COOLAH
NEW SOUTH WALES
THURSDAY 28TH
FEBRUARY 2019

GRAINS RESEARCH UPDATE

DRIVING PROFIT THROUGH RESEARCH

GRDC™
GRAINS RESEARCH & DEVELOPMENT CORPORATION

GRDC Welcome

Welcome to the 2019 GRDC Grains Research Updates

Growers, advisers and industry stakeholders are constantly faced with challenges to farm profitability and productivity, which makes staying informed about the latest research and development outcomes a critical part of being in business.

Keeping growers and advisers informed is the key role of the annual Grains Research and Development Corporation (GRDC) Grains Research Updates, which are premiere events on the northern grains industry calendar and bring together some of Australia's leading grain research scientists and expert consultants.

For more than 25 years the GRDC has been driving grains research capability and capacity with the understanding that the continued viability of the industry hinges on rigorous, innovative research that delivers genuine profit gains. GRDC's purpose is to invest in research, development, and extension (RD&E) to create enduring profitability for Australian grain growers.

Despite the tough seasonal conditions currently being experienced across much of the Queensland and New South Wales grainbelts, the industry remains confident about the future and committed to learning more about innovation and technology and embracing practice change that has the potential to make a tangible difference to on-farm profits.

In response, this year's GRDC Grains Research Updates offer regionally relevant, credible and new science-based information covering priority issues like climate and environmental variability, new technology and market conditions to ensure growers and their advisers have up-to-date knowledge to make informed decisions on-farm.

So, I hope you enjoy the 2019 Updates and that the events provide an invaluable opportunity for learning, knowledge sharing and networking.

Luke Gaynor,

GRDC Senior Manager Extension and Communication

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GRDC Grains Research Update
COOLAH

Thursday 28th February 2019, Coolah Sporting Club

Registration: 8:30am for a 9am start, finish 2.35pm

AGENDA		
Time	Topic	Speaker(s)
9:00AM	**GRDC welcome**	
9:10AM	**International speaker: Green on green camera spraying – in-crop camera spraying –** a game changer on our doorstep?	*Guillaume Jourdain (CEO Bilberry France)*
9:45AM	**Sorghum agronomy** – seed size & vigour, early sowing & heat stress.	*Loretta Serafin (NSW DPI)*
10:15AM	**Morning tea**	
10:45AM	**Drift mitigation –** 2,4-D labels; nozzles; new research; low pressure systems; camera sprayers & nozzle options.	*Bill Gordon*
11:10AM	**Maximising systems benefits from dual purpose crops** – early sowing & grazing strategies.	*John Kirkegaard (CSIRO)*
11:35AM	**The agronomy of dual purpose cropping & fit of new varieties into early sowing windows.**	*Peter Matthews (NSW DPI)*
12:10PM	**Lunch**	
1:10PM	**Nutrition in dual purpose crops.**	*John Kirkegaard (CSIRO) & Jim Laycock (Incitec Pivot)*
1:40PM	**Management & profitability of dual purpose crops in central eastern New South Wales.**	*Ed Blackburn (Cudgegong Rural Supplies)*
2:05PM	**Assessing crop nutritional needs for 2019**	*Discussion session led by Jim Laycock*
2:35PM	**Close**	

Contents

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Green on green camera spraying - a game changer on our doorstep?

Guillaume Jourdain, Bilberry

Key words

green on green, camera spraying, spot spraying, technology

Take home messages

- Green on green camera technologies is now used on farms. This will lead to important financial benefits for growers but will also have impacts on farm management
- Growers need to understand the benefits but also the limitations of these new technologies. This is only way it will bring real benefits.

Overview of vision systems for spraying and identifying weeds

In this paper, we will only focus on systems embedded on sprayers or spraying equipment, and thus we will not talk about drones. Drones are a very interesting technology, however there are current limitations on their convenience of use such as regulation, the need for a pilot, necessity of good weather conditions (no wind or rain), and ground resolution is often not as high as with embedded sensors.

Systems on the market and their limitations

Two optical camera systems to spray weeds have been on the market for several years, WEEDit and WeedSeeker. These systems are now commonly used in Australia for green on brown applications. Previous analysis of these can be found in a GRDC Update paper:

https://grdc.com.au/__data/assets/pdf_file/0015/117231/pa-in-practice-ii-incrop.pdf.pdf

and here is a link to a factsheet from the Australian Society of Precision Agriculture, SPAA:

https://spaa.com.au/pdf/456_9056_SPAA_fact_sheet_(Weed_Sensing)_A4.pdf

Summary of key facts for these sensors

- Active sensors – chlorophyll sensing
- High number of sensors (one per meter for WEEDit and one per nozzle for WeedSeeker)
- Significant reduction in chemical usage
- High cost ($4000 / meter)
- Day and night usage
- Limited speed (15 km/h for WeedSeeker and 20 km/h for WEEDit)
- Boom stability is important, so wheels are usually added on the booms
- Calibration is needed on the WeedSeeker, while the WEEDit has an autocalibration mode
- Both technologies cannot work on green on green applications.

Systems under development

Many companies, both start-ups, large corporations and universities are now developing systems with green on green capability. The technology used is similar: artificial intelligence with cameras (sometimes RGB/colour cameras, sometimes hyperspectral cameras).

Examples of companies working on green on green technologies:

- Bilberry, a French AI based start-up that specialises in cameras for recognising weeds (more below)
- Blue River Technology, acquired by John Deere in September 2017 for more than $300M, developing a See and Spray technology - a spraying tool with smart cameras, trailed by a tractor, that can spray weeds very accurately at about 10 km/h
- Ecorobotix, a Swiss based start-up developing an autonomous solar robot that kills weeds. They are also developing the camera technology
- AgroIntelli, a Danish company developing an autonomous robot to replace tractors, that will also include spraying capacity. They are also developing the camera technology
- Bosch, the German company, that is more and more involved in agriculture has launched a project call Bonirob a couple of years ago, a robot that includes smart cameras to kill weeds in a more efficient way

Figure 1. From top left to bottom right: Agrointelli robot, Blue River Technology tool, Bosch robot and Ecorobotix robot.

Artificial intelligence to detect weeds

Past research

Recognising weeds within crops is a topic that has been interesting companies and researchers for a very long time. First patents on this topic are from the 1990s. The main approach was to differentiate weeds from crops thanks to their colour and shape. Through mathematical formulas, a range of colours and a range of shapes for each weed (we can call these algorithms conventional algorithms) would be created.

To give a very simplistic example, one could define, through experimentation, that radish colour would be within a specific green range, as shown on the graph below.

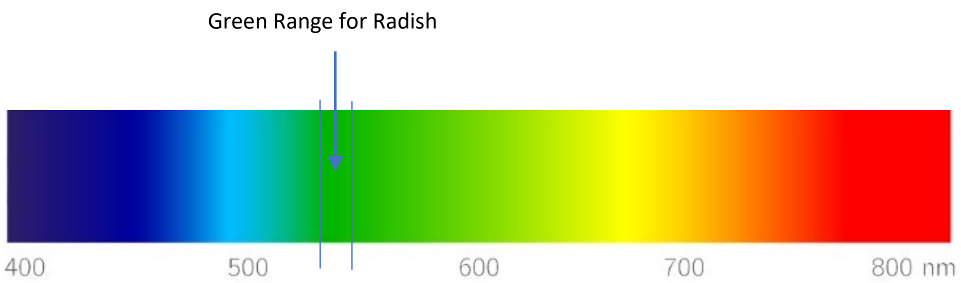

Figure 2. Simplistic example of conventional algorithms mechanism

This way of working gave good results in the lab, because they have excellent conditions, that can be replicated easily: the light is constant and homogeneous, there is no wind, all crops and weeds are from the same variety and are not stressed etc. Since all these conditions are very controlled, it is often true that you can differentiate two types of weeds / crops thanks to colour and shape.

However, paddock conditions are completely different. Indeed, the sun can be high or low, in your back or in your eyes, there can be clouds, there can be shadows from the tractor/sprayer cabin or from the spraying boom, crops can be wet in the morning (which would create sun reflection), soils always have different colours …

It became clear that conventional algorithms could not work in field conditions.

Artificial intelligence as a game changer

Artificial intelligence and especially deep learning is another way of working on images to recognise different objects. It is now the most widely used technology for computer vision when it comes to complex images (recognising weeds within crops, or on bare soil, is definitely a complex image). Complex images could be defined as images that show high variability between the same category of object (an object being a cat, a dog, a human, or a weed).

Deep learning is part of the family of machine learning and is inspired by the way the human brain works (deep learning often uses deep neural networks architecture). The learning part can be either supervised or unsupervised. We will discuss supervised learning and how to apply it to weed recognition more in depth below.

Below is an example of different kind of deep learning architectures applied to computer vision.

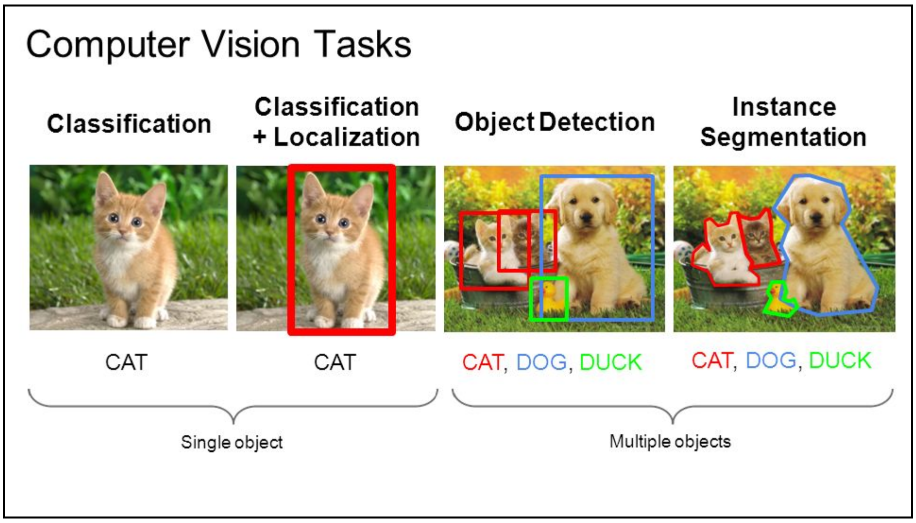

Figure 3. Different deep learning architectures

Deep learning is now possible on embedded systems

Research on deep learning also started in the 90s, however it only became widely used in the 2010s. There are 3 key components needed to develop deep learning applications, and these 3 key components have only been available for very few years. These are:

1. Plenty of data
2. High computing power
3. Powerful algorithms

Data generation has grown at an incredible speed since the early 2000s and the fast development of internet. We now have access to data about almost everything, in very large quantity.

Computing power is needed twice for deep learning: firstly during algorithm training and secondly during the "inference", which is the moment the algorithm is being used. Deep learning is run on GPUs (Graphics Processing Unit), and these GPUs became really powerful with the development of autonomous vehicles.

Since more powerful processing units were available, more powerful algorithms were also developed by engineers.

The 3 conditions above are now met and so deep learning is therefore applicable to many situations and is especially relevant for farming.

Supervised process for deep learning

Here is the classical process to develop a deep learning algorithm with the supervised method:

- Define algorithm usage and objectives
  - Example with weed recognition (WR): Recognize flowering radish in wheat with > 90% accuracy
- Gather data
  - WR: Take pictures in the fields of flowering wild radish in wheat
- Sort and label data
  - WR: On each picture, indicate what is wheat, what is wild radish etc.
  - WR: Also separate all images into 2 sets, training set and testing set. Training set is only used for training, and testing set is only used for testing (images cannot be on both sets)
- Train algorithm
  - WR: Show the training set (thousands of times) to the algorithm so that it can learn patterns
- Test algorithm
  - WR: Show the test set (one time) to the algorithm to compare the results of the algorithm with the reality
  - WR: Once happy with the results of the algorithms, go into the paddock to test (paddock testing is the most crucial part of the process)
    - Note: It NEVER works first time …
- Repeat until you reach your objectives

Two of the most important steps are data gathering and paddock testing (these 2 steps happen in the field). What is especially complex and important about data gathering is to be able to capture the diversity of situations. Below is an example of different situations, where the aim is to spray any live weed on bare soil.

Figure 4. Different situations for summer spraying in Australia (sandy soils, high stubble, no stubble)

Research and results at Bilberry

Bilberry presentation

Bilberry was founded in January 2016 by three French engineers, with the idea to use artificial intelligence to help solve problems in agriculture. The main product of Bilberry is now embedded cameras on sprayers. They scan the paddocks to recognise the weeds and then control the spraying in real time to spray only on weeds and not the whole paddock. Bilberry also develops cameras that recognize weeds on rail tracks. The technology is similar, with just a higher speed (60 km/h) and day and night applications.

The biggest focus to develop this product is now Australia, with several sprayers already equipped with Bilberry cameras. One of the reasons of this focus is the huge interest among Australian growers and agronomists towards green on green spot spraying.

On the booms of the sprayer, there is one camera every 3 meters and then computing modules (to process the data) and switches (to distribute power and data to each camera). In the cabin, there is one screen to control the system.

Figure 5. Bilberry cameras on an Agrifac 48 metre self-propelled sprayer

Results achieved until now

Three algorithms are now validated and usable directly by growers in the field (two are more focused on Australian growers):

- Weeds on bare soil detection (using AI, but same application as WEEDit or WeedSeeker)
- Rumex (dock weed) in grasslands
- Wild radish in wheat (especially when they are flowering) (link to a video for wild radish spraying, watch in HQ to see the sprays better: https://drive.google.com/file/d/1vUfCC7hN77VI2Jp2S6XDEFr8CJ_pU7LL/view

It is important to note that large chemical savings are made with the cameras, however it is also a very interesting tool to fight resistant weeds, potentially enabling the use of products that cannot be currently used in crop due to either cost or crop impact.

Below are some pictures taken by our cameras and what is seen by the algorithm.

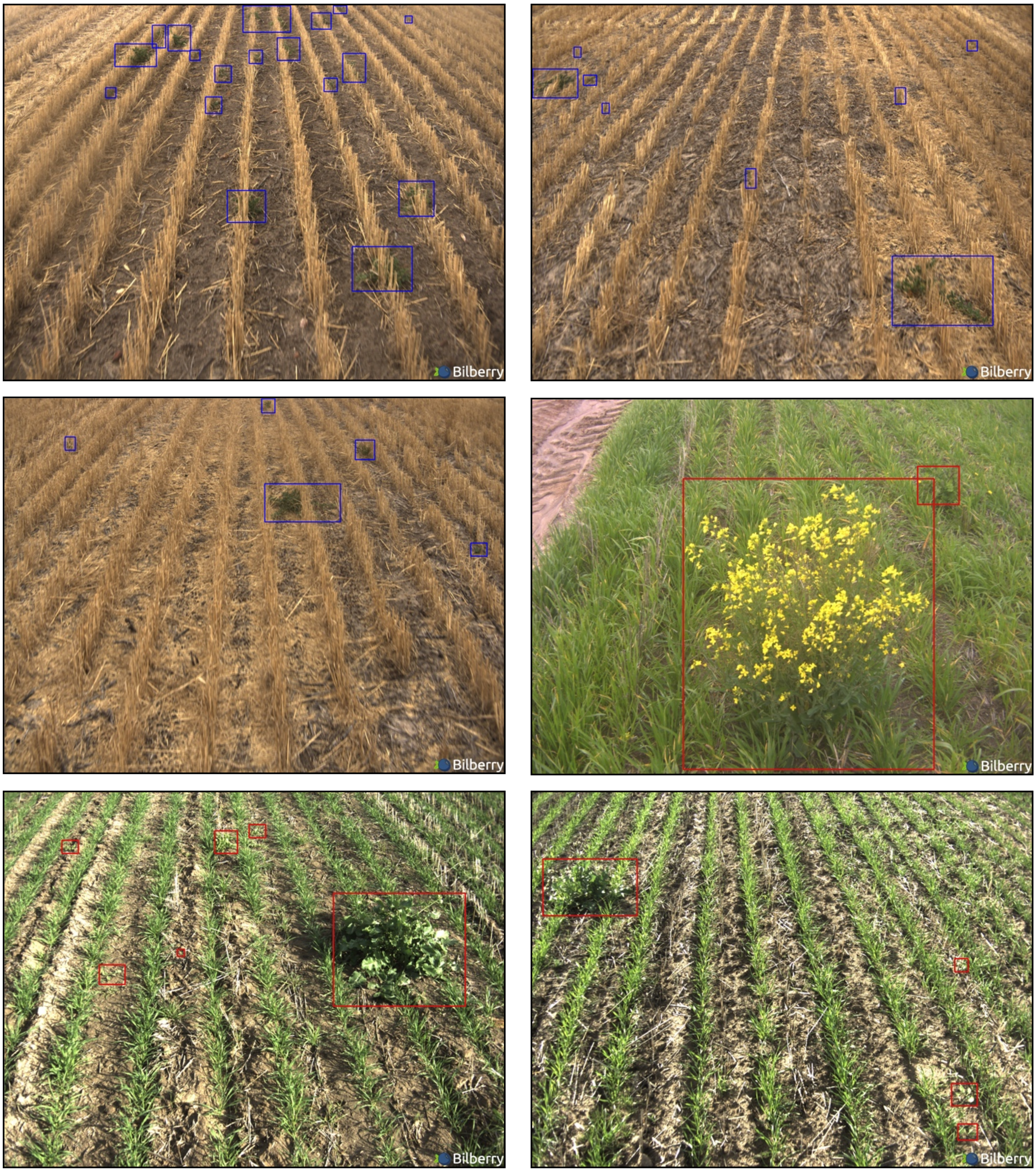

Figure 6. Weed detection on bare soil (3 first pictures) and wild radish detection in wheat (3 last pictures) - Images taken from Bilberry cameras - results in real time

Main usage conditions of the Bilberry camera

The cameras are used at up to 25 km/h speed and can be used on wide booms (widest boom used is 49 metres, but could be more if needed). This means there is a very high capacity with the sprayer equipped with cameras.

Theoretical camera capacity = 25 km/h * 48 meters = 120 ha/hour

In real spraying conditions, capacity is of course lower, since the speed is not always 25 km/h and the sprayers need to be refilled.

Summer spraying in Australia (New South Wales example)

One Agrifac 48 metre boom is equipped with cameras in a farm in New South Wales. Before the cameras were used by the grower and his team, a comparative test was made with current camera sprayer technology. It was then decided to use Bilberry cameras as much as possible on the farm.

Figure 7. Test field after spraying with dye

Thus, the cameras have been used since the beginning of the 2018-2019 summer spraying season, directly by the grower and his team. Over a 3 weeks period, here are the most important figures:

Table 1. Figures from the 2018-2019 summer spraying season

Total area sprayed	Ha / day	Ha / hour	Chemical savings
6199 ha	413 ha	75 ha	93.5%

The carrier volume used was generally set at 150 litres / ha.

It is very important to note that the chemical savings are directly linked to the extent of weed infestation in the paddocks. A paddock with high weed infestation will get little savings whereas a paddock with low weed infestation will get high savings.

Spraying dock weeds in grasslands (Netherlands)

In the Netherlands, a 36 meters Agrifac boom is equipped with Bilberry cameras and uses an algorithm to spray dock weeds on grasslands. The same testing process as described earlier was used to ensure the algorithm was working properly.

Once the grower validated that the algorithm was working, it was used during the whole spraying season. About 500 ha were sprayed during the season, and the average chemical savings were above 90 %. The cost of the chemical is about 50€/ha for this specific application, which means 45€ chemical savings / ha with the cameras.

Here is a link to see the machine spraying dock weed (to see the sprays happening, play the video in high quality): https://drive.google.com/file/d/1EF1qqIRjzj0pVCYf67cSBlHvh47xDHKz/view

Future machine capabilities

Obviously, the biggest focus is to develop new weeding applications (which means new algorithms) to be able to use the cameras more often.

Other important development focuses we have right now include:

- Working at night (already working on rail tracks, but not on sprayers)
- Working at 30 km/h
- Delivering a weed map after a spray run (already working on rail tracks, but not on sprayers), to compare with the application map
- New weed applications

In the future, we believe that every time the sprayer goes in the field, the cameras should be able to bring value to the grower. Sometimes it would mean direct application (for instance for weed spraying) and other times it would mean building maps (maps to give growth stage throughout the paddock or disease status or anything that could help growers and agronomists do their job).

We will also look into algorithms for modulating nitrogen and fungicide applications.

In a completely opposite direction, spraying with cameras will generate a lot of data. The data will be very precise (because the data is saved with the GPS coordinates) and will give agronomists and farmers new tools to improve their overall farm management strategy.

Concrete implications for growers

Cameras that detect green on green bring multiple new possibilities for growers. The most important and immediate consequences are new possibilities to fight resistant weeds and impressive chemical savings and reduced herbicide environmental load. The potential to reduce the area of crop sprayed with in-crop selective herbicides, may also assist by reducing stress on stress interactions that are sometimes associated with in-crop herbicide use.

It is also very important to note that, as for any new technologies, it will only work well if growers get to know the technology, how it works, its limitations and possibilities. The first and most important thing for growers will be to be very attentive to the results of each spraying: first, are all weeds killed, and second, how much did I save? The cameras might work perfectly on 90% of their paddocks, and for some reason not perform as well on 10%. This can definitely be corrected within the algorithms (see above how to train an algorithm), but to correct an algorithm the designer of the cameras must be made aware there is an issue.

Acknowledgements

Presenting this green on green technology has been possible thanks to the interest and passion of the GRDC Update coordinators and the support of the GRDC to bring me to Australia to present at the Updates. I would also like to express my thanks to the first growers that believed in Bilberry in Australia.

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Sorghum agronomy: Seed size and sowing depth, early sowing and heat stress

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[2] Department of Agriculture and Fisheries, Toowoomba

Key words

grain sorghum, early sowing, heat stress, seed size

GRDC code

DAN00195 Tactical Sorghum and Maize Agronomy for the Northern Region – NSW Component
UQ00075 Tactical Sorghum and Maize Agronomy for the Northern Region – Qld component
UOQ1808-001RTX Optimising sorghum agronomy

Take home messages

- There is an opportunity to sow sorghum earlier than currently recommended but the risks and benefits of this practice need further investigation
- Early sowing could lead to yield benefits by avoiding the overlap of flowering and peak heat periods but also a possible increase in the cropping intensity through double cropping
- Early sowing had a major impact on plant establishment in the season of these experiments, with less than half the targeted plant population being achieved from the super early sowing at the start of August
- Using seed of good quality, with both high germination and vigour are important especially when planting into sub optimal soil temperature conditions
- Deep (7 cm) planting reduced total emergence at all temperatures by 9% compared to planting at 3 cm
- Planting smaller seed (<2.5 mm) reduced establishment by 7% compared to sowing large (>2.5 mm) seed
- Variations in hybrid cold tolerance could not be definitively detected in this season’s research.

Introduction

Grain sorghum is the most important summer cereal crop in northern NSW, providing important rotational, logistical and cash flow benefits for growers in the region.

Many in the industry would agree that climatic variability in the past 10 years has seen an increasing trend of reduced crop yields, and sometimes failure, as a result of sorghum crops flowering and filling grain in periods of extreme heat and moisture stress.

GRDC, NSW DPI and the University of Queensland have partnered in research since 2014 to evaluate options for sorghum agronomic management that challenge our current practices. This includes challenging our accepted views on ideal sowing time and hybrid selection by comparing alternative practices. Such practices could be readily adopted by growers using current genetics and technology.

Research in recent seasons (2017-19) has focused on the possibility of sowing sorghum earlier than traditionally accepted to evaluate the impacts of cold soil temperatures and early spring conditions on plant establishment, growth and yield. Results from 2018-19 are not available at the time of publication (January 2019) as research trials have not yet been harvested.

A number of factors that can impact on final plant establishment were included in the research. These included seed quality (germination and vigour), seeding depth, seed size and seedbed moisture.

2017- 18 Seasonal overview

Three experimental sites were sown in northern NSW in 2017-18; Gurley (south east of Moree), Mallawa (west of Moree) and Breeza on the Liverpool Plains. At each of these sites, three treatments were included:

1. ***Time of sowing***; seeds were sown based on soil temperature measured at 8 am eastern standard time (EST). Seeds were sown at 8 am EST; super early (~ 10°C), early (14°C) and a standard (16-18°C) in an attempt to move the flowering and grain fill window forward.
2. ***Varying sowing depth***; standard (3-4 cm) and deep (7-8 cm) seeding depth to chase warmer soil temperatures.
3. ***Comparing cold tolerance of hybrids;*** 9 commercial hybrids: MR Buster, MR Apollo, Cracka, Tiger, HGS114, HGS102, Archer, Agitator, G33 were compared.

The 2017-18 season produced three distinct environments (Table 1):

1. Breeza experienced cool late winter -spring temperatures (21 days with temperatures <0°C for the early August sowing) and warm summer temperatures (35 days with temperatures >36°C).
2. Gurley experienced mild and wet late spring conditions (109 mm in Oct), as well as warmer flowering and grain fill conditions compared to Breeza.
3. Mallawa experienced cool conditions for August (12 days with temperatures <0°C) and then extreme heat (60 days with temperatures >36°C), followed by dry summer conditions for December – January.

Table 1. Summary of weather conditions for sorghum trials sown during the 2017-18 season. Soil temperature is at 8 AM EST across seven days after sowing.

Site	Time of sowing	Sowing date	Sowing depth	Average Soil T (°C) at sowing	Mean max T (°C)	Mean min. T (°C)	In-crop rainfall (mm)	*No.* days ≤ 0 °C	*No.* days ≥ 36 °C
Gurley (NE NSW)	Super early	2nd Aug	Shallow	10.8	29.8	13.7	315	2	39
			Deep	11.4					
	Early	21st Aug	Shallow	12.0	30.5	14.5	293	2	39
			Deep	12.2					
	Standard	17th Oct	Shallow	20.0	33.0	17.5	206	0	39
			Deep	19.1					
Mallawa (NW NSW)	Super early	1st Aug	Shallow	8.4	31.5	13.2	222	12	60
			Deep	10.5					
	Early	24th Aug	Shallow	9.2	32.7	14.6	222	6	60
			Deep	10.8					
	Standard	18th Oct	Shallow	18.6	35.2	17.9	149.5	0	57
			Deep	15.6					
Breeza (LP)	Super early	10th Aug	Shallow	9.7	29.3	11.6	225	21	35
			Deep	10.2					
	Early	28th Aug	Shallow	10.8	30.2	12.8	225	12	35
			Deep	11.5					
	Standard	21st Sept	Shallow	15.8	31.4	14.7	220	0	35
			Deep	15.7					

Statistical methods

A split-split plot design was used at all sites. Data was analysed using the REML procedure in ASReml-R and the level of significance for least significant difference (LSD) testing was set at 5%.

Results

Investigating factors affecting establishment

What impact does early sowing have on plant establishment in the field?

Sowing super early with very cold soil temperatures (8.4 – 10.8°C) at the NSW sites of Gurley, Mallawa and Breeza demonstrated that plant establishment can be less than half of the sown population target of 5 plants/m^2 (**Error! Reference source not found.**).

The resulting plant stands can also be slow to emerge. For example, there were no plants present until 3 weeks post sowing at Breeza for the super early and early sowing times. Plants were still emerging up to 6 weeks post sowing, however, were patchy and prone to weed infestation. In these experiments, weeds were controlled using mechanical means to remove this possible influence on yield. This would not be considered feasible by many growers.

The early sowing time also established significantly fewer plants than the standard sowing time (Table 2) when soil temperatures were still sub optimal (9.2 – 12.0°C). The standard sowing time achieved acceptable crop establishment levels.

There was no difference in the establishment of hybrids. At the Mallawa site, Agitator had significantly lower establishment as a result of poor seed quality (data not shown).

Table 2. Established plant populations (plants/m^2) at sorghum trials sites - averaged across treatments

Site	Established population (plants/m^2)			LSD value
	Super early (early August)	Early (late August)	Standard (Mid Oct[1], late Sept[2])	
Mallawa[1]	1.9	2.5	4.1	0.9
Gurley[1]	1.6	2.8	4.4	0.6
Breeza[2]	3.2	3.3	5.0	0.5

What impact does soil temperature have on emergence in a controlled environment?

Soil temperature is influenced by solar radiation, daily fluctuations of air temperature, monthly fluctuations of air temperature, ground cover and rainfall. Typically, there are larger fluctuations in soil temperature in the seed bed zone (0-10 cm) during the change of seasons (e.g. late August through to late September) when there are both frosts as well as warm days.

In the field, seeds are exposed to these conditions which means periods of "suitable" and "unsuitable" soil temperature for germination within a 24 hour period in some cases. As such, super early sowing of sorghum (August) produced a stop/ start growth pattern, resulting in slow and delayed emergence. To further investigate factors which are driving this result, a controlled environment experiment was also established.

Seed of the 9 hybrids used in the field trials were separated using a 2.5 mm sieve to achieve two different seed lots; small (<2.5 mm) and large (>2.5 mm). This seed was used to establish an experiment where seeds were sown at 2 different depths, 3 and 7 cm in small pots.

The pots were then kept in controlled temperatures of 10, 14 and 18-20°C, the latter seen as 'ideal', and emergence dates for each seed were recorded. When no more plants emerged, the remaining seeds were dug up to investigate if they had germinated or not.

In the pot trial where seeds were maintained at 10°C, very little sorghum seed emerged (3.3%). In contrast, 65% and 79% of sorghum seeds emerged where seeds were maintained at 14°C and 18-20°C respectively (Table 3). Seedling emergence at 14°C and 18-20°C (Table 3) was similar to seedling emergence in field trials, where between 2/3 – 3/4 of seedlings emerged.

At each temperature, a percentage of seedlings germinated but never reached the surface (Table 3). These results indicate that seed vigour as well as germination is important, and this becomes more important as you plant in less ideal conditions. At 10°C, over half (57.3%) of the seeds germinated, however, the temperature was too low to allow sufficient growth to reach the soil surface. Of those seeds that germinated, twice as many failed to reach the surface at 14° C (15.1%) compared to where seeds were maintained at our ideal sowing temperature (7.5%).

Table 3. Sorghum germination and emergence at constant temperatures (averaged across 9 hybrids and 2 sowing depths)

Soil temperature	**10°C**	**14°C**	**18-20°C (ideal)**
Emerged (%)	3.3[a]	64.4[b]	78.8[c]
Germinated, not emerged (%)	57.3	15.1	7.5

Does seed size and sowing depth have an impact on emergence?

Choosing to sow sorghum into earlier than ideal soil temperatures and conditions means we need to consider what other factors could influence the final establishment.

Information about seed germination, sowing depth and seed size can be used to improve establishment. Seed germination is provided by seed companies as a guaranteed minimum and can easily be tested in a petri dish.

The impact of seeding depth on establishment was compared both in the field and in the controlled environment experiment. Seed was sown either shallow at 3-5 cm (3 cm in the pot trial and between 3 and 5 cm in the field to ensure sowing into moisture) or deep at 7 cm. For shallow seed application, seed was sown at 3 cm in the pot trial and between 3 and 5 cm in the field, in order to ensure sowing into moisture.

The results showed that both seeding depth and seed size had an effect on emergence. Deep (7 cm) planting reduced total emergence at all temperatures by approximately 9%, and this reduction was the same at every temperature (Figure 1a).

Seed size followed a similar pattern; the penalty for planting small (<2.5 mm) seed rather than large (>2.5 mm) seed was 7% (Figure 1b).

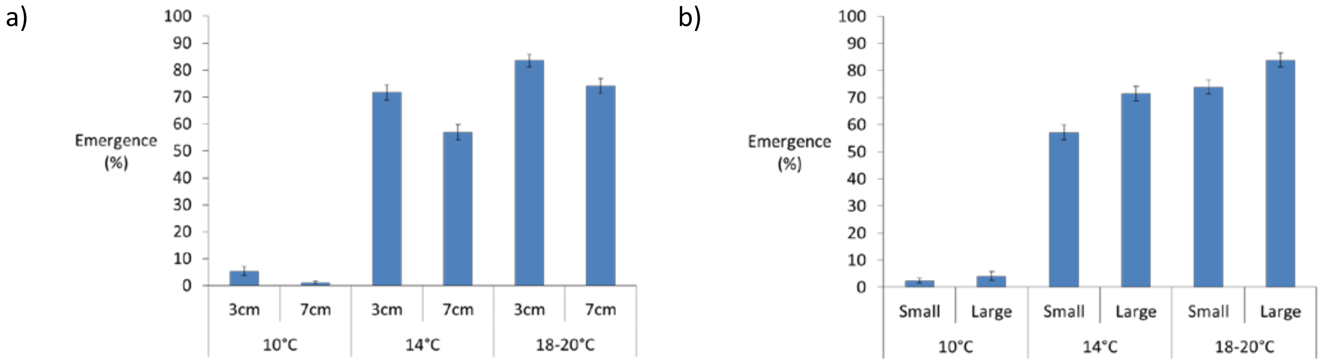

Figure 1. Impact of sowing depth and temperature on emergence (a) and Impact of seed size and temperature on emergence (b)

Can we move the flowering window earlier to avoid heat stress?

Super early sowing generally means that a higher number of days are needed to reach flowering, as growing conditions are cooler. Therefore, sowing earlier does not always mean the crop will flower earlier.

At Breeza, there was very little impact of sowing time on days to 50% flowering, with all three times of sowing flowering around the same time (early to mid-December). This is likely due to emergence being slow and over an extended period at this site, for the super early and early sowing times.

In contrast, at the Mallawa and Gurley sites, there was a large reduction in the time taken to reach 50% flowering. At the Mallawa site, the super early sowing times took 120-136 days to reach 50% flowering and the early sowing times took 105 -116 days (Figure 2).

Similarly, at Gurley, the days to 50% flowering were reduced between each of the sowing times (116 – 132 days for super early planting dates, 101-116 days for early planting dates and 66-69 days for standard planting dates), as was the spread between hybrids. At Gurley and Mallawa, this equates to flowering in late November – mid December for the super early planting times and mid-December for the early sowing time. The standard sowing time flowered between Christmas and New Year.

The spread of flowering times between hybrids also reduced with the later sowing dates, from 16 to 11 days. There was a significant hybrid effect on flowering, with MR Buster and Agitator flowering much earlier than the other hybrids. MR Apollo was the slowest to reach flowering.

Sowing depth had no significant impact on flowering date at either the Mallawa or Gurley sites. At Breeza, the shallow sowing depth was quicker to reach 50% flowering than the deep sowing (data not shown).

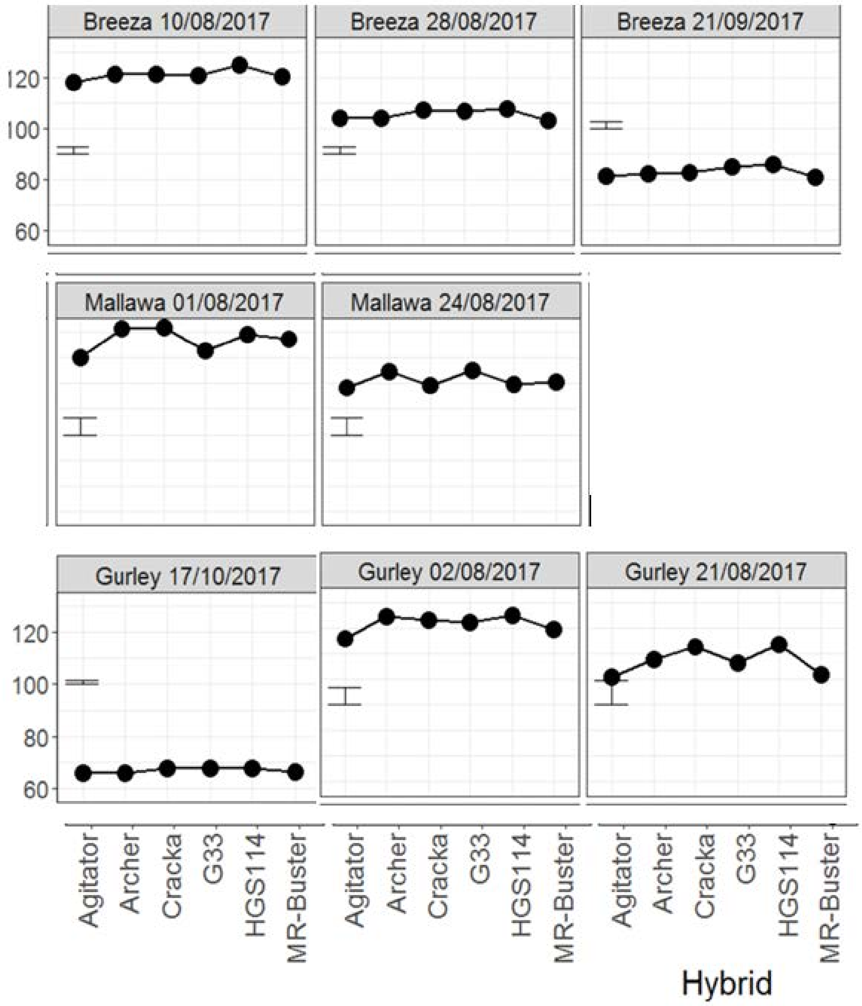

Figure 2. Days to 50% flowering of 9 sorghum hybrids in 2017/18

What was the impact of varying sowing time, seed depth and hybrid selection on final grain yield?

Grain yields (at 0% moisture content) ranged from a low of 1.3 t/ha on average at Mallawa, to 3.2 t/ha and 3.4 t/ha at Gurley and Breeza respectively, averaged across treatments.

At Mallawa, the super early (early August) and early (late August) sowing times produced higher yields than the standard sowing time, despite having highly reduced plant establishment. At Gurley, the standard October sowing performed better than the super early (early August) and early (late August) treatments.

At Breeza, yields were generally higher from the super early (early August) and early (late August) sowing times compared to when plants were sown in September, even though established plant populations were only two thirds of the plant stands achieved with the standard sowing time in September.

Even though established populations were reduced and early growth was delayed, the final grain yields which resulted (from the early sowing times) were better than waiting for the standard sowing time to occur, in two out of three situations during this season (Figure 3). A large proportion of these results is attributed to the fact that sorghums plasticity in growth means additional tillers compensate for lower plant stands. There was a significant interaction between hybrid and environment.

Nine hybrids were included in the experiments with the expectation that there may be some difference in genotype cold tolerance. However this was not seen, in this season. Hybrid responses to sowing time were variable across sites (Figure 2). It must be noted that all hybrid seed was produced from different locations and had different production histories, so there are complicating issues such as seed germination and vigour.

At Mallawa, there was no difference in grain yield associated with varying sowing depth (data not shown). At Breeza, there was a significant sowing time by seeding depth interaction effect. The early sowing time had a significantly higher yield than the standard sowing time, for the shallow but not the deep seeding depth.

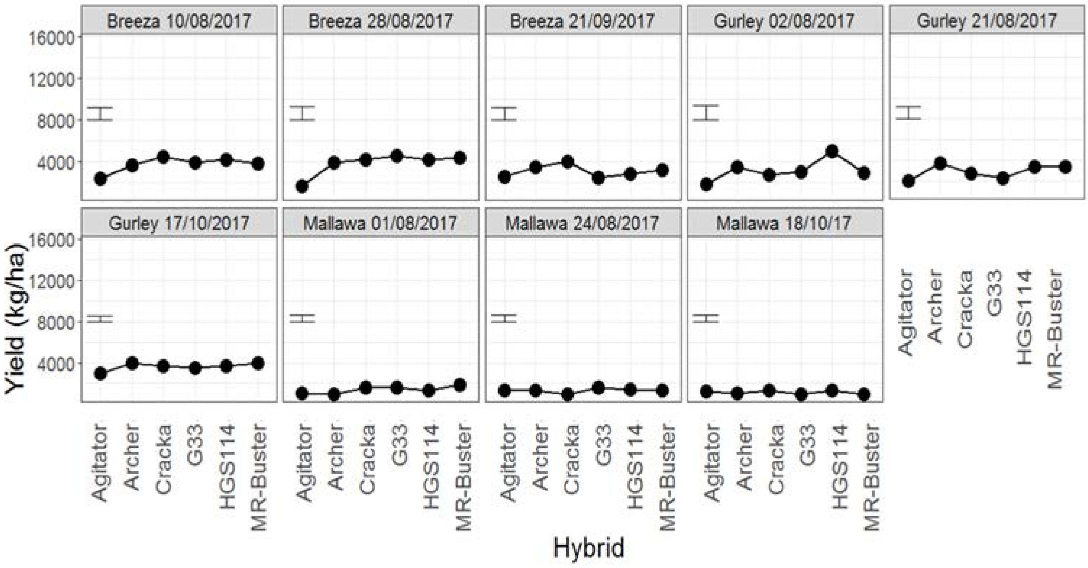

Figure 3. Grain yield (0% moisture) resulting from the interaction of sowing time, trial location and hybrid

Conclusions

Growers currently have access to a range of tools to vary the time of flowering, and therefore the conditions experienced, by their sorghum crops during grain fill. Some of these tools are, however, accompanied by an increased level of risk of poor plant establishment.

Sowing in early and late August at all three sites showed that sorghum can be established at sub optimum soil temperatures and handle some cold (<0°C) conditions. However, this early sowing time came at a significant establishment cost. Further, evaluation of the impacts of cold soil temperatures, particularly in the range of 12- 14°C, as well as the effects of severe frosting on plant growth and survival are needed.

At Mallawa and Gurley, establishment was less than half that which occurred in the standard sowing time. Therefore, a lot of seed never contributed to grain yields but an input cost had been incurred. The impact of drying seedbed soil conditions at these two sites needs to also be considered.

In contrast, at Breeza, where soil moisture was controlled through irrigation, establishment losses from the super early and early (late August) sowing were still significant. However, establishment losses were not as great as the other two sites, when compared to the standard sowing time.

At all three sites, viable plant stands were established. At Mallawa and Breeza, the two early sowing times resulted in superior yields compared to the standard sowing time. At Gurley, the opposite was observed, most likely due to the timing of in-crop rainfall.

Flowering data has shown that it is possible to move the flowering and grain fill window to earlier in the season, provided that the time taken for crop establishment is not excessively prolonged by cool early growing conditions, as occurred at Breeza. At Breeza, there was little difference in days to flowering between all three sowing times even though sowing time varied from 10th August to 21st September.

With respect to cold tolerance, it was not possible to detect many differences between hybrids in this year's field trials due to confounding background effects including seed production and quality attributes.

In 2017-18, across the three field sites, benefits from varying sowing depth in order to seek warmer soils for early sowing conditions were minor. While differences in soil temperatures between the two depths either shallow or deep were detected, this did not equate to improvements in plant establishment or grain yield at two of the three field sites.

Seed size and sowing depth did have an impact on sorghum emergence. Small seed had 7% lower emergence than large seed. Sowing seed deep also reduced emergence by 9%. These are relatively small differences, however, these differences could still warrant consideration since many small factors can add up.

Early sowing could also lead to yield benefits by avoiding overlap of flowering and peak heat periods, but also a possible increase in the cropping intensity through providing additional opportunities for double cropping.

Current commercial sorghum hybrids are providing reliable performance across a wide range of environments, however, improved targeting of specific traits (e.g. quicker maturity for the western environment, uniculms or cold tolerance) offer the potential for step change transformation in crop performance.

These results should be considered as preliminary as they are the results of three experimental sites in one season. This research is being continued for coming seasons to allow further validation of these preliminary findings.

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 and NSW DPI, the author would like to thank them for their continued support.

In particular thanks to our trial co-operators; Mark & Wendy Manchee, Gurley; Jason & Geoff Hunt, Mallawa, Geoff Manchee and JR McDonald Bogamildi, and Scott Goodworth NSW DPI Breeza for their assistance with the sites.

Thanks to Delphi Ramsden, Alice Bowler and Simon Tydd for technical assistance and to Tendo Mugerwa and Guy McMullen for editing the paper

Thanks to the seed companies: Pacific, Pioneer, Nuseed, Elders, Heritage and Radicle for supplying seed

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Drift mitigation, efficacy and 2,4-D

Bill Gordon

Key words

pesticide application technology, drift management, adjuvants, nozzle selection, 2,4-D

Take home messages

- All spray applications must comply with the directions on the product label or APVMA approved permit. Applicators need to be aware of the changes to how 2,4-D must be applied
- Applicators need to carefully select appropriate nozzles to meet the new spray quality requirements for products containing 2,4-D (on updated labels or according to APVMA approved permits)
- When using a very coarse spray quality or larger, an increase the application volume may be required to ensure the target weeds receive appropriate spray coverage
- Be aware that nozzle selection has a greater impact on drift reduction than an adjuvant will
- APVMA approved permits exist that allow for the application of certain products containing 2,4-D through OSST (Optical Spot Spraying Technology, such as WeedIT® and WeedSeeker®) provided the weed cover does not exceed 10 percent and other permit requirements are met.

Label changes to products containing 2,4-D – a summary of recent changes

On October 3, 2018 the APVMA suspended all labels of products containing 2,4-D and replaced them with a permit (PER87174) outlining new instructions for how the products must be used. Many manufacturers have already updated their labels to reflect the new instructions.

In summary, the new 2,4-D labels, or existing permits (PER87174, PER87451 (aerial application), PER87338 (larger booms) and PER87570 (OSST)) provide updated instructions, such as;

- A mandatory requirement to apply products containing 2,4-D with a Very Coarse (VC) spray quality. During summer from October 1st to April 15th there is an advisory statement to use an Extremely-Coarse (XC) or Ultra-Coarse (UC) spray quality in cereals, fallow and pasture. Clearer definitions for recognising inversion conditions are included on the label or APVMA approved permit
- Mandatory no spray zones (downwind buffers) to aquatic areas and terrestrial vegetation (typically less than 50 metres for ground application) have been included
- Specific instructions and larger no spray zones included for aerial applications
- Additional record keeping requirements, including boom height.

Nozzles required to achieve very coarse, extremely coarse or ultra-coarse spray qualities

The GRDC nozzle selection guides have been updated to include a wider selection of nozzles that can produce very coarse, extremely coarse and ultra-coarse spray qualities.

For most operators, there will be very few low-pressure air induction nozzles that will be able to produce a very coarse spray quality or larger at reasonable pressures, unless they consider a 04 orifice size or larger, which may require a significant increase in application volume. To maintain reasonable pressures and application volumes, most operators will need to consider high pressure air induction nozzles, which have a minimum operating pressure around 3 bar, and ideally should be run at 5 to 6 bar pressure.

For growers operating Pulse Width Modulation (PWM) systems there has also been a new GRDC nozzle selection guide for PWM. This has been produced to assist owners of this technology with nozzle selection to meet new label requirements. There are several nozzle choices for PWM systems to achieve a very coarse spray quality or larger.

Determining suitable application volumes

The move to larger droplets may have implications on efficacy if spray coverage is not maintained. When using a very coarse spray quality or larger, the minimum application volume for fully translocated products, such as 2,4-D should be 70 L/ha in low stubble environments. In heavier stubble, this should be increased to at least 80 L/ha.

Where hard to wet weeds such as flax leaf fleabane exists, trial work conducted by Northern Grower Alliance (NGA) (funded by GRDC) have shown that when using 2,4-D, efficacy was maintained, even when using ultra coarse spray quality.

When moving to a coarser spray quality it may be useful to assess spray coverage using water sensitive paper (WSP) to determine if the application volume you are considering is appropriate for the stubble load present. Useful instructions for using WSP can be found in the GRDC GrowNote on Spray Application for Grain Growers.

Tank mix and adjuvant effects on drift potential – GRDC funded research

Tank mix and adjuvant selection can impact on droplet size and drift potential, but their effect on the droplet spectrum is not as great as that of the nozzle type itself.

Recent droplet size analysis funded by GRDC was conducted by the Centre for Pesticide Application and Safety (CPAS) at their wind tunnel facility at University of Queensland, Gatton. This work measured the impact of a range of common summer fallow tank mixes, with and without the addition of common adjuvants, on the spray quality and the driftable fraction produced through three different nozzle types.

Treatments used in this study consisted of 9 different herbicides, applied alone and in two or three way tank mix combinations, with or without the addition of 8 different adjuvants.

Each treatment was evaluated for the impact on the droplet sizes produced by three different nozzle types (TeeJet® TT, TeeJet AIXR and TeeJet TTI) operated at 4 bar pressure. Tables 1 and 2 summarise a selection of the data generated from this study. A more comprehensive analysis will be included in a fact sheet to be released in coming months.

Table 1. Comparison of driftable fines (<150 microns) for all tank mixes by nozzle type

	% of volume < 150 microns for all treatments		
Nozzle type	***Average***	***Range***	***Relative to AIXR 110-02***
TeeJet TT 110-02	26.65%	16.37% – 37.94%	329 % (3.29 times as much as AIXR)
TeeJet AIXR 110-02	8.11%	5.19% - 13.21%	100%
TeeJet TTI 110-02	1.40%	0.78% – 2.28%	17% (more than 80% less than AIXR)

When comparing the nozzle tested there was a difference of between 2.31 times and 2.92 times as much of the volume existing as droplets less than 150 microns between the best tank mix and adjuvant combination and the worst tank mix and adjuvant combination. However, the values obtained for each nozzle type did not overlap, meaning the nozzle type had a greater influence on the reduction of driftable droplets than the adjuvant or tank mix did. As the initial spray quality increased, the impact of formulation and adjuvant became relatively smaller.

A TTI nozzle (extremely coarse spray quality) with any adjuvant added to the tank mixes had less than half the driftable fines than an AIXR (coarse spray quality) with the best drift reduction adjuvant added.

Where product labels or APVMA approved permits for products including 2,4-D require the use of a very coarse spray quality or larger, choose an adjuvant that provides the greatest increase in efficacy. Where an adjuvant can demonstrate both increased efficacy and drift reduction, it is a logical choice in areas where sensitive crops exist.

Table 2 illustrates the average impact of various adjuvants on the percentage of the volume existing as droplets less than 150 microns, average across all nozzle types and all tank mixes. A simple ranking system from 1 to 4 has been included, with a ranking of 1 indicating the best drift reduction properties.

Table 2. Adjuvant Impact on % volume < 150 microns averaged across nozzle types and tank mixes

Product/s	% of volume <150 micron in diameter	Relative to average % < 150 microns for all nozzles* (100%)	Ranking for Drift Reduction (1-4)
AMS	10.67	99%	3
AMS + LI-700®	11.94	98%	3
AMS + Hasten®	13.52	111%	4
BS1000®	13.26	109%	4
Dead Sure®	8.80	72%	1
Hasten®	14.13	116%	4
Kombo®	10.47	86%	2
LI-700®	12.39	102%	3
Liberate®	11.01	90%	2
Average all nozzles and tank mixes	12.05	100%	

In Table 2, the values around 100% in the third column are relatively neutral on the production of driftable fines (droplets less than 150 microns in diameter). Adjuvants with values above 100% tend to increase driftable fines and adjuvants with values less than 100% tend to reduce driftable fines.

Permits to apply 2,4-D using Optical Spot Sprayer Technologies (OSST) sprayers

The APVMA has issued a permit (PER87570) that allow for the application of certain products containing 2,4-D through OSST, provided the permit conditions are fully met.

While the WeedIT® and WeedSeeker® setups currently produce a coarse spray quality, their use has been granted under permit for certain products containing 2,4-D provided the weed cover is not more than 10% and other label requirements, including record keeping are adhered to. Operators of these systems must only use registered products covered by the permit.

Conclusion

Like all things in agriculture, application technology is constantly changing, both in the equipment available and the rules and regulations governing how we can use the products that are available.

It is the grower and applicators responsibility to stay informed about their legal requirements and to seek out information and equipment that will help them maintain efficacy and work within the legal framework. Make use of the various GRDC publications related to nozzle selection, drift management and application technology.

Acknowledgements

The droplet size research undertaken by the Centre for Pesticide Application and Safety (CPAS) at the University of Queensland was made possible by the support of the GRDC, the author would like to thank them for their continued support.

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Maximising systems benefits from dual-purpose crops – early sowing and grazing strategies

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Key words

lock-up times, whole-farm profit, mixed farming, canola, wheat, feed gaps

GRDC codes

CSP00160, CSP00132, CFF00111

Take home messages

- Winter and spring cereal and canola varieties can be used for dual-purpose. Early sowing with a suitable maturity type for the site and sowing date will maximise forage and yield potential
- Higher profits rely on attention to detail with both crop and livestock management – systems benefits include management flexibility and risk management
- Timing of lock-up based on growth stage AND residual biomass is a key decision point - but decisions depend on grain *vs* livestock prices
- The tough 2017 and 2018 years with good livestock prices demonstrated the flexible exit options of early-sown dual-purpose crops – graze-out, hay, silage or graze-grain were all profitable.

Introduction

Dual-purpose crops hold great potential to utilise early-season sowing opportunities to provide extra grazing for livestock and maintain grain yield. With good management, the period of grazing can increase net crop returns by up to $600/ha and have a range of system benefits including widening sowing windows, reducing crop height, filling critical feed gaps, spelling pastures and providing flexible exit options in dry years. Over ten years of experiments, simulation studies and collaborative on-farm validation across Australia has demonstrated that a wide range of cereal and canola varieties can be successfully grazed and recover to produce combined livestock and crop gross margins that exceed grain-only crops (Table 1). Systems experiments and collaborating farmers have increased whole-farm profitability by up to $100 per farm hectare by introducing dual-purpose crops onto a portion of the farm.

Table 1. Typical examples of forage, grain yield and gross margins achieved from well-managed dual-purpose crops by collaborating growers in NSW

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

Here we provide brief explanations of how grazed crops are able to recover, some best-bet tips on increasing the success and profitability with dual-purpose crops and give some case studies of what we have achieved experimentally and with collaborating growers.

Early sowing with the right variety is the key

Early-sown, slower-maturing "winter" cereal and canola varieties have the longest vegetative period (i.e. produce leaves before heading/flowering) because they have a requirement to experience prolonged cold temperatures to stimulate flowering. As a result, they can be sown very early (February/March) and provide the most grazing potential. For example, **each week delay in sowing wheat after early March reduces grazing potential by 200-250 DSE.days/ha and potential grain yield by 0.45 t/ha in central and southern NSW.** Winter hybrid canola can grow even faster than wheat in the autumn, so that similar reductions in potential forage with late sowing occur.

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.

Capitalising on early sowing opportunities means being prepared – careful paddock selection (manageable weed burdens), strict summer weed control and careful residue management will maximise surface soil water storage to increase the chances of successful establishment.

Safe grazing and lock-up rules

The ultimate goal for managing dual-purpose crops is to maximise 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. 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 2 weeks - depending on grazing duration.

Our studies have demonstrated that the time of lock-up <u>and</u> 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 1). 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 <u>target grain yield</u> can assist growers with lock-up decisions to avoid yield loss while maximising grazing potential.

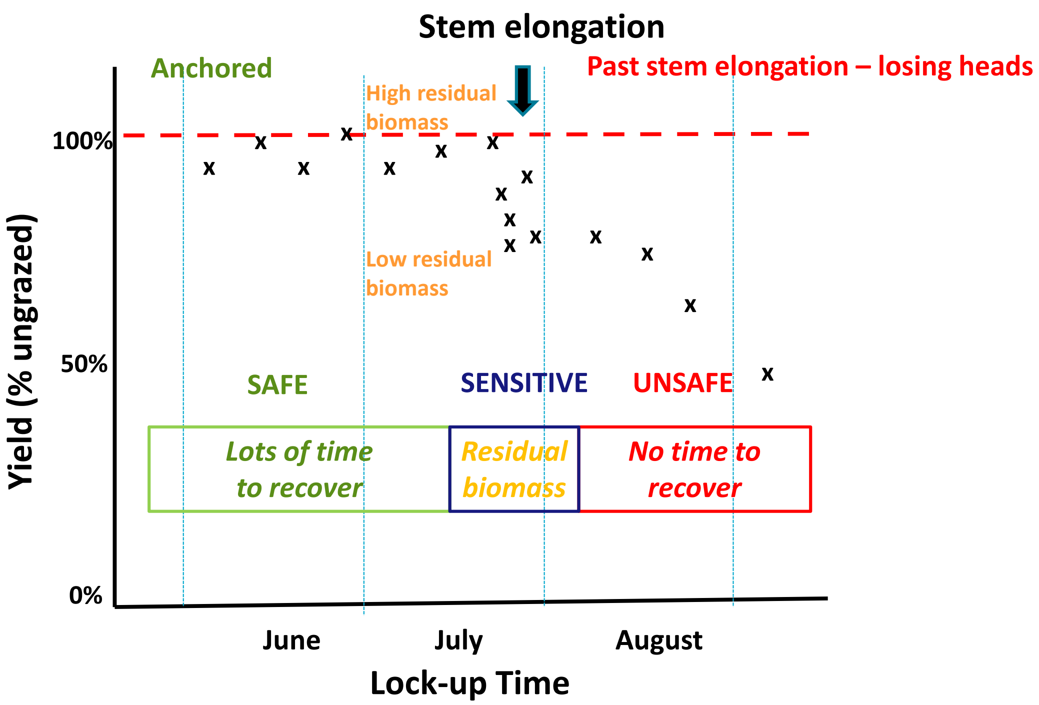

Figure 1. Yield recovery (% of un-grazed crop) of grazed dual-purpose crops highlighting the safe, sensitive and unsafe periods of grazing. Yield recovery from grazing during the sensitive period for a given target yield is affected by the residual biomass at lock-up. Late grazing reduces the time for recovery, so more residual biomass is needed.

At our main experimental site near Greenethorpe, we used experiments with different times and intensity of grazing to investigate the relationship between:

Residual biomass (lock-up) ⇔ Critical biomass (anthesis) ⇔ Target yield

An example is that a typical grazing Kittyhawk wheat crop sown on 10 April with a target yield of 4.5 t/ha would require a critical anthesis biomass of around 8 to 9 t/ha. This critical biomass would require at least 0.5 t/ha of residual biomass to be left in late July when the crop becomes unsafe to graze without removing elongating heads (i.e. heads removed if past Z30). 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 achieve the same critical anthesis biomass, because there is less time left to reach the biomass for the target yield (see Table 2). Note that the spring wheat EGA Gregory sown on 8 May generally had similar critical and residual biomass levels to attain similar yields.

Table 2. Indicative biomass requirements on different lock-up dates to reach different yield targets in wheat. As the target grain yield increases from 3 to 5 t/ha, it is necessary to either lock-up earlier or leave more residual biomass to achieve the critical anthesis biomass required.

Target grain yield (t/ha)	Critical anthesis biomass (t/ha on 1 October)	Residual lock-up biomass required (t/ha) on:			
		14 July	1 August	14 August	28 August
3.0 t/ha	5.4	<0.2	<0.2	<0.2	1.3
4.0 t/ha	7.2	<0.2	<0.2	1.2	3.5
5.0 t/ha	9.0	0.8	1.8	3.0	5.3

For canola the residual biomass requirement left after grazing is higher than wheat, due to the inherently heavy and thick stem bases and slower regrowth after grazing. Spring canola requires about 1.5 t/ha of residual biomass left when locked up at the end of July (when the stems begin to elongate) to ensure 2.5 to 3.0 t/ha yield potential. Earlier-sown winter canola has even thicker stem bases and requires around 2.5 t/ha of residual biomass for recovery.

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 dual-purpose 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 3).

Table 3. Amount of grazing achieved and grain yield from different grazing treatments in a EGA Wedgetail⸸ crop at Greenethorpe in 2013. Income was highest with a small grain yield penalty as the extra grazing was more profitable than yield lost.

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

In a review of 134 different grazing wheat experiments we found <10% returned less than grain only, the median increase in net returns from grazing was 25% and in one third of cases, net returns increased by 75% or more. In the 87 canola grazing experiments returns were somewhat less (median 17%) due to less grazing, and higher grain-value and so increased economic risks from yield reductions.

A grazing tool to assist decision making at lock-up

Advice on grazing and lock-up management has mostly revolved around crop phenology rules, or calendar dates that come from trial and error over many years. The significant impacts on yield from the removal of reproductive parts by late-grazing are well known. To maximise grain yield growers are advised to remove stock before DC30 for cereals and bud elongation in canola.

Our work demonstrates that the risk of a yield penalty associated with grazing is likely to increase as the grain yield potential increases, because a 5 t/ha crop requires a higher level of biomass at anthesis than a 3 t/ha crop. As a result, either an earlier lock-up, or more residual biomass at lock-up is required to reach the higher yield target. Decisions to continue grazing at the possible expense of grain yield depend on the yield target (**Table 2**).

Decisions about lock-up times and trade-offs between grazing and grain will be specific to seasonal prices and grazing enterprises. Our grazing tool allows users to set the yield target and investigate the consequences of different lock-up decisions based on relative prices for grain and livestock. The tool at present does not deal with situations such as 2017 and 2018 where high livestock prices and probable yield failure meant grazing out was a wise financial decision.

Whole-farm flexibility and risk management

A well-chosen dual-purpose crop should flower in a suitable window – <u>even if not grazed</u>. This maximises yield potential for the crops whether they are grazed or not and provides peace-of-mind if circumstances change making grazing impossible or unwise. Likewise, where seasonal conditions deteriorate (as in 2018) and crop recovery after grazing is poor, the crops can be cut for hay, silage or grazed out as sacrifice crops. In this way, dual-purpose crops provide an excellent risk-management tool on mixed farms with several “exit points” as seasonal conditions and relative prices change.

On a typical 1500ha cropping program, the inclusions of around 500ha of dual-purpose crops might create an extra 2-3 DSE/ha of winter stocking that can be considered as available. Growers can utilise this as feed by increasing the stocking rate, or maintain livestock at the same farm level, but take the opportunity to winter-clean areas of pastures. Dual-purpose crops can also be introduced onto graze-only farms to assist in rejuvenating areas of perennial pastures, and to generate income to control difficult weeds, with an excellent opportunity to re-establish clean pastures after a period of cropping.

At Greenethorpe in 2018, the value of early-sown grazing crops was demonstrated in a Decile 1 Year (Table 4 – grazed treatment EBIT are shown in bold). The Manning winter wheat failed to produce grain due to very late flowering under drought but grazing it out (i.e. an extra 3.2 t/ha forage in early summer) proved to be the most profitable option. The dual-purpose (graze/grain) Kittyhawk wheat and Hyola970 canola both provided much higher profitability than the grain only options and were also more profitable than either of the grain only spring crop options (Coolah wheat or Invigour4510TT) sown in early May (Table 4).

Table 4. Forage and grain production and summary economics of different graze and grain crop options at Greenethorpe in 2018 in a Decile 1 rainfall year. Estimated at real 2018 costs and prices.

Crop	Sow	Grain Yield (t/ha)	Winter graze (t/ha)	Summer graze (t/ha)	Gross income ($/ha)	Total costs ($/ha)	EBIT ($/ha)
Wheat							
Manning (graze out)	3/4	0.0	2.3	3.2	2,058	349	**1,709**
Kittyhawk (graze/grain)	3/4	1.9	1.5	0.0	1,360	497	**862**
Kittyhawk (grain only)	3/4	1.6	0.0	0.0	685	561	123
Coolah (grain only)	8/5	2.5	0.0	0.0	1,102	452	650
Canola							
Hyola® 970CL (graze/grain)	4/4	0.9	3.5	0.0	1,816	565	**1,251**
Hyola970CL (grain only)	4/4	1.0	0.0	0.0	527	568	-41
InVigor® 4510TT (grain only)	7/5	1.1	0.0	0.0	609	566	43

Grazing value ($/ha) = Plant DM (kg) removed x Dressed wt. (c/kg) x FCE (0.12)/kg DM x dressing percentage [DM removed x $6.25/kg x 0.12 x 0.5]. All grazing was done by lambs.
Lamb prices=average of light/heavy/trade at correct distribution across NSW for last 3 yrs.=$6.25/kg dressed.
All grain yields are from HI cuts and are at 8% moisture (canola, pulses) or 12% moisture (wheat).
All wheat was at APH2 (>15% protein with < 5% screenings).

The opportunities are significant, but the crop and livestock management requirements to capitalise on dual-purpose crops are considerable. Successful early establishment, weed control and withholding requirements, stock planning, management and logistics are not trivial to optimise the whole-farm benefits of the extra winter forage.

Managing in and out of early-sown dual-purpose crops

We have mentioned that managing into the DP crop requires good planning and paddock selection, managing weed seed banks down, and choosing situations with good water and N storage (e.g. after cleaned pasture, grain legume or fallow).

Managing out of the crop also requires some consideration. Long-season, dual-purpose crops can leave profiles extremely dry, especially after dry seasons such as 2017 and 2018. For example, in 2018 at Greenethorpe, the roots of dual-purpose winter wheat and canola sown on April 1 reached depths of 3.8m and left the subsoils extremely dry. Depending upon the summer and autumn rainfall, some consideration needs to be given to a wise crop/pasture option in the following season. For example, following a winter canola with another early-sown DP cereal would only be advisable if substantial rainfall had refilled the profile to reduce the risk of poor forage production in a dry autumn. In contrast, should a wet summer and autumn refill the profile to facilitate a subsequent early-sown winter wheat (an excellent option under those circumstances), then high nitrogen levels are likely to be required (i.e. ensure the crop has at least 150 kg/ha N available at sowing from soil and fertiliser).

A few tips for success with grazing crops

- **First time? Get good agronomic advice and plan well ahead.**
  - What is your livestock plan to make money from the extra winter feed?
- **Select a suitable paddock and be prepared to sow early**
  - Weed control, withholding periods, stubble management, stored water for early-sown crops
- **Sow early with the right crop and variety – several options available**
  - Winter wheats in March, long-season springs wheats in mid-April, spring wheat late-April
  - Winter canola types in March, spring hybrid types from mid-April
  - Select vigorous canola varieties (hybrids) with good blackleg resistance (>R-MR)
- **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.
- **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
- **Ensure sufficient N up-front for good early biomass production**
  - 100-150 kg/N for winter wheats and canola; 50-100 kg/ha for spring wheats and canola
- **Don’t graze too early as crops are building root mass and can be checked**
  - Twist and pull test – usually need at least 1.5 t/ha biomass (6-8 leaf stage in canola)
  - Recovery and winter growth of canola slower than cereals
  - Graze canola once for longer as animals take some time to adjust (at least 2 weeks grazing)
- **Animal health issues**

- Take usual precautions for bloat and nitrate poisoning as usual for palatable feed
  - Don't fertilise with N close to grazing, apply upfront and post-grazing
- ***Na/Mg supplements required for grazing wheat to maximise live-weight gain**
  - For canola take usual Brassica precautions, cattle are more sensitive than sheep
- **Grazing management**
  - Stocking rates around 1000 kg/ha live-weight work well, but adjust to feed on offer
  - Animals take time to adjust to feed and do best if grazed for longer – avoid frequent change
- **Lock-up time is key!!**
  - Remove stock before DC30 in wheat and bud elongation in canola
  - If grazing later, ensure grazing does not remove reproductive parts
- **Top-dress N after grazing to assist yield recovery**
  - Assume wheat needs to see 40 kg N/ha for every 1 t/ha of yield and canola 80 kg N/ha - and adjust topdressing according to existing N and target yield.

Further reading

https://www.grdc.com.au/uploads/documents/GRDC_Dual-PurposeCrops.pdf

http://www.ausgrain.com.au/Back%20Issues/241mjgrn14/Match%20flowering.pdf

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 Kershaw, "Iandra", Greenethorpe for the use of land since 2013, Peter Hamblin and staff at Kalyx (Young) for management of the field experiments at Greenethorpe in 2013 and 2014, and staff at CSIRO Ginninderra Experiment Station for assistance with field experiments in 2017 and 2018.

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Profit and risk optimisation in canola – linking physiology and tactical agronomy

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Key words

phenology, optimum flowering date, early sowing, hybrid, nitrogen

GRDC code:

CSP00187

Take home messages

- Know the optimum start to flowering time for your location, and match variety phenology with a sowing date to achieve it (see https://grdc.com.au/10TipsEarlySownCanola)
- Early sowing of slow developing spring canola has been successful in the tough years of 2017 and 2018, and suits areas with late-March to early-April sowing opportunities
- Early-sown hybrid varieties with robust N have performed well in 2017 and 2018 despite fears of excessive biomass, rapid water use and yield loss – the opposite has been the case
- Profitability and risk management in canola is underpinned by sound systems agronomy – especially summer fallow management to conserve water and facilitate timely sowing, and attention to crop nitrogen requirements.

Introduction

The Optimised Canola Profitability Project has been working across eastern Australia for 5 seasons (2014 to 2018) to develop profitable tactical agronomy advice for canola based on a better understanding of the physiology and phenology of canola. We have presented the outcomes at many previous GRDC Updates (see reference list), but 2017 and 2018 have provided challenging conditions to put the outcomes of our work to the test. In general, the advice we have developed and tested over the years has held up, and in this paper we outline the physiological research that underpins our tactical agronomy advice, and provide examples and recommendations related to central west NSW.

Know your optimal flowering periods

In every location there will be an optimal period for canola to commence flowering that minimises the combined risks of too little biomass or frost (if flowering too early), and heat and water stress (if flowering too late). Our team has identified the critical period when canola yield is most affected by these stresses (around 300-400 °C days after flowering starts). By combining this knowledge with weather data at specific sites, we have been able to identify the best time for canola to start flowering to minimise these risks and maximise yield (Table 1). Full information is available in the E-booklet https://grdc.com.au/10TipsEarlySownCanola but a few sites are shown below.

Table 1. Recommended optimum start of flowering (OSF) dates at selected sites to minimise the combined risk of frost, heat and drought. The start of flowering is defined as 50% of plants with one open flower. The range provided assumes the optimum date is the midpoint (i.e. for Trangie 13 days before or 13 days after 26 July is an acceptable start date).

Site	Optimum start of flowering	Acceptable range (days)	Assumed soil type	PAWC (mm)
Trangie	26 July	26	Sandy clay loam	141
Condobolin	25 July	21	Red clay	126
Canowindra	2 August	15	Red clay	150
Parkes	3 August	19	Sandy clay loam	197
Wellington	5 August	12	Sandy clay loam	101

In northern frost-prone environments the later end of the OSF period should be targeted and crops sown on good soil moisture to reduce heat and drought risk. In medium and high rainfall environments in high canola intensity areas, targeting the later end of the OSF will also reduce risk of upper canopy blackleg and sclerotinia (see https://grdc.com.au/10TipsEarlySownCanola). In the experimental series throughout 2017 and 2018 and across all sites, yield was optimised in crops that flowered close to the optimum start of flowering date (OSF).

Understanding drivers of phenology to match variety phenology to sowing dates

In order to determine when different canola varieties should be sown to achieve the OSF, it was necessary to understand how each variety reacted to the drivers of canola development – temperature, day-length and vernalisation (cold). Our team has used detailed sites at Canberra (cold) and Gatton (warm) over two years with lights to extend day-length, as well as controlled temperature cabinets to fully understand how current Australian canola varieties respond, and to recommend sowing dates in each environment that will achieve optimum flowering time. These recommendations have been validated across the experimental series, including all new varieties released in 2018. A selection of sites for central west NSW are shown in Table 2, but the full information is available in the Ebooklet https://grdc.com.au/10TipsEarlySownCanola.

In experiments specifically designed to reveal which canola varieties may be suitable for earlier sowing, large differences in the development of the spring cultivars were revealed. Fast cultivars unsuited to early April sowing included Hyola® 350TT, Hyola 506RR, ATR Stingray⦶, Diamond and 43Y23 (RR)®. At Wagga Wagga in 2018, early sowing of these fast cultivars resulted in early flowering and significant frost damage, with a resultant machine harvest yield of <0.5 t/ha. The fast cultivars did better from early May sowing. Commercial cultivars that were relatively slow developing from early sowing included 45Y25 (RR)®, 45Y91 (CL)®, Victory® 7001CL, InVigor® 5520P, ATR Wahoo⦶, GT-53 and SF Ignite. These cultivars yielded in a range from 1.1 to 1.7 t/ha from early sowing but had reduced yield from later sowing.

A key tactic to stabilise flowering date across and within seasons is to select a cultivar that slows its development when sown early, but then speeds up when sown later, providing a relatively stable flowering date despite different sowing dates. The best examples of this “flexible” phenology were 44Y90 (CL)® and 44Y27 (RR)® which, along with HyTTec® Trophy, Quartz and 43Y92 (CL)®, were the only cultivars to yield >1 t/ha from both sowing dates.

Table 2. Recommended sowing dates at three sites in CWNSW for different canola phenology types (slow, mid, fast) to achieve optimum flowering dates. For the phenology types of current varieties see full details at https://grdc.com.au/10TipsEarlySownCanola. Black is preferred sowing date, grey earlier or later than optimal.

Site		March				April				May			
	Phenology	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Wellington	**Slow**			░	░	■	■	░					
	Mid					░	■	■	■	░			
	Fast							░	■	■	░		
Trangie	**Slow**			░	■	■	■	░					
	Mid				░	■	■	■	░				
	Fast						░	■	■	░			
Condobolin	**Slow**			░	░	■	■	░					
	Mid					░	■	■	░				
	Fast						░	░	■	░			

The frequency of early sowing opportunities

The ability to capitalise on early sowing opportunities will depend on the location and soil type which determine how often sufficient rainfall for a successful establishment opportunity occurs. The frequency of sowing opportunities for a range of sites in southern and central NSW are shown in Table 3. Based on the sowing rule developed by Unkovich (2010), there is a 22% chance of having enough seedbed moisture to germinate canola in the second half of March and a 17% chance in the first half of April at Condobolin. In contrast there is a 33% chance in the second half of March at Canowindra and a 31% chance in the first half of April. These sowing opportunities will influence varietal phenology choice. There are limited opportunities to plant a slow or mid-slow canola cultivar before mid-April at Condobolin, therefore fast-mid cultivars are recommended as these perform well from late-April/early May sowing but have some flexibility if there is an early break. At Canowindra the chances are >50% so the slow and slow-mid cultivars should be considered. To ensure flowering date targets are met while also responding to variable seasonal breaks, growers can either (i) have access to two or three canola cultivars with contrasting phenology (e.g. a slow and a fast-mid) or (ii) select a canola cultivar with relatively "flexible" phenology, which is relatively slow from early sowing, but fast from later sowing - which we have identified in our recent experiments.

A combination of strict fallow management and maintenance of even residue cover will increase the chance of establishing canola successfully in any window. Conversely, poor summer weed control, overgrazing, cultivation and early stubble burning will decrease the chances of successful early establishment.

Table 3: Chance (%) of a canola sowing (germination) opportunity <u>within defined date ranges</u> in autumn in southern NSW. A sowing opportunity is defined as when rainfall > pan evaporation in a 7 day period (Unkovich 2010).

	16-31 Mar	1-15 Apr	16-30 Apr	1-15 May	16-31 May
Condobolin	21	17	33	43	57
Wagga Wagga	30	30	45	50	83
Canowindra	33	31	52	53	67

Capitalising on earlier sowing systems

Canola is a crop that is known to benefit in both yield, oil, and water-use efficiency from earlier sowing, provided a variety is chosen that achieves the optimal flowering date (Kirkegaard *et al.,* 2016). However, at the beginning of the project, there was concern that early-sown hybrid varieties with robust N may grow too much biomass, run out of water and perform poorly. During the course of the project, we have clearly demonstrated that this has not been the case - even in the tough seasons of 2017 and 2018, and across a wide range of environments, hybrid varieties sown early with robust N nutrition (assuming crops need a total of 80 kg N/t of expected yield from soil and fertiliser) have generated more profitable outcomes than later-sown OP-TT varieties – when both flower in the OSF. The capacity to cover the soil early to reduce evaporation, produce higher biomass at flowering to support a higher yield, and grow deeper roots to access the deeper water in dry springs all contribute to the improved performance of early sown crops. At Greenethorpe in 2018 hybrid canola sown on 4 April had roots 1m deeper (3.2 m) than that sown on 7 May (2.2m) and the deeper roots were able to capture an extra 35 mm of water from the soil.

A comparison of similar phenology pairs of hybrid Clearfield® and open-pollinated triazine tolerant cultivars sown within their highest yielding window highlighted the advantages of hybrids with adequate N. At Condobolin, where supplementary water provided a total of 334mm of in-crop rainfall, the hybrid Clearfield cultivars yielded 25% more than the open-pollinated triazine tolerant cultivars (Table 4). At Wagga Wagga the advantage was 40% and across the 18 sites in 2018 with a wide range of yields (0.5 to 4 t/ha) this advantage was evident and most pronounced at sites with high starting water and low in-crop rainfall, a regular feature in the CW.

Table 4. Comparative yield of canola phenology pairs (hybrid Clearfield (CLF) versus open-pollinated triazine tolerant (OP TT)) from their highest yielding sowing date at Condobolin in 2018 (l.s.d. $P<0.05 = 0.32$ t/ha).

Phenology	Sow date	Hybrid CLF	OP TT	Hybrid CLF Yield (t/ha)	OP TT Yield (t/ha)
Mid-slow	5-Apr	Archer	ATR Wahoo ⌽	2.4	2.2
Mid-fast	26-Apr	44Y90 (CL)®	ATR Bonito ⌽	2.7	2.1
Fast	26-Apr	Diamond	ATR Stingray ⌽	2.5	1.7

Getting the system right

In NSW during 2017 and 2018, extreme weather conditions made it difficult to grow canola profitably, yet there were crops that yielded around twice as much as others in the same landscapes. Generally, where a sowing opportunity did occur, these more profitable crops had some consistent features in their pre-crop and in-crop management. The keys to success were:

1. Strict fallow weed control that conserved soil moisture from late spring and summer rain.
2. Evenly spread straw at harvest, minimal stubble grazing to maintain and preserve seedbed moisture to provide timely and successful establishment.
3. Selection of paddocks with relatively high starting soil water and nitrogen.
4. Matching variety phenology with sowing date to ensure flowering starts close to the optimum start of flowering (OSF) to minimise stresses and maximise yield.
5. Sowing hybrid canola (although this alone did not guarantee success).
6. Application of sufficient nitrogen to match grain yield potential.
7. Some luck with timely rainfall, or elevated locations with reduced frost damage.

If the points above (especially 3-5) can't be achieved, then it may be better to leave the canola seed in the bag to be planted in a season when conditions are more suitable.

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 author would like to thank them for their continued support. The projects supporting this research are co-investments from GRDC, NSW DPI, CSIRO and SARDI, and I acknowledge and thank the whole OCP experimental teams.

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Unkovich M (2010) A simple, self-adjusting rule for identifying seasonal breaks for crop models. Proceedings of 15th Australian Agronomy Conference 2010, Lincoln, New Zealand.

Kirkegaard et al. (2016) Re-evaluating sowing time of spring canola (Brassica napus L.) in south-eastern Australia – how early is too early? Crop and Pasture Science 67, 381-396.

Further Reading

https://grdc.com.au/10TipsEarlySownCanola

http://www.australianoilseeds.com/__data/assets/pdf_file/0003/12189/AusCanola_2018_Proceedings_E-book.pdf

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Dual purpose wheat varieties for central NSW

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Key words

wheat, dual-purpose, grazing, dry matter, grain recovery

GRDC codes

DAN00184: Evaluation and agronomic management of dual-purpose cereal varieties for NSW mixed farming systems

DAN00213: Grains Agronomy and Pathology Partnership (GAPP) – *Optimising grain yield potential of winter cereals in the Northern Grains Region*

Take home messages

- Newly released dual-purpose wheat varieties do fit into central NSW farming systems and offer growers greater flexibility in sowing time and maturity compared to EGA Wedgetail⑊
- Matching a variety's flowering time and maturity to growing conditions is critical in maximising grain yield recovery of a dual-purpose variety
- Illabo⑊ and LRPB Kittyhawk⑊ are potential replacements for EGA Wedgetail⑊ in central NSW and offer improved disease resistance and grain quality over EGA Wedgetail⑊
- Longsword⑊ and DS Bennett⑊ offer growers varietal choice with winter habit, for both lower and higher rainfall areas respectively
- Variety selection also must consider the required grazing period for livestock and grain quality as these are drivers of dollar returns from the crop.

Introduction

EGA Wedgetail⑊ has been widely grown in central NSW and supported grower farming systems where they have included grazing and grain varieties. EGA Wedgetail⑊ was released in 2002 and has been affected by changes in stripe rust ratings, has lower grain quality compared with the some of the more currently grown milling varieties, and its delivery classification in the northern zone is only Australian Hard (AH), compared with Australian Prime Hard (APH) in the south-eastern zone.

While stripe rust can be economically controlled with fungicides, it adds an extra complication when using the variety for grazing and is seen as a disadvantage for growers. With EGA Wedgetail's⑊ winter habit and slower maturity, it doesn't fit well in all the growing areas in central NSW, so both yield and grain quality are affected when spring conditions are drier, or the season finishes quickly. The shift from APH to AH in the northern zone has meant growers in the central region cannot take advantage of premiums for APH in years where they achieve high grain protein levels.

In the last 5–10 years, increased emphasis has been placed by breeding programs on dual-purpose types that suit both grazing and grain recovery. New varieties released in the last five years now provide growers with more choice and overcome some of the shortfalls in EGA Wedgetail⑊. The releases have been both companion varieties offering different maturities and growing season length; Longsword⑊ and DS Bennett⑊ and also more direct replacements for EGA Wedgetail⑊; LRPB Kittyhawk⑊ and Illabo⑊.

Methodology

A series of experiments run over the past five years looked at the performance of dual-purpose varieties for both dry matter production and grain recovery (DAN00184); as well as separate time of sowing response and plant physiology experiments in the last two years (DAN00213) to better describe varieties and identify regions in NSW where they are best suited.

The grazing and grain recovery experiments were run across the state, with key in-crop management decisions based around EGA Wedgetail⊕, the current industry benchmark. When comparing varieties, this needs to be considered, as it influences how results are interpreted.

The grazing cereal experiments were sown from the last week of March through to early May, depending on the seasonal break. Key measurements recorded at all sites included dry matter (DM) production through the season at mid tillering and then before stem elongation i.e. growth stage (GS)31 on the Zadoks scale (Zadoks *et al.* 1974). The experiments were then grazed by livestock following DM measurement and allowed to recover for either further DM assessment, or carried through to grain production.

The trials were conducted based on randomized complete block design, with column and row arrangement. Linear mixed model approach was used to analyse the data. All the analyses were performed using ASReml-R 3 (Butler *et al.,* 2009), considering spatial variations in the model, where needed (Gilmour, *et al*., 1999).

The results presented in figures 2, 3 and 4 are from Multi-Environment Trials (MET) analysis using one-stage factor analytic method (FA) of Smith *et al.* (2015), showing values for single site years and across years and sites for NSW from 2011–2017.

Newer dual-purpose wheat variety performance

Key questions to consider when comparing dual-purpose varieties:

- What is the earliest date I can normally sow a dual-purpose wheat variety in my district and reliably establish the crop? Target sowing date? Figure 1 shows the different phase periods for a group of dual-purpose wheat varieties at Wallendbeen in 2018. This highlights the differences between the fast-winters, mid-winters and slow-winters for time to first node, SD1 98–143 days, SD2 97–132 and SD3 96–114 days and the opportunity to tailor variety choice for grazing period length
- What is your main focus in your farming system, grain production or fodder production for livestock?
- Include grazing returns (livestock weight gains/$) in any comparison between varieties, as this can account for between 20–50% of total gross crop return
- Is grain production for use on farm for livestock feed or sale? Returns from higher grade milling varieties can compensate for lower grain yields
- What diseases are important in your region and can they be controlled effectively by fungicides, or do you need to rely on plant resistances to manage?
- Is late season frost risk management important, because your farming landscape has more frost-prone areas in paddocks? Should you grow an awnless variety to mitigate this risk and provide alternative income from hay/silage production?

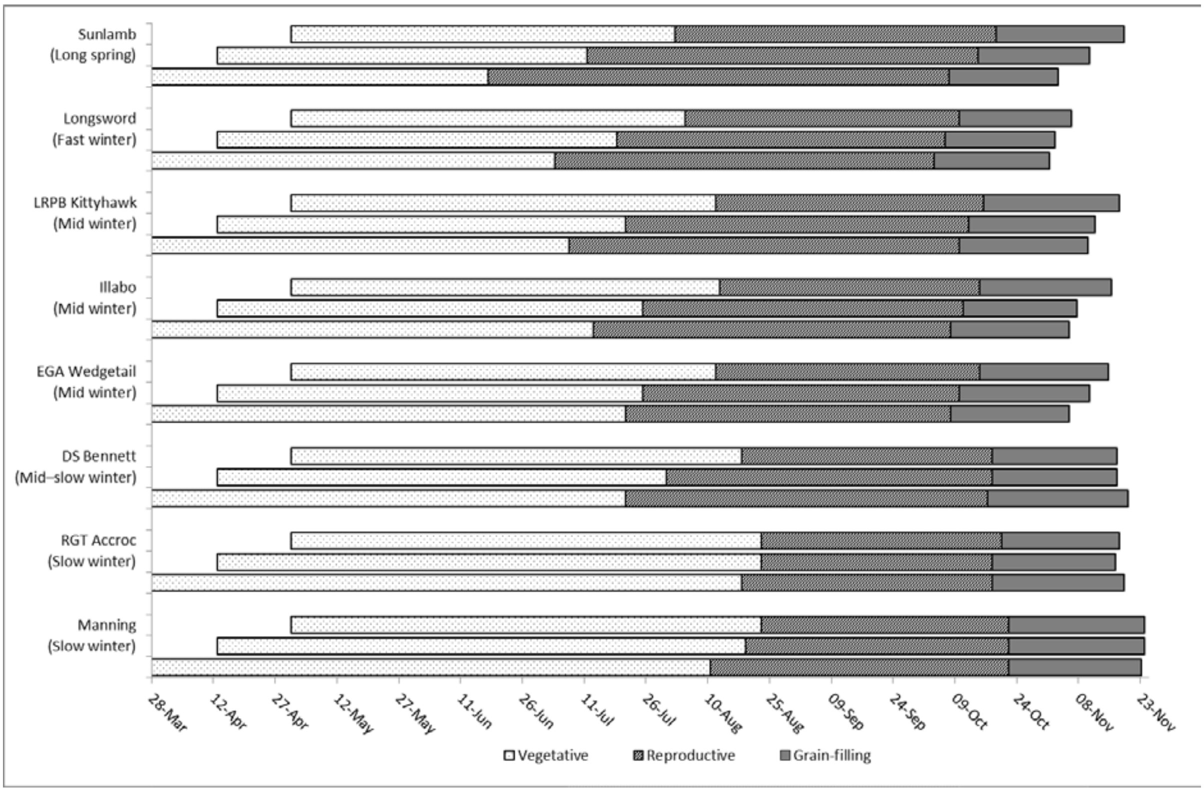


Figure 1. Influence of sowing date on phasic development of dual-purpose wheat varieties sown 28 March (SD1), 13 April (SD2) and 1 May (SD3) at Wallendbeen, 2018 (DAN00213 – GAPP – Optimising grain yield potential of winter cereals in the northern grains region). Vegetative phase (sowing to GS30); reproductive phase (GS30 to flowering); grain-filling stage (flowering to maturity). Sunlambᶲ, Longswordᶲ, LRPB Kittyhawkᶲ, Illaboᶲ, EGA Wedgetailᶲ, DS Bennettᶲ and Manningᶲ are protected under the Plant Breeders Rights Act 1994.

The performance of new wheat varieties compared with EGA Wedgetailᶲ is shown in figures 2, 3 and 4.

Recently released and evaluated lines include (see Table 1 for summary):

- DS Bennettᶲ – A mid–slow winter wheat suited to early March–late April sowings. Due to the longer vegetative phase and slower maturity, it is not well suited to drier environments. It is a high yielding winter wheat, with photoperiod sensitivity and generally flowers 7–10 days later then EGA Wedgetailᶲ. It is suited to both grazing and grain production, or straight grain production. DS Bennettᶲ is a tall, awnless wheat and a possible replacement for Naparooᶲ in more frost-prone areas where hay production is also part of the farming program
- Illaboᶲ – A mid maturing winter wheat, with a similar maturity and planting window to EGA Wedgetailᶲ, with higher grain yield potential. Illaboᶲ has been observed to be 2–3 days quicker to maturity than EGA Wedgetailᶲ. Good grain quality, with improved black point tolerance over EGA Wedgetailᶲ. Tolerant of acid soils, it has improved stripe rust resistance
- Longswordᶲ – A fast-maturing winter wheat, most suited to April sowings. Longswordᶲ is a true winter wheat and has three winter genes. It has Maceᶲ as a parent and is relatively quick to mature. This earlier flowering and quicker maturity provides growers in medium–low rainfall environments a more suitable variety then EGA Wedgetailᶲ or similar mid-winter types. Good physical grain package with low screenings and high test weights

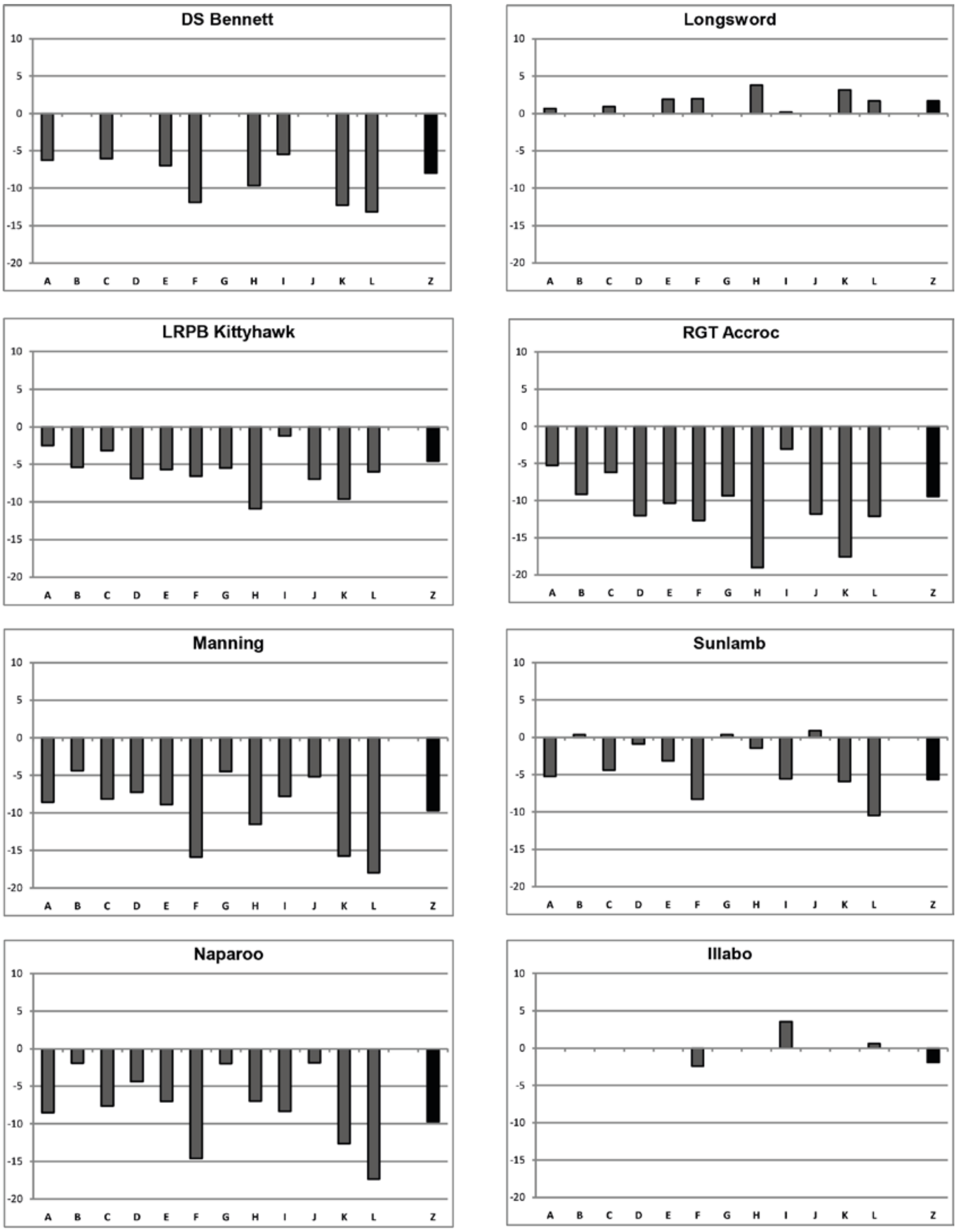
- LRPB Kittyhawk – A mid maturity winter wheat, with a similar maturity and planting window to EGA Wedgetail, with higher grain yield potential. LRPB Kittyhawk has improved stripe rust resistance and grain quality over EGA Wedgetail
- Manning – A slow-maturing winter wheat that can be sown as an alternative to Mackellar in late February in some regions for early grazing. Not well suited to late April sowings due to its longer maturity. Awnless wheat with good standability. High yield potential in longer-season environments
- RGT Accroc – A red winter wheat of feed grain quality, suited to higher rainfall zones. Suitable for sowing in late February to early April for early grazing. Good standability. Flowering time and maturity is later than EGA Wedgetail
- Sunlamb – An awnless, long-season spring wheat suited to early April plantings, with strong photoperiod sensitivity. Suited to grazing and grain recovery across NSW. Similar flowering time to EGA Wedgetail, and a few days earlier than Naparoo (Matthews *et al.* 2018).

Table 1. Summary of new dual-purpose wheat varieties suitable for grazing and grain recovery in NSW

Variety	Year of release	Develop-mental type	Head type	Maximum quality classification^		Disease ratings#			
				Northern zone	South-eastern zone	Stripe rust (WA Yr17–27)	Leaf rust	Stem rust	Yellow leaf spot
DS Bennett	2018	Mid - Slow winter	Awnless	Feed	ASW	R	S	MR–MS$^{(P)}$	MR–MS
EGA Wedgetail	2002	Mid winter	Awned	AH	APH	MS	MS–S	MR–MS	MS–S
Illabo	2018	Mid winter	Awned	AH	APH	R–MR$^{(P)}$	S$^{(P)}$	MR–MS$^{(P)}$	MS$^{(P)}$
Longsword	2017	Fast winter	Awned	Feed	Feed	R–MR	MS–S	MR	MR–MS
LRPB Kittyhawk	2016	Mid winter	Awned	APH	APH	R–MR	MS	MR–MS	MR–MS
Manning	2013	Slow winter	Awnless	Feed	Feed	R–MR	MS	R–MR	MR–MS
Naparoo	2007	Mid winter	Awnless	Feed	Feed	R	R	R–MR	MS
RGT Accroc	2016	Slow winter	Awned	Red feed	Red feed	R	S	MS	MR–MS
Sunlamb	2015	Long spring	Awnless	ASW	ASW	MR–MS	MS	R	MR–MS

Rating from 2018 national disease screening for NSW or breeding company updates, check for more recent disease ratings from the 2019 *Winter crop variety sowing guide* for NSW. $^{(P)}$–Provisional

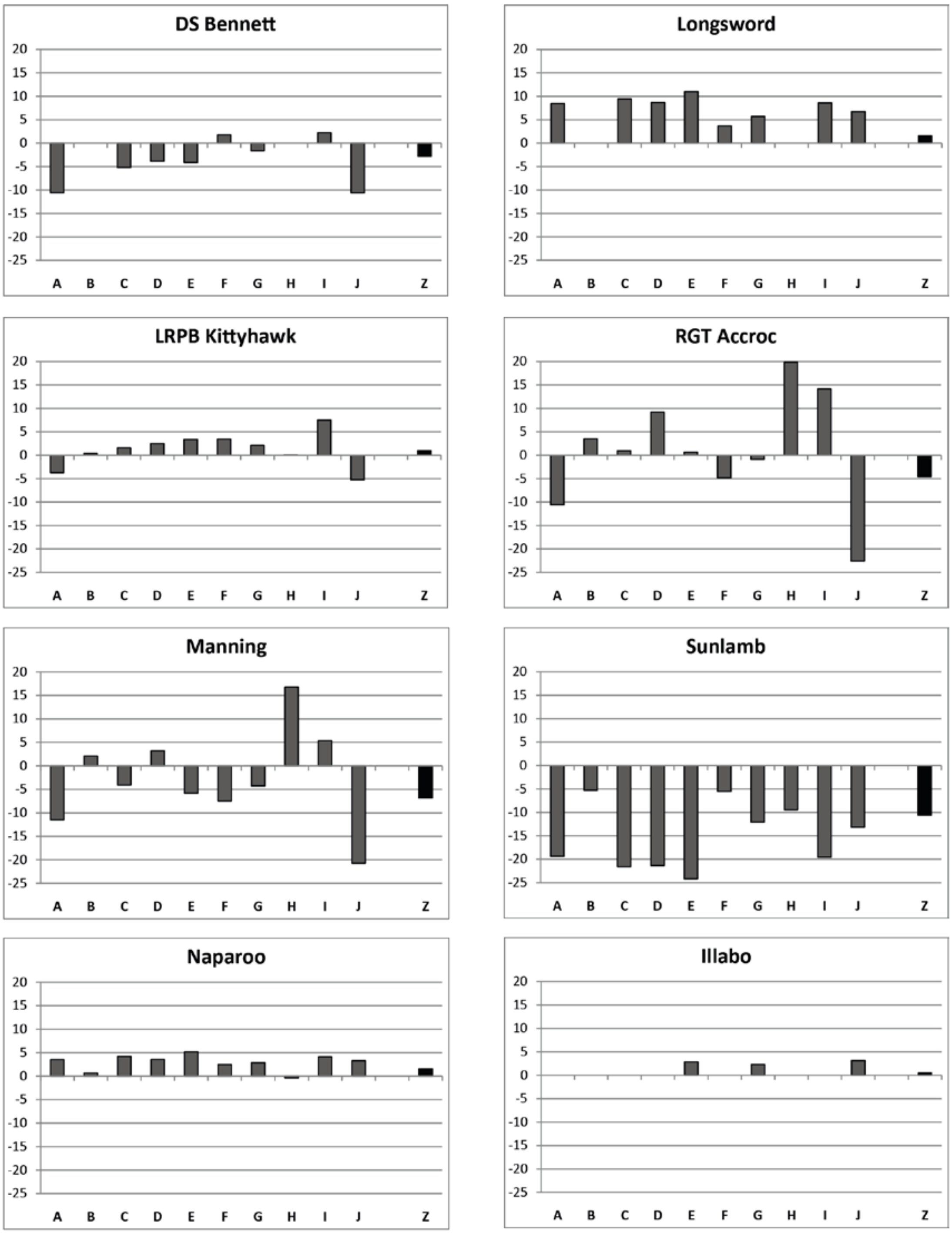
^ Wheat quality classification based on latest information in January 2019; some new varieties might have updated classifications pending reviews by Wheat Quality Australia for the coming season.



KEY

A	Bathurst 2016	H	Somerton 2016
B	Cowra 2015	I	Somerton 2017
C	Cudal 2016	J	Spicers Creek 2015
D	Purlewaugh 2015	K	Spicers Creek 2016
E	Purlewaugh 2016	L	Spicers Creek 2017
F	Purlewaugh 2017	**Z**	**Across all sites and years 2011–2017**
G	Somerton 2015		

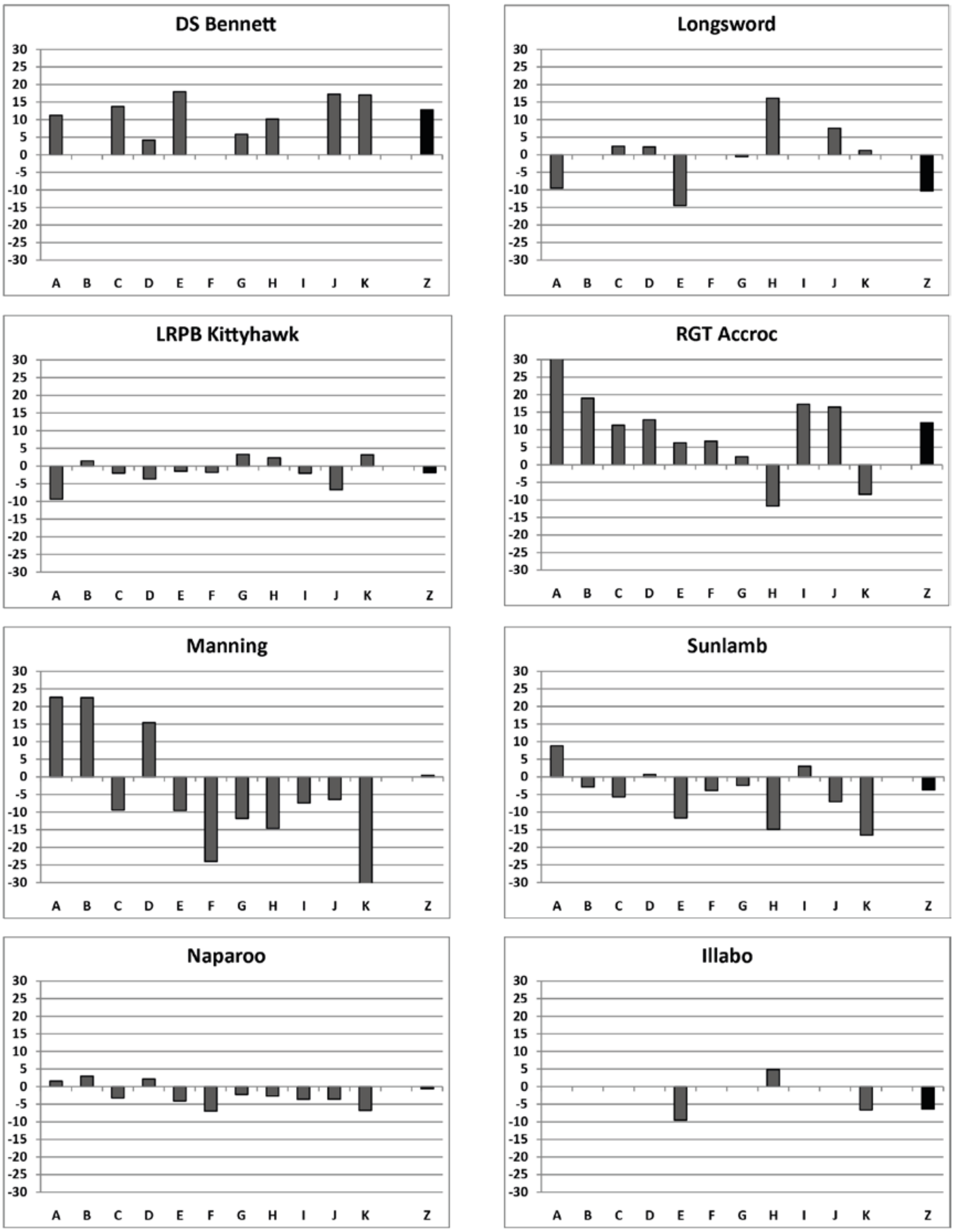
Figure 2. Predicted initial dry matter (DM1) responses of new wheat varieties across NSW from 2011–2017 compared with EGA Wedgetail⊕ (percentage difference %) and individual predicted site performance from selected sites in central and northern NSW. DS Bennett⊕, Longsword⊕, LRPB Kittyhawk⊕, Manning⊕, Sunlamb⊕, Naparoo⊕ and Illabo⊕ are protected under the Plant Breeders Rights Act 1994.



KEY

A	Bathurst 2016	G	Somerton 2017
B	Cowra 2015	H	Spicers Creek 2015
C	Cudal 2016	I	Spicers Creek 2016
D	Purlewaugh 2016	J	Spicers Creek 2017
E	Purlewaugh 2017	Z	**Across all sites and years 2011–2017**
F	Somerton 2016		

Figure 3. Predicted dry matter recovery responses of new wheat varieties following grazing (DM2) across NSW from 2011–2017 compared with EGA Wedgetail (percentage difference %) and individual predicted site performance from selected sites in central and northern NSW. DS Bennett, Longsword, LRPB Kittyhawk, Manning, Sunlamb, Naparoo and Illabo are protected under the Plant Breeders Rights Act 1994.



KEY

A Bathurst 2016	G Somerton 2016
B Cowra 2015	H Somerton 2017
C Cudal 2016	I Spicers Creek 2015
D Purlewaugh 2016	J Spicers Creek 2016
E Purlewaugh 2017	K Spicers Creek 2017
F Somerton 2015	**Z Across all sites and years 2011–2017**

Figure 4. Predicted grain yield responses of new wheat varieties following grazing across NSW from 2011–2017 compared with EGA Wedgetail⊕ (percentage difference %) and individual predicted site performance from selected sites in central and northern NSW. DS Bennett⊕, Longsword⊕, LRPB Kittyhawk⊕, Manning⊕, Sunlamb⊕, Naparoo⊕ and Illabo⊕ are protected under the Plant Breeders Rights Act 1994.

Summary

There is a strong relationship between a dual-purpose wheat dry matter production and grain yield recovery with seasonal conditions, with varieties showing they are better suited to particular climatic conditions and season length. No single variety is suited to all growing situations. Experiments across NSW have identified that there is a significant variation in performance of new varieties with older industry checks such as EGA Wedgetail⦶, and that sowing date and in-crop management influence this performance.

Growers need to consider not only the grain yield potential of a variety, but its suitability for grazing in their region and farm business. Returns from dual-purpose crops are driven by three primary factors: grain yield, grain quality classification and dry matter/fodder production. Placing an economic value on fodder production can be difficult as it might not be directly related to livestock sales, but rather providing a fodder source in key periods through the season where pasture production is limited.

Properly managed dual-purpose wheat crops have the ability to compete with grain only crops on an economic basis and in many cases provide a higher dollar return per hectare than grain only crops.

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 them for their continued support.

This research was co-funded by NSW DPI and GRDC under projects; DAN00184: 'Evaluation and agronomic management of dual-purpose cereal varieties for NSW mixed farming systems' and DAN00213 'GAPP – Optimising grain yield potential of winter cereals in the Northern Grains Region'.

A sincere thank you for the assistance of project staff from DAN00184 - Jennifer Pumpa, Philip Armstrong, Peter Roberts, Ryan Potts, Jessica Perry and Emma Angove for technical assistance in managing the field trials and the grower co-operators across NSW for hosting on property trials.

And project staff from DAN00213 – Dr Felicity Harris, Hugh Kanaley and Dean Maccallum (Wallendbeen experimental site) and Greg Brooke and Jayne Jenkins (Wongarbon experimental site), for project results used in this paper and presentation

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⦶Varieties displaying this symbol beside them are protected under Plant Breeders Rights Act 1994.

Grazing cereal and canola crop nutrition

Jim Laycock, Incitec Pivot

Key words

nitrogen, phosphorus, potassium, sodium, sampling

Take home message

- Sample surface soils 0-10cm and deep to a minimum of 60cm 3/4 weeks before planting
- Manage fallows to maximise early crop emergence opportunities
- Early availability to phosphorus is crucial. Phosphorus deficiency limits wheat grain yield principally by depressing early growth, leaf emergence rate and maximum rate of tiller emergence
- Confirm any suspected in crop macro or micro nutrient deficiency or toxicity with tissue testing

Phosphorus

Apply recommended phosphorus rates based on mg/kg Colwell P and phosphorus buffering index (PBI) from recent or this season's soil test results and yield expectations for your area. 43% of central NSW soil tests sampled January to June 2018 were less than 35mg/kg Colwell phosphorus. Normally starter fertiliser rates as MAP or DAP are recommended banded with the seed considering seed bed utilisation (SBU)% and soil moisture at planting. Canola is more sensitive than cereals to nitrogen placed with the seed.

When sowing forage cereals and especially canola, it is important to accurately assess planting soil moisture and soil temperature to maximise early emergence and time to first graze. Phosphorus banded with the seed at planting encourages early root development, increasing root area to access soil moisture and soil phosphorous through the growing season.

Table 1. Distribution of results from Colwell P tests conducted for the central NSW region. From 1897 soil samples, 0-10cm depth. Results from Nutrient Advantage Laboratories Jan-June 2018

Colwell P mg/kg	<20mg/kg	20-35mg/kg	35-50mg/kg	50-80mg/kg	>80mg/kg
% of samples	15%	28%	24%	21%	12%

Western Australian field trials showed a trend towards higher critical Colwell P for cereals on canola with PBI>70 (Andreas Neuhaus *et al,* 2015). When sowing cereals following canola in the rotation, additional phosphorus at planting should be budgeted for.

Remember with phosphorus there is no second chance.

Nitrogen

If deep N soil test results are showing >120kg/ha nitrogen in the profile, or coming out of an early fallowed pasture phase with >30% productive legume component, or following a high biomass grain legume, then no additional nitrogen may be required.

If deep N soil test results are <60kg/ha (and that was 65% of soil samples in 2018), nitrogen is required and rates will be dependent on the starting soil nitrogen levels, paddock history, organic carbon percentage, rainfall and expected grain yield targets. Assume wheat needs to see 40 kg N/ha for every 1 t/ha of grain yield. Canola needs ~80 kg N/ha. The primary objective when growing forage crops is to maximise dry matter production and efficiently utilise that dry matter.

Table 2. Distribution of results from Deep N tests conducted for the central NSW region. (769 soil samples, 0-60cm depth). Results from Nutrient Advantage Laboratories Jan-June 2018

Nitrogen kgs/N	<30kgs/N	30-60kgs/N	60-120kgs/N	>120kgs/N
% of samples	34%	31%	25%	10%

Early nitrogen and time to first graze is the key with nitrogen. Apply nitrogen on low nitrogen paddocks at rates of 35-50kgs/ha/N broadcast and incorporated at planting.

Rates of N loss from urea post broadcasting without incorporation through volatilisation can be 5.4-19% on northern soils (Schwenke *et al,* 2014).

Additional nitrogen can be applied post grazing through the growing season dependant on seasonal conditions. "Lock up time" can also be managed depending on commodity prices, residual biomass targets and seasonal conditions.

Nitrite/nitrate levels in forage may be an issue in both canola and wheat if; the crop is immature, growth has been slow due to frosts, weather has been cold and cloudy or there has been intermittent water logging. Plants will continue to take up and accumulate nitrate during periods of slow growth and most of that plant nitrate is also located in the bottom third of the stalk. Allow cereals and canola to regain leaf area before reintroducing stock if urea has been top-dressed post grazing.

Manage the risk of high nitrate with controlled grazing, including carbohydrate in the diet. Avoid grazing with hungry stock. Risk is further reduced by grazing actively growing crops.

Potassium

Cropping soils in the central west generally have more than adequate soil potassium levels, with only 8 out of 1930 samples received at Nutrient Advantage Laboratories January to June 2018 below the critical soil potassium level of 60mg/kg available potassium for wheat/canola.

Wheat forage has a high potassium (K) content – about three to four per cent of dry matter – and a very low sodium (Na) content, often less than 0.02 per cent of dry matter. This can result in a very high K:Na ratio in wheat forage, which can reduce absorption of magnesium (Mg) in the gut of livestock and limit liveweight gains.

The high K and low Na contents in the wheat tissue sample from the Incitec Pivot grazing trial at Millvale in 2018, resulted in K:Na ratios in that forage of 460-500.

This compares with an implied required ratio of 5-7. (Dove *et.al,* 2009). Most current wheat varieties have similar K:Na ratios to this Kittyhawk⊕ sample and supplementation with 1:1 Causmag and sodium chloride mix is recommended to improve animal productivity.

Table 3. Nutrients in Kittyhawk⊕ wheat tissues, Millvale grazing trial 2018 sampled 6/6/2018

Total Nitrogen %	**Nitrate mg/kg**	**Phosphorus %**	**Potassium %**	**Sulphur %**	**Calcium %**	**Magnesium %**	**Sodium %**	**Chloride %**	**K/Na Ratio**
4.8	630	0.38	5	0.36	0.36	0.16	0.01	1.8	500
4.6	520	0.33	4.6	0.34	0.39	0.16	0.01	1.2	460

Sulphur

As sulphur is a dynamic nutrient, in that it is a mobile nutrient in soil and additional sulphur can come into the soil pool through mineralisation during the season. It is recommended to include testing for sulphur when sampling for deep nitrogen. In most areas, soil sulphur levels at depth are more than adequate for cereals. Additional sulphur may be required for canola.

Table 4. Distribution of results from sulphur tests (KCL40S) conducted for the central NSW region. (1786 soil samples, 0-10cm depth).
Results from Nutrient Advantage Laboratories Jan-June 2018

KCL40S mg/kg	<4mg/kg	4-8mg/kg	>8mg/kg
% of samples	15%	28%	24%

Trace elements

There have not been any documented responses in dry matter and/or grain yield to trace element application in grazing cereals or grazing canola in the central west. Zinc deficiency has been confirmed with tissue testing in main season wheat plantings on alkaline soils during cold wet conditions. Manganese toxicity is often seen in the leaves of early sown canola when surface soils are warm and dry. Frost damage in cereals is often misdiagnosed as copper deficiency. Confirm any observed symptoms with tissue testing before undertaking any remedial action. Withholding periods will need to observed if foliar application is undertaken.

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Management and profitability of dual-purpose crops

Ed Blackburn

Key words

dual purpose crops, profit, nutrition, graze, grain, nutrition, crop selection, weed control

Take home messages

- Sound summer fallow management will allow the soonest possible establishment when an opportunity arises
- Getting crops up and away at the earliest opportunity (once safe to do so) is critical to allow a decent grazing period
- Select species and varieties to suit each individual operation and enterprise
- Grazing management will directly impact liveweight gains and grain yields
- Excellent gross margins are on offer from grazing both home bred and trade cattle, especially when this allows cattle to be marketed at premium prices rather than being forced to take the going market price for store cattle
- Careful consideration needs to be given to nutrition (primarily nitrogen) through the longer growing season
- Most profitable outcome may not necessarily be from managing to maximise grain yield at the expense of liveweight gains.

The key drivers to success of dual-purpose crops can be considered in two main areas, management practices and decisions involved in getting the crop to a grazeable state, and then the management through the grazing period until lockup and on to grain harvest.

'Dual purpose' or 'graze and grain' crops allow potential increases in productivity, profitability and diversity of a farm's enterprises and incomes and can also arguably reduce overall risk. Management of dual-purpose crops is involved and certainly not set and forget. A well-managed dual-purpose crop has the potential to return greater gross margins than both grain only and grazing only crops, though when not managed well, this performance can be significantly reduced.

On our family owned mixed farm near Mendooran NSW, the vast majority of crops sown are dual purpose and are primarily utilised to grow weaner cattle to feedlot entry weights. In good seasons when feed allows, a percentage of cattle may be kept and grown out to heavier weights for processors. We find that having dual purpose crops provides high quality feed for the young (10-month-old) weaners through a time of year when other pastures would be very limited and the timing of their sale to feedlots generally coincides with a suitable time for the crops to be shut up for grain recovery. This leaves some significant upside in grain harvest, if and when the season allows. If well managed, the dual-purpose cropping phase also leaves paddocks clean of weeds and ready to be sown to improved perennial pastures at the end of the crop rotation.

Pre-grazing management – 'getting the crop up and away'

The process begins with a clean and disciplined *summer fallow program*, preferably no-till though in some cases cultivation may be required when bringing new paddocks into the cropping phase to level them up to allow zero or minimum till from that point on. Ideally this commences in the spring before barley grass, ryegrass, silver grass and other weeds set viable seed. Well maintained summer fallows have been shown to have up 86mm more plant available water and up to 69 more units of stored nitrogen per hectare (McMaster and Graham 2014) when compared to uncontrolled summer fallows. More stored moisture increases the chance of an early sown crop germinating and surviving warm periods through March soon after sowing, and often allows for positive growth to continue despite limited rainfall through March and early April. More stored nitrogen is vital for these longer dual-purpose crops which can have up to a 10-month growing season.

In many years in our area, (2018 was one of them), an early sowing opportunity arises in late February or early March only to be followed by significant periods of limited rainfall through March and April (13mm 19th Feb 2018, then 25mm 25th Feb, 26mm 5th March, 25mm 26th March followed by no rain in April, 13mm in two falls 21 days apart in June and no rain in July). If crops aren't *sown in a timely fashion* to capitalise on available moisture, patchy and disappointing or late crop establishments occur, and the result is limited dry matter production for hungry stock come May-June-July.

There are numerous species and varieties suitable for dual purpose cropping ventures. Oats, triticale, barley and wheat in the cereals, as well as canola in more recent times. Given we are a cattle operation, we have stuck with cereals to date.

There are a number of considerations when *selecting* which *crop and variety* to grow. The sowing of awnless varieties in frost prone areas allows crops to be grazed out late or cut for hay in the event the crop is frost damaged. Spread crop maturity and dry matter production via either varying sowing dates or sowing several varieties. We find keeping one variety with a true and strong winter habit means we can capitalise on early sowing opportunities in late February, while also being a good fit if no sowing opportunity arises until April. Variety selection may also be based on the likelihood of the crop being harvested. For example; in a more livestock focused operation where grain harvest may be a nice benefit in the right season, an awnless variety which can easily be grazed out late may be the best fit, even if it comes at the cost of a lesser disease and grain package. While for an enterprise more focused on the grain harvest where the manager seeks to capitalise on a quick grazing opportunity, a quicker variety perhaps with less dry matter production and a better grain and disease package could be the best option. Finally, where weed control is paramount, selecting the best species to keep open the most weed control options for the problem weeds is often a big factor.

Getting crop *nutrition* right early is an important factor in getting early sown dual-purpose crops away and to a grazeable state in the least possible time. Shallow and deep soil testing 2-3 months prior to sowing allows fertiliser budgets to be designed to ensure supply of sufficient nutrients, namely phosphorus (P) and nitrogen (N) to the crop. Some rules of thumb when nitrogen budgeting for dual purpose crops are that; 25-35 units of N are required for each tonne of dry matter to be grown. This is then followed by another large N requirement when the crop is locked up and expected to make grain. For H2 wheat at 11.5% protein, this requires another 44 units per tonne of grain produced. At 5 tonnes of dry matter and 3 tonnes of grain per hectare, that totals 282 units of nitrogen required per hectare to grow the crop (not all is removed from the paddock, but it is required through the season). See the nitrogen supply curve (Figure 1) for a paddock which was summer fallowed and sown to a dual-purpose crop of winter wheat. Note the extremely low N availability by early winter, when the crop still has more dry matter and grain to produce.

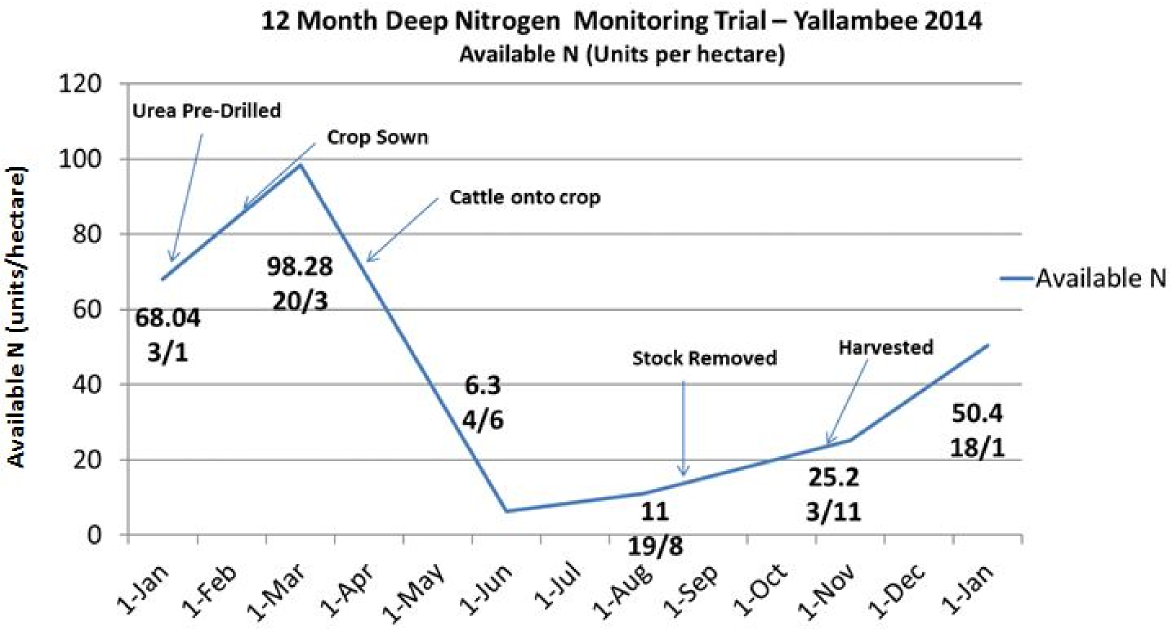

Figure 1. Nitrogen availability over a 12-month period in a winter wheat cropped paddock - 'Yallambee', Cassilis, 2014

Finally, early in-crop *weed control* and *insect management* are often vital in ensuring the crop is grazeable in the least amount of time possible. Controlling weeds early, often results in the best possible kill and also minimises their competing with the crop for resources. This is particularly important in paddocks which are destined to be sown to improved pastures. Early control of insects, namely aphids, prevents both crop damage and perhaps most importantly, the infection of the crop with barley yellow dwarf virus for which they are a vector. When spraying insecticides and herbicides consideration needs to be given to grazing withholding periods of products used.

Grazing management of the crop – 'maximising utilisation, regrowth and grain recovery'

Being able to graze crops in a timely manner and move stock onto the next area, cell or paddock to allow recovery before re-grazing is an important management consideration. By grazing a smaller paddock with a good number of animals, an even grazing to an ideal height or amount of ground cover can be achieved. This *increases utilisation* and *maximises* the crops *recovery* ready for the second and sometimes third grazing.

A key consideration is the *number of stock* required to graze the crop at certain times, or alternatively how many stock will need to be on hand (bred, purchased or agisted) at certain times to properly graze the crops to optimise grazing income. This is something that needs to be considered well before sowing when planning the cropping rotations. In our case, we work on stocking crops for around half of the grazing period at a rate of 1 tonne of liveweight per hectare of crop. For example, three 330 kg cattle weaners or 40 x 25 kg lambs per hectare. At this rate we would normally expect a paddock to last around 4 to 6 weeks, before moving them to the next area and allowing around 4 weeks recovery before grazing again. This is often a hard budget to do as it can be so variable with the seasons. In 2016 for example, a very wet year, we couldn't graze crops down at that stocking rate even when they were left on the one paddock for 2-3 months, while in 2017, we had around 4 weeks grazing at that stocking rate and then recovery for a second grazing was extremely slow given the dry conditions which saw more crops then left to be grazed out into the spring than had been planned initially. Most years we allow 0.8 ha per weaner, as well as 1 ha per calving heifer which are drifted on after they calve.

Nitrogen management is an important issue to consider throughout the crop, with earlier applications towards the end of, or after the first grazing hastening recovery and bulk for the second grazing, and also providing nitrogen for the grain production phase later in spring. We find nitrogen management in dual purpose crops to be quite variable with each season different as it unfolds. Supplying enough up-front to ensure good establishment and growth until the first or second grazing is a good approach. This then allows a decision to be made depending how the season is shaping up (primarily on the moisture front) as to whether a top-dressing will take place. In good rainfall years, in the majority of paddocks, it is likely that without decent in-crop nitrogen applications later (around July-August), grain yield will not be able to be maximised due to a short-term nitrogen deficit. This is often reflected in low grain protein percentages. In these cases, yield potential has been left in the paddock. As good work by Grain Orana Alliance (*GOA)* has shown over past seasons, a large percentage of applied nitrogen, even if not utilised by the crop to which it was applied, will remain for the following crop/s (provided good fallow management in between crops).

Animal health management is a big part of ensuring weight gains are maximised and risk of mortality is minimised. Ensuring 5 in 1 or 6 in 1 vaccinations are up to date and young animals are free of parasite burdens, reduces the risk of losses to clostridial diseases and improves animal performance.

How hard and how long into spring *to graze the crop* are important decisions. Often the choice is a difficult one, with the most profitable formula depending on livestock and grain prices at that point in time and how likely grain yield will be affected by each extra day's grazing. A trial conducted at 'Tongy Station' Coolah, in 2014 in conjunction with Dr Lindsay Bell of CSIRO, found that yield of dual-purpose crops was determined by both timing of stock removal and the amount of residual dry matter at the time of lockup (Table 1). In essence, it was a sliding scale where locking crops up earlier with good amounts of dry matter gave the best grain yield, through to the treatments which were locked up late and had lower amounts of dry matter giving the lowest grain yields. It is important to note that the most profitable outcome may not necessarily be from managing to maximise grain yield at the expense of liveweight gains.

Table 1. Summary of results for winter wheat lockup timing and grazing intensity trial - 'Tongy Station', Coolah, 2014.

Treatments	Residual biomass @ lock-up (t/ha)		Grain yield (t/ha)	Yield reduction % vs un-grazed	Screenings (%)	Protein (%)
	29 Jul	29 Aug	Harvest			
Ungrazed	1.39		2.15	NA	9.6	9.6
Grazed only	0.76		1.91	11.2	10.5	10.5
Grazed + mow	0.55		1.64	23	10.4	10.4
Late graze only		0.93	1.55	27.9	9.6	9.6
Late graze + mow		0.72	1.49	30.69	10.0	10.0
Late graze + hard mow		0.55	1.49	30.69	9.8	9.8

Different varieties will reach the ideal growth stage for lock-up at different times. This will often vary year to year. The ideal growth stage to maximise grain recovery is around Zadok's growth stage 32. This can be determined by slicing the cereal primary stem open longitudinally to assess where the growing point is up to and whether or not the nodes have begun to move up. The GRDC publication 'Disease management and crop canopies', details different cereal growth stages and shows how to distinguish the crop growth stage. The publication also gives an idea of what percentage of yield each of the reproductive leaves contribute and importantly, when (and where) the crops reproductive capacity is being set. Knowledge of the latter in particular, helps inform decisions as to when stock are removed.

After stock removal it is important to continue to *monitor the crop*. This is primarily to ensure everything is going to plan for grain production. Depending on variety, seasonal conditions and an assessment of inoculum load, foliar fungicides for leaf and stripe rust may be required. Note that disease susceptibility ratings do change for varieties over time and varieties once resistant may now be susceptible to infection as the pathogens overcome plant genes for resistance or tolerance. A potentially more devastating occurrence is a late frost which can see crops written off. Given the time at which these crops are often flowering, periodic monitoring for frost damage is important. As mentioned earlier an awnless variety can be easily cut for hay as soon as frost damage is identified (if severe enough) and a good income still salvaged.

Profitability considerations of dual-purpose crops

The profitability of dual-purpose crops, as with all cropping and pasture enterprises is driven by the costs incurred, the quantity of commodities they produce and the price of those commodities. Every year on the back of ever variable cattle, sheep and grain markets, variable dry matter and grain yields and varying prices and amounts of inputs such as fertiliser and herbicides, gross margins will go up and down.

Over the years we have found that on <u>average</u> we manage to run around 2.5 weaners or steers/ha for 60 of the 90 days of June-July-August and while doing so, achieve average daily gains (ADG) most often in the vicinity of 1.4-1.6 kg per head (cattle). Even at a more conservative 1.25 kg ADG, that is 250 kg meat produced per hectare, and at $3/kg into feedlots is $750 income per hectare just from the grazing. In an average year, grain yields are generally around 2.5t/ha and in good years have been above 5t/ha. At 2.5t/ha and $300/t on farm for H2, that is another $750 income per hectare for the grain.

A big feature we like about dual purpose crops, (other than of course being able to grow our young cattle to feedlot entry weights), is the position you are in the day before harvest. In the gross margin tables below, you will see that the dual-purpose crop has already made money, whilst the main season crop is still standing in the paddock yet to return a cent. If insured, this income is protected, though this risk management aspect is something we really like about the dual-purpose crop option.

Table 2. Winter wheat vs main season wheat gross margin

WINTER WHEAT			MAIN SEASON WHEAT		
COSTS			COSTS		
Timing	Activity	Cost $/ha	Timing	Activity	Cost $/ha
1st Dec	Fallow spray one	$20.00	1st Dec	Fallow spray one	$20.00
1st Feb	Fallow spray two	$20.00	1st Feb	Fallow spray two	$20.00
1st Apr	Knockdown spray	$19.00	1st Apr	Fallow spray three	$20.00
	Sowing	$40.00	1st Jun	Knockdown spray	$19.00
	Seed cost @50kg/ha	$21.50		Sowing	$40.00
	Starter fertiliser cost	$56.00		Seed cost @50kg/ha	$21.50
2nd Apr	Logran® spray	$10.00		Starter fertiliser cost	$56.00
1st Jun	Top dress urea @ 150kg/ha	$90.00	2nd Jun	Logran spray	$10.00
15th Jun	In crop broadleaf spray	$35.50	1st Aug	In crop broadleaf spray	$35.50
1st Sep	Foliar fungicide	$12.25	15th Aug	Top dress urea @ 125kg/ha	$77.00
15th Dec	Harvest @ $17/t	$40.80	15th Dec	Harvest @ $17/t	$68.00
Total Costs		**$365.05**	**Total Costs**		**$387.00**
INCOME			**INCOME**		
15 May-15 Jun	1st graze	$290.63		grain (4t @ $300/t)	$1200.00
15 Jul-15 Aug	2nd graze	$290.63			
	grain (2.4t @ $300/t)	$720.00			
Total income		**$1301.25**	**Total income**		**$1200.00**
Position day before harvest		**$257.00**	**Position day before harvest**		**-$242.00**
Gross margin (income - costs)		**$936.20**	**Gross margin (income - costs)**		**$813.00**
ASSUMPTIONS					
Grower retained seed - $60/t grading cost, Hombre® Ultra treated, $300/t grain value on farm					
Croplift® 15 as starter applied @ 80kg/ha @ $700/t					
Urea is worth $550/t					
Contract spraying ($8/ha) sowing ($40/ha) and harvesting ($17/ha), urea spreading $8/ha					
Fallow sprays all 1.25L Roundup® Attack™ ($7.50/L) and tank-mix partner ($9/L), at 8-week intervals					
Post sow/Pre-em Logran ($2), In crop broadleaf spray 1.5L, Precept® ($27.50)					
Livestock gain 1.25kg/hd/day, cattle worth $3/kg into feedlot					
Stocking rate of 2.5 steers per hectare for 60 days of the 90 days of winter					
Grazed 15/5 for a month, spelled 15/6 for a month, grazed 15/7 for a month, locked up 15/8					
Grain (H2) is worth $300/t on farm					

The other big fit for dual purpose crops in our system is that they allow us to bring old run-down pasture paddocks into a cropping phase to be cleaned up from weeds without totally losing livestock feed production from those paddocks. In a year of oversupply of dry matter for the young stock, cows (particularly younger cows) and their calves can be utilised to help graze down crops and allow pasture country to rest and get away for spring. This also allows the cows to gain more weight, which is a safety net for later on, with generally little impact on grain yield if managed correctly.

A 2018 case study to finish

2018 was one of the worst rainfall years on record (the worst on record for many areas). The market for young store condition cattle was very weak, with prices often $1.80-$2/kg liveweight (LWT) for 200-250 kg weaners (even lower if lighter than that). In this case without dual purpose crops, or perhaps a dual-purpose crop which became grazing only in the end, you would either be forced to hand feed at high cost per head or sell and take whatever price you can get. At this time, the feedlot price for light feeder steers weighing 300-500kg was around $3.10/kg and relatively firm. This presented a very enticing trading opportunity and/or allowed the value of homebred stock to be drastically increased. While growth of most crops was very disappointing last year, many would have run 2 light steers per hectare for 2.5 months (it must be said many crops never germinated or germinated and died, unfortunately in those cases very little could be salvaged).

A 250 kg steer at $1.90/kg was worth $475 (either home bred or traded). Growing at 1.25 kg ADG for 75 days, the steer would have weighed 343.75 kg and at $3.10/kg into the feedlot, was suddenly worth $1,065, an improvement of $590 in just 75 days. Two per hectare gives $1,180 gross income per hectare, even with a complete grain production failure in a terrible drought year.

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