is forming about 1 cm above the base of the plant. The method of dissecting a plant to test for growth stage is described (see side story 12).

3.4.2 Crop recovery after grazing

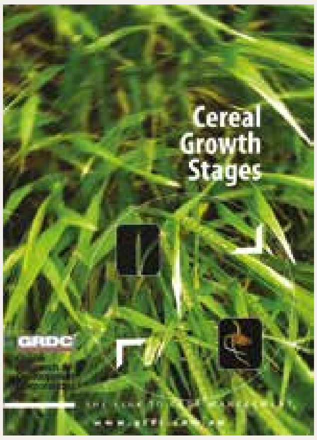
Stresses on the crop after grazing can affect plant recovery and grain yield. Moisture deficiencies and high temperatures can restrict regrowth of leaves and the aborting of tillers in the period up to flowering. The importance of these influences is being examined in the current Grain and Graze 3 program.

While there is no way of predicting what conditions may prevail in the period between grazing and flowering, limited soil water at grazing will increase the risk of a yield loss, even in the high rainfall zone. Observations from a trial in South West Victoria during the 2006 drought shows a dramatic reduction in grain yield of two long season wheat varieties compared to the ungrazed crop, even though GS 30 had not been reached. Soil moisture probes indicated the crop had reached wilting point (no soil moisture available for plant growth) during late August, so despite grazing before GS 30, crop recovery was poor which led to lower grain yield (figure 19).

Side story 12: How to dissect a cereal plant to determine growth stage



- Pull up a plant and shake the dirt off the roots
- Pass your hand around the plant and draw upwards to identify the tallest leaf (this will be attached
  to the main stem of the plant)
- Peel off any dying leaves
- Cut the roots from the plant at the stem base
- Cut the stem lengthwise along the stem to expose the embryonic ear.



Want more information? Refer to the Cereal Growth Stages booklet available from the GRDC. It can be ordered from the GRDC website http://www.grdc.com.au in the publications section

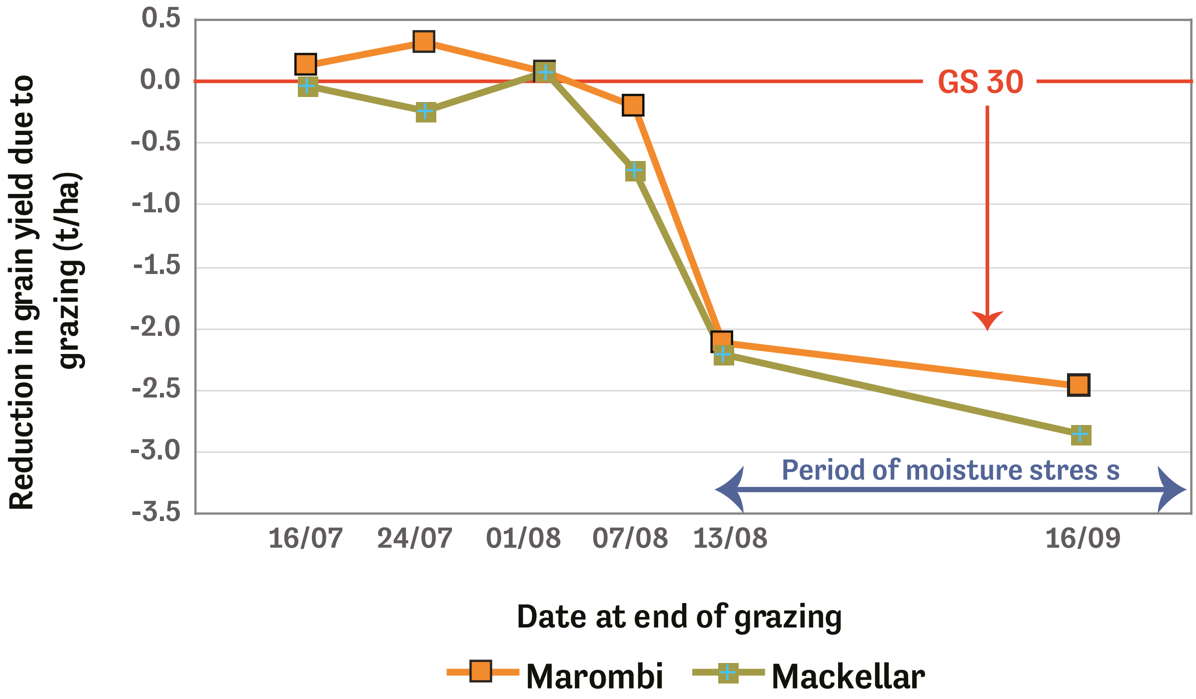


Figure 19: Grain yield comparison of grazing against no grazing for long season wheats (Marombi, MacKellar), indicating period of moisture stress, Inverleigh, Vic, 2006.

Modelling by the CSIRO[6] for the high rainfall zones in Western and Southern Australia provided an indicative end grazing date for winter type wheats sown in mid-March, Mid-April and Mid-May which would enable enough time for crop recovery before flowering (figure 20). The end grazing date was determined when GS 30 was reached or when only 200 kg/ha of crop dry matter remained after grazing (grazed at 25 DSE/ha, commencing when 1000 kg/ha of dry matter was available). However field experience would suggest earlier end of grazing with later sowing dates may be wise.

6 Dr John Kirkegaard (2013) - Optimising the integration of dual-purpose crops in the high-rainfall zone. Report to the GRDC.

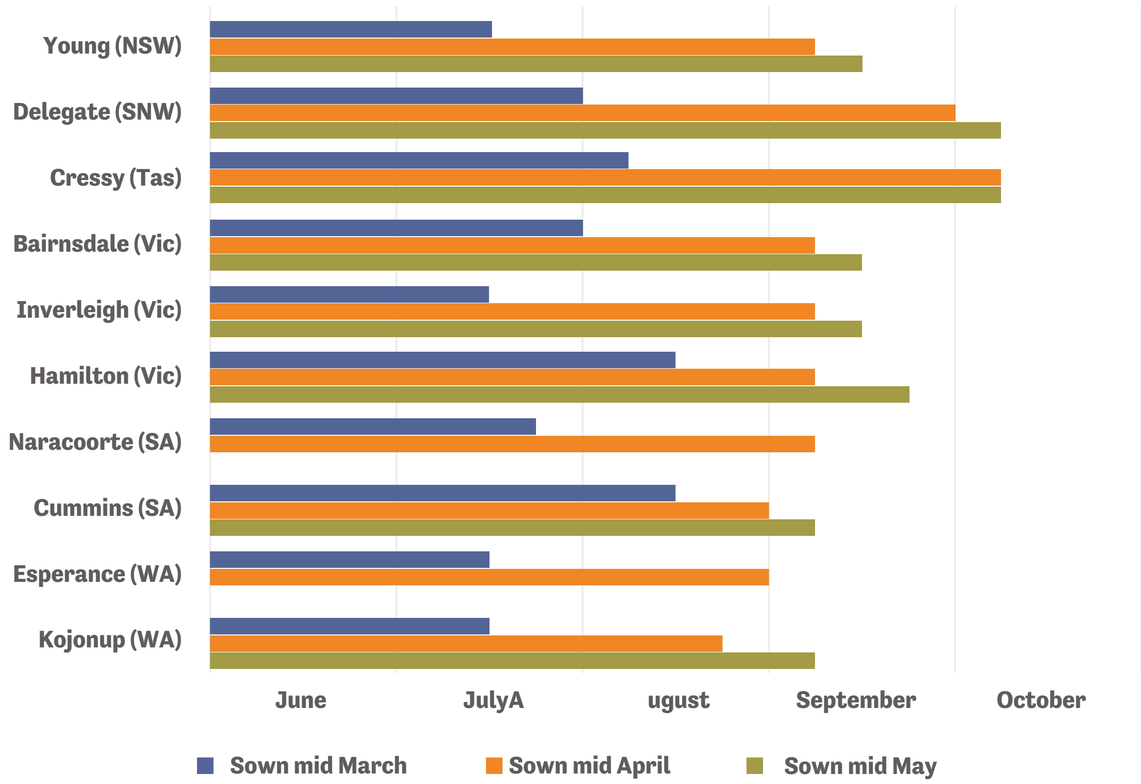


Figure 20: Indicative end point for grazing to allow sufficient time for plant recovery for winter wheats sown in mid-March, mid-April and mid-May.

3.4.3 Delay in crop maturity

Grazing delays the maturity of a crop. Trial data would indicate the delay to maturity is between three and 14 days, although this will vary depending on when grazing commences and the duration of grazing.

In Western Australia, where crops are grazed early, the common rule is 1 day of delay in flowering for every two days of grazing[7]. So a crop grazed for 20 days would have flowering delayed by approximately 10 days.

In areas where crops are grazed later, delayed grazing delays maturity more so than early grazing (figure 21).

7 Steve Curtin and Ben Whisson (2013) - Delaying wheat flowering time through grazing to avoid frost damage. ConsultAg Lake Grace.

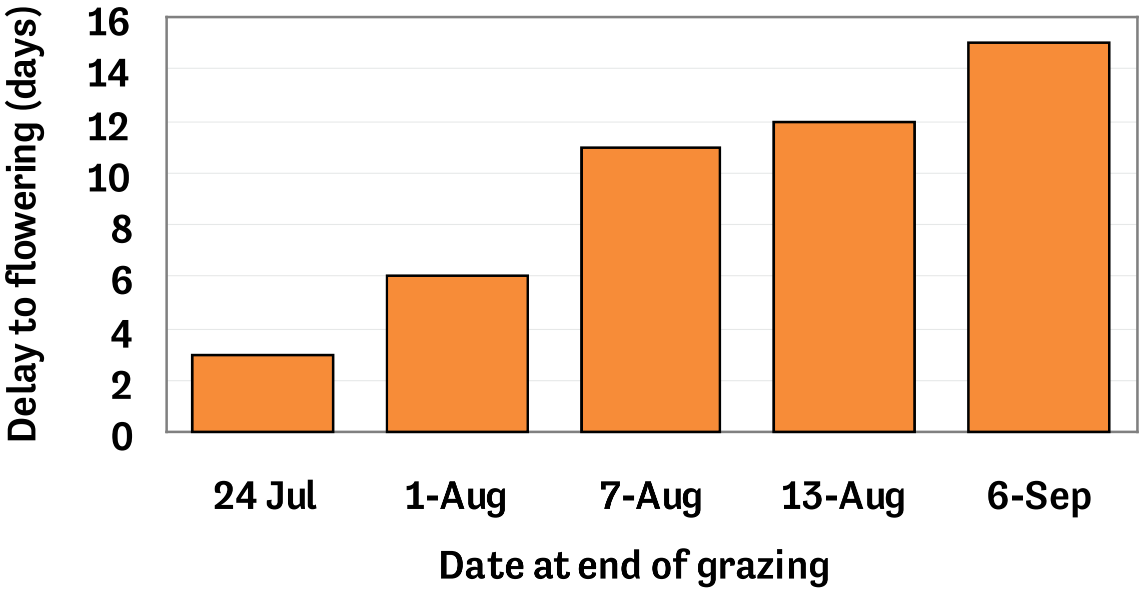


Figure 21: Delay in flowering of barley (cv *Gairdner*) grazed at different times compared to no grazing, Inverleigh, Vic 2007. Grazing duration 7 days.

Delayed maturity has both positive and negative implications. If the crop cannot be grazed evenly there will be variability in crop ripening, which may create difficulties at harvest, especially with barley which is prone to drop grain heads when mature. On the positive side, grazing may be used strategically to delay flowering that may avoid damage caused by late frosts. Yet it may push maturity into a period of late moisture and/or heat stress.

Uneven grazing will lead to different rates of crop maturity. Three samples taken from an unevenly grazed triticale paddock on 20/07/07. Grazed down to 10 cm (left), grazed down to 15 cm (middle), ungrazed (right). Note position of embryo ear along stem.

3.5 Stocking rate (intensity and duration of grazing)

The three considerations of when grazing starts, the amount of crop to leave behind and when to stop grazing enables a calculation of the total number of grazing days available (see side story 13). Once this is known, the grazing intensity or stocking rate can be calculated if animal consumption is included (see side story 14).

Where only a small grazing 'window' exists before GS 30 is reached, very high stocking rates are appropriate. This ensures even grazing of the crop and avoids the 'lawn and rough' effect that can occur when stock concentrate grazing on a small area.

If the period of grazing can be increased through early sowing or very favourable growing conditions, then the approach to grazing can involve a lower stocking rate for a longer period of time. In this case crop growth should also be taken into account (see side story 15).

The effect of different stocking rates on crop dry matter is illustrated in figure 22. Grazing at 20 lambs per hectare roughly maintained crop cover. At higher stocking rates dry matter declined and at lower lamb numbers, crop growth during grazing was in excess of animal intake. This suggest crop growth was approximately 30 kg/ha/day (20 lambs eating 1.5 kg/hd/day).

Side story 13: What are grazing days?

Grazing days are a simple way to calculate the total amount of grazing available in a paddock. It is calculated by dividing the amount of feed available for grazing by the amount each animal will eat. For example if there is 600 kg/ha of dry matter available to graze in a crop and the animals that will be grazing it eat 1.5 kg each per day (see side story 15), then there are 400 grazing days available.

The advantage of using grazing days is there can be many combinations of stocking rate and duration of grazing to achieve the same result. For example if you wanted to use the 400 grazing days over a 10 day period, then you would need a stocking rate of 40 animals per hectare (400/10 = 40). If you wanted the 400 grazing days to last for 30 days, then the stocking rate should be 13.3/ha (400/30 = 13.3).

Grazing days can also be used to determine how long feed will last in a paddock. If we had the same 400 grazing days and we are stocking at 20 animals/ha, then the feed will last 20 days (400/20 = 20).

Side story 14: How much will an animal eat?

Animal intake is regulated by the amount of feed on offer and the quality of that feed.

High quality feed takes less time to digest than low quality feed. Winter crops are high quality feed, which means not only are they high in energy and protein, but they move through the animal rapidly, creating space in the stomach to eat more. However just because a feed can be processed quickly by the animal does not necessarily mean it will eat a lot. Intake may also be limited by the height of the feed.

Sheep and cattle only graze for a maximum of 12 to 13 hours per day. If the feed on offer is very short they get very little in each bite and have insufficient time to fill their stomach. The taller the feed, the more they get in each bite and therefore the more they can consume.

Winter crops have both high quality and are upright growing (compared to pasture). This means the potential intake can be high. The following intake can be expected on winter crops.

Livestock	Intake at 200 kg/ha crop on offer (kg/hd/day)	Maximum intake (kg/hd/day)
Trade lambs	1.4 - 1.5	1.6 – 1.7
Late pregnant ewes	1.3 - 1.4	1.4 - 1.5
Early lactation merino ewes[1]	1.8	2.0
Early lactation first cross ewes[1]	2.0	2.3
Steers (10 – 14 mths old)	7.5	8.5

First value is for merinos, second value for first cross

[1] = add ~10% extra for ewes with twins

Side story 15: Estimated crop growth rates

The average crop growth rates for wheat and barley in the vegetative stage from 88 trials are presented.

Zone	Crop	Crop growth rate (kg/ha/day)			
		40 days from sowing	60 days from sowing	80 days from sowing	100 days from sowing
High rainfall	Wheat	10	15	20	25
	Barley	20	20	25	25
Low rainfall	Wheat	4	7	8	Too late for grazing
	Barley	7	10	15	

Low rainfall examples were grown in years of below average rainfall

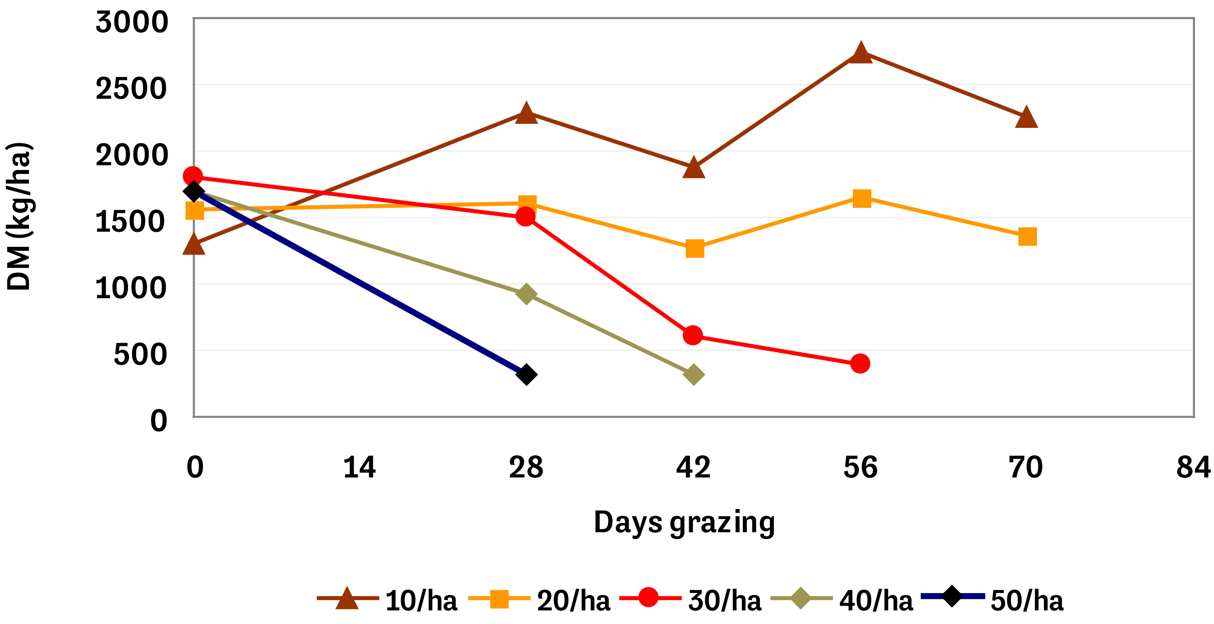


Figure 22: Comparison of dry matter of *MacKellar* wheat with five different lamb stocking rates, Cressy, Tas, 2007.

For many farmers a significant challenge is to find enough stock to graze the crop evenly within the grazing window. This is especially true if the cropping paddocks are large, sowing is early in the season or there are many crops that could be grazed all at the one time.

Temporary fencing is one way of creating smaller paddocks so that the grazing intensity can be optimised.

3.5.1 Multiple grazings

Multiple grazing can be undertaken which gives access to more dry matter, however, the second and subsequent grazing are likely to occur after GS 30 has occurred. This usually results in a loss of grain yield (table 14).

Table 14: Impact of single and double grazing on grain yield, Edillilie SA, 2006 (summary of 6 wheat and 3 barley varieties)

Crop	Grazed early mid tillering, 63 days after sowing (t/ha)	Repeat grazing mid stem elongation, 84 days after sowing (t/ha)	No grazing (t/ha)
Wheat	2.00	1.20	1.92
Barley	2.72	1.81	2.65

4 Other considerations

There are other considerations that farmers need to appreciate when grazing winter crops. The information presented here seeks to quantify the magnitude of these risks under different situations. With this understanding, each farmer can make a decision on whether to accept the risk and graze the crop.

4.1 Stubble after grazing

In most cases grazing will reduce the amount of stubble left compared to no grazing. The average across all observations was 37%, although there is less effect the earlier the crop is grazed. The average reduction during early vegetative growth was 18%, 29% during tillering and 64% in early stem elongation. The smaller reduction when grazed early is probably because there is more time for the plants to recover before stem elongation commences (figure 23).

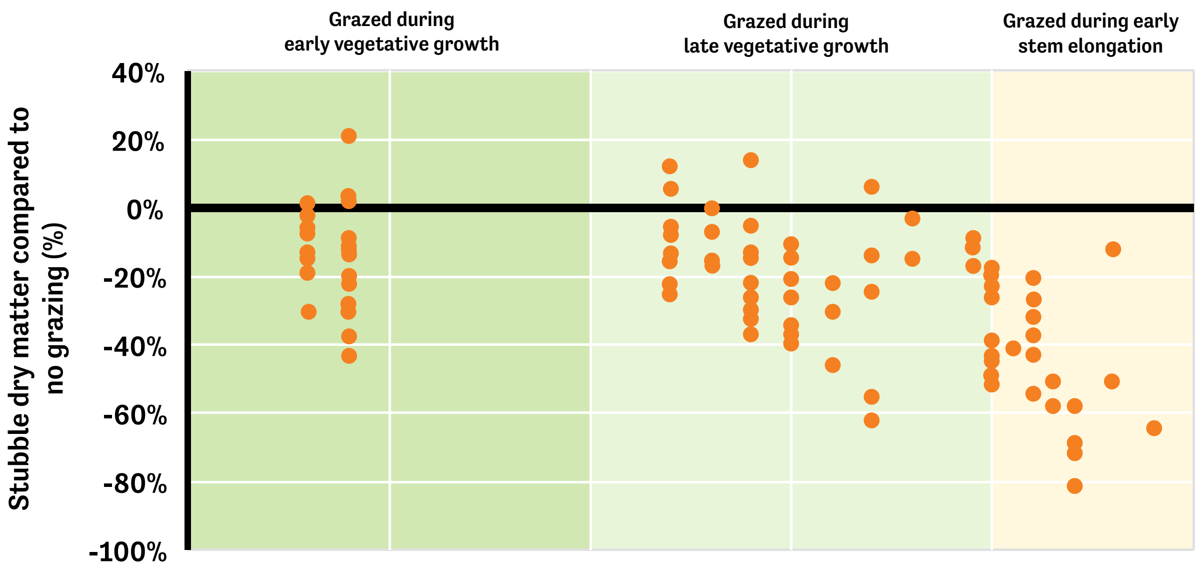


Figure 23: Remaining stubble comparison of grazing against no grazing for wheat, barley and triticale crops at different growth stages 2004 – 2011 (107 observations).

The reduction in remaining stubble may be useful for farmers who have difficulty managing high stubble loads. However for those farmers who can bale and sell the straw, grazing will reduce stubble available.

There is limited information on the effect on silage or hay production, although it would be reasonable to assume similar reductions to the dry matter available for baling when grazing occurs.

4.2 Weeds

Creating weed problems is a common concern expressed by farmers grazing winter crops. The fear is that grazing removes crop competition, encourages germination of weed seeds and increases tillering once the weeds are grazed.

Weed populations are dynamic (see side story 16), which makes a simple answer to the question *does grazing increase weeds* impossible to answer. However information from 12 trials conducted throughout the Grain and Graze program is beginning to shed light on weed populations and to enable some general statements to be made.

Weed free paddocks are the safest to graze

When weed populations are already very low, grazing does not increase these populations, except with the possibility of opportunistic weeds such as toadrush (*Juncus bufonius*) which has an extremely long seed dormancy and only germinates when soil becomes saturated and pugged. An example is presented for annual ryegrass populations monitored for 4 years in South West Victoria (figure 24).

Side story 16: Some facts about weed seeds

- Most weed seeds have some form of dormancy after seed set
- A soft finish to the season (when weeds are setting seed) will create stronger seed dormancy and a harsh finish less dormancy
- This dormancy is broken by:
  - fluctuating temperature and moisture over summer.
  - seed on the soil surface being buried or
  - buried weed seed being exposure to light
- Weeds in higher rainfall areas often have a longer period over which they germinate
- Surface seed is less likely to survive because of predation and exposure than buried seed
- Approximately 15% of weed seeds eaten by an animal will remain viable when excreted.

Source: Andrew Storrie, Integrated weed management workshop notes

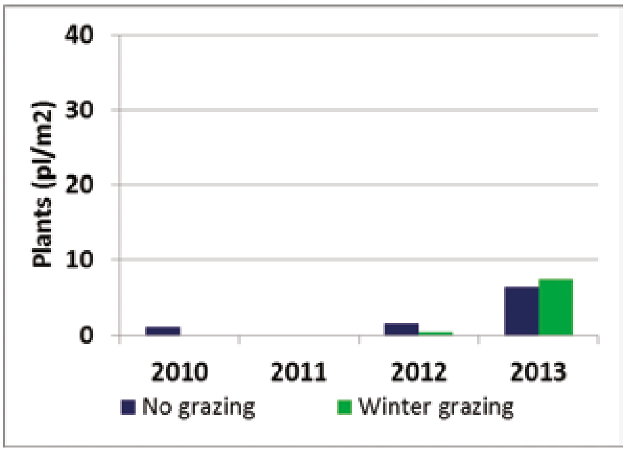


Figure 24: Annual ryegrass population in grazed and ungrazed crops measured in July from 2010 to 2013 (rotation of wheat, barley, canola, wheat).

Crop competition is important in controlling weeds

Early crop competition will reduce weeds. This can be achieved through:

- Variety selection, using early vigorous types like oats and barley compared with winter wheat
- Higher sowing rates and narrow row spacing
- Earlier sowing, although this may compromise the timing of pre sowing herbicides
- Adequate fertility and soil conditions.

Grazing obviously removes plant competition and may change the subsequent weed populations. In a Tasmanian trial, the density of annual ryegrass plants was five to six times lower in 'undergrazed' plots with 10 lambs/ha compared with 20 lambs/ha or higher stocking rates of 30, 40 and 50 lambs/ha (table 15). It was thought the extra leaf in the crop grazed with 10 lambs/ha continued to shade the ryegrass, potentially reducing germination and vigour. In nil-grazed exclusion areas the density of ryegrass was comparable with the lowest stocking rate.

Table 15: Effect of grazing intensity on density of annual ryegrass plants for Mackellar wheat, Cressy, Tas, 2007

Stocking rate (lambs/ha)	Average crop cover at start of grazing (kg/ha)	Average crop cover at end of grazing (kg/ha)	Ryegrass (plants/m²)
10	1,305	2,260	3
20	1,565	1,360	17
30, 40, 50 (average)	1,730	345	21

Grazing may increase or decrease weeds

The Grain and Graze data from 19 trials in Western Australia and Victoria (high rainfall) provides examples where weeds have increased, stayed the same or decreased after winter grazing (table 16).

Table 16: Number of trials recorded where annual ryegrass has increased, stayed the same or decreased after grazing

Change in weed population due to grazing	Number of trials
Increased by 10 pl/m² or more	4 (21%)
Similar (+/-10 pl/m²)	8 (42%)
Decreased by 10 pl/m² or more	7 (37%)

Intensity of grazing is important

If both weeds and cereals are intensively grazed to the same level early in the growth of the crop, the actively growing cereal re-grows more rapidly than most weeds, thereby putting the weeds at a disadvantage. Lax grazing, where only the top part of the canopy is removed has a tendency to reduce shading of the weeds by the cereal, allowing the weed to intercept more sunlight.

While there are examples of sheep actively seeking out some weeds in a cereal crop, it is unlikely that this can be assumed over a range of crops, population of weeds, varieties and growth stages. Also the variability in the response of different weeds to grazing adds to the confusion.

So what does this mean for grazing crops?

The basic principles of weed control in winter grazed crops are the same as the practices used in ungrazed winter crops. Maximizing leaf production through high plant density, adequate soil fertility and selection for rapid growing crops all suit weed control strategies and DM production for grazing.

4.3 Soil structure

The impact of grazing on soil structure remains difficult to quantify. Trials in NSW and Victoria attempted to measure changes in soil structure after winter grazing which imposed extreme winter grazing conditions over multiple years. The main conclusions of this work were:

- Grazing resulted in visual changes to the soil surface (see picture) and reduced roughness in the soil surface (figure 25)
- There were no measurable changes to water infiltration or soil water storage as the result of grazing
- There was no difference in crop establishment in the year after grazing had occurred.

These findings are consistent with a review undertaken by the CSIRO[8] that concluded grazing had no long term impact on soil structure and if there was any short term impact, the soil had an ability to 'repair itself', as long as the biological activity of the soil was adequate.

Photo: Severely pugged soil after grazing

8 Bell et al (2011). Impacts of soil damage by grazing livestock on crop productivity. Soil and Tillage Research 113 pp13-23.

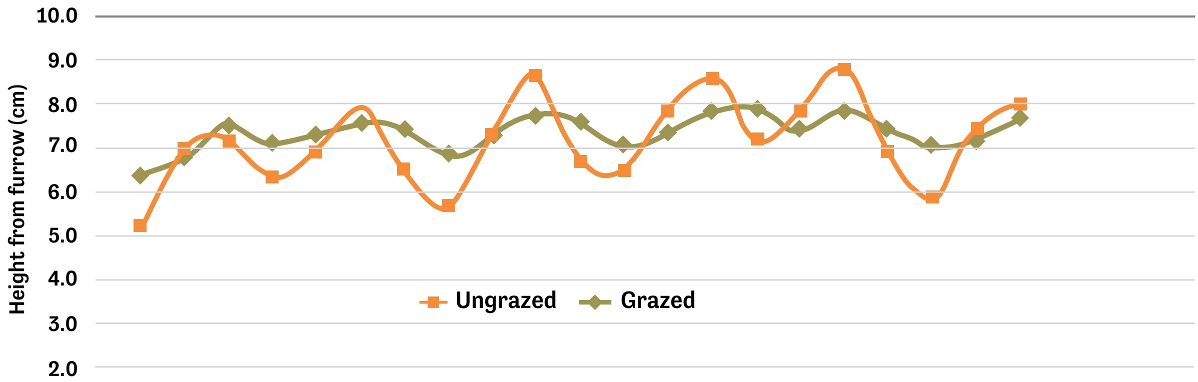


Figure 25: Surface profile of winter grazed and ungrazed soil, 2011.

4.4 Animal health

Farmers who have been grazing winter crops in the last few years have observed some animal health issues. In interviews conducted with 14 farmers in South West Victoria who were grazing winter crops, 40% believed there were slightly higher ewe mortalities and 30% reported increased scouring and dags.

Crops grazed in winter tend to be lush and are characterised by high moisture content and lower amounts fibre compared to more mature feed. This can potentially create animal health issues that need to be appreciated.

Fibre

Fibre is required in a diet to maintain healthy rumen function. It slows down the flow of feed through the animal (but can also restrict intake) and helps stimulate contractions or mixing of the feed in the stomach. Neutral detergent fibre (NDF) is the common test for digestible fibre in feeds.

Currently there is no Australian standard for the amount of fibre to be fed to ruminants[9], however practical recommendations are that dairy cows require above 35% NDF to avoid reduction in milk fat[10].

Water

Most water absorption in a ruminant occurs in the third stomach (the omasum) and the large intestine. The removal of water 'hardens' the excreted material. In diets with high moisture content, the animal is unable to absorb sufficient water to prevent loose faeces and appear to have 'runny bums'.

There is no benchmark for the maximum amount of water to prevent loose faeces although moisture contents above 85% are often observed to be threshold.

Winter crops in the early vegetative stage of growth are commonly low in fibre and high in moisture (table 17).

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9 Standing Committee on Agriculture (1990). In 'Feeding Standards, Ruminants'. (CSIRO: East Melbourne, Australia.).

10 Wales, W, Doyle P, Dalley D and Williams C. Anim. Prod. Aust. 2002 Vol. 24: 257-260

Table 17: Average moisture and digestible fibre content for early season cereals and canola (range for 50% of results in brackets).

Crop	Moisture (%)	NDF (%)
Cereals (pre GS 30)	80.6% (79.0% to 85.8%)	39.5% (35.6% to 43.0%)
Cereals (GS 30 to GS 39)		42.8% (40.1% to 45.5%)
Canola (pre flower bud development)	89.5% (88.4% to 90.7%)	23.9% (23.7% to 25.8%)
'Recommended' level	< 85 %	> 35%

Scouring may also be caused by a rapid change in diet, where the animal has not become accustomed to the different quality feed. The simplest way to minimise the potential scouring effect is to provide roughage just before entry to the crop and maintain access to this material during grazing. Late pregnant or lactating cows, or ewes, especially need good quality hay. Additional actions can include introducing stock to the type of feed over a three or four day period or only graze late in the afternoon for the first few days (to avoid potential nitrate poisoning). Always avoid turning hungry stock into a crop on an empty stomach (see side story 17).

Side story 17: Helping stock cope with grazing winter crops

Mick Shawcross from Ceres near Geelong, Victoria, has been grazing winter crops for many years. Mick tries where possible to introduce ewes and lambs onto cereals gradually so they can adjust to the change in feed. This involves grazing the stock on an area where he has 'scratched in' some left over cereal seed into pasture. He grazes them on this pasture cereal mix prior to putting the stock on the cereal crop. Hay is also used. He finds the stock don't get daggy on the cereals because they have access to hay and have an introduction period with cereals to help them adapt.

Minerals

Work conducted by Hugh Dove, former Chief Research Scientist with CSIRO Plant Industry in Canberra identified that low magnesium was present in wheat crops. Acute magnesium deficiencies result in grass tetany, however more marginal deficiencies present themselves as lower than expected growth rates. The cause of the magnesium deficiency is an imbalance of potassium and sodium in the cereal the animals are grazing. Excess potassium combined with low sodium reduces the absorption of magnesium in the rumen. This deficiency can be easily rectified with a simple mineral lick (see side story 18).
Sheep only need 20g/d and cattle 150 g/day.

Side story 18: Recipe for magnesium loose lick

- Mix equal parts of Causmag (MgO), ground limestone and salt
- Place in containers (drench drum cut in half) and locate in an accessible area for livestock.

Metabolic disorders

Canola can pose a greater risk to animal health than cereals, but this usually occurs when animals are suddenly introduced to the crop, often combined with conditions that make the crop stressed such as a lack of moisture, frost or herbicide application. The potential animal health problems include pneumonia, gastroenteritis, hypocalcemia, polio, liver damage, photosensitisation and nitrate poisoning. Stock should be fully vaccinated against enterotoxaemia before grazing. The recommendation when grazing canola is to offer hay and observe the animals closely for at least the first two weeks of grazing.

4.5 Crop diseases

The anecdotal information on diseases in cereal crops is quite variable. Some farmers believe grazing reduces disease such as rust by removing the diseased leaves and therefore the source of ongoing infection, or by reducing the canopy which improves air circulation and creates a less favourable condition for disease build up.

There is limited information on the effect of grazing on disease incidence. Observations of stripe and leaf rust in two barley and four wheat varieties in South West Victoria revealed no significant difference in rust incidence in the grazed and ungrazed plots, although the observations were taken during a drought year where the rust incidence was extremely low.

In contrast a trial in Western Australia on barley where powdery mildew was about threshold control levels early in the season showed a substantial reduction in disease incidence until later in the season[11].

Example of grazing reducing disease incidence in crop (ungrazed on left, grazed crop on right).

11 Andrea Hills and Blakely Paynter (2012) - Grazing barley controls early foliar diseases, has manageable impacts on malting barley grain quality but suffers a yield penalty. Department of Agriculture and Food WA.

Appendix 1: Dry matter percentiles (kg/ha) for wheat, barley and canola at different growth stages.

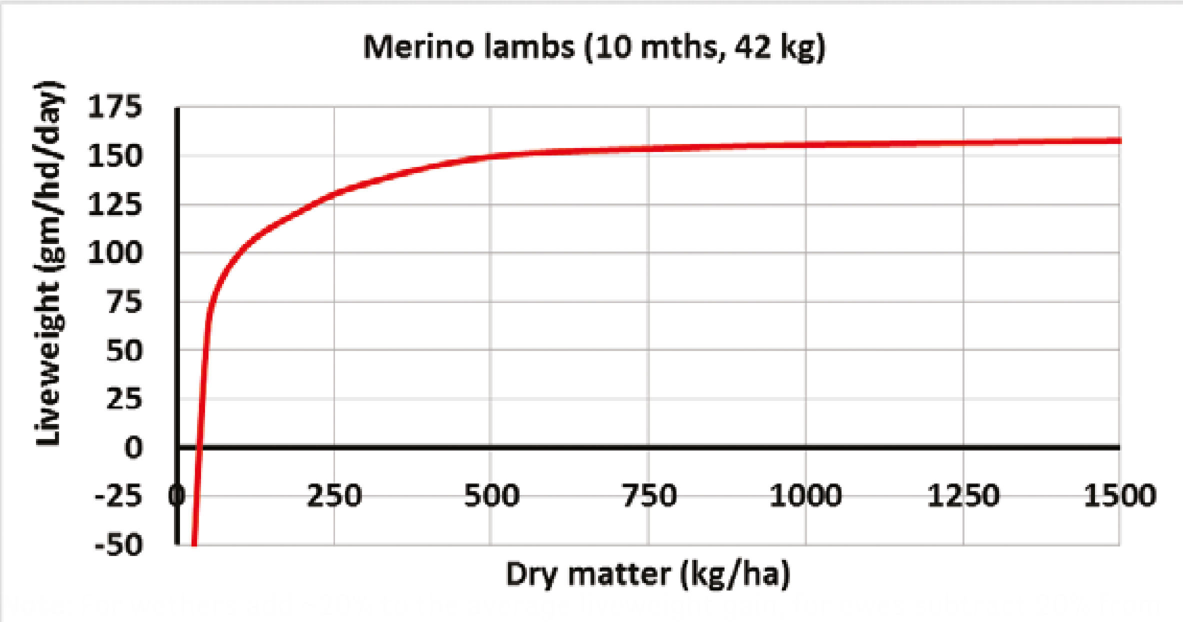
High rainfall zone

	Early vegetative			Late vegetative			Start of stem elongation	
	Wheat (9 weeks from sowing)	Barley (9 weeks from sowing)	Canola (11 weeks from sowing)	Wheat (12 weeks from sowing)	Barley (12 weeks from sowing)	Canola (14 weeks from sowing	Wheat (16 weeks from sowing)	Barley (16 weeks from sowing)
Decile 1	582	747	305	304	312	527	892	211
Decile 2	614	1031	337	371	607	1069	1056	240
Decile 3	627	1090	379	723	802	1248	1108	493
Decile 4	654	1182	397	956	1434	1371	1180	2129
Decile 5	700	1235	597	1080	1700	1644	1420	2889
Decile 6	730	1298	678	1306	1804	1690	1789	3181
Decile 7	754	1348	941	1506	2020	1765	2579	3185
Decile 8	817	1510	1020	1810	2201	1906	3199	3491
Decile 9	891	1827	1219	2107	2536	2011	3740	3824

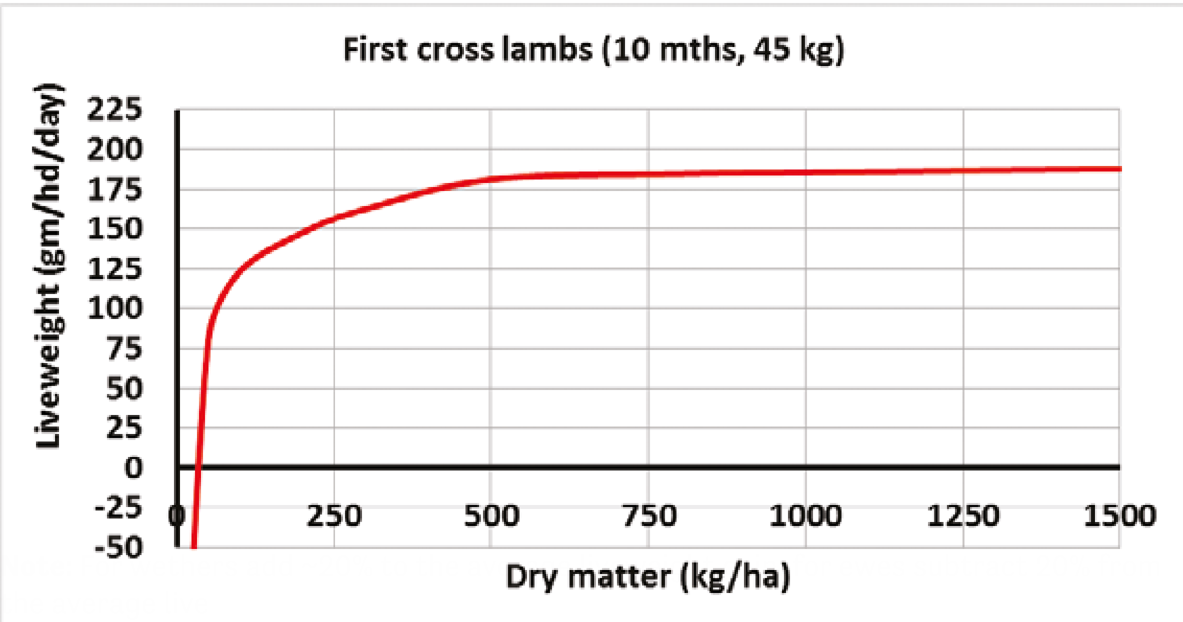
Low rainfall zone

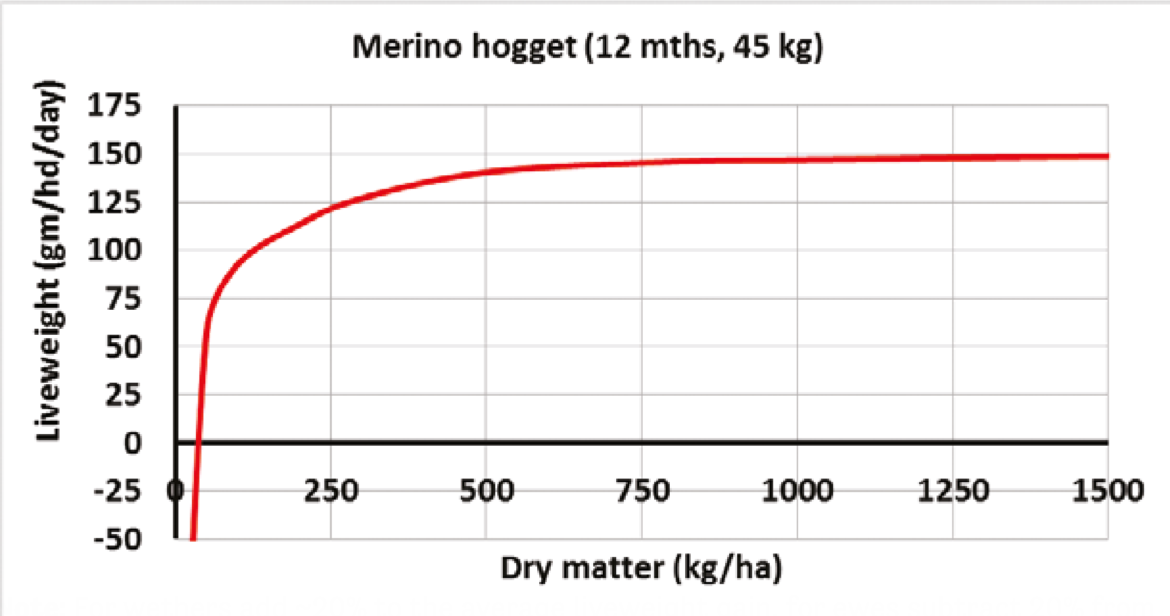
	Early vegetative		Late vegetative	
	Wheat (5 weeks from sowing)	Barley (4 weeks from sowing	Wheat (9 weeks from sowing)	Barley (8 weeks from sowing)
Decile 1	131	128	137	219
Decile 2	133	130	190	233
Decile 3	135	132	212	256
Decile 4	136	140	219	306
Decile 5	141	153	497	418
Decile 6	146	165	526	444
Decile 7	149	232	548	870
Decile 8	152	407	601	1150
Decile 9	160	583	727	1184

Appendix 2: Anticipated liveweight gain for different classes of livestock grazing winter crops.

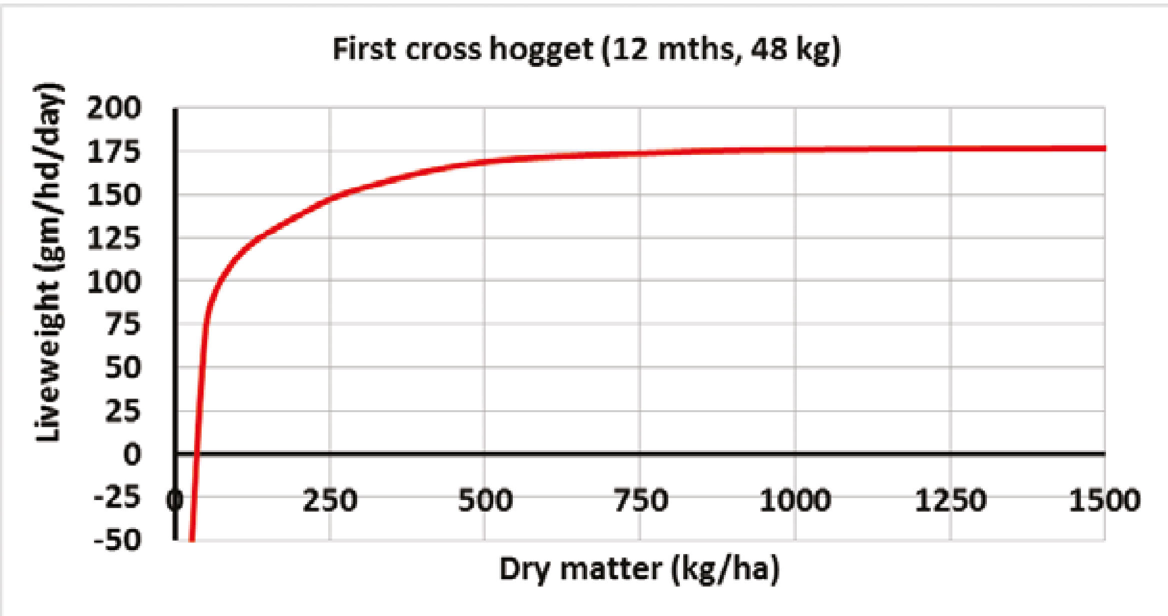


the average liveweight gain.

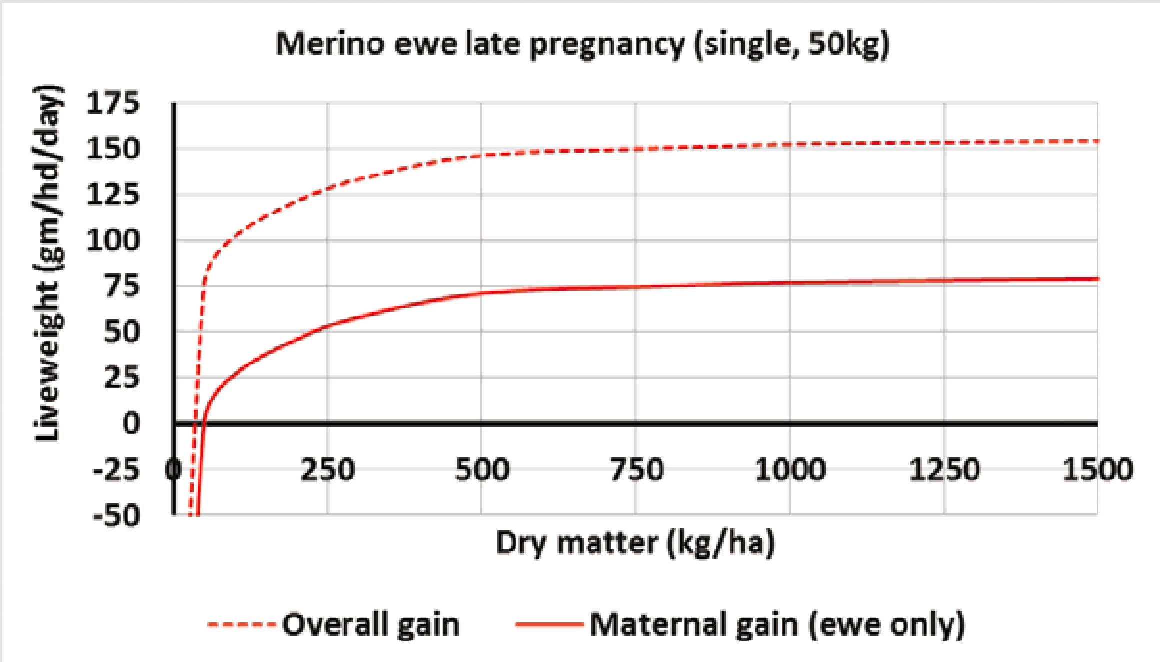




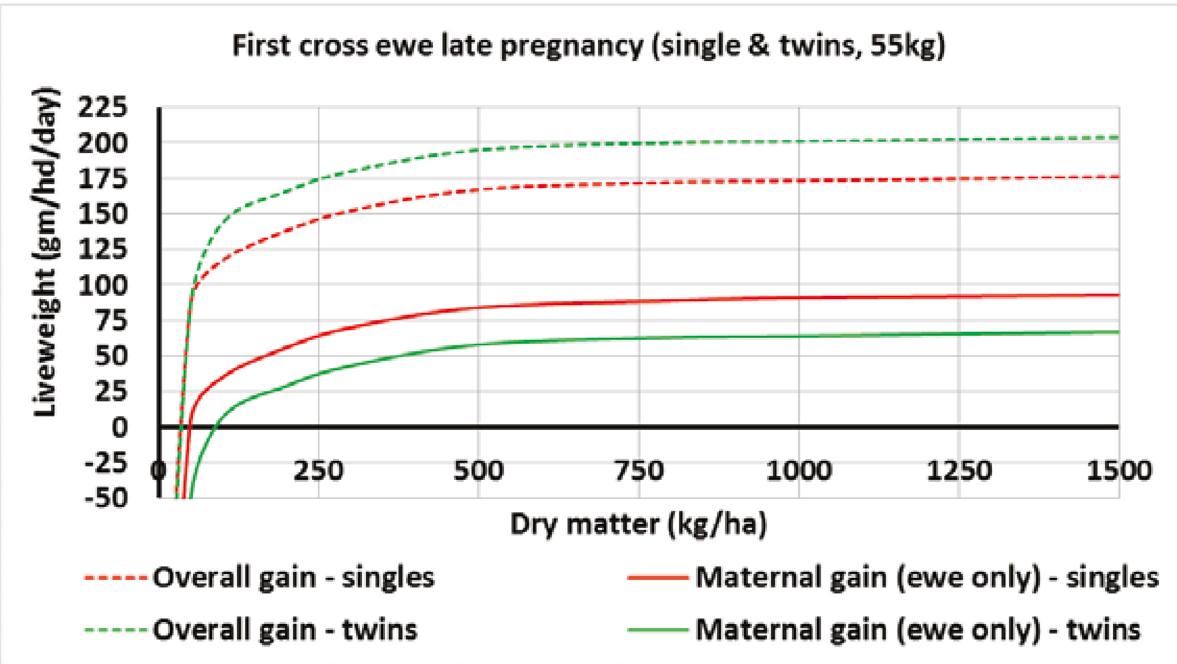
the average liveweight gain.



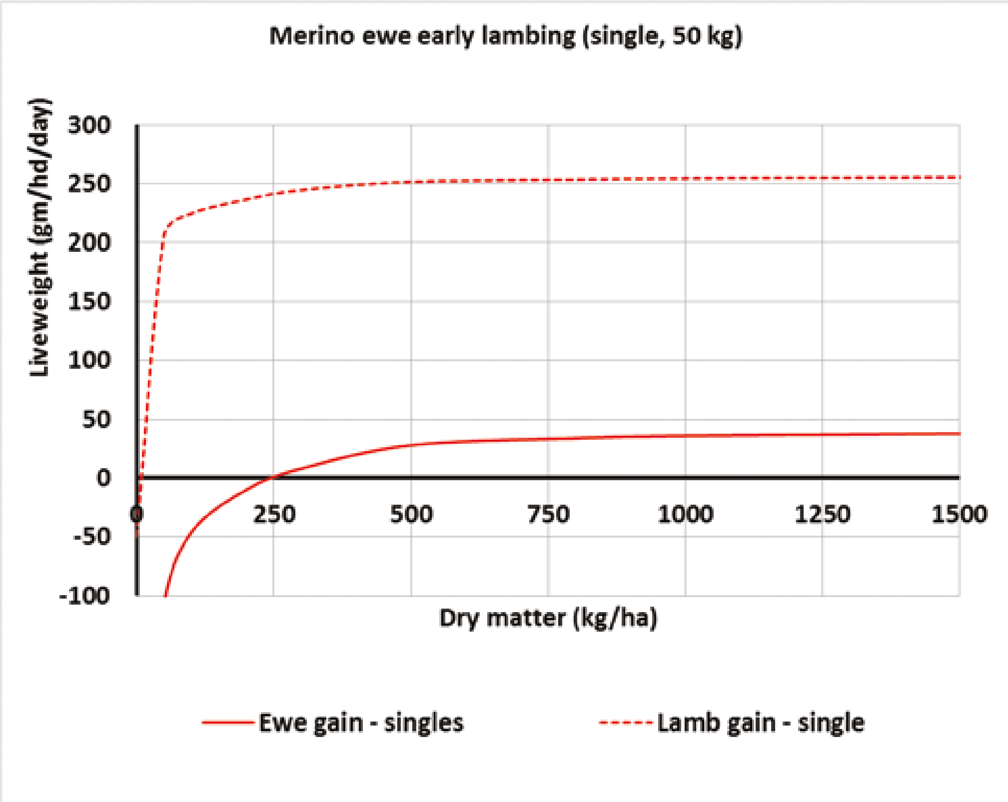
Note: For wethers add ~20% to the average liveweight gain, for ewes subtract 20% from the average liveweight gain.



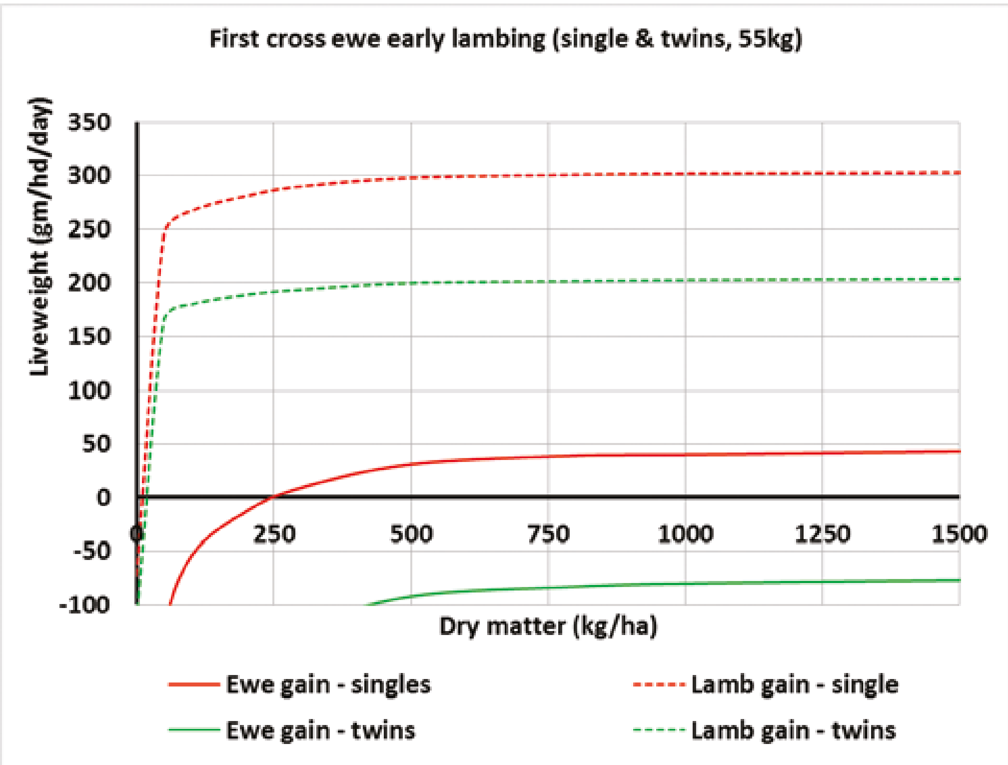
Note: Late pregnancy = 120 days after joining. Overall gain includes changes in ewe weight and foetus.



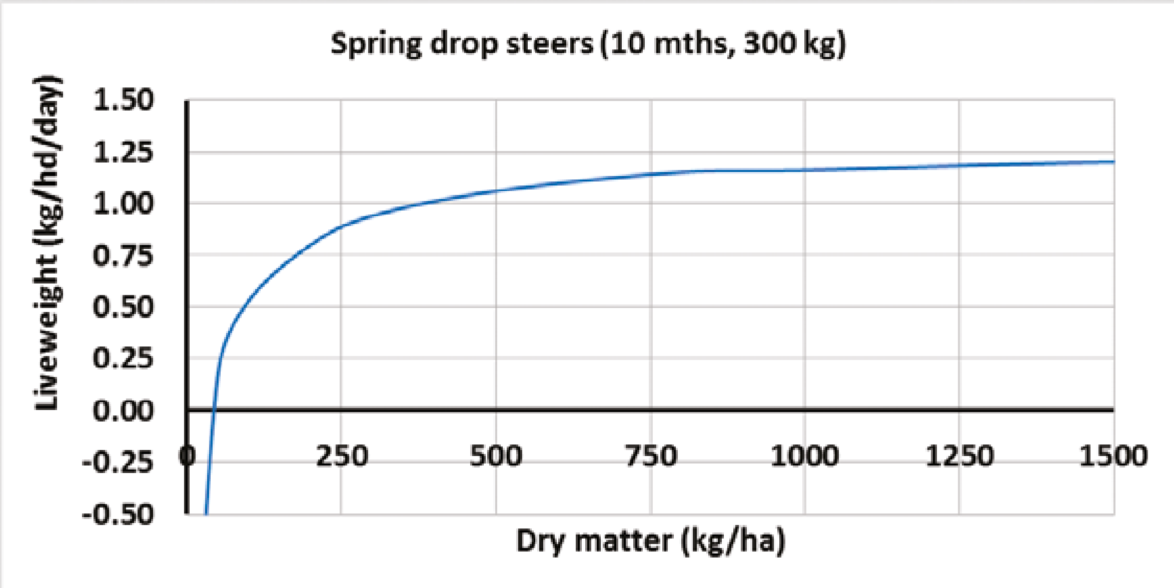
Note: Late pregnancy = 120 days after joining. Overall gain includes changes in ewe weight and foetus.

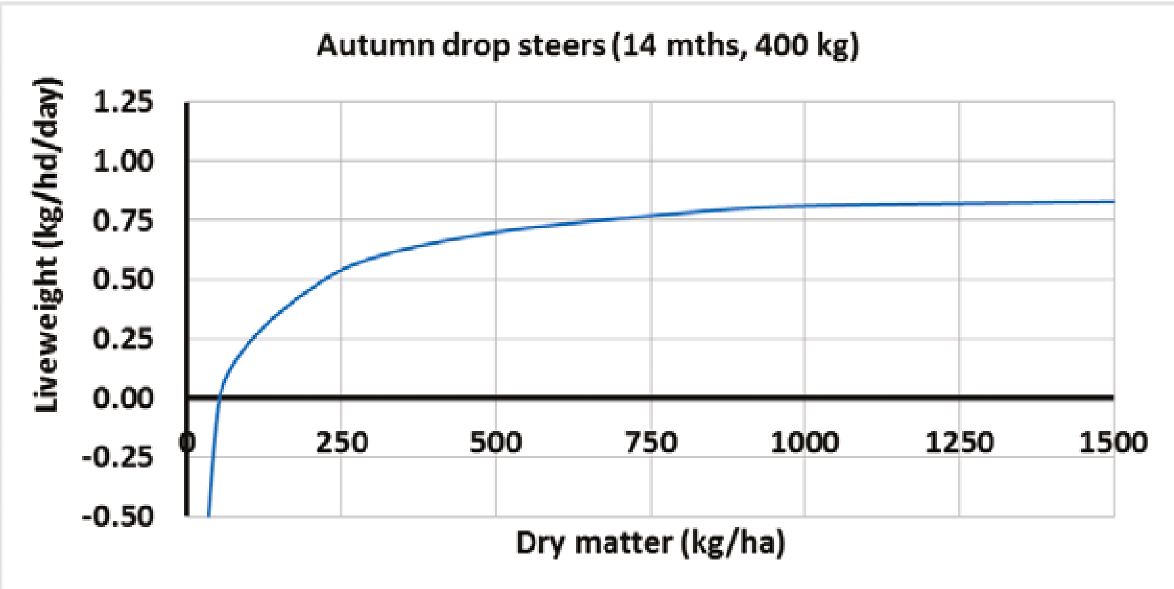


Note: Early lambing = 15 days after lambing.



Note: Early lambing = 15 days after lambing.


Spring drop steers (10 mths, 300 kg)
Liveweight (kg/hd/day)
1.50
1.25
1.00
0.75
0.50
0.25
0.00
-0.25
-0.50
0
250
500
750
1000
1250
1500
Dry matter (kg/ha)


Autumn drop steers (14 mths, 400 kg)
Liveweight (kg/hd/day)
1.25
1.00
0.75
0.50
0.25
0.00
-0.25
-0.50
0
250
500
750
1000
1250
1500
Dry matter (kg/ha)

Appendix 3: Grazing withholding periods on commonly used seed dressings, herbicides, insecticides and fungicides

Seed dressings

Common name	Active ingredient	Grazing Withholding Period
Baytan	Triadimenol, Triflumuron	5 weeks after sowing
Comos	Fipronil	9 weeks after sowing
Dividend	Difenoconazole, Metalaxyl-M	6 weeks after sowing
Gaucho	Imidacloprid	9 weeks cereals, 16 weeks pulses
Hombere	Imidacloprid, Tebuconazole	9 weeks after sowing
Impact	Flutriafol	4 weeks in furrow 10 weeks, foliar barley 7 weeks wheat
Jockey	Fluquiconazole	6 weeks cereals, 8 weeks canola
Mesurol	Methiocarb	1 week after application
Rancona C	Ipconazole, Cypermethrin	6 weeks after sowing
Raxil	Tebuconazole, Triflumuron	4 weeks after sowing
Zorro	Imidacloprid, Triadimenol	9 weeks after sowing

Pre-emergent herbicides

Common name	Active ingredient	Grazing Withholding Period
Avadex Xtra	Tri-allate	11 weeks cereals 13 weeks oilseeds/pulses
Boxer Gold	Prosulfocarb, S-metolachlor	10 weeks
Diuron	Diuron	Nil when used as directed
Dual Goal	S-metolachlor	10 weeks
Gesaprim	Atrazine	15 weeks pre-emergent 6 weeks post emergent
Gesatop	Simazine	15 weeks canola
Hammer	Carfentrazone	2 weeks
Logran	Triasullfuron	7 weeks pre-emergent 2 weeks post emergent
Roundup Attack	Glyphosate	Nil when used as directed
Sakura	Pyroxasulfone	6 weeks
Sprayseed	Paraquat/ Diquat	1 day, 7 days horses
Stomp	Pendimethalin	Nil when used as directed
Terbyne	Terbuthylazine	6 weeks
TriflurX	Trifluralin	Nil when used as directed

Post-emergent herbicides

Common name	Active ingredient	Grazing Withholding Period
Achieve	Tralkoxydim	2 weeks
Alley	Metsulfuron-Methyl	Nil
Amicide	2,4-D Amine	1 week
Atlantis	Mesosulfuron-Methyl	4 weeks
Axial	Pinoxaden	3 weeks
Buttress	2,4-DB	1 week
Eclipse	Metolsulam	2 weeks cereals 4 weeks lupins
Ester	2,4-D Ester	1 week
Hassar	Iodosulfuro-Methyl Sodium	4 weeks
Hoegrass	Diclofop-Methyl	7 weeks
Igran	Terbutryn	1 week
Intervix	Imazamox + Imazaphr	5 weeks
Jaguar	Bromoxynil+Diflufenican	2 weeks
Lontrel	Clopyralid	1 week
MCPA	MCPA	1 week
On Duty	Imazapic + Imazaphr	4 weeks wheat 6 weeks canola
Precept	MCPA+Pyrasulfotole	2 weeks cereal 4 weeks barley
ProGibb	Gibberellic Acid	Nil when used as directed
Roundup Ready	Glyphosate	Nil when used as directed
Select	Clethodim	2 weeks pasture legumes, 3 weeks canola
Sencor	Metribuzin	2 weeks
Tigrex	MCPA+Diflufenican	1 week
Velocity	Bromoxynil+Pyrasulfotole	5 weeks
Verdict	Haloxyfop	4 weeks

Insecticides

Common name	Active ingredient	Grazing Withholding Period
Cypermethrin	Cypermethrin	5 weeks cereals 5 weeks chick peas
Dimethoate	Dimethoate	1 day
Endosulfan	Endosulfan	10 weeks cereals 8 weeks canola
Fastac Duo	Alpha-Cypermethrin	3 weeks
Le mat	Omethoate	1 day
Lorsban	Chorphrifos	2 days
Primor	Pirimicarb	6 weeks cereals 2 weeks canola
Talstar	Bifenthrin	4 weeks

Fungicides

Common name	Active ingredient	Grazing Withholding Period
Amistar Xtra	Azoxystrobin, Cyproconazole	3 weeks
Folicur	Tebuconazole	2 weeks
Opera	Epoxiconazole, Pyraclostrobin	3 weeks
Opus	Epoxiconazole	6 weeks
Prosaro	Prothioconazole,Tebuconazole	2 weeks
Tilt	Propiconazole	1 week cereals
Tilt Xtra	Propiconazole, Cyproconazole	3 weeks

GRAZING CROPPED LAND

Reduction in the amount of dead material at the base of the plant due to grazing. Grazed plant (left), ungrazed (right). These two crops yielded the same.