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# GROWNOTES™

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GRAINS RESEARCH & DEVELOPMENT CORPORATION

# CEREAL RYE

## SECTION 2

## PRE-PLANTING

CEREAL RYE FOR FORAGE | VARIETAL PERFORMANCE AND RATINGS | PLANTING SEED QUALITY

# Pre-planting

## Key messages:

- Although cereal rye has been grown in Australia for more than 150 years, its agronomic development and breeding has been neglected compared to other winter-grown cereals.
- A Grains Research and Development Corporation project was funded to produce higher yielding rye varieties with new end uses. These include a rye with higher soluble pentosan, a white rye suitable for New South Wales.
- Varieties include Bevy, Southern Green Forage Rye, Ryesun, Westwood and Vampire.
- 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.
- Rye can be susceptible to lodging.
- Ensure that the seed is pure and has come from safe seed storage conditions.

## 2.1 Cereal rye for forage

Key points:

- Alternative forage cereal and legume pastures offer opportunities for grazing at different times during the season.
- Choose varieties according to your needs: ability to fill feed gaps; what benefits to rotation in terms of nutrition, root and foliar disease management, weed control; and suitability for hay production.

Forage cereal rye produces rapid winter feed because it does not have a vernalisation (cold temperature) requirement and goes into reproductive mode almost immediately. Cereal rye plants should be grazed early, before Zadoks growth stage Z31 (stem elongation), to ensure two to three grazings. After Z31, grazed rye plants will not recover well and will lose palatability and feed quality, and are therefore not a good silage or hay option. Cereal 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.

In one trial, forage cereal rye showed outstanding early dry matter (DM) production, reaching 416 kg DM per hectare (DM/ha) at Z14/21 (four-leaf stage, one tiller) only two weeks after sowing (Table 1) on 5 July. Ten days later on July 15, forage cereal rye had increased production by 469 kg/ha, to reach 885 kg DM/ha—exceptional production at this time of year. [1]

1 A Frischke, K Drever (2010). Alternative winter pastures. Online Farm Trials, Grains Research and Development Corporation,, http://www.farmtrials.com.au/trial/14012

**Table 1:** *Alternative pasture dry matter production (kg/ha), Culgoa 2010.*

| Pasture | 5 July | 15 July | 14 October | | Grain yield grazed (t/ha) |
|---|---|---|---|---|---|
| | Ungrazed | Ungrazed | Grazed | Ungrazed | |
| Forage cereal rye | 416 | 885 | 8759 | 6962 | Not intended for harvest |
| Forage wheat | 142 | 287 | 4602 | 4389 | 2.5 |
| Oats–medic mix | 160 | 255 | 4952 | 3262 | 1.44 |
| Eastern star clover | 41 | 56 | 4799 | 1569 | Not harvested |

Source: http://www.farmtrials.com.au/trial/14012

## 2.1.1 Cereals for grazing

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

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 cereal rye, barley, triticale and some wheats, although awnless varieties of barley and wheat and reduced-awn triticale are available.

Selection of crop types or varieties tolerant to root and/or leaf diseases will lessen the disease impact in susceptible situations. Cereal rye variety Bevy was developed with improved leaf and stem rust disease resistance. Southern Green has excellent resistance to cereal cyst-nematode (CCN), a significant problem in lighter soils around Australia. It is also resistant to take-all (caused by *Gaeumannomyces graminis* spp.). Where annual grass control (e.g. *Vulpia* spp., 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) is a serious disease on the Slopes and Tablelands. Large losses of both DM and grain production can occur when susceptible crops (especially oats and barley) are sown early. Tolerance of BYDV will therefore influence crop and variety choice. Control of aphids will also play a role.

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. [2]

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

## 2.1.2 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 $1000–$1500/ha with typical costs of $300–$350/ha. In addition, they take pressure off the

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

remaining grazing base (pastures) so it is in an improved position to provide good feed when the dual-purpose crop is 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. [3]

## IN FOCUS

### New South Wales dual-purpose cereal cropping trials

With the support of the GRDC, the NSW Department of Primary Industries has managed a series of dual-purpose cereal cropping trials across New South Wales, 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 excellent results. All trials were assessed for DM production and then grazed. A second DM assessment was taken later in the season. The crops were then allowed to develop through to harvest.

Once grazing of the crop is finished and it is locked up for grain recovery, it is important to treat it as a grain crop, with the necessary nutritional (i.e. N), weed and disease management undertaken to maximise possible grain yields.

A highlight of the trial was the high early DM production from two new cereal ryes. It is the first time for several years that newly available cereal ryes are suited to both grazing and grain recovery. These included the varieties 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 early DM production, the popular option has been oats, but now suitable cereal ryes are also available.

However, although the cereal ryes were quick to produce feed, their palatability dropped later in the season compared with the other cereals, so they should make up only a part of an overall forage production system.

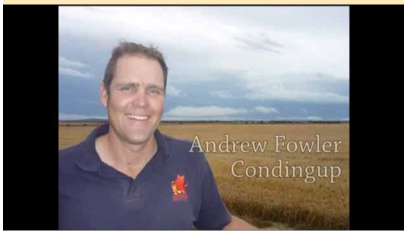
After the first grazing, the difference in production between the crops (i.e. oats, rye, barley, triticale and wheat) narrowed significantly.

The trials also showed that grazing periods and rest periods were important for DM recovery. Generally, grazing too hard slows regrowth. If possible, farmers should leave some DM in the paddock to aid recovery from grazing. In this way, stock can be returned to the paddock faster. This could affect gross margins, because DM production and grain recovery are both important to the overall profitability of dual-purpose crops.

These DM figures add up to a bonus for producers, with excellent returns from livestock enterprises as well as a profitable grain yield. [4]

## VIDEOS

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




## MORE INFORMATION

GRDC Factsheets: Dual-purpose crops.

GRDC Update Papers: 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 Papers: Profitable dual purpose cereals in the north and central west (a Purlewaugh case study).

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

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

### 2.1.3 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. [5]

#### Cover cropping to prevent 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. [6]

## IN FOCUS

#### Growing cereal rye to Increase carbon and prevent wind erosion

The owners of a farm in Western Australia had long-term problems with areas in paddocks that were consistently producing very low yields. They decided that these areas would perform better if they were sown to a lower input crop such as cereal rye. In addition, they could reduce their inputs by as much as 50%, because rye is cheaper to sow than most cereals.

In the second and third years, the rye was left to self-sow. Then it was run over with the seeder bar to topdress some additional seed. Having grown rye for three successive seasons, the owners believe it has accomplished what they set out to do. The groundcover produced by the cereal rye is significantly 'better than wheat has been able to provide and it will outperform both wheat and barley on poor acid soils'.

In the third year, however, they believe they should have been more proactive on their weed control within the cereal rye crop because a weed-control issue developed.

Soil sample results show that the soil organic carbon (SOC) improved in the affected areas. Since 2012, the SOC increased in the topsoil, by 27.8% in 2013 and 16.7% in 2014. This represents a total improvement of 47% since 2012.

Conclusions

- Cereal rye has established well on poor windblown sand.
- It has been successful in preventing further erosion.
- Approximately 80% of land cropped to rye has recovered sufficiently to return to normal rotation.
- Weeds became an issue after three years of continuous rye. [7]

5 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(6), 1589–1596, https://dl.sciencesocieties.org/publications/aj/pdfs/101/6/1589

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

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

Cereal rye is the plant commonly used for reclamation on the solonised brown soils, which lie largely in a zone of low rainfall, ~23–38 cm per annum of unreliable, winter incidence. Soils are deep sandy to shallow loamy 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. These soils make up a large part of the low-yielding wheat lands of southern Australia. They are farmed on a wide rotation, comprising volunteer pasture–fallow–wheat, in which superphosphate is used solely with the wheat. Sheep graze the pastures. These soils, especially the sands, are very susceptible to wind erosion, and much effort is now devoted to the stabilisation of the once-cleared and cultivated dunes. [8]

### 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. [9] In the absence of herbicides, cereal rye cover crops are typically terminated with tillage, or with mowing in no-till situations.

Do not use rye as a cover crop just before growing other cereal grains. Volunteer rye may contaminate wheat, oats and barley. [10]

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 1). [11]

**Photo 1:** *Shorter stands of cereal rye can still produce seed heads.*

Source: University of Nebraska)

## 2.2 Varietal performance and ratings

### 2.2.1 Identifying products for industry

Low amylose or sticky ryes were perceived to be of benefit to the feed industry in that high amylopectin is relevant to growth of both ruminants and monogastrics. They were also seen as potentially useful as products for the human food industry including snack foods, breakfast cereals and crispbreads. None of these uses has been realised as the Winter Cereals Committee rated this objective of low priority in

**VIDEOS**

WATCH: Over the Fence: cover crop ensures soil moisture

**MORE INFORMATION**

University of Manitoba article: Fall rye cover crops for PFP and organic pulse crop production

Research paper: Cover crop impact on nitrogen availability and dry bean in an organic system

USDA study report: Effects of mixed species crop cover on soil health

8 ABS (2012) The soils of Australia. Australian Bureau of Statistics, November 2012, http://www.abs.gov.au/ausstats/abs@.nsf/Previousproducts/1301.0Feature%20Article801966

9 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

10 N Rector, T Harrigan, DR Mutch, S Snapp (2009). Cereal rye: manure and livestock's new best friend. Manure $ense. Michigan State University Extension, February 2009

11 D Lyon, R Klein (2007) Rye control in winter wheat. NebGuide G1483. University of Nebraska, https://web.archive.org/web/20140413144910/http://www.ianrpubs.unl.edu/pages/publicationD.jsp?publicationId=106

the second cycle of funding. Options to develop these ryes for the above purposes are still available, and the low amylose materials developed for this project have been kept in storage. The low amylose selections will be crossed with waxy wheats with a view to developing waxy or low amylose triticales for the food and feed industries.

High amylose ryes were also isolated and crosses made to high amylose durums in 2004 with a view to developing high amylose triticales.

Low and high pentosan ryes were developed for the food and feed industries. Both were evaluated for their roles in bread making (George Weston Foods). The line for commercial increase will be tested by industry in 2005 (George Weston Foods, Byron Agricultural Company) and released to growers at the same time. The low and high pentosan ryes were seen of zero and high priority, respectively by the Winter Cereals Committee, therefore the low pentosan ryes were placed into storage, although they may be relevant to bread making and as feed for monogastrics in the future.

White rye is being commercially developed and will be tested by George Weston Foods in 2005, at the same time as it will be released to growers. It was seen as relevant for use in breads and crispbreads. However, with the shutdown of the Weston crispbread factory in Australia, its only relevance is now in the development of white rye breads.

High molecular weight (HMW) glutenin rye was seen as important to the bread making industry i.e. high loaf volume. However, there has been a shift to high baking triticale in recent years. Although this material had commenced development, high molecular weight rye from Professor Adam Lukaszewski (University of California, Riverside) was made available, but to date has not been tested under Australian rye baking technology. Yield was approximately 30% lower than conventional rye, and until it is improved, it is unlikely that this project will have a high priority.

### Low- and high-amylose rye

It was anticipated that low amylose ryes would be useful for food products such as breakfast cereals, as well as feed for ruminants and monogastrics.

Both high- and low-amylose ryes were identified. The low-amylose lines had amylose contents of 6–10%. Nine high-amylose lines were identified with a range in amylose of 33–37%.

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

### Low-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.

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.

### High-pentosan rye

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 population was also tested in 2004 as a rye for grazing for the Queensland cattle industry.

### White rye

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

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

A high-molecular-weight (HMW) glutenin was seen as a priority by the rye industry, which sought a better baking rye.

A rye line with a wheat–rye chromosome translocation was supplied by Professor Lukaszewski, 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 line 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.

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 at least 10% higher yielding than Ryesun in NSW, and with improved lodging resistance. [12]

## 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.

Cereal rye is suited to the acid soils of central and southern NSW and to 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 SA was not as high yielding as Bevy.

### High-pentosan rye for NSW

The high-pentosan rye developed for central NSW was coded HP Rye. This was a combination of 11 high-pentosan lines 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. In yield trials, this line proved higher yielding than the control, Ryesun, by 5–10% and had better lodging resistance. Subsequent quality testing by Westons found that this synthetic produced an excellent rye bread, and that the variation in seed colour was suitable for making kibble. The new rye variety is a good grazing-and-grain line for NSW growers and has the potential for southern Queensland as a grazing variety for the cattle industry.

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

### White rye suitable for NSW

Thirteen white-seeded selections were combined to produce a white rye synthetic. The population from which it was developed was 20% lower yielding than Ryesun. Based on yield trials in 2001 and 2002, the best lines were combined to make the synthetic variety. This line was 10–15% lower yielding than Ryesun, and taller. Quality analysis by Westons revealed that the white rye synthetic produced a poor rye loaf due to underlying quality problems and the method used to produce rye bread in Australia.

### Opportunities

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

1. Biofuel (hybrid rye now out-yields most other cereals and can be grown on marginal land which does not affect the current food and feed requirements of other cereal grains).
2. White bread making rye. The rye industry would benefit substantially from a high baking rye that would reduce the need for the addition of wheat flour (70%) in rye loaves. This option is possible using white grain triticales with excellent bread making characteristics that can be crossed with new and existing sources of white rye. [13]

Growers should be aware that cereal rye is a cross-pollinating species and it will out-cross. 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 is a composite variety of mainly semi-dwarf rye lines. Most plants (80%) are semi-dwarf, with 15% as tall as SAC and 5% very short. When mature, heads also range in length.

Bevy has excellent resistance to CCN and is superior to SAC for stem and leaf rust resistance.

Bevy is up to two weeks later maturing than SAC, which may assist in avoiding effects of frost. The yield of SAC is frequently frost-affected whereas Bevy may escape.

Grain quality is similar to SAC for milling and baking, although seed size is slightly smaller.

Compared with SAC, Bevy shows increased seedling vigour and superior tillering ability and is the most suitable cereal for fragile, sandy soils. Bevy appears better adapted than SAC in most situations where rye is grown, and this benefit appears greater in longer growing seasons.

The milling yield of Bevy is slightly improved over SAC and baking quality is similar for the two varieties. Bevy has slightly smaller seed, marginally lower 1000-grain weight and a smaller proportion of very dark grains than SAC. [14]

13 GRDC (2004) Rye—new products for industry. GRDC Project US00022, Final Report, http://finalreports.grdc.com.au/US00022

14 R Saunders, R Wheeler. Bevy. Teague Australia Seed and Grain Brokers, http://www.teague.com.au/members/pdf/9749370EA20CA886DBF1899.pdf

### Southern Green

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. [15]

Key points:

- Southern Green forage cereal rye is 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 45 days after sowing (Photo 2).
- In a trial, by late July (90–100 days after sowing) oat growth rates 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.

Cereal rye has resistance and tolerance to CCN, making it a valuable rotation option on lighter soils where CCN is often severe. [16]

**Photo 2:** *Winter feed trial (sown 21 April 2008) of Southern Green forage cereal rye (left) and Wintaroo Oats (right) at Ballarat. Photo was taken 45 days after planting. Southern Green was ready for grazing whereas Wintaroo would have been damaged by grazing at this early development stage.*

Source: Wrightson Seeds

### Vampire(b

Vampire(b cereal rye is recommended for extremely vigorous growth and early grazing. It is suited to very poor soils and revegetation projects.

Key characteristics:

- main season variety
- rapid early growth
- good tolerance to acid soils and high aluminium

15 P Matthews, D McCaffery, L Jenkins (2016) Winter crop variety sowing guide 2016. NSW Department of Primary Industries, https://www.dpi.nsw.gov.au/agriculture/broadacre-crops/guides/publications/winter-crop-variety-sowing-guide

16 Wrightson Seeds. Forage focus—southern green ryecorn. http://www.pggwrightsonseeds.com.au/assets/FTP-Uploads/Forage_Focus/Cereals/FF_Southern-Green-Forage-Ryecorn.pdf

- improved lodging resistance and grain yield compared to Ryesun
- suitable for grazing and grain recovery
- good rotation for suppression of root-lesion nematode. [17]

### Ryesun

Ryesun is 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.

### Westwood

Westwood is a main season variety with similar maturity to Ryesun. It has adequate stem and leaf rust resistance, is at least 10% higher yielding than Ryesun in NSW, and has improved lodging. Westwood was released commercially in 2003. [18] [19]

## 2.3 Planting seed quality

Seed should be free of weeds and ergot bodies, 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 that has proven adaptation to local conditions. Fungicide seed treatments used for other small grains are suitable for use on rye, and can often improve stands. [20]

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. [21]

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 3). During bulk storage, areas of excessive moisture can lead to microbial-induced 'hot spots' and since moisture moves from hot to cooler areas, further local heating is caused, setting off a chain reaction. [22]

**Photo 3:** *Normal cereal seed (left) compared to heat-damaged seed (right). Note the distinct colour difference.*

Source: Grain South Africa

For information about grower-retained seed, see the GRDC Fact Sheet: Retaining seed: Saving weather damaged grain for seed.

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

18 P Matthews, D McCaffery, L Jenkins (2016) Winter crop variety sowing guide 2016. NSW Department of Primary Industries, https://www.dpi.nsw.gov.au/agriculture/broadacre-crops/guides/publications/winter-crop-variety-sowing-guide

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

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

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

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

### 2.3.1 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. [23]

Seed germination drops rapidly when cereal rye is stored for longer than one year. [24]

Seed vigour affects the level of activity and performance of the seed or seedlot during germination and seedling emergence. Loss of seed vigour is related to 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 due to 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).

However, seeds lose vigour before they lose the ability to germinate. That is why seedlots that have similar, high germination values can differ in their physiological age (the extent of deterioration) and so differ in seed vigour and therefore the ability to perform. [25]

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

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 window-sill. 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%.

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

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

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

- Germination of 80% is considered acceptable for cereals.
- The results from a laboratory seed-germination test should be used for calculating seeding rates. [26]

### 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. [27]

## 2.3.2 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 in the northern grains region.
- 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 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. [28]

For more information, see Section 13: Storage.

## 2.3.3 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 N/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. [29]

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

VIDEOS

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


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

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

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

29 Wrightson Seeds. Forage focus—southern green ryecorn. Wrightson Seeds , http://www.pggwrightsonseeds.com.au/products/cereals/southerngreenryecorn/

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. [30]

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. [31]

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. To avoid this increased fertiliser concentration in wide-row systems, the safe rate of in-furrow fertiliser decreases as row spacing increases (Table 2). 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 3). Higher seedbed utilisation can optimise crop grain-yield potential, as well as minimising fertiliser toxicity risk. [32] [33]

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 2:** *Approximate safe rates (kg/ha) 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). SBU, Seedbed utilisation = (width of seed row/row spacing) × 100..*

| 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 |

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 3:** *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 |

30 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

31 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

32 GRDC (2011) Care with fertiliser and seed placement. GRDC Fertiliser Toxicity Fact Sheet, May 2011, https://grdc.com.au/resources-and-publications/all-publications/factsheets/2011/05/fertiliser-toxicity

33 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

Source: Incitec Pivot Fertfact

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