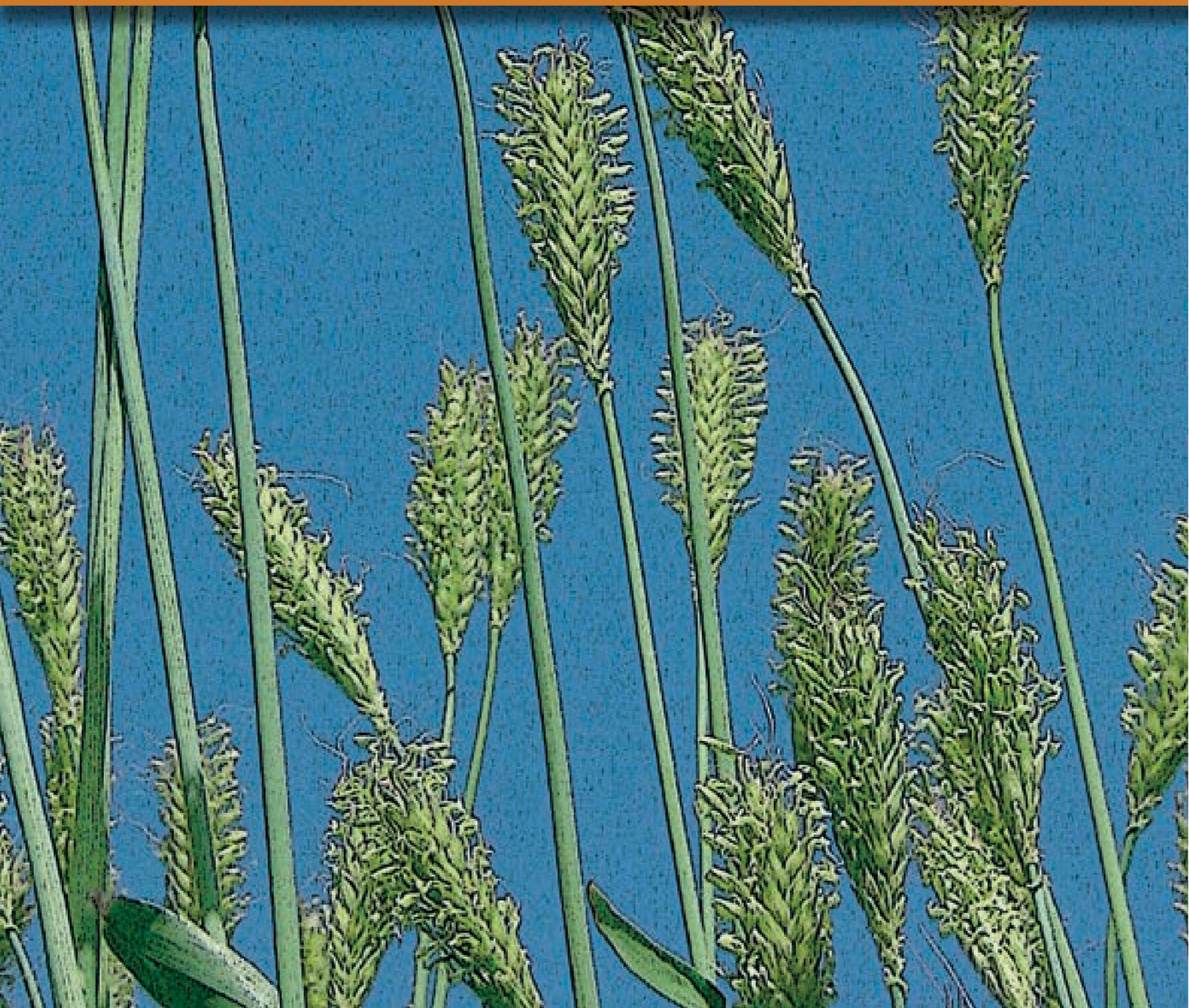
Producing irrigated cereal grain and fodder in northern Victoria

A best management guide

Produced by the Victorian Irrigated Cropping Council for the Dairy Services Branch of Department of Primary Industries Victoria



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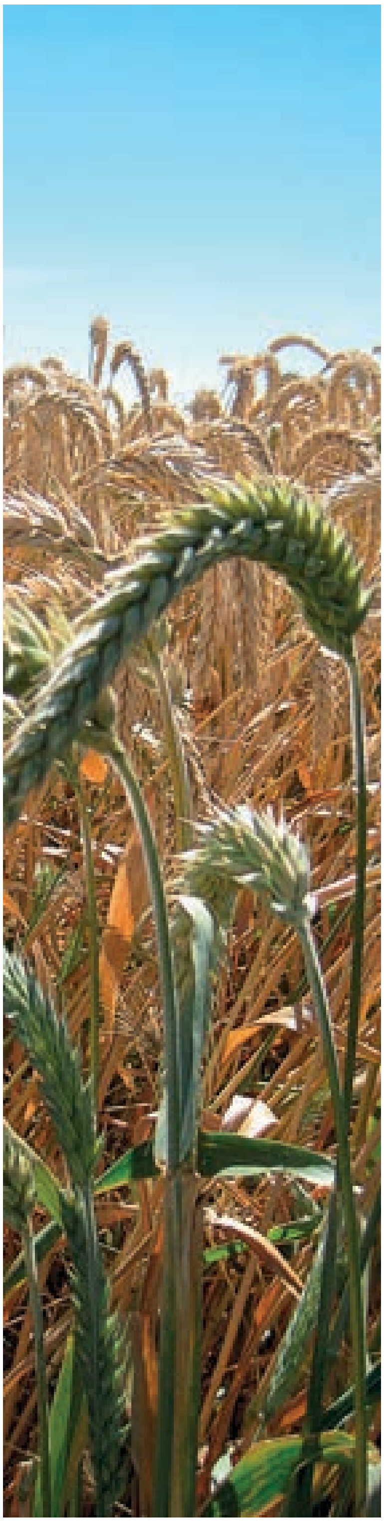

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Introduction — doing more with less

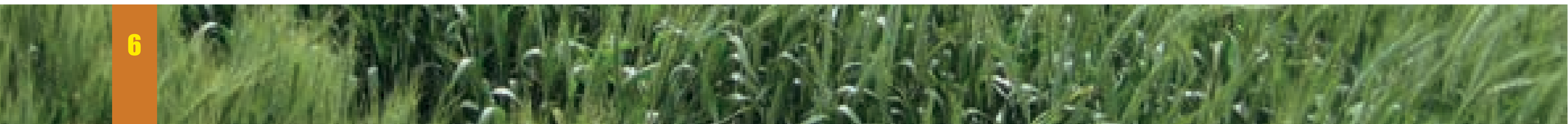
This cereal fodder guide primarily is intended to help farmers decide what cereals to grow for fodder when irrigation water is limited and to help identify the risks that may threaten the viability of the forage crop. This guide will also help farmers to determine the cost effectiveness of home-grown forages and the best end use for the forage grown.

The Victorian Irrigated Cropping Council (VICC) has a long association with the Victorian Department of Primary Industries (DPI). Since 2002, the two organisations have conducted collaborative trial work on cereal grains and cereal fodder, which has greatly improved the understanding of crop and forage agronomy under dryland and irrigated systems in northern Victoria. This guide presents a summary of that research work. The guide also includes a range of relevant agronomic information developed by DPI and other agencies.

This guide had its beginnings in the recent history of below-average irrigation allocations and drought. This history has changed the way that farmers in northern Victoria approach water use. As a direct result of low water availability, many farmers have converted all or part of their irrigation enterprises to dryland operation or have selected crops, such as cereals for fodder, that require less water to achieve the same production.

The shift to more efficient water use has brought about a range of challenges. Many farmers are learning new skills as they manage leaner systems which are more finely balanced in terms of fertiliser, water, pests, diseases and climatic pressures. Other farmers are learning to grow new crops for the first time. In all cases, decision making has become more complex because of the greater risk of crop failure when irrigation water is limited.

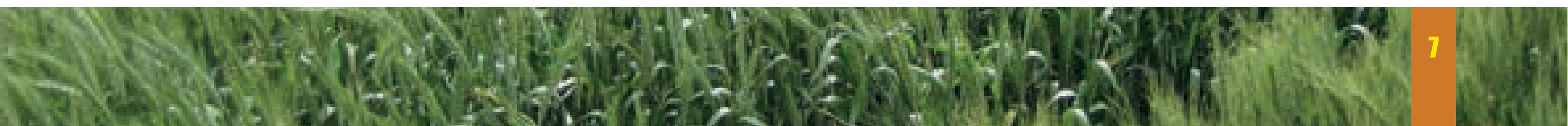
All of these challenges have highlighted the need for more detailed information regarding the production of cereal fodder crops and this guide is the end result of lessons learned and research done during the historic dry times of the early 2000s.



Take home messages

Cereals are an effective dryland or irrigated crop when water resources are limited. Cereals produce sizeable quantities of good quality forage compared with ryegrass.

1. To make the most of a cereal crop, identify the feed gap (autumn, winter or spring) and use this to help determine whether grazing, hay or silage production, grain production or a combination of these is the end target.
2. Select a cereal variety that will meet the end use requirements.
3. Understand the characteristics and correct planting window for the variety to prevent the cereal maturing at the wrong time of year.
4. In rain fed systems, sowing time and end use strategy will be influenced by the time of the break.
5. Pre-irrigation can ensure crops are sown on time and can help increase dry matter production. Deferring sowing until the break can save valuable irrigation water but possibly at the cost of reduced production.
6. Early dry matter production is proportional to sowing date. The earlier the sowing, the more dry matter produced. However, it is important that dry matter is used when it is ready, to maintain quality.
7. Seeding rate is proportional to sowing date. The later the sowing, the more seed is required to achieve the same dry matter production.
8. The average soil temperature should be less than 25 °C before sowing cereals.
9. Unless cereals are sown early and grazing occurs at the correct plant stage, grazing will decrease total dry matter production and potential hay yields.
10. The developing head of the cereal plant should be protected from grazing to maximise hay or grain yields.
11. Irrigation is a valuable tool to manage soil moisture and can significantly increase dry matter production.
12. Apply fertiliser and other inputs with due consideration of the prevailing seasonal conditions.
13. High quality hay is generally achieved by cutting early (booting) but this incurs a significant yield penalty. Hay cutting at the early milk stage increases yield at the expense of quality.
14. The economics of production are heavily reliant on the weather and input prices.



1 Cereals versus ryegrass

Well-managed cereal fodder crops are an excellent alternative to ryegrass pastures when water availability is limited.

As a result of low water allocations due to drought throughout the early 2000s and potential reductions in water availability due to longer-term changes in water policy, alternatives to ryegrass-based forage pastures are increasingly being considered in northern Victoria.

Ryegrass requires significant inputs of rainfall or irrigation water to produce good quality feed. It has a relatively shallow root system and requires frequent watering because it cannot access water stored at depth in the soil. Because of these limitations, dairy, beef and sheep producers are looking to cereal fodder crops (oats, barley, triticale and wheat) as an alternative to irrigated pastures.

Cereals are an attractive alternative to ryegrass, mainly because they are more efficient at using water, and so can yield more forage.

In their vegetative state, cereals can produce similar quality forage to ryegrass, and if managed correctly they will also produce large quantities of good quality hay and silage. Cereals can survive for longer periods between rainfall events, making them more drought tolerant than pastures, and they are relatively simple to establish and grow.

Experience and research have shown that well-managed cereal fodder crops are an excellent alternative to ryegrass pastures when water availability is limited.

2 Choosing the best crop

Understanding the key characteristics of a variety will help achieve the best possible results.

Identifying the feed gap in the production system is the single most important step in choosing a cereal variety for fodder.

- Will grazing feed be needed early in the season or in winter, if there isn't enough water to get early pastures up and running?
- Is there a requirement for hay or silage, or is grain production also an option?
- Would a combination of grazing and then locking up for hay, silage or grain be the ideal scenario?

Determining the need for feed will make variety selection much simpler.

Each variety has its own strengths and weaknesses. There is a cereal variety for just about every end use. Some varieties produce good quantities of early fodder for grazing, some make good quality hay and silage, some produce high grain yields, and then there are those that can do a combination of these things. Because there is so much choice, choosing the right variety for a fodder crop can seem confusing, at first.

Characteristics of cereal fodder crops

By working out when feed is most valuable to the business, choosing a variety for a given system becomes relatively easy. If, for whatever reason, there is a commitment to growing a particular variety, understanding the key characteristics of that variety will help achieve the best possible result.

Maturity

Cereal varieties can be broken down into seven main types, based on the time they take to mature or special requirements to trigger the reproductive phase. These types are:

- very early (VE)
- early (E)
- mid (M)
- mid–late (ML)
- late (L) or very late (L–VL)
- winter habit (WH) — responds to increasing day length
- vernalisation requirement (VR) — responds to cold.

Very early and early maturing types, also called quick maturing, are best sown late (late May, June and July) and are ideal for a late break. Sown early (i.e. March), these types will only be useful for grazing because they will run up to head during winter, which is the wrong time for hay or silage production. Because of their quick growth habit, quick maturing types provide good early dry matter production. Examples include Yiddah oats, Dictator barley and Ventura wheat.

Mid maturing types are ideally sown in mid-May and will generally be ready for hay cutting in mid-October. Sown too early, mid maturing types will be a 'grazing only' option, because they will run up to head in winter without producing much dry matter. Mid maturing types are still productive for hay or grain when sown late. Examples include Wintaroo oats and Tahara triticale.

Late and very late maturing types, also known as long-season, are best sown early (late March–late April) and are ideal for early grazing(s) before being locked up for hay. Not all long-season varieties have winter habit so they may still run to head if sown too early. Care should be taken when choosing late or very late varieties as they may be heading or filling grain during periods of high temperatures and/or moisture stress, and irrigation (if available) may be required to help the crop reach maturity. Very late types will struggle to make hay on dryland in normal seasons in areas with less than 450 mm average annual rainfall. Examples include Saia oats and Crackerjack triticale.

Winter habit types will not run to head until day length increases after the winter solstice. These types are ideal for early sowing for grazing and then locking up for hay. Examples include Bimbil and Blackbutt oats and Wedgetail wheat.

Types with a vernalisation (cold) requirement need a cumulative exposure to cold temperature over winter before head formation is initiated. This makes these types suitable for early planting because they can grow and produce useful grazing dry matter before being locked up for a late spring hay cut or grain harvest. However, there are limitations to early sowing (see Section 4, *Soil temperature*, page 20). Vernalisation requirement occurs mainly in oats (i.e. Esk, Galileo, Nile) and wheat (i.e. Brennan, Rudd, Tennant), so it is important to know which varieties have this trait (see tables 3, 4, 5 & 6).

Matching sowing time to maturity type is essential to fill the feed gap. Table 1 shows the possible end uses for different maturity types for a range of sowing times.

Most cereals begin reproduction in response to accumulated temperature (day degrees); therefore they will run to head when this requirement is met. This is the reason an early sown, early maturing type will produce a head in winter and be ready for hay or silage cutting at a time of year when it is wet, cold and unsuited to forage conservation. Early head emergence also exposes a potential grain crop to frost damage.

A late sown crop is associated with yield penalties because there is less time for vegetative growth, leading to less reserves of the stored carbohydrates needed to maximise dry matter production or grain yield. Late sowing will often mean grazing as well as hay, silage or grain is not feasible — the crop will be best used for a single purpose only. Where grazing as well as hay, silage or grain is intended, it is best to sow a mid–late to very late variety relatively early, in order to increase dry matter production. Grazing will delay the time when most varieties reach maturity.

Vigour

Vigour describes how quickly plants emerge and grow in the early stages of development. The better the early vigour of a variety, the more quickly the crop will be ready for the first grazing. In general, barley has better early vigour than oats, which in turn are better than wheat and triticale. However there are significant variations within each cereal class.

Plant habit & grazing height

Like pastures, some cereals grow upright (wheat and triticale) while others spread along the ground before becoming more upright (barley). However all plant habits (growth types) exist to some degree in each cereal category.

If the variety is a prostrate (flat) type, it can be safely grazed to 5.0 cm, while a more upright type should only be grazed to 10 cm. This preserves leaf area on the plant, which ensures a more rapid recovery from grazing.

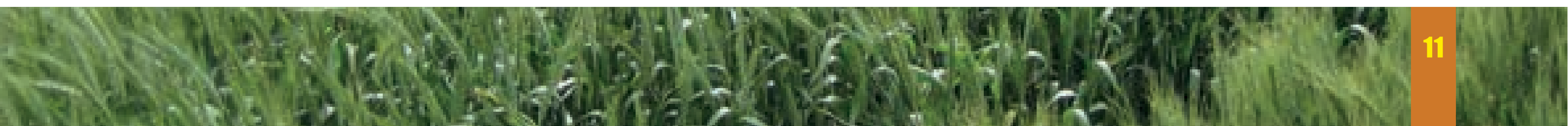
Plant height

In general, most wheat is semi-dwarf and generally grows to a medium height (75–85 cm). Oats can be any height. Short varieties (65–70 cm) like Echidna and Eurabbie may produce less dry matter if sown late but they are competitive for dry matter production when sown on time. Other oats may be tall, like Wintaroo and Graza 50, and some varieties can be up to 130 cm tall. Tall varieties may be prone to lodging (falling over). Triticale is generally taller (up to 150 cm) than the other cereals.

Table 1. Possible end uses for cereals of different maturity types based on sowing time

Maturity type	Sowing time			
	March	April	May	June
Very early	grazing	grazing | silage	grazing | silage | hay	grazing | silage | hay
Early	grazing	grazing | silage	grazing | silage | hay	grazing | silage | hay
Mid	grazing	grazing | silage	grazing | silage | hay	grazing | silage | hay
Late	grazing | silage	grazing | silage | hay	grazing | silage | hay	grazing | silage | hay
Very late	grazing | silage | hay	grazing | silage | hay	grazing | silage | hay	grazing | silage | hay

Source: Dale Grey, DPI Victoria, Cobram



Awns

Many of the winter wheats and early grazing wheats are awnless (better for hay production), but recent experience with cereals suggests time of cutting has more impact on palatability than awns. Awns can cause damage to sensitive parts of the mouths of grazing animals.

Tillering

There can be large differences between varieties of the same cereal class when it comes to tillering. In general, and assuming sowing is not delayed past May, barley tillers better than oats, which in turn tiller better than wheat, which in turn tillers better than triticale. Some specialist grazing varieties, i.e. the longer-season triticales, will tiller more prolifically than some wheat, particularly the early maturing varieties.

Generally, the earlier the sowing, the more tillers produced. However, some early maturing types (wheats in particular) have limited tillering bred into them. Varieties with winter habit tend to tiller more. Tillering ability can affect total dry matter yield so low tillering varieties should be sown more densely for hay, and high tillering types sown less densely.

Fodder quality

Different cereals appear to be reasonably similar to each other when measured across the main fodder quality parameters. The single most important determinant of quality for cereal crops is time of cutting. This is more important than the class of cereal chosen.

Feedtest™ is a commercial testing service that analyses hay and silage samples across a range of quality parameters. Table 2 shows aggregated Feedtest™ results from 2008–09. When the average results from each cereal are compared, only slight differences are evident across the main quality indicators, with barley hay being slightly better quality.

The results in Table 2 are similar to Feedtest™ averages collected since 2005–06 (not presented) which show small levels of variability between averages of cereal classes and seasons. The data demonstrates that the quality of individual samples within each class can vary significantly (see data range in Table 2), suggesting that individual management and seasonal conditions are more important than the class of cereal grown. There is evidence to suggest hay quality is improved in drought years, possibly because hay is cut earlier and includes less stem content than in normal years.

Key characteristics of the main cereals

There are countless varieties of oats, barley, triticale and wheat available. Tables 3–6 provide a small selection of some of the varieties that may fit within a grazing, hay, silage or grain production system. For varieties not included in the tables, information can be sourced from seed companies or seed merchants.

Oats

Oats can provide large quantities of good quality forage, particularly in the vegetative growth stages. However, its nutritive value declines as the grain begins to form in the head, due to the amount of seed husk compared with other cereal types. In comparison with other cereals, the window for grain harvest for oats is more narrow, due to its tendency to shed grain from the head. So if grain production is required, select a variety suitable for harvesting. Oat varieties suitable for forage are presented in Table 3.

Table 2. Aggregated feed quality data from Feedtest™ analyses 2008–09 (mean value presented first, range of values in brackets)

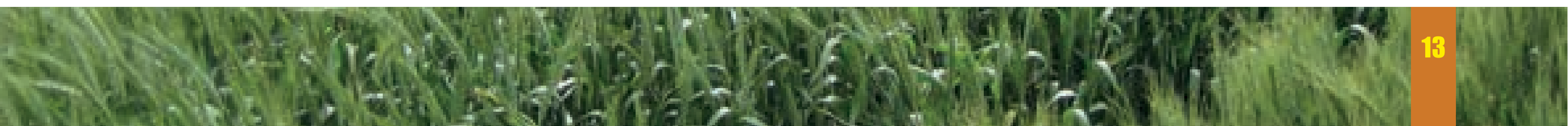
Description	Sample number	Crude protein (%)	Dry matter digestibility (%)	Metabolisable energy (MJ/kg DM)	Neutral detergent fibre (%)
Oaten hay	4846	7.9 (2.9–18.2)	65.9 (41.8–85.5)	9.7 (5.6–13.1)	54.5 (32.1–76.0)
Barley hay	252	11.0 (4.1–25.6)	70.5 (54.7–82.8)	10.5 (6.3–12.6)	49.0 (39.2–64.6)
Triticale hay	102	9.0 (4.0–13.3)	63.8 (51.7–71.9)	9.4 (7.3–10.8)	53.9 (45.6–67.4)
Wheaten hay	1180	10.7 (3.4–18.7)	66.7 (33.2–79.2)	9.9 (4.1–12.0)	52.1 (40.3–77.7)
Cereal/pasture hay	145	8.5 (3.6–20.2)	63.3 (48.4–76.8)	9.3 (6.7–11.6)	54.4 (42.1–73.7)

Source: Feedtest™ website, 2008–09 data. Information based on Feedtest data, derived from samples submitted by clients

Table 3. Key characteristics of selected oat varieties

Oat variety	Release	Maturity	Height	Early growth	Grazing recovery
Coolabah	1967	E	Medium–tall (semi prostrate)	Good	Moderate
Wallaroo	1987	E	Tall	Good	Moderate
Yiddah	2001	E	Tall	Good	Moderate
Bimbil	1993	E–M*	Tall	Good	Good
Bundalong	-	E–M	Tall	Good	Poor
Swan	1967	E–M	Tall	?	Poor
Echidna	1984	E–M	Short	Good	Poor
Yarran	1988	E–M	Medium	Medium	Moderate
Bettong	1992	M	Medium–tall	?	Poor
Cooba	1961	M*	Medium (prostrate)	Slow	Good
Kangaroo	2005	M	Tall	Good	Poor
Mannus	2006	M	Tall (prostrate)	Medium	Good
Marloo	1987	M	Tall	Good	Moderate
Tungoo	2007	M	Tall	Medium	Poor
Wintaroo	2002	M	Tall	Good	Poor
Eurabbie	1998	M*	Short (semi-prostrate)	Good	Good
Graza 50	1994	M–L	Tall	Good	Good
Graza 51	2005	M–L	Tall	Good	Good
Volta	2003	M–L	Tall	Medium	Good
Warrego	1999	M–L	Tall (semi-prostrate)	Medium	Good
Blackbutt	1975	L*	Medium (prostrate)	Slow	Good
Cluan	1988	L#	Medium	Good	Good
Drover	2006	L*	Tall	Medium	Good
Glider	1999	L	Tall	Medium	Moderate
Graza 68	1998	L*	Tall	Medium	Good
Graza 80	2004	L*	Tall	Good	Good
Nugene	2000	L*	Tall	Good	Good
Saia	Brazil	L	Tall	Good	Good
Taipan	2001	L*	Tall	Good	Good
Bass	1998	VL*	Tall	Slow	Good
Enterprise	1993	VL*	Tall	Medium	Good
Esk	1975	VL*#	Tall	Good	Good
Galileo	2006	VL*#	Tall (semi-prostrate)	Good	Good
Gwydir	1998	VL*	Tall (semi-prostrate)	Medium–slow	Good
Lampton	1928	VL*#	Tall	Slow	Good
Moola	1998	VL*	Tall	Good	Good
Nile	1982	VL*#	Medium (prostrate)	Good	Good
Riel	1993	VL*	Tall	Good	Good
Targa	1999	VL*	Tall	Slow	Good

Maturity: * winter growth habit, # vernalisation requirement, VE = very early, E = early, M = mid, L = late, VL = very late
Source: Dale Grey, DPI Victoria, Cobram



Barley

Several barley varieties are suitable as forage types. Because of their relatively quicker maturity, they can be sown later than the other cereals. Forage barley can be sown late (early July) if seasonal and soil conditions allow. Barley is generally less tolerant of acidic soils than wheat. Barley varieties suitable for forage are presented in Table 4.

Triticale

Triticale is a hardy cereal developed from a cross between wheat and rye corn. Triticale can tolerate more waterlogging than the other cereals but not as well as ryegrass pastures. Triticale varieties suitable for forage are presented in Table 5.

Wheat

Wheat is available with many different maturities and end quality characteristics. The best types for grazing, hay, silage or grain tend to be the winter wheats or those with winter habit because they can be sown earlier and produce large amounts of dry matter. If sown early (e.g. March), and with favourable moisture and temperature conditions, growth rates of up to 100 kg DM/ha/day are possible. During the grazing period, average growth rates should be about 30–60 kg DM/ha/day. Wheat varieties suitable for forage are presented in Table 6.

The Winter Crop Sowing Guide, published annually by DPI Victoria, has further information on the key characteristics of cereal varieties.

A note on Plant Breeder's Rights

Most new cereal varieties are covered by Plant Breeder's Rights (PBR), which can make sourcing seed of these varieties from other farmers illegal. Levies are usually payable where grain is produced but this can also apply to hay production. Older varieties like Whistler and Diamondbird wheat can be freely traded and delivered to any buyer. Check the PBR status of seed to understand your commitments.

Table 4. Key characteristics of selected barley varieties

Barley variety	Release	Maturity	Height	Early growth	Grazing recovery	Maximum quality
Dictator	2002	VE	Tall	Good	Good	Forage
Schooner	1983	E–M	Medium	Good	Moderate	Malting
Baudin	2002	E–M	Short–medium	Good	Moderate	Malting
Flagship	2006	E–M	Tall	Good	?	Malting
Gairdner	1998	M	Medium (prostrate)	Good	Moderate	Malting
Urambie	2005	L*	Medium	Good	Good	Feed
Yambla	1998	L*	Short	Good	Good	Feed
Yerong	1991	L*	Short	Good	Good	

Maturity: * winter growth habit, VE = very early, E = early, M = mid, L = late, VL = very late
Source: Dale Grey, DPI Victoria, Cobram

Table 5. Key characteristics of selected triticale varieties

Triticale variety	Release	Maturity	Height	Early growth	Grazing recovery	Stripe rust status	Maximum quality
Monstress	2004	M	Tall	Good	Good	?	Feed
Rufus	2006	M	Tall	Good	Good	MR	Feed
Tahara	1987	M	Tall	Medium	Poor	MR	Feed
Abacus	1992	M–L	Tall	Medium	Poor	MS	Feed
Yukuri	2006	M–L	Medium	Good	Good	MR?	Feed
Crackerjack	2003	L	Tall	Good	Good	MR–R	Feed
Falcon	2006	L	Tall (prostrate)	Medium	Good	?	Feed
Tobruk	2007	L*	-	Good	Good	MR	Feed
Breakwell	2004	VL*	Medium	Medium	Good	S	Feed
Endeavour	2007	VL*	-	Good	Good	R	Feed
Jackie	1999	VL*	Tall	Good	Good	VS	Feed
Maiden	1993	VL*	Tall	Good	Good	?	Feed

Maturity: * winter growth habit, VE = very early, E = early, M = mid, L = late, VL = very late
Stripe rust status: VS = very susceptible, S = susceptible, MS = moderately susceptible, MR = moderately resistant, R = resistant
Source: Dale Grey, DPI Victoria, Cobram

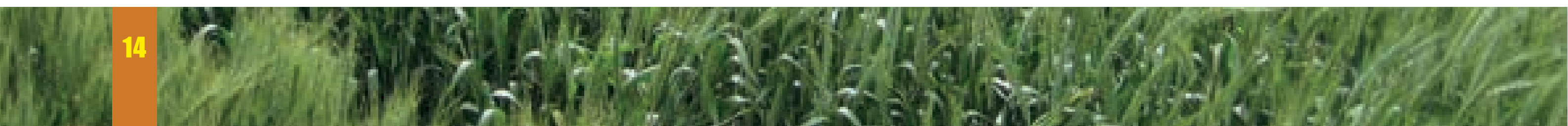


Table 6. Key characteristics of selected wheat varieties

Wheat variety	Release	Maturity	Height	Early growth	Grazing recovery	Stripe rust	Max quality (Victoria)
GBA Hunter	200?	E	Medium	Medium	Poor	R-MR	Feed
Diamondbird	1997	M	Medium	Medium	Poor	MS	AH
Yitpi	2000	M	Medium	Medium	Poor	MR-MS	AH
Chara	1999	M–L	Medium	–	–	MS	AH
Gregory	2004	M–L	Medium	Medium	Moderate	MR	APW
Yenda	2006	M–L*	Medium	Medium	Good	R-S	Biscuit
Wylah	1999	M–L*	Medium	Medium	Good	MS	APW
Currawong	1994	L*	Medium	Medium	Good	MR–MS	Feed
Rosella	1985	L*	Medium	Medium	Good	MR–MS	ASW
Wedgetail	2002	L*	Medium	Medium	Good	MR–MS	APW
Whistler	1998	L*	Medium	Medium	Good	MS	ASW
Wrangler	2007	L*	Medium	Medium	Good	R–MR	Feed
Marombi	2001	L–VL*	Medium	Medium	Good	R–MS	Feed
Naparoo	2008	L–VL*	Medium	Medium	Good	R	Feed
Amarok	2007	VL*#	Medium	Medium	Good	R–MS	Feed
Brennan	1998	VL*#	Medium	Medium	Good	R	Feed
Mackellar	2001	VL*#	Medium	Medium	Good	R	Feed
Rudd	2001	VL*#	Medium	Medium	Good	R	Feed
Tennant	1998	VL*#	Medium	Medium	Good	MR	Feed

Maturity: * winter growth habit, # vernalisation requirement, VE = very early, E = early, M = mid, L = late, VL = very late
Stripe rust status: VS = very susceptible, S = susceptible, MS = moderately susceptible, MR = moderately resistant, R = resistant
Source: Dale Grey, DPI Victoria, Cobram

3 Growing a successful cereal crop

A successful crop depends on good preparation, the right inputs and good crop husbandry throughout the growing season.

Many elements contribute to a successful cereal forage or grain crop. Establishment is the first hurdle, with nutrition, soil health and pest and disease management critical to overall success.

Seed quality

Seed quality can be affected by long-term storage, moisture at harvest or storage, mechanical damage or insect infestation; all significantly reduce germination and establishment rates. Always ask for germination results on purchased seed or conduct a home germination test. Poor germination results mean a higher seeding rate may be required.

Home germination test

- Count 100 seeds
- Leave in moist, rolled paper towel in a dark drawer for 4–6 days
- The number of germinated seeds will give the germination percentage

Seed treatments

Bunts and smuts are fungal diseases that can devastate grain crops because spores grow in place of the grain. The fungi are seed and wind borne, and once a paddock is infected the spores can survive in the soil for many years.

To combat these diseases, use a seed treatment annually on all planting seed. Seed treatments are inexpensive insurance and are recommended for hay crops, as infected heads will make hay unpalatable.

Seedbed preparation

Soil pH

Cereals are tolerant of a wide range of soil pH: 4.5–7.5 (pH_{CaCl2}), although strongly acidic soils (pH_{CaCl2} < 4.5) will cause yield loss and should be avoided. Strongly acidic soils should be treated with lime several months before sowing. Some cereal varieties are more tolerant of moderately acidic soils than others.

Slaking & dispersive soils

Slaking usually occurs in soils that are low in organic matter. Upon wetting, soil aggregates collapse and block the soil pores. When the soil surface dries out an almost impenetrable layer (crust) may form, through which the germinating seed will struggle to emerge. Water infiltration may also be a problem in slaked soils.

The application of organic matter will improve conditions for seedling emergence and growth in soils that are prone to slaking under irrigation or heavy rainfall on bare ground.

Dispersive soils have high levels of sodium. As with slaking soils ,wetting of dispersive soils causes aggregates to collapse and block the soil pores, leading to difficulties with seedling emergence and waterlogging. The application of gypsum may correct the problem and improve the success of seedling establishment.

Saline soils

Cereals have different tolerances to saline conditions. Oats and wheat are generally considered to be moderately tolerant to salt, and barley is usually regarded as the most salt tolerant of cereals. Soil salinity levels over 6 dS/m will result in decreased production.

Saline soils may also be sodic or otherwise poorly structured, making them prone to waterlogging. On such soils, even the most salt tolerant barley may struggle to survive. Waterlogging can reduce the salt tolerance of a specific variety and can affect moisture availability within the soil.

Conventional cultivation

Conventional seedbed cultivation may be recommended in highly compacted soils or soils with hardpan layers to help roots penetrate more easily. Cereals require a much less finely tilled soil than ryegrass, so fewer cultivation passes may be required. Avoid sowing cereals into cloddy soils, as seed to soil contact can be poor and emergence will be hindered.

Cultivation can be an effective weed control strategy, when preparing to sow; however relying on cultivation for pre-sowing weed control can delay sowing due to the time lost waiting for weeds to germinate. In rain fed systems, waiting for weeds to germinate also increases the risk of soils drying out before sowing and could be costly in terms of dry matter production. Cultivation costs more per hectare than minimal or no-till operations.

Direct drilling

Direct drilling is popular with cereal growers. Seed is sown directly into existing stubbles or old pastures, generating less soil disturbance, which is better for soil structure than cultivation. Direct drilling can also reduce soil moisture loss due to evaporation compared with cultivation, which can be valuable if soil moisture is limited during establishment.

For direct drilling to be successful, pre-sowing weed control needs to be effective to give establishing cereals a competitive advantage over weeds. Direct drilling also requires the correct choice of machinery with modern machinery more likely to place seed and fertiliser evenly and at a suitable depth.

Sowing

Seeding rate & plant density

Seeding rate influences plant density, which in turn affects the way water, nutrients and light are shared by plants in the crop.

Crops sown at high seeding rates tend to yield more and present greater risks than crops sown at low seeding rates. A densely planted or highly tillered crop may run out of water before maturity and therefore may be risky in marginal dryland situations or where irrigation is limited. Densely planted crops also restrict airflow, creating a warm moist microclimate within the crop. This may be ideal for the development of cereal diseases, which can reduce quality and yield if left uncontrolled.

High seeding rates may be beneficial for paddocks where weeds are a problem and herbicide use is restricted, as the growing cereal crop may be able to out-compete weeds for nutrients and light.

Optimum seeding rates depend on the time of sowing and the intended end use of the crop. Generally, a higher seeding rate will hasten the time to the first grazing. For an April–May sowing, approximately 80–120 kg/ha of seed is required if the crop is dual purpose and 60–80 kg/ha if the crop is for hay only. Earlier-sown crops (February–March) can be sown less densely because they have a longer time to produce tillers. Later-sown crops (late May–June–July) should be sown more densely to compensate for the reduced tillering time.

Crop establishment is about getting enough plants established to allow the crop to meet feed requirements, be it grazing, hay or grain. Table 7 shows target populations for these end uses, for a mid-May sowing. If sowing is a little earlier, reduce the target population. If sowing is in mid-June, increase the target, e.g. wheat for grain would be 200–250 plants/m^2. Tillering or shoot production is greater when conditions are warm, and reduced when the conditions are cooler. Higher targets are required with grazing as early growth needs to be maximised.

Table 7. Target population (plants/m^2) for cereal crops of different end uses, for mid-May sowing

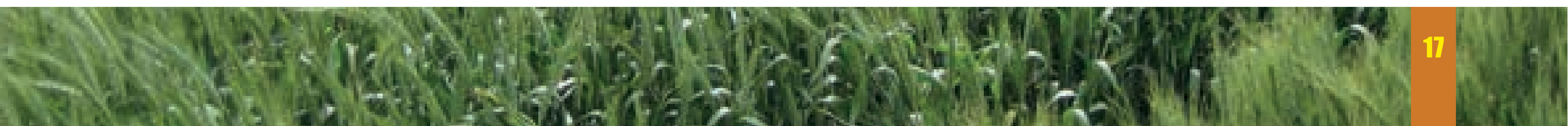
Crop	Target plant population		
	Hay	Grain	Grazing
Irrigated oats	200	180	250
Dryland oats	170	140	200
Irrigated barley	180	140	250
Dryland barley	160	120	200
Irrigated wheat	200	160	250
Dryland wheat	180	140	200

Calculating seeding rate

Seeding rate can be calculated by:

$$\frac{\text{Target plants per metre squared x grain weight of 1000 seeds (grams)}}{\text{Emergence percentage (viable plants per 100 seeds)}}$$

As an example, wheat seed is to be planted in a 400 mm rainfall zone, and the target plant population is 200 plants/m^2, the 100 seed weight is 45 grams and the emergence percentage is 70%.



The seeding rate in this example would therefore be:

$$\frac{200 \text{ plants/m}^2 \times 45 \text{ grams}}{70\%} = 128 \text{ kg/ha}$$

Seed size

Seed size can vary between cereals as a result of finishing conditions. Drought or other stresses can make seeds much smaller than normal, which means the seeding rate can be decreased because there are more seeds per kilogram. Seed size alone can decrease seeding rates by much as 50% in some cases. Conversely, good finishing conditions can increase seed size and may require an increase in rate.

Sowing depth

Sowing depth will depend on seasonal conditions and the species and variety sown. As a general rule, forage cereals should be sown at an average depth of 3–4 cm when soils are moist, or up to 7 cm when chasing moisture. Sowing deeper than 7 cm can affect emergence, while a shallow sowing risks seed desiccation or damage from herbicide uptake.

Row spacing

In general, cereal crops are sown at a row spacing of 15–30 cm. Wider row spacings facilitate trash flow at sowing where stubble is retained, however recent research in north east Victoria suggests that sowing wider than 30 cm can be detrimental to final yield (Nick Poole, Riverine Plains, 2010).

Weed control

Weeds compete with crops for moisture, nutrients and light. Successful forage crop production relies on good weed management, at or before sowing, to discourage early weeds from outcompeting cereals during establishment. Summer weed control also conserves stored soil moisture for use later in the season.

Weeds can be controlled by:

- physical methods such as cultivation, hay making, grazing, burning and mulching
- chemical methods using herbicides
- biological methods using naturally occurring enemies of the weed
- cultural methods such as increasing seeding rates, using narrower row spacings and choosing competitive crops.

Grass weeds can be very problematic in cereal systems because they can host a range of soil borne cereal diseases such as take-all, rhizoctonia, fusarium and pythium. Grasses such as annual ryegrass, while often a key component of pasture systems, can out-compete cereals in the establishment phase and severely reduce yield if plant numbers are too high. Annual ryegrass and wild oats will not cause quality concerns if hay is cut early enough, however other species such as brome, barley and silver grasses are not desirable and should be removed.

In oat crops, post-emergent grass spray options are limited. There are more options for grass weed control in the other cereals but they can be expensive. Ideally, grass weeds should be controlled at the 2- to 3-leaf stage, or in the season before sowing the cereal crop. Because of genetic similarity, there are no control options for barley grass in barley crops, nor wild oats in oat crops. Where these weeds will cause problems, pre-emergent control is the only option.

> **Withholding periods & label directions**
>
> Always check pesticide labels carefully. The label will provide specific directions regarding timing (weed size or crop stage) to ensure pests (weeds or diseases) are removed without damaging the crop. Label rates may differ between states or cereal classes. Understanding plant back and withholding periods for a particular herbicide is also critical. Recent changes to legislation regarding droplet size in applied pesticide spray must also be considered.

In-crop herbicide control of broadleaf weeds is relatively simple with a range of products available. Best control is achieved while weeds are still small (less than 8 cm diameter).

If grain production is an objective, maintaining weed-free paddocks is essential because of the low weed-seed threshold in delivered grain. Consult a professional agronomist or local chemical reseller to obtain information on herbicide selection

Pests & diseases

Many pests and diseases attack crops and can cause yield losses in hay and grain. Cereals are susceptible to a range of fungi, viruses and pests. Fortnightly monitoring will enable quick identification of developing problems. An agronomist will be able to identify pests and diseases causing damage and will advise on the best control method from a range of control options. Control pests when they reach economically damaging thresholds. Beneficial insects may also help control damaging pests.

Soil borne diseases

There are several soil-borne diseases that affect both pasture grasses and cereal crops. Take-all, rhizoctonia and cereal cyst nematodes are common examples. Where these diseases exist in pastures, use a break crop (usually a broadleaf winter crop) to disrupt the disease cycle before planting the cereal.

Stripe rust

Stripe rust has become widespread in wheat and triticale due to a breakdown in genetic resistance. Barley and oats are unaffected by stripe rust. Stripe rust can cause severe grain yield losses and reduce hay quality through the loss of leaf area and leaf sugars, though it won't affect dry matter yield or livestock health.

In wet springs or for irrigated crops, control is recommended for susceptible varieties. This will help maintain yield or quality and will minimise spores spreading to other local crops. Stripe rust can be managed by choosing a resistant variety (it won't require spraying) or by monitoring and spraying a fungicide if the season requires it. Grazing will also reduce the spore load and will open up the crop canopy, reducing infection by improving airflow and decreasing humidity.

Mites

As with pastures, red-legged earth mite and blue oat mite may be a problem in emerging cereal crops. Mites can also be a vector for virus transmission in crops. Keep a lookout for mite damage and control as appropriate.

Fertiliser & nutrition

Nutrition at sowing

Cereal seed is usually sown with small amounts of nitrogen (N) and phosphorus (P) to aid establishment. Most dairy pastures will have good nitrogen and phosphorus reserves as a result of regular fertiliser application, however the phosphorus will be mostly in an insoluble form and unavailable to plants until it is mineralised. Therefore some phosphorus should always be sown with the cereal seed. Soil testing will give an indication of soil reserves of phosphorus and a level of 35–40 mg/kg Colwell P is generally considered adequate for cropping.

Nitrogen and phosphorus are often applied together at sowing in combination (as DAP or MAP) at rates of 60–120 kg/ha depending on paddock fertility. Phosphorus is usually applied in a band below the seed. Avoid applying DAP at rates above 150 kg/ha at sowing as excess fertiliser can burn the germinating seed.

In-crop nutrition

Nutrients are removed from soils when cereals are grazed and/or harvested, and these must be replaced to maintain yields over the years. Table 8 shows the amount of nutrient removed per tonne of grain produced. Table 9 shows the amount of nutrient removed from a 1.0 t DM/ha cereal hay crop.

Table 8. Nutrient removal by grain production (kg/t)

Crop type	Nitrogen	Phosphorus	Potassium	Sulfur
Oats	17	2.5	4.0	1.5
Barley	20	2.7	5.0	1.5
Triticale	21	3.0	5.0	1.5
Wheat	21	3.0	5.0	1.5

Table 9. Nutrient removal by hay production (kg/ha for one tonne of dry matter)

Nutrient	Nutrient removed (kg/ha)
Nitrogen	20
Phosphorus	2.0
Potassium	12
Sulphur	1.4

Source: Peverill, Sparrow & Reuter (eds) *Soil analysis interpretation manual* (1999), Table 25.5

Working out the amount of nitrogen required for a grain crop can be approximated by allocating 40 kg of nitrogen for every tonne of grain being targeted. So a 4.0 t/ha grain crop will require 4 x 40 = 160 kg N/ha. This allows for the nitrogen removed in the grain as well as that required to build the roots and stems. Hay will require approximately 20 kg of nitrogen for every tonne of dry matter produced per hectare.

Nitrogen required for crop growth can be obtained from the soil (by mineralisation of organic nitrogen) or fertiliser. Paddocks that have been in permanent pasture for many years often have high organic levels and can yield large amounts of nitrogen to the crop, up to 200 kg N/ha. A deep soil test to 60 cm will give a good indication of available soil nitrogen and can save on unnecessary fertiliser applications.

Cereals can produce excessive or rank growth if too much nitrogen is available early, potentially leading to nitrate toxicity at the first grazing. Too much nitrogen can also lead to excessive tillering, which while good for winter dry matter production, may mean the crop requires large amounts of water during spring. Moisture stress in spring may cause high dry matter crops to hay-off prematurely and quality may be impacted.

Excessive growth may also cause lodging in spring, which can lead to dry matter losses through rotting and make mowing difficult. When paddocks have high fertility, growth can be managed by decreasing the seeding rate or by grazing.

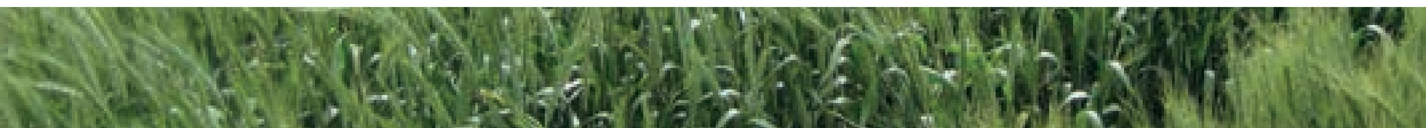
Dark green crops with lots of tillers suggest that the crop has access to large amounts of nitrogen. Pale plants with poor tillering may indicate nitrogen deficiency although yellowing may also be caused by other deficiencies, herbicide damage or pests and diseases.

Timing of in-crop nitrogen applications

Deep soil nitrogen testing is *always recommended* to determine the value of in-crop nitrogen applications. If soil tests indicate that nitrogen is not excessively high, a topdressing of 50–100 kg/ha of urea or 20–40 kg/ha of nitrogen is generally recommended after each grazing to stimulate vegetative growth.

If further nitrogen is required for hay or 'grain only' crops, then it is ideally applied at the start of stem elongation, when there are one or two nodes visible on the plant. This is a time when nitrogen is most efficiently converted into hay or grain yield. Later applications of nitrogen (around flag leaf emergence) may increase grain yield slightly, but are more likely to improve protein content.

In rain fed systems or where irrigation is not assured, applying nitrogen in a large dose early in the season is not recommended. As well as being potentially dangerous for animal health, it also commits an expensive application at a time when little is known about the prevailing rainfall pattern. A dry season may see nitrogen wasted because plants don't have enough moisture to maximise uptake or the plants may grow excessively in response to abundant nitrogen and hay-off prematurely.



4 When to sow

Sowing time will be guided by soil temperature and moisture, and combined with variety, all will influence the end use of the crop.

The ideal sowing date will depend on soil temperature, moisture, irrigation availability, varietal choice and the intended end use of the crop.

Soil temperature

Wheat, barley and triticale germinate best in soils with a temperature range of 15–25 °C (average 24 hour temperature). If soil temperature is higher, poor germination (10–50%) may occur. Soil temperature above 20–25 °C can cause a shortening of the coleoptile, which can reduce emergence when the seed is sown too deep. This can be compensated by a shallow sowing depth but shallow sowing may expose the germinating seed to desiccation.

Oats can be sown at slightly higher soil temperatures than the other cereals. Queensland DPI research from 1992 suggests that oat varieties such as Echidna, Saia, Taipan and Cluan may still have 80% germination at soil temperatures up to 30 °C but Mortlock and Algerian may have germination rates as poor as 10% or 50%, respectively, at 30 °C. This suggests a genetic link for tolerance to high soil temperature and highlights the value of understanding individual varieties (Radford *et al*, 1993).

The temperature tolerance of a range of locally adapted cereals was investigated by DPI Victoria (Table 10). All cereals showed a reduction in germination rate at the maximum average March daytime and night-time temperatures, with notable differences between varieties.

Table 10. Germination results from growth cabinet treatments set at maximum average temperatures for March: 32 °C for 12 hours (daytime) and 17 °C for 12 hours (night-time)

Cereal	Variety	% germination
Oats	Outback	0
Barley	Urambie	50
Triticale	Endeavour	69
Wheat	MacKellar	56
Wheat	EGA Wedgetail	89

Source: DPI Victoria, Kerang, & VICC, 2009

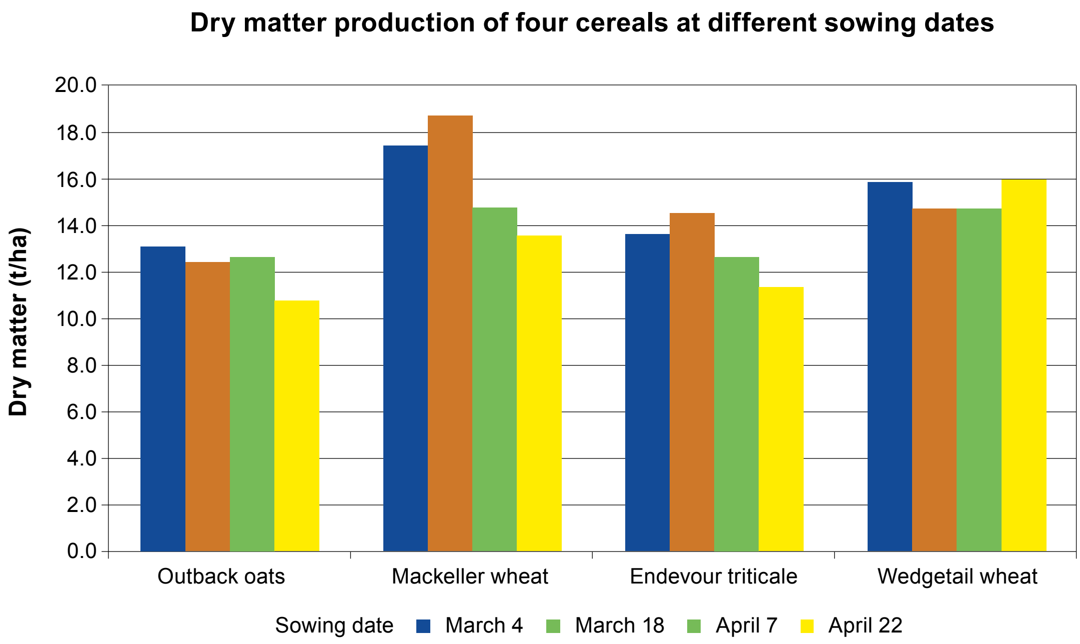


Figure 1. Dry matter production for cereals at four different sowing dates at the VICC & DPI trial block at Kerang. Source: Damian Jones, DPI Victoria, Kerang, 2009

A follow-up experiment showed that Graza 51, Mulgara and Outback oats, and MacKellar wheat were more sensitive to increasing maximum and minimum temperature and had significantly reduced germination percentages, between 27 and 32 °C (DPI Victoria, Kerang, 2010).

While early sowing (February and March) of some oat varieties is possible in northern Victoria, the likelihood of high soil temperature and dry conditions increases the risk of crop failure without irrigation.

How early can a cereal be sown?

The earlier the crop is sown, the higher the total dry matter production. But maximising dry matter production needs to be balanced with the risk of high temperatures and poor follow-up rainfall if irrigation is unavailable.

Annual ryegrass pastures in the irrigation zone of northern Victoria are typically started in early March. A 2009 Victorian Irrigated Cropping Council (VICC) trial at Kerang compared dry matter production of Wedgetail and MacKellar wheats, Endeavour triticale and Outback oats sown on four dates: 4 and 18 March, and 7 and 22 April. All plots were pre-irrigated but only the 4 March sowing required a second watering.

Figure 1 shows varietal dry matter production for varieties for the four sowing dates. The cereals were very competitive for dry matter production (10.0–18.2 t DM/ha). Sowing in March allowed three grazings, while the early April sowing allowed three grazings and the late April sowing one grazing. This trial confirmed that for a grazing cereal crop, sowing in March is ideal if soil temperatures are suitable, though irrigation will generally be required to ensure crop survival. The dry matter totals in this experiment showed little was gained from starting in early March compared with late March, given actual soil temperature was above 25 °C until late March. Delaying sowing until April will reduce the risk of high soil temperatures and increases the chances of having adequate soil moisture without irrigation (which may be important in low allocation years). As this trial demonstrated, sowing in April will produce less dry matter than a March sowing.

The break & sowing strategies

If irrigation is unavailable or limited, then sowing time will probably be guided by the arrival of autumn or winter rains — *the break.*

> The break is often defined as the date from which rainfall is frequent enough to sustain a ryegrass plant for three months.

Sometimes, poor follow-up rains after good rain events in March, April or May and can cause a false break. A false break supplies enough moisture for germination but not enough to keep the seed alive.

The risk of a false break decreases as the year progresses. Table 11 shows the percentage of true and false breaks at Kyabram, and the precentage of true breaks at Berriwillock and Rutherglen from January to July. The data shows that in 16% of years at Kyabram there was enough rain in January to germinate a crop, however a lack of follow-up rain meant that these rains were all subsequently considered false breaks. In contrast, only 7% of rainfall events in May at Kyabram were considered to be false breaks. The break tends to occur earlier at Rutherglen than at Kyabram or Berriwillock, where the break occurs at a similar time.

The chances of germinating and maintaining a crop improves once April is reached because the chance of a rainfall event being a true break has improved. Sowing dry before late April is risky without irrigation because there is a greater chance of a false break.

Most grain growers consider that the planting season commences on Anzac Day.

Dry sowing

Seed is often sown dry if the break has not arrived by mid-May. Growth slows with colder temperatures and decreasing day length, so dry sowing makes maximum use of residual soil warmth when rain does arrive. Generally, dry sowing after Anzac Day is considered acceptable in terms of risk. Grain growers will also dry sow if they have large areas to cover and are doubtful about finishing their sowing program before it gets too wet and cold.

Dry sowing can be risky in the event of small rain events after sowing. Light rains may provide enough moisture for germination, but not be enough for plants to survive until the next rain. Resowing may then be necessary. Losses can also occur with a very large rainfall event following sowing, which may cause the seed to swell rapidly and burst.

Dry sowing is not recommended for weedy paddocks because the opportunity to control weeds after a germinating rain will be foregone. Wheat and barley growers often spray a knockdown herbicide treatment, like a glyphosate + trifluralin mix, immediately ahead of sowing to give better weed control in no-till systems (ensuring the seed is placed below the herbicide layer).

With dry sowing there is a risk that pests such as ants, mice and birds may remove dry seed, particularly if the seed has been in the ground some time.

Pre-irrigation

Pre-irrigation avoids some of the risks of the false break. When water is available pre-irrigation can ensure fodder crops are sown on time to maximise dry matter production.

A pre-irrigation in late March/early April will typically require 1.5–2.0 ML/ha under a flood irrigation system, depending on the amount of summer–early autumn rainfall received and the water holding capacity of the soil. Overhead sprinkler systems will use less water (0.5–1.0 ML/ha) because water can be applied without incurring the deep percolation and evaporation losses of a flood irrigation system.

In most years, pre-irrigation increases dry matter production or grain yields by allowing sowing and germination to occur earlier than would otherwise be possible. This may not be the case in very wet years, or in a wet autumn, where plants may be waterlogged and yield may in fact decline. This was true in a 2010 VICC trial at Kerang when pre-irrigation (with or without spring irrigation) did not give a yield advantage to Hindmarsh or Gairdner barley or Ventura wheat.

After pre-irrigation, seed should be sown as soon as soil conditions allow. This may be as soon as seven days after a 1 April pre-irrigation on lighter soils, through to 3–4 weeks later on some heavy clay soils (*Irrigated winter forages*, DPI Victoria).

Later irrigations (after 1 April) which are then followed by heavy rains can make soils excessively wet. This may delay sowing if the paddock becomes untrafficable, leading to lower potential dry matter production and the deferral of grazing.

In most years, pre-irrigation should be complete by 1 April to avoid soils becoming very wet when April rains arrive.

Watering up

Cereals can be watered up (irrigated up) after sowing, although this is best considered in March when soil temperatures are below 25 °C and soils are still dry. Avoid watering up if rainfall is forecast in less than two weeks' time because seeds are more likely to become waterlogged or burst if the soil becomes excessively wet. Watering up in April is considered risky because of the increased chance of waterlogging from rain. Oats are a little more adapted to watering up than wheat or barley.

For watering up to be successful, choose paddocks with few weeds and good soil structure. Irrigation bays should be well laid out and have good drainage to ensure water is on and off in under eight hours. Soils prone to crusting or slumping may form a hard layer over the germinating seed, preventing the

Table 11. The percentage of years that true and false breaks occur in the months January through to August, at Kyabram, Berriwillock and Rutherglen

Month	Kyabram (% of years 1886–2010)			Berriwillock (% of years 1899–2010)		Rutherglen (% of years 1913–2010)	
	False breaks	True breaks*	Cumulative true breaks	True breaks*	Cumulative true breaks	True breaks*	Cumulative true breaks
January	16	0	0	-	-	-	-
February	18	1	1	-	-	-	-
March	18	7	8	11	10	31	32
April	8	23	31	25	32	28	60
May	7	40	70	46	73	27	86
June	2	24	94	24	95	10	98
July	1	6	100	5	99	2	100
August	-	-	-	1	100	-	-

*True break defined as adequate soil moisture following germination to maintain plant growth for a minimum of three months
Source: Kevin Kelly (DPI Victoria, Kyabram) & Dale Grey (DPI Victoria, Cobram)

seed from pushing through to the surface. Sow less than 25 mm deep to avoid waterlogging the seed, and ensure irrigation takes place quickly and that water does not pond in the bays.

Watering up can produce more grain per millimetre of applied water compared with pre-irrigating. This is because a smaller proportion of the water applied is lost as soil evaporation, so more is available to contribute to crop growth.

Time of sowing

Varietal & end use considerations

Even if soil moisture and soil temperature are ideal, the time of sowing can be constrained by varietal choice and the intended use of the crop. While an earlier sowing can lead to higher potential dry matter or grain production, sowing an unsuitable variety too early can cause heading at the wrong time of year or expose a grain crop to frost damage. To maximise production and ensure the crop meets its intended end use, individual varieties should be sown within their recommended planting window (Table 12 and Section 2).

Cereals should only be sown in March when either multiple grazings are intended, or 'grazing plus hay' or fodder conservation is intended.

A cereal crop sown in March for hay, silage or grain production only, would produce too much vegetative matter early on, and then die before the spring hay making season. Because plants take time to recover from grazing, sowing in mid to late June or July restricts crop use to either 'grazing only' (or multiple grazings into the ground), or hay , silage or grain production only.

Table 12 is a list of a range of current oat, barley, wheat and triticale varieties and their recommended planting times. This list is not a complete list of options. For further information and additional varieties, consult DPI Victoria's crop sowing guides.

Managing frost damage

Sowing a variety earlier than its recommended sowing window increases the risk of frost damage and yield loss when the crop is intended for grain.

While cereals are sensitive to frost damage at several growth stages, cereals are especially vulnerable at the flowering stage. The anthers of the flowering head carry pollen and allow fertilisation and development of the grain. The anthers are easily damaged by frost, preventing grain forming within the floret. Frost damage may be limited to just a few florets within the head or it may affect the entire head.

Frost damage usually affects crops in low lying areas but even a mild frost in higher areas can cause significant yield loss. Severe frosts may cause yield loss over a wide area.

Severely frosted crops can be salvaged for hay, however making good quality hay requires early detection of damage. Often, frost damage is not noticed until grain fill is almost complete, when the empty florets in the head are more obvious. At this stage, the crop may require immediate cutting to preserve feed quality, which can have logistical problems with contractors or weather. Late detection means that the crop may already be past its prime for hay, and the resulting hay quality may be poor.

If a heavy frost occurs around flowering (the pale yellow anthers which are 3–5 mm in length will be visible on the outside of the head after flowering), monitor for progress of grain development and if unsure of the extent of frost damage or if grains are developing normally, seek advice. See also the GRDC publication *Back pocket guide to frost*.

Frost injury can occur in grazing crops, particularly if the crop is only a few centimetres high and the soil is loose and dry. Under severe frost conditions, stock should be removed from the crop each night because the growing point of the plant can be damaged by the trampling of frost-covered leaves.

Table 12. Sowing time guide for oats, wheat, barley and triticale in northern Victoria, based on end use of crop.

		Potential fodder use based on sowing time					Optimum sowing time for grain only														
Maturity	Variety	March	April	May	June	July	April				May				June			July			
Oats: north central (dryland)																					
Very late	Blackbutt, Galileo	grazing + silage or hay	grazing +/or silage or hay	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay				>	✓	✓	✓	✓	✓	✓	✓	<	<	<	
Late	Taipan, Saia, Glider, Graza 50	grazing + silage or hay	grazing +/or silage or hay	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay				>	✓	✓	✓	✓	✓	✓	✓	<	<	<	
Mid	Wintaroo, Marloo, Kangaroo	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay				>	✓	✓	✓	✓	✓	✓	✓	<	<	<	
Early	Wallaroo, Yiddah, Swan	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay				>	>	✓	✓	✓	✓	✓	✓	<	<	<	
Early	Milling – Echidna, Euro, Mitika, Possum, Yallara Feed grain – Potoroo, Quoll	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay					>	>	✓	✓	✓	✓	<	<	<		
Oats: higher rainfall or irrigation																					
Very late	Enterprise, Blackbutt, Gwydir, Galileo, Nile, Esk	grazing + silage or hay	grazing +silage or hay	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay				>	✓	✓	✓	✓	✓	✓	✓	<	<	<	
Late	Taipan, Saia, Glider, Graza 50	grazing + silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay				>	✓	✓	✓	✓	✓	✓	✓	<	<	<	
Mid	Wintaroo, Marloo, Kangaroo	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay				>	✓	✓	✓	✓	✓	✓	✓	<	<	<	
Early	Wallaroo, Yiddah, Swan	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay				>	>	✓	✓	✓	✓	✓	✓	<	<	<	
Early	Milling – Echidna, Euro, Mitika, Possum, Yallara Feed grain – Potoroo, Quoll	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay				>	✓	✓	✓	✓	✓	<					
Wheat: north central (dryland)																					
Late	Bolac, Rosella, Yenda	grazing + silage	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay				>		✓	✓	✓	✓	✓	<				
Mid	Annuello, Barham, Catalina, Chara, Clearfield JNZ, Correll, Derrimut, Drysdale, Frame, Gladius, Guardian, Janz, Lincoln, Livingston, Peake, Ruby, Sapphire, Yitpi	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay						>	✓	✓	✓	✓	<	<			
Early	Axe, Ventura, Wyalkatchem, Young	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay							>	>	✓	✓	✓	✓	<	<	
Wheat: higher rainfall or irrigation																					
Very late	McKellar, Rudd, Tennant	grazing + silage or hay	grazing + silage or hay	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay	✓	✓	✓	<											
Late–very late	Brennan	grazing + silage or hay	grazing + silage or hay	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay	✓	✓	✓	✓	✓	<									
Late	Rosella, Wedgetail, Whistler	grazing + silage	grazing + silage or hay	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay	>	✓	✓	✓	✓	✓	✓	<							
Mid–late	Bolac, Chara, Gregory, Sentinel, Yenda	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay			>	✓	✓	✓	✓	✓	<	<					

Maturity	Variety	March	April	May	June	July	April				May				June			July			
Early–mid	Annuello, Barham, Bowie, Catalina, Clearfield JNZ, Diamondbird, Drysdale, Guardian, Janz, Lincoln, Pugsley, Ruby, Scythe, Yitpi	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay				>	✓	✓	✓	✓	✓	<					
Early	Ventura, Wyalcatchem, Young	grazing only	grazing + silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay							>	✓	✓	✓					
Barley: north central (dryland)																					
Mid–late	Gairdner	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay				>	>	✓	✓	✓	✓	✓	<	<			
Early–mid	Buloke, Flagship, Schooner, Vlamingh, Sloop, Sloop Vic, Sloop SA	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay						>	>	✓	✓	✓	<	<			
Early	Hindmarsh	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay					>	✓	✓	✓	✓	✓	✓	✓	✓	<	<
Early	Barque, Fleet	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay					>	>	>	✓	✓	✓	✓	<	<		
Very early	Keel	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay							>	>	✓	✓	✓	✓	✓	<	<
Barley: higher rainfall or irrigation																					
Mid–late	Urambie, Gairdner,	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay		>	>	✓	✓	✓	✓	✓	<	<					
Mid	Baudin	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay					>	>	✓	✓	✓	✓	<	<			
Early–mid	Buloke, Flagship, Schooner, Sloop, Sloop Vic, Sloop SA Vlamingh	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay							>	>	✓	✓	✓	<	<		
Early	Hindmarsh	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay						>	✓	✓	✓	✓	✓	✓	<	<	
Early	Barque, Fleet	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay							>	>	✓	✓	✓	✓	<	<	
Very early	Cowabbie, Keel	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay						>	>	✓	✓	✓	✓	✓	✓	<	<
Early forage	Dictator, White stallion, Moby	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay															
Triticale: north central (dryland)																					
Late	Tobruk, Falcon, Crackerjack	grazing + silage or hay	grazing +/or silage or hay	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay					>	>	✓	✓	✓	✓	<				
Mid	Credit, Hawkeye, Jaywick, Kosciuskco, Rufus, Tahara, Tickit, Treat	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay					>	>	✓	✓	✓	✓	<				
Early	Speedee	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay						>	>	✓	✓	✓	<				
Triticale: higher rainfall or irrigation																					
Very late	Jackie, Endeavour, Breakwell	grazing + silage or hay	grazing +/or silage or hay	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay	✓	✓	✓	✓	✓	✓	<								
Late	Abacus	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay				>	✓	✓	✓	<	<						
Mid–late	Credit, Hawkeye, Jaywick, Kosciuskco, Tahara, Tickit, Treat, Rufus	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay					>	✓	✓	✓	<						
Early	Speedee	grazing only	grazing or silage	grazing +/or silage or hay	grazing +/or silage or hay	grazing or silage or hay						>	✓	✓	✓	<					

Source: DPI Victoria Winter Crop Summary, 2010

5 Irrigation issues

Suitable irrigation infrastructure and good irrigation management is essential for a successful irrigated cereal fodder crop.

Cereals dislike waterlogging, so having suitable irrigation infrastructure is essential. Bays should be designed to ensure that water drains away quickly and does not pond, as this can lead to yield penalties or crop losses. Avoiding waterlogging is particularly important on saline sodic or poorly structured soils. On such soils, even the most salt tolerant barley may struggle to survive. Waterlogging can reduce the salt tolerance of the plant and affect moisture availability within the soil.

> The slope of a border check bay should be less than 1:1250. Water should be on and off the bay in under eight hours.

The quality of irrigation water in northern Victoria is generally good. With good management and good layouts, there may be little impact when using irrigation water with salinity over 1500 μS/cm (1000 ppm). However, if the salt content of irrigation water approaches 3000 μS/cm (2000 ppm) some yield loss can be expected, assuming deep drainage of approximately 10% of the applied water (irrigation plus rainfall) and no saline water table (see *Irrigated Winter Forages*, DPI Victoria). If saline water is suspected, arrange to test a sample with an EC meter.

Irrigation management

Successful irrigated cereal crop production (forage or grain) depends on maintaining a readily available supply of soil moisture. Stretching irrigations out too far will place the crop under significant water stress, causing plants to 'shut down' metabolically. This reduces their potential growth and lowers water use efficiency of any water that may be applied afterwards. Irrigating too frequently increases water losses due to deep percolation and runoff and can cause crop loss through waterlogging.

Autumn irrigation

The number of irrigations required for cereals is generally lower than for ryegrass because cereals have a deeper root system to access water at depth. Early-sown grazing cereals will generally require one or two autumn irrigations of 0.5–1.0 ML/ha each, depending on rainfall.

Experience suggests two or three irrigations will be required for an early March start-up, one or two irrigations for a mid to late March start-up and a single irrigation for an early April start-up.

A fully irrigated crop may require two or three irrigations in spring, on top of autumn irrigations. By comparison, ryegrass pastures may need as many as seven autumn irrigations for an early February start as well as one to four spring irrigations.

Where water availability is limited in autumn, delaying sowing until May or later (depending on the break) may be the preferred strategy because it reduces the total number of irrigations required.

> **Irrigating in warm weather**
>
> If soil temperature permits sowing in February or March, take care when irrigating in warm conditions (over 25 °C). Cereal crops that haven't yet reached canopy closure are not able to shade irrigation water effectively and the water may become warm enough to 'cook' the plants.

Spring irrigation

The stem elongation phase (the beginning of the reproductive phase) is when cereals start to accelerate growth and the demand for water increases. This often coincides with the first seasonal delivery of irrigation water, making it possible for farmers to meet the increasing moisture needs of the crop.

Crops with high yield potential will have a higher moisture demand because they will have more vegetation to maintain. Moisture stress in spring will cause more loss in paddocks with higher yield potential than those with lower yield potential.

Monitoring & scheduling

Determining the best time to irrigate can be difficult without some method of soil moisture monitoring. Soil moisture monitoring equipment (such as tensiometers, gypsum blocks, neutron probes and gophers) can identify moisture stress in crops that show no outward signs, making them especially valuable for scheduling. Monitoring equipment should monitor the whole root zone (generally down to 60 cm) to provide as much information as possible.

As a general rule, the level of moisture in the root zone should be kept above 50% of the plant available water (PAW) to minimise plant stress. Once plant available water falls below 50%, plants use a lot of energy extracting the remaining moisture from the soil and this means less energy is available for growth.

> Moisture in the root zone should be kept above 50% of plant available water (PAW) to minimise plant stress.

If moisture monitoring equipment is not available, a simple method for scheduling irrigations (after the first irrigation in autumn or spring) involves determining when the cumulative evaporation less rainfall interval reaches 75 mm on grey soils and 50 mm on red soils. Daily evaporation rates are available from the Bureau of Meteorology website: www.bom.gov.au

If water is being applied using a centre pivot or linear irrigator, a soil water potential reading of -60 kPa at a depth of 15 cm appears to be a simple indicator of when to irrigate wheat for maximum yield in the southern Riverina, irrespective of soil type (North *et al*, 2009).

Leaf wilting — visible moisture stress

Wilting is caused by loss of water pressure (turgor) in plant cells. Lower leaves lose turgor sooner than upper ones, and flag leaf rolling also occurs in many varieties at the onset of water stress.

> To do a quick assessment for moisture stress, bend (not crush) a leaf on a plant. The leaf of a well-watered plant will quickly regain its original position while a leaf on a severely water-stressed plant will remain limp.

Irrigation scenarios

The benefit of irrigating a crop and the potential return from irrigation will vary with the availability of water, seasonal conditions and the potential of the crop. The next sections discuss when to apply water for maximum return.

Irrigation water is plentiful

If there is plenty of irrigation water available, irrigation scheduling is guided by crop demand. However, the value of water will also influence the decision to irrigate.

The year is very dry

In a very dry year or when grazing has set the crop back, a winter watering at the start of stem elongation will stimulate growth and may help the crop survive until the next rain. This could be valuable when feed is short or the rain outlook is very poor.

Irrigation water is limited

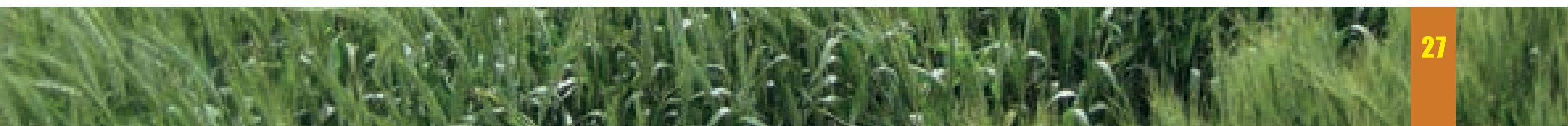
When irrigation water is limited, or water is very expensive, the decision to irrigate is complex because the frequency and timing of irrigation will depend on the variety sown, the end use of the crop, the prevailing seasonal conditions and the value of water.

If irrigation supply is limited, there may be only one opportunity for spring irrigation for hay or grain production. In this situation, irrigating during the late stem-elongation phase when the head starts to swell in the boot (just before heading), could be the most efficient use of a single irrigation as it may keep profitable hay or grain market options open.

At the late stem-elongation stage, a large amount of dry matter is usually added to the crop in a very short space of time. Irrigating with 1.0 ML/ha may double the amount of dry matter production during this period (see Figure 4, page 38, for a typical dry matter accumulation pattern). If water is withheld at this stage and rains fail, dry matter levels may remain low so that hay making or grain production are uneconomical. In this case, salvaging the crop through grazing may be the only option.

Enough water for a second irrigation

If enough water is available and there is reasonable hay or grain yield potential, then a second irrigation at head emergence will help maintain yield if conditions are dry. The combined action of irrigating at the start of stem elongation and at head emergence should result in good hay yields (6–12 t/ha), although a cost



analysis of water will need to determine whether this is actually economical. Because hay cutting usually occurs during early to mid grain-fill, avoid irrigating hay crops too close to flowering as this may make the paddock too wet to access for cutting (see Section 7 for timing of hay cut).

Yield potential at flowering is high

For grain crops (as opposed to hay crops), another critical development point is the flowering stage. Grain size is determined in the 10 days following flowering when grains form and enlarge (Stapper, 2007). Moisture stress during this stage can be very damaging to yield. In a crop intended for grain and where enough water is available, irrigating a grain crop just before flowering will help maximise yield potential.

For grain crops with high yield potential, an irrigation may also be required at the early milk stage to allow good grain fill up to the mid-dough stage. The decision on a final irrigation during grain filling will depend on crop status, water availability and price, recent and forecast rainfall, and the expected price of grain. In very dry seasons up to five spring irrigations may be required to maximise yield potential in grain crops, however the average is usually closer to two or three. For an efficient irrigation system, the average return from irrigation water could be 1.5 tonnes of grain per megalitre supplied to the paddock, that is, 15 kg/ha/mm water applied (Stapper, 2007).

Irrigation & lodging

When a cereal is approaching maturity, a late irrigation or heavy rainfall can cause the crop to lodge. This can make hay cutting more difficult and is also a problem if the crop is intended for grain, as lodging often reduces yields and makes harvesting difficult. Plants that have been grazed tend to be better anchored and resist lodging better. However, varieties differ in their genetic resistance to lodging, so avoid growing varieties that are known to be susceptible to lodging.

6 Cereals for grazing

Understanding crop development, and the influence of variety choice and sowing time, will ensure feed is available when it's needed.

A good understanding of development stages is needed to get the most out of a cereal crop. Understanding the effect of variety choice and sowing time will help ensure feed is available when needed. Knowing when to start grazing and when to finish is vital to optimise production, especially if the crop is to be conserved for fodder or harvested for grain.

When to start grazing

Cereal plants have two root systems. The primary root system is attached to the seed and can grow down to one metre in some soils. The secondary root system grows from the crown (where the plant meets the ground) and supports individual tillers. This is a shallow root system that also anchors the plant to the soil.

Tillering and development of the secondary root system usually start when the plant has four true leaves. Grazing should start after the secondary roots have developed, so the plants are sufficiently anchored in the soil and cannot be uprooted. At the 4- to 5-leaf stage there could be between 0.2–1.3 t DM/ha present. If plants are grazed too early, dry matter production levels will be low.

The right time to introduce stock is when plants are well anchored but before the crop becomes too tall. A tall crop will be prone to uneven grazing and become clumpy due to soiling and trampling. As a result, maturity may occur unevenly affecting crops that are to be later conserved for hay or silage. In general, grazing will be more even with crops that have less dry matter.

Similar to ryegrass, cereal crops need residual leaf matter to recover from grazing. Prostrate varieties should not be grazed below 5 cm, while more erect varieties should not be grazed below 10 cm. Crops that are grazed too hard form bare patches, letting in light and encouraging weed growth.

When to finish grazing

The developing head of the plant must be protected if the crop is to recover after grazing and go on to produce maximum hay or grain yields.

The plant will signal the shift to the reproductive phase (stem elongation) by producing hard swellings on the stem (nodes or joints), which usually begins when the main stem of the plant

Table 13. Effect of grazing on hay yield of irrigated Enterprise oats, sown 17 May 2005, Kerang

Treatment	Simulated grazing yield (t DM/ha)			Hay yield (t DM/ha)	Total production (t DM/ha)
	2 Aug 5-leaf stage	26 Aug 2-node stage	19 Sep 4-node stage	(date cut)	
ungrazed	-	-	-	24.5 (14 Nov)	24.5
1 grazing	1.3	-	-	17.3 (17 Nov)	18.6
2 grazings	1.3	1.17	-	12.8 (22 Nov)	15.3
3 grazings	1.3	1.17	1.4	8.6 (1 Dec)	12.5

Source: DPI Victoria & VICC

has six or seven leaves. The first node will be felt 1.0–2.0 cm from the ground and the developing head will always be positioned above the highest node.

When monitoring the position of the developing head, check the main stem rather than the tillers because node formation begins on the main stem. If the crop has been grazed, the main stem will be the fattest of the tillers, while for an ungrazed crop the main stem will be the longest stem when the plant is stretched out. Alternatively, slice the stem in half with a knife to determine where the head is.

There is usually a grazing window of 4–8 weeks before reproduction is initiated, although this may be longer if the variety is a winter type or has a cold requirement. If a stem with a developing head is removed through grazing, that stem will not be able to produce another head. Given adequate time and good growing conditions, a plant will usually grow more tillers to compensate, however yield penalties can be severe.

It is well established that grazing will lead to a lower total dry matter yield than if the crop was left for hay alone. This is because the plant takes time and energy to recover the growth lost by grazing and often, the growth point is also inadvertently removed by grazing animals. If the growth point is removed then hay yield will be drastically reduced.

Table 13 shows the results of an experiment where an irrigated Enterprise oats crop was grazed past the start of the reproductive phase. The 'hay only' crop yielded 24.5 t DM/ha. A single grazing yielded 1.3 t/ha plus 17.3 t/ha of hay; grazing twice (preserving the growth point) yielded 2.5 t/ha plus 12.8 t/ha of hay; and grazing three times added another 1.4 t/ha to the grazing yield but reduced the hay yield to 8.6 t/ha, causing dry matter production to drop to half that of the 'hay only' crop. This highlights the decreasing level of dry matter production associated with higher frequencies of grazing. This grazing penalty may be reduced with an earlier (February–March) sowing.

Because total dry matter production decreases with each grazing, it is important to assess grazing and hay targets (in combination with sowing date) as a second or third grazing may make hay production uneconomical depending on the time of sowing. A detailed Zadoks Decimal Code is presented in Appendix 1 and describes the various cereal growth stages.

Cereal growth rates

Leaves and tillers emerge at a rate determined by ambient and soil temperatures. Warmer temperatures speed crop growth (though very high temperatures have the opposite effect). The earlier the crop is sown, the more dry matter can be produced, theoretically, because the crop is growing for longer during a warmer part of the year.

If sown early (e.g. March) and soil moisture and temperature conditions are favourable, cereal growth rates of up to 100 kg DM/ha/day can be achieved. During the cooler grazing period, average growth rates may be closer to 30–60 kg DM/ha/day (*Establishing Forage Cereals*, 2008). For situations where moisture may be more limited, the crop growth rate will vary and could be as low as 20–30 kg DM/ha/day in July and 40–80 kg DM/ha/day in August (*Grazing winter cereals in low rainfall regions*, Grain & Graze).

Stocking rates for cereals

Work by Kirkegaard *et al* (2011) suggested that dual purpose cereals can be grazed with about 1000 kg of live animal/ha (e.g. 33 sheep/ha at 30 kg each or 3 cattle/ha at 333 kg each) without much grain yield loss. This should result in about one month's grazing. Excessively high stocking rates may lead to overgrazing and make crop recovery more difficult.

Figure 2 shows that for MacKellar wheat sown across a range of seasons, the number of sheep grazing days/ha ranged from 1000 in a dry season (2006) to 1500 in an excellent spring (2005).

How many grazings?

The number of grazings possible in any given year will depend on sowing date, the maturity type of the cereal, the growth rate at a particular time of year, available soil moisture, nutrition and pest and disease pressures. Each grazing could yield between 0.5–2.0 t DM/ha.

- Long-season or winter habit types started in March may provide three or more grazings as well as a reasonable hay yield (8.0–18 t/ha) if managed appropriately. In all but the wettest autumns, irrigation would be required.
- Crops started with irrigation in early April could potentially produce up to two or three grazings plus a hay crop of 8.0–15 t/ha.
- Crops sown on the break in May should provide at least one grazing, possibly two, however there will be a final dry matter yield penalty associated with grazing. If the effect of grazing on final fodder yield is not to be too great, then the crop really needs to be sown in March or April.
- If green feed is more valuable than hay or grain and the crop is to be grazed into the ground, then three or four grazings would be possible depending on the time of sowing.

Potential risks to stock

Nitrate poisoning

Nitrate poisoning of stock is possible with cereal crops that have been moisture stressed or stressed by frost. Stock grazing 'at risk' crops should be monitored carefully, have alternative food sources available and spend limited time grazing the affected crop until the rumen adjusts.

Applying nitrogen fertiliser too close to grazing can also lead to nitrate toxicity in grazing stock. The risk is increased under cool, cloudy conditions and when stock water has high nitrate levels as well. Cattle seem more susceptible than sheep (Kirkegaard *et al*, 2011). Deferring in-crop fertiliser applications until grazing is finished will reduce the risk of stock poisoning.

Table 14. Hay quality of grazed and ungrazed Dictator barley, Kerang, 2004

Quality parameter	Grazed	Ungrazed
Cut 2 – milky dough (t DM/ha)	9.8	13.6
Moisture (%)	10.7	13.2
Dry matter (%)	89.3	86.8
Crude protein (%)	6.9	6.5
Non detergent fibre (%)	63.6	58.3
Water soluble carbohydrate (%)	7.5	16.1
Digestibility (%)	52.0	56.3
Metabolisable energy (MJ/kg DM)	7.3	8.0

Source: DPI Victoria & VICC, 2004

Nutrient deficiencies

Wheat forage tends to have a high potassium (K) content (3–4% of dry matter) and a very low sodium (Na) content (often <0.02% of dry matter) which results in a very high K/Na ratio. This is important because a very high dietary K/Na ratio can reduce the absorption of magnesium (Mg) in the gut. Magnesium is present in wheat forage at rates only slightly higher than the value required by animals for growth, so sheep or cattle grazing wheat should be supplemented with sodium and magnesium. Supplementation is inexpensive and in grazing trials, has resulted in improved liveweight gains.

Livestock grazing oats or barley do not need mineral supplements, because of the sodium content of these cereals. The sodium content of triticale is variable, and so responses to supplements with triticale have been variable (Kirkegaard *et al*, 2011).

Grazing & hay quality

Grazing does not appear to greatly affect the quality of hay produced, although data is limited. Table 14 shows the results of a 2004 trial looking at quality differences between a grazed

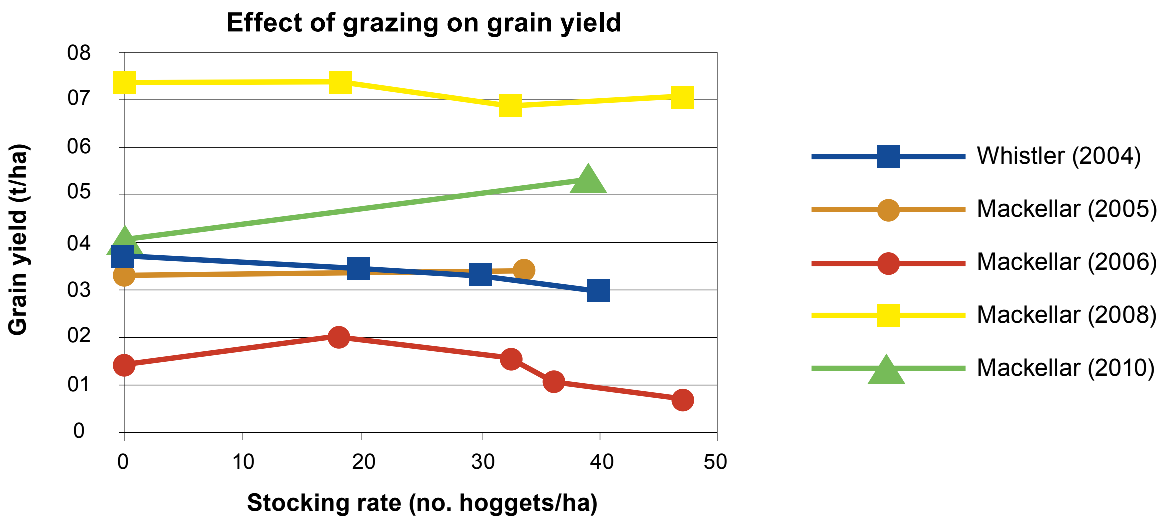


Figure 2. Grain yield (t/ha) of grazing dual purpose wheats when grazed at a range of stocking rates (number of 30 kg Merino hoggets/ha). Source: Kirkegaard et al. *2011.*

and ungrazed barley crop at Kerang. The main difference related to the higher water soluble carbohydrate found in the ungrazed crops compared with the grazed plots.

Grazing & grain production

A grazed paddock may be locked up for grain instead of hay or silage. The grain could be saved for future seed, fed to livestock or sold into another market.

Many cereal varieties have been bred specifically for their ability to recover from grazing to produce grain. The feed quality winter wheats (Brennan, Tennant, Rudd and Mackellar), some milling wheats with winter habit (Whistler, Rosella, EGA Wedgetail) and some triticale and grazing milling oats are examples of true dual purpose varieties. If grain is being grown for the milling market, varietal choice will be additionally important due to differences in grain quality.

Similarly to hay yield, grain yield will also be affected by grazing, though the degree will depend on the maturity type of the variety, time of sowing, grazing frequency, as well as seasonal and other factors.

Table 15 describes the effects of grazing on three different dual purpose cereals grown under irrigation at Kerang in 2005. An early grazing at the 5-leaf stage provided a grazing yield in the range of 0.4–1.4 t DM/ha and recovered to a grain yield between 2.3–5.7 t/ha (stripe rust reduced the grain yield of Whistler). In this example, the grain yield for the single grazing treatment was similar to the ungrazed treatment. Grazing at the 4-node stage provided an additional 2.7–3.9 t DM/ha but removed the growth point, so that grain yields were noticeably reduced. Grazing delayed maturity so that the ungrazed treatments were ready for harvest before the grazed treatments.

The effect of grazing the growing points is further demonstrated in the results of another trial run by VICC and DPI at Kerang in 2006. Table 16 shows that grazing Mackellar wheat at the 2-node stage reduced grain yield by almost 50% because the growth point was removed, however the trade off was nearly 5.0 t/ha of dry matter. For Ventura and Whistler wheats in this trial, grazing did not greatly affect grain yield. Ventura wheat yielded the least of the three. Ventura is an early maturing type which may have been exposed to a frost event at flowering.

The production from a grazed crop that is locked up for grain will depend on the time of sowing, variety sown, access to irrigation water and spring growing conditions. Similarly to hay crops, early sown grain crops will produce more dry matter and will generally have greater grain yield potential than late sown crops. Because grain crops reach maturity later than hay crops they are more vulnerable to hot and dry finishing conditions, which can have a large bearing on yield. Grain crops yield more when the season remains relatively cool, moisture is not limiting and irrigation is generally beneficial. Early sown crops will most likely require irrigation.

- For a crop sown early (i.e. March), three or more grazings may be possible with subsequent grain yields in the range of 1–7 t/ha, depending on finishing and moisture conditions.
- For a dual purpose cereal sown in mid-May, a single grazing will probably only decrease grain yield slightly, compared with an ungrazed crop, if the growing point is protected.
- For a mid-May sowing, a second grazing will probably be uneconomical given cereals (including the winter wheats) will begin stem elongation in late winter/early spring and another grazing will remove the developing head, severely reducing grain yield.
- Sowing earlier will increase dry matter production and increase the number of possible grazings but will probably require irrigation.
- Even after grazing, grain yields of 3–6 t/ha are common under irrigated systems or when spring growing conditions are favourable. Yields will be lower (1–4 t/ha) where moisture is more marginal.
- A single grazing will have a greater negative affect on yield if soil moisture in spring was marginal, or where nutrients or other factors limited growth. The same is true for crops sown later where cold temperatures may slow growth and recovery from grazing may be delayed.

Effect of maturity on grazing potential

Long-season varieties tend to produce more dry matter than shorter-season types, but they can also be more susceptible to haying off at the end of the season if moisture runs out. In contrast, quick-maturing varieties can provide excellent early growth because they have been bred to reach maturity more quickly.

Table 17 shows the trend to increasing dry matter production with increasing maturity, with the longest maturing varieties within each class performing reasonably similarly (Mackellar wheat (16.2 t/ha), Urambie barley (12.7 t/ha), Graza 80 oats (15.2 t/ha), Endeavour triticale (15.7 t/ha) and Tetila ryegrass (12.6 t/ha).

Short-season varieties may reach maturity much more quickly than anticipated, especially in warm conditions. In this example, Rufus and Yukuri triticale reached the stem elongation phase by 24 June and grazing inadvertently removed the developing heads, severely decreasing dry matter production and yield. More careful monitoring would have avoided this.

This trial also showed that the dry matter production at the milky dough stage was two to three times that at booting. Dictator barley sheds its seed at maturity, which explains its low grain yield.

Another trial (Table 18) provides an interesting comparison to that shown in Table 17 because it sown almost a month earlier. The differences in early growth between varieties can be seen by the low dry matter figures for cut 1 in Mackellar wheat and Urambie barley. Their slower early growth meant they weren't quite ready for cutting compared to the other varieties. Waiting several days would have seen dry matter results increased considerably.

This trial also showed that the addition of cereal rye or rye corn (Southern Green) to Mackellar wheat and Urambie barley boosted early dry matter production but had a negative effect on yield. Adding rye corn to Endeavour triticale did not increase early production or decrease grain yield.

Table 15. Grain yield following grazing of Jackie triticale and Mackellar and Whistler wheat, sown 17 May 2005, Kerang. The trial was pre irrigated & had one spring irrigation, total water use 3.75 ML/ha.

Cereal class	Variety	Grazing	Grazing yield (t DM/ha)		Grain yield t/ha
			Cut 2 Aug 1- to 5-leaf	Cut 19 Sep 2- to 4-node	
Triticale	Jackie	ungrazed	-	-	4.5
		1 grazing	1.4	-	4.6
		2 grazings	1.4	3.9	1.3
Winter wheat	Mackellar	ungrazed	-	-	5.0
		1 grazing	0.4	-	5.7
		2 grazings	0.4	2.7	3.1
Winter habit wheat	Whistler*	ungrazed	-	-	2.7
		1 grazing	1.2	-	2.3
		2 grazings	1.2	3.8	0.8

*Stripe rust decreased overall yield
Source: VICC & DPI Victoria, 2005

Table 16. Grain yield and quality following grazing of Mackellar, Ventura and Whistler wheat, sown 5 May 2006, Kerang.

Cereal class	Variety	Grazing	Date cut (growth stage)	t DM/ha	Grain yield t/ha	Screenings %	Protein %
Winter wheat	Mackellar	Grazed	4 Sep (2nd node)	5.0	3.5	5.7	10.8
	Mackellar	Ungrazed	-	-	7.6	10.7	9.8
Early maturing wheat	Ventura	Grazed	28 July (1st node)	1.9	4.3	2.8	11.8
	Ventura^	Ungrazed	-	-	3.9	3.6	12.0
Winter habit wheat	Whistler	Grazed	28 July (6 leaf)	1.4	6.4	2.4	11.2
	Whistler	Ungrazed	-	-	6.0	3.0	12.0

^Ventura is an early-season spring wheat and non-grazed plots matured earliest on site; these plots sustained sparrow damage, leading to lower grain yields.
Source: VICC & DPI Victoria, 2006

Table 17. Dry matter and grain yields of several cereals compared with Tetila ryegrass. Trial sown 9 April 2008 and watered up, at Kerang. Plots grazed when the majority of treatments had sufficient feed, at beginning of stem elongation, booting and milky dough stage.

Cereal class & variety		Grazing yield (t DM/ha)					Total dry matter** (t DM/ha)	Grain yield (t/ha)
		Cut 1	Cut 2	Assessments		Cut 3		
		28 May	24 Jun	Zadok 32*	Booting	Milky dough		
Ryegrass	Tetila	1.4	1.3	0.6	4.5	9.9	12.6	-
Oats	Yiddah	1.4	1.0	1.1	4.5	9.4	11.8	2.5
	Eurabbie	1.1	1.1	1.1	6.3	11.2	13.4	6.5
	Graza 80	1.1	0.6	0.5	3.3	13.5	15.2	3.9
Barley	Dictator	1.4	0.6	0.4	3.6	7.6	9.6	1.7
	Gairdner	1.3	0.9	1.2	3.7	9.6	11.9	5.9
	Urambie	1.2	1.3	1.1	5.1	10.2	12.7	6.2
Triticale	Rufus	1.2	0.8	0.4	-	-	-	-
	Yukuri	1.3	0.8	0.6	-	-	-	-
	Endeavour	1.1	0.8	0.9	4.1	13.8	15.7	6.4
Wheat	Yitpi	1.0	0.7	0.9	2.8	8.2	9.9	4.1
	Wedgetail	1.2	1.2	1.1	4.4	12.6	15.2	5.6
	Mackellar	0.3	0.8	1.0	5.8	15.1	16.2	7.4

* These plots were not cut again, ** does not include Z32 and booting DM assessments
Source: Damian Jones, DPI Victoria & VICC

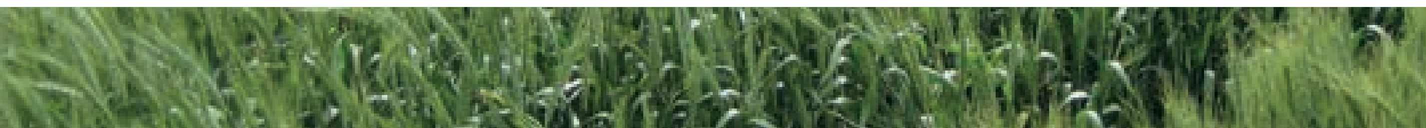


Table 18. Dry matter and grain yields of several cereals compared with ryegrass, trial sown 28 April 2010, Kerang.

Treatment	Dry matter yield (t DM/ha)						Total dry matter (t DM/ha)	Grain yield (t/ha)
	Cut 1 23 Jun	Cut 2* 26 Jul	Cut 3 23 Aug	Cut 4**	Cut 5	Cut 6		
Adrenalin ryegrass	0.1	1.0	1.7	1.2	1.6	0.3	5.9	n/a
Endeavour triticale	0.3	1.1	-	-	-	-	1.4	6.3
Endeavour/rye corn 70/30	0.3	1.1	-	-	-	-	1.4	5.89
Feast ryegrass	0.1	0.6	1.5	1.1	1.7	0.3	5.2	n/a
Mackellar wheat	0.1	0.7	1.6	-	-	-	2.4	
Mackellar early	0.1	0.7	-	-	-	-	0.8	6.3
Mackellar continuously grazed	0.1	0.8	1.6	1.4	1.5	-	5.3	n/a
Mackellar grazed to Z31	0.1	0.6	1.5	-	-	-	2.2	4.4
Mackellar grazed to Z34	0.1	0.7	1.6	1.4	-	-	3.8	1.8
Mackellar grazed to Z49	0.1	0.6	1.6	-	5.1		7.4	n/a
Mackellar grazed to Z 60	0.1	0.7	1.7	-	-	9.8	12.4	n/a
Mackellar + Logran®	0.1	0.5	1.4	-	-	-	2.0	4.6
Mackellar/rye corn 30/70	0.3	0.9	1.3	-	-	-	2.5	2.5
Mackellar/rye corn 50/50	0.3	1.1	1.5	-	-	-	2.9	2.6
Mackellar/rye corn 70/30	0.2	0.9	1.6	-	-	-	2.6	3.3
Outback oats	0.4	1.3	-	-	-	-	1.7	4.5
Rye corn	0.3	1.2	-	-	-	-	1.5	3.7
Urambie barley	0.1	1.1	-	-	-	-	1.2	5.6
Urambie/rye corn	0.2	1.1	-	-	-	-	1.3	3.3
Wedgetail wheat***	0.4	1.0	-	-	-	-	1.4	4.5
lsd	ns	0.21	0.27	0.20	0.52	0.52	-	1.05
cv%	> 20	14.7	10	8	10.6	12.7	-	14.8

* all varieties except Mackellar were only cut twice due to initiation of stem elongation
** subsequent cuts in Mackellar removed the growth point to quantify yield loss of continued grazing rather than grain
*** Wedgetail grain yields were affected by stripe rust

7 Cereals for fodder conservation

A dedicated hay crop can be sown on the break and will use less irrigation water than a crop that is intended for grazing.

The decision on whether to reserve a cereal crop solely for hay or silage can be made during the growing season. If feed is reasonably plentiful in autumn or winter, conserving the entire crop for hay or silage can maximise yields and increase conserved feed reserves for summer and the following autumn. Because a dedicated hay crop does not need to be sown as early as a crop intended for grazing, the crop will use less irrigation water. Hay dry matter production is still proportional to sowing date, but a hay crop can generally be sown on the break with limited yield penalty.

When seasonal conditions are favorable, hay yields can be as high as 8.0–15 t DM/ha in rain fed systems but as low as 2.0–7.0 t DM/ha under more marginal conditions. Recent experience of grain growers with salvaging failed grain crops for hay showed that grain crop yield (t/ha) was roughly half that of crops cut for hay (t DM/ha). Irrigation will further improve dry matter yield potential.

Most hay yield and variety research has focused on oaten hay so there is less information available for other cereal classes. Since 1995, the Rutherglen Research Institute has conducted numerous dryland oaten hay trials and average annual results are shown in Table 19. Rutherglen has an average annual rainfall of 580 mm so yields may be lower in rain fed systems across northern Victoria. The Rutherglen data shows that hay yields of up to 16 t DM/ha have been achieved in good years and yields of 7.0–9.0 t DM/ha have still been possible under drought.

Dedicated irrigated oaten hay trials have been conducted since 2002 by VICC and DPI Victoria at Kerang. Results from these trials show a yield range of 10–18 t DM/ha (Table 20). Annual seasonal conditions and irrigation scheduling will have a large bearing on final yield.

2010 was the wettest season in almost a decade and the 2010 hay variety trials showed the high hay yields that are achievable when water is not limiting (Figure 3). The trial (sown in mid-May) yielded an average of 16.7 t/ha, with the range of 13.0 t DM/ha for Potoroo through to 21.7 t/ha for Wintaroo. In this case, higher yields were not necessarily associated with later maturity.

Table 19. Dryland oaten hay dry matter yields (t DM/ha) at Rutherglen Research Institute

Variety	2000	2001	2002	Long term 1997–02	2004
Marloo	13.7	12.6	7.9	13.6	7.5
Swan	15.1	13.1	8.8	14.3	8.9
Wallaroo	14.3	13.2	7.8	13.7	9.0
Glider	14.6	13.5	8.0	14.0	8.2
Eurabbie	13.2	12.2	8.9	13.5	8.3
Wintaroo	16.0	15.2	8.8	14.3	9.1
Brusher	15.9	12.9	9.2	14.0	9.0
Kangaroo	14.3	15.1	9.5	-	7.6
Sowing date	15/5/00	9/5/01	14/5/02	-	25/6/04

Table 20. Irrigated oaten hay dry matter yields (t DM/ha) at Kerang Trial Block

Variety	2002	2004	2005	2006	2007	2008	2009	2010	average 2004–10
Riel	-	-	15.7	11.5	10.4	17.7	12.4	13.5	13.5
Eurabbie	13.4	15.0	14.4	11.1	12.0	17.4	10.8	17.1	14.0
Kangaroo	-	15.9	15.3	12.1	11.5	16.9	12.4	19.2	14.8
Targa	-	-	13.5	14.2	12.6	15.9	11.4	14.5	13.7
Tungoo	-	14.5	14.6	10.6	11.6	15.7	14.0	15.3	13.8
Glider	14.5	12.7	15.1	14.5	11.3	13.1	12.0	15.6	13.5
Volta	-	-	-	13.3	-	-	-	-	-
Lordship	-	-	-	11.5	-	-	-	-	-
Marloo	15.1	12.9	14.9	-	-	-	-	-	-
Swan	10.1	11.8	-	-	-	-	-	-	-
Wallaroo	12.0	13.3	14.5	-	-	-	-	-	
Wintaroo	12.7	12.1	12.8	-	-	-	-	-	-
Brusher	-	12.9	-	-	-	-	-	-	-
Sowing date	6/5/02	20/5/04	6/6/05	23/5/06	28/5/07	23/5/08	-	10/5/10	-

Source: Dale Grey & Damian Jones, DPI Victoria & VICC

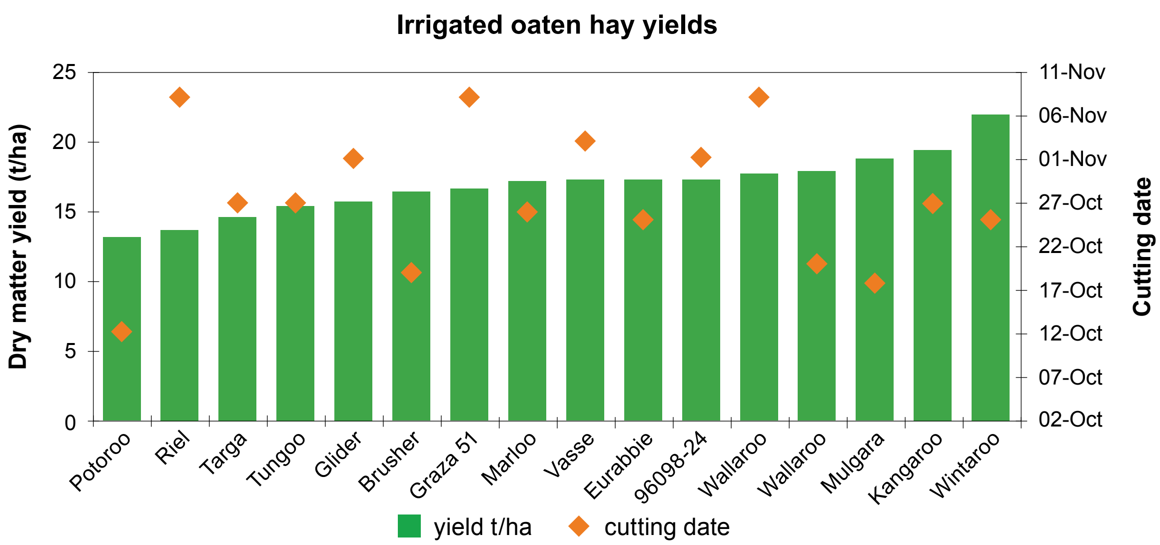


Figure 3. Yields of irrigated oaten hay variety trial, 2010, Kerang Trial Block

Table 21. Time of cutting for four maturity types of oats

Location	Year	Sowing date	Maturity type			
			Early	Mid	Late	Very Late
Rutherglen	1995	3 May	24 Oct	30 Oct	6 Nov	15 Nov
	2000	15 May	23 Oct	30 Oct	16 Nov	—
	2001	9 May	15 Oct	22 Oct	4 Nov	—
Kerang	2002	6 May	24 Sep	4 Oct	18 Oct	—
	2004	20 May	11 Oct	20 Oct	2 Nov	—
	2005	6 Jun	27 Oct	27 Oct	11 Nov	17 Nov
	2006	23 May	—	16 Oct	30 Oct	4 Nov

Source: Rutherglen Research Institute mobile unit and DPI Victoria, Kerang, & VICC

Maturity type & time to cutting

Varieties of different maturity type will take different times to reach physiological maturity. Table 21 describes the approximate time to hay cutting for the four different maturity types of oats. There is roughly a 7-day gap between readiness for hay cutting (milky dough stage) between early, mid and late-maturing varieties, sown on the same day in mid-May; though the actual time to cutting will be influenced by seasonal conditions, as well.

For a mid-May sowing, an early type will generally be ready for cutting in early to mid-October, a mid-maturing type in mid-October and a late type in late October. The difference in maturity will be more pronounced if the crop is left for grain. Grazing will delay maturity.

For a late sowing (e.g. June), the differences in time to cutting will be lessened because all varieties have less time for vegetative growth and all will respond to increasing spring temperatures, narrowing the gap between cultivars.

As described in Section 2, early sowing (February–April) may cause early or mid-maturing wheats to run up to head prematurely in winter, making them unsuitable for hay or grain production. Early sowing for hay should be restricted to varieties that have a vernalisation requirement or a winter habit.

Optimising hay quality

The optimum cutting time for oaten hay is highly dependent on the intended quality of hay. A high quality product will require some yield sacrifice, while maximising yield will mean sacrificing quality.

To illustrate the effect that cutting time has on dry matter production and the quality of cereal hay, a crop of irrigated Marloo oats (a multipurpose, mid-maturity variety) was followed from sowing (09/06/2005 at Kerang) through the various stages of maturity. Samples were taken at a range of maturity stages (Table 22) and sent to Feedtest for quality analysis. The oats were pre-irrigated and then irrigated once in late September (total water applied was 3.75 ML/ha).

Figure 4 shows the increase in dry matter production as the crop matures and a corresponding decrease in hay quality. From the 4th node stage (1st cutting date) until the watery ripe stage (4th cutting date) there was a tripling of the total dry matter present although quality — digestibility, metabolisable energy (ME) & crude protein (CP) — declined during this period. Quality was highest at 4th node stage (Z34) when plants were still leafy and the stem was not too lignified or tough. The hay cut at this stage had a metabolisable energy of 11.3 MJ/kg, crude protein of 18.6% and digestibility of 75%, meaning the hay was good enough for weight gain in most livestock.

Traditionally hay is cut at the milky dough stage, but hay cut at this point showed a considerable decline in quality compared to hay cut at the 4th node stage. Delaying cutting reduced metabolisable energy to around 8 MJ/kg, crude protein to 8.3% and digestibility to 56% (though samples were cut at ground level which meant more of the relatively indigestible lower stem and more dry matter was sampled than normal). The results confirm that high quality oaten hay is best cut early, though there will be significantly less yield (t DM/ha) at this stage.

The highest quality hay will be cut between booting and ear emergence.

There is little point in cutting earlier than the watery ripe stage if the hay is intended for "bulk" to fill stock up and waiting for grain fill will not improve hay quality. These results confirm that the ideal conservation time for oats is between the booting and ear emergence stages, as the digestibility of oats falls rapidly from booting onwards.

For wheat and barley, the highest quality hay will also be cut between booting and ear emergence. Delaying wheat and barley hay cutting until the soft dough stage will yield more hay but it will be of a lower quality compared with that cut earlier. Digestibility of wheat and barley hay declines rapidly after

Table 22. Cutting dates for quality analysis of Marloo hay

	Growth stage at cutting	Zadoks scale rating	Date
1	4th node	Z34	16 September
2	First florets visible	Z49	30 September
3	Flowering	Z65	14 October
4	Watery ripe	Z72	28 October
5	Milky dough	Z75	4 November
6	Early dough	Z83	11 November

the booting stage (similar to oats), but then increases slightly during the early stages of grain-fill (the flowering to the soft dough stage), before declining again. Wheat and barley should not be conserved at the flowering to early milk stage as quality and palatability are low (*Irrigated Winter Forages*, 2004).

Hay making — avoiding stack fires

Making hay from cereals requires attention to the same principles as making other types of hay. Although this guide does not detail the specifics of hay making, it is worth noting a large number of hay stack fires are caused by cereals being baled at high moisture content. Because of their relatively larger stems, cereals can take much longer to cure than grass. While a cereal crop may appear to meet the 'crank test' for hay and seem brittle enough for baling, deceptively high amounts of moisture may be present in the nodes along the stem. Smashing the nodes will determine if moisture is still present. Alternatively, conduct an oven drying test to determine moisture content or use a hand held moisture meter as a guide.

To aid drying of cereal crops, consider raking, conditioning or super-conditioning, particularly when rain is forecast or in cool, cloudy weather.

Recommended levels of moisture for baling cereals

- Large bales: 12–14%
- Round bales: 13–16%
- Small square bales: 16–18%

Source: DPI Victoria Agnote 1356 (2008)

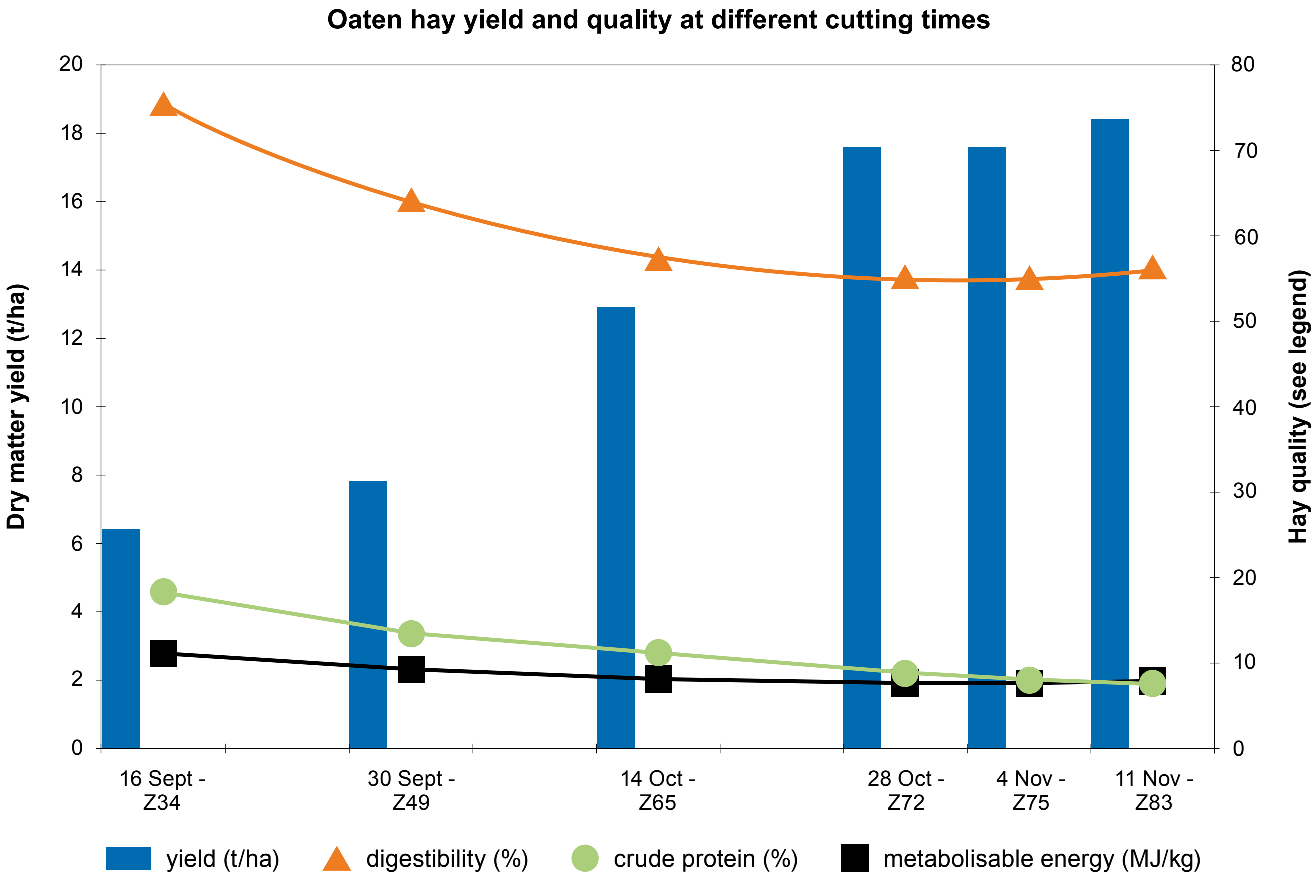


Figure 4. Yield and quality of oaten hay samples cut at six different times from 16 September through to 11 November.

8 Cereals for grain production

If feed supplies are ample or grain prices attractive, a fodder crop may be kept for grain with only little extra management.

In the event that cereal fodder has become surplus to needs or grain prices are much more attractive than hay or silage prices, a crop may be kept for grain instead of conserving the crop as forage. A late switch to grain does not require much additional management, providing varietal choice is suitable, weeds and diseases have been kept in check and the potential grain yield makes harvesting economical.

Access to harvesting equipment and reliable advice is critical if grain harvesting is being considered for the first time.

Grain yield

Grain yield is significantly affected by nutrient and moisture availability during the growing season. Severe moisture stress and heat during grain fill can cause heads to tip off (go white and abort grains). Moisture stress is often indicated by limp crops, leaf rolling and leaf tipping, or leaf loss in lower leaves and decreased growth rates. Severely moisture-stressed crops may not be a viable grain option and may need to be salvaged for hay.

Dryland grain yields can be as high as 4.0–6.0 t/ha in good conditions or less than 1.0 t/ha under severe drought. Irrigated grain yields can range from 4.0–8.0 t/ha. Table 23 shows predicted grain yields (not grazed) from dryland trials, 2000–2009, in the north central and north eastern areas of Victoria. The effect of long-term dry seasonal conditions is reflected in the low average yields.

Harvesting grain from a hay crop

If the season and/or markets are favourable, a cereal crop planned for hay could be grown out for grain. This will require some additional management.

If the season is warm and moist, additional fungicide may be needed to protect the developing head, particularly from stripe rust. A late irrigation may be necessary where water is available to maximise yield (see Section 5 for timing recommendations). If grain yield is to be maximised and grain protein is important, additional fertiliser may be required. Grain crops require about 40 kg N/ha for each tonne of grain targeted.

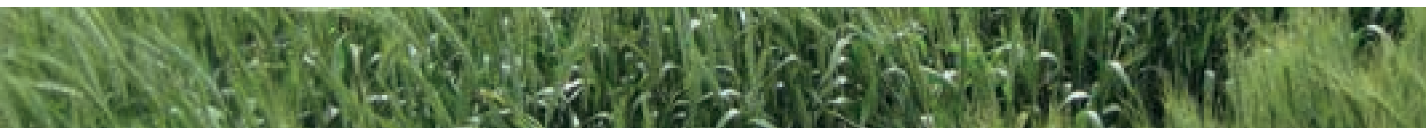


Table 23. Predicted cereal grain yields (t/ha) for main season dryland crops, 2000–2009.
The figure in brackets is the number of years the variety has been in trials in the area.

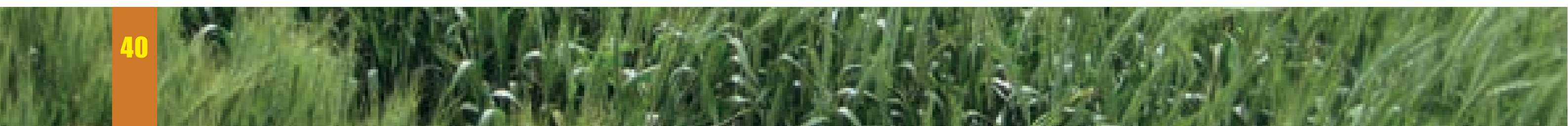
Wheat as % of Yitpi or Janz yield		
Variety	**North central**	**North east**
Yitpi	**2.9 t/ha**	
Janz		**3.6 t/ha**
Annuello	95 (27)	99 (28)
Axe	101 (10)	105 (14)
Beaufort	111 (3)	115 (6)
Bolac	99 (7)	104 (11)
Bullet	102 (6)	104 (9)
Carinya	99 (9)	105 (10)
Catalina	99 (7)	102 (11)
Chara	96 (34)	93 (38)
Clearfied Janz	-	98 (3)
Correll	102 (10)	105 (14)
Crusader	92 (6)	96 (9)
Dakota	97 (6)	99 (9)
Derrimut	102 (10)	105 (140)
EGA Bounty	-	97 (6)
EGA Wedgetail	92 (3)	96 (8)
EGA Wentworth	97 (6)	100 (8)
EGA Wills	-	92 (9)
Espada	104 (7)	109 (11)
Frame	95 (26)	98 (28)
Gasgoigne	-	106 (6)
GBA Ruby	102 (15)	108 (23)
Gladius	103 (9)	107 (14)
Guardian	101 (7)	104 (8)
Hornet	-	101 (8)
Janz	96 (29)	100 (39)
Kellalac	93 (3)	98 (3)
Lincoln	102 (6)	106 (9)
Magenta	102 (3)	108 (7)
Merinda	99 (7)	103 (11)
Orion	-	102 (6)
Peake	99 (10)	101 (14)
Preston	-	105 (6)
Pugsley	101 (17)	108 (27)
Rosella	90 (34)	91 (42)
Sentinel	99 (12)	104 (16)
Ventura	96 (14)	102 (19)
Waagan	104 (8)	109 (11)
Wyalkatchem	99 (9)	101 (19)
Yitpi	100 (28)	101 (28)
Young	101 (14)	107 (19)

Barley as % of Gairdner yield		
Variety	**North central**	**North east**
Gairdner	**2.7 t/ha**	**4.0 t/ha**
Malt		
Baudin	97 (22)	98 (10)
Buloke	103 (19)	102 (9)
Commander	105 (19)	105 (9)
Flagship	95 (18)	95 (8)
Franklin	88 (260	90 (15)
Gairdner	100 (29)	100 (15)
Schooner	92 (29)	91 (15)
Sloop	95 (19)	94 (11)
Vlamingh	98 (8)	98 (3)
Feed		
Barque	99 (19)	99 (11)
Capstan	102 (19)	103 (9)
Cowabbie	99 (4)	99 (3)
Finniss (Hulless)	89 (10)	88 (4)
Fleet	108 (11)	107 (4)
Hannan	102 (8)	99 (3)
Hindmarsh	110 (12)	106 (5)
Keel	102 (27)	100 (15)
Lockyer	106 (5)	106 (3)
Maritime	100 (4)	-
Oxford	100 (3)	-
Roe	103 (7)	-
Tantangara	98 (8)	100 (6)
Yarra	100 (21)	102 (12)

Oats as % of Echidna yield		
Variety	**North central**	**North east**
Echidna	**2.2 t/ha**	**2.3 t/ha**
Echidna	100 (12)	100 (10)
Euro	96 (14)	92 (120
Kojunup	98 (7)	96 (5)
Mitika	101 (14)	100 (12)
Mortlock	86 (13)	83(11)
Numbat	64 (4)	-
Possum	100 (14)	102 (12)
Potoroo	103 (14)	102 (12)
Quoll	102 (12)	99 (100
Yallara	96 (11)	95 (9)

Triticale as % of Tahara yield	
Variety	**North east**
Tahara	**3.1 t/ha**
Bogong	118 (6)
Canobolas	116 (6)
Credit	100 (14)
Endeavour	-
Hawkeye	112 (8)
Jaywick	111 (8)
Kosciuszko	101 (15)
Rufus	102 (4)
Speedee	95 (4)
Tahara	100 (19)
Tickit	101 (13)
Tobruk	111 (8)

Source: Victorian Winter Crop summary 2011



Grain quality

If cereal grain is to be sold for milling or feed purposes, it must meet the quality requirements of the buyer. Most buyers and all bulk handlers adhere to receival standards published by Grain Trade Australia. These standards specify limits for moisture, protein, screenings, weed seeds, fungal staining, insect/pest infestation and grain weight for each classification grade.

Determining grain maturity

Grain harvesting usually commences when the moisture content of a grain sample reaches 12.5%. Moisture content is determined using a moisture meter. High moisture content in harvested grain can lead to spoilage during storage.

Harvesting issues

Harvesting is a specialised operation that needs to be carried out carefully to prevent grain damage or grain loss. Consider using an experienced contractor with modern equipment if this is outside your area of expertise.

Harvesting becomes difficult when humidity is high, as grain fails to thresh from the heads properly, leading to a poor quality sample. Rain during harvest may make soils too wet to support heavy harvesters. Conversely, in very hot conditions or when seed has a very low moisture content, seed can shatter from the head and end up on the ground instead of in the grain bin. Stubble fires are also common in hot dry conditions and harvesting is usually restricted on total fire ban days.

Weather-damaged grain

Rain in the lead-up to harvest can cause physiologically mature seed to begin the germination process while still in the head. Affected cereal seeds will often show visual symptoms and are referred to as shot, sprung or sprouted. Weather-damaged wheat will have a higher level of alpha-amylase activity, an enzyme which breaks down starch and causes difficulties in the dough-making process.

The degree of weather damage is measured with a falling numbers test and for most milling wheats the threshold is 250 (300 for APH) and 300 for malt barley. Grain under these thresholds is usually downgraded to feed quality.

Grain storage to preserve seed quality

Stored grain needs to be kept cool and dry to prevent the build-up of pests such as grain weevils. Weevils attack the germ of the seed which can significantly reduce the germination percentage of planted seeds and will also diminish the grain's value to livestock due to the reduced grain weight. Weevil-damaged grain will require treatment before delivery to bulk handlers or before feeding to livestock. Weevils are becoming increasingly resistant to fumigating agents, so seek advice before treating grain.

Grain can be stored in sealed or unsealed bins or in silo bags. Each storage option has a range of advantages and disadvantages, which should be explored before deciding to store grain.

9 Economics of production

The most profitable cereal fodder crops are those that best match inputs to seasonal conditions.

The economics of grazing, conserving fodder or grain production will fluctuate annually, depending on the prevailing seasonal conditions and the domestic and international market forces that drive price, supply and demand for feed or grain.

Profitable cereals need good agronomy

The most profitable cereal crops are those that best match inputs (such as seed, fertiliser and pesticides) with seasonal conditions. While farmers can't control the weather, good agronomy practices will reduce the risk of things going wrong in extreme conditions.

Reducing risk involves:

- choosing a variety with an appropriate maturity
- seeding at the right rate for the purpose
- sowing at the right rate for the sowing time
- applying fertiliser at the right rate in response to the season
- managing economically damaging pests
- if irrigating, taking care not to put unnecessary stress on the crop — this is critical
- when grazing, being mindful of the possible impact on hay yield, grain yield and harvesting operations.

Timeliness of all operations is critical.

There is an inevitable level of risk both from the weather (such as rainfall, frost, heat waves and hail) and other factors. Staying informed and asking questions in response to the season retains flexibility and will help decision making. Making well informed decisions is the key to profitability.

Retail or private agronomists are also available to help with in-crop management decisions and pesticide choices.

Using contractors

Contractors usually bring experience, knowledge and modern equipment to an operation. Contractors are available for every activity from sowing, spraying, spreading fertiliser and hay making through to harvest. Contractors provide a service without tying up a farmer's own capital in machinery and they free up time for the farmer to do other jobs. However, contractors may be delayed by weather or other jobs, which can impact on the timeliness and quality of operations and outcomes.

Contractor rates will depend on the capacity of the machine. Always check whether diesel is included in the rate or whether it is an additional cost. Some contractors quote in dollars per hectare while some quote in dollars per hour, which can be confusing.

Cost of production

In cropping, some operations are essential to the crop growth and these will inevitably incur costs, for example, weed control, seed, starter fertiliser, and sowing and harvesting operations (for hay or grain). Other operations may only be needed under certain conditions and the farmer will determine these on their individual value, for example in-crop weed and pest control, irrigation, fungicide application or in-crop fertiliser. A poor season might see a scaling-back of inputs, while a good season may demand more fertiliser or pest control.

Preparing a budget can help identify areas of potential savings or potentially high cost while also considering the implications of poor yields or poor prices. Over-spending (or under-spending) on a crop can have significant financial implications so reviewing the budget during the growing season can be beneficial.

Tables 24 and 25 present a basic guide to the variable costs and income that can be expected during an 'average' year and the resulting gross margin. Changing input prices, yields and feed values will have a very significant effect on the profitability of a given crop. A similar gross margin analysis (using a range of yield and price scenarios) can help determine the merit of a given management decision (i.e. whether to cut the crop for hay or retain for grain production) or help guide an entire production system.

Table 24 looks at the example of a rain fed crop sown on the break from May–June. It will probably yield one grazing and, depending on the season's rainfall, may produce a hay yield as low as 3.0 t DM/ha through to 12 t DM/ha or more. Grain yield may be between 0.5–5.0 t/ha. Grazing plus hay or grain, if done correctly, will only have a minimal impact on final yield. Costs presented are a guide only.

Table 25 looks at a basic gross margin where adding water through irrigation can reduce risks and increase yield potential. This example requires a greater up-front financial commitment because of the additional water, fertiliser and pest management needed to reach the potential yields of between 10–20 t DM/ha or grain only yields of 4–8 t/ha.

From Tables 24 and 25, increasing inputs increases costs, but it is also more likely to lead to increased production so that the per tonne cost of production is reduced.

Changing plans

If the season becomes worse or better than expected, or the water price or the value of feed changes, it may be worth adjusting the end target to maximise profitability. If a crop has been intended for hay but the season is poor and the costs of producing a light hay crop are expensive given the potential yield, it may be better to graze the crop into the ground. Conversely, a good season might see a 'grazing only' crop conserved for hay or grain.

More difficult is whether to cut a crop for hay or keep it for grain in a dry season. This requires a careful risk analysis of the relative value of hay or grain and the possible yields. Hay crops tend to yield about twice the tonnage per hectare of grain crops, but usually tend to be worth only half as much, though prices may be skewed in a panicked market. Ultimately the decision to proceed to grain will depend on the price on offer and the likelihood of the crop reaching maturity with limited or no rain. Grain yields can be dramatically reduced by moisture stress and an early decision to make hay may help salvage profitability.

When an intended hay crop receives good moisture and grain is expensive (usually due to a shortage in world markets), a farmer may decide to switch to grain production to maximise returns. This is a good strategy if the farmer has the resources (knowledge and infrastructure) for a timely and efficient harvest.

Opportunity cost of water

Where water is expensive, the decision becomes more complex because of the opportunity cost of water. Irrigated cropping is usually uneconomical when water prices are high because the water can itself be worth more than the grain or hay it is being used to produce. Hence water is often traded to users that need to keep trees or permanent pastures alive, while the seller gains some valuable cash flow. Deciding to sell or purchase water will depend on individual circumstances and the seasonal outlook.

Table 24. Example gross margin for rain fed cereal, sown 15 May, assuming average rainfall and yield

Income									**$/ha**
Grazing only#	5.0	t DM/ha @	$ 130	per t					$ 650
Grazing plus hay #	1.5	t grazing DM/ha @	$ 130	per t plus	5.0	t hay DM/ha @	$ 130	per t	$ 845
Hay only	7.0	t DM/ha @	$ 130	per t					$ 910
Grazing plus grain #	1.5	t grazing DM/ha @	$ 130	per t plus	3.0	t grain/ha @	$ 240	per t	$ 915
Grain only	3.5	t/ha @	$ 240	per t					$ 840
Costs									**$/ha**
Cultivation	1	pass (if necessary) @	$ 38	per ha					$ 38
Knockdown herbicide – pre sowing	1	herbicide @	$ 5	per ha plus		application @	$ 8	per ha	$ 13
Sowing			$ 40	per ha		plus diesel			$ 40
Sowing seed	70	kg/ha @	$ 0.75	per kg					$ 53
Seed treatment			$ 3	per ha					$ 3
Sowing fertiliser – DAP	80	kg/ha @	$ 850	per t					$ 68
Mite spray + application			$ 4	per ha plus		application @	$ 8	per ha	$ 12
Urea at tillering, booting or after grazing*	217	kg/ha @	$ 580	per t					$ 126
Application - urea spreading	2	applications @	$ 8	per ha					$ 16
In-crop herbicide	1	spray @	$ 5	per ha plus		application @	$ 8	per ha	$ 13
Pre-irrigation:		nil							$ -
1st spring irrigation		nil							$ -
2nd spring irrigation		nil							$ -
Hay – cutting			$ 60	per ha					$ 60
Hay – conditioning			$25	per ha					$ 25
Hay – baling^	7	t/ha @	$ 24	per t					$ 168
Hay cartage to shed	7	t/ha @	$ 8	per t					$ 56
Grain insurance			$ 11	per '000		value of grain			$ 11
Harvesting			$ 40	per ha plus		per 100 kg over 2.5 t/ha	$1.25	per ha	$52.50
Storage plus handling (grain)			$ 20						$ 20
Gross margins									**$/ha**
Grazing only #	5.0	t DM/ha @	$ 130	per t					$ 268
Grazing plus hay #	1.5	t grazing DM/ha @	$ 130	per t plus	5.0	t hay DM/ha @	$ 130	per t	$ 218
Hay only	7.0	t DM/ha @	$ 130	per t					$ 219
Grazing plus grain #	1.5	t DM/ha grazing @	$ 130	per t plus	3.0	t grain/ha @	$ 200	per t	$ 456
Grain only	3.5	t/ha @	$ 240	per t					$ 375

excludes operation of animal enterprise ^ hay yield is for hay only crop
* urea application rate will vary based on crop end-use, target yield and soil fertility

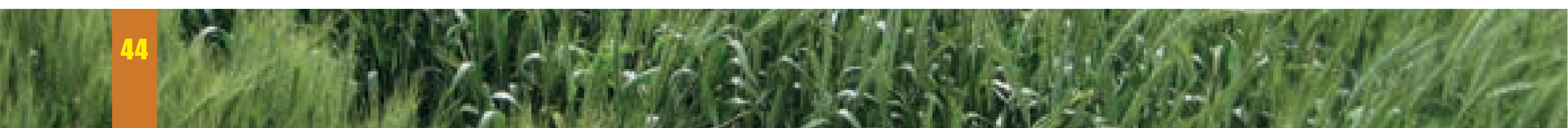


Table 25. Example gross margin for irrigated cereal, sown sown 1 April, pre-irrigated + 2 spring irrigations (3.5 ML/ha)

Income									**$/ha**
Grazing only#	8.0	t DM/ha @	$ 130	per t					$1,040
Grazing plus hay#	4.0	t grazing DM/ha @	$ 130	per t plus	9.0	t hay DM/ha @	$ 130	per t	$1,690
Hay only	12.0	t DM/ha @	$ 130	per t					$1,560
Grazing plus grain#	4.0	t grazing DM/ha @	$ 130	per t plus	5.0	t grain/ha @	$ 240	per t	$1,720
Grain only	6.5	t/ha @	$ 240	per t					$1,560
Costs									**$/ha**
Cultivation	1	pass (if necessary) @	$ 38	per ha					$ 38
Knockdown herbicide – pre sowing		herbicide @	$ 5	per ha plus		application @	$ 8	per ha	$ 13
Sowing			$ 40	per ha		plus diesel			$ 40
Sowing seed	100	kg/ha @	$ 0.75	per kg					$ 75
Seed treatment									$ 3
Sowing fertiliser – DAP	125	kg/ha @	$ 850	per t					$ 106
Mite spray + application			$ 4	per ha plus		application @	$ 8	per ha	$ 12
Urea at tillering, booting or after grazing*	435	kg/ha @	$ 580	per t					$ 252
Application – urea spreading	3	applications after grazing @	$ 8	per ha					$ 24
In-crop herbicide	1	spray	$ 5	per ha plus		application @	$ 8	per ha	$ 13
Pre-irrigation:	1.5	ML/ha @	$ 50	per ML					$ 75
1st spring irrigation	1	ML/ha @	$ 50	per ML					$ 50
2nd spring irrigation	1	ML/ha @	$ 50	per ML					$ 50
Hay – cutting			$ 60	per ha					$ 60
Hay – conditioning			$ 25	per ha					$ 25
Hay – baling^	12	t/ha @	$ 24	per t					$ 288
Hay cartage to shed	12	t/ha @	$ 8	per t					$ 96
Grain insurance			$ 11	per '000		value of grain			$ 11
Harvesting			$ 40	per ha plus		per 100 kg over 2.5 t/ha	$1.25	per ha	$ 90
Storage plus handling (grain)			$ 20						$ 20
Gross margins									**$/ha**
Grazing only #	8.0	t DM/ha @	$ 130	per t					$ 464
Grazing plus hay #	4.0	t grazing DM/ha @	$ 130	per t plus	9.0	t hay DM/ha @	$ 100	per t	$ 218
Hay only	12.0	t DM/ha @	$ 130	per t					$ 219
Grazing plus grain #	4.0	t DM/ha grazing @	$ 130	per t plus	5.0	t grain/ha @	$ 200	per t	$ 456
Grain only	6.5	t/ha @	$ 240	per t					$ 375

excludes operation of animal enterprise ^ hay yield is for hay only crop
* urea application rate will vary based on crop end-use, target yield and soil fertility

Table 26. How much to pay for water

		Amount	Unit	Value
Amount of purchased water used	A	2.0	ML	
Amount of extra feed grown & consumed from water purchased	B	1.5	t DM	
Tonnes DM ÷ ML used (B ÷ A)	C	1.5 ÷ 2.0	t DM/ML	0.75 t DM/ML
Value of purchased feed of equal quality	D	$350	$/t DM	
t DM/ML x $/t DM (C x D)	E	0.75 x 350	$/ML	$263/ML

Source: ***Should I buy some water?,*** DEC notes, 2010

Economic thresholds for irrigation

Dairy farmers often consider the value of the feed grown to be the same as the cost of buying a tonne of feed of the same quality. Understanding the relative cost of feed will help decide whether to buy water to produce fodder or whether purchased feed is a better option. This also applies to deciding whether to use water to finish off a high yielding grain crop or whether to save the water and cut the crop for hay.

Calculating how much to pay for temporary water compared with buying in equivalent feed can be done using the formula in Table 26. The last number in this formula (E) gives a rough idea of how much you could pay for temporary water versus buying in equivalent quality feed. A margin for risk should always be included in an analysis in case the figures you use don't eventuate, i.e. you use more water on your first irrigation than expected or don't get the growth rates you counted on. Risk should also be considered in terms of growing a crop which is then damaged (i.e. through rain at hay making time) versus buying something that is already baled and quality tested.

Using the formula in Table 26 and with purchased feed valued at $350, a farmer could afford to pay up to $263/ML for the water required to produce the extra 1.5 t of DM produced. If feed dropped in value to $100/tonne then the farmer should avoid paying more than 0.75 x 100 = $75 per ML. For a water use of 3.5 ML/ha and at a feed price of $200/ha then 3.5 ÷ 6 = 0.58 x 200 = $117/ML. As seen in recent years, when supplies of water are limited, its relative value increases. Once the value of water has exceeded the value of the additional feed produced from irrigating, it makes sense to sell the water and realise its actual tradeable value. The advantage of using cereals for fodder production is that farmers can be flexible with how and when they apply irrigation water — right up to the early grain-fill stage when hay is usually cut. Before this stage, a decision can be made to graze the crop or retain it for hay or grain, depending on the economic and financial conditions. Leaving the crop for grain production may require more analysis because the crop may require an additional two or three irrigations to finish.

The true value of grazing or fodder production will be determined by how much feed is produced per hectare, as well as the efficiency at which feed is converted to milk in a dairy system or meat in a prime lamb/beef cattle enterprise.

Summary

The success of a cereal crop for forage, conservation or grain production is heavily dependent on a range of factors, some of which can be controlled by the farmer and some which cannot. The risks from external influences can be limited by practising good agronomy and making informed decisions in response to the season and to input prices. Sound economic judgements also have to be made in regard to management decisions and this will have a large bearing on profitability. Each enterprise will have different challenges, limitations or potential and will determine the relative merit of how a cereal best fits into a particular system.

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Appendix 1

Adapted Zadoks Decimal Growth Scale

From Crop Monitoring and Zadoks growth stages for wheat, Maarten Stapper, 2007

0 Germination

00 Dry seed
01 Start of imbibition (water absorption)
02 -
03 Imbibition complete
04 -
05 Radicle (root) emerged from caryopsis (seed)
06 -
07 Coleoptile (shoot) emerged from caryopsis
08 -
09 Leaf just at coleoptile tip

1 Seedling growth

10 First leaf through coleoptile
11 First leaf emerged
12 2 leaves emerged
13 3 leaves emerged
14 4 leaves emerged
15 5 leaves emerged
16 6 leaves emerged
17 7 leaves emerged
18 8 leaves emerged
19 9 or more leaves emerged

2 Tillering

20 Main shoot only
21 Main shoot and 1 tiller
22 Main shoot and 2 tillers
23 Main shoot and 3 tillers
24 Main shoot and 4 tillers
25 Main shoot and 5 tillers
26 Main shoot and 6 tillers
27 Main shoot and 7 tillers
28 Main shoot and 8 tillers
29 Main shoot and 9 or more tillers

3 Stem elongation

30 Pseudostem (leaf sheath) erection
31 First node detectable
32 2nd node detectable
33 3rd node detectable
34 4th node detectable
35 5th node detectable
36 6th node detectable
37 Flag leaf just visible
38 Flag leaf half visible
39 Flag leaf ligule just visible

4 Booting

40 -
41 Early boot - flag leaf sheath extending
42 -
43 Mid boot - boots just visibly swollen
44 -
45 Full boot - boots swollen
46 -
47 Flag leaf sheath opening
48 -
49 First awns visible

5 Inflorescence (ear/panicle) emergence

50 -
51 First spikelet of inflorescence just visible
52 -
53 Inflorescence 30 % emerged
54 -
55 Inflorescence 50% emerged
56 -
57 Inflorescence 70% emerged
58 -
59 Inflorescence 90% emerged

6 Anthesis (flowering)

60 Whole spike visible
61 Early – 20% spike with yellow anthers
62 -
63 30% of spikes with yellow anthers
64 -
65 Mid – 50% of spikes with yellow anthers
66 -
67 70% of spikes with yellow anthers
68 -
69 Late – 90% of spikes with yellow anthers

7 Milk development

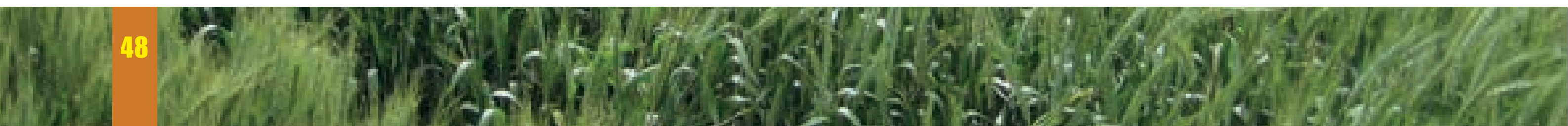
70 -
71 Caryopsis (kernal) watery ripe, clear liquid
72 -
73 Early milk, liquid off-white
74 -
75 Medium milk, contents milky liquid
76 -
77 Late milk, more solids in milk
78 -
79 Very late milk, half solids in milk

8 Dough development

80 -
81 Very early dough, more solids and slides when crushed
82 -
83 Early dough, soft, elastic and almost dry, shiny
84 -
85 Soft dough, firm, crumbles but fingernail impression not held
86 -
87 Hard dough, fingernail impression held, spike yellow brown
88 -
89 Late hard dough, difficult to dent

9 Ripening

90 -
91 Caryopsis hard (difficult to divide)
92 Caryopsis hard (not dented by thumbnail)
93 Caryopsis loosening in daytime
94 Over-ripe straw dead and collapsing
95 Seed dormant
96 Viable seed giving 50% germination
97 Seed not dormant
98 Secondary dormancy induced
99 Secondary dormancy lost



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