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GRDC GROWNOTES™

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

TRITICALE

SECTION 2

PRE-PLANTING

TRITICALE AS A DUAL-PURPOSE CROP | VARIETAL PERFORMANCE AND RATINGS YIELD | PLANTING-SEED QUALITY

Pre-planting

Key messages

- Triticale breeding programs have aimed at improving grain yield and dry-matter production, producing winter habit triticales with a wider range of sowing dates, improving the grazing ability (having the growing point closer to the ground), and incorporating new sources of rust resistance.
- These breeding programs have produced a number of new varieties designed for particular uses and regions.
- Triticale is extensively used in dual-purpose cropping systems, with varieties bred specifically for them.
- It is important to ensure that seed quality is of a high standard. Check for damage and discolouration as affected seeds may have poor germination and emergence.
- The larger seed size of triticale means that emergence is consistently good; however, high-quality seed must be used.
- Consult local variety sowing guides for the best practices for your region; Winter crop variety sowing guide–NSW 2017.

There are two types of triticale to choose from: grain-only, and dual-purpose (Photo 1). [1] Dual-purpose varieties can be sown very early, grazed during winter, and then shut up for forage conservation or grain recovery. [2]

Photo 1: *Triticale combines the high yield potential and good grain quality of wheat with the disease and environmental tolerance of rye.*

As far as amount of vegetative growth, triticale is very similar to that of a cereal rye plant, growing 90–150 cm in height. It also has an extensive fibrous root system that makes it an excellent choice for preventing erosion, scavenging for nutrients, and also for building soil structure.

Triticale has excellent grazing and forage values. It has a heavy residue on the surface, much like that of cereal rye, if allowed to reach maturity, thus also making it a good choice for weed suppression. [3] Tritcale is also tolerant to waterlogging.

2.1 Triticale as a dual-purpose crop

Key points:

- Advantages of dual-purpose crops include capitalising on early rainfall, flexibility in enterprise mix, and improved and spread out cash-flow.

1 Seed Technology (n.d.) Triticale. Seed Technology, http://seedtech.ie/index.php/en/products/cereals/triticale

2 Waratah Seed Company (2010) Triticale: planting guide. Waratah Seed Company, http://www.porkcrc.com.au/1A-102_Triticale_Guide_Final_Fact_Sheets.pdf

3 Advance Cover Crops (n.d.) Triticale. Advance Cover Crops, http://www.advancecovercrops.com/portfolio_item/triticale/

- Dual-purpose crops require a high standard of management.
- Ideal grazing facilities would allow for an excellent water supply, shelter belts and rotational grazing, and drafting cattle into similar weight ranges before being placed onto grazing crops. Try to minimise handling and ensure that all animal health issues are addressed. [4]
- Triticale feed grain has similar nutritional qualities as wheat and can be fed to livestock in the same way.
- It is recommended to split the variety selection and sowing time of dual purpose cereals where possible. This will spread the period when grazing can occur and also the risk of crop failure due to dry conditions or disease.

Dual-purpose crops hold great potential for farmers to utilise early-season sowing opportunities to provide extra grazing for livestock and yet maintain grain yield. With good management, the period of grazing can increase net crop returns, and give a range of system benefits including widening sowing windows, reducing crop height, filling critical feed gaps, and spelling pastures. Over 10 years of experiments, simulation studies and collaborative on-farm validation across Australia have demonstrated that a wide range of cereal and canola varieties can be successfully grazed and recover sufficiently to produce an acceptable grain yield, The combined livestock and grain gross margins can exceed grain-only crops, and increase whole-farm profitability. [5]

The Australian dual-purpose cereal crop (which includes triticale, wheat, oats, barley and cereal rye) is increasing in importance because of factors such as higher-value animal industries. The ability of several recent variety releases to provide valuable winter grazing, as well as a grain yield similar to grain-only crops, helps farmers to improve winter feed supply. [6]

When a dual-purpose triticale is grown with the intention of providing winter grazing and then optimising grain production, the time of stock removal or lock-up is important. Locking-up grazing stock early in the season is important to along for the grain crop to recover. For more information about grazing timing see Section 2.1.3 When to graze, below.

Dual-purpose crops can be a vital part of a mixed farming operation. Although, reliable dual-purpose crops require a high standard of agronomy, including timely sowing, careful choice of variety, good sub soil moisture, and high soil fertility, there are pay-offs. They also take a lot of pressure off the remaining grazing base (pastures), commonly giving them a chance to get away and be in an improved position to provide good feed when the dual-purpose crop is locked up for grain. [7]

2.1.1 Benefits of growing dual-purpose or winter-forage crops

Minimises risks

Dual-purpose or winter-forage crops can protect against several natural hazards:

- Floods or large amounts of rainfall close to grain harvest, which have caused or can cause severe damage to ripening crops and downgrade grain quality
- Minimise the risks associated with dry periods in late winter–spring.
- Being able to sow early when moisture is available that may not still be there when the main season crop is due to be planted or if seasonal conditions are too

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

5 J Kirkegaard, S Sprague, J Lilley, L Bell L (2016) Managing dual purpose crops to optimise profit from grazing and grain yield north. GRDC Update Paper. GRDC, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/Managing-dual-purpose-crops-to-optimise-profit-from-grazing-and-grain-yield-north

6 GRDC (2007) Dual-purpose crops: Adaptable triticale steps up. Ground Cover. No. 66. GRDC, https://grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-66-January-February-2007/Dualpurpose-crops-Adaptable-triticale-steps-up

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

wet in the main sowing window. This spreads the risk; giving an opportunity to sow in an earlier window than main season wheat.

Capitalises on early rainfall

These crops can help the grower make the most of early rainfall because:

- Grazing or dual-purpose crops can be planted in late February and up till late March to capitalise on late-summer rain. It also spreads workloads.
- Early-sown crops will provide quality feed from mid-May in most seasons, provided that paddock nutrition is correctly addressed.

Flexibility in enterprise mix

Dual-purpose or winter-forage crops mean that the farm business:

- Isn't totally vulnerable to fluctuations in grain prices, export markets, grain-quality issues, and downgrading because of weather damage.
- Can tap into the profits from weight gains available with buying and selling cattle thus spreading cash flow throughout the year
- Capitalise on cattle prices at feedlots, which are usually higher when grain prices are down—grain is a major input cost for feedlots and therefore it has a major impact on feedlot margins.
- Can delay the decision to lock up dual-purpose crops until late July—during a normal average season when late winter–early spring feed reserves (pastures) are looking good, dual-purpose crops can be locked up, top-dressed, or controlled for weeds if necessary, and kept for grain production.
- Can elect to continue to graze the crop, taking into account cattle and grain prices, levels of stored soil moisture, and the seasonal outlook.

Improved cash-flow

Cash flow is increased because:

- Dual-purpose crops offer the benefit of generating early income from the start of the grazing period.
    - » Cattle are often sold in late July, after 70 days of grazing and after achieving a weight gain of 90–120 kg/head;
    - » i.e. budget 70 days × average 1.6 kg/head/day for a good crop
- Producers don't need to finish the cattle—the best returns are often obtained from backgrounding cattle for local feedlots. A good idea is for growers to speak with the feedlot before they buy cattle; alternatively, there may be an opportunity to background cattle on behalf of a feedlot, being paid for the weight gain only.
- A well-managed forage crop can provide sufficient early-season feed for up to 5 weaners/ha.
- Cash flow is generated in different times of the year to straight grain income. For grain recovery in dual-purpose crops in the southern part of the Northern region, growers should budget 50% of un-grazed crops although in good seasons this number can be much higher. [8]

MORE INFORMATION

Dual purpose crops

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

IN FOCUS

Dual purpose cereal crops - NSW trials

With the support of the Grains Research and Development Corporation, NSW DPI managed a series of dual-purpose cereal cropping trials at Somerton, Purlewaugh, Cowra and Culcairn between 2008–2012. The main points made from these trials are:

- Oats and barley produced more dry matter than wheat or triticale across sites and seasons.
- Triticale produced the highest grain yield following grazing.
- No single variety excelled in terms of ranking in the top 10 for both dry-matter production and grain yield. Urambie barley was the best overall performer, followed by El Alamein and Endeavour⦅D⦆; triticales and Tennant, a winter wheat.
- Dual-purpose varieties should always be selected based on individual enterprise needs.

Dual purpose cereal trials have been conducted by the NSW Department of Primary Industries for over 40 years. Two trial sites located in northern NSW between 2008–2012 included a range of wheat, oat, barley, triticale and cereal rye varieties, both commercial and experimental lines, which amounted to 127 different entries over the five-year period.

Somerton trial sites were located at "Clermont Park" in 2008–2012, while Purlewaugh sites where located at "Naparoo" in 2008, 2009, 2010, 2012 and "Kurrajong Vale" in 2011. The trials were sown each year in the first three weeks of April. In each year dry matter assessments were conducted around the end of June for dry matter 1 and at the beginning of August for dry matter 2. Dry matter assessments were followed by a 'crash' grazing using both sheep and cattle to remove the dry matter evenly across all plots. The second dry matter assessments did not occur at either site in 2008–09 due to the dry seasons. Following the final grazing in each trial animals were excluded for the remainder of the season to allow grain recovery to be assessed in late November/ Early December. Trial plots were harvested using a KEW plot header.

Dry matter and grain yield data for each of the four species, wheat, oats, barley and triticale were compared, across varieties for an indication of their respective performances (Table 1).

Species selection should be based on the priority end use for each individual paddock. The best early dry matter production was provided by oats. Oats were also comparable to barley by providing the best total dry matter production over the length of the season. Triticale was significantly superior to all other species for final grain recovery. Wheat produced the least amount of dry matter but the second highest grain yield. Oats in comparison had the poorest grain recovery of all species. Barley appeared to give the best balance between dry matter production and grain recovery. It should be noted that wheat has a higher return price for the sale of the grain.

Table 1: *Species mean dry matter and grain yields from 2008–2012 trials.*

Species	Dry matter 1 yield (t/ha)	Dry matter 2 yield (t/ha)	Grain yield (t/ha)
Barley	2.796	3.313	3.076
Oats	2.923	3.307	2.390
Triticale	2.502	3.074	3.975
Wheat	2.384	2.982	3.304

* Data for dry matter 2 was only available for 2010–2012.

Source: GRDC.

A total of 40 varieties were selected from the overall 127 varieties that data was collected for. The dry matter assessment and grain yield results for 8 barley, 13 oat, 5 triticale and 14 wheat varieties are presented in Table 2.

No one variety was ranked in the top 10 for both dry matter production and grain yield. The barley variety Urambie was the most consistent performer for grazing and grain recovery ranking number 11 for dry matter production at 6.12 t/ha and number 5 for grain yield at 3.72 t/ha. Three other strong performers were the two triticale varieties; El Alamein (6.08 t/ha dry matter and 4.14 t/ha grain yield) and Endeavour⚶ (5.91 t/ha DM and 4.08 t/ha grain yield); and Tennant, a winter wheat that produced 5.78 t/ha DM and 3.57 t/ha.

Table 2: *Across sites and seasons, variety performance of commercially available dual purpose triticale varieties tested in Somerton and Purlewaugh trials between 2008–2012.*

Variety	Dry matter 1 yield (t/ha)	Dry matter 2 yield (t/ha)	Total dry matter (t/ha)	Grain yield (t/ha)	Trial number
Crackerjack⚶	1.93	3.63	5.56	4.27	5
El Alamein (AT573)⚶	2.66	3.41	6.08	4.14	7
Endeavour⚶	2.50	3.41	5.91	4.08	9
Tobruk⚶	2.75	2.82	5.56	4.58	7
Tuckerbox⚶	1.79	3.05	4.84	3.49	4

Source: GRDC.

The triticale varieties came to the fore when grain yield was taken into consideration with all five triticale varieties ranking in the top 10 for grain yield (Table 3). [9]

9 L Serafin, M Gardner, J Fleming, D Pottie, S Harden (2013) GRDC Update Papers: Dual Purpose Cereals: Varieties and management for the Northern Slopes and plains. https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/02/Dual-Purpose-Cereals-Varieties-and-Management-for-the-Northern-Slopes-and-Plains

MORE INFORMATION

[Dual purpose cereals: varieties and management for the northern slopes and plains]

GRDC factsheet, [Dual-purpose crops]

[Optimising grazing and grain yield in dual-purpose crops, North Region]

[Dual purpose cropping]

[Dual purpose crops: do they have a fit in your system and how can they be managed to optimise forage and grain production]

VIDEOS

WATCH: [Over the Fence: Grazing crops—reaping big rewards and returns]

PODCAST

LISTEN: [Dual purpose cropping: a farmer's perspective]

Table 3: *The top 10 ranked varieties for grain yield from Somerton and Purlewaugh dual purpose cereal trials between 2008–2012*

Variety	Species	Grain yield (t/ha)	Grain yield Ranking
Tobruk⒫	T	4.58	1
Crackerjack⒫	T	4.27	2
El Alamein (AT573)⒫	T	4.14	3
Endeavour⒫	T	4.08	4
Urambie⒫	B	3.72	5
SQ⒫ Revenue⒫	W	3.61	6
Marombi⒫	W	3.59	7
Tennant⒫	W	3.57	8
Na⒫aroo⒫	W	3.55	9
Tuckerbox⒫	T	3.49	10

* Species included are B = Barley, O = Oats, T = Triticale and W = Wheat.

Earlier trials in NSW also compared yield outcomes of dual-purpose triticale varieties (Table 4). [10]

Table 4: *Dual-purpose yield-performance experiments 2004–2009 in triticale varieties.*

Compared with Endeavour⒫; = 100%.

Variety North	First grazing DM Endeavour⒫; = 2.63 t/ha	Second grazing DM Endeavour⒫; = 2.39 t/ha	Grain recovery Endeavour⒫; = 2.41 t/ha
Breakwell⒫;▲	99	97	85
Crackerjack⒫;▲	103	87	100
Endeavour⒫;	100	100	100
Tobruk⒫;▲	76	111	111
South	Endeavour⒫; = 2.19 t/ha	Endeavour⒫; = 2.23 t/ha	Endeavour⒫; = 2.98 t/ha
Breakwell⒫;▲	93	102	83
Crackerjack⒫;▲	101	85	90
Endeavour⒫;	100	100	100
Tobruk⒫;▲	76	108	110

▲ Outclassed: Breakwell⒫;, Crackerjack⒫; and Tobruk⒫; (stri⒫e rust)

Source: NSW DPI

2.1.2 Choice of variety is critical

Winter habit is a characteristic where the growing point remains at ground level until a sufficient amount of cold weather triggers plants to change to spring habit, referred to as vernalisation. Vernalisation is the induction of a plant's flowering process by exposure to the prolonged cold of winter. After vernalisation, plants have acquired the ability to flower, but they may require additional seasonal cues or weeks of

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

growth before they will actually flower. Spring-habit varieties have no delay, and heads grow 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 form. This can be slow, especially in the middle of winter and if the supply of soil water is low.

Varieties vary in their levels of winter habit: this means varieties with only a low level will switch to a spring habit with heads growing up the stem after a shorter period of cold winter weather than varieties with a high level. High levels of winter habit mean heads remain at ground level for a much longer period in a given environment.

The desirable level of winter habit is largely related to climate and the purpose of growing the crop. For example, if the purpose is mainly for early sowing and for 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 best suit a variety with moderate levels of winter habit. This allows early sowing with no running to head too early, nor loss of tillers, and a period of 30 to 100 days of grazing before it is locked up for grain recovery. Desirable length of grazing is variable and is not only related 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 that is satisfied faster, therefore varieties with greater winter habit are needed. In warmer environments, varieties with less winter habit are needed, unless they will be used only for grazing.

Varieties with winter habit tend to grow slower at first than spring-habit types. This is often of little consequence if sowing earlier, as the crop tends to make it up with better recovery after grazing in winter and early spring. [11]

MORE INFORMATION

Profitable dual purpose cereals in the north and central west: a Purlewaugh case study

2.1.3 When to graze

Managing the timing and intensity of grazing dual purpose cereals is critical to achieving maximum dry matter and grain yield. In order to achieve this some knowledge of individual varieties growth rates is useful. The rate of growth of each variety needs to be monitored carefully to ensure grazing is timely.

Grazing can commence once the plants are adequately anchored with secondary roots. This is to prevent stock from removing plants from the ground (Photo 2). Identifying when to commence grazing is easier than identifying when to cease grazing.

Photo 2: *Triticale grazed by cattle and used to clean up a paddock.*

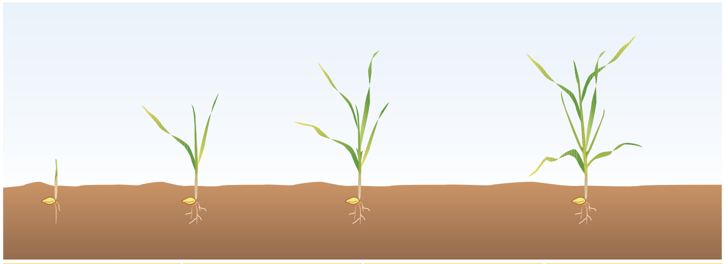
Source: EverGraze

Dual-purpose varieties can be sown early for winter grazing (30–100 grazing days). The ideal grazing time is when the canopy is closed (growth stages GS21–GS29, Figure 1). Continuous grazing is better than rotational grazing for fattening stock. Maintain adequate plant material (1,000–1,500 kg DM per ha) to give continuous and

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

quick regrowth of the crop. Do not graze below 5 cm with prostrate varieties and below 10 cm for erect varieties. [12] The higher grazing height is particularly important with the erect-growing varieties. Over-grazing greatly reduces the plant's ability to recover. [13]

The crop must be monitored regularly (at least twice a week) for stem elongation and the appearance of the first node. This indicates that the plant has gone into reproductive mode and grazing from this time onwards will reduce grain yield. Once the crop reaches this stage grazing should cease. [14]



Zadoks Growth Stage	GS 00-09	GS10-19	GS20-29	GS30-39
Development phase	Germination	Seedling growth	Tillering	Stem elongation

Figure 1: *Zadoks cereal growth stages. The ideal grazing period for dual purpose triticale is between GS21-GS29. Stock should be removed from the paddock at the stem elongation phase (GS30).*

Source: GRDC.

Once a variety reaches Zadoks growth stage 30 it is changing from vegetative to reproductive phase. Beyond this stage nodes may be felt inside the stem of the plant indicating that the developing head has now moved above ground level. At this stage livestock should be removed and the paddock locked up for grain recovery or hay production. If livestock are allowed to continue grazing beyond this point, developing heads may be grazed off leading to significant reductions in grain yield and tiller death. Growth stage assessment should always be carried out of the primary tiller as it is the most advanced.

The time taken to reach growth stage 30 varies with variety, temperature, grazing intensity and several other factors. Quick maturing varieties offer a reduced length of grazing, while long season varieties are often slow to produce dry matter and slower to reach growth stage 30 (Table 5). [15]

12 Birchip Cropping Group (2004) Triticale agronomy 2004. Online Farm Trials, http://www.farmtrials.com.au/trial/13801

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

14 Waratah Seed Company (2010) Triticale: planting guide. Waratah Seed Company, http://www.porkcrc.com.au/1A-102_Triticale_Guide_Final_Fact_Sheets.pdf

15 L Serafin, M Gardner, J Fleming, D Pottie, S Harden (2013) GRDC Update Papers: Dual Purpose Cereals: Varieties and management for the Northern Slopes and plains. https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/02/Dual-Purpose-Cereals-Varieties-and-Management-for-the-Northern-Slopes-and-Plains

MORE INFORMATION

[Yorke Peninsula and Mid-North trials highlight benefits of grain and graze]

[Effect of cutting on early sown triticale and wheat]

[Dual Purpose Triticale Improvement Program]

[Triticale: grazing guide]

Table 5: *Somerton dual purpose cereal trial 2011 growth stage records in crop (planted 19th April, 2011).*

Variety	Zadoks growth stage 27th June, 2011	Zadoks growth stage 16th August, 2011	Zadoks growth stage 14th September, 2011
Crackerjack⚐	26	39	64
El Alamein (AT573)	23	33	53
Endeavour⚐	24	32	51
Tuckerbox	27	39	64

Source: GRDC.

2.1.4 Breeding dual-purpose triticale

Grain producers on the south-western slopes of NSW have expressed the importance of dual-purpose triticale varieties, as they want to graze the crop through autumn and winter and have a subsequent grain crop, to increase their gross margin per hectare and also provide an insurance against harvest failure.

There is a high demand for feed grain in the southern part of the Northern region, especially for triticale from the dairy and pig industries. The reduced transport costs and the slightly higher price for triticale compared to other feed grains makes triticale an attractive proposition. Triticale is particularly suited to some areas due to its tolerance of acid soils and the high levels of exchangeable aluminium in these soils, especially where the subsoil is acidic and cannot be easily corrected by liming.

With support from the GRDC, the University of Sydney has been working to improve the productivity of dual-purpose triticales through plant breeding. This involves improving the grain yield and dry-matter production, producing winter triticales so there is a wider range of sowing dates, improving the grazing habit (so that the growing point is closer to the ground), and incorporating new sources of rust resistance. Shorter triticales are also produced to reduce the amount of stubble after harvest, suiting conservation-tillage farming practices, and also to improve grain yield.

The breeding program is also addressing grain quality, with the aim of improving ruminant productivity on triticale feed. [16]

2.1.5 Triticale grain for livestock

The major uses for triticale grain are as a feed supplement in the dairy industry, as a component in feeds used in beef feedlots, and as a constituent of compound rations for intensive pig and poultry farming. In livestock diets, triticale has a similar role to other cereals: it is primarily a good source of energy, as it has a moderate amount of protein and high amounts of starch and other carbohydrates. [17]

A key physical feature of triticale is that it is a soft grain; it has a hardness index almost half that of wheat and barley. This is an advantage in that less mechanical energy is required to mill triticale than wheat and barley prior to inclusion in livestock diets.

On the farm, triticale can be fed to livestock in the same way wheat or barley would be. [18] It is well suited to feeding dairy cows, with the benefits stated in Table 6.

16 University of Sydney (2012) Triticale. Plant Breeding Institute. University of Sydney, http://sydney.edu.au/agriculture/plant_breeding_institute/key_work_results/triticale.shtml

17 EA Oelke, ES Oplinger, MA Brinkman (n.d.) Triticale. In Alternative Field Crops Manual. University of Wisconsin, https://www.hort.purdue.edu/newcrop/afcm/triticale.html

18 Agriculture Victoria (2012) Growing triticale. Note AG0497. Revised. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/grains-and-other-crops/crop-production/growing-triticale

MORE INFORMATION

Triticale: stock feed guide

A guide to the use of triticale in livestock feeds

Assessing stock feed additives and mineral supplements

Table 6: *Average composition of cereal feed grains.*

	Triticale	Wheat	Barley	Sorghum
Available energy				
Pigs DE (MJ/kg as fed)	13.5	13.8	12.9	14.6
Poultry AME (MJ/kg as fed)	12.8	12.7	11.4	14.3
Cattle ME (MJ/kg DM)	12.6	12.7	12.4	10.5
Crude protein (% as fed)	12.9	10.4	11.3	9.7
Lysine (% as fed)	0.44	0.31	0.38	0.20
Methionine (% as fed)	0.20	0.15	0.16	0.12
Threonine (% as fed)	0.42	0.29	0.37	0.27
Starch (%DM)	63	66	58	74
ND fibre (%DM)	15.9	15.9	21.3	12.7

Data derived from AusScan calibrations of Australian feed grains and "Feeding Standards for Australian Livestock-Pigs (CSIRO, 1987)

2.1.6 Triticale as a cover crop

A cover crop is planted primarily to manage soil erosion, soil fertility, soil quality, water, weeds, pests, diseases, biodiversity and wildlife in an agro-ecosystem. One approach used in southern cropping regions involves annual crops being sown into established lucerne, a practice known as lucerne inter-cropping (Figure 2). [19] The benefits of doing this include reducing the risk of rainfall leakage during the cropping phase, as well as eliminating the costs of lucerne removal and re-establishment.

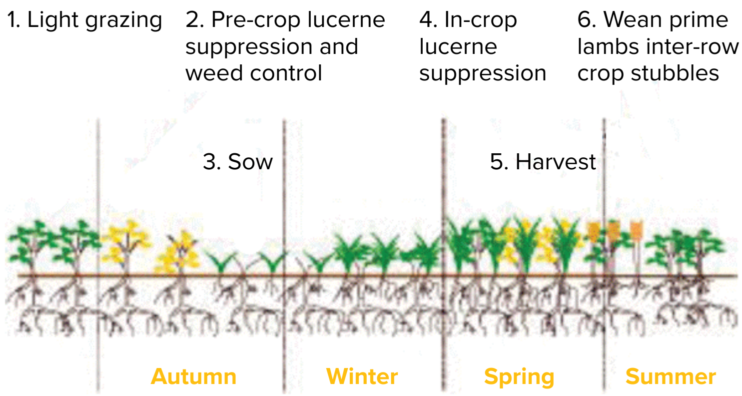


Figure 2: *Lucerne inter-cropping practice.*

Source: Agriculture Victoria

19 Agriculture Victoria (2015) Farmers' experiences. Agriculture Victoria

Under-sowing lucerne

Triticale is one of the most commonly used cereals for undersowing with Lucerne (Photo 3). [20] Triticale has poor tillering capacity and good tolerance to shattering. This makes it a useful cereal as a cover crop to establish under-sown lucerne or medic, but seeding rates may need to be reduced. [21]

Only use a grain variety that is early maturing and choose a paddock with a low weed seed bank because of limited options for herbicides with varying species.

When under-sowing:

- Use a grain-only variety with the earliest available maturity suited to your region
- Sow the triticale at lower seeding rate (15–30 kg/ha) than used for optimising grain yield (60–100 kg/ha)
- Choose a paddock with low weed numbers as the combination of species can dramatically reduce herbicide options.
- Expect a reduction in grain yield. [22]

Photo 3: *A paddock of cereal under-sown with lucerne.*

Photos: Andy Howard

MORE INFORMATION

AGT, Astute⟇

2.2 Varietal performance and ratings yield

Astute⟇; is a new mid-season triticale that is an alternative for Hawkeye⟇;. Bison⟇; first listed in 2015, became fully available in 2016. Cartwheel⟇; (which was tested as AT674) was also new for 2016,.

Astute⟇

Astute⟇; is a fully-awned variety suited to medium–high-yielding environments, and with excellent agronomic characteristics for grain production. It is rated:

- stem rust: R-MR
- stripe rust:
  - Tobruk⟇ pathotype: not known
  - Yr17-27: R-MR
- leaf rust:R-MR

It was bred by AGT (as TSA0466) to produce a very high-yielding triticale which would be the choice for growers looking to maximise the production from their triticale crops in high-potential environments. Astute⟇; combines broad adaptation, resistance to rust and CCN, good physical grain quality, and top-end yield capabilities.

Astute⟇; is suited to high yield potential areas of NSW and Victoria, with a very similar flowering time to Hawkeye⟇; and Fusion⟇;.It is very tolerant of acid soils.

20 Agriculture Victoria (2015) Farmers' experiences. Agriculture Victoria

21 Agriculture Victoria (2012) Growing triticale. Note AG0497. Revised. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/grains-and-other-crops/crop-production/growing-triticale

22 Waratah Seed Company (2010) Triticale: planting guide. Waratah Seed Company, http://www.porkcrc.com.au/1A-102_Triticale_Guide_Final_Fact_Sheets.pdf

Berkshire⚖

Berkshire⚖; is a mid-season, awned variety with good straw strength. This variety has now been outclassed. It is rated:

- stem rust: R
- stripe rust:
  - » Tobruk⚖ pathotype: MS
  - » Yr17-27: MR-MS
- leaf rust: R-MR*

* Provisional rating

This variety was purpose bred for high yield and feed quality traits for pigs by the University of Sydney and Pork CRC; it was registered in 2009. Its characteristics are:

- Improved digestible energy—13 MJ/kg compared to Tahara at 12 MJ/kg.
- Reduced fibre content—5% to 10% less than Tahara.
- Excellent yield—equivalent to best grain-only varieties currently available.
- Good straw strength.
- Quick to mid-season maturity.
- Moderately resistant to WA and Jackie strains of stripe rust.

Bison⚖

An early- to mid-season reduced-awn variety, Bison⚖; is best suited to low–medium-yielding environments. It was intended as a replacement for Rufus. Bison⚖; is an older variety.

Its characteristics are:

- Early-mid maturing, feed quality triticale.
- Tall plant type, with reduced awns and excellent disease resistance.
- Suited to central western NSW, southern NSW, northern Victoria, and SA.
- Moderately resistant to yellow leaf spot, and resistant–moderately resistant to *Septoria tritici* blotch.
- Tolerant to acid soils.

Bogong⚖

Bogong⚖; (tested as H127) was released by the University of New England, Armidale, in 2008. It is a grain variety with early- to mid-season flowering (similar to Treat). It is fully awned and stiff-strawed. It has good resistance to all common field strains of rust. Bogong⚖; has been one of the top-yielding varieties in evaluation trials across all environments in the seven seasons to 2015, up to 15% above Tahara. It is a widely adapted spring variety that is moderately susceptible to CCN. [23]

Canobolas⚖

This is an early- to mid-season awned variety with stiff straw, shorter than Tahara. it was bred by the University of New England, and registered in 2009. It is a widely adapted spring variety and tolerates acid soil. It is rated:

- stem rust—R
- stripe rust—MRMS#
- leaf rust—RMR.

Trials in Trangie, NSW in 2014 found that Canobolas⚖; although sown later than ideal, out-yielded some barley varieties and also provided better weed suppression. Canobolas⚖; has a quick erect growth features that assist in early weed competition. It was also the tallest variety at maturity reaching a greater height than the weeds. [24]

23 C Jeisman (2015) Triticale variety sowing guide 2015. PIRSA

24 G Brooke, L Jenkins, R Graham, G McMullen (2015) Cereal variety × weed competition–Trangie 2014. NSW DPI. http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/578288/northern-grains-region-trial-results-autumn-2015.pdf

MORE INFORMATION

Berkshire⚖ brings home the bacon

Bogong⚖ and Fusion⚖ inseparable in 2014 trials

Bogong⚖ and Canobolas⚖—SA, Vic, NSW

Big win for triticale

MORE INFORMATION

AGT, Chopper(D

GRDC, Fusion(D

Goanna

PODCAST

LISTEN: Ground Cover Radio 110: Triticale program further lifts crop productivity

Chopper(D

Chopper(D; is a fully awned, semi-dwarf spring variety which resists lodging in high-yielding environments; it is significantly shorter than all other currently available triticale varieties (15% shorter than Tahara). It matures very early: 3–4 days earlier than Speedee, and 7–15 days earlier than Tahara. The variety was released in 2010. It has good grain quality, and performs best in short growing seasons or late-sowing situations. This variety has now been outclassed. It is rated:

- stem rust: MR-MS
- stripe rust:
  - Tobruk(D pathotype: MS-S
  - Yr17-27: MR-MS
- leaf rust: R-MR*.
- CCN: R

* Provisional rating

Fusion(D

Fusion(D; is a mid-season (similar to Tahara), fully awned, grain-only spring triticale. It has moderate plant height, slightly taller than Hawkeye(D; and Jaywick(D;, and similar height to Rufus. It yields well in dry or sudden finishes. Very tolerant of acid soils. It is rated:

- stem rust: R
- stripe rust:
  - Tobruk(D pathotype: MR#
  - Yr17-27: R-MR
- leaf rust: R-MR*
- CCN:R

mixed population, some plants are more susceptible to stripe rust.

*Provisional rating

It was released in 2012. Fusion(D; produces large grain with low screening losses. Hectolitre weight is similar to that of Hawkeye(D; and Jaywick(D;, the benchmark varieties for this attribute. Its desirable sowing time is similar to Hawkeye(D; and Tahara. Fusion(D; is a fully awned triticale variety. It was released in 2012.

Goanna

Goanna is an early- to mid-season, fully awned, grain-only spring triticale, with a similar heading time to Treat, Tickit, Rufus and Hawkeye(D;. It is a tall, white-chaffed variety. It is rated:

- stem rust: R
- stripe rust:
  - Tobruk(D pathotype: MR-MS
  - Yr17-27: R-MR
- leaf rust: R-MR*
- CCN: R.

It was released in 2011.

KM10

KM10 is a fast-growing early- to mid-season awned variety. It has excellent early forage production in all rainfall zones. It tends to have a smaller grain, and is ideally suited to grain production in short-season environments. It is rated:

- stem rust: R
- stripe rust:

- » Tobruk⦶ pathotype: no data
- » Yr17-27: R-MR
- leaf rust: MR-MS
- CCN—susceptible.

It was released in 2014.

Tahara

A variety that has been widely grown for many years because of its reliability across a range of environments, Tahara is now outclassed by newer options. It may lodge in high-yielding situations. It is very tolerant of acid soils. Tahara is suited to most districts with rainfall up to 550 mm. It is rated:

- stem rust: R
- stripe rust:
  - » Tobruk⦶ pathotype: MS
  - » Yr17-27: MR-MS
- leaf rust: R-MR*
- CCN—resistant

*Provisional rating

Its resistance makes it a valuable disease-break option. Released 1987 by the Victorian Department of Agriculture, Tahara has long been the benchmark variety for use in cereal rotations in most districts up to 500 mm average annual rainfall.

Yowie

Yowie is a medium to tall mid-season spring grain triticale that has slightly later heading than Tahara. It is fully awned and white-chaffed. It is rated:

- stem rust: R
- stripe rust:
  - » Tobruk⦶ pathotype: MR-MS, MS#
  - » Yr17-27: MR
- leaf rust: R-MR*
- CCN: R.

mixed population, some plants are more susceptible to stripe rust.

*Provisional rating

It was released in 2010, and has shown similar yield performance to other triticale varieties in the National Variety Trials.

MORE INFORMATION

Yowie

Hawkeye⦶

Hawkeye⦶; (tested as TSA0108) was released by AGT in 2007, and is a broadly adapted, mid-maturing variety with high yield potential. It produces large grain with low screenings (similar to Tahara) and good test weight (like Treat), and is considered to be a high-yielding alternative to Tahara. It has very good acid soils tolerance.

Jaywick⦶

Jaywick⦶; (tested as TSA0124) was released by AGT in 2007 and is a broadly adapted, mid-maturing variety with high yield potential. It produces large grain with low screenings and good test weight. It is considered a slightly earlier, higher-yielding alternative to Tahara. It has CCN resistance, and moderate to good resistance to all rusts.

2.2.1 Dual-purpose triticales

These varieties can be grazed early and then allowed to produce grain or cut for hay.

Cartwheel⚪

Cartwheel⚪; is a long-season, dual-purpose triticale that is suitable for sowing from early March to early April. It is considered to be a stripe-rust resistant replacement for Tobruk⚪;. It has good early forage production when sown in March, and recovers from grazing to give excellent grazing in winter. Straw strength is good and has shorter stature than Tobruk⚪;. Grain yield after grazing is equivalent to that of Tobruk⚪;. It is rated:

- stem rust: R
- stripe rust:
  - Tobruk⚪ pathotype: no data
  - Yr17-27: R
- leaf rust: R.

Endeavour⚪

Endeavour⚪; is a long-season variety with similar maturity to Breakwell⚪;. It is semi-awnless and has good straw strength, with excellent dry-matter production and excellent grain recovery after grazing. It is very tolerant of acid soils. It is rated:

- stem rust: R
- stripe rust:
  - Tobruk⚪ pathotype: R-MR
  - Yr17-27: R
- leaf rust: R-MR*
- CCN: R

*Provisional rating

It was registered in 2008.

MORE INFORMATION

Endeavour⚪

Tobruk⚪

Rufus

Rufus is a mid-season-maturing variety, with a tall growth habit and reduced awns, making it favoured for hay production. Grain yields in higher-rainfall regions have been superior to Tahara, but may also cause lodging. It is rated:

- stem rust: R
- stripe rust: MR-MS#
- leaf rust: R
- CCN: R.

It was released in 2005 by the University of New England.

Tobruk⚪

With a strong winter habit Tobruk⚪; is a dual-purpose triticale, or a long-season grain-only variety with excellent grain yield. This variety, which was released in 2007, flowers earlier than Breakwell⚪; and Endeavour⚪;. This variety has now been outclassed. It is rated:

- stem rust: R
- stripe rust
  - Tobruk⚪ pathotype: MS-S"
  - Yr17-27: MR
- leaf rust: R.

"Susceptible to head infection

Its characteristics are:

- Strong winter habit.
- Excellent yield after grazing compared to all other varieties in the NSW mixed cereal trials.
- Easy threshing.

Tuckerbox

Tuckerbox is a late-medium season, tall, high-tillering variety. It is a reduced-awn head type, and may be grown for forage or grain. It is very tolerant of acid soils. It was released in 2009. It is rated:

- stem rust: MR
- stripe rust:
  - Tobruk⫏ pathotype: MR-MS
  - Yr17-27: MR
- leaf rust: R-MR
- CCN: R

Yukuri

Yukuri was bred by the University of New England in 2004, and is a late-medium season variety and a reduced-awn head type. It is suitable for forage and grain production in environments with 450 mm+ rainfall. Yukuri is susceptible to CCN.

Crackerjack⫏

Crackerjack⫏; is a medium-season, dual-purpose variety. Optimum sowing time is from mid April. It has excellent establishment and early vigour, excellent grain recovery after grazing, and produces grain with a high test weight. It is tall when mature, and can be prone to lodging if not grazed.

2.2.2 Forage varieties

SF Bolt

SF Bolt is for forage only. It was bred in New Zealand for lower acid detergent fibre (ADF) and higher metabolizable energy level (ME) to make it suitable for grazing, green chop or whole-crop silage. It can be autumn or spring sown. There is very limited data on its performance in NSW.

2.2.3 Triticale trials

In trials in NSW, researchers compared yield performances for grain-only triticale (Table 7). [25] No recent data is available for north-western NSW as only a limited number of trials were conducted from 2008 to 2015.

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

Table 7: *Grain-only yield performance experiments, 2008–2015, compared with Fusion⚕ (which = 100%).*

Variety	North-east Fusion⚕ = 4.14 t/ha	Number of trials	South-east Fusion⚕ = 4.57 t/ha	Number of trials	South-west Fusion⚕ = 6.09 t/ha	Number of trials
Astute⚕	104	6	105	10	–	–
Berkshire⚕▲	95	15	93	29	100	6
Bison⚕	101	6	101	10	–	–
Bogong⚕▲	99	15	96	29	104	6
Canobolas⚕▲	97	13	95	26	106	5
Chopper⚕▲	89	15	87	29	87	6
Fusion⚕	100	11	100	22	100	5
Goanna	87	10	86	18	91	4
Hawkeye⚕	95	15	95	29	102	6
Jaywick⚕	92	15	93	29	103	6
KM10	87	4	89	7	–	–
Rufus▲	85	15	84	29	87	6
Tahara▲	84	15	83	29	86	6
Tobruk⚕▲	85	5	85	11	–	–
Tuckerbox	76	13	76	25	85	5
Yowie	86	11	86	22	96	5
Yukuri	74	15	75	29	95	6

▲Outclassed: Berkshire⚕, Bogong⚕, Canobolas⚕, Chopper⚕, Rufus, Tahara and Tobruk⚕ (all stripe rust)
*Includes some irrigation trials
The table presents data of NVT 'production value' multi-environmental trials on regional mean basis from 2008–2015.

Source: NSW DPI

MORE INFORMATION

Triticale variety trials NSW 2015 - NVT

Triticale variety trials SA 2015 - NVT

Grain-quality characteristics and feed value for livestock are similar for all triticale varieties and are influenced more by seasonal conditions than by varietal differences (Table 8 [26]).

26 C Jeisman (2015) Triticale variety sowing guide 2015. SARDI

Table 8: *Agronomic and disease characteristics of triticale varieties.*

Variety	Grazing production	Straw strength	Maturity	Resistances						Acid soils–sensitivity to aluminium
				Stem rust	Leaf rust	Stripe rust: Tobruk pathotype	Stripe rust: Yr 17–27 pathotype	Cereal cyst nematode	RLN P. neglectus	
Dual-purpose										
Cartwheel⦇	quick–early	very good	mid–late	R	R–MR[P]	–	R	–	–	–
Crackerjack⦇ 2	quick–early	moderate	mid-late	–	–	–	–	–	–	–
Endeavour⦇	quick–early	very good	late	R	R–MR[P]	R–MR	R–MR	R	–	V. tol
Tobruk⦇▲	quick–early	very good	mid–late	R	R–MR[P]	MS–S[a]	MR	–	–	–
Tuckerbox	quick–early	–	mid	MR	R–MR[P]	MR–MS	MR	R	–	V. tol
Grain only										
Astute⦇	NR	very good	early–mid	R–MR	R–MR	–	R–MR	–	–	V. tol
Berkshire⦇▲	NR	good	early–mid	R	R–MR[P]	MS	MR–MS	–	–	–
Bison⦇	NR	good	early–mid	R–MR	R–MR	–	R	R	R	V. tol
Chopper⦇▲	NR	very good–good	very early	MR–MS	R–MR[P]	MS–S	MR–MS	R	MR	–
Fusion⦇	NR	medium-good	mid	R	R–MR[P]	MR[b]	R–MR	R	R	V. tol
Goanna	NR	good	early–mid	R	R–MR[P]	MR–MS	R–MR	R	–	–
Hawkeye⦇	NR	good	mid	R–MR	R–MR[P]	MR, MS–S[b]	MR, MS[b]	R	R	V. tol
KM10	NR	good	very early	R	MR–MS	–	R–MR	S	–	–
Tahara▲	NR	moderate	early–mid	R	R–MR[P]	MS	MR–MS	R	R	V. tol
Yowie	NR	good	mid	R	R–MR[P]	MR–MS, MS[b]	MR	R	–	–

NR Not recommended
R Resistant
R–MR Resistant to Moderately resistant
MR Moderately resistant
MR–MS Moderately resistant to Moderately susceptible
MS Moderately susceptible
MS–S Moderately susceptible to Susceptible
S Susceptible
S–VS Susceptible to Very susceptible
VS Very susceptible
V. tol Very tolerant
P Provisional rating
▲ Outclassed
a Susceptible to head infection
b mixed population, some plants are more susceptible to stripe rust.
– Unknown or no data

Where ratings are separated by '&' the first is correct for the majority of situations, but different pathotypes are known to exist at a low level and the latter rating reflects the response to these pathotypes.

Source: NSW DPI

2.3 Planting-seed quality

Before determining seed-sowing rates, seed-germination levels need to be known. For purchased seed this will be stated on the bags supplied. Seed with approximately 80% germination or more is suitable for sowing. Seed produced in cooler tableland environments may tend to have poorer germination levels than seed produced in warmer regions, hence the need to check the germination rate. [27]

But seed produced under higher temperatures can have slower germination, delayed emergence of the primary leaf, stunted growth, or even termination of the germination process (Photo 4). [28] In severe cases, seeds may die. During bulk storage, areas of excessive moisture can lead to the formation of microbe-induced 'hot spots' and since moisture moves from hotter to cooler areas, further local heating is caused, setting off a chain reaction.

Photo 4: *Normal seed (left) compared to heat-damaged seed (right). Note the distinct colour difference.*

Source: Grain SA

Seed impurities can occur from contamination through harvest, storage and machinery. Measurement of seed impurity will be included in a seed-purity certificate. Varieties that have been retained for multiple generations have a greater risk of seed impurity, with the build up of multiple chances for contamination. Ensuring that seed comes from clean, pure and even crops is imperative, and even so 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. This is because ryegrass and black oats now frequently appear in harvested grain samples, and have the potential to infest otherwise clean paddocks. [29]

2.3.1 Seed size

Seed size is an important physical indicator of seed quality that affects vegetative growth and is frequently related to yield, market grade factors and harvest efficiency. A wide array of different effects of seed size has been reported for seed germination, emergence, and related agronomic aspects in many crop species. Generally, large seed has better field performance than small seed. Triticale has the largest seed size of all common small-grained cereal crops (Photo 5 [30]).

In triticale, higher germination and emergence has been noted with bigger seed size,. Large seeds show a higher emergence potential than smaller seeds. Larger seeds

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27 RS Jessop, M Fittler (2009) Appendix 1. Triticale production manual: an aid to improved triticale production and utilisation. In J Roake, R Trethowan, R Jessop, M Fittler, Improved triticale production through breeding and agronomy. Pork CRC, http://www.apri.com.au/1A-102_Final_Research_Report_.pdf

28 Grain SA (2012) Factors affecting wheat seed germination. Grain SA, http://www.grainsa.co.za/factors-affecting-wheat-seed-germination

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

30 Alberta Agriculture and Forestry (2016) Triticale crop production. Revised. Alberta Agriculture and Forestry, http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/fcd10571

are capable of emerging from greater planting depths and have shown an enhanced ability to penetrate ground cover and survive burial by litter. [31]

Photo 5: *Triticale seed (left) is much larger than wheat seed (right).*

Source: Alberta Agriculture and Forestry

Early researchers of triticale found that plants from larger seed were superior in total germination, seedling dry weight, and in seedling establishment than those from small seed. Large seed of a given cultivar gave 51% higher field stand, 62% more seedling dry weight and 37.8% higher grain yield than plants from small seed. [32]

Early seedling growth relies on stored energy reserves in the seed — the larger the seed, the greater the endosperm and starch reserves Good seedling establishment is more likely if seed is undamaged, stored correctly, and comes from a plant that had adequate nutrition. Seed should not be kept when it comes from paddocks that were 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. Although size does not alter germination, 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 1,000 grains, known as the 1000-grain weight. Sowing rate needs to vary according to the 1,000-grain weight for each variety, in each season, in order to achieve desired plant densities. [33] To measure 1,000-grain weights, count out 10 lots of 100 seeds, then combine and weigh the whole lot. When purchasing seed, remember to request the seed-analysis certificate, which includes germination percentage, and the seed weight of each batch where available.

For a seed to emerge successfully from the soil, the seed should never be planted deeper than the plant's coleoptile length. The coleoptile is the pointed, protective sheath that encases the emerging shoot as it grows from the seed to the soil surface. Coleoptile length is an important characteristic to consider when planting a crop, especially in drier seasons when sowing deeper to reach soil moisture. Sowing varieties with short coleoptile lengths too deep can cause poor establishment, because the shoot will emerge from the coleoptile underground and it may never reach the soil surface. [34]

31 S Ambika, V Manonmani, G Somasundaram (2014) Review on effect of seed size on seedling vigour and seed yield. Research Journal of Seed Science, 7, 31–38.

32 UR Bishnoi, VT Sapra (1975) Effect of seed size on seedling growth and yield performances in hexaploid triticale. Cereal Research Communications, 49–60.

33 NSW DPI District Agronomists (2007) Wheat growth and development. Procrop Series. NSW DPI, http://www.dpi.nsw.gov.au/agriculture/broadacre-crops/winter-crops/wheat,-barley-and-other-winter-cereals/growth-and-development

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

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 [35]

Triticale has excellent vigour due to its hybrid characteristics [36], and germination increases with increasing seed size. Seed vigour affects how well the seed or seed lot germinates and emerges. 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 grow well. This process, called physiological ageing (or deterioration), starts before harvest and continues during harvest, processing and storage. Seed performance is progressively reduced 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), the timescale depending on genetic, production and environmental factors that are not yet 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 seed lots that have similarly high germination values can differ in their physiological age (the extent of deterioration) and so differ in vigour and therefore the ability to perform. [37]

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, and so requires laboratory testing. [38]

For purchased seed, request a copy of the germination and vigour-analysis certificate from your supplier. For seed stored on the farm, you can send a sample to a laboratory for analysis.

While a laboratory seed test for germination should be carried out before seeding so growers can 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 the drainage holes, and fill with clean sand, potting mix or freely draining soil (Photo 6). [39] 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 on this. Moisten and place on a window-sill. Keep moist, and count the seeds.
- 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.

35 NSW DPI Agronomists (2007) Wheat growth and development. Procrop Series. NSW DPI, http://www.dpi.nsw.gov.au/agriculture/broadacre-crops/winter-crops/wheat,-barley-and-other-winter-cereals/growth-and-development

36 AGF Seeds (2012) Triticale. AGF Seeds, https://agfseeds.com.au/triticale/

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

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

39 P Matthews, D Holding (n.d.) Germination testing and seed rate calculation. Pulse Point 20. NSW DPI, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/157442/pulse-point-20.pdf

- Keep the soil moist but not wet, as overwatering will result in fungal growth and possible rotting.
- After 7–10 days, most of the viable seeds will have emerged.
- Count only the normal, healthy seedlings. If there are 78 normal vigorous seedlings, for example, 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. [40]

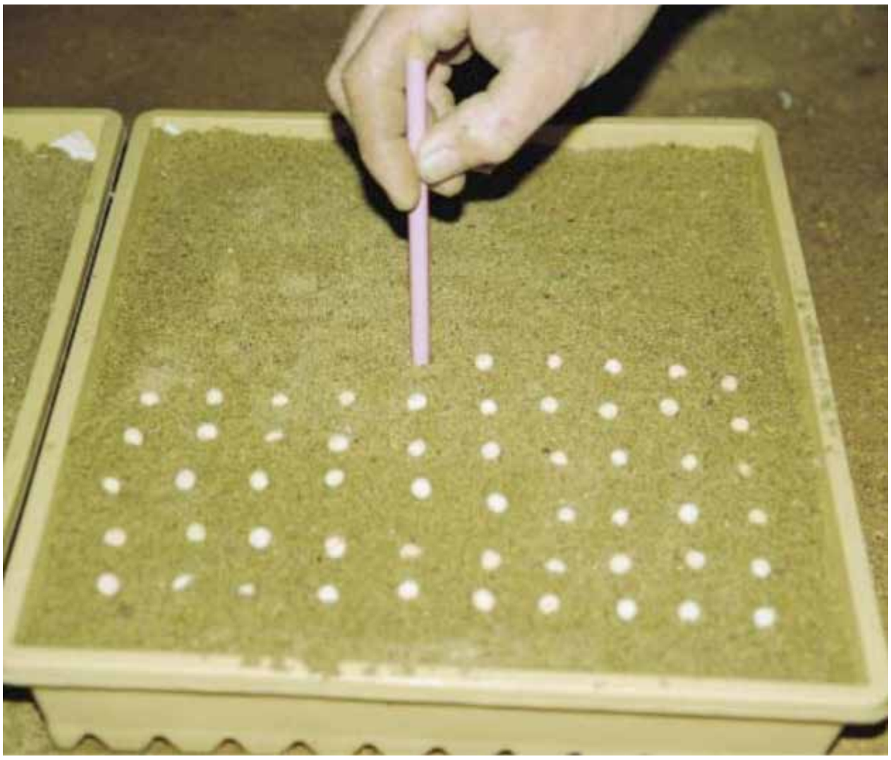


Photo 6: *Use can use a pencil or straw to poke holes in a testing tray.*

Source: NSW DPI

MORE INFORMATION

Germination testing and seed rate calculation

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.

Triticale is a softer grain than wheat and barley, which may make it easier to mill for livestock diets, but also means that it is more susceptible to insect damage in long-term storage. [41] The ideal storage conditions are listed below.

- Temperature <15–20°C—high temperatures can quickly reduce seed quality and its ability to germinate. 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.

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

41 Waratah Seed Company (2010) Triticale: planting guide. Waratah Seed Company, http://www.porkcrc.com.au/1A-102_Triticale_Guide_Final_Fact_Sheets.pdf

VIDEOS

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

- Aeration slows the rate of deterioration of seed with 12.5–14% moisture content. Aeration markedly reduces grain temperature and evens out temperature differences that cause moisture movement.
- No pests—a temperature of <15°C stops all major grain insect pests from breeding, arresting activity at all stages of the life cycle so that they cause little to no damage. [42]

For more information, see Section 13: Storage.

2.3.4 Safe rates of fertiliser to sow with seed

Key points:

- Care must be taken to separate fertiliser and seed to prevent damage to emerging seedlings.
- Crops vary in their tolerance to fertiliser and fertilisers vary in toxicity.
- Seeding systems with narrow seed spread, wide row spacing and no seed/fertiliser separation are more susceptible to toxicity.
- There is greater potential for damage when high fertiliser rates are used, especially in lighter soil types or cooler, drier seeding conditions.
- Seedbed utilisation is a method of quantifying safe fertiliser rates for different seeding systems (see page 3).

Increased row spacing and zero-till seeding can result in more fertiliser being placed in the seeding row, causing damage to emerging seedlings. This risk can be reduced by increasing the spread of seed and fertiliser in the row, reducing in-furrow fertiliser rates or separating seed and fertiliser bands.

A productive triticale will require the application of phosphorous (P) and nitrogen (N) at sowing. Additional nitrogen is likely to be required for maximum dry-matter production for grazing and grain yield, particularly if the crop has been grazed. Consider applying 15–20 kg P/ha at sowing depending on the row spacing's of your machine . This is equivalent to 75–100 kg of mono-ammonium phosphate (MAP) per ha, which will also include 7.5–10 kg N/ha. [43]

Soil testing, including deep nitrogen testing, is especially important following wet summers as the loss of nutrients by water-logging, leaching and summer weeds, may or may not be balanced by higher release of mineralised nutrients from the warm, moist soils. Where soil nutrient status is low, and soil moisture is high, there is the opportunity to use higher rates of fertiliser at seeding to meet the needs of the crop. While placing fertiliser in the seed row is an effective practice, germinating seeds are susceptible to damage by fertiliser. Care must be taken to create space between seed and fertiliser, especially with high fertiliser rates and under wide row spacing. If row spacing is increased but the fertiliser rate per hectare remains constant, then the amount of fertiliser in each row increases. The narrow seed spread typically created by disc seeders can also increase the potential for seedling damage by fertiliser.

The separation of seed from fertiliser is three-dimensional–along, across and down the furrow. The concept of seed bed utilisation (SBU) has been used to address this issue.

Factors to consider when selecting fertilisers and rates

There are several factors that contribute to the safe amount of fertiliser that can be placed with the seed.

Fertiliser type

All fertilisers are relatively concentrated chemical compounds that can affect delicate germinating seeds in a couple of ways.

42 NSW DPI Agronomists (2007) Wheat growth and development. Procrop Series, NSW DPI, https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/449367/Procrop-wheat-growth-and-development.pdf

43 Waratah Seed Company (2010) Triticale: planting guide. Waratah Seed Company, http://www.porkcrc.com.au/1A-102_Triticale_Guide_Final_Fact_Sheets.pdf

Osmotic effect - In chemical terms fertilisers are salts and can affect the ability of the seedling to absorb water by osmosis. Too much fertiliser (salt) near the seed and desiccation or 'burn' can occur. However, fertilisers vary in salt index or burn potential depending on composition. As a general rule, most common nitrogen and potassium fertilisers have a higher salt index than phosphorus fertilisers.

Potential to release ammonia - Fertilisers that have the potential to release free ammonia can cause ammonia toxicity in seed. Consequently, in-furrow placement of ammonium phosphate and urea-containing fertilisers is usually not advisable. A solution of urea and ammonium nitrate (UAN) can be applied successfully in-furrow but there is a risk of ammonia damage where high rates are used, especially in situations when germinating seedlings are stressed.

Efficiency enhancers - Some strategies to enhance fertiliser efficiency, such as the use of polymer coatings or urease inhibitors will slow the rate of ammonia production and make these products less likely to cause crop damage.

Soil type and environment

Soil conditions that tend to concentrate salts or stress the germinating seed increase the potential for damage. So, the safe limit for in-furrow fertilisation is reduced with lighter soil texture (sands) and in drier soil conditions. It is also reduced when environmental conditions such as cool temperatures induce stress and/or slow germination. These can result in prolonged fertiliser-seed contact, increasing the likelihood of damage. Good rain immediately after sowing can reduce the potential for damage as salts are diluted and ammonia is dissolved, which reduces the concentrations around the seed.

Machinery configuration

The type of sowing point, seed banding boot used and the spacing between the drill rows both affect the concentration of fertiliser near seed and the likelihood of damage.

Increasing seed bed utilisation (SBU) using seeding systems - When high SBU seeding systems were combined with high seed rate, the grain yield and crop/weed competition were both maximised. Practical options to achieve a high SBU include fitting paired row seeding boots to existing tillage systems, using greater soil disturbance ribbon sowing systems, or reducing row spacing. When tyne-based systems are used to achieve high SBU, stubble clumping is typically increased and uniformity of seeding depth decreased.

Row spacing - 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. For example, the rate of fertiliser applied in a 30 cm row is basically double that of a 15 cm row. To avoid this increased fertiliser concentration in wide-row systems the safe rate of in-furrow fertiliser decreases as row spacing increases (Table 9).

Table 9: *Approximate safe rates of N as urea, mono-ammonium phosphate (MAP) or di-ammonium phosphate (DAP) with the seed of cereal grains if seedbed has good moisture at or near paddock capacity).*

	25 mm (1") seed spread2			50 mm (2") seed spread2		
Soil Texture	Row spacing			Row spacing		
	180 mm (7")	229 mm (9")	305 mm (12")	180 mm (7")	229 mm (9")	305 mm (12")
	SBU3			SBU3		
	14%	11%	8%	29%	22%	17%
Light (sandy loam)	20	15	11	40	30	22
Medium-Heavy (loam to clay)	25	20	15	50	40	30

Source: GRDC

Seedbed utilisation - The concept of SBU has been used to help quantify this issue. SBU is simply the seed/fertiliser row width divided by the seed row spacing, that is, the proportion of row space occupied by the seeds. The wider the lateral seed spread, for a specific row spacing, the greater the SBU. As SBU increases, so does the safe rate of in-furrow fertilisation. The greater the lateral scatter of seed and fertiliser in the seed band or row (along, across and to depth) the more fertiliser that can be safely applied with the seed. The type of planting equipment and seed opener influences the closeness of seed-fertiliser contact (Table 10). For example, minimal lateral spread is achieved by many disc openers, with lateral spread generally increasing with share width. Double shoot/ribbon seeding openers, where seed is spread across a wider furrow, achieve the greatest lateral spread. When the lateral seed spread = share width = row spacing, a 100 per cent SBU is achievable.

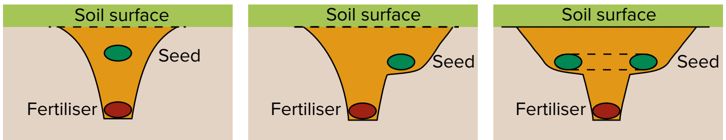
Table 10: *Differences in seed bed utilization for a range of seeding points and boot combinations.*

Seeding point	Common seed spread (mm)	% seed bed utilisation (SBU)		
		Row spacing (mm)		
		150	225	300
125 mm share	65	43	29	22
65 mm share	46	31	20	15
Single side band opener	36	24	16	12
Spear point	25	17	11	8
Inverted T	25	17	11	8

Source: GRDC

Openers with split banding systems can separate the seed and fertiliser laterally and vertically (Figures 3 A, B and C). The greater the angle of the fertiliser boot to the seed boot the greater the vertical separation potential between the seed and fertiliser. The width of spread must be checked under field conditions. It may vary with air velocity, ground speed, seeding depth and soil conditions. Along with seeding system crop type, fertiliser and environmental conditions must still be considered. Table 9 shows the safe rates of fertiliser urea for wheat. Seedbed moisture content is also an important factor, and damage is more likely with dry soils rather than moist soils. If the soils are dry or borderline, then rates should be at least halved from those in Tables 2. [44]

44 GRDC (2011) Fertiliser Toxicity–Fact sheet: Care with fertiliser and seed placement. https://grdc.com.au/resources-and-publications/all-publications/factsheets/2011/05/fertiliser-toxicity



A. Single outlet with centre banding
Pros: Sub-seed soil disturbance, fertiliser separation banded at depth.
Cons: High draft and breakout force required compared with tillage at seeding depth, seed placement quality variable.

B. Single outlet with side banding
Pros: Sub-seed soil disturbance, fertiliser separation banded at depth, improved seed placement, good moisture transfer to seed.
Cons: High draft and breakout force required, potentially higher soil and residue disturbance.

C. Dual outlet paired row and ribbon sowing systems
Pros: Sub-seed soil disturbance, fertiliser separation, good seed placement except over centre section, higher seed-bed utilisation.
Cons: High draft and breakout force required, higher soil and residue disturbance influencing seeding depth uniformity.

Figure 3: *Three arrangements of split seed and fertiliser banding with tillage below the seeding point that illustrate the different types of seed and fertiliser separation achieved.*

Source: GRDC

MORE INFORMATION

Care with fertiliser and seed placement–GRDC Factsheet