SOUTHERN
FEBRUARY 2016

GRDC GROWNOTES™

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

WHEAT

SECTION 3

PLANTING

SEED TREATMENTS | TIME OF SOWING | CONTROLS ON WHEAT DEVELOPMENT | TARGETED PLANT POPULATION | SOWING DEPTH | GERMINATION TESTING | PLANTING TECHNIQUES | SOWING EQUIPMENT

SECTION 3

Planting

3.1 Seed treatments

Seed treatments are applied to seed to control diseases such as smuts, bunts or rust, and insects. When applying seed treatments, always read the chemical label and calibrate the applicator. Seed treatments are best used in conjunction with other disease-management options such as crop and paddock rotation, clean seed, and resistant varieties, especially when managing diseases such as stripe rust.

There are risks associated with using seed treatments. Research shows that some seed treatments can delay emergence by:

- slowing the rate of germination
- shortening the length of the coleoptile, the first leaf and the sub-crown internode

If there is a delay in emergence due to decreased vigour, it increases exposure to pre-emergent attack by pests and pathogens, or to soil crusting; this may lead to a failure to emerge. The risk of emergence failure increases when seed is sown too deeply or into a poor seedbed, especially in varieties with shorter coleoptiles. As the amount of certain fungicides increases, the rate of germination slows (Figure 1).

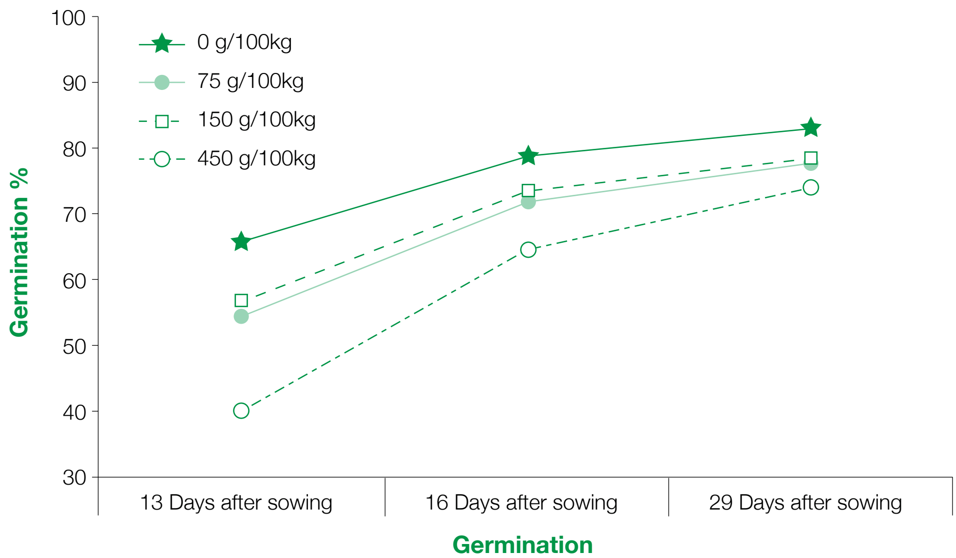

Figure 1: Impact of seed-treatment fungicide on the rate of germination. (Source: based on P Cornish 1986)

Some seed treatments contain azole fungicides (triadimenol and triadimefon). Research has found that these seed treatments can reduce coleoptile length, and that the reduction increases as the rate of application increases. [1]

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

Product registrations change over time and may differ between states and between products containing the same active ingredient. The registration status for the intended use pattern in your state must be checked on the current product label prior to use.

3.1.1 Choice of seed or in-furrow treatments

The principal reason for using a fungicide at sowing for wheat crops has been for the control of smuts, but with the increased incidence of stripe rust in recent years, fungicide is being applied both to the seed and in-furrow. Jockey® (fluquinconazole) seed dressing is being used for stripe rust mostly in lower rainfall areas or Impact® (flutriafol) in-furrow is used for stripe rust in medium- and high-rainfall areas where the risk is greater.

If growers think that they may have a problem with seed-borne infection, it is recommended they have the seed tested by the Cereal Pathology Subprogram, Plant Health and Biosecurity at the South Australian Research and Development Institute. [2]

Videos

Optimal flowering Part 1

Optimal flowering Part 2

Early sown wheat series

3.2 Time of sowing

Choosing the optimal planting time for wheat involves compromise. Planting early will increase the chance of frost damage at flowering. With late-maturing varieties, it can also increase the bulk of crops, i.e. vegetative growth, and lead to stored soil water being used before flowering. In early-maturing varieties, sowing late may reduce the bulk of the crop because development is hastened, as well as reduce rooting depth. This can lead to reduced yield potential and reduced access to deeper moisture and nutrients.

Key points:

- Early sowing can accelerate establishment and make full use of the available moisture and nutrients but can increase the risk of frost during critical growth stages and haying-off in a dry finish.
- Early-sown crops can have a larger root system that better enables them to handle dry conditions and forage for nutrients.
- Flowering time of wheat is controlled by the interaction of several factors, including temperature, day length and cold requirement.
- Most Australian wheat varieties flower in response to the accumulation of warm temperatures. Many varieties also have a cold temperature requirement, i.e. vernalisation, which is important in some winter wheats, and some varieties flower in response to longer days.
- To minimise risk, varieties with a range of flowering dates and maturities should be sown, provided other criteria such as disease resistance are also met.
- The relationship between sowing date and crop development can interact with disease development and nutrition management.
- Late sowing can increase the severity of most root diseases. Early sowing can increase the severity of several leaf diseases (e.g. stem rust) due to the bulk of growth. Rusts are not consistently affected by sowing time. [3]
- Late-sown crops that emerge in colder, wetter conditions are more prone to leaf diseases such as yellow leaf spot, due to slower early growth.

Timing of wheat planting is critical and high soil temperatures can reduce establishment. The ideal temperature range for wheat germination is 12°–25°C, but germination will occur between 4°C and 37°C. [4] Different varieties have been bred to suit different

[2] H Wallwork (2015) Cereal seed treatments 2016. South Australian Research and Development Institute/ GRDC, http://pir.sa.gov.au/__data/assets/pdf_file/0005/237920/cerealseedtreat2016.pdf

[3] GRDC (2011) Impact on yield and quality of wheat. Southern Region. Time of Sowing Fact Sheet, GRDC, 3 March 2011, fhttp://www.grdc.com.au/uploads/documents/grdc_fs_timeofsowing_south.pdf

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

planting times, and varieties differ in their ability to achieve high yield from different sowing times.[5] The optimal sowing date results in flowering and grain-filling occurring when risk of frost and heat is minimised (Figure 2).

A season that breaks in April is ideal because of the opportunity to use all options. Long-season (winter) wheat varieties are sown first at the optimum time of mid–late April through to mid-May (south-western and north-western Victoria), and midseason varieties follow in May–June. If the break is later, the same principle applies, except that in an extremely late season, farmers would forego sowing long-season wheats.

Figure 2: The optimal sowing date results in flowering and grain-filling occurring when frost and heat risk is minimised.

Recent experience has demonstrated the benefit of sowing a portion of the crop dry if a seasonal break has not been received by late April. These crops germinate rapidly when rain falls and generally make the best use of limited growing-season rainfall. [6]

Four years of trials have demonstrated that early sowing of wheat (late April to mid-May) is essential in order to achieve the high yields on offer in south-western Victoria. However, sowing early in the high-rainfall zone (HRZ) is not without challenges and, to be successful, needs to fit into a farm-management system designed to manage trade-offs with weed control, frost risk, waterlogging and disease.

Many of the management decisions that affect crop yields in rainfed cropping systems are made months or years before a crop is planted. The management factors that most contribute to yield and interact with sowing time and cultivar choice are:

- seeding system
- crop rotation
- summer fallow management
- time of sowing and cultivar selection
- dual-purpose grazing
- foliar disease management
- nitrogen (N) management

More information

- GRDC Update Papers: Managing the risks of early sown wheat in South West Victoria
- GRDC Update Papers: Early sowing in Victoria 2014
- Australian Agronomy Conference: Turning sowing times on their head—spring sown winter habit canola and wheat in a mixed farming system
- Australian Agronomy Conference: Wheat time of sowing and cultivar selection can be used to manage risk in low rainfall southern Australia
- Australian Grain: Early sowing adds yield to slow-maturing wheats
- Australian Agronomy Conference: Time of sowing affects small grain screenings in wheat in a dry season
- Riverine Plains Inc.
- GRDC Update Papers: Wheat variety response to sowing time

5 GRDC (2011) Impact on yield and quality of wheat. Southern Region. Time of Sowing Fact Sheet, GRDC, 3 March 2011, fhttp://www.grdc.com.au/uploads/documents/grdc_fs_timeofsowing_south.pdf

6 Agriculture Victoria (2012) Growing wheat. DEDJTR Victoria, http://agriculture.vic.gov.au/agriculture/grains-and-other-crops/crop-production/growing-wheat

Each of these factors forms part of a package that allows early sowing to deliver high yields in the HRZ. [7]

Varieties differ in the time they take from sowing to flowering. Late-sown (quicker maturing) varieties take fewer days to flower than early-sown (late-maturing) varieties. This difference is more marked from early sowings (April) than from late sowings (July). [8]

Genes control the plant's developmental responses to the accumulation of temperature, daylength and cold requirement (vernalisation). Various combinations of genes are present in Australian wheat varieties, which result in a wide spectrum of responses to temperature and daylength.

The products of the vernalisation genes and photoperiod genes almost certainly interact to promote or delay flowering (Figure 3). Australian wheat breeders now have tools to improve identification of the vernalisation and photoperiod genes in wheat varieties.

To ensure that the crop flowers at the optimal time, an understanding is required of how sowing time affects flowering time as well as the frequency of frosts and high temperatures. [9]

More information

[GRDC Fact Sheets: Time of sowing]

[GRDC Media Centre: Early sowing delivers benefits in LRZ]

Figure 3: EGA Gregory⦼ wheat in flower. Most Australian wheat varieties flower in response to the accumulation of warm temperatures. (Photo: Penny Heuston)

3.2.1 Why sow early?

Advantages of early sowing include:

- yield benefits in seasons with hot and dry finishes, particularly where frost is not a major problem

[7] J Hunt *et al.* (2015) Mud, weeds, frost, sheep and disease—managing the risks of early-sown wheat in South West Victoria. GRDC Update Papers, 27 August 2015, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/08/Managing-the-risks-of-early-sown-wheat-in-South-West-Victoria

[8] P Matthews, D McCaffery, L Jenkins (20142015) Winter crop variety sowing guide 20142015. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/agriculture/broadacre/guides/winter-crop-variety-sowing-guide

[9] GRDC (2011) Impact on yield and quality of wheat. Southern Region. Time of Sowing Fact Sheet, GRDC, 3 March 2011, http://www.grdc.com.au/uploads/documents/grdc_fs_timeofsowing_south.pdf

- better establishment from early sowing providing competitive crops for weed control
- longer grain-filling period in varieties that flower earlier
- increased biomass for increased yield potential in a wet season
- deeper roots than late-sown crops, allowing access to moisture later in the season
- less yield loss from crown rot than in later sown crops
- logistical benefits
- less risk of several root diseases
- adaptation of winter varieties to early sowing

Disadvantages of early sowing include:

- risk with dry sowing due to a false break, especially on heavier soil types
- some early varieties not being suited to early sowing and flowering very early, resulting in reduced biomass and root depth at flowering, and reduced potential yields
- greater risk of frost damage in frost-prone areas for varieties that flower earlier
- increased risk of haying-off as biomass increases, especially in drier springs
- greater risk of a number of leaf diseases and take-all
- tall crops at greater risk of lodging
- less opportunity for knockdown or mechanical weed control for herbicide-resistance management
- increased chance of weed problems and poor establishment with complete reliance on in-crop weed control [10]

More information

GRDC Fact Sheet: Early-sowing wheat in Victoria

GRDC Update Papers: Sowing early in 2014—how did it work?

infocus

3.2.2 Sowing early in 2014—how did it work?

Take home messages

Despite widespread stem frost in 2014, time of sowing trials in South Australia (SA) indicated that the highest yields still came from mid–late April sowing.

Based on one year of data, Trojan⍬ (mid-maturing) complements Mace⍬ (fast-maturing) in a cropping program and allows growers to sow earlier and achieve higher yields (16%) than with Mace alone sown in its optimal window.

Existing slow-maturing wheat cultivars from other states are poorly adapted to most regions in SA.

For growers in frosty environments wishing to sow before about 20 April, EGA Wedgetail ⍬ is the safest option evaluated in these trials, but yields are likely to be less than with Mace⍬ sown in its optimal window.

Background

In SA, the time at which wheat flowers is very important in determining yield (Figure 4). With farm sizes increasing and sowing opportunities decreasing, it is difficult to get wheat crops established so that they flower during the optimal period for yield. Although no-till and dry sowing have been used successfully in SA so that a greater area of the crop will flower on time, an opportunity exists to take advantage of rain in March and April to begin sowing crops earlier than currently practiced. This tactic complements dry sowing. Earlier sowing is now possible with modern no-till techniques, summer fallow

10 GRDC (2011) Impact on yield and quality of wheat. Southern Region. Time of Sowing Fact Sheet, GRDC, 3 March 2011, http://www.grdc.com.au/uploads/documents/grdc_fs_timeofsowing_south.pdf

management, and cheaper insecticides and fungicides to protect against the diseases associated with early sowing.

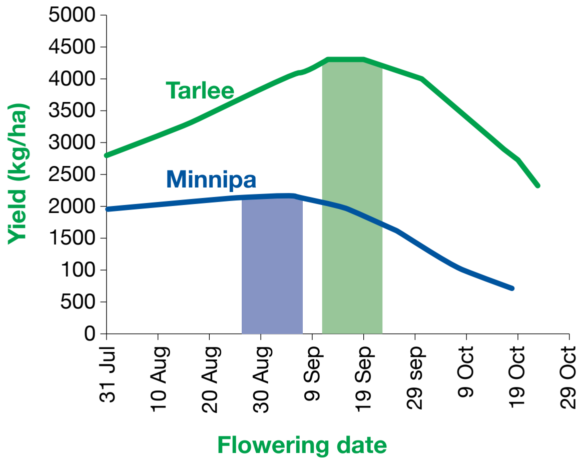

Figure 4: Relationship between flowering time and yield at Minnipa and Tarlee. Optimal flowering periods are highlighted by light-grey and dark-grey boxes. Curves are derived from APSIM from 120 years of climate data and with a yield reduction for frost and extreme heat events. Optimal flowering periods are late August–early September at Minnipa, and mid-September at Tarlee.

However, in the last few decades wheat breeding has focused on mid–fast-maturing varieties, which are only suited to sowing in late April–May. Sowing earlier than is currently practiced requires cultivars that are not widely grown in SA, and which are much slower to mature, either through having a strong vernalisation–cold requirement (winter wheats) or strong photoperiod–daylength requirement (slow-maturing spring wheats, Figure 5).

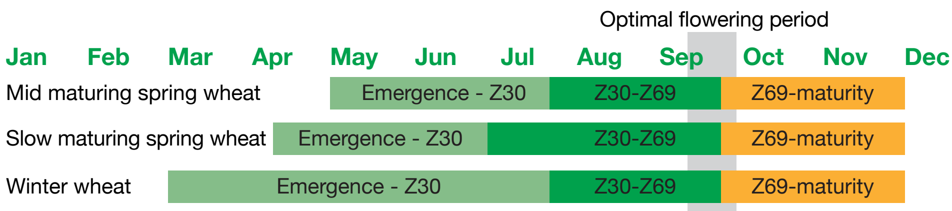

Figure 5: Diagram showing pattern of development in winter and slow-maturing spring wheat relative to mid-maturing spring (most currently grown varieties in SA are mid–fast). When sown at their optimal times, they all flower during the optimal period in a given environment. Winter wheats also have a very flexible sowing window and, if well adapted, will flower during the optimum period in a given environment from a broad range of sowing dates. Zadoks growth stages are indicated.

GRDC-funded research in New South Wales (NSW) has demonstrated that slow-maturing varieties sown early yield more than mid–fast varieties sown later, when they flower at the same time. This is because early sowing increases rooting depth and water use, reduces evaporation and increases transpiration efficiency. Early sowing of slow-maturing varieties is a way of increasing yield potential with very little initial investment.

APSIM modelling indicates that, even with SA's Mediterranean climate, adoption of slow-maturing varieties to allow early sowing has the potential to increase whole-farm wheat yield, particularly in mid–high-rainfall zones (Table 1). GRDC has funded a series of trials across rainfall zones to evaluate the suitability of early sowing in SA.

Table 1: Average farm wheat yields from 50 years of simulation at different locations in South Australia

Current practice: mid–fast varieties sown from mid-May, including dry sowing; early sowing: addition of a slow-maturing variety to the cropping program, which can be planted from 1 April but is only when planting opportunities arise (~60% of years)

Location	Average farm yield (t/ha)		Yield benefit from early sowing	
	Current practice	Early sowing		(%)
Conmurra	4.0	6.1	2.1	53%
Cummins	3.3	4.0	0.8	24%
Minnipa	2.1	2.2	0.1	5%
Port Germein	1.9	2.1	0.2	11%
Tarlee	3.5	4.0	0.5	14%

Methodology

GRDC early-sowing trials in SA are at five locations (Cummins, Minnipa, Port Germein, Tarlee and Conmurra), each with three times of sowing (aimed at mid-April, early May, late May) and 10 wheat lines (6 commercial; 4 near-isogenic lines, or NILs, in a Sunstate background). The commercial lines are described in Table 2. The Hart Field Site Group planted a similar early-sowing trial, and there are trials funded by *South Australian Grain Industry Trust* Fund (SAGIT) evaluating different wheat lines for early sowing in the Mid North and Upper Yorke Peninsula.

Table 2: Commercial wheat varieties used in the South Australian trials at Cummins, Minnipa and Port Germein

NIL, Near-isogenic line

Variety	Maturity	Comments
Manning (Conmurra only)	Very slow winter (very strong vernalisation, unknown photoperiod)	White feed. Resistant to *Barley yellow dwarf virus* but adapted only to environments with a very long, cool growing season
SQP Revenue (Conmurra only) (NIL match: W46A)	Slow winter (strong vernalisation, unknown photoperiod)	Red feed. Also adapted to long, cool growing seasons, it is widely grown in SW Victoria and SE SA
EGA Wedgetail (NIL match: W8A)	Mid-maturing winter (strong vernalisation, moderate photoperiod)	APW (default in SA), APH in NSW. Early-sowing and dual-purpose standard in southern NSW and an excellent grain-only option. May be too slow in most of SA, has only APW quality and can be quite intolerant of problems associated with alkaline soils (cereal cyst nematode, boron, aluminium).
Rosella (NIL match: W7A)	Fast-maturing winter (strong vernalisation, weak photoperiod)	ASW. Slightly faster than Wedgetail, and trials in Victoria show better adaption to alkaline soils. However, being 29 years old, it is at a distinct yield disadvantage compared with modern spring wheats
EGA Eaglehawk (NIL match: W16A)	Very slow-maturing spring (moderate vernalisation, very strong photoperiod)	APW (default in SA), APH in NSW. Very slow-maturing, photoperiod-sensitive spring wheat that will flower at the same time as Wedgetail from a mid-April sowing but will reach Zadoks growth stage 30 about 3 weeks earlier, and therefore not as suited to grazing
Forrest (NIL match: W16A)	Very slow-maturing spring (weak vernalisation, very strong photoperiod)	APW. Very slow-maturing, photoperiod-sensitive spring wheat that performs well in higher yielding environments
Bolac (Tarlee and Conmurra only)	Slow-maturing spring (moderate vernalisation, moderate photoperiod)	AH. Bred for the HRZ of SW Victoria but has performed well when sown early in the low-rainfall regions of the western Riverina in NSW
Estoc	Mid-maturing spring (weak vernalisation, strong photoperiod)	APW. Probably the slowest maturing recently released variety with good adaptation to SA. Not suited to sowing much before 20 April in most environments

Variety	Maturity	Comments
Trojanⓟ	Mid–fast-maturing spring (moderate vernalisation, moderate photoperiod)	APW. Has demonstrated good adaption to SA and has an unusual photoperiod gene, which may allow it to be sown in late April and flower at the optimal period
Maceⓟ (NIL match: Sunstate)	Fast-maturing spring (weak vernalisation, weak photoperiod)	AH. SA main-season benchmark, and in the trial as a control from a mid–late May sowing
Cobraⓟ (Conmurra only)	Fast-maturing spring (weak vernalisation, weak photoperiod)	AH. Very similar maturity to Maceⓟ but, based on NVT results, may outyield it in higher yielding environments

Results

Results from all experiments are presented in Table 3. At four of five sites, Trojanⓟ sown in mid–late April was the highest or equal highest yielding treatment. Slow-maturing cultivars bred in other states (e.g. EGA Wedgetailⓟ, EGA Eaglehawkⓟ and Rosella) showed poor adaptation to all sites.

Table 3: Grain yield for five of six early-sowing trial sites in South Australia in 2014 (results for Conmurra not available at time of preparation)

FA, Treatments known to have been affected by frost

Location	Cultivar	Time of sowing		
Cummins		**11 April**	**13 May**	**28 May**
	EGA Wedgetailⓟ	4.0	2.9	3.7
	Rosella	4.0	4.1	2.5
	EGA Eaglehawkⓟ	3.8	2.9	2.7
	Estocⓟ	4.3	4.7	3.8
	Trojanⓟ	4.9	5.0	4.4
	Maceⓟ	2.6 (FA)	5.1	4.1
	P-value	<0.001		
	l.s.d. (*P* = 0.005)	0.6		
Minnipa		**11 April**	**13 May**	**28 May**
	EGA Wedgetailⓟ	2.9	2.2	2.1
	Rosella	2.7	2.4	2.1
	EGA Eaglehawkⓟ	3.0	1.8	1.7
	Estocⓟ	4.0	2.7	2.6
	Trojanⓟ	4.6	3.1	3.0
	Maceⓟ	3.7	3.0	2.8
	P-value	<0.001		
	l.s.d. (*P* = 0.005)	0.2		
Port Germein		**11 April**	**30 April**	**20 May**
	EGA Wedgetailⓟ	2.5	1.9	1.7
	Rosella	2.2	1.7	1.6
	EGA Eaglehawkⓟ	3.0	2.1	1.9
	Estocⓟ	4.4	3.5	3.4
	Trojanⓟ	5.2	4.2	3.9
	Maceⓟ	4.3	4.3	3.7
	P-value	<0.001		
	l.s.d. (*P* = 0.005)	0.5		
Hart		**14 April**	**8 May**	**2 June**
	EGA Wedgetailⓟ	4.5	4.0	3.0

Location	Cultivar	Time of sowing			
	Rosella	4.3	3.7	2.8	
	Trojanᶲ	5.7	5.3	3.7	
	Maceᶲ	3.9 (FA)	4.7	3.3	
	RAC1843 (Hatchet CL Plusᶲ)	0.8 (FA)	3.6	3.5	
	P-value	<0.001			
	l.s.d. (*P* = 0.005)	0.3			
Tarlee	**Cultivar**	**14 April**	**29 April**	**12 May**	**30 May**
	Rosella	5.5	5.4	4.6	3.5
	Bolacᶲ	6.1	6.1	4.6	3.7
	Trojanᶲ	6.6	7.4	6.1	4.6
	Maceᶲ	4.1 (FA)	7.4	6.4	5
	P-value	<0.001			
	l.s.d. (*P* = 0.005)	0.6			

Putting early sowing into practice in SA

Based on the 2014 trial data, growers in SA could improve whole-farm yields by including Trojanᶲ in their cropping program to complement Maceᶲ (Figure 6). Trojanᶲ has an unusual-photoperiod sensitivity allele that is inherited from a European parent and is rare in Australian cultivars. This allele seems to delay flowering from an April sowing relative to Maceᶲ quite successfully (Table 4).

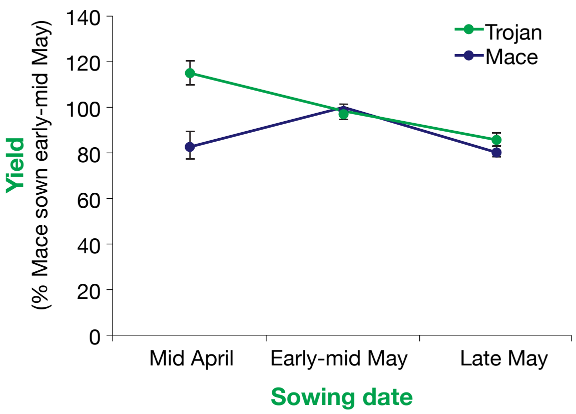

Figure 6: Mean yield performance (Minnipa, Cummins, Port Germein, Hart, Tarlee) of Trojanᶲ and Maceᶲ at different times of sowing relative to Maceᶲ sown in its optimal window of early–mid May. Error bars are standard error of means.

Table 4: Flowering dates for Trojanᶲ and Maceᶲ from different times of sowing at Minnipa in 2014

Cultivar	Time of sowing		
	11 April	**13 May**	**28 May**
Trojan	6 August	10 September	17 September
Mace	8 July	6 September	13 September

Despite performing strongly from a mid-April sowing in these trials, Trojanᶲ is not recommended for planting this early in most SA locations because it incurs excessive frost risk. As a guide, Trojanᶲ is best suited to being planted ~10 days earlier than Mace ᶲ. As an example of how it may fit in a program, if 10 May is the optimal sowing time for Maceᶲ in a given environment, then the optimal sowing time for Trojanᶲ is 1 May. If a grower has a 20-day wheat-sowing program and wants to grow half Trojanᶲ and half

Mace⟮D, to maximise whole-farm yield, they should start with Trojan⟮D on 25 April, switch to Mace⟮D on 5 May and aim to finish on 15 May.

Sowing mid-April in low-frost environments such as Port Germein carries little risk, and as the year's results show, significant yield gains (0.9 t/ha relative to Mace⟮D) can be achieved by sowing Trojan⟮D in mid-April, because its longer growing season allows it to accumulate more dry matter.

For growers in frosty environments who wish to sow earlier than is safe with Trojan ⟮D–Mace⟮D, EGA Wedgetail⟮D is probably the best option. However, because of its poor adaption to SA even if sown in early–mid April, it is unlikely to yield as well as Mace⟮D sown in its optimal window. In this set of trials, there was an average yield penalty of 0.5 t/ha between EGA Wedgetail⟮D sown mid-April and Mace⟮D sown mid-May. Grazing early-sown EGA Wedgetail⟮D would offset some of the reduction in income compared with mid-May-sown Mace⟮D.

Remember that early-sown crops require different management to achieve potential:

- Do not dry-sow slow-maturing varieties (EGA Wedgetail⟮D, EGA Eaglehawk⟮D). They will flower too late if not established early. Seedbed moisture is needed and ideally some stored soil water to get them through to winter.
- If growing winter wheat (EGA Wedgetail⟮D) and not grazing, sow at lower plant density and defer N inputs until after Zadoks growth stage 30 (Z30 or GS30).
- Choose clean paddocks; winter wheat at low plant densities is not competitive with ryegrass, and common root diseases are exacerbated by early sowing.
- Protect against diseases associated with early sowing: *Barley yellow dwarf virus* (BYDV) (imidacloprid on seed, backed up with in-crop insecticides at the start of tillering if aphid is pressure high); *Septoria tritici* in some areas (flutriafol on fertiliser and timely foliar applications of epoxiconazole at Z30 and Z39). Many slow-maturing varieties also have poor resistance to stripe rust (flutriafol on fertiliser and timely foliar fungicide application at Z39)

Conclusion

Despite July and August being frosty, highest yields in most trials came from mid-April sowing, with Trojan⟮D being the standout performer. Trojan⟮D complements Mace⟮D in a cropping program and extends the sowing window to about 10 days earlier. EGA Wedgetail⟮D was the best performing variety suited to a very early sowing, but even when sown early it yields less than Mace⟮D planted in its optimal window. [11]

More information

GRDC Update Papers: Sowing early in 2014—how did it work?

GRDC Update Papers: Early sowing in Victoria 2014

3.2.3 Variety and sowing-time options

Growers need to select wheat varieties to match their specific growing-season and agronomic requirements; selecting varieties with a spread of flowering dates can help to minimise risk if sowing starts early and spans at least a month. The later and shorter the sowing window, the less the difference that will occur in flowering time, even between varieties with different maturities (Figure 7).

Recommended sowing times for individual varieties and regions in Victoria and NSW are provided in state government department crop guides. Details of flowering dates are reported in the SA Wheat variety sowing guide. The commercial program Yield Prophet® can assist with variety selection. [12]

[11] J Hunt *et al.* (2015) Sowing early in 2014—how did it work? GRDC Update Papers, 10 February 2015, http://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/02/Sowing-early-in-2014--how-did-it-work

[12] GRDC (2011) Impact on yield and quality of wheat. Southern Region. Time of Sowing Fact Sheet, GRDC, 3 March 2011, http://www.grdc.com.au/uploads/documents/grdc_fs_timeofsowing_south.pdf

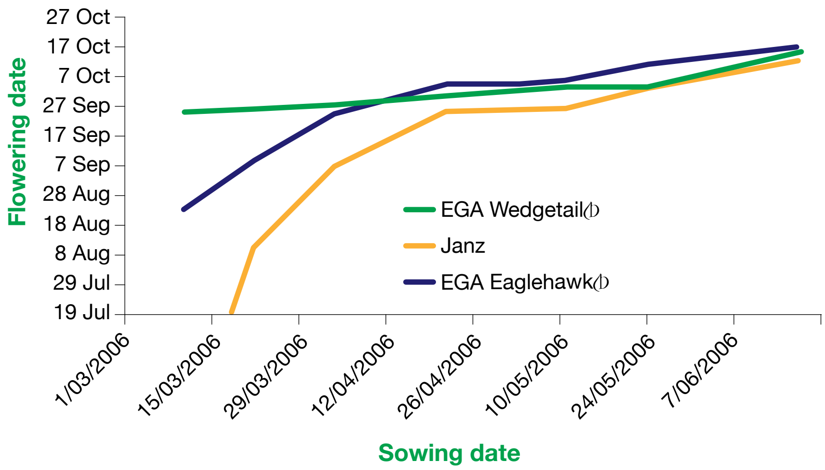

Figure 7: Flowering time as related to sowing date. Large differences in flowering time between varieties can be identified with very early sowing. In the southern region, when sowing from late April onwards, flowering dates become closer. EGA Wedgetail⊕ is a winter variety and can be sown early because flowering is delayed until the strong cold requirement is met. By contrast, Janz has low vernalisation requirement, so very early sowing will cause very early flowering. EGA Eaglehawk ⊕ is intermediate for cold requirement.

Source: Peter Martin, NSW I&I

Yield Prophet®

Yield Prophet® is an online decision-support tool for growers and advisers that can be accessed via a paid subscription. One part of the program can help with the process of selecting the best variety for a given sowing date or the best sowing date for a variety in the grower's own paddock (Figure 8). [13]

The model uses information about individual varietal responses to daylength and thermal time and cold requirements, in conjunction with information about the paddock and long-term climate data. More information is provided for some varieties and regions than for others; newer varieties and locations are supported by fewer data.

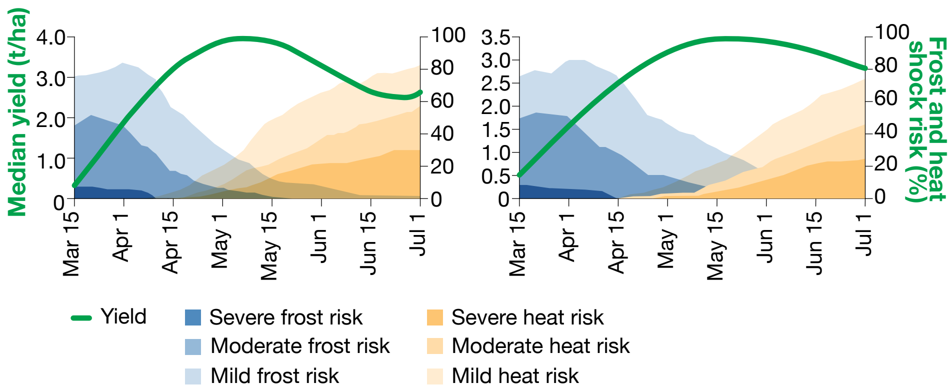

Figure 8: Example of a report from Yield Prophet®, showing that the optimal sowing time of the main-season variety Yitpi (left panel) is about 2 weeks before that of the early variety Young⊕ (right panel) in a paddock at Culgoa, north-western Victoria. Although early-sown Yitpi has the highest potential yields, Young⊕ is likely to yield 0.5 t/ha more if sowing is delayed until 15 June. Risk of frost and heat stress based on long-term climate data and relating to flowering and grainfill periods.

Source: Tim McClelland, BCG

[13] GRDC (2011) Impact on yield and quality of wheat. Southern Region. Time of Sowing Fact Sheet, GRDC, 3 March 2011, http://www.grdc.com.au/uploads/documents/grdc_fs_timeofsowing_south.pdf

3.2.4 Balancing the risks

Early sowing within the recommended window for the variety generally maximises yields, with dry springs and no frosts favouring early flowering. Later sowings can require a different variety.

Given adequate rainfall and soil moisture, early sowing can set the potential for high yields. It aids fast establishment and good early growth due to warmer days.

Biomass contains carbohydrates, allowing grains to fill later in the season. Strong early growth provides more heads and a greater potential number of grains in each head.

Early sowing of an early-maturing variety with little or no vernalisation requirement and relatively insensitive to daylength (e.g. Axe⚘) will cause rapid development. The lack of biomass at flowering will reduce the number and size of heads and the number of grains. The lack of root depth will also limit the crop's ability to access moisture later in the season, leading to lower yields. Winter wheat varieties (e.g. EGA Wedgetail⚘) should be used for very early sowing opportunities.

Yield loss from delayed sowing within the window is not large, on average, but can be high in dry years. Modelling over 30 years showed that delaying sowing in the Victorian Mallee from 1 May to 1 June caused an average 2% yield loss. In two of these years, the yield loss was 0.5 t/ha. Similar results have been seen in trials across the southern region (Figure 9).

In seasons with a dry finish, early sowing (within the sowing window) has generally resulted in lower screenings and higher yields as crops mature during milder conditions. In those years, the benefit from early sowing in reducing moisture and heat stress has outweighed the effects of frost damage.

However, if high rates of N are applied upfront in early-sown crops, growth before flowering can be excessive. If moisture is limited during grainfill, the canopy will have limited capacity to fill all grains, leading to higher screenings and lower yields, even in the absence of frosts. [14]

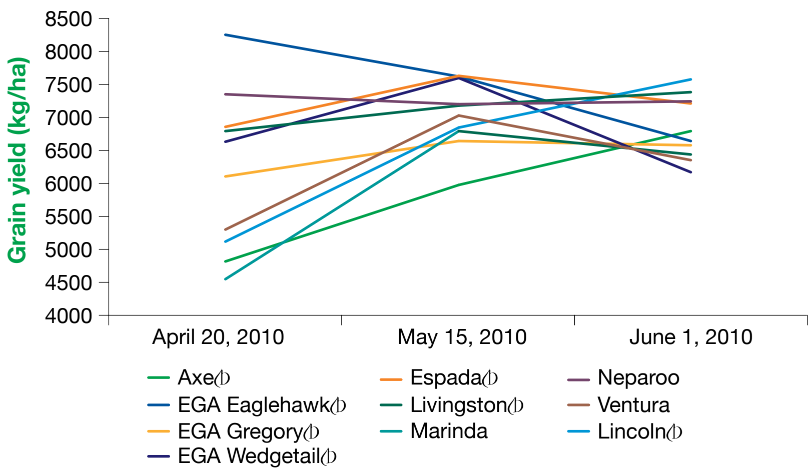

Figure 9: Example of variety response in yield to sowing time in a single trial at Cowra in 2010. Responses vary between trials (for more information visit NSW DPI Primefact: Yield response of wheat varieties to sowing time 2013).

Source: Jan Edwards, NSW I&I

Sowing time effect on diseases

Earlier sowing tends to increase the severity of yellow leaf spot and *Septoria tritici* blotch. *Wheat streak mosaic virus* (WSMV) and BYDV can also be worse with early sowing; however, for BYDV it depends on timing of the aphid flight. Warmer temperatures in early autumn favour wheat curl mite, which transmit WSMV.

[14] GRDC (2011) Impact on yield and quality of wheat. Time of Sowing Fact Sheet, GRDC, 3 March 2011, http://www.grdc.com.au/uploads/documents/grdc_fs_timeofsowing_south.pdf

Delaying sowing is not a useful tool to aid stripe rust control because it is not consistently affected by sowing time. Early sowing can provide the benefit of the crop being more advanced when the disease arrives in a district. Conversely, early sowing can also increase levels of stripe rust at early crop stages, due to warmer temperatures in early autumn favouring rust cycling, and allow adult plant resistance to begin working at a later growth stage. [15]

Growers can identify the risk of significant soilborne and crown diseases with a PreDicta B soil test. Delayed sowing increases the severity of *Rhizoctonia*, cereal cyst nematode, *Pratylenchus* and crown rot. This is due to slower root growth with late sowing.

Delayed sowing can increase yield loss and screenings from crown rot, which is worsened by moisture and heat stress during grainfill. The effects are more severe in seasons with a hot and dry finish.

Take-all is less severe in later sown crops but only if weeds are controlled and inoculum has decomposed before sowing. [16]

Frost risk of early sowing

The main risk of early sowing is frost between flowering and early grainfill. The optimal flowering window is based on long-term climatic data. However, frosts can still occur during the flowering window.

Winter wheats can be sown early where frost risk is a concern because their cold requirement delays flowering.

Managing frosts with sowing time

Frosts can cause damage that reduces yield and can affect grain quality. Some varieties sown too early will flower in late winter. Varieties sown too late have little chance of reaching their yield potential because flowering and grainfill occur under hot, dry, stressful conditions.

Choice of sowing time is a management compromise between having the crop flowering soon after the last heavy frost, and allowing flowering sufficiently early for adequate grainfill before the onset of moisture stress and heat in spring.

If varieties are sown within the optimum sowing period, they can produce their highest yields, but the best sowing date varies with topography and variety. Sowing dates may need to be extended (earlier or later) depending upon local climatic conditions, paddock topography and soil types.

Although outlying severe frosts cannot be mitigated, the risk of seasonal frosts at flowering should be assessed and balanced. Frost damage (Figure 10) is a major consideration and the risk cannot be eliminated; therefore, the potential for higher yields from earlier sowings needs to be balanced against the risk of frost damage at flowering.

There are several ways of doing this:

1. Where the risk of frost is high (i.e. low-lying paddocks, regions with lower winter temperatures), sow later than the suggested optimum sowing period. As a rule of thumb, 3 days difference at planting makes 1 day of difference at heading.
2. Change varieties. Use maturity differences to have the crop flowering at a time when the seasonal frost risk is acceptable (Figure 11). Consider winter wheat, which can be grazed to delay maturity. If a significant frost event occurs, some income has already been achieved through grazing. Income can also be salvaged through cutting for hay.
3. Change crop type. Barley and oats are less susceptible to frost damage than wheat.

Videos

National frost initiative

Frost ratings

Frost susceptibility ranked

15 GRDC (2011) Impact on yield and quality of wheat. Southern Region Time of Sowing Fact Sheet, GRDC, 3 March 2011, http://www.grdc.com.au/uploads/documents/grdc_fs_timeofsowing_south.pdf

16 GRDC (2011) Impact on yield and quality of wheat. Southern Region. Time of Sowing Fact Sheet, GRDC, 3 March 2011, http://www.grdc.com.au/uploads/documents/grdc_fs_timeofsowing_south.pdf

4. Consider zoning the farm based on topography so that lower lying, high-risk areas can be managed separately. Some growers choose to sow these areas to pasture or implement rotations with a short cropping phase (grazing wheat and barley) followed by a long pasture phase.

Rain at sowing is often erratic; therefore, varieties must be chosen carefully to achieve this balance. [17]

Figure 10: Frosted wheat. (Photo: Rachel Bowman)

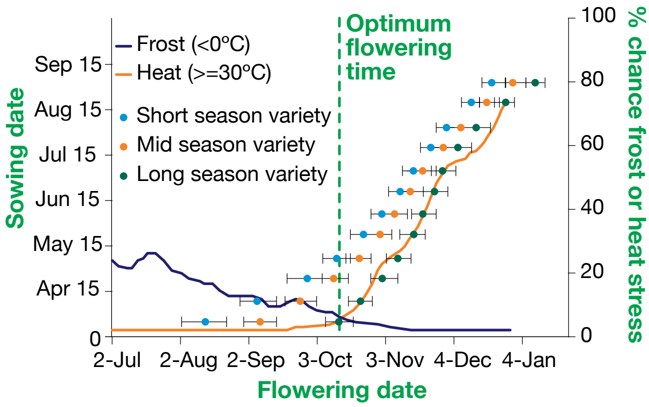

Figure 11: Relationship between variety maturity of wheat and sowing date to optimise time of flowering. The best sowing time results in flowering when the risks of frost, heat stress and dry conditions are lowest. In this example at Dunkeld, south-western Victoria, the optimal flowering time is, on average, 10 October. To achieve timely flowering, the winter variety needs to be sown early April, the midseason variety early May, and the early variety mid-May.

[17] P Matthews, D McCaffery, L Jenkins (2015) Winter crop variety sowing guide 2015. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/agriculture/broadacre/guides/winter-crop-variety-sowing-guide

3.3 Controls on wheat development

The rate of development in wheat is controlled by vernalisation, temperature and daylength.

Development is different from growth, in that development refers to the crop moving between stages, whereas growth refers to an increase in biomass. In Australia, developmental stages are commonly referred to as 'growth stages'. [18]

3.3.1 Vernalisation

To trigger flowering, winter wheat varieties need to experience low average temperatures of ~3°–17°C above a base temperature (often assumed as 0°C) after emergence. However, as temperatures become warmer within that range, the vernalisation rate is slower.

The minimum duration and temperature will depend on the variety. For this reason, winter varieties should not be sown in spring. Winter wheats vary in their need for cold temperatures. Most grower guides will state whether a variety is a winter wheat. Winter wheats are often dual-purpose varieties and, in Victoria and SA, are recommended only for high-rainfall regions with a long growing season, such as southern Victoria and the lower South-East of SA.

Most Australian wheat varieties are known as spring varieties. Spring wheats have little or no need for vernalisation, and the mild winter conditions in southern Australia's cropping areas are sufficient to meet the low vernalisation requirements of Australian spring wheats. The varieties H45⦶, Axe⦶, Janz, Young⦶ and Silverstar have only a very small vernalisation response.

Most spring wheats tolerate a shorter growing season than winter wheats. [19]

3.3.2 Thermal time

Australian wheat crops will develop faster in warmer conditions provided the vernalisation requirement has been met. The accumulation of average daily temperatures largely dictates development for most Australian wheat varieties.

The time and temperature relationship governing growth and development is called 'thermal time' and is measured in 'growing degree-days'. This requirement differs between varieties. For barley, it is sometimes referred to as the 'basic vegetative phase'.

Thermal time is the average daily temperature, above a base temperature, multiplied by the number of days. Plants will stop developing if temperatures are below the base temperature. The base temperature is often assumed as 0°C for calculations, although it actually differs between varieties. For the calculation to proceed, the average daily temperature needs to be above the base temperature for the crop.

For spring wheats, thermal time is the main driver of development (Figure 12). It usually takes 150 degree-days from sowing for wheat to emerge. When average daily temperature is 10°C, emergence will take 15 days (i.e. 10°C x 15 days = 150 degree-days). If the average daily temperature is 15°C, emergence will take only 10 days. [20]

[18] GRDC (2011) Impact on yield and quality of wheat. Southern Region. Time of Sowing Fact Sheet, GRDC, 3 March 2011, http://www.grdc.com.au/uploads/documents/grdc_fs_timeofsowing_south.pdf

[19] GRDC (2011) Impact on yield and quality of wheat. Southern Region. Time of Sowing Fact Sheet, GRDC, 3 March 2011, http://www.grdc.com.au/uploads/documents/grdc_fs_timeofsowing_south.pdf

[20] GRDC (2011) Impact on yield and quality of wheat. Southern Region. Time of Sowing Fact Sheet, GRDC, 3 March 2011, http://www.grdc.com.au/uploads/documents/grdc_fs_timeofsowing_south.pdf

Figure 12: For spring wheats, thermal time is the main driver of development. (Photo: Emma Leonard)

3.3.3 Daylength

For some Australian wheat varieties, mainly grown in northern Australia, daylength (photoperiod) can also affect the length of time required to reach growth stages. Genetic studies and observations of wheat varieties grown at different latitudes suggest that many Australian wheat varieties are daylength-sensitive (to varying degrees). However, most varieties are not well characterised for responses to daylength.

The closer to the equator, the less is the variation in daylength. Daylength increases after 22 June. The longer the days, the shorter the thermal time needed to initiate flowering in photoperiod-sensitive wheat varieties.

Varieties released before 1973 generally carried a photoperiod-sensitive gene, making them more sensitive to daylength. They tended to flower later for a given sowing date when sown before 22 June—on average 1 week later in the Mallee—than current varieties. A photoperiod-sensitive variety will flower 4–12 days later than a photoperiod-insensitive variety when sown early in southern Australia, depending on its need for vernalisation. [21]

3.4 Targeted plant population

Plant population, determined by seeding rate and establishment percentage, can be an important determinant of tiller density and, at a later stage, head density. [22]

High yields are possible from a wide range of plant populations. This is because wheat compensates by changing the number of tillers and the size of the heads in response to the environmental conditions, including weather, fertility and plant competition (Figure 13). Varieties differ in their ability to do this; for example, Spitfire⸙ produces low tiller numbers, whereas Sunvale⸙ produces very high tiller numbers (Figure 14).

Despite the ability to compensate, targeting a variety's optimum plant density at sowing makes the most efficient use of water and nutrients. To reach a target plant population

[21] GRDC (2011) Impact on yield and quality of wheat. Southern Region. Time of Sowing Fact Sheet, GRDC, 3 March 2011, http://www.grdc.com.au/uploads/documents/grdc_fs_timeofsowing_south.pdf

[22] G Butler, W Manning, L Serafin (2003) Population density studies in sorghum and wheat. GRDC Update Papers, 19 Sept. 2003, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2003/09/Population-density-studies-in-sorghum-and-wheat

for the environment and seasonal conditions, adjust sowing rates to allow for:

- sowing date—higher rates with later sowings
- seed germination percentage
- seed size
- seedbed conditions
- tillage, e.g. no-till
- double-cropping
- soil fertility
- soil type
- soil moisture and seasonal outlook
- weed seed burden—higher sow rates for increased plant competition, e.g. if combatting herbicide-resistant ryegrass populations [23]

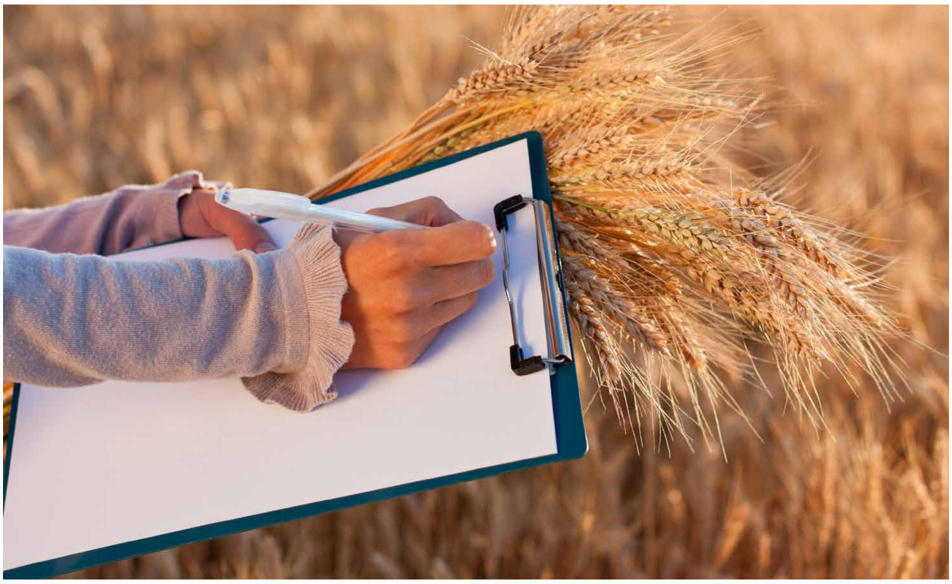

Figure 13: Trials showed that high plant populations do not necessarily lead to small grain or high screenings.

Figure 14: Sunvale⑪ wheat is an example of a variety with the ability to produce a high number of tillers. (Photo: Susan McDonnell)

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

In 2000, TOPCROP Victoria investigated sowing rates for wheat to achieve target plant densities by using large-scale paddock demonstrations. TOPCROP farmer groups established 30 sites across Victoria comparing 75%, 100%, 150% and 200% of the district practice for sowing rate, using Silverstar and a farmer-selected wheat variety. Initial findings indicated that poor seeder calibration and a lack of understanding of the influence of grain size have led to target plant densities not being reached. This highlights the need for sowing recommendations to be based on target plant densities rather than sowing rates. [24]

FAQ

3.4.1 Calculating a seeding rate

Because seed sizes may vary depending on production years and variety type, a fixed quote for the weight of seed needed to sow 1 ha is not always an accurate measure for obtaining a desired plant population per hectare. Average graded seed sizes are:

- large, 24,000 seeds/kg
- medium, 27,500 seeds/kg
- small, 30,000 seeds/kg

An actual seed count is required to calculate a more accurate sowing rate. A formula based on 1000-seed weight can be used. To determine 1000-seed weight, count out 200 seeds, weigh to within 0.1 g and multiply by 5. Then calculate the sowing rate:

Sowing rate = (target density x 1000-seed weight/100)/
(establishment percentage x germination percentage)

Germination percentage can be found on bag labels, or you can do your own germination tests and/or seed counts.[25]

3.4.2 Plant spacing

Crop establishment

Establishment in the field can be affected by a number of factors such as:

- seedbed moisture
- seed–soil contact
- high temperatures
- disease
- soil insects and soilborne diseases
- depth of planting (may be inaccurate or variable)
- certain seed treatments that reduce coleoptile length
- herbicide residues
- germination and vigour of the seed

The impact of poor establishment and seedling vigour will be lessened if seedbed requirements are matched to machinery capabilities and seed quality.

Surface sealing may be a problem if heavy rains fall immediately after sowing and prior to emergence. The emerging shoot is often unable to penetrate the hard surface crust that forms as the soil dries. The problem is more prevalent on soils with declining organic matter, especially red-brown earths and grey clays. In many instances, this has

24 A Johnson, M Evans, K Wansink (2001) Challenging sowing rates for wheat to achieve target plant densities. 10th Australian Agronomy Conference, Australian Society of Agronomy/The Regional Institute Ltd, http://www.regional.org.au/au/asa/2001/p/10/johnson.htm

25 DAF Qld (2012) Wheat—planting information. Department of Agriculture and Fisheries, Queensland, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/planting-information

doubled the initial emergence. Gypsum application may help alleviate this problem on hard-setting clays. [26]

Establishment depends on seedbed conditions, soil moisture, presence of insect pests, and climate. Establishment percentage is the percentage of seed planted that establishes on planting moisture. Establishment may be as high as 95% under ideal conditions, or drop to as low as 40% with rough seedbeds, early planting and limited moisture.

Poor-quality seed with low laboratory germination will give poor establishment; for example, weathered seed that has been stored under high temperature and humidity, or seed that has been attacked by insects.

How to measure your plant population

Here is a simple way to check the plant population in your wheat crop.

Cut to size a 1-m length of steel rod or wooden stick. While the crop is still young, preferably no later than day 20 after sowing (to identify individual plants easily), place the 1-m rule along a row and count the number of plants along this row. Do this 10 times at different locations to get a representative count, and calculate the average.

More information

GRDC: Crop placement and row spacing—Southern Fact Sheet

3.4.3 Row-spacing effects

The depth of seed placement and the distance from the adjacent row both influence crop performance. With greater uptake of no-till and precision farming, the opportunities to vary row spacing by crop and to sow on the inter-row have increased. However, increasing row spacing is not always beneficial to yield.

The traditional row spacing in much of southern Australia has been 15–20 cm. Greater adoption of no-till farming systems has increased interest in wider row spacing, such as 30–50 cm, depending on the crop type and region.

Until recently, the trend was to widen row spacing to accommodate stubble retention practices. Recent evidence shows that widening row spacing decreases yields, particularly in areas of higher yield potential. Growers in these areas are returning to narrower row spacing for yield and weed-control benefits (crop competition). Improvements to disc or tine/knife-point seeding systems means that stubble handling at narrow row spacing has also improved, although tine systems usually require some form of stubble management such as mulching after harvest.

Row spacing is a compromise between:

- ease of stubble handling
- optimising seedbed utilisation and travel speed
- managing weed competition and soil throw
- achieving effective use of pre-emergent herbicides

Although row spacing is relatively simple to change, the effect on the whole-farm system can be complex.

The change can influence yield, time of sowing, machinery choice and setting, herbicide type, seed costs, and fertiliser type and timing. Using different row spacing for different crop types will influence the types of crops sown and their sequence in the rotation.

[26] P Keys, AM Bach (2010) Plant population for Queensland. Department of Agriculture and Fisheries Queensland, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/plant-population

Effect on yield

The higher the yield potential, the greater the negative impact of wide rows on cereal yields. [27] The impact of row spacing on yield varies depending on the growing-season rainfall.

Analysis of data from the NSW DPI VSAP project, covering a large number of row-space experiments in wheat, canola and lupins, revealed that widening the row space of wheat decreased yields when yields were above ~1.3 t/ha (Table 5). However, at yields <1.3 t/ha there was a small increase in grain yield.

In trials in the Victorian Mallee, wide row spacing at 30 cm has been shown to improve yields of wheat and barley slightly where the yield potential is low (<1 t/ha). Some other trials on wide row spacing and the effect on yield in cereal crops with low yield potential (1–2.5 t/ha) have been inconclusive.

Generally, increasing row spacing up to 30 cm has no effect on wheat yield when yield potential is <3.5 t/ha (Figure 15). [28]In higher rainfall zones, where yields are >3.5 t/ha, significant yield decreases have been recorded in crops with wider row spaces.

Trials conducted over three consecutive years by the Southern Farming Systems near Geelong, Victoria, have shown that row spacing of 40 cm reduced wheat yield by ~6% compared with row spacing of 20 cm.

The value of these yield reductions should be taken into account when considering farming system options that use equipment with wider row spacing. The likely economic loss from row-space widening should be offset by the economic advantages of the minimum-till stubble-retention system. At low yield, it is easy to justify the decision to widen row space.

However, at higher yield levels, the loss of yield with widening of rows increases, and the offset benefits of stubble-retention system need to be carefully evaluated. If benefits are not sufficient to make up for the loss associated with wide rows, then alternative methods for retaining stubble, including sowing into stubble using narrower row spacing, should be investigated. [29]

Table 5: Yield (t/ha) and economic cost or benefit ($/ha) of using wide sowing with wheat and canola in central and southern NSW (wheat at $250/t and canola at $500/t

Row spacing—wheat			Row spacing—canola		
18cm	30cm	42cm	18cm	30cm	42cm
1.00	1.03 (+$6)	1.05 (+$13)	1.00	0.95 (–$25)	0.90 (–$50)
2.00	1.95 (-$12)	1.90 (–$24)	2.00	1.91 (–$47)	1.81 (–$97)
4.00	3.81 (-$48)	3.61 (–$97)	3.00	2.86 (–$71)	2.71 (–$144)
6.00	5.66 (-$85)	5.32 (–$170)	4.00	3.81 (–$94)	3.62 (–$191)

[27] GRDC (2011) A systems approach to row spacing. Southern Region. Crop Placement and Row Spacing Fact Sheet, GRDC, January 2011, http://www.grdc.com.au/uploads/documents/GRDC_FS_CropPlacement_South.pdf

[28] BJ Scott, P Martin, GP Riethmuller (2013) Row spacing of winter crops in broad scale agriculture in southern Australia. Graham Centre Monograph No. 3, Graham Centre for Agricultural Innovation, http://www.csu.edu.au/__data/assets/pdf_file/0010/922465/2013-Row-spacing-of-winter-crops-in-broad-acre-agriculture-in-southern-Australia.pdf

[29] NSW DPI (2012) Wide row spacing reduces wheat and canola yields. *Agriculture Today* May 2012, NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/archive/agriculture-today-stories/ag-today-archive/may-2012/wide-row-spacing-reduces-wheat-and-canola-yields

Figure 15: Generally, increasing row spacing up to 30 cm has no effect on wheat yield where yield potential is <3.5 t/ha. (Photo: Emma Leonard)

Soil moisture

Closer row spacing can reduce evaporation by increasing the rate of canopy closure. Wider row spacing can increase evaporation from the soil between the rows, but this can be offset by inter-row stubble mulching and the interception and concentration of rainfall into the crop row.

Field experiments in SA during 2006 investigated the water- and radiation-use efficiency of wheat, barley and faba beans grown on conventional spacing (18 cm) and wide row spacing of 36 and 54 cm.

The trial was conducted during a dry season with growing-season rainfall 181 mm (median 300 mm) and found clear differences in yield responses for the crops grown at different spacings. The yield trends for wheat and barley were similar.

Doubling the row spacing from 18 to 36 cm resulted in a 2% loss in yield in barley and a 5% loss in wheat. When row spacing was extended to 54 cm, a yield reduction of up to 24% was recorded in both cereals. [30]

Weed competition

At Merredin, Western Australia, in a 27-year trial run by Glen Riethmuller from Department of Agriculture and Food WA, narrow row spacing (18 cm) with normal

30 GRDC (2011) A systems approach to row spacing Southern Region. Crop Placement and Row Spacing Fact Sheet, GRDC, January 2011, http://www.grdc.com.au/uploads/documents/GRDC_FS_CropPlacement_South.pdf

herbicide use and full stubble retention greatly reduced ryegrass numbers compared with the 36-cm row spacing (0.17 *v.* 7.67 seed heads/m²). [31]

Increasing row spacing can create weed problems. Wider spacing reduces the crop's ability to close the canopy and compete with weeds between rows. At row spacing >40 cm, canopy closure in cereals may never occur. This makes weed control extremely important.

Wider row spacing can allow weeds to be controlled by using higher rates of incorporated-by-sowing (IBS) herbicides.

Trifluralin and pendimethalin can be applied as a 'hot blanket' of herbicide and incorporated between the crop rows by using a seeding bar fitted with tines, not discs.

Trials by the Birchip Cropping Group in the Victorian Mallee found that reduced plant establishment could occur when relatively high rates of pre-emergent herbicide were used with narrower row spacing (<22.5 cm). Slightly higher seeding rates can be used to compensate for these reductions. The risk of crop damage from pre-emergent herbicides is greatly reduced when used with wide row spacing. [32]

Equipment

Most growers in the Southern Region use either a knife-point/press-wheel tine system or a single disc. Disc seeders can handle greater quantities of stubble but experience crop damage issues with pre-emergent herbicide use. Tine seeding systems do not have the same herbicide safety issues but usually require some form of post-harvest stubble treatment, such as mulching or burning. [33]

Inter-row cropping

In combination with GPS guidance that provides at least ±10 cm accuracy, wide row spacing allows subsequent crops to be located on the inter-row. Inter-row systems can improve stubble flow; however, it is important that tines do not catch the stubble row because this can cause establishment problems. When using RTK guidance that provides ±2 cm accuracy, the best results are achieved when the minimum wide-row spacing is ~25 cm.

Fertiliser

Fertiliser rates may need to be refined for wide row spacing. Wider row spacing can lead to an increased concentration of fertiliser in rows or a reduced fertiliser rate per hectare at seeding. Consequently, changes in the amount of fertiliser applied at seeding and during the growing season may be required with wider row spacing. Increased fertiliser requirements can occur when there is incomplete exploration of the surface soil by plant roots, such as in dry years.

Banding fertiliser below the seed will help to minimise the effects of fertiliser toxicity. This can occur if seeding fertiliser rates are maintained but row spacing is increased. Soil fertility can also vary between the row and inter-row space in wide-row cropping systems. There may be residual phosphorus in the soil following a dry year. Nitrogen fixation following pulses or nutrient tie-up by stubble may affect soil fertility. This can influence the fertiliser required for the following crop.

To establish soil nutrient status in systems using wider row spacing, a modified approach to soil sampling is suggested. Take equal numbers of soil samples from the row and inter-row for an average fertility content of the paddock. If planning to precision-sow (either row or inter-row), there may be value in having the row and

31 WeedSmart. Narrow row spacing: is it worth going back? WeedSmart, http://www.weedsmart.org.au/bulletin-board/narrow-row-spacing/

32 GRDC (2011) A systems approach to row spacing Southern Region. Crop Placement and Row Spacing Fact Sheet, GRDC, January 2011, http://www.grdc.com.au/uploads/documents/GRDC_FS_CropPlacement_South.pdf

33 K Condon (2014) Disc seeding in southern NSW. Grass Roots Agronomy, http://www.grassrootsag.com.au/assets/disc-lr.pdf

inter-row samples tested separately. This will allow any variation in soil fertility to be exploited. Sowing into an area of high residual phosphorus or nitrogen may reduce starter fertiliser requirements, and sowing away from residual fertility will delay crop access. [34]

3.5 Sowing depth

Factors that influence a seedling's ability to emerge from depth include:

- seed size
- seed treatments
- coleoptile length (this varies with variety)
- herbicides
- soil conditions including temperature

In seasons with a dry start, deep sowing into moisture can ensure that crops are established in their optimal sowing window. The deeper sowing may reduce crop germination, but the yield from the earlier sowing may offset yield losses associated with delaying sowing to later in the season.

Deep sowing is only an option in soils that store soil moisture and can be cultivated to depth. Care should be taken to avoid bringing sodic clays into the topsoil, which can increase dispersion, hard-setting and salinity. Some fungicidal seed treatments reduce coleoptile length in cereals and treated seeds should be shown at shallower depths.

A uniform seeding depth is achieved with press-wheels, which minimise the variation in soil cover provided they produce a regular, stable furrow.

Optimum planting depth varies with planting moisture, soil type, seasonal conditions, climatic conditions, and the rate at which the seedbed dries. The general rule is to plant as shallow as possible, provided the seed is placed in the moisture zone, but deep enough that the drying front will not reach the seedling roots before leaf emergence and that the seed is separated from any pre-emergent herbicides used. [35]

Optimum planting depth for wheat is 30–35 mm for semi-dwarf varieties through to 50–70 mm for tall wheat varieties, which have a longer coleoptile. Coleoptile length will be reduced with warm seedbed conditions and with the addition of some seed dressings.

Planting depth will therefore be more critical with early planting (e.g. April and early May), and varieties with short coleoptiles should be avoided at this time.

In trials, although deeper sowing (10–15 cm) reduced establishment rate, the gains from maximising yield potential by sowing at the optimal time tended to compensate for the lower plant population. Thus, it was better to sow deeper and on time and chance a lower plant population than to wait for another rainfall event and plant outside the optimal window. [36]

Sowing depth influences the rate of emergence and the percentage emergence. Deeper seed placement slows emergence; this is equivalent to sowing later. Seedlings emerging from greater depth are also weaker and more prone to seedling diseases, and may tiller poorly.

Crop emergence is reduced with deeper sowing because the coleoptile may stop growing before it reaches the soil surface, with the first leaf emerging from the coleoptile

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34 GRDC (2011) A systems approach to row spacing Southern Region. Crop Placement and Row Spacing Fact Sheet, GRDC, January 2011, http://www.grdc.com.au/uploads/documents/GRDC_FS_CropPlacement_South.pdf

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

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

while it is still below the soil surface. Because it is not adapted to pushing through soil (does not know which way is up), the leaf usually buckles and crumples, failing to emerge and eventually dying. [37]

For more information on the effect of coleoptile length, see GrowNotes Wheat South Section 2. Pre-planting.

3.5.1 Deep planting

In some seasons, moisture seeking or deep sowing is a tool that growers can use to ensure that crops are established in their optimal window.

Some of the potential disadvantages of deep sowing are delayed emergence, poor establishment, reduced early vigour, increased disease susceptibility and reduced grain yield. Research trials are investigating wheat and durum varietal responses to seeding depth and the impact of triadimenol on emergence. [38]

Deep sowing may delay or stifle emergence, whereas shallow sowing risks seed damage from herbicide uptake. The length of the first shoot (coleoptile) has a bearing on depth of sowing. If a variety is sown deeper than the natural growth extension of the coleoptile then the seedling may not emerge. Most current varieties are derived from so-called semi-dwarf lines, which have shorter stems and shorter coleoptiles than older varieties.

Seasonal differences in depth and availability of moisture influence decisions about depth of sowing. A sowing depth 25–50 mm, depending on soil type and available moisture, is a useful guide for seed placement. In moist conditions, shallower sowing may encourage faster emergence and crop establishment. [39]

The main benefits from deep sowing are gained by establishing varieties in the optimal sowing window. When considering deep sowing or moisture seeking, use seed of large size and high germinative capacity. Also, consider increasing seeding rates to compensate for the reduced emergence of deep sown crops. [40]

Trials during 2009–11 at Coonamble, NSW, showed that deep sowing could have a significant effect on the establishment and yield of wheat; however, none of the varieties evaluated showed an enhanced ability to establish from deep sowing compared with other, commonly grown varieties in the region. Producers need to make several decisions when considering moisture seeking; however, there appears no resultant advantage in crop establishment from changing varieties. [41]

It was unclear whether the reduced yield from deep sowing in 2009 was due to a reduced plant population or to subsequent effects on crop growth and development. Other trials at the same site and in the same season reported no significant difference in wheat yield from plant populations in the range 60–180 plants/m^2. However, the lower plant populations in that work were still higher than the populations achieved in the deep-sowing treatments of the sowing-depth trial. [42] Hence, there was likely some yield

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

38 G McMullen, R Brill, N Fettell (2011) Row spacing and deep sowing. GRDC Update Papers, 18 April 2011, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2011/04/Row-spacing-and-deep-sowing

39 Agriculture Victoria (2012) Growing wheat. DEDJTR Victoria, http://agriculture.vic.gov.au/agriculture/grains-and-other-crops/crop-production/growing-wheat

40 G McMullen, R Brill, N Fettell (2011) Row spacing and deep sowing. GRDC Update Papers, 18 April 2011, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2011/04/Row-spacing-and-deep-sowing

41 R Brill, G McMullen, M Gardner (2012) The effect of sowing depth on the establishment of several commercial wheat varieties. 16th Australian Agronomy Conference. Australian Society of Agronomy/The Regional Institute Ltd, http://www.regional.org.au/au/asa/2012/crop-production/8196_brillr.htm#TopOfPage

42 G McMullen, R Brill, N Fettell (2011) Row spacing and deep sowing. GRDC Update Papers, 18 April 2011, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2011/04/Row-spacing-and-deep-sowing

effect due to reduced population. Deep sowing reduces tillering and subsequent head number per plant and per unit area, which might also have reduced yield in the sowing-depth trial.

The 2011 trial highlighted the potential benefits of moisture seeking; in that season, reduced establishment from a relatively early, deep sowing resulted in higher yield than a shallow, late sowing that achieved a higher plant population. In this trial, the adverse effect of delayed sowing on wheat yield was greater than that of deep sowing. Where producers and agronomists are faced with situations of low seedbed moisture but high plant-available water beyond the seedbed (>5 cm soil depth), planting decisions need to balance the potential effect of reduced yield from deep sowing with the potential yield loss from delayed sowing. [43]

3.5.2 Depth control

Some compromises to planting machines to minimise depth variation:

- Frame length and width affects seed depth. Flexible frames with sectional widths <3 m will assist, as will large-diameter, tandem walking wheels.
- Planter units fitted behind tillage implements give good depth control. Depth control wheels should be as close as possible to the line of planting tines. Select planting tines on bars towards the centre of the planter rather than on the front or rear bar.
- To overcome the problem of high breakout tines driving too deeply into small hills in the seedbed, some form of scraper on the tine may be useful. Flat chisel tines have some advantage in displacing surplus soil.
- In controlled traffic situations where crossing contour banks is necessary, ground-following tools such as pivoting tines or parallelograms will give much better depth control and may justify the additional cost over fixed tines.
- Press-wheels will often compensate for poor depth control. [44]

3.6 Germination testing

For information on quality of planting seed, see GrowNotes Wheat South Section 2. Pre-planting.

3.7 Planting techniques

The benefits of conservation farming are increased fallow stored moisture, less soil erosion, opportunity cropping and lower tillage costs. Even with no-tillage or reduced-tillage planting, a seedbed is required in the zone where the seed is to be placed.

Typical ‘planting techniques’ now involve stubble retained or no-till systems based on managing soil structure and soil moisture levels through strict fallow management and, increasingly, controlled traffic systems.

3.7.1 Inter-row sowing

Inter-row sowing has been shown to reduce the impact of crown rot and increase yield by up to 9% in a wheat–wheat sequence. Crop rotation reduces the incidence and severity of crown rot, resulting in yield gains of 17–23% over continuous wheat. Research reported in 2013 examined whether row-placement strategies coupled with a break crop–wheat rotation would result in differences in grain yield over a 5-year crop sequence. [45]

[43] R Brill, G McMullen, M Gardner (2012) The effect of sowing depth on the establishment of several commercial wheat varieties. 16th Australian Agronomy Conference. Australian Society of Agronomy/The Regional Institute Ltd, http://www.regional.org.au/au/asa/2012/crop-production/8196_brillr.htm#TopOfPage

[44] DAF Qld (2012) Wheat—planting information. Department of Agriculture and Fisheries, Queensland, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/planting-information

[45] A Verrell (2013) *Row placement strategies in a break crop wheat sequence.* GRDC Update Papers, 26 Feb. 2013, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/02/Row-placement-strategies-in-a-break-crop-wheat-sequence

More information

[GRDC Ground Cover: Helping hand on inter row sowing for SA growers]

[GRDC Update Paper: Row placement strategies in a break crop wheat sequence]

[GRDC Research & Development: On-row versus inter-row sowing]

[GRDC Update Papers: Reduce losses from crown rot through variety choice and inter-row sowing]

Video

[SFS Seeder Trial]

Following a wheat crop, the break crop (pulse or oilseed) should be sown between the standing stubble rows. In the next year, the wheat crop should be sown directly over the previous season's break-crop row. Then in the next year of the rotation, the break crop should be sown between the standing wheat rows. Finally, in the fifth year, the wheat crop should again be sown directly over the previous year's break-crop row.

There are two simple rules to follow:

- Sow break crops between standing wheat rows, which need to be kept intact.
- Sow the following wheat crop directly over the row of the previous year's break crop.

By adopting these rules, you ensure the following:

- 4 years between wheat crops being sown in the same row space
- a substantially reduced incidence of crown rot in wheat crops
- improved germination of break crops, especially canola, not hindered by stubble
- benefit to chickpeas from standing stubble reducing the impact of virus
- standing wheat stubble providing better protection to break-crop seedlings [46]

3.8 Sowing equipment

As much as 60% of the final yield potential for a wheat crop is determined at planting. Seeding too thinly, using poor-quality seed, and uneven stands result in end-of-season yield losses that cannot usually be overcome. [47]

During the shift from conventional to no-till farming systems, the effective use of herbicides has become increasingly important. To remain effective, herbicide strategies are being used in conjunction with other measures including crop competition, harvest weed seed control, brown manure and strategic hay cutting.

Over the last 5–6 years, the rapid change in farming systems has overtaken farmer knowledge on how to use many herbicides in conservation farming systems. Older, more traditional herbicides that were designed for use in cultivated systems can still be used effectively in no-till systems; however, they are usually used in a different manner.

In addition, many herbicide labels (especially older type or generic herbicides) have the same content now as they did 10–15 years ago. Some products with generic counterparts have different label claims for the same active ingredient. This creates problems for farmers and agronomists wanting to use these herbicides in modern, no-till farming systems.

Residual herbicides at sowing are very effective for controlling a wide range of weeds both in-crop and into the following summer. Some residual herbicides also have valuable knockdown properties. This is very useful, because knockdown herbicide options prior to sowing are limited for hard-to-kill weeds.

Knowing the chemistry and mode of action of each herbicide is paramount to enable the best combination of crop safety and weed control. Heavy rainfall just after sowing when combined with certain soils can lead to crop damage.

Some herbicides are mobile with soil water, while others are less so. Mobility can also change with time for particular herbicides. For example, the longer that Boxer Gold® (a.i.s prosulfocarb, S-metolachlor) is allowed to bind to soil particles, the less chance there is of the herbicide becoming mobile in the soil. Other herbicides such as Logran® (a.i. triasulfuron) are mobile regardless of binding period.

[46] A Verrell (2013) *Row placement strategies in a break crop wheat sequence.* GRDC Update Papers, 26 Feb. 2013, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/02/Row-placement-strategies-in-a-break-crop-wheat-sequence

[47] W Thomason (2004) Planting wheat: seeding rates and calibration. Virginia Cooperative Extension, http://www.sites.ext.vt.edu/newsletter-archive/cses/2004-10/plantingwheat.html

The IBS application technique appears the safest way of using most residual herbicides because the seed furrow is left free of high concentrations of herbicide. The soil from that furrow is thrown on the inter-row, where it is needed most. In-furrow weed control is generally achieved by crop competition and/or small amounts of water-soluble herbicides washing into the seed furrow. For this reason, best results with IBS application occur when water-soluble herbicides are used either solely or in conjunction with a less-soluble herbicide.

Because of the furrow created by most no-till seeders, post-sowing pre-emergence (PSPE) applications of many herbicides are not ideal and are usually not supported by labels. The herbicides can concentrate within the seed furrow if washed in by water and/or herbicide-treated soil. For volatile herbicides that need incorporation following application, PSPE is not a viable option.

Tine seeders vary greatly in their ability to incorporate herbicides, with many tine shapes, angles of entry into the soil, breakout pressures, row spacings, and soil-surface conditions. Each of these factors causes variability in soil throw, especially when combined with faster sowing speeds (>8 km/h). Consequently, residual herbicide incorporation is variable between seeders. There are, therefore, no rules of thumb for sowing speed, row spacing and soil throw. It is important to check each machine in each paddock.

Disc machines show similar variability in their ability to incorporate herbicides. Disc angle, number of discs, disc size, disc shape, sowing speed, closer plates and press-wheels all have an impact on soil throw and on herbicide-treated soil returning into the seed furrow. Some discs can throw enough soil for incorporation of herbicides such as trifluralin.

In all cases with tines and discs, crop safety is usually enhanced by IBS rather than PSPE application of herbicides.

Knife-points and harrows cause a lot of herbicide-treated soil to return into the seed furrow and are, therefore, not ideally used in IBS application. Knife-points and press-wheels do a much better job. [48]

Seeder calibration is important for precise seed placement and seeders should be checked regularly during sowing (Figure 16).

48 B Haskins (2010) Residual herbicides at sowing using disc and tyne no till seeding equipment. NSW. Riverine Plains, http://riverineplains.com.au/_literature_53801/Residual_Herbicides_-_Barry_Haskins

Figure 16: Seeder calibration is important for precise seed placement and seeders need to be checked regularly during sowing. (Photo: Rohan Rainbow)

FAQ

3.8.1 Using pre-emergent herbicides with different seeding equipment

Seeder design has changed dramatically in recent years, aiming to maximise trash flow and seed placement uniformity while minimising soil disturbance. This has led to increased uptake of knife-point and press-wheel seeders and, more recently, disc seeders.

Each seeder will create a different environment for an establishing crop, and it is essential to understand this before use of pre-emergent herbicides.

Knowledge of how this environment may change with IBS or PSPE incorporation methods is also necessary. In general, much difference in crop safety is achieved between seeders in IBS systems, and less difference between PSPE application methods. The PSPE technique relies on uniform seeding depth and 'flatter' seedbeds without pronounced furrows. The focus here is on the IBS method of incorporation, this typically being the preferred method in conservation farming systems.

The sowing process is relied upon to ensure that the pre-emergent herbicide is incorporated effectively and that the seed is placed into a micro-environment that allows safe and effective germination. In all cases, it is ideal to use a knife-point or disc followed by a press-wheel. Press-wheels are essential to provide the seed with good soil contact and to minimise the amount of herbicide-treated soil from the inter-row being dragged into the seed furrow. They also allow seeders to pass through stubble without the machine becoming choked with trash. It is important to understand that all seeding gear is different, which, in turn, creates varying seedbed conditions.

Other factors not associated with the type of seeding system also importantly influence seedbed conditions. These include soil type, soil moisture, soil compaction, row spacings, seeding depth and sowing speed.

To ensure adequate soil throw, some users assume 1 km/h for every 1 cm of row spacing. This is not correct, and there is no rule for soil throw, row spacing and sowing speed because of the variability discussed previously. The only way to check for adequate soil throw is to check every situation.

The suitability of pre-emergent herbicides in both tine and disc seeding systems has attracted much research recently. Unfortunately, many herbicide labels will not support the use of some pre-emergent herbicides with disc seeders, because of a greater risk of crop damage due to varying machine designs that form very different seedbed conditions.

Regardless of the disc seeder, research in southern NSW has clearly shown that a well-set-up tine seeder will offer greater crop safety than a well-set-up disc seeder. This is mostly because a knife-point and press-wheel will place more soil on the inter-row, minimising herbicide-treated soil washing into the seed furrow. Soil throw in tines is also 'better controlled', resulting in less herbicide-treated soil in a typically wider furrow.

This research has also shown that some herbicides and rates of particular herbicides are better suited to a disc seeder system than are others (Figure 17). This is usually correlated with how a seedling metabolises a particular herbicide if contact is made. From Figure 17, trifluralin at higher rates is definitely not suited to disc seeding systems, because crop vigour may be adversely affected. [49]

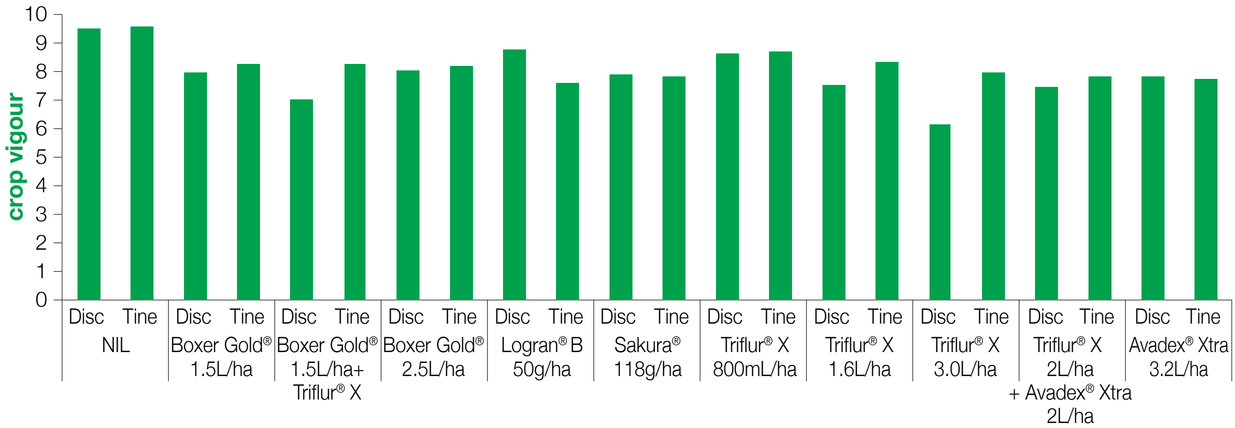

Figure 17: Difference in crop safety between discs and tines across commonly used pre-emergent herbicides in trials in southern and central NSW. Various disc and tine seeders were used for these trials. 0, No crop vigour; 10, vigorous crop.

[49] B Haskins (2012) Using-pre-emergent-herbicides-in-conservation-farming-systems. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0003/431247/Using-pre-emergent-herbicides-in-conservation-farming-systems.pdf