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Marnoo, Victoria

22nd July 2020

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- Durum crops (crown rot)

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- Cereal cyst nematode
- Stem nematode
- Blackspot (field peas)
- Yellow leaf spot
- Common root rot
- Pythium clade f
- Charcoal rot
- Ascochyta blight of chickpea
- White grain disorder
- Sclerotinia stem rot

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Crop diseases – What to look out for in 2020

Joshua Fanning[1], Mark McLean[1] and Grant Hollaway[1].

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GRDC project codes: DJP1097-001RTX, CUR00023, DAV00150, UA00163, DAS1905-013SAX, DJP1907-004RTX, DJP1905-002SAX, DAW1810-007RTX, DJP1907-002RMX, CUR1905-001SAX

Keywords

- cereals, pulses, disease resistance, integrated disease management, fungicides.

Take home messages

- Economic crop disease management relies on an integrated disease management strategy and consideration of yield potential and seasonal conditions.
- Disease ratings may change and it is important to consult the latest disease guide for the latest ratings and up to date disease management information.

Integrated Disease Management

A good integrated disease management strategy will incorporate:

- Diversity of crops within the paddock rotation.
- Avoidance of sowing into stubble from the same crop.
- Management of the green bridge.
- Avoidance of varieties with very susceptible ratings where possible.
- Monitoring for diseases at key growth stages.
- Consideration of seasonal conditions.
- Seeking assistance to identify diseases where required.
- Timely fungicide application.
- Knowledge of where and when to get help.

Disease ratings

There have been some important disease resistance rating changes in both pulses and cereals and it is always important to consult the latest disease guide to get the up to date ratings. These ratings indicate which varieties will require monitoring and in-season management with fungicides. Specifically, in pulses there is a revised set of pulse disease rating definitions to be familiar with. A summary of some disease rating changes is provided in the next section.

Pulse ratings

Several new varieties have recently been released with many providing improvements in resistance to diseases of importance in Victoria. A nationally standardised approach to pulse disease resistance ratings has now been implemented with new rating definitions (Table 1) and this has resulted in some minor changes to resistance classifications. With the changes in diseases over time it is always recommended to consult a current disease guide.

Table 1. The updated pulse disease ratings used in the National Variety Trials which will be implemented in pulse ratings released during 2020 and onwards.

Rating Category		Definition
R	Resistant	No symptoms visible. No fungicides are required.
RMR	Resistant to Moderately Resistant	The disease may be visible but will not cause significant plant damage or loss. However, under extreme disease pressure or highly favourable environments conditions fungicide applications may be required e.g. to prevent seed staining.
MR	Moderately Resistant	The disease may be visible but will not cause significant plant damage or loss. However, under high disease pressure or highly favourable environments conditions fungicide applications may be required e.g. to prevent seed staining.
MRMS	Moderately Resistant to Moderately Susceptible	The disease symptoms are moderate and may cause some yield and/or seed quality losses in conducive conditions. Fungicide applications, if applicable, may be required to prevent yield loss and seed staining.
MS	Moderately Susceptible	Disease symptoms are moderate to severe and will cause significant yield and seed quality loss in the absence of fungicides in conducive seasons, but not complete crop loss.
S	Susceptible	The disease is severe and will cause significant yield and seed quality loss, including complete crop loss in the absence of fungicides, in conducive conditions.
VS	Very Susceptible	Growing this variety in areas where a disease is likely to be present is very high risk. Significant yield and seed quality losses, including complete crop loss can be expected without control and the increase in inoculum may create problems for other growers.

Faba Bean

PBA Amberley$^{\phi}$ has improved chocolate spot resistance, provisionally rated MR compared with the other commercial varieties. Preliminary field data is showing minimal yield losses due to chocolate spot, although currently there are few experiments with good levels of infection. Glasshouse results are also showing good resistance to Ascochyta blight pathotypes 1 and 2.

Lentil

PBA Highland XT$^{\phi}$ has improved resistance to Ascochyta blight (rated MR), including the isolates in South Australia that are now compromising the resistance in PBA Hurricane XT$^{\phi}$ and PBA Hallmark XT$^{\phi}$.

Wheat stripe rust

There is a risk of stripe rust development in 2020. There was a late outbreak of stripe rust in wheat crops during 2019, particularly in the variety LRPB Trojan$^{\phi}$ due to the occurrence of a new pathotype. This could reoccur in 2020, so monitor wheat crops during late winter and spring.

A new stripe rust pathotype

During 2019, there were reports of stripe rust in the wheat varieties LRPB Trojan$^{\phi}$ and DS Bennett$^{\phi}$ at higher than expected levels. Data collected from the field during 2019 by NSW DPI and AgVic, as part of GRDC's National Variety Trials (NVT) disease rating project, indicated that this new pathotype has implications for several wheat varieties, such as DS Bennett$^{\phi}$ and LPB Trojan$^{\phi}$ and to a lesser extent Devil$^{\phi}$, Illabo$^{\phi}$, DS Darwin$^{\phi}$, Emu Rock$^{\phi}$ and Hatchet CL Plus$^{\phi}$. There were also implications for several durum varieties, such as DBA Spes$^{\phi}$, DBA Lillaroi$^{\phi}$, DBA Vittaroi$^{\phi}$ and EGA Bellaroi$^{\phi}$.

It is important to consult a current disease guide to be aware of changes such as these.

Decision support for stripe rust control: StripeRustWM

A new tablet-based app, StripeRustWM, has been developed to support in-crop decision making for the management of stripe rust of wheat. The app is based on the already successful BlacklegCM and SclerotiniaCM apps that are widely used in canola. StripeRustWM estimates potential losses using information such as variety resistance rating, plant growth stage, fungicide history, presence of rust either within the crop or the district, climatic conditions, expected yield and economics. StripeRustWM was developed using data and information from the last 30 years' national pathology research projects. The app will be updated annually with the latest research findings so that new information can be utilised by industry as soon as available.

StripeRustWM is designed to be quick to use in the field, to guide profitable decisions about stripe rust management. It has a straight-forward user interface that asks for inputs that can be readily estimated by agronomists.

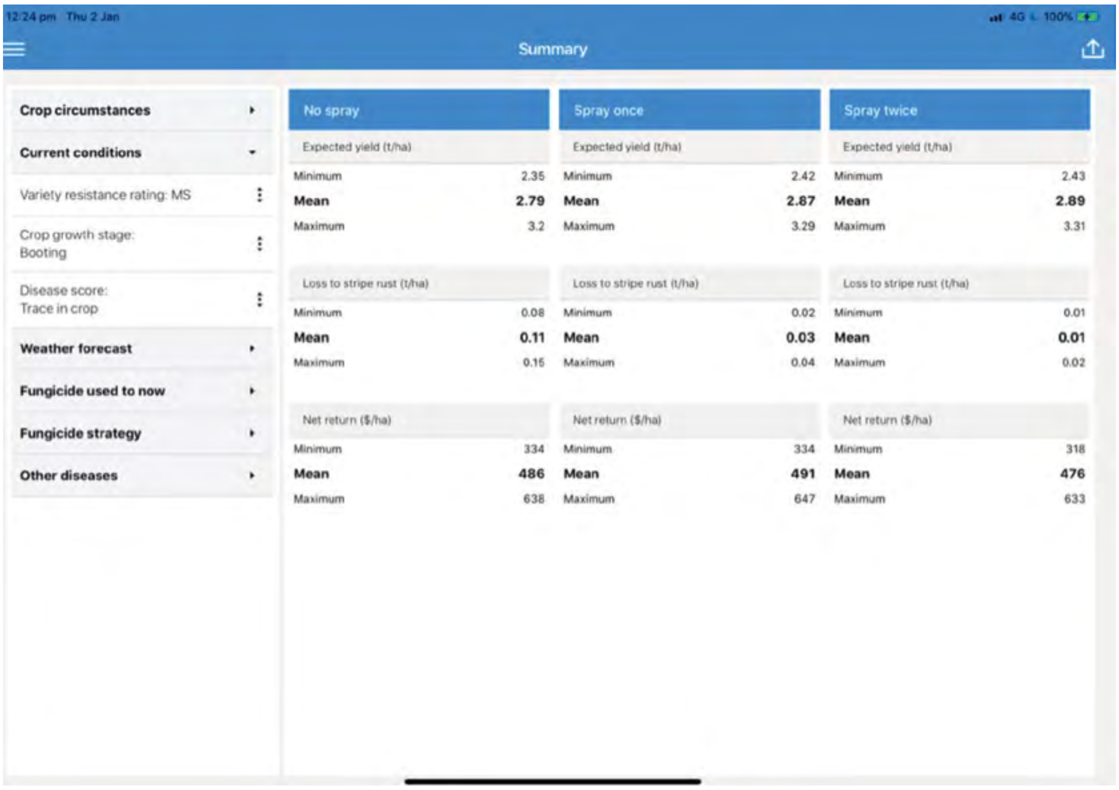

Figure 1. The summary view from StripeRust Wheat Management (StripeRustWM) comparing expected yield, loss to stripe rust and net return for the cases where fungicide is not applied, is applied once, or is applied twice.

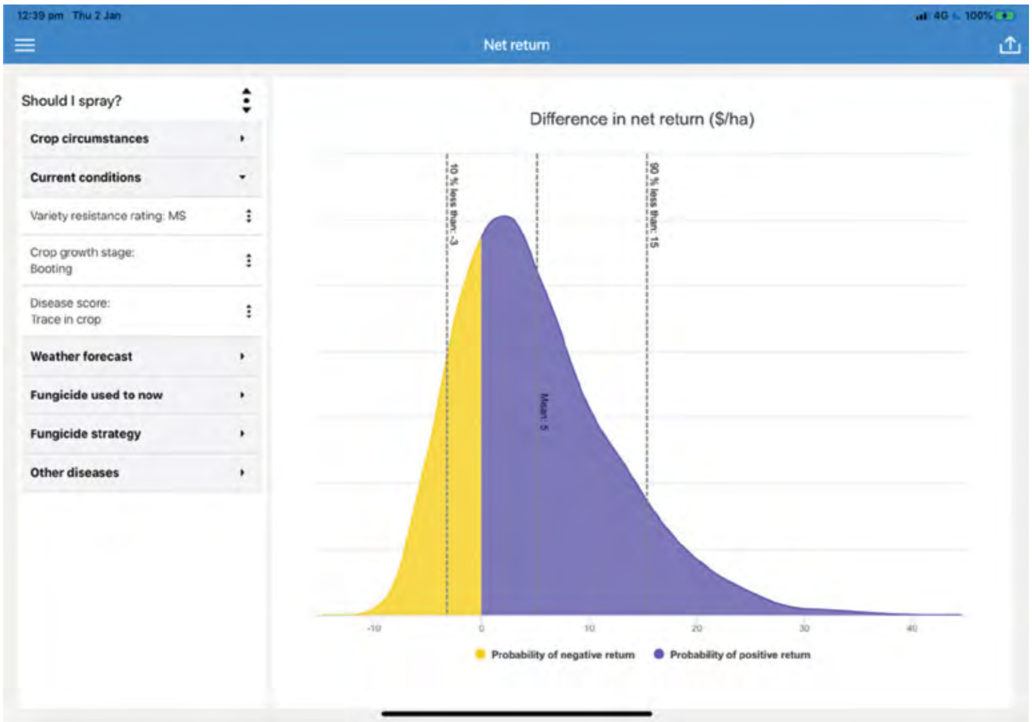

Figure 2. The net return view from StripeRust Wheat Management (StripeRustWM) showing the distribution of expected net return resulting from a single fungicide application.

Figure 1 illustrates the StripeRustWM app interface, where a trace of stripe rust has been detected in a crop with a resistance rating of moderately susceptible (MS), at the booting growth stage. The output shows that a marginally higher net return would be expected if fungicide was applied to the crop once, compared with not spraying. The net return would probably be lower if the crop were sprayed twice.

An alternate presentation of the StripeRustWM app is shown in Figure 2, illustrating the range of possible outcomes, as a probability, from a single fungicide application. This reflects the variable nature of a biological system where a range of outcomes are possible. It shows the relative likelihood of positive and negative returns from the spray based on different environmental conditions and yield potentials.

StripeRustWM is available at no cost for iPads or Android tablets from the Apple App Store or Google Play — search for 'StripeRustWM'.

Fungicide resistance

Fungicide resistance is an important issue for the management of diseases in cereals. During the last 20 years fungicides have provided a cheap and reliable control of many fungal diseases, but their frequent use has resulted in a selection pressure which favours pathotypes that have mutations for fungicide resistance. Subsequently, there are increasing reports of diseases displaying reduced fungicide sensitivity and fungicide resistance. It is important that the agricultural industry adopts strategies that reduce reliance on fungicides to ensure their longevity.

During 2019, there were several reports of fungicide resistance in cereal diseases across Australia. The most significant was the identification of fungicide resistance in barley net form of net blotch (NFNB) to fluxapyroxad (a member of the SDHI group of fungicides) in the seed treatment Systiva®. This resistance was confirmed by the fungicide resistance researchers from the Centre for Crop and Disease Management at Curtin University in collaboration with SARDI in samples taken from multiple paddocks across the Yorke Peninsula (YP) in South Australia. Whilst testing for resistance to SDHI fungicides, a very high level of resistance to tebuconazole (used as an indicator of resistance within the DMI group of fungicides) was also detected in all 15 paddocks tested across the YP. Testing so far has focused on the YP but given the widespread dispersal of airborne spores, it is possible that spores of the dual-resistant pathotype of NFNB will have been dispersed during 2019 and may be present across a wider area, albeit at a low level during 2020. Further field testing is planned for 2020.

This development and spread of fungicide resistance for NFNB is likely to have been enhanced with the sowing of susceptible barley varieties into infected barley stubbles and the repeated use of fluxapyroxad (Systiva®) and a narrow range of DMI fungicides. This incidence highlights the importance of not becoming over-reliant on a single option for disease control.

The agricultural industry can slow the development of fungicide resistance and thus protect the longevity of the limited fungicides available by adopting the following disease management strategies;

- Use a range of control strategies to minimise disease development, including;
  - avoid growing highly susceptible cultivars
  - use crop rotation to avoid planting into paddocks with disease present
  - manage the green bridge for diseases such as mildew and rust.
- Use seed and/or fertiliser treatments, if available, to suppress early disease development.
- Avoid unnecessary fungicide use.
- Use fungicide mixtures formulated with more than one mode of action.
- Do not use the same active ingredient more than once within a season.
- Adhere to label recommendations.

How can you help Pulse Pathology Research?

Samples of pulse crops with the following diseases are being sought:

- Ascochyta blight.
- Botrytis (BGM or chocolate spot).
- Sclerotinia.
- Soil-borne diseases.

Provision of these samples from the field ensures researchers are using the latest disease samples for monitoring changes in both the pathogen populations and variety resistance. If you can help, please contact Joshua Fanning (Victoria) for a collection kit that includes sample envelopes and a return post envelope.

Useful resources

- Pulse disease guide https://agriculture.vic.gov.au/biosecurity/plant-diseases/grain-pulses-and-cereal-diseases/pulse-disease-guide
- Cereal disease guide: https://agriculture.vic.gov.au/biosecurity/plant-diseases/grain-pulses-and-cereal-diseases/cereal-disease-guide
- Field Crop Diseases Victoria website: https://extensionaus.com.au/FieldCropDiseasesVic/
- National Variety Trial (NVT) website https://www.nvtonline.com.au/
- Victorian crop sowing guide https://grdc.com.au/2020-victorian-crop-sowing-guide

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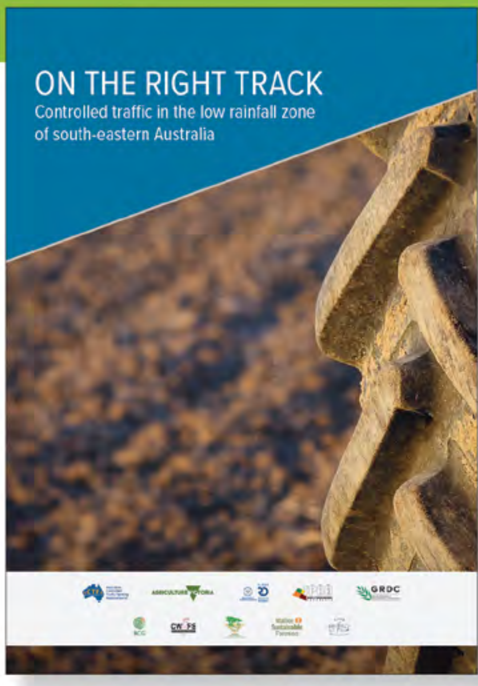

- » DO LRZ SOILS SELF-REPAIR OR IS AMELIORATION WORK NEEDED?
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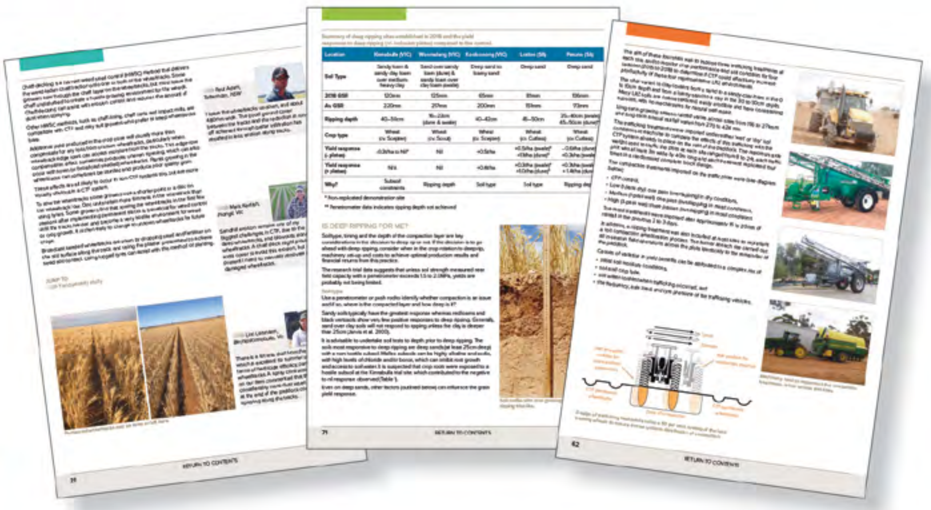

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Key agronomic practices and management to maximise profits from dual-purpose crops

Susie Sprague, John Kirkegaard, Julianne Lilley, Lindsay Bell and Tony Swan.

CSIRO Agriculture and Food.

GRDC project codes: CSP00160, CSP00132, CFF00011

Keywords

- mixed farming, grazing wheat, grazing canola, feed gaps, lock-up.

Take home messages

- Dual-purpose (DP) crops can increase farm profit across a range of environments. Learnings from experiences in southern NSW are presented as examples.
- Higher whole-farm profit relies on attention to detail with crop and livestock management. Establishing the right crop early and correct lock-up time are key to increasing profit and reducing risk.
- Lock-up time is the critical decision to maximise profit. The time of lock-up in relation to crop growth stage and residual biomass, influences crop recovery and yield potential.
- Good livestock prices have highlighted the profitable and flexible options for DP crops under different seasonal conditions.

Background

Grain producers have become more proficient atIn southern NSW, outputs from experimental research and grower experience over two decades has firmly established dual-purpose (DP) crops (both cereals and canola) into mixed farming systems. Crops are grown across a wide range of environments from Feb-March sown winter crops, a mix of winter and spring varieties sown in March and April and opportunistic grazing of April-sown spring crops. Systems experiments, simulation and the early adopters in the district have demonstrated that the benefits to whole-farm businesses can increase whole-farm profit by more than $100/farm ha, i.e. across the entire farm, not just from the paddock used for dual-purpose production. Well-managed crops can provide significant forage with none or little impact on grain yield (Table 1). Appropriate integration of DP crops provides growers with increased profit, flexibility and risk management strategies. Here we present findings from almost two decades of research on DP crops with the aim of highlighting the main messages and considerations for successful adoption.

Table 1. Typical examples of forage, grain yield and gross margins achieved from well-managed dual-purpose crops by collaborating growers in medium/high rainfall zones of southern NSW. DSE = dry sheep equivalent.

Crop type	Grazing achieved (DSE.days/ha)	Grain yield (t/ha)	Paddock $GM increase above grain only
Winter wheat	1600 - 2700	4.5 – 6.5	+$600 - $1000
Spring wheat	400 - 800	3.0 - 5.0	+$300 - $500
Winter canola	750 - 2500	2.0 – 4.0	+$600 - $1000
Spring canola	300 - 700	1.5 – 2.5	+$300 - $500

What are some of the key agronomic practices needed to successfully establish dual-purpose crops for maximum grazing potential?

Consider the fit of dual-purpose crops for your enterprise

A livestock plan is important to ensure that you optimise profit from the extra feed provided by DP crops. Consider the potential dry matter available and feed requirements of livestock. Canola has higher growth rates than cereals under ideal autumn conditions (up to 100kg DM/ha/day) but is lower than cereals once conditions cool into winter. Early-sown cereals can offer the potential for multiple periods of grazing but due to the slower adaptation to feed by livestock and slower recovery, canola is better suited to a single, extended graze.

Early establishment with the right variety is the key to success

Successful establishment in the earliest window with the right variety to flower at the optimum time provides maximum grazing potential. Grazing potential of wheat declines by 200-250 DSE.days/ha for every week's delay of sowing after March 1. There are a variety of things to consider for successful establishment and protection to maximise forage:

(i) Select a suitable paddock and **be prepared** to sow early! Consider weed control, chemical with-holding periods, stubble management, and stored water for early-sown crops which is particularly important for small-seeded canola.

(ii) Sow early with the right crop and variety to ensure flowering at the optimum time. Grazing can delay the onset of flowering, however, selecting the right cultivar ensures the correct flowering time if the crop is not grazed or is grazed unevenly. Early-sown, slower-maturing crops have the longest vegetative period and provide the most grazing potential, but typical grain-only spring crop varieties can also be sown early, and provide useful grazing without significant yield loss following the same principles – but the potential grazing is much reduced (Figure 1), and closer management of lock-up timing is required to ensure that crops are not over-grazed. Though different strategies and crop types are better suited to different regions due to the rainfall and season length, a mix of the different approaches shown in Figure 1 can be used on the same farm to take advantage of early sowing opportunities in specific seasons to increase and widen the overall operational and crop grazing window.

(iii) Protect early-sown crops from establishment pests and aphids that transmit virus. Seed dressings are affordable and effective, but follow-up aphid sprays in warm autumns may be required if aphids persist due to Barley Yellow Dwarf virus. Winter canola tends to carry over aphids through colder weather as they persist deep in the rosette.

(iv) Aim for a good plant population for good early biomass production for grazing.

- 150 plants/m^2 for wheat; 40 plants/m^2 for canola.

(v) Ensure sufficient nitrogen (N) up-front (soil and fertiliser) for good early biomass production. Canola is more responsive than wheat to nutrition.

- 100-150 kg/N for winter wheats and canola; 50-100 kg/ha for spring wheats and canola.
- the seasonal N requirements for grain yield are 80kg N/tonne for canola and 40kg N/tonne for wheat. Top-dress post-grazing to available N and target yield.

What do we need to know regarding management of livestock?

Lockup time is the critical management decision to maximise profit from both the stock and the crops.

Stock

Liveweight gain on DP crops can be up to 2.5kg/hd/day for cattle and 350g/hd/day for sheep. However, animal health issues are a concern, and therefore, close management is required. Grazing canola poses greater risks than cereals, particularly for cattle, and for this reason many growers in southern NSW only put cattle onto cereals. For canola, introduce stock slowly with a full stomach, to avoid gorging and bloat, and monitor regularly. Consecutive days of frost have been associated with bloat in cattle as animals don't feed on frosted crops and then gorge themselves. Provide hay as an alternative feed or consider removing stock under these conditions. Nitrate poisoning can occur in highly fertilised crops (apply N at least three weeks prior to grazing) and is more prevalent under cloudy conditions. Photosensitisation (swelling, blistering and scabbing on exposed face and ears) is caused by grazing stock, especially young lambs, on young Brassica crops. There are few animal health issues

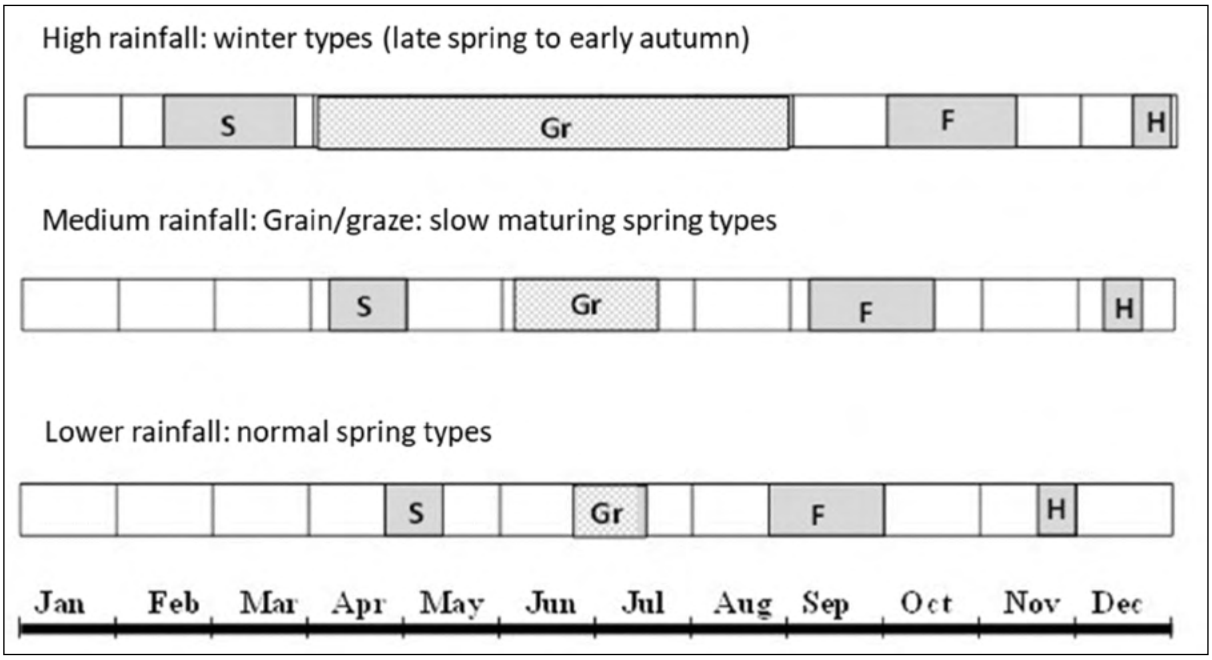

Figure 1. Increased grazing window of winter varieties in longer-season areas compared to spring types in the cropping zones. (Typical windows shown are S=Sow, Gr=graze, F=flowering, H=harvest).

for grazing wheat, however, a supply of mineral supplements (Causmag) can increase liveweight by up to 20-30%. Mineral supplementation has not shown benefits for grazing canola.

Aim for stocking rates of approximately 1000kg/ha liveweight but adjust for feed on offer. Canola is best grazed for an extended period of time as animals require a period of adaptation, so lower stocking rates may be required.

Crops

Don't graze too early as crops are building root mass and growth can be checked or plants pulled out. To check when crops are ready, twist and pull to ensure the crop is well anchored. Crops usually need at least 1.5t/ha biomass (~6-8 leaf stage in canola).

Experiments have shown that crops can be grazed without a yield penalty, but how can we understand this?

The yield potential of any grain crop is related to the biomass at anthesis to support grain-filling. The yield achieved then depends on conditions during flowering and grain fill to realise the potential. In Australia, because crops grow the biomass from autumn to early spring, but flower and fill grain as conditions are getting hot and dry, they almost always grow more biomass than what will be needed for the grain yield that can be achieved. For example, a rule of thumb is that each 1t/ha of wheat grain yield needs 1.8t/ha of biomass at flowering (i.e. 3t/ha crop needs 5.4t/ha of biomass at flowering, etc.). Well-managed, early-sown crops in medium and high rainfall areas often produce significantly more biomass at flowering than is needed for the likely grain yield. This explains why we can use some of this excess biomass with careful and timely grazing, and still achieve the target yield.

The 'safe' grazing period for cereal and canola crops is from the time the crop is well anchored until the reproductive parts start to elongate above the ground and can be damaged or removed by the livestock (DC30 for cereals and bud elongation for canola). Any crop can be grazed in this window and grazing will usually delay flowering from a few days to two weeks, depending on grazing duration and intensity.

Crop recovery - safe lock-up and grazing rules

Grain yield penalties occur when grazing too late (i.e. removing reproductive parts) and too hard (leaving insufficient biomass to reach target yield). The decision is significantly influenced by the crop yield outlook and the relative prices for livestock and grain. These different 'exit options' depending on circumstances provide significant flexibility.

The ultimate goal for managing DP crops is to maximise the profit from the combined income from the grazed forage and the grain. This requires an understanding of how grain yield is affected by heavier or delayed grazing.

Our studies have demonstrated that the time of lock-up **and** the residual biomass are the critical issues. We can define the overall grazing window into 'safe', 'sensitive' and 'unsafe' periods related to the impact on grain yield (Figure 2). The early and 'safe' grazing period is once the crop is well anchored and there is still plenty of time for recovery after a period of grazing, even if the crop is grazed quite heavily. The late and 'unsafe' period is when the reproductive parts of the crop (spikes in wheat, or buds in canola) are elongating above the ground, and can be removed by stock, and there is also too little time for the crop to recover enough biomass by anthesis to set a reasonable yield potential. Most growers can easily identify these two periods by testing crop anchorage to start grazing and checking crop development stage to stop grazing. The 'sensitive' period is the period in which the crop has not yet begun to elongate, but where yield recovery can be very sensitive to the amount of residual biomass left. This is the period where some idea of how much residual biomass is needed to reach a specified target grain yield can assist growers with lock-up decisions to avoid yield loss while maximising grazing potential.

Experiments with different times and intensity of grazing have been used to investigate the relationship between: Residual Biomass (lock-up) <=> Critical Biomass (anthesis) <=> Target Yield.

A range of different winter and spring wheat and canola crops were used in the studies. An example is that a typical grazing EGA Wedgetail[⊕] wheat crop sown on 25 March with a target yield of 4.5t/ha would require a critical anthesis biomass of around 8 to 9t/ha (Figure 3A). This critical biomass would require at least 0.5t/ha of residual biomass to be left in late July (Figure 3B), when the crop becomes unsafe to graze without removing elongating heads (i.e. heads removed if past DC30). Grazing past this point would require close attention to grazing height to ensure heads were not being removed, and more residual biomass (1.0 -1.5 t/ha) would be needed to be left at lock-up in mid-August to still achieve the same critical anthesis biomass, because there is less time left to reach the biomass for the target yield. Note that the spring wheat EGA Gregory[⊕] sown on 8 May generally had similar critical and residual biomass levels to attain similar yields.

For canola, the residual biomass requirement after grazing is higher than wheat, due to the inherently heavy and thick stem bases and slower regrowth after grazing. Spring canola requires about 1.5t/ha of residual biomass left when locked up at the end of

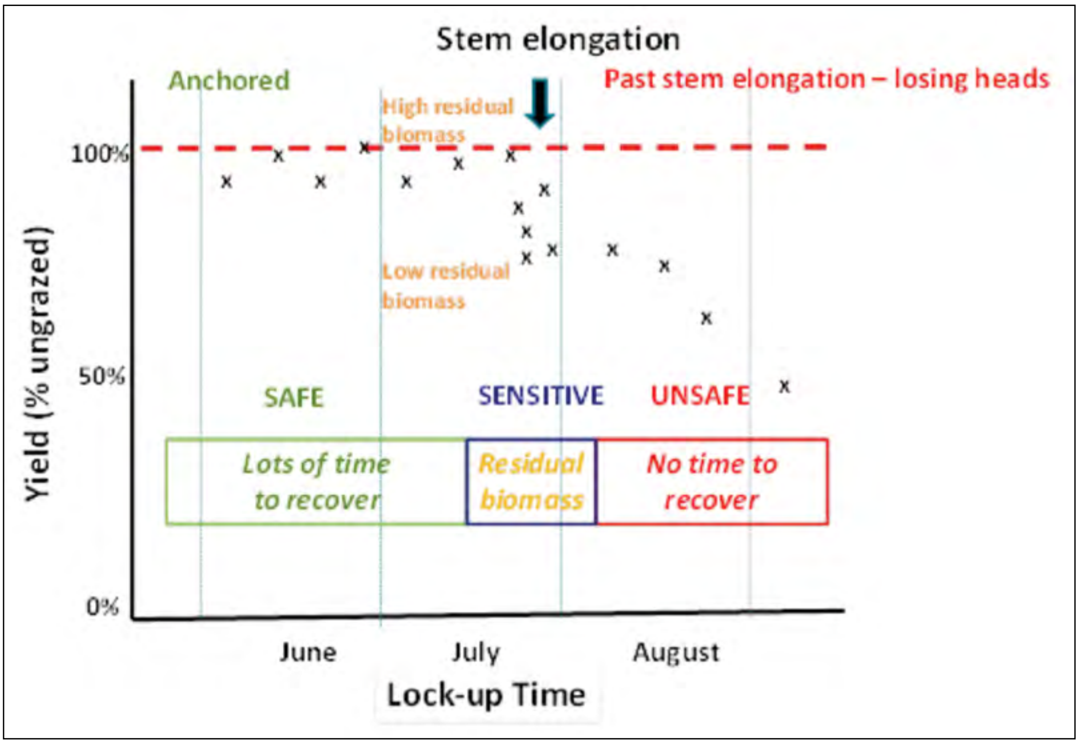

Figure 2. Yield recovery (% of un-grazed crop) of grazed dual-purpose crops highlighting the safe, sensitive and unsafe periods of grazing. Yield recovery from grazing during the sensitive period for a given target yield is affected by the residual biomass at lock-up. Late grazing reduces the time for recovery, so more residual biomass is needed.

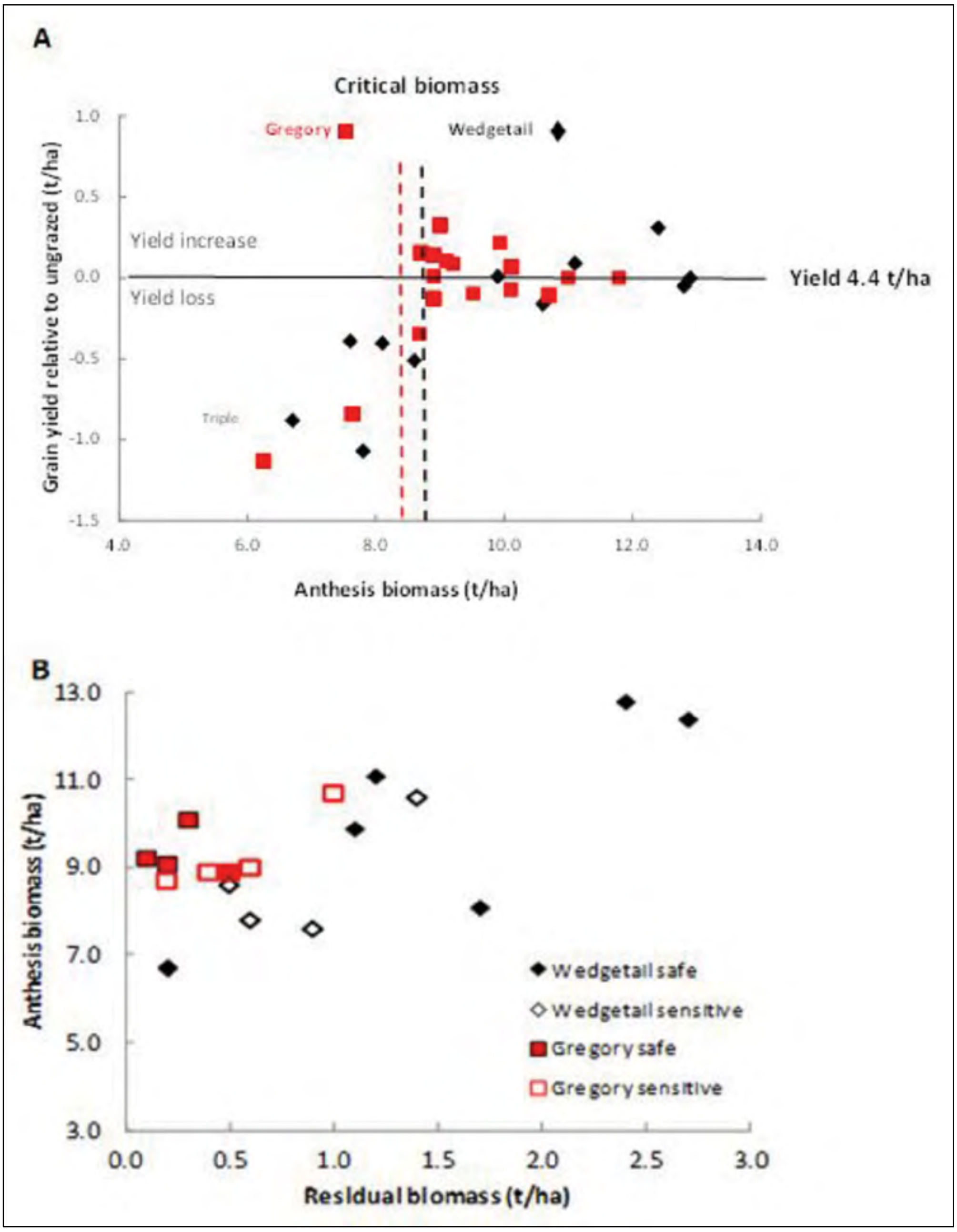

Figure 3. (A) – Shows that for a 4.4t/ha target yield in wheat, around 8.0 to 9.0t/ha was required at anthesis, and treatments with less than this had reduced yield. (B) Shows that residual biomass after grazing of >0.5t/ha in late July was sufficient to reach the critical anthesis biomass for 4.4t/ha yield.

July (when the stems begin to elongate) to ensure 2.5 to 3.0t/ha yield potential. Earlier-sown winter canola has even thicker stem bases and requires around 2.5t/ha of residual biomass for recovery.

What practical takeaways can growers get from looking at the trial work?

Trial work underpinning the key strategies for success have been outlined in the preceding section, however, there are a number of other things to consider.

Trade-offs and economics

Ultimately economics (feed value vs grain value) in the farm enterprise dictates the acceptable level of grain yield loss (if any) for DP crops. In many cases, especially where the feed is being used to fatten or finish lambs or cattle, it is possible that accepting a grain yield penalty makes the most economic sense, as shown for the moderately grazed crop shaded in Table 2.

Table 2. Amount of grazing achieved and grain yield from different grazing treatments in an EGA Wedgetail⁽ᴰ crop at Greenethorpe, NSW, sown on 15 March 2013. Income was highest with a small grain yield penalty as the extra grazing was more profitable than the yield lost. The crops received 333mm of GSR (Apr-Oct) but spring conditions were very dry so crops largely filled on stored soil water.

Lock-up time	Grazing intensity	Sheep grazing d/ha	Grain Yield	Paddock $GM increase above Un-grazed
Un-grazed	None	0	4.35	0
DC30 (safe)	Hard	1730	4.36	$653
DC32 (sensitive)	Moderate	2530	3.96	$853
DC32 (sensitive)	Hard	2730	3.28	$758

(Economics calculated at $250/t grain and grazing at $0.38/sheep grazing day (i.e. $1.7/kg LW for a sheep growing at 225g/day and eating 1.5 kg biomass/day)

Table 3. Amount of grazing achieved, grain yield and additional income from different grazing treatments in a Gregory⁽ᴰ wheat crop at Greenethorpe, NSW, sown on 28 April 2014. The best outcome was to graze safely with economic penalties for later or harder grazing. The crops received 333mm of GSR (Apr-Oct) but spring conditions were very dry so crops largely filled on stored soil water.

Lock-up time	Grazing intensity (and residual t/ha)	Sheep grazing d/ha	Grain Yield	Paddock $GM increase above Un-grazed
Un-grazed	None	0	4.78	0
DC30 (safe)	Hard (0.5)	1070	4.68	$382
DC32 (sensitive)	Moderate (1.5)	800	4.85	$321
DC32 (sensitive)	Hard (0.6)	1390	3.94	$316
DC32 (unsafe)	Hard (0.4)	1520	3.65	$291

Spring wheats such as Gregory⁽ᴰ can also be grazed with success, but due to the later optimum sowing dates and smaller safe grazing window (Figure 1, the amount of grazing achieved is much less (Table 3). The effect of grazing too late and/or leaving too little residual biomass (<0.5 t/ha) can be seen to impact on the economic outcome. In this case with spring wheat, yield was only maintained with later grazing if a large amount of residual remained, and this did not match the economics of grazing hard earlier to provide time for recovery. In general, a much greater level of attention is needed to manage the timing of lock-up in spring crops as development is rapid and the plants less robust. But grazed spring wheat and canola crops can widen the crop-grazing window at the farm-scale, allowing significant spelling of pastures.

Exceptional performance in drought but legacies must be managed

Early-sown DP wheat and canola options have been highly profitable at GRDC farming systems sites at Greenethorpe and Wagga Wagga, NSW, in two recent decile 1 seasons in comparison with timely-sown grain only crops (Table 4). However, the success largely depended on deep stored water from either summer rainfall and good fallow management, or sequences with legumes which left legacies of water and N. At Greenethorpe, consecutive early-sown DP crops (phased canola and wheat) were able to capitalise on higher amounts of stored water to produce more than three times the profit achieved by a grain-only (or hay) system ($1122/ha vs $334/ha). At Wagga Wagga, under drier conditions, income for the same DP crops declined in the second year in 2019 due to the legacy of drier soil from 2018, but the DP system still had higher profit than the grain-hay system ($379/ha vs $172/ha). In medium rainfall areas, selecting the paddocks and seasons to go for early-sown winter options can maximise profits.

Conclusions

Dual-purpose crops provide a range of direct and indirect benefits at the farm scale, however, attention to detail is required to optimise profits. Preparation and planning is crucial for early establishment which will maximise forage production. Monitor animals to avoid health issues, particularly for canola, and consider both crop development and residual biomass at lock-up. Other considerations include the trade-offs between grazing and grain value, and seasonal legacies.

Table 4. Annual and 2-Year profit (EBIT) at Greenethorpe and Wagga Wagga, NSW, for early-sown (March) dual- purpose canola-wheat systems compared with timely sown (April) canola-wheat grain-hay systems in 2018 and 2019. Systems were phased (both crops were grown in each year).

Site/Crop	Dual-Purpose System				Grain only System		
	Variety (Sow)	Graze (t/ha)	Grain (t/ha)	EBIT ($/ha)	Variety/Sow	Grain/ (Hay) (t/ha)	EBIT ($/ha)
Greenethorpe							
2018 Wheat	Kittyhawk (5/4)	1.5	1.9	$862	Coolah (7/5)	2.7	$619
2019 Canola	Hyola970 (23/3)	5.0	0	$1,414	HyTecTT (1/5)	(3.1)	$96
Ave 2-Yr EBIT				$1,138			$358
2018 Canola	Hyola970 (3/4)	3.5	0.9	$1,251	HyTecTT (7/5)	1.1	$79
2019 Wheat	Bennett (26/3)	3.5	0	$960	Coolah (1/5)	(4.8)	$538
Ave 2-Yr EBIT				$1106			$309
Average 2-Yr System EBIT				$1122			$334
Wagga Wagga							
2018 Wheat	Kittyhawk (3/4)	2.0	1.9	$974	Beckom (2/5)	2.1	$333
2019 Canola	Hyola970 (8/4)	2.7	0	$78	43Y92 (26/4)	1.1	$124
Ave 2-Yr EBIT				$526			$229
2018 Wheat	Hyola970 (3/4)	3.1	0	$347	43Y92 (3/4)	1.2	$34
2019 Canola	Kittyhawk (8/4)	2.8	0	$114	Beckom (6/5)	(3.5)	$198
Ave 2-Yr EBIT				$231			$116
Average 2-Yr System EBIT				$379			$172

Acknowledgements

The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC, the authors would like to thank Rod and Nick Kershaw, 'Iandra' for the use of land since 2013; Peter Brookes, Angus Gibson and James Cheatham (DeltaAg) for supporting research at Goulburn.

Useful resources

https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2019/02/maximising-systems-benefits-from-dual-purpose-crops-early-sowing-and-grazing-strategies

https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2020/03/dual-purpose-crops-direct-and-indirect-contributions-to-profit

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LOOK AROUND YOU.

1 in 5 people in rural Australia are currently experiencing mental health issues.

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Looking for information on mental wellbeing? Information and support resources are available through:

www.ifarmwell.com.au An online toolkit specifically tailored to help growers cope with challenges, particularly things beyond their control (such as weather), and get the most out of every day.

www.blackdoginstitute.org.au The Black Dog Institute is a medical research institute that focuses on the identification, prevention and treatment of mental illness. Its website aims to lead you through the logical steps in seeking help for mood disorders, such as depression and bipolar disorder, and to provide you with information, resources and assessment tools.

www.crrmh.com.au The Centre for Rural & Remote Mental Health (CRRMH) provides leadership in rural and remote mental-health research, working closely with rural communities and partners to provide evidence-based service design, delivery and education.

Glove Box Guide to Mental Health
The *Glove Box Guide to Mental Health* includes stories, tips, and information about services to help connect rural communities and encourage conversations about mental health. Available online from CRRMH.

www.rrmh.com.au Rural & Remote Mental Health run workshops and training through its Rural Minds program, which is designed to raise mental health awareness and confidence, grow understanding and ensure information is embedded into agricultural and farming communities.

www.cores.org.au CORES™ (Community Response to Eliminating Suicide) is a community-based program that educates members of a local community on how to intervene when they encounter a person they believe may be suicidal.

www.headsup.org.au Heads Up is all about giving individuals and businesses tools to create more mentally healthy workplaces. Heads Up provides a wide range of resources, information and advice for individuals and organisations – designed to offer simple, practical and, importantly, achievable guidance. You can also create an action plan that is tailored for your business.

www.farmerhealth.org.au The National Centre for Farmer Health provides leadership to improve the health, wellbeing and safety of farm workers, their families and communities across Australia and serves to increase knowledge transfer between farmers, medical professionals, academics and students.

www.ruralhealth.org.au The National Rural Health Alliance produces a range of communication materials, including fact sheets and infographics, media releases and its flagship magazine *Partyline*.

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Rural & Remote Mental Health | Heads up Better mental health in the workplace | National Centre for Farmer Health | National Rural Health Alliance Ltd

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Managing nitrogen for high crop yields and sustainable farming systems

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Keywords

- Nitrogen, yield, sustainable, farming systems

Take home messages

- Nitrogen (N) deficiency is the single biggest factor contributing to the Australian wheat yield gap.
- You need to soil test in order to make any sort of rational decision about N fertiliser.
- Yield Prophet®, back of the envelope calculations and 'N bank' targets are all valid ways of managing N fertiliser to achieve potential yields and avoid running down total N.
- Don't fear overapplication of N - on most soils in the Wimmera-Mallee unused N carries over and is available for use by subsequent crops and helps maintain soil organic matter.

Background

Australian wheat yields are only half what they could be for the rainfall received (Hochman et al. 2017). Nitrogen (N) deficiency is the single biggest factor contributing to this yield gap. This is also likely to be true for other non-legume crops (barley, canola and oats) which reduces farm profitability and global food security. Alleviating N deficiency would increase national wheat yields by 40 per cent (Hochman and Horan 2018), and substantially improve farm profit.

On farms with no legume pastures, most of the crop N supply must come from fertiliser. Grain legumes do not provide enough N to support yield of subsequent crops at the intensity at which they are currently grown. N fertiliser is a costly input and use of it increases cost of production and value-at-risk for growers. Growers fear that over-fertilisation will result in 'haying off', which reduces both yield and quality. There is also the concern that overapplied fertiliser that is not used by crops is lost to the environment by leaching, volatilisation and denitrification. Consequently, efforts continue to be made to match N fertiliser inputs to seasonal yield potential. This is difficult in southern Australia due to the lack of accurate seasonal forecasts for rainfall.

The difficulty in matching N supply to crop demand and a tendency for growers to be conservative in their N inputs is responsible for a large proportion of the yield gap that can be explained by N deficiency. Chronic N deficiency has also caused soil organic matter to decline (Angus and Grace 2017) and has driven a rise in the proportion of low protein grain produced in Australia, which has eroded our standing as a producer of quality wheat in export markets.

'N banks' are a strategy for managing N in crop production areas with low environmental losses (leaching, denitrification). Most of the Wimmera-Mallee has soils which are free-draining and hold a reasonable amount of water, and therefore, environmental losses of N are low. N banks are therefore an effective strategy for managing N in most of the region. Exceptions are areas prone to waterlogging or have very sandy soils. The advantages of N banks are that they are simple to calculate, crops are rarely N deficient, and if set at an appropriate level for the environment, soil organic N is not mined. They also shift the cost of N fertiliser into years following a year of high production, rather than in the year of **possible** high production.

N banks require growers to set a locally relevant target for crop N supply (soil mineral N plus fertiliser N) that is enough to maximise yield in the majority of seasons. Soil mineral N is then measured early in the growing season, and if less than the target N bank, is topped up to the target value with fertiliser N. A more detailed description of N banks and a long term experiment investigating their effectiveness can be found here: http://www.ausgrain.com.au/Back%20Issues/301mjgrn20/Grower%20group%20focus.pdf

Key Question 1 How do we assess the N bank after a big season last year?

Assessment of the N bank is achieved by soil testing for nitrate and ammonium. The 'N bank' management system relies on growers knowing how much mineral N (nitrate and ammonium) they have available to a crop early in the growing season. Consequently, for any rational decision to be made on N management, it is critical that paddocks are soil tested to measure mineral N. This can be done any time from March through to June, but if done following sowing it is essential that samples are taken from the inter-row to avoid sampling any fertiliser N applied at sowing. Soil cores should be taken to at least 0.6m (ideally >1.0m) and segmented into different depths (e.g. 0-0.1 m, 0.1-0.3 m, 0.3-0.6 m). At least six cores need to be taken per paddock or production zone within a paddock, and bulked samples carefully mixed. Samples should be kept cool and ideally air dried before being sent to an accredited laboratory for analysis. A good soil sampling contractor will do all of these things for you!

Key Question 2 With a big production year in mind, what are the key messages for growers to consider when developing a nitrogen strategy?

The yield gap due to N deficiency is always bigger in high production years. Growers either need to make a realistic assessment of current economic yield and associated crop nitrogen demand or choose an N bank target (see calculations in following section). They then need to calculate how much mineral N was available to crops early in the season from soil samples (refer preceding section), and therefore how much fertiliser N needs to be applied to achieve economic yield or the N bank target.

The bulk of this fertiliser should be applied in July-early August when cereal crops are at Z30-31 and canola hasn't started elongating. Applying at this time minimises volatilisation losses (cold often wet soil with rain fronts coming through) and maximises chances of crop uptake. If you are applying N during

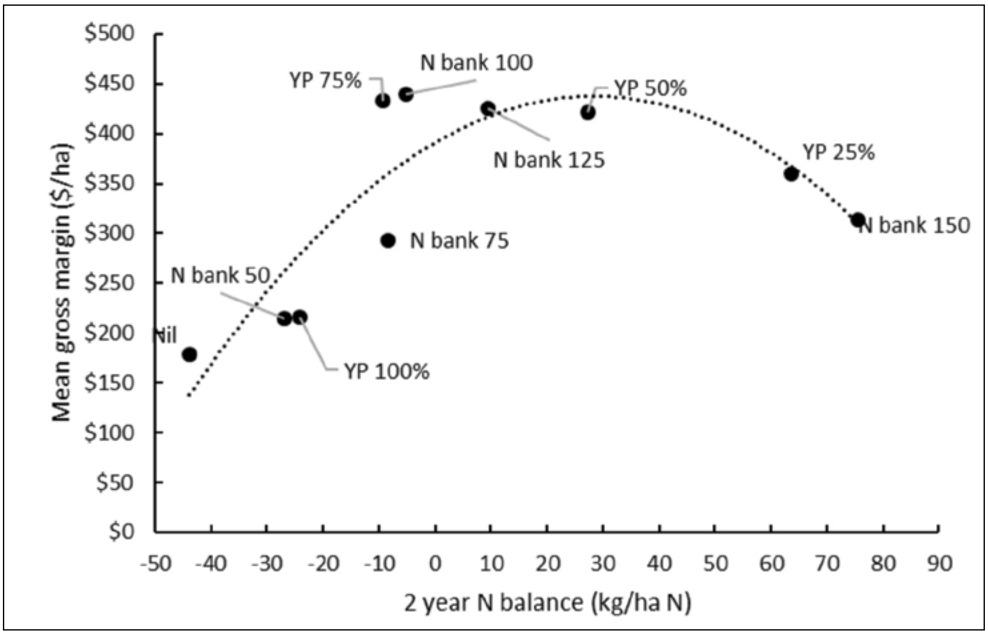

Figure 1. The BCG-La Trobe University long-term N management experiment at Curyo is showing that N management strategies that over-apply (i.e. have a neutral to positive N balance) are more profitable. These strategies will also avoid mining soil mineral N and thus running down soil organic matter. For details of the experiment see http://www.ausgrain.com.au/Back%20Issues/301mjgrn20/Grower%20group%20focus.pdf the number following 'N bank' treatments is the N bank target in kg/ha. YP=Yield Prophet treatments at different levels of probability (YP100% targets yield assuming the worst season finish on record, YP50% targets yield assuming a median finish etc.).

July you do not need to do it right in front of a substantial rain, just do it by the calendar. Crops can be topped up later in the season (e.g. Z37), but risk of volatilisation losses are higher and substantial rain is needed to make sure the N becomes available to crops. If top-dressing later than mid-August you should do it in front of a substantial (>15 mm) forecast rain.

Growers in the Wimmera and Mallee shouldn't fear over-application (supplying more N than the crop needs this year) on paddocks that aren't sandy or don't reliably get waterlogged. Leaching and denitrification losses are very low and N that is not used by the crop this year will be available for next year's crop. Crop simulations and the BCG-La Trobe long-term N field experiment at Curyo is showing that occasional over-application is more profitable in the long-term than under-application (Figure 1). This agrees with findings from a similar long term experiment in semi-arid China (Guo et al. 2012). The only other reason not to overapply is if your cash flow is tight and you can't afford not to get a return on investment in fertiliser N this year.

Many growers continue to be concerned about 'haying off' (negative yield and quality response to applied fertiliser N), but chances of this happening are low in modern farming systems. This is due to;

1. The shift to continuous cropping and decline in pasture area has reduced both soil mineral N prior to sowing, and the amount that mineralises in-season.
2. Stubble retention further reduces in-crop mineralisation by increasing immobilisation.
3. Soil testing prevents N from being applied to paddocks with very high levels of soil mineral N.
4. Modern crops are less susceptible to haying off. Canola and high harvest index cultivars of barley, such as Spartacus⁽ᵈ⁾ are virtually immune. Modern wheat cultivars that have been heavily selected for grain size (e.g. Scepter⁽ᵈ⁾) carry a very low risk.

Key question 3 What tools are available for growers and consultants to help with decision making?

Yield Prophet® is still an effective tool for attempting to match N supply to seasonal demand. The downside of Yield Prophet® is that it is data-hungry and requires experience to get it right. This simple spreadsheet tool (available here; https://www.bcg.org.au/understanding-crop-potential-and-calculating-nitrogen-to-improve-crop-biomass-workshop-recording/) requires less data but doesn't give probabilistic output or include seasonal forecasts. It uses the old 'back of the envelope' calculation as follows;

Crop water supply (mm) = 0.25*(Nov-Mar rain) + growing season rain to-date + your guess at rain for the rest of the season

Water limited potential yield (t/ha) = 0.022*(crop water supply – 60)

Economic yield = 0.8*(water limited potential yield)

Crop N demand (kg/ha N) = 40*(economic yield)

Fertiliser N requirement (kg/ha N) = crop N demand – (soil mineral N + previous fertiliser application)

If you allow for in-crop mineralisation when calculating fertiliser requirement, you will run down soil organic N and thus soil organic matter. We can work this through with an example for a wheat crop in the Wimmera using rainfall from Rupanyup Post Office with a conservative estimate of how much rain we might get for the remainder of the season (120 mm). We'll also assume there was 75kg/ha mineral N measured in soil cores prior to sowing.

Crop water supply (mm) = 0.25*(157mm) + 125mm + 120mm = 284mm

Water limited potential yield (t/ha) = 0.022*(284 – 60) = 4.9t/ha

Economic yield = 0.8*(4.9) = 3.9t/ha

Crop N demand (kg/ha N) = 40*(3.9) = 156kg/ha N

Fertiliser N requirement (kg/ha N) = 156kg/ha N – (75kg/ha N + 7kg/ha N) = 74kg/ha N

This crop needs 74kg/ha N applied as fertiliser (160kg/ha urea) to achieve economic yield assuming there is 120mm of rain between now and the end of October.

The problem with Yield Prophet® and the 'back of the envelope' strategy is they require a forecast of the future (i.e. how much rain is going to fall between now and the end of the season). With the N management strategy that is currently being developed, we don't even attempt to match crop N supply to seasonal demand, we just make sure that the crop has enough N supply (soil mineral N measured early in the season + fertiliser) to achieve water limited potential yield in the majority of seasons. We do this by selecting an N bank target appropriate for the environment. A target of 125kg/ha N is proving most profitable in the southern Mallee, but it is likely to be more like >175kg/ha N in the Wimmera (E Meier et al. CSIRO unpublished). We then use soil mineral N measurements from soil cores to work out how much mineral N the crop has and top up the balance with fertiliser. For example;

Soil mineral N measured in soil cores = 75kg/ha N

N bank target = 175kg/ha N

Fertiliser required to meet N bank target = 175 – 75 = 100kg/ha N (217kg/ha urea)

This system relies on having low leaching or denitrification losses so that any surplus N applied carries over to the next season. You need to apply less N following a low yielding year with a lot of carryover, and more N following a high yielding year with lots of crop N uptake and N offtake in grain.

Two years of results from the experiment at Curyo indicate that the N bank strategy and Yield Prophet® use similar amounts of N and are equally profitable (Figure 2), and this is confirmed by simulation studies over many seasons (E Meier et al. CSIRO unpublished).

Conclusion

Nitrogen deficiency is the single biggest cause of the Australian wheat yield gap. Growers can easily reduce this yield gap, increase profitability and stop mining soil N by better managing fertiliser N inputs. Soil testing is essential to do this. N banks, Yield Prophet® or 'back of the envelope' calculations are all equally effective at reducing N limitation and increasing profit. N banks are much simpler to calculate but run a higher risk of losses and have not been validated in the field over the long-term.

Acknowledgements

This project is funded by La Trobe University through the Securing Food, Water and the Environment Research Focus Area and the Mallee Catchment Management Authority, through funding from the Australian Government's National Landcare Program.

Useful resources

http://www.ausgrain.com.au/Back%20Issues/301mjgrn20/Grower%20group%20focus.pdf

https://www.bcg.org.au/managing-n-fertiliser-to-profitably-close-yield-gaps/

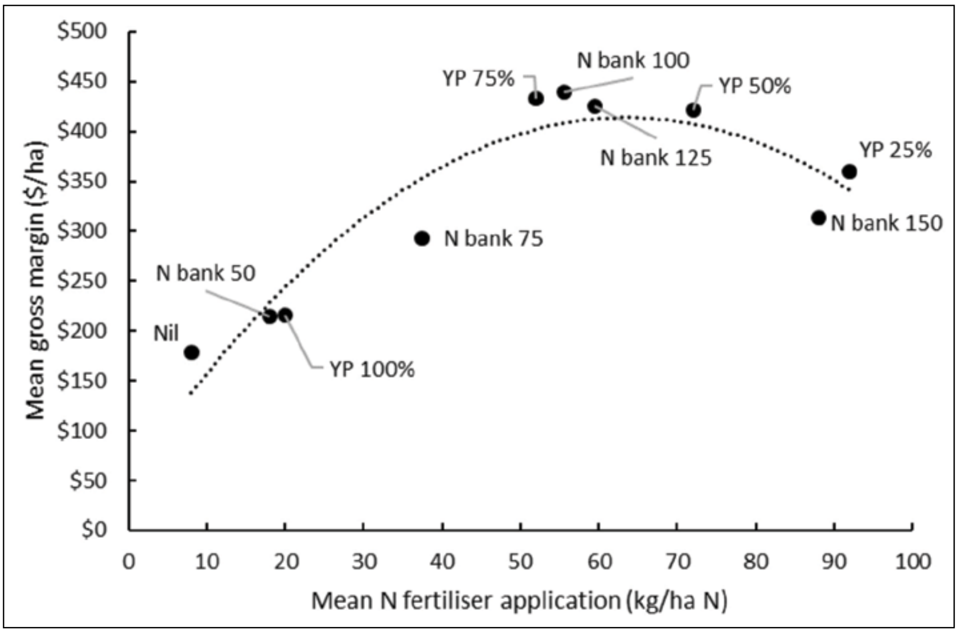

Figure 2. Mean fertiliser application and mean gross margin (2018-2019) for the BCG-La Trobe University long-term N management experiment at Curyo. For details of the experiment see http://www.ausgrain.com.au/Back%20Issues/301mjgrn20/Grower%20group%20focus.pdf the number following 'N bank' treatments is the N bank target in kg/ha. YP=Yield Prophet treatments at different levels of probability (YP100% targets yield assuming the worst season finish on record, YP50% targets yield assuming a median finish etc.).

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TOP 10 TIPS FOR REDUCING SPRAY DRIFT

01 **Choose all products in the tank mix carefully**, which includes the choice of active ingredient, the formulation type and the adjuvant used.

02 **Understand** how product uptake and translocation may impact on coverage requirements for the target. Read the label and technical literature for guidance on spray quality, buffer (no-spray) zones and wind speed requirements.

03 **Select the coarsest** spray quality that will provide an acceptable level of control. Be prepared to increase application volumes when coarser spray qualities are used, or when the delta T value approaches 10 to 12. Use water-sensitive paper and the Snapcard app to assess the impact of coarser spray qualities on coverage at the target.

04 **Always expect** that surface temperature inversions will form later in the day, as sunset approaches, and that they are likely to persist overnight and beyond sunrise on many occasions. If the spray operator cannot determine that an inversion is not present, spraying should NOT occur.

05 **Use weather forecasting** information to plan the application. BoM meteograms and forecasting websites can provide information on likely wind speed and direction for 5 to 7 days in advance of the intended day of spraying. Indications of the likely presence of a hazardous surface inversion include: variation between maximum and minimum daily temperatures are greater than 5°C, delta T values are below 2 and low overnight wind speeds (less than 11km/h).

06 **Only start spraying** after the sun has risen more than 20 degrees above the horizon and the wind speed has been above 4 to 5km/h for more than 20 to 30 minutes, with a clear direction that is away from adjacent sensitive areas.

07 **Higher booms increase drift**. Set the boom height to achieve double overlap of the spray pattern, with a 110-degree nozzle using a 50cm nozzle spacing (this is 50cm above the top of the stubble or crop canopy). Boom height and stability are critical. Use height control systems for wider booms or reduce the spraying speed to maintain boom height. An increase in boom height from 50 to 70cm above the target can increase drift fourfold.

08 **Avoid high spraying speeds**, particularly when ground cover is minimal. Spraying speeds more than 16 to 18km/h with trailing rigs and more than 20 to 22km/h with self-propelled sprayers greatly increase losses due to effects at the nozzle and the aerodynamics of the machine.

09 **Be prepared** to leave unsprayed buffers when the label requires, or when the wind direction is towards sensitive areas. Always refer to the spray drift restraints on the product label.

10 **Continually monitor** the conditions at the site of application. Where wind direction is a concern move operations to another paddock. Always stop spraying if the weather conditions become unfavourable. Always record the date, start and finish times, wind direction and speed, temperature and relative humidity, product(s) and rate(s), nozzle details and spray system pressure for every tank load. Plus any additional record keeping requirements according to the label.

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THE 2017-2020 GRDC SOUTHERN REGIONAL PANEL

JANUARY 2020

CHAIR - JOHN BENNETT

Based at Lawloit, between Nhill and Kaniva in Victoria's West Wimmera, John, his wife Allison and family run a mixed farming operation across diverse soil types. The farming system is 70 to 80 percent cropping, with cereals, oilseeds, legumes and hay grown. John believes in the science-based research, new technologies and opportunities that the GRDC delivers to graingrowers. He wants to see RD&E investments promote resilient and sustainable farming systems that deliver more profit to growers and ultimately make agriculture an exciting career path for young people.

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DEPUTY CHAIR - MIKE MCLAUGHLIN

Mike is a researcher with the University of Adelaide, based at the Waite campus in South Australia. He specialises in soil fertility and crop nutrition, contaminants in fertilisers, wastes, soils and crops. Mike manages the Fertiliser Technology Research Centre at the University of Adelaide and has a wide network of contacts and collaborators nationally and internationally in the fertiliser industry and in soil fertility research.

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PETER KUHLMANN

Peter is a farmer at Mudamuckla near Ceduna on South Australia's Western Eyre Peninsula. He uses liquid fertiliser, no-till and variable rate technology to assist in the challenge of dealing with low rainfall and subsoil constraints. Peter has been a board member of and chaired the Eyre Peninsula Agricultural Research Foundation and the South Australian Grain Industry Trust.

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JON MIDWOOD

Jon has worked in agriculture for the past three decades, both in the UK and in Australia. In 2004 he moved to Geelong, Victoria, and managed Grainsearch, a grower-funded company evaluating European wheat and barley varieties for the high rainfall zone.
In 2007, his consultancy managed the commercial contract trials for Southern Farming Systems (SFS). In 2010 he became Chief Executive of SFS, which has five branches covering southern Victoria and Tasmania. In 2012, Jon became a member of the GRDC's HRZ Regional Cropping Solutions Network.

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FIONA MARSHALL

Fiona has been farming with her husband Craig for 21 years at Mulwala in the Southern Riverina. They are broadacre, dryland grain producers and also operate a sheep enterprise. Fiona has a background in applied science and education and is currently serving as a committee member of Riverine Plains Inc, an independent farming systems group. She is passionate about improving the profile and profitability of Australian grain growers.

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LOUISE FLOHR

Lou is a farmer based at Lameroo in the Southern Mallee of South Australia. Along with her parents and partner, she runs a mixed farming enterprise including export oaten hay, wheat, barley a variety of legumes and a self-replacing Merino flock. After graduating Lou spent 3 years as a sales agronomist where she gained valuable on-farm experience about the retail industry and then returned to her home town of Lameroo. She started her own consultancy business three years ago and is passionate about upskilling women working on farms.

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RICHARD MURDOCH

Richard along with wife Lee-Anne, son Will and staff, grow wheat, canola, lentils and faba beans on some challenging soil types at Warooka on South Australia's Yorke Peninsula. They also operate a self-replacing Murray Grey cattle herd and Merino sheep flock. Sharing knowledge and strategies with the next generation is important to Richard whose passion for agriculture has extended beyond the farm to include involvement in the Agricultural Bureau of SA, Advisory Board of Agriculture SA, Agribusiness Council of Australia SA, the YP Alkaline Soils Group and grain marketing groups.

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MICHAEL CHILVERS

Michael runs a collaborative family farming enterprise at Nile in the Northern Midlands of Tasmania (with property also in northern NSW) having transitioned the business from a dryland grazing enterprise to an intensive mixed farming enterprise. He has a broad range of experience from resource management, strategic planning and risk profiling to human resource management and operational logistics, and has served as a member of the the High Rainfall Zone Regional Cropping Solutions Network for the past seven years.

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KATE WILSON

Kate is a partner in a large grain producing operation in Victoria's Southern Mallee region. Kate and husband Grant are fourth generation farmers producing wheat, canola, lentils, lupins and field peas. Kate has been an agronomic consultant for more than 20 years, servicing clients throughout the Mallee and northern Wimmera. Having witnessed and implemented much change in farming practices over the past two decades, Kate is passionate about RD&E to bring about positive practice change to growers.

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ANDREW RUSSELL

Andrew is a forth generation grain grower and is currently the Managing Director and Shareholder of Lilliput AG and a Director and Shareholder of the affiliated Baker Seed Co - a family owned farming and seed cleaning business. He manages the family farm in the Rutherglen area, a 2,500 ha mixed cropping enterprise and also runs 2000 cross bred ewes. Lilliput AG consists of wheat, canola, lupin, faba bean, triticale and oats and clover for seed, along with hay cropping operations. Andrew has been a member of GRDC's Medium Rainfall Zone Regional Cropping Solutions Network and has a passion for rural communities, sustainable and profitable agriculture and small business resilience.

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DR NICOLE JENSEN

Nicole Jensen is GRDC General Manager for the newly created Genetics and Enabling Technologies business group. Nicole brings a wealth of experience in plant breeding and related activities arising from several roles she has held in Australia and internationally in the seed industry including positions as Supply Innovation Lead with the Climate Corporation - Monsanto's digital agricultural flagship, Global Trait Integration Breeding Lead for Monsanto.

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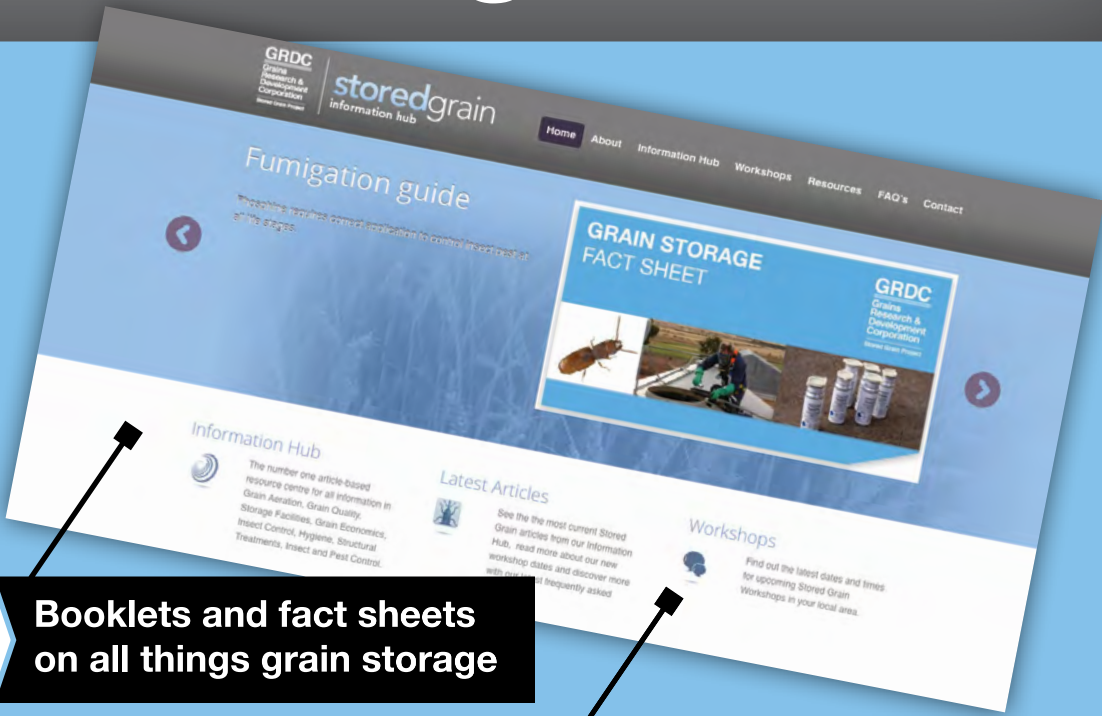

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