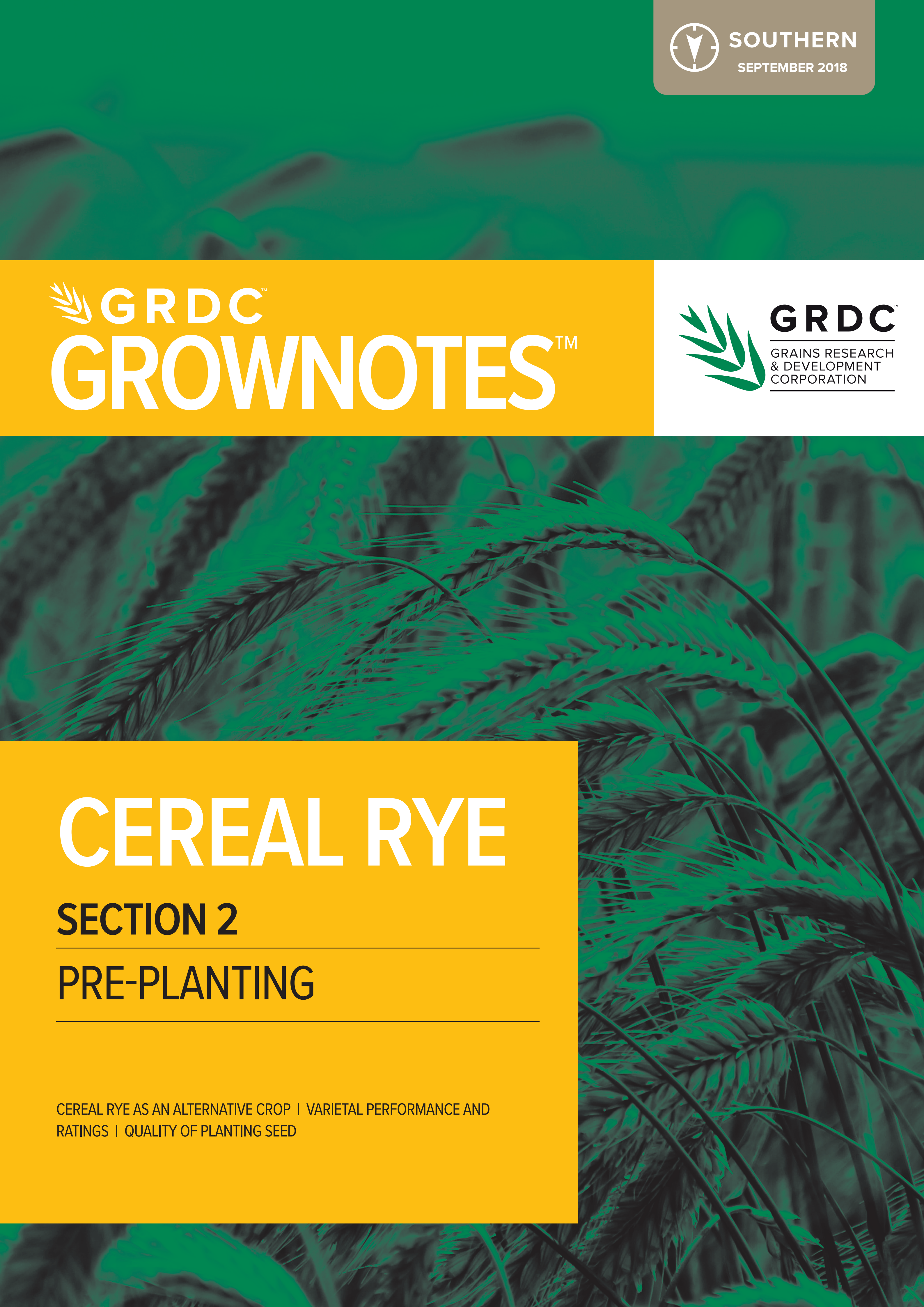

SOUTHERN

SEPTEMBER 2018

GRDC GROWNOTES™

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

CEREAL RYE

SECTION 2

PRE-PLANTING

CEREAL RYE AS AN ALTERNATIVE CROP | VARIETAL PERFORMANCE AND RATINGS | QUALITY OF PLANTING SEED

Pre-planting

Key messages

- Although cereal rye has been grown in Australia for more than 150 years, its agronomic development and breeding have been neglected compared with other winter-grown cereals.
- Rye is used for early sowings as a dual-purpose cereal, providing abundant, quick, early stock feed and as a grain-only crop. [1]
- Rye is relatively inexpensive and easy to establish, and outperforms all other cover crops on infertile, sandy or acidic soil or on poorly prepared land. It is widely adapted, but grows best in cool, temperate zones, especially southern Australia.
- Cereal rye helps to build soil structure, productivity and health, and reduce susceptibility to erosion.
- Ensure that seed quality is of a high standard. Check for damage and discoloration, because affected seeds may have poor germination and emergence.
- Rye seed deteriorates quickly after one year of storage. Ensure the seed is pure and has come from safe seed-storage conditions.
- Several strains and selections have been introduced into southern Australia at different times. They were referred to by names such as SA rye, South Australian Commercial rye, rye, cereal rye or ryecorn. Bevy is now the most widely grown variety. [2]

2.1 Cereal rye as an alternative crop

IN FOCUS

Cereal rye—an alternative grain crop

Potato growers near Ballarat, Victoria, traditionally grow rye as a green manure crop before planting potatoes in spring, and rye crops were rarely harvested for grain. Two flourmills that process rye products nearby obtain the bulk of their grain from 300–500 km away.

Farmers grow barley, wheat or oats in rotation with potatoes but due to low pH and high aluminum levels in the soil, wheat and barley crops frequently yield poorly or fail. Rye is known to be tolerant to these conditions and to the cold winters that prevail in the area.

The aim of this trial was to determine the potential for rye as an alternative grain crop.

Methods

Replicated field experiments were conducted near Springbank, (annual rainfall 900–950 mm) in 1986 and 1987. Separate experiments compared rates of sowing, varieties, growth regulators and nitrogen (N) fertiliser applied at various growth stages and rates.

1 P Matthews, D McCaffery, L Jenkins (2016.) Winter crop variety sowing guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/272945/winter-crop-variety-sowing-guide-2016.pdf

2 Agriculture Victoria (2013) Growing cereal rye. Victorian State Government EDJTR, http://agriculture.vic.gov.au/agriculture/grains-and-other-crops/crop-production/growing-cereal-rye

Results

A sowing rate of ~100 kg/ha gave the highest grain yield in 1986. In 1987, responses to N applied at early jointing stage were recorded at both low and high sowing rates (Table 1).

Table 1: *Effect of sowing rate on rye grain yield and protein.*

	1986 sowing rate:				l.s.d. (*P* = 0.05)
	50 kg/ha	100 kg/ha	150 kg/ha	200 kg/ha	
Grain yield (t/ha)	1.07	1.38	1.41	1.46	0.10
Grain protein (%)	14.2	13.3	13.0	12.3	
	1987 sowing rate ± 20 kg N/ha applied at jointing:				
	80 kg/ha	140 kg/ha	80 kg/ha (+N)	140 kg/ha (+N)	
Grain yield (t/ha)	3.07	3.31	3.69	3.74	0.23

Yield responses to growth regulator (Cycocel®) were measured in each year (Table 2.) Multiple applications and the addition of N further enhanced yield. Crop height was reduced by ~15 cm with each application.

Table 2: *Effect of Cycocel® growth regulator (CCC, applied at 293 g/ha) on rye grain yield.*

Zadoks decimal growth stage at application of CCC	Rye yield (t/ha)	
	1986	1987
Control (no CCC)	1.84	2.97
Z23	2.07	3.00
Z30	1.84	3.28
Z23 + Z30	–	3.40
Z23 + Z30 + Z40	–	4.25
l.s.d. (*P* = 0.05)	0.13	0,22

The trial demonstrated that rye can be successfully grown in high rainfall environments and that high grain yields can be achieved. [3]

2.1.1 Dual-purpose cropping

Key points:

- Advantages of dual-purpose crops include minimising risks, capitalising on early rainfall events, flexibility in enterprise mix, and improved cash-flow.
- Dual-purpose crops require a high standard of management.
- Ideal grazing facilities would allow for an excellent water supply, shelter-belts, rotational grazing, and drafting of cattle into similar weight ranges before they are placed onto grazing crops. Try to minimise handling and ensure that all animal health issues are addressed. [4]

3 K Bishop K (1989) Rye as an alternative cereal under high rainfall conditions. 5th Australian Agronomy Conference, http://www.regional.org.au/au/asa/1989/contributed/crop/p1-18.htm

4 K Harris (2016) Dual purpose crops. GRDC Update Papers, February 2016, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/Dual-purpose-crops

Dual-purpose crops can be a vital part of a mixed-business farming operation. Reliable dual-purpose crops require a high standard of agronomy including timely sowing, careful choice of variety, good subsoil moisture, and high soil fertility.

Dual-purpose winter crops, or grazing-only crops, can regularly gross $1,000–$1,500/ha with costs typically $300–$350/ha. In addition, they relieve pressure on the remaining grazing base (pastures), commonly giving them a chance to rest and be in an improved position to provide good feed when the dual-purpose crops are locked up for grain.

Dual-purpose crops supply quality feed in good quantities when other pastures are growing at a slow rate, especially in years with dry autumns (five of the last six years). [5]

Another advantage of grazing cereals is that if the season turns out favourably with adequate rainfall, farmers can also harvest grain yield from the paddock.

A successful strategy in the Mallee is to treat the paddock as a crop paddock and graze it rotationally until early to mid-tillering, and then shut the gate on livestock. If the paddock receives reasonable rain during July, there is a good opportunity for grain harvest; otherwise, the option exists of cutting for hay. Another successful strategy implemented by South Australian Mallee farmers (especially those who are more risk-averse) is to sow the paddock early merely for feed, and in favourable seasons when there is enough feed on offer in other paddocks, remove livestock from the grazed cereal paddock (before late tillering stage) and turn it into potential grain.

When selecting pasture for the farming system, a few points need to be taken into consideration, such as when and how much feed will be needed, quality of feed and possible animal health issues, weed competition and broadleaf weed control, fitting into farm rotation to provide early autumn feed, and a root disease break for future cropping.

Results from all Murray Mallee research/demonstration sites proved that all cereals could be safely grazed until their start of tillering (Zadoks growth stage Z26) without any yield penalty.

In trials at the Waikerie site, rye and wheat performed the best with respect to feed and gross income, followed by triticale and barley (Figure 1).

5 R Freebairn (2016) Profitable dual purpose cereals in the north and central west (a Purlewaugh case study). GRDC Update Papers, February 2016, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/Profitable-dual-purpose-cereals-in-the-north-west

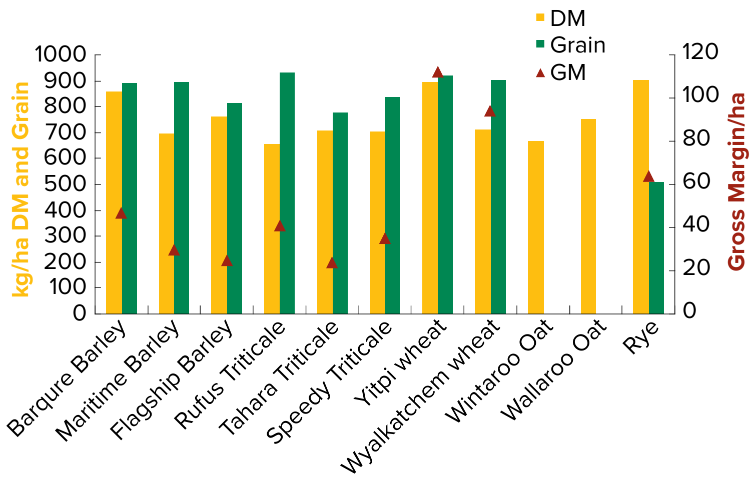

Figure 1: *Comparison of grain yield, dry matter (DM) and gross margin for grazing cereals at Waikerie, 2008.*

Source: Agronomy Matters

Cereal rye appears to be a viable option for Murray Mallee hilly and lighter soil paddocks, owing to its vigorous growth.

The majority of Mallee farmers tend to sow cereal rye just for grazing, but farmers who treated their cereal rye paddock as a crop paddock have been harvesting reasonable grain. Their strategy was to observe the forecast for opening rainfall and sow the paddock just before or after. In a few instances, farmers treated their grazing rye as crop, stopped grazing it around mid-tillering (Z28), and yielded 1 t/ha of rye grain. Considering the price of cereal rye, this seems a profitable trade.

Some other characteristics that make cereal rye a feasible dual-purpose cereal option are its early feed production compared with any other types of pasture, and high quality of feed (Figure 2). In addition, cereal rye usually makes a good break crop if the paddock is experiencing root and fungal disease. Grain quality was not affected by grazing or different seeding–fertiliser rates, although there were some fluctuations in screenings. [6]

6 Agronomy Matters (2009) Sustainable and productive pasture systems in the Murray Mallee—Final report summary. Agronomy Matters Vol 6, Issue 1, http://s3.amazonaws.com/zanran_storage/www.msfp.org.au/ContentPages/2479778786.pdf

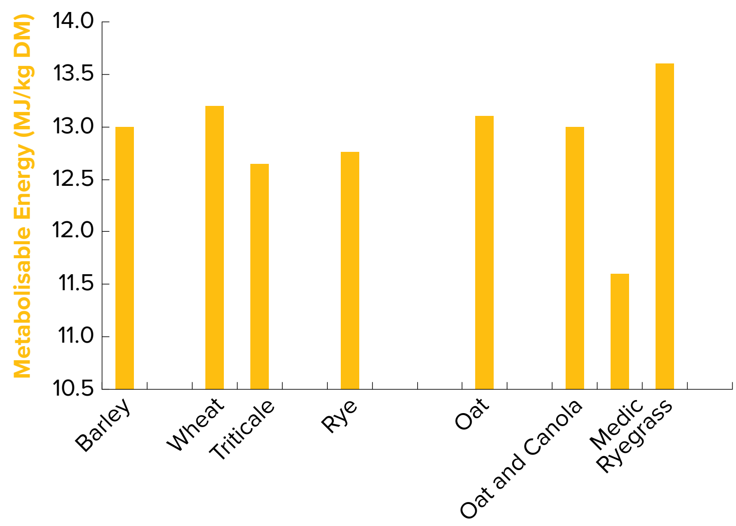

Figure 2: *Feed quality of different pasture options in the Mallee.*

Source: Agronomy Matters

With the support of the Grains Research and Development Corporation, NSW Department of Primary Industries managed a series of dual-purpose cereal cropping trials across New South Wales (NSW) at Somerton, Purlewaugh, Cowra and Culcairn.

The trials included the newest grazing varieties of wheat, triticale, cereal rye, oats and barley. Sown in mid-April, the crops in the northern areas had a difficult start with the drier conditions at sowing, but still produced some good results. All trials were assessed for dry matter (DM) production and were then grazed (Photo 1). A second DM assessment was taken later in the season. The crops were then allowed to develop through to harvest.

It was concluded that once grazing is finished and the crop is locked up for grain recovery, it should then treated as a grain crop, with the necessary nutritional (N), weed and disease management undertaken to maximise possible grain yields.

Photo 1: *Sheep grazing a dual-purpose crop.*

Source: GRDC

A highlight of the trial was the high early DM production from two new cereal ryes. It was the first time for several years that new cereal ryes were available that suited both grazing and grain recovery. These included Southern Green and Vampire⒧. Both varieties provided strong early growth and DM production, outperforming the traditional early feed producer oats at many of the sites. When looking for quick,

MORE INFORMATION

GRDC Fact Sheet: Dual-purpose crops. Bolstering feed supply to improve profitability and sustainability

GRDC Update Paper: Dual purpose crops

GRDC Update Paper: Dual purpose crops, do they have a fit in your system and how can they be managed to optimise forage and grain potential?

GRDC Update Paper: Dual purpose crops: economics and their management early DM production, the popular option has been oats, but now suitable cereal ryes are available.

Although the cereal ryes were quick to produce feed, their palatability dropped compared with the other cereals later in the season. Therefore, they should make up only a part of an overall forage production system. After the first grazing, the difference in production between crops (i.e. oats, rye, barley, triticale and wheat) narrowed significantly.

The trials also showed that grazing periods and rest periods were important for DM recovery. Generally, grazing too hard slows regrowth. Therefore, leaving some dry matter in the paddock will aid recovery from grazing and the stock can return to the paddock sooner. This could affect gross margins, because DM production and grain recovery are both important to the overall profitability of dual-purpose crops.

These DM values add up to a bonus for producers, with excellent returns from livestock enterprises as well as a profitable grain yield. [7]

Importance of variety choice

On a property in 30 km east of Coonabarabran, NSW, spring-habit winter cereal varieties (cereal rye, oats, wheat, barley, triticale) sown in February or March commonly came to head in May, June or July, with time dependent on sowing time variety and environment. These crops commonly recovered slowly and often poorly after grazing.

By contrast, varieties with winter habit recovered far better after grazing, were less likely to be adversely affected by frost, and retained high quality for longer.

Winter habit is a characteristic whereby the growing point remains at ground level until a sufficient amount of cold weather triggers plants to change to spring habit, which means the head begins rising up the stem. Spring habit varieties have no such delay, with heads growing up the stem as soon as tillering occurs.

When animals graze below the growing point, which can be quite early for spring-habit types, the tiller dies and new tillers need to reform. Reforming of tillers can be slow, especially in the middle of winter and if soil-water supply is low.

Varieties differ in their levels of winter habit. This means that varieties with low winter-habit level will transfer to spring habit with heads growing up the stem after a shorter period of cold winter weather than varieties with high levels of winter habit. High levels of winter habit mean that the heads remain at ground level for a much longer period in a given environment.

Desirable level of winter habit is largely related to climate and purpose. For example, if the purpose is mainly early sowing and long grazing time over winter and spring, a variety with a high level of winter habit may suit best.

A dual-purpose role is more likely to suited best to a variety with moderate to lower levels of winter habit. This allows early sowing with no running to head too early, nor loss of tillers, and a period of 30–100 days grazing prior to locking up for grain recovery. Desirable length of grazing is variable and is related not only to variety type but also to sowing time (more if early) and seasonal conditions.

Climate also has a big role in choosing how much winter habit a variety should have. Colder areas have winter habit satisfied faster; therefore, varieties with greater winter habit are needed. By contrast, in warmer environments varieties with less winter habit are needed, unless used only for grazing.

Varieties with winter habit tend to grow slower at first than spring-habit types. This slower growth is usually of little consequence if sowing earlier, because the crop tends to make it up with better recovery post-grazing in winter–early spring. [8]

VIDEOS

WATCH: Over the Fence south: Grain and graze combination delivers dollars at Raywood.

WATCH: Grazing dual purpose crops.

WATCH: Over the Fence: Grazing Crops: reaping big rewards and returns.

7 A Norris (2012) Dual purpose cereals shine. The Land, 25 February 2012, http://www.theland.com.au/story/3611427/dual-purpose-cereals-shine/

8 R Freebairn (2016) Profitable dual purpose cereals in the north and central west (a Purlewaugh case study). GRDC Update Papers, February 20016, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/Profitable-dual-purpose-cereals-in-the-north-west

2.1.2 Cereal rye for forage

Key points:

- Alternate forage cereal and legume pastures provide grazing opportunities at different times during the season.
- Choose varieties according to farm needs: ability to fill feed gaps; contribution to the farm's rotation in terms of nutrition, root and foliar disease management, weed control, and suitability for hay production.

Grazing of cereals is not a new technique in mixed-farming enterprises, but increased adoption of intensive cropping saw a reduction in its use.

In low-rainfall regions such as the Mallee, grazing of cereals seems to be working very well compared with other pasture systems that are not as reliable during the feed-shortage months (March–July).

There is a debate over whether to feed livestock with grain and hay, or with sown cereals for grazing during feed-shortage months. A cereal sown as pasture is a higher input option, but the amount of feed and the liveweight gain are significantly higher. [9]

Forage rye produces quick winter feed because it does not have a vernalisation (cold temperature) requirement and goes into reproductive mode almost immediately. Plants should be grazed early, before Z31 (stem elongation), to ensure two or three grazings. After Z31, grazed plants will not recover well and will lose palatability and feed quality. They are therefore not a good silage or hay option. Forage rye is best sown in combination with another forage, either as a mix or followed by a spring-sown summer forage. It can be grown in all rainfall areas, but as rainfall decreases, its ability to produce biomass and recover from grazing declines.

Based on trials in Culgoa (Victoria), forage rye was outstanding for early DM production relative to three other pasture types, reaching 416 kg DM/ha at Z14/21 (four-leaf stage, one tiller) on 5 July, only two weeks after sowing (Table 3). Ten days later on 15 July, forage rye had increased DM production by 469 kg/ha to 885 kg/ha, an exceptional production at this time of year.

Table 3: *Alternative pasture dry matter production (kg/ha) in trials at Culgoa in 2010.*

Pasture	5 July	15 July	14 October		Grain yield grazed (t/ha)
	Ungrazed	Ungrazed	Grazed	Ungrazed	
Forage rye	416	885	8,759	6,962	Not intended for harvest
Forage wheat	142	287	4,602	4,389	2.5
Oats–medic mix	160	255	4,952	3,262	1.44
Eastern star clover (*Trifolium dasyurum*)	41	56	4,799	1,569	Not harvested

Source: Online Farm Trials

All alternative pastures—forage rye, forage wheat and eastern star clover—showed potential as feed sources in 2011, filling feed gaps at different times and offering different end uses and rotation benefits. [10]

Similar results have been found in Tasmania. There were significant differences between the accumulated grazing DM yields of different varieties. Spring varieties of rye, barley, oats, and triticale showed rapid early growth and can be planted for feed supply early in winter. However, damage and/or removal of plant growing points

9 Agronomy Matters (2009) Sustainable and productive pasture systems in the Murray Mallee—Final report summary. Agronomy Matters Vol 6, Issue 1, http://s3.amazonaws.com/zanran_storage/www.msfp.org.au/ContentPages/2479778786.pdf

10 A Frischke, K Drever (2010) Alternative winter pastures. Online Farm Trials, http://www.farmtrials.com.au/trial/14012

reduced their subsequent regrowth, suggesting that the first cut was too severe; therefore, caution is required when grazing these types. [11]

For overall forage production, oats will generally produce more forage than will wheat, barley, cereal rye or triticale. The total amount of feed available will be influenced by the type of crop, variety, disease resistance and sowing time.

Cereals that produce large awns can cause mouth injuries to livestock and they should be avoided for hay production, or where head emergence under grazing cannot be controlled. These cereals include barley, triticale, cereal rye and some wheats.

Selecting crop types or varieties tolerant of root and/or leaf diseases will lessen the disease impact in susceptible situations. Where annual grass control (e.g. soft brome, barley grass and ryegrass) has been poor in the winter–spring prior to sowing, cereal root diseases are likely to cause serious production losses, particularly on non-acid soils. Highly susceptible crops such as wheat and barley should be avoided; cereal rye has good tolerance, with oats the next best, followed by triticale. Barley yellow dwarf virus (BYDV) can cause large losses of both dry matter and grain production, particularly in higher rainfall areas, when susceptible crops (especially oats and barley) are sown early. Tolerance of BYDV will therefore influence crop and variety choice.

Quality tests on the forage of cereal rye, oats, wheat, barley and triticale, when grown under similar conditions, show no significant differences in levels of protein, energy and digestibility. Therefore, a cereal with higher grain returns may be chosen as an alternative to oats. [12] Feed test results from Ballarat in 2008 show that rye varieties were as good as, or better than, other forages with respect to feed quality (Table 4).

Table 4: *Feed test results from Ballarat Winter Feed trial in 2008, with samples taken 22 July 2008.*

Variety	Dry matter (%)	Crude protein (%)	Neutral detergent fibre (%)	Dry matter digestibility (%)	Metabolisable energy (MJ/kg DM)
Southern Green rye	9.9	33.6	36.7	81.6	12.5
Common rye	9.7	32.7	36.8	79.5	12.0
Forage oats	9.8	31.9	36.5	81.7	12.5
Italian ryegrass	10.7	32.3	34.0	81.4	12.4
Appin leafy turnip	7.1	34.8	20.1	87.2	13.4

Source: Forage Focus

Ideally, only be one type of cereal should be sown in a paddock, as stock will preferentially graze one cereal over another.

2.1.3 Break or cover cropping

Cover crops are crops that are planted primarily for the benefits they provide to the soil. Interest in cover crops is increasing in Australia, driven by groups such as the Victorian No-Till Farmers Association.

Cover cropping has the potential to reduce herbicide reliance and minimise tillage while improving soil fertility, reducing soil erosion, sequestering soil carbon, increasing soil water infiltration and storage, and suppressing weeds. [13]

11 G Dean, A Merry, R Smith (2015) Evaluation of short-term fodder options between cropping phases in Tasmania. 17th Australian Agronomy Conference, http://www.agronomy2015.com.au/papers/agronomy2015final00240.pdf

12 G Hennessy, B Clements (2009) Cereals for grazing. Primefact 720, NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/288191/Cereals-for-grazing.pdf

13 SB Mirsky, WS Curran, D Mortensen,MR Ryan, DL Shumway (2009) Control of cereal rye with a roller/crimper as influenced by cover crop phenology. *Agronomy Journal* 101, 1589–1596.

VIDEOS

WATCH: The importance of Crop rotation.

Cover crops are an important addition to farming systems to improve soil quality and decrease soil erosion or nutrient loss. According to assessments in Iowa, USA, cover crops on average can reduce N loading by 28% and phosphorus loading by 50%. In view of these benefits, research was done identify any effects of a cereal rye cover crop on yields of maize and soybean cash crops. Since 2008, 46 site-years have been conducted, with farmers reporting that in 42 of 46 site-years, properly managed cover crops had little or no negative effect on maize and soybean yield (and actually increased soybean yield in four site-years). [14]

Cover-crop mixtures

Cover crops can be planted as a single species or in mixtures. The most common mixtures include a legume such as vetch and a cereal grain such as rye (Photo 2). Mixtures provide advantages and disadvantages compared with single species.

In a rye–hairy vetch, mixture, rye protects the vetch during establishment and throughout the winter, and provides physical support for the climbing vetch during the spring growth period. The rye also protects the soil from winter erosion better than a pure stand of vetch. The amount of N available to the subsequent crop is not as great as with a pure vetch stand. In addition, more N is tied up during decomposition of the mixture due to the higher carbon to N ratio of the rye. [15]

Lodging can be a problem with cereal rye, and sowing rate is therefore an important consideration.

Photo 2: *A mixture of hairy vetch plus rye can produce a lot of biomass that can enhance soil quality while providing a significant amount of nitrogen to a subsequent crop.*

Source: University of Vermont

14 S Gailans (2015) Winter cereal rye cover crop effect on cash crop yield: results from long-term, on-farm research. In Synergy in Science 2015: Partnering for Solutions, ASA/CSSA/SSSA Annual Meeting, https://scisoc.confex.com/scisoc/2015am/webprogram/Paper91725.html

15 WS Curran, DD Lingenfelter, L Garling, P Wagoner (2006) Cover crops for conservation tillage systems. Conservation Tillage Series 5. Penn State Extension, http://extension.psu.edu/plants/crops/soil-management/conservation-tillage/cover-crops-for-conservation-tillage-systems

Break benefits on Mallee soils

Take home messages

- Break options including a low-cost volunteer medic-based pasture have led to wheat yield gains of over 0.7 t/ha on some soils and in some cases significant effects in the third year after the break.
- Across a range of soil types, seasons and break types, breaks have led to a typical cumulative benefit of almost 1 t/ha of wheat.
- This relatively consistent level of benefit is likely to be the result of a changing range of physical, chemical and biological drivers that differ across soils, season and break types.
- Canola greatly reduced risk of Rhizoctonia disease compared with other options.
- Pasture provided the highest N mineralisation potential in the second wheat crop.
- Although yield effects of break crops were generally similar across the soil types, there are considerable differences in gross-margin benefits due to the differences in break crop yields and wheat yields that could have been achieved when the break option was grown.
- The ability to reduce the opportunity cost of growing break crops, and taking advantage of potential for second- and third-year break effects, are important for maximising the value from break options.

Wheat is a relatively low-risk crop, but relying on continuous cropping can increase vulnerability to weeds, disease and declining nutrition and lead to increased costs. The inclusion of break crops can address these issues, but in a low-rainfall environment this often involves growing a crop that is riskier than cereal.

Several field trials in the Mallee have examined both the performance of break crops and their impact on the performance of subsequent wheat crops. At Karoonda, South Australia, the effects of a range of break crops and a low-cost, medic-based pasture were evaluated over three subsequent wheat crops. The study highlighted the importance of evaluating the benefits of break crops (or pasture) over several years, and that often there are different drivers of the break effect (e.g. disease, nutrition, stored soil water) across different soil types and seasons. [16]

Evaluating break crops

Trials were established at Karoonda (337 mm average annual rainfall) on different soils ranging from heavy swale to deep sand dune. Single-year break crops were grown in 2010 and 2011 comprising legume (field peas and lupins), canola, rye (grain and 'grain + graze') and volunteer pasture on a paddock that had a cereal history of at least four years. Wheat was grown following break crops with 16 kg N/ha applied as urea and 9 kg N/ha as di-ammonium phosphate, all at seeding, in addition to phosphorus, sulfur and micronutrients. Yields are shown in Table 5.

16 R Llewellyn, T McBeath, B Davoren, V Gupta, M Moodie, B Jones (2013) Break benefits on Mallee Soils—the long and the short. GRDC Update Paper, July 2013https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/07/Break-benefits-on-Mallee-soils

Table 5: *Grain yields (t/ha) of different crop types on each soil type in 2009–12, with mid-slope split into mid-top and mid-bottom in 2010.*
Within a season, soil × crop type combinations followed by the same letter are not significantly different at P = 0.05.

	Dune	Mid-top	Mid-bottom	Swale
2009				
Rye	1.78a	1.86a		0.81de
Rye (cut)	0.90de	1.06cd		0.53e
Field peas	0.59e	0.69de		0.69de
Wheat	1.77ab	1.94a		1.40bc
l.s.d. (P = 0.05)	0.38			
2010				
Canola	1.87i	1.14j	1.35j	2.04hi
Rye	3.10de	2.88ef	3.43cd	3.36cde
Rye (cut)	2.39gh	1.92hi	2.39gh	2.32ghi
Lupins	3.80bc	4.00b	3.27de	2.55fg
Wheat	2.99def	2.24ghi	4.03b	5.17a
l.s.d. (P = 0.05)	0.48			
2011				
Wheat	3.60	2.17	3.47	3.75
2012				
Wheat	2.09	1.30	2.56	3.43

Source: GRDC

In 2010, the best break effect was following field peas (+0.93 t/ha) and pasture (+0.83 t/ha) when averaged across all soils. In 2011, the first-year break effects followed a similar pattern (Figure 5). In general, soil type was found not to be a statistically significant influence on the break effects.

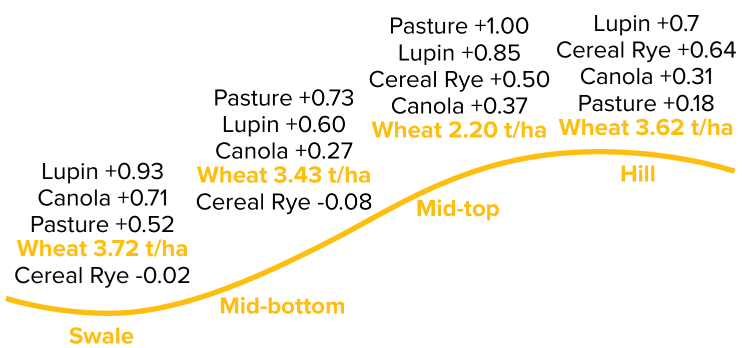

Figure 3: *Yield gain in the 2011 wheat crops following various break crops grown in 2010 at Karoonda. Continuous wheat yields for 2011 are shown in the black boxes. (l.s.d. (P = 0.05): swale, 0.42 t/ha; mid-bottom, 0.41 t/ha; mid-top, 0.49 t/ha; hill, 0.53 t/ha).*

Source: GRDC

Both field peas and pasture caused a significant second-year effect on wheat production in 2011. In 2012, there were some significant second-year break effects with lupins, pasture and canola all leading to significant wheat yield gains compared with continuous wheat. Pasture grown in 2009 led to a statistically significant third-year break effect (in 2012).

The benefits of breaks are relatively consistent in terms of the gains in wheat yield, irrespective of wheat crop yield, soil type or the range of break options. The cumulative effect of the breaks over 3 years is shown in Figure 4. A big yield boost in year 1 after a break can sometimes come with reduced benefits in year 2. The results so far show that the breaks have led to a total benefit of almost 1 t/ha of wheat over 3 years across the range of soils and break types.

Figure 4: *Cumulative yield of wheat over 3 years after breaks showing benefit of breaks compared with continuous wheat (1:1 line is presented).*

Source: GRDC

The drivers for the break effects vary across soils, break types and seasons. They included increased soil available N, higher available soil water levels at sowing following breaks, and disease differences.

An example of potential disease risk reduction is shown in Figure 5. Cereal crops have promoted the build-up of *Rhizoctonia solani* inoculum, whereas canola reduced inoculum levels. *Rhizoctonia* inoculum was lowest after the canola crop and highest after the wheat crop across all soils.

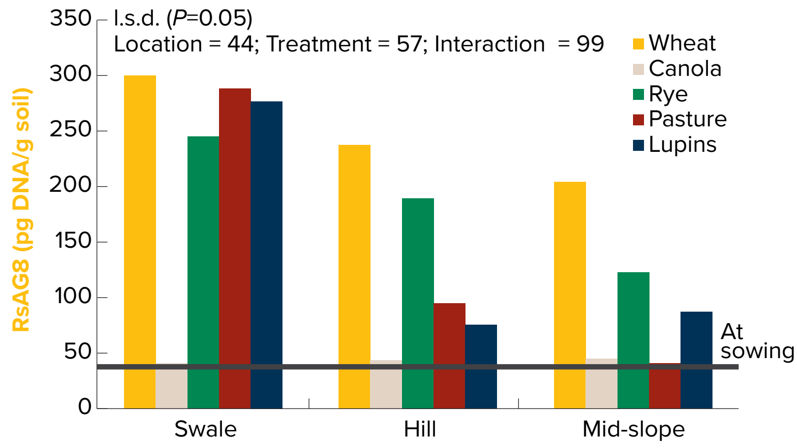

Figure 5: *Inoculum levels of Rhizoctonia solani (Rs) AG8 measured in 2011 following different crops grown in 2010 (Gupta et al. 2011, in collaboration with GRDC project CSP00150—Managing Rhizoctonia disease risk in cereals).*

Source: GRDC

The strong performance of the volunteer pasture, which had a medic base but was not maintained grass-free, is partly explained by the estimated N mineralisation potential shown in Figure 6. Soil that was under pasture in 2010 had significantly more potential to supply N to the 2012 crop than soil on which break crops were grown in 2010.

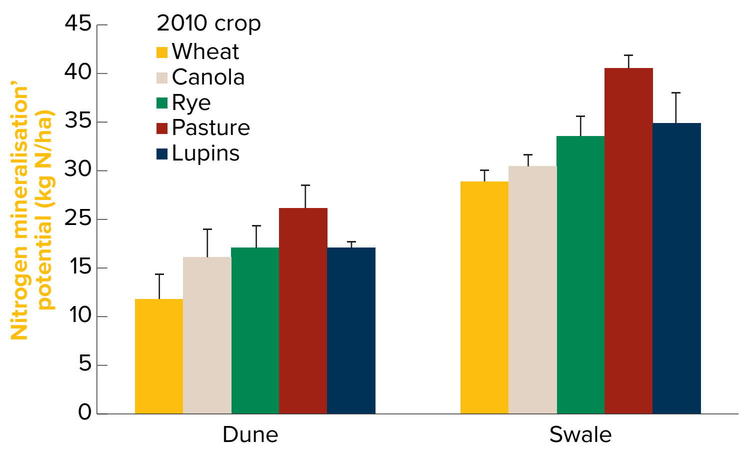

Figure 6: *Effect of 2010 break crops on N mineralisation potential (estimate for decile 5 season) measured at time of sowing in 2012.*

Source: GRDC

Four-year cumulative gross margins were calculated for each soil type × crop sequence combination where breaks were grown in 2009 (Table 6). Although the effects of break crops on wheat yield were generally similar across the soil types, there were considerable differences in relative gross margins due to the differences in the yields of the break crops and the wheat yields that could have been achieved when the break option was grown in 2009.

Table 6: *Gains in cumulative gross margin from break crops relative to continuous wheat across different soil types.*

Rotation				Swale	Mid-bottom	Mid-top	Hill
2009	**2010**	**2011**	**2012**	**$/ha**	**$/ha**	**$/ha**	**$/ha**
Field peas	Wheat	Wheat	Wheat	+283	+113	+52	+80
Rye grain	Wheat	Wheat	Wheat	+75	+62	+119	+112
Rye grazed	Wheat	Wheat	Wheat	+301	–133	+60	–217
Pasture	Wheat	Wheat	Wheat	+250	+74	+233	+191

The costs were calculated using the Rural Solutions Farm Gross Margin Guide; grain prices are five-year average, pasture biomass valued at $35/t/ha. Gains (or losses) are presented relative to the cumulative gross margin for the four years of continuous wheat (swale $2989/ha, mid-bottom $2488/ha, mid-top $1267/ha and dune $2038/ha).

Source: GRDC

Where breaks were grown in the relatively poor-yielding year of 2009, profitability over the 4-year sequence was generally higher than continuous wheat (Table 6). This was particularly the case on the swale, where wheat performed poorly in 2009. Breaks grown on the swale in 2010 were expected to be less profitable over the sequence because wheat would have been a highly profitable option in that year.

Given the possibility of benefits in the third year following the breaks, the trial was continued into 2013 to evaluate the longer term profitability of break options grown in 2010. [17]

Control of cover crops

Cover crops that interfere with growth of primary crops defeat their purpose. Effective control or suppression of the cover crop is generally necessary before emergence of the main crop. Commonly used methods include tillage, mowing, herbicides, or selection of species that winterkill or have a short life cycle. [18]

In the absence of herbicides, cereal rye cover crops are typically terminated with tillage, or with mowing in no-till situations. Mowing has several drawbacks including the risk of regrowth, accelerated residue decomposition, and patchy distribution of the surface residue. Uniformity of coverage of surface soil from cover-crop residue is critical for optimising weed suppression. A roller–crimper is a viable alternative to mowing and tillage (Photo 3). The residue is deposited uniformly on the soil surface. The resulting layer of rye residue persists for longer than with mowing, enhancing weed suppression, moisture retention, and soil conservation. [19]

17 R Llewellyn, T McBeath, B Davoren, V Gupta, M Moodie, B Jones (2013) Break benefits on Mallee Soils—the long and the short. GRDC Update Paper, July 2013, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/07/Break-benefits-on-Mallee-soils

18 W Curran, DD Lingenfelter, L Garling, P Wagoner (2006) Cover crops for conservation tillage systems. Conservation Tillage Series Number Five. Pennsylvania State University, http://extension.psu.edu/plants/crops/soil-management/conservation-tillage/cover-crops-for-conservation-tillage-systems

19 SB Mirsky, WS Curran, DA Mortensen, MR Ryan, DL Shumway (2009) Control of cereal rye with a roller/crimper as influenced by cover crop phenology. *Agronomy Journal* 101, 1589–1596.

Photo 3: *Well-designed roller–crimpers, and a good management plan, can help no-tillers and strip-tillers to smother weeds, improve soil protection and get the most from high-biomass cover crops.*

Source: No-Till Farmer

Rye should not be used as a cover crop just before growing other cereal grains. Volunteer rye may contaminate wheat, oats and barley. [20]

Under stressful conditions such as those found in tilled and chemical fallow fields, grassy field edges and roadsides, rye plants can still grow and produce seed despite attaining heights of only 25 cm or less (Photo 4). [21]

Photo 4: *Shorter stands of cereal rye can still produce seed heads.*

Source: NebGuide

Tillage not only controls cover crops, it also incorporates them into the soil, allowing them to degrade quickly and release nutrients for the primary crop. An example of incorporation is a cover crop used as a green manure. Mouldboard ploughing may be necessary if large amounts of cover crop biomass are present. Chisel ploughing followed by discing may be inadequate for certain cover crops such as cereal rye if large amounts of residue are present. If timed properly, mowing can successfully control certain covers prior to planting the primary crop. To insure successful control, producers should mow cereal grains after heading; mowing prior to head emergence will likely result in regrowth from tillers. Regrowth from cereal grains harvested for

20 Manure $ense (2009) Cereal Rye: Manure and Livestock's new best friend. Michigan State University Extension, http://mccc.msu.edu/wp-content/uploads/2016/09/MI_2009_CerealRyeManure.pdf

21 D Lyon, R Klein (2007) Rye control in winter wheat. University of Nebraska, https://web.archive.org/web/20140413144910/http://www.ianrpubs.unl.edu/pages/publicationD.jsp?publicationId=106

forage in the boot stage of development is a common problem for producers who do not use an appropriate herbicide program or tillage. [22]

IN FOCUS

Control of cereal rye with a roller/crimper as influenced by cover crop phenology

Adoption of reduced-tillage practices have been driven by the need to enhance soil quality, minimise field labor time, and scale up farm size. However, concerns about increased reliance on herbicides and demand for organically grown foods call for adoption of production practices that can reduce both tillage and herbicide use. This study assessed the influence of planting and termination dates on efficacy of mechanical cover-crop control (by roller–crimper) to limit tillage and herbicide use. A thermal-based phenological model using growing degree-days (GDD; base 4.4°C) was developed to predict cereal-rye growth stage. Mechanical control of cereal rye increased as rye matured. Variations in growth rates of cultivars were observed; however, they responded similarly to rolling when terminated at the same growth stage. Consistent control was achieved at Z61 (rye anthesis). A thermal-based phenological model separating the effects of heat units accumulated in autumn from those accumulated in the spring best predicted the phenological development of cereal rye. Predicting when cereal rye can be successfully controlled with a roller–crimper along with the use of the thermal-based phenological model should aid growers in decision-making regarding cereal rye planting and termination dates. [23]

VIDEOS

WATCH: Over the Fence: Cover crop ensures soil moisture.

Prevention of wind erosion

Cereal rye can establish well on poor, windblown sand. It has four primary roots that originate from the seed and can send out roots and tillers from the second, third and fourth node. This extensive root system within the first 30 cm of soil is more developed than in other cereals. It can withstand greater sowing depths, which is useful when sowing over eroded or disturbed sites or where depth is hard to control, and it makes the plant more drought-resistant.

Cereal rye straw and grain are the least preferred fodder for sheep; this aids in the recovery of wind-eroded soils, because sheep will graze other stubbles before turning to rye stubble. An on-farm trial in Western Australia found that rye was successful in preventing further erosion. Approximately 80% of land cropped to rye recovered sufficiently to return to normal rotation. However, disease became an issue after three years of continuous rye. [24]

Cereal rye is the plant commonly used for reclamation on the solonised brown soils that make up a large part of the low-yielding wheat lands of southern Australia. They lie largely in a zone of low rainfall, ~225–375 mm per annum of unreliable, winter incidence. Soils are deep sandy to shallow loamy soils overlying deep rubbly and powdery calcareous clay subsoils, and are neutral to alkaline at the surface, becoming more alkaline with depth. Their landscape is frequently characterised by a parallel east–west dune system. They are farmed on a wide rotation, comprising volunteer pasture–fallow–wheat, in which superphosphate is used solely with

22 WS Curran, DD Lingenfelter, L Garling, P Wagoner (2006) Cover crops for conservation tillage systems. Conservation Tillage Series 5. Penn State Extension, http://extension.psu.edu/plants/crops/soil-management/conservation-tillage/cover-crops-for-conservation-tillage-systems

23 SB Mirsky, WS Curran, D Mortensen,MR Ryan, DL Shumway (2009) Control of cereal rye with a roller/crimper as influenced by cover crop phenology. *Agronomy Journal* 101, 1589–1596.

24 L Martin (2015) Growing cereal rye to increase carbon and prevent wind erosion. Liebe Group, http://www.liebegroup.org.au/wp-content/uploads/2015/03/Case-Study-Jeff-Pearse-March-2015.pdf

the wheat. Sheep graze the pastures. These soils, especially the sands, are very susceptible to wind erosion, and much effort is devoted to stabilisation of the once-cleared and cultivated dunes. [25]

2.2 Varietal performance and ratings

Rye is a cross-pollinated plant, and when seed is grown in a particular environment for a period of years, types more suitable to that environment evolve by natural selection.

The cultivar types or strains most commonly grown have fast and erect early growth and are of early maturity.

The cultivar South Australian was a popular early crop and was widely grown in South Australia, Victoria and Western Australia. [26]

New varieties have since been bred and incorporated into growers' rotations.

2.2.1 Identifying products for industry

A project funded by the GDRC aimed to deliver new products for the rye industry. [27]

Low- and high-amylose rye

Low-amylose or sticky ryes were anticipated to be of use for food products such as breakfast cereals and crispbreads, as well as feed for ruminants and monogastrics.

Both high and low amylose ryes were identified. The low lines had amylose contents of 6–10%. Nine high amylose lines were identified with a range in amylose of 33–37%. The low amylose materials were kept in storage for potential future use.

In 2004, the high-amylose ryes were used in crosses with high-amylose durum wheats with a view to developing high-amylose triticales.

Low- and high-pentosan rye

Low viscosity rye was seen as a priority for the feed industry, whereby a significant reduction in pentosans was perceived to be of value for monogastric nutrition.

Twelve very low pentosan lines gave rise to a population of 100–200 low viscosity lines, which were selected for field-testing. The materials were put into storage.

George Weston Foods tested the baking of some low pentosan lines. Low pentosan lines gave a better baking response using local technology (30% rye flour, 70% wheat flour) than the normal or high-pentosan rye lines.

Industry expressed an interest in high-pentosan rye believing that this would be of benefit to bread volume and quality parameters such as reduced staling and dietary considerations.

High-viscosity lines were identified and sown in the field in 1998. A high-pentosan population (HP) was identified and built up but it did not have expected improvements in bread volume. This rye population was also tested in 2004 as a rye for grazing for the Queensland cattle industry.

White rye

White rye was intended for a specialty niche market, and consideration was given to the preference for white breads and to the development of a white crispbread from cereal rye.

25 ABS (2001) The soils of Australia. ABS Feature Articles 1966. Australian Bureau of Statistics, http://www.abs.gov.au/ausstats/abs@.nsf/Previousproducts/1301.0Feature%20Article801966

26 RL Reid (Ed.) (1990) The manual of Australian agriculture. Elsevier.

27 GRDC (1998) Project US200 Cereal Rye—New products for industry. GRDC Final Reports, http://finalreports.grdc.com.au/US200

From a population that was originally very tall, several good agronomic types of normal height were selected following identification of fixed white lines both selfing and inter-mating.

Following further selection and yield trials, a white-seeded population was increased for commercial release. The white rye could also be used in crosses with white durum with a view to developing additional sources of white triticale.

High-molecular-weight glutenin rye

High molecular weight (HMW) glutenin rye was seen as important to the bread making industry, i.e. for high loaf volume.

A rye line carrying a wheat–rye translocation was supplied by Professor Adam Lukaszewski (University of California, Riverside), and this line showed some improvement in baking quality. However, the translocation had also been shown to reduce the yield by 30%. This HMW glutenin rye was crossed with the best local rye germplasm, and the material grown for a further cycle before being put into storage.

Long-season dual-purpose rye

Numerous rye lines were developed that had the dual-purpose (graze-and-grain) capacity of the earlier variety, Ryesun. Dual-purpose trials were conducted at the Cowra Research Station, NSW, and several promising lines were identified.

Feedback from growers in South Australia indicated that taller rye varieties (unlike the dwarf variety Bevy) were preferred for feed purposes.

The development of dual-purpose ryes and the high-yielding variety Westwood was the result of ongoing breeding, trialing and selection for quality traits. Westwood was released commercially in 2003, being least 10% higher yielding than Ryesun in NSW, and with improved lodging resistance. [28]

2.2.2 Developing products for industry

The aim of a follow-up GRDC project was to produce higher yielding rye varieties with new end uses. [29]

Cereal rye is suited to the acid soils of central and southern NSW and the sandy soils of the South Australian Mallee. Its main use is for rye breads (30–50% rye flour) or kibble in multigrain bread. Rye is very high in soluble fibre and is therefore of benefit to human health.

The new varieties to be developed included a higher soluble-pentosan rye and a white rye suitable for NSW, and a rye suitable for the South Australian Mallee.

A high-yielding, open-pollinated rye with improved levels of soluble pentosans was developed. A white-seeded rye line was also produced. The new rye line for South Australia was not as high yielding as Bevy.

The high pentosan rye, coded HP Rye, has the desired quality characteristics for rye bread and kibble. It yields 5–10% better than Ryesun, has better lodging resistance than Ryesun, and is a good graze-and-grain line for rye growers in NSW. HP Rye is a combination of 11 high-pentosan lines from a population comprising Australian and European germplasm that had been allowed to randomly cross (rye is a cross-pollinating species). Selection of lines for the mixture (synthetic) was based on adjusted yield results from Cowra in 2002 and subsequent tests for soluble pentosans.

The white rye synthetic, produced from 13 white-seeded selections, was 10–15% lower yielding than Ryesun and taller. In quality analysis by Westons, it produced a poor rye loaf due to underlying quality problems and the method used to produce rye bread in Australia.

28 GRDC (1998) Project US200 Cereal Rye—New products for industry. GRDC Final Reports, http://finalreports.grdc.com.au/US200

29 GRDC Project US00022 (2005) Rye—New products for industry, http://finalreports.grdc.com.au/US00022

Opportunities

The outstanding yields of the new hybrid ryes offer opportunities for the development of new and improved products for:

- Biofuel. Hybrid rye now outyields most other cereals and can be grown on marginal land, therefore not affecting the current food and feed requirements for other cereal grains.
- White bread-making rye. The rye industry would benefit substantially from a high baking rye, which would reduce the need for the addition of wheat flour (70%) in rye loaves. This option is possible by using white grain triticales with excellent bread making characteristics that can be crossed with new and existing sources of white rye. [30]

Growers should be aware that cereal rye is a cross-pollinating species and it will outcross. To maintain pure seed and varietal type, growers should regularly source new seed. The availability of seed of the older cereal rye varieties is limited and some could no longer be under commercial seed production.

2.2.3 Varieties

Bevy

Bevy is higher yielding than SA Commercial (SAC) rye and a direct replacement. Bevy was developed at the University of Adelaide from a composite of nine predominantly semi-dwarf spring rye types. Most plants (80%) are semi-dwarf, with 15% as tall as SAC and 5% very short. When mature, heads also range in length.

Bevy flowers about two weeks later than SAC, and this later maturity may assist in avoiding effects of frost. The yield of SA Commercial is frequently frost-affected, whereas Bevy may escape.

Compared with SAC, Bevy has increased seedling vigour and superior tillering ability and is the most suitable cereal for fragile sandy soils. It is well adapted to Mallee environments and has performed far better than SAC in longer growing seasons.

The milling yield of Bevy is slightly better than SAC and baking quality is similar. Bevy has slightly smaller seed, marginally lower 1000-grain weight and a smaller proportion of very dark grains than SAC.

Bevy is superior to SAC for stem and leaf rust resistance. [31]

Bevy is resistant to cereal cyst nematode (CCN) and is a poor host to the root-lesion nematode *Pratylenchus neglectus*, meaning that it can be useful to manage these diseases. However, Bevy is a host for the root disease take-all, and this should be carefully monitored. [32]

Bevy is the primary variety used for rye grain production, with most other varieties primarily used for forage purposes.

MORE INFORMATION

Teague Australia: Bevy

Southern Green forage rye

Southern Green is a forage rye that was developed for very rapid growth to first grazing. It has high tiller density and leaf development, and strong tiller survival after initial grazing. It has a spring habit, but is likely to lodge under good conditions. It is marketed by PGG Wrightson Seeds. [33]

Key points:

30 GRDC Project US00022 (2005) Rye—New products for industry, http://finalreports.grdc.com.au/US00022

31 R Saunders, R Wheeler. Bevy. Teague Australia, http://www.teague.com.au/members/pdf/9749370EA20CA886DBF1899.PDF

32 Agriculture Victoria (2013) Growing cereal rye. Victorian state Government EDJTR, http://agriculture.vic.gov.au/agriculture/grains-and-other-crops/crop-production/growing-cereal-rye

33 P Matthews, D McCaffery, L Jenkins (2016) Winter crop variety sowing guide 2016. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/272945/winter-crop-variety-sowing-guide-2016.pdf

- Southern Green forage rye is bred for quick winter feed—ready to graze in 30–55 days. Some brassicas may be quicker with a March break but Southern Green grows quickly even if the break is late.
- It can produce twice the DM of oats at 45 days after sowing (Photo 5).
- In a trial, by late July (90–100 days after sowing) oat growth rates have increased but cereal rye was still 30% ahead in DM yield.

Southern Green is a much more uniform and leafy crop than common cereal rye. It is also early maturing and earlier to reach stem elongation than most other cereals. It will bolt to head in autumn if planted early and not grazed. It is for quick feed and must be used.

Because of its lack of vernalisation requirement, Southern Green will go into reproductive mode almost immediately. This habit is the driver of quick winter feed production, but means it can be damaged easily by overgrazing.

Photo 5: *Ballarat Winter Feed Trial (sown 21 April 2008). Southern Green forage rye (left) Wintaroo Oats (right). Photo taken 45 days after planting. Southern Green is ready for a graze where Wintaroo would be damaged by grazing at this early development stage.*

Source: Wrightson Seeds

After winter grazings, a spring brassica can be sown into thinned out Southern Green; the scattered regrowth may set seed and regenerate well from the seed the following year.

Cereal rye's resistance and tolerance to CCN make Southern Green a valuable rotation option on lighter soils where CCN is often severe. Resistance and tolerance to take-all make rye varieties such as Southern Green a useful break crop for sowing before susceptible wheat, triticale or barley crops. It can also be sown in situations where take-all is expected—following grassy pasture on soils that are unsuitable for oats. (Note that the variety Bevy does not have resistance to take-all.) Forage rye such as Southern Green used in rotation may reduce the severity of wheat leaf diseases *Septoria tritici* blotch, glume blotch and yellow leaf spot, and the barley leaf diseases scald and leaf net blotch. [34]

Grazing management

Timing of early grazing is critical if regrowth is wanted. In the 2008 Ballarat Winter Feed trials (Photo 5 above) where rain delayed the first harvest (trial was 95 days to the first cut), Southern Green had its growing points removed by the mower and regrowth was reduced.

34 Wrightson Seeds (2010) Forage focus—Southern Green forage ryecorn, http://www.pggwrightsonseeds.com.au/assets/FTP-Uploads/Forage_Focus/Cereals/FF_Southern-Green-Forage-Ryecorn.pdf

MORE INFORMATION

Wrightson Seeds: Southern Green forage ryecorn

If the first grazing is early, before stem elongation (Z31), Southern Green has the potential to give three grazings. However, if Southern Green reaches 25 cm growth, it may have initiated stem elongation (>Z31) and may provide only one or two grazings. This is because the growing point may be removed and further tillers are unlikely.

Southern Green can be left for one large grazing in mid-August at early stem elongation, or for an early silage cut in very dry areas or drought years. Management of the first grazing is similar to that for other cereals (e.g. oats) because the secondary roots are not developed until after the first grazing, or when plants are reasonably advanced. Therefore, the first grazing should be not too heavy, or should be by sheep rather than cattle. [35]

Ryesun

A main-season variety with adequate stem rust resistance. It is likely to lodge under good conditions. Ryesun is an early variety with dual-purpose capacity.

Ryesun and the traditional variety SAC were compared over two years. In both years, Rysun significantly outyielded SAC by ~20%. [36]

Vampire⯑

Vampire⯑ cereal rye is recommended for its extremely vigorous growth and for early grazing. It is suitable for grazing and grain recovery. It is very suited to poor soils and revegetation projects.

Vampire⯑ is a main-season variety. It has good tolerance of acid soils and high aluminium, and it has improved lodging resistance and grain yield compared with Ryesun.

Vampire⯑ is suited to rotation for suppression of root-lesion nematode. [37]

Released by the University of Sydney and marketed by Waratah Seed Company, Vampire⯑ was selected for its long coleoptile length (i.e. improved early vigour, see Photo 6) and excellent early DM production. It can be grazed by stock within four weeks.

Vampire⯑ is an option if a summer crop was planned or a triticale pasture–silage mix. It suits autumn–winter sowing for five months' feed, can be sown before summer crop (rape, lucerne, etc.), and has the potential to give three grazings. [38]

Grazing management

The first grazing can be light to promote growth and secondary root development; this can be followed by second grazing before stem elongation or third grazing to graze out the crop for spring sowing. It can also be left for one large grazing in winter. Recommended sowing rate is 40–50 kg/ha.

35 Wrightson Seeds (2010) Forage focus—Southern Green forage ryecorn, http://www.pggwrightsonseeds.com.au/assets/FTP-Uploads/Forage_Focus/Cereals/FF_Southern-Green-Forage-Ryecorn.pdf

36 K Bishop (1989) Rye as an alternative cereal under high rainfall conditions, http://www.regional.org.au/au/asa/1989/contributed/crop/p1-18.htm

37 Hart Bros Seeds, http://www.hartbrosseeds.com.au/all-products/vampire-ryecorn.aspx

38 AGF Seeds. Vampire forage rye-corn. Australian Grain and Forage Seeds, https://agfseeds.com.au/ryecorn

Photo 6: *Chew and chop cereal blend including Vampire⚉ (left), and other commercial forage cereal (right) at seven weeks post-sowing, demonstrating early vigour in Vampire⚉.*

Source: AGF Seeds

Westwood

Westwood is a main-season variety with maturity similar to Ryesun. It has adequate stem and leaf rust resistance. Westwood was released commercially in 2003. It is at least 10% higher yielding than Rysun in NSW, and has improved lodging resistance. [39] [40]

2.3 Quality of planting seed

Early seedling growth relies on stored energy reserves in the seed. Good seedling establishment is more likely if seed is undamaged, stored correctly and from a plant that had adequate nutrition. Seed should not be kept from paddocks rain-affected at harvest. Seed grading is an effective way to separate good-quality seed of uniform size from small or damaged seeds and other impurities, such as weed seeds. [41]

Seed should be free of weeds and ergot bodies (*Claviceps purpurea*), and have at least 85% germination. Stored rye seed loses its ability to germinate more rapidly than seed of other cereals. It is recommended to buy certified seed, which has proven adaptation to local conditions. Fungicide seed treatments used for other cereal grains are suitable for use on rye and can often improve stands. [42]

Rye seed should be cleaned thoroughly to remove weed seeds, foreign material (including ergot) and cracked kernels. Ergot bodies must be removed to prevent re-infestation of fields. Use of pedigreed seed ensures high quality. There are no ergot-resistant rye varieties. The only practical control is to sow clean, year-old seed on land that has not grown rye for at least one year. [43]

39 NSW DPI (2016) Winter crop variety sowing guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/272945/winter-crop-variety-sowing-guide-2016.pdf

40 GRDC (1998) Cereal rye—new products for industry. GRDC Project US200, Final Report, http://finalreports.grdc.com.au/US200

41 NSW DPI District Agronomists (2007) Wheat growth and development. PROCROP Series, NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/449367/Procrop-wheat-growth-and-development.pdf

42 EA Oelke, ES Oplinger, H Bahri, BR. Durgan, DH Putnam, JD Doll, KA Kelling (1990) Alternative field crops manual: Rye. University of Wisconsin Cooperative or Extension Service, https://hort.purdue.edu/newcrop/afcm/rye.html

43 Alberta Government (2016) Fall rye production. Alberta Agriculture and Forestry, http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex1269/$file/117_20-1.pdf

Heat damage causes slower germination, delayed emergence of the primary leaf, stunted growth or termination of the germination process. In severe cases, seed death may occur (Photo 7). During bulk storage, areas of excessive moisture can lead to microbially induced 'hot spots', and because moisture moves from hot to cooler areas, further local heating is caused in a chain reaction. [44]

Photo 7: *Normal cereal seed (left) and heat-damaged seed (right). Note the colour difference.*

Source: Grain SA

MORE INFORMATION

GRDC Fact Sheet: Retaining seed: saving weather-damaged grain for seed

2.3.1 Seed size and coleoptile length

Cereal rye generally has a smaller seed size than wheat. Therefore, sowing depth should be adjusted according to this smaller seed size.

Seed size is important—the larger the seed, the greater the endosperm and starch reserves. Although size does not alter germination percentage, bigger seeds have faster seedling growth, a higher number of fertile tillers per plant and potentially higher grain yield.

Seed size is usually measured by weighing 1000 grains (1000-grain weight). Sowing rate needs to vary according to the 1000-grain weight for each variety, in each season, in order to achieve desired plant densities. [45]

Because small seeds contain less starch reserves than larger seeds, they have less energy to get the seedling out of the ground and less energy to fight stresses such as disease, waterlogging or false breaks.

Small seed—for example, 1000-seed weight <30 g—should not be sown deep, and should only be sown where there is ideal moisture. Increase sowing rates by 10–15% to compensate for potentially low vigour. [46]

The coleoptile is the pointed, protective sheath that encases the emerging shoot as it grows from the seed to the soil surface (see Photo 8). Coleoptile length is an important characteristic to consider when planting a crop, especially in drier seasons when sowing deep to reach soil moisture.

44 H Hatting (2102) Factors affecting wheat seed germination. Grain South Africa, http://www.grainsa.co.za/factors-affecting-wheat-seed-germination

45 NSW DPI District Agronomists (2007) Wheat growth and development. PROCROP Series, NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/449367/Procrop-wheat-growth-and-development.pdf

46 K Condon K (2003) Targeting optimum plant numbers. NSW Agriculture, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0007/168523/targeting-optimum-plant-numbers.pdf

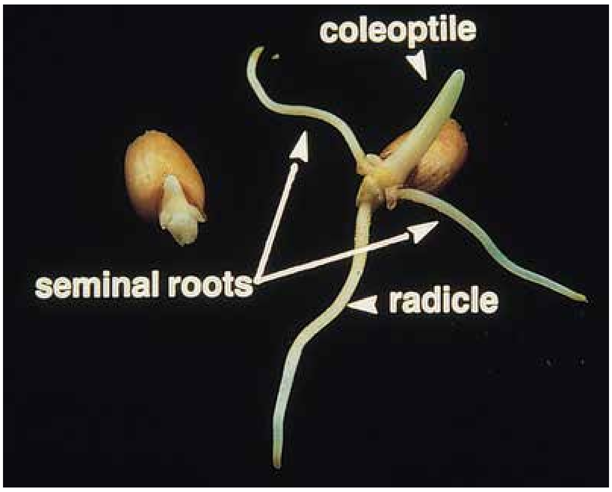

Photo 8: *The coleoptile is the pointed, protective sheath that encases the emerging shoot as it grows from the seed to the soil surface.*

Photo: David L. Hansen, University of Minnesota).

For a seed to emerge successfully from the soil, the seed should never be planted deeper than the coleoptile length. If varieties with short coleoptiles are sown too deep, it can cause poor establishment because the shoot will emerge from the coleoptile underground and may not reach the soil surface.

Coleoptile length is influenced by several factors including variety, seed size, temperature and soil water and by certain seed dressings, such as those with the active ingredient triadimenol or flutriafol. Trifluralin and several Group B pre-emergent chemicals can also affect coleoptile length. Growers should read the label when using any seed-dressing fungicide, to see what affect it may have on coleoptile length. [47]

2.3.2 Seed germination and vigour

Seed germination and vigour greatly influence establishment and yield potential.

Germination begins when the seed absorbs water, and ends with the appearance of the radicle. It has three phases:

- water absorption (imbibition)
- activation
- visible germination. [48]

In rye, seed germination drops rapidly when seed is stored for longer than one year. [49]

Seed vigour is the level of activity and performance of the seed or seedlot during germination and seedling emergence. Loss of seed vigour is a reduction in the ability of the seeds to carry out all of the physiological functions that allow them to perform.

This process, called physiological ageing (or deterioration), starts before harvest and continues during harvest, processing and storage. It progressively reduces performance capabilities through changes in cell membrane integrity, enzyme activity and protein synthesis. These biochemical changes can occur very quickly (a few days) or more slowly (years), depending on genetic, production and environmental factors not fully understood. The end-point of this deterioration is death of the seed (i.e. complete loss of germination).

47 J Pumpa, P Martin, F McCrae, N Coombes (2013) Coleoptile length of wheat varieties. NSW Department of Primary Industries, February 2013, http://www.dpi.nsw.gov.au/agriculture/broadacre-crops/winter-crops/wheat,-barley-and-other-winter-cereals/coleoptile-length

48 NSW DPI Agronomists (2007) Wheat growth and development. PROCROP Series, NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/449367/Procrop-wheat-growth-and-development.pdf

49 Alberta Government (2016) Fall rye production. Alberta Agriculture and Forestry,, http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex1269/$file/117_20-1.pdf

Seeds lose vigour before they lose the ability to germinate. Therefore, seedlots with similar, high germination values can differ in their physiological age (the extent of deterioration) and so differ in seed vigour and the ability to perform. [50]

For more information on factors affecting germination, see Section 4: Plant growth and physiology.

Grain retained for seed from a wet harvest is more likely to be infected with seed-borne disease. It is also more likely to suffer physical damage during handling, increasing the potential for disease. Seed-borne disease generally cannot be identified from visual inspection; it requires laboratory testing. [51]

Request a copy of the germination and vigour analysis certificate for purchased seed from your supplier. For seed stored on-farm, you can send a sample to a laboratory for analysis (see Australian Seeds Authority website).

Although a laboratory seed test for germination should be carried out before seeding to calculate seeding rates, a simple on-farm test can be done in soil at harvest and during storage:

- Use a flat, shallow, seeding tray (about 5 cm deep). Place a sheet of newspaper on the base to cover drainage holes, and fill with clean sand, potting mix or freely draining soil. Ideally, the test should be done indoors at a temperature of ~20°C or lower.
- Alternatively, lay a well-rinsed plastic milk container on its side and cut a window in it, place unbleached paper towels or cotton wool in the container, and lay out the seeds. Moisten and place on a windowsill. Keep moist, and count the seeds as outlined below.
- Randomly count out 100 seeds—do not discard damaged ones—and sow 10 rows of 10 seeds at the correct seeding depth. This can be achieved by placing the seed on the smoothed soil surface and pushing in with a pencil marked to the required depth. Cover with a little more sand or soil and water gently.
- Keep soil moist but not wet, as overwatering will result in fungal growth and possible rotting.
- After 7–10 days, the majority of viable seeds will have emerged.
- Count only normal, healthy seedlings. If you count 78 normal vigorous seedlings, the germination percentage is 78%.
- Germination of 80% is considered acceptable for cereals.
- The results from a laboratory seed-germination test should be used for calculating seeding rates. [52]

Seed purity

Seed impurity can occur from contamination through harvest, storage and machinery. This measurement will be included in a seed purity certificate. Varieties that have been retained for multiple generations have an increased risk of seed impurity due to multiple chances for contamination events and build-up. Ensure that seed comes from clean, pure and even crops; seed-purity tests should be carried out. Growers should conduct paddock audits prior to harvest to establish which paddocks best meet these criteria.

With dramatic increases in herbicide resistance, growers need to take seed purity into account when selecting paddocks for seed. Ryegrass and black oats frequently appear in harvested grain samples and have the potential to infest otherwise clean paddocks. [53]

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50 ISTA (1995) Understanding seed vigour. International Seed Testing Association, http://www.seedtest.org/upload/prj/product/UnderstandingSeedVigourPamphlet.pdf

51 GRDC (2011) Saving weather damaged grain for seed, northern and southern regions. Retaining seed Fact Sheet, GRDC, January 2011, http://storedgrain.com.au/wp-content/uploads/2013/06/GRDC_FS_RetainingSeed2.pdf

52 GRDC (2011) Retaining seed. Saving weather damaged grain for seed, northern and southern regions. GRDC Fact Sheet Jan. 2011, http://storedgrain.com.au/wp-content/uploads/2013/06/GRDC_FS_RetainingSeed2.pdf

53 S Simpfendorfer, A Martin, M Sutherland (2012) Seed impurity undermines stripe rust resistance. 16th Australian Agronomy Conference. Australian Society of Agronomy/the Regional Institute Ltd, http://www.regional.org.au/au/asa/2012/disease/8325_simpfendorfer.htm#TopOfPage

2.3.3 Seed storage

The aim of storage is to preserve the viability of the seed for future sowing and maintain its quality for market. A seed is a living organism that releases moisture as it respires.

The ideal storage conditions:

- Temperature <15°C. High temperatures can quickly reduce seed germination and quality. This is why germination and vigour testing prior to planting is so important.
- Moisture control. Temperature changes cause air movements inside the silo, carrying moisture to the coolest parts of the seed. Moisture is carried upwards by convection currents in the air; these are created by the temperature difference between the warm seed in the centre of the silo and the cool silo walls, or vice versa. Moisture carried into the silo head-space may condense and fall back as free water, causing a ring of seed to germinate against the silo wall.
- Aeration. This slows the rate of deterioration of seed with 12.5–14% moisture. Aeration markedly reduces grain temperature and evens out temperature differences that cause moisture movement.
- No pests. Temperature <15°C stops all major grain insect pests from breeding, slowing their activity and reducing damage. [54]

For more information, see Section 13: Storage.

VIDEOS

WATCH: Over the Fence: Insure seed viability with aerated storage.

2.3.4 Safe rates of fertiliser sown with the seed

Most varieties of cereal rye do not require any additional fertiliser over requirements of other cereals. However, given its ability to produce winter feed very quickly, strong economic responses can be gained by supplying the crop with a good amount of starter fertiliser (e.g. >100 kg/ha of di-ammonium phosphate). Follow up with a topdressing of N (30–50 kg/ha) when the crop is at early tillering stages, perhaps three weeks after emergence. Additional fertiliser and lime can be applied according to a soil test. [55]

Crop species differ in tolerance to N fertiliser when applied with the seed at sowing. Research funded by Incitec Pivot Fertilisers has shown that the tolerance of crop species to ammonium fertilisers placed with the seed at sowing is related to fertiliser product (ammonia potential and osmotic potential), application rate, row spacing and equipment used (such as a disc or tyne), and soil characteristics such as moisture content and texture.

The safest application method for high rates of high ammonium-content fertilisers is to place them away from the seed by physical separation (combined N-phosphorus products) or by pre- or post-plant application (straight N products). For the lower ammonium-content fertilisers, e.g. mono-ammonium phosphate, adhere closely to the safe rate limits set for the crop species and the soil type. [56]

High rates of N fertiliser applied at planting in contact with, or close to, the seed may severely reduce seedling emergence. If a high rate of N is required, it should be applied pre-planting or applied at planting but not in contact with the seed (i.e. banded between and below sowing rows). Rates should be reduced by 50% for very sandy soil and increased by 30% for heavy-textured soils or if soil moisture conditions at planting are excellent. [57]

If the same fertiliser rate is used with different row spacings, then the amount distributed along each seeding row will increase as row spacing becomes wider.

54 NSW DPI Agronomists (2007) Wheat growth and development. PROCROP Series. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/449367/Procrop-wheat-growth-and-development.pdf

55 Wrightson seeds (2010) Forage Focus: Southern Green forage rye, http://www.pggwrightsonseeds.com.au/assets/FTP-Uploads/Forage_Focus/Cereals/FF_Southern-Green-Forage-Ryecorn.pdf

56 Incitec Pivot Fertilisers (2014) Nitrogen fertiliser placement and crop establishment. Incitec Pivot Fertiliser Ltd, http://bign.com.au/Big%20N%20Benefits/Nitrogen%20Fertiliser%20Placement%20and%20Crop%20Establishment

57 QDAF (2102) Wheat —nutrition. Queensland Department of Agriculture and Fisheries, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/nutrition

To avoid this increased fertiliser concentration in wide-row systems, the safe rate of in-furrow fertiliser decreases as row spacing increases (Table 7). Seedbed utilisation percentage is a term that has been developed to describe the effect of row spacing and opener type on seed-furrow fertiliser concentration, and thereby quantify safe fertiliser rates (Table 8). Higher seedbed utilisation can optimise crop grain-yield potential, as well as minimising fertiliser toxicity risk. [58] [59]

Nitrogen rates should be significantly reduced when using narrow points and press wheels or disc seeders. When moisture conditions are marginal for germination, growers need to reduce N rates if fertiliser is to be placed with, or close to, the seed.

Table 7: *Approximate safe rates of nitrogen as urea, mono-ammonium phosphate or di-ammonium phosphate with the seed of cereal grains if the seedbed has good soil moisture (at or near field capacity).*

Soil texture	25-mm seed spread			50-mm seed spread		
Row spacing:	**180 mm**	**229 mm**	**305 mm**	**180 mm**	**229 mm**	**305 mm**
SBU:	14%	11%	8%	29%	22%	17%
Light (sandy loam)	20	15	11	40	30	22
Medium–heavy (loam–clay)	25	20	15	50	40	30

SBU, Seedbed utilisation = (width of seed row/row spacing) × 100.

Source: RW Rainbow and DV Slee (2004), The essential guide to no-till farming (South Australian No-Till Farmers Association), reproduced in GRDC Fertiliser Toxicity Fact Sheet

Table 8: *Urea rates (kg/ha) for wheat and barley at different levels of seedbed utilisation (SBU = width of seed row/row spacing × 100) and on different soil types, with good soil moisture.*

SBU	5%	10%	15%	20%	25%	30%	40%	50%
Heavy soil	55	60	65	70	75	80	95	105
Medium soil	45	50	55	60	65	70	80	90
Light soil	25	30	35	40	45	50	60	65

Source: Incitec Pivot Fertfact

For more information, see Section 5: Nutrition and Fertiliser.

58 GRDC (2011) Care with fertiliser and seed placement. GRDC Fertiliser Toxicity Fact Sheet, May 2011, https://grdc.com.au/uploads/documents/GRDC_FertiliserToxicity_FS.pdf

59 J Laycock (2013) Seedbed utilisation. Fertfact—Guidelines for suggested maximum rates of fertiliser applied with the seed in winter crops. Incitec Pivot Fertilisers, http://farmercommunity.incitecpivotfertilisers.com.au/Guides%20and%20Publications/Agronomic%20Insights/Seed%20bed%20utilisation