GRAINS RESEARCH UPDATE

BOOSTING PROFITABILITY – RESILIENT SOLUTIONS

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

Corowa

Thursday 21 February

9.00am to 1.00pm

Corowa RSL Club,

30 Betterment Parade, Corowa

#GRDCUpdates

Corowa GRDC Grains Research Update convened by ORM Pty Ltd.

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GRDC Grains Research Update
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Contents

NORTHERN REGION*

PREDICTA DNA Soilborne disease tests B

PREDICTA® B
KNOW BEFORE YOU SOW

*NORTHERN NSW AND QUEENSLAND

Cereal root diseases cost grain growers in excess of $200 million annually in lost production. Much of this loss can be prevented.

Using PREDICTA® B soil tests and advice from your local accredited agronomist, these diseases can be detected and managed before losses occur. PREDICTA® B is a DNA-based soil-testing service to assist growers in identifying soil borne diseases that pose a significant risk, before sowing the crop.

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Potential high-risk paddocks:

- Bare patches, uneven growth, white heads in previous crop
- Paddocks with unexplained poor yield from the previous year
- High frequency of root lesion nematode-susceptible crops, such as chickpeas
- Intolerant cereal varieties grown on stored moisture
- Newly purchased or leased land
- Cereals on cereals
- Cereal following grassy pastures
- Durum crops (crown rot)

There are PREDICTA® B tests for most of the soil-borne diseases of cereals and some pulse crops:

- Crown rot (cereals)
- Rhizoctonia root rot
- Root lesion nematodes
- Yellow leaf spot
- Common root rot
- Pythium clade f
- Charcoal rot
- Ascochyta blight of chickpea
- Sclerotinia stem rot
- Long fallow disorder
- Phytophthora root rot
- Fusarium stalk rot
- White grain disorder
- Sclerotinia stem rot

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Program

8:55 am	**Announcements**	***Brett Symes,*** *ORM*
9:00 am	**Welcome**	***Riverine Plains Inc representative***
9:05 am	**GRDC welcome and update**	***GRDC***
9:15 am	**The 'National Paddock Survey' – what have we learned**	***Harm van Rees,*** *Cropfacts Pty Ltd*
9:55 am	**Applying R&D to help drive farm business profitability**	***Jordan Lindgren,*** *Lindgren Farms, Canada*
10:40 am	***Morning tea***	
11.10 am	**Riverine Plains Inc. research in progress**	***Cassandra Schefe,*** *Riverine Plains Inc.*
11:30 am	**Managing crop nutrient supply after a dry period**	***Graham Sandral,*** *NSW DPI*
12.10 pm	**Canola agronomy – key learnings from the 'Optimised Canola Profitability' project**	***Rohan Brill,*** *NSW DPI*
12.50 pm	**Emerging management tips for early sown winter wheats**	***James Hunt,*** *La Trobe University*
1.30 pm	**Close and evaluation**	***Brett Symes,*** *ORM*
1.35 pm	**Lunch**	

On Twitter? Follow **@GRDCUpdateNorth** and use the hashtag **#GRDCUpdates** to share key messages

Riverine Plains Inc

RiverinePlains

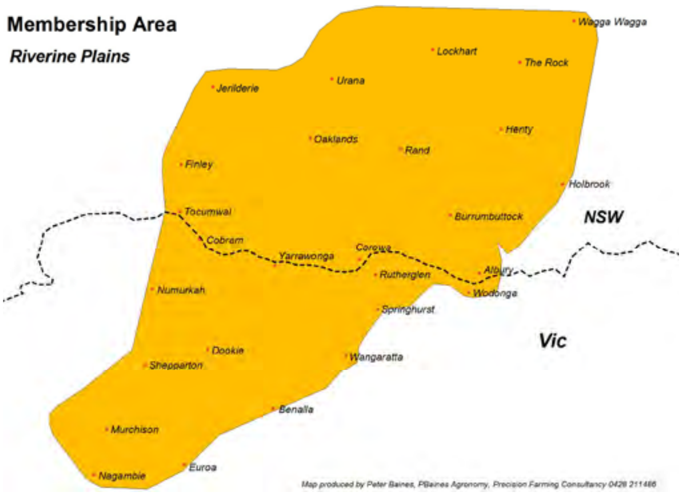
Farmers inspiring farmers

Riverine Plains Inc is an independent farming systems group dedicated to improving the productivity of broadacre farming systems in northeast Victoria and southern NSW.

Our membership (and our name) is drawn from the agro-ecological zone known as the Riverine Plain.

Riverine Plains Inc specialises in farmer driven research and extension that delivers on-the-ground benefits to the region's growers. Our focus is on providing independent, timely and relevant information through a rigorous research program and our annual schedule of events and publications.

As an independent organisation operating across state boundaries, Riverine Plains Inc works to enhance the extension of state and regionally based research results to the region's growers. Our ties to industry, research and funding organisations also means that we can design and develop new projects to address regionally specific or cross-border issues.



Providing quality information

Riverine Plains Inc delivers information and research results across a range of formats to meet the needs of our members. We publish a bi-monthly hardcopy newsletter and send out regular email communications, including our grower updates, event invitations and the Grower Bulletin which is produced on an as-needs basis throughout the growing season.

Our flagship annual publication "*Research for the Riverine Plains*" delivers the results of research carried out by the group, as well as external research relevant to the Riverine Plains region.

Sharing ideas

Central to our philosophy of 'Farmers inspiring Farmers' is our annual events program, which includes field and machinery days, paddock walks, seminars, discussion groups and study tours. Our events bring together farmers, researchers and industry experts to share ideas, seasonal information, research results, technical experience and business expertise.

Leading research

The research capacity of Riverine Plains Inc is widely recognised across the Australian grains industry and we partner with a range of leading research and extension organisations to carry out locally-relevant, farming systems projects. This delivers meaningful, local results that address the challenges faced by our members and the wider grains community.

Membership

We have 3 different membership options available; $80/year Farming Membership ($220 for 3 years), $350/year Corporate Membership, or a free university Student Membership.

For further information, or to download a membership application form please visit our website at riverineplains.org.au/membership/ or contact the office on 03 5744 1713.

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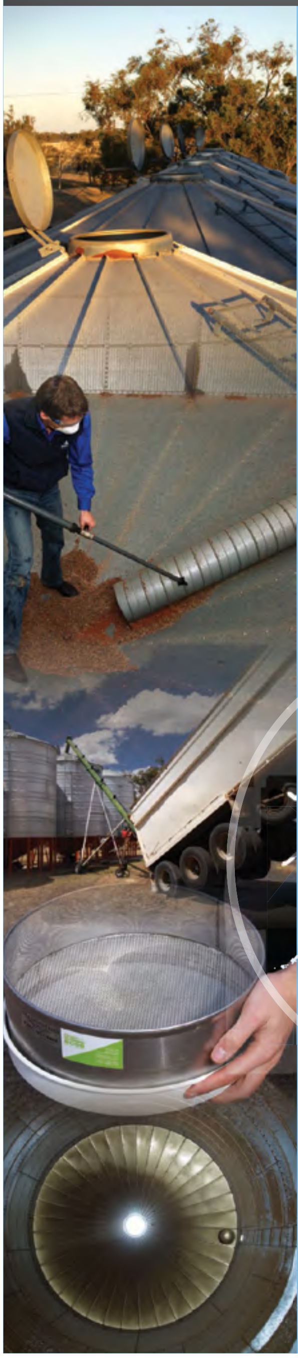

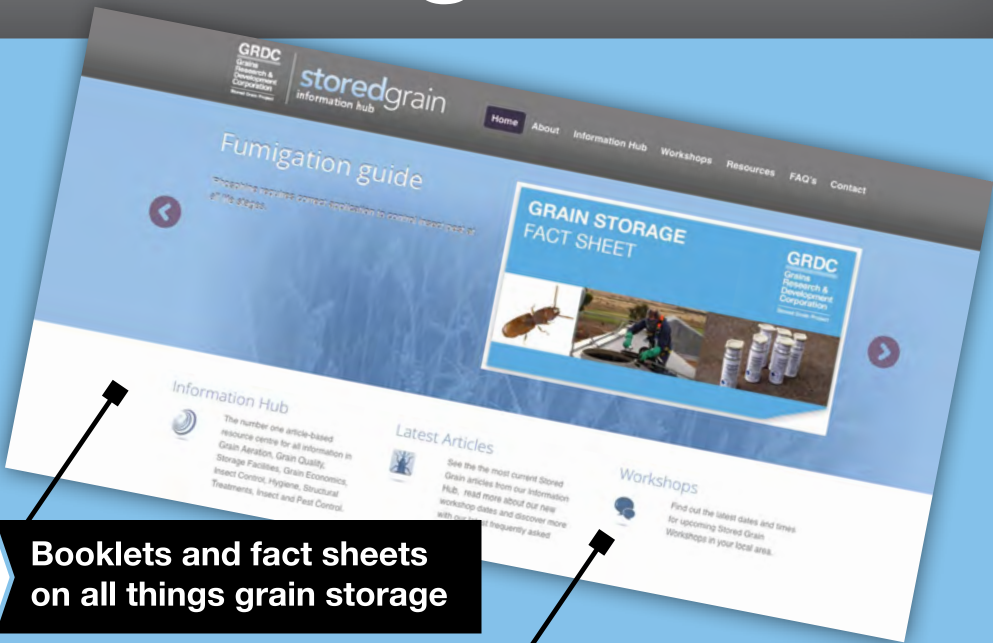

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Workshops in all regions covering topics such as:

- Economics of on-farm storage
- Grain storage hygiene
- Aeration cooling or drying
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- Insect pest management
- Managing different storages
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National Paddock Survey – closing the yield gap and informing decisions

Harm van Rees[1], Chris Minehan[2], Jeremy Whish[3], Elizabeth Meier[3], David Gobbett[3], Roger Lawes[3], Chao Chen[3], Tim McClelland[4], Stephen van Rees[5], Vicki Lane[5], Alan McKay[6] and Steven Simpfendorfer[7].

[1]Cropfacts/BCG; [2]RMS; [3]CSIRO; [4]Model Agronomics/BCG; [5]SquareV; [6]SARDI; [7]NSW DPI.

GRDC project code: BWD00025

Keywords

- potential yield, yield gap, limiting factors, APSIM, WUE.

Take home messages

(from work undertaken on 15 paddocks in southern NSW, 2015 to 2018)

- Intensive monitoring of soils and crops over a rotation sequence has identified why crops do not achieve their potential yield.
- Reviewing paddock performance at the end of the season and using paddock records are essential for sustained improvement in agronomic performance.
- Over the four-year rotation, 120 paddock zones were intensively monitored. Out of these, 100 paddock zones were planted to a cereal or canola. Insufficient nitrogen (N) was the main cause for the yield gap in 34 paddock zones. Half of these occurred in 2016, with the other half distributed between 2015 (10) and 2017 (7). No N deficiencies were seen in 2018. Waterlogging in 2016 caused significant damage and decreased yield. Diseases, weeds and insects also contributed, but were less severe in impact. Frost and heat shock were also a significant cause of the yield gap, especially in 2017 and 2018.

Background

Yield gap is the term applied to the difference between achieved and potential yield, where potential yield is estimated from simulation models. On average, Australia's wheat growers are currently estimated to be achieving about half their water-limited potential yield (Hochman et al. 2016, Hochman and Horan, 2018). Previous research with individual growers in the Wimmera/Mallee in Victoria determined that the long-term yield gap for those growers was approx. 20% (van Rees et al. 2012). For a national overview of the estimated yield gaps, see www.yieldgapaustralia.com.au

National Paddock Survey (NPS) is a four-year (2015 to 2018) GRDC project designed to quantify the yield gap on 250 paddocks nationally and to determine the underlying causes. Further, its aim is to establish whether management practices can be developed to reduce the yield gap to benefit farm profitability. The project aims to provide growers and their advisers with information and the tools required to close the yield gap.

Method

Nationally 250 paddocks, 80 in each of WA and northern NSW/Qld, and 90 in southern NSW, Vic and SA, were monitored intensively over a four-year rotation (2015 to 2018). Consultants and Farming Systems groups undertook the monitoring. Two zones in each paddock were monitored at five geo-referenced monitoring points along a permanent 200m to 250m transect. Each monitoring point was visited four times per season (pre- and post-season soil sampling and in-crop at the equivalent crop growth stages of GS30 and GS65). Yield map data was obtained for each paddock which enabled the yield of each zone to be determined accurately. Table 1 lists the annual monitoring undertaken in each zone.

All paddocks were simulated with the Agricultural Production Systems sIMulator (APSIM) (Holzworth et al. 2014) and, during the season, Yield Prophet® was available to all consultants and growers.

The whole data set (four years x 500 paddock zones) is being analysed by Roger Lawes, CSIRO, for factors primarily responsible for the yield gap in each of the three GRDC regions (Lawes et al. 2018).

This paper outlines the results of fifteen paddocks from one consultant, Chris Minehan, working in southern NSW. The results are discussed as a paddock specific yield gap analysis over four seasons focused on outcomes for the grower and consultant.

Results are presented as the modelled APSIM simulations in which:

- Ya = Actual Yield (as determined for each zone from yield map data).
- Ysim = Simulated Yield (for the same conditions as those in which the crop was grown).
- Yw= Simulated water limited, N unlimited yield (for the same conditions as those in which the crop was grown, but with N supply unlimited). Yw is considered the potential yield for the crop.
- The Yield Gap is calculated as the % difference between Yw and Ya using the equation ((Yw-Ya)/Yw).

Note: *APSIM currently accurately simulates wheat, barley and canola. We have not attempted to simulate the other crop types grown (lupins, lentils, faba beans, chickpeas, vetch, field peas).*

Data was entered via the NPS website and stored in a purpose-built SQL Server database.

Results and discussion

Annual individual paddock results

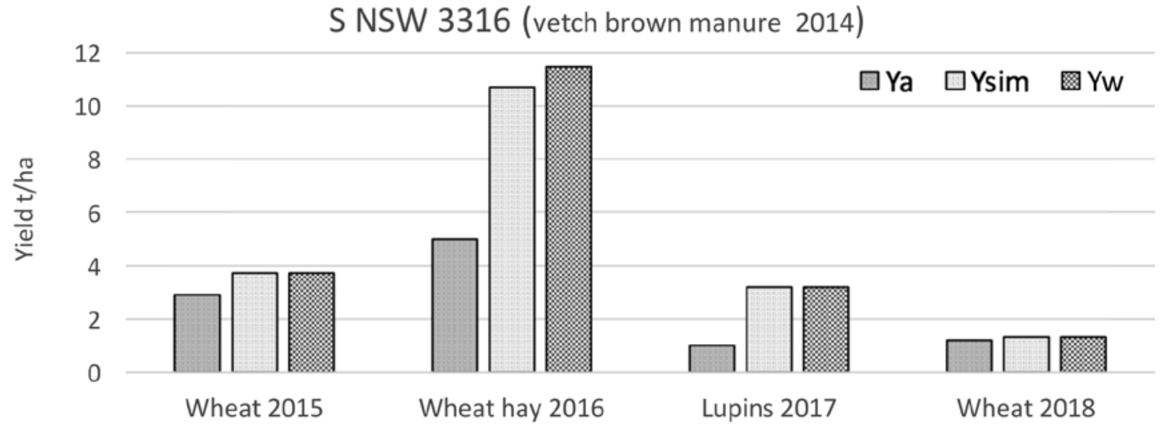
Data from three paddocks in southern NSW are presented as examples of outputs as informed by the paddock monitoring.

Table 1. Overview of monitoring and data collected per zone for each NPS paddock.

Monitoring	Timing	Monitoring	Timing
Deep soil test 4 depths (0-100cm)	Pre-sow	Paddock yield and yield map data	Post-harv
PREDICTA® B (0-10cm)	Pre-sow	Crop density, weeds, foliar diseases, insects (/m^2)	GS30
Deep soil test 4 depths (0-100cm)	Post-harv	Cereal root sample to CSIRO	GS30
Crop and variety		Weeds, foliar diseases, insects/m^2)	GS65
Sowing date and rate		Cereal stubble/crown for Fusarium	Post harv
Fertiliser, herbicide type, rate, date		General observations	
Temp buttons (1 per paddock)	GS60-79		

Example 1. Rotation: vetch brown manure (2014), followed by wheat, wheat, lupins, wheat.

Paddock southern NSW. NPS 3316 Zone A: sandy loam over clay.
Ya=Actual yield; Ysim=Simulated yield; Yw=Water limited N unlimited yield (potential yield).



Paddock and crop information over the rotation. (Note - nd is 'not detected')
N available* 2015 (following vetch brown manure): 189kg/ha
N available 2016 (following wheat): 216kg/ha
N available 2018 (following lupins): 172kg/ha
Water available# 2015: 296mm
Water available 2016: 524mm
Water available 2018: 182mm

*Note: * N available = soil N pre sow – N post harvest + fertiliser N*
 # Water available = water pre sow – water post harvest + in-crop rain

Disease
PREDICTA® B: all years: Pythium* mod level
Root Health GS30: 2015, 16 Low to Mod
(Fusarium observed on roots in 2015)
Fusarium stubble: not observed
In-crop GS65: not observed
Weeds
In-crop GS30: 2015 Wild Oats 1/m^2
2016 Ryegrass 6/m^2
In-crop GS65: 2015 none
2016 Toadr 80, WO 2, Stonecrop 7/m^2
Insects: not detected

Days of Heat and Frost during GS60-79

	Heat > 34°C	Frost 0 to -2	-2 to -4°C
2015	1	0	0
2016	0	0	0
2017	0	2	0
2018	0	0	0

(note: temperature records from nearest BoM)

* Pythium root rot: all crops/pastures Canola/ pulses susceptible. Cereals less so

Interpretation

Crop 2014: Vetch brown manure

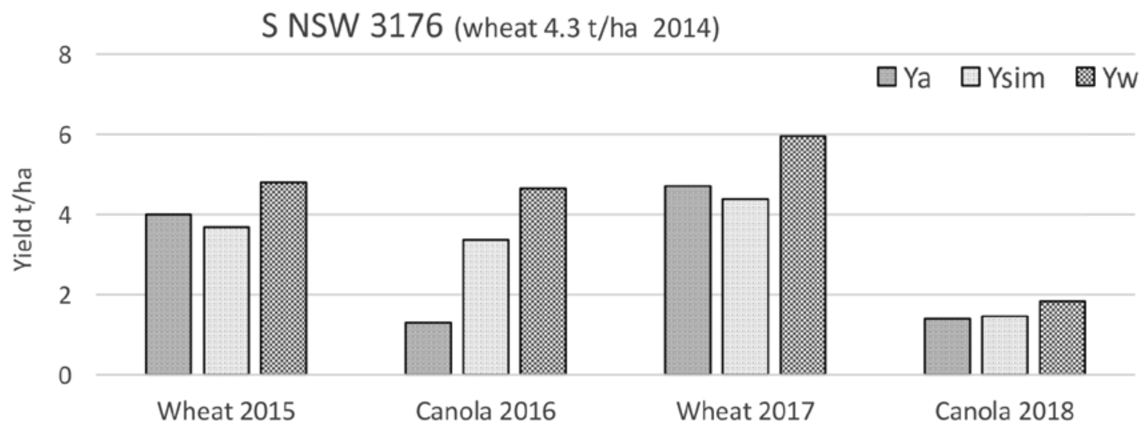
Wheat 2015: Ya<Ysim=Yw. When Ysim=Yw, it is a strong indication that the crop is not N limited. Simulated yield was 0.8t/ha (28%) higher than the actual yield which indicates some factors were limiting production. The crop did not have measurable disease, weed or insect problems. A possible factor contributing to the loss in yield appears to be one hot day during flowering and grain filling. *(Consultant note: Dart⁽ᶦ⁾ sown on 30cm spacings on 18 May, 2015)*

Wheat hay 2016: Ya<Ysim=Yw. N unlimited yield (Yw) was similar to simulated yield (Ysim), indicating the crop was not N deficient. *(Consultant note: Ya<Ysim: The paddock was heavily grazed during the wet winter, compaction resulted and recovery was poor)*

Wheat 2018: Ya=Ysim=Yw. Dry season with a low yield (1.2t/ha) and no factors were limiting production (i.e. the crop achieved its water limited yield potential)

Example 2. Rotation: wheat (2014), followed by wheat, canola, wheat, canola.

Paddock southern NSW. NPS 3176 Zone A: sandy clay loam over light clay.
Ya=Actual yield; Ysim=Simulated yield; Yw=Water limited N unlimited yield (potential yield).



Paddock and crop information over the rotation. (Note - nd is 'not detected')
N available* 2015 (following wheat): 225kg/ha (68kg N from fertiliser)
N available 2016 (following wheat): 292kg/ha (100kg N from fertiliser)
N available 2017 (following canola) : 169kg/ha (73kg N from fertiliser)
N available 2018 (following wheat) : 86kg/ha (8kg N from fertiliser)
Water available# 2015: 398mm
Water available 2016: 531mm
Water available 2017: 276mm
Water available 2018: 197mm

*Note: * N available = soil N pre sow – N post harvest + fertiliser N*
 # Water available = water pre sow – water post harvest + in-crop rain

Disease
PREDICTA® B: all years: Pythium* mod level
Root Health GS30: 2015, 2017 Low to Mod
2017 Prats High
Fusarium stubble: not observed
Disease in-crop GS65: not observed
Weeds
in-crop GS30: 2015 Ryeg. 30; 2016 132, 2017 11, 2018 18/m²
in-crop GS65: 2015 none
2016 Toadr 36/m²
Insects: Aphid 1/m²

Days of Heat and Frost during GS60-79

Heat	> 34°C	Frost 0 to -2	-2 to -4 °C
2015	0	0	0
2016	0	1	0
2017	0	1	0
2018	0	0	0

(note: temperature records from nearest BoM)

Consultant observations: 2016 waterlogging - lost crop; 2017 – frost damage significant

* Pythium root rot: all crops/pastures Canola/ pulses susceptible. Cereals less so

Interpretation

Crop 2014: wheat

Wheat 2015: Ya=Ysim<Yw. Ya = Ysim is a strong indication that the crop is not limited by biotic or abiotic stresses. Yw, potential yield, was higher than Simulated and Actual yield indicating N is limiting.

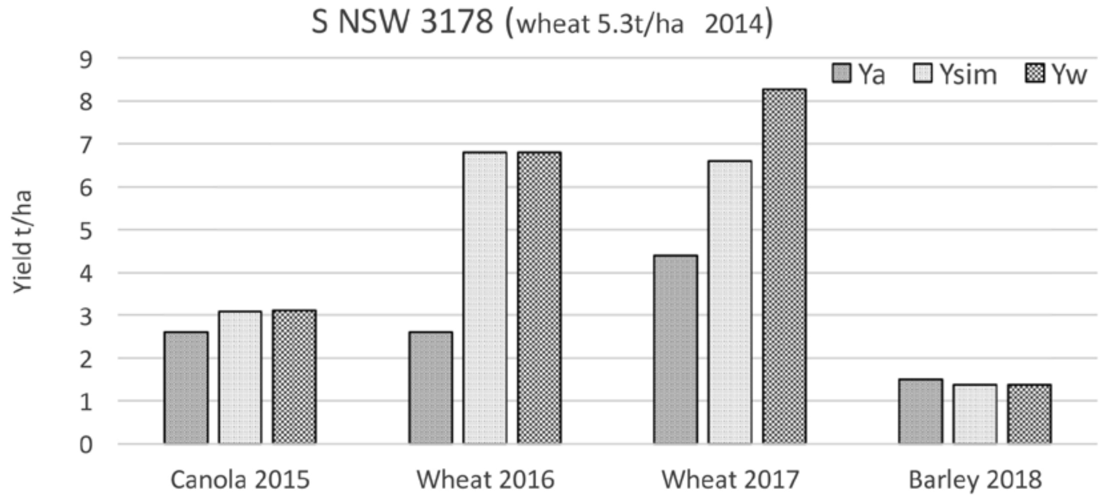
Canola in 2016: Ya<Ysim<Yw indicating that N was limiting, waterlogging was common for most of the winter. It is possible that Pythium had an effect on root development and possibly one day of frost (between 0 and -2) could have had an impact on the canola yield.

Wheat in 2017: Ya=Ysim<Yw is N limited.

Canola in 2018: Ya=Ysim=Yw no limiting factors.

Example 3. Rotation: wheat (2014), followed by canola, wheat, wheat, barley.

Paddock southern NSW. NPS 3176 Zone A: clay loam over clay
Ya=Actual yield; Ysim=Simulated yield; Yw=Water limited N unlimited yield (potential yield).



Paddock and crop information over the rotation. (Note - nd is 'not detected')
N available* 2015 (following wheat): 282kg/ha (117kg N from fertiliser)
N available 2016 (following canola): 259kg/ha (115kg N from fertiliser)
N available 2017 (following wheat) : 200kg/ha (97kg N from fertiliser)
N available 2018 (following wheat) : 136kg/ha (26kg N from fertiliser)
Water available# 2015: 345mm
Water available 2016: 422mm
Water available 2017: 382mm
Water available 2018: 159mm

*Note: * N available = soil N pre sow – N post harvest + fertiliser N*
 # Water available = water pre sow – water post harvest + in-crop rain

Disease
PREDICTA® B: all years: YLS high;
Pythium* mod level in 2015, 2016 and 2017
Root Health GS30: 2016, 2017 Mod
2017 Fusarium Mod
Fusarium stubble: 2017 very low level
Disease in-crop GS65: not observed
Weeds
in-crop GS30: Ryegr. 2016 28; 2017 28, 2018 54/m^2
in-crop GS65: 2016 Prick. Let. 4/m^2
2017 Silvg 4, WO 18/m^2
Insects: not detected

Days of Heat and Frost during GS60-79

	Heat > 34°C	Frost 0 to -2	-2 to -4°C
2015	0	2	0
2016	0	0	0
2017	0	0	0
2018	0	1	0

(note: temperature records from nearest BoM)

Consultant observations: 2016 severe waterlogging in Zone A. 2018 30% tillers frosted.

* Pythium root rot: all crops/pastures. Canola/ pulses susceptible. Cereals less so.

Interpretation

Crop 2014: wheat

Canola 2015: Ya=Ysim=Yw crop is not N limited, and no other limiting biotic or abiotic stresses.

Wheat 2016: Ya<Ysim=Yw crop is not N limited, yield penalty likely to be due to severe water logging.

Wheat 2017: Ya<Ysim<Yw crop is N limited and has been impacted by abiotic or biotic stresses (Fusarium was recorded in the stubble but only at very low levels). Wild oats were prolific (18 pl/m^2).

Barley 2018: Ya=Ysim=Yw low yielding crop with no yield penalties in a dry year.

Assessing crop performance - Water Use Efficiency versus modelling

The first paper on Water Use Efficiency (WUE) was published by French and Schultz in 1984. It was a break through at the time, enabling growers and agronomists to benchmark crop performance against a target and compare performance against other wheat crops. The French and Schultz WUE equation has since been updated by Sadras and Angus, 2006, and Hunt and Kirkegaard, 2012.

Hunt and Kirkegaard, 2012, calculate Crop Water Use as: Soil water pre-sowing – Soil water post-harvest + Rainfall during the same period. WUE is then calculated as Yield (kg/ha)/(Crop Water Use - 60). Potential yield is calculated as 22 x (Crop Water Use – 60).

The 2015 to 2018 southern NSW NPS cereal yields are plotted against Crop Water Use in Figure 1. The graph reveals a general tendency for Ya to increase with Crop Water Use with an upper boundary of yield. The upper boundary is reasonably interpreted as Yw for well-managed crops as Crop Water Use increases. The two lines included on the diagram are the Yw lines proposed by French & Schultz, 1984, and Sadras & Angus, 2006, calculated as Yw = 22 x (Crop Water Use – 60), to describe the most efficient use of water. This establishes a common maximum WUE of 22kg/mm/ha.

How useful is WUE compared with computer modelled assessments of potential yield, and what will the future hold?

Figure 1 and other data analysed by French & Schultz (1984) and Sadras & Angus (2016) demonstrate a considerable variation in Ya relative to Yw, i.e. a considerable yield gap in many crops. Key questions for growers and agronomists are what is the cause of the yield gap in each individual case and how can it be alleviated?

There are many possible causes that cannot be identified without careful paddock monitoring of abiotic and biotic factors, as attempted in the present project.

We must remember that using WUE to assess yield potential is a bucket approach to a complex problem in a system with many interactions. WUE will not explain the causes of a yield gap, nor can it inform on reasons for favourable outcomes. It may identify the presence of a yield gap, but not their underlying cause(s).

Causes of yield gaps

Abiotic factors

Variability is a feature of farming in Australia and there are several reasons why crop roots cannot access soil water and nutrition such as soil type (texture) and physical and chemical limitations. Chemical and physical constraints to root development can have a large impact on potential yield, such as due to severe waterlogging in some NPS paddocks in southern NSW in 2016.

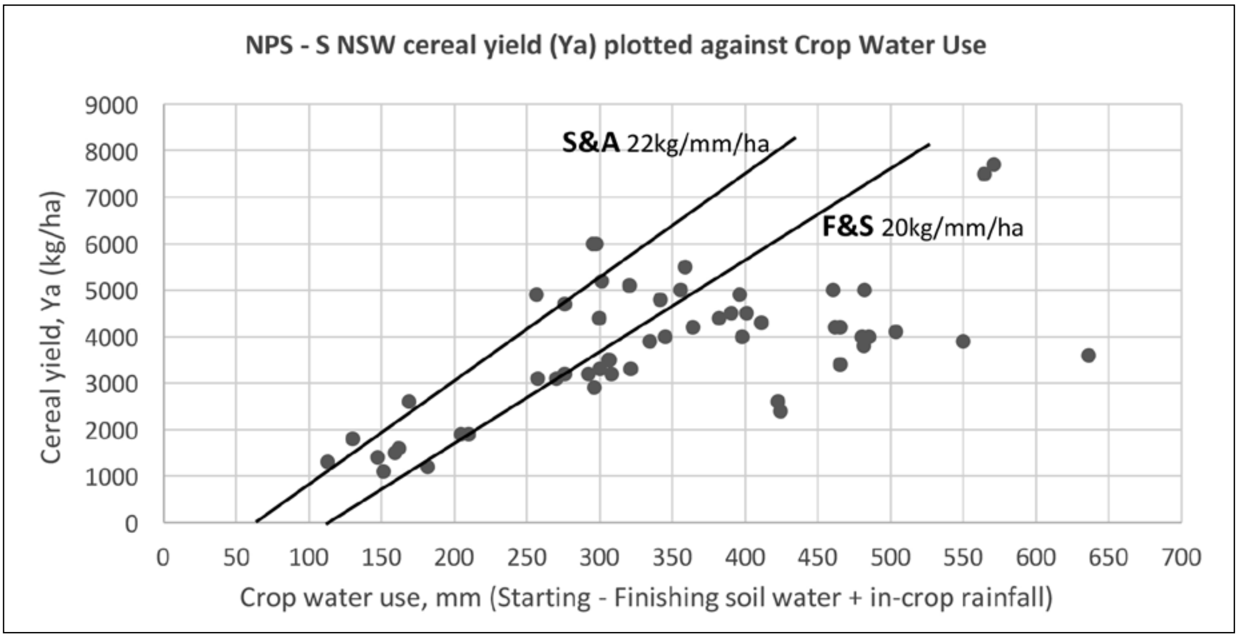


Figure 1. NPS – Southern NSW cereal yields (Ya) plotted against Water Use (2015 to 2018).

Interactions between soil type, available soil water and the amount of water extracted by the growing crop are influenced by crop growth and the distribution and amount of rainfall. If these factors are ignored, there is limited predictive capability of yield.

High and low temperatures at critical times of crop development can further cause devastating yield loss.

Crop nutrition appropriate to achieving potential yield (Yw) is relatively well understood and in the case of N, with many examples of successful tactical responses to fertilisation. But this is not matched for other nutrients such as phosphorus (P) and potassium (K), and micronutrients such as zinc (Zn).

Biotic factors

Major infestations of weeds, pests and diseases can cause dramatic yield loss and less serious infestations may cause greater losses than are commonly appreciated and remain unknown without careful paddock monitoring.

The nature of these biotic causes of yield loss vary greatly from site to site, paddock to paddock and also within paddock.

Going forward with crop simulation models

Crop models, such as APSIM used in this study, are focused on abiotic factors, but include biotic factors such as N nutrition. Their objective is to simulate yield (Ysim) in the absence of biotic factors such as weeds, diseases and pests and to estimate Yw by removing the effect of N shortage. For this, APSIM grows the crop on a daily time step and takes into account daily solar radiation, rainfall and availability of N. It uses soil-specific information for Crop Lower Limit (CLL) (wilting point) of the soil, defined as the soil water content below which water is not accessible to the crop. CLL is influenced by soil texture (sand, silt, clay content) and subsoil limitations (such as high chloride levels). APSIM also explains the importance of rainfall distribution in terms of growth reductions due to transient water stress. Extreme events of temperature (hot and cold), which may be important at less-than daily time scales, need to be further addressed.

Over the past decade, our industry has made huge advances in engineering, with precision agriculture enabling mapping of soil types across paddocks, understanding what affects the ability of crops to extract water and most importantly empowering growers to adopt precision seeding and to apply nutrients as required.

To fully utilise the power of crop models, we need to incorporate on-the-go modelled outputs to field operations such as seeding and nutrient applications. This could well be the next frontier in crop management. Biotic stresses such as weeds, diseases and pests can be included if the appropriate in-field observations are made.

The NPS project has demonstrated that, as crop management becomes more sophisticated, it is essential to understand the reasons why crops fail to perform at their potential. When we understand the reasons why crops do not reach their potential yield, we can better advise the growers we are working with.

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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 support of GRDC staff in the regional offices is also much appreciated.

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Observations from the 2018 Saskatchewan Young Farmer of the Year Award winners

Jordan and Jennifer Lindgren.

Lindgren Farms.

Notes

Jordan and Jennifer Lindgren, along with their four children, own and operate Lindgren Farms at Norquay, Saskatchewan, Canada. Lindgren Farms is a grain and oilseed farm that works diligently at maximising production for these crops, while minimising cost of production. They do this by using field scale trials to determine what products, genetics and practices work on their farm. By combining these methods, with the latest advancements in technology, they continue to meet and exceed their production goals.

They not only place importance on educating themselves, but also sharing this information with fellow farmers. Jordan and Jennifer partner with local agricultural distributors to host the 'Field of Dreams' tour that is held annually on their farm. It is an opportunity to share trial results from previous years and showcase the current trials that are focussed on new genetics, applications and variable fertiliser rates. They also educate the next generation on the importance of farming and teaching them where their food comes from.

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Riverine Plains Inc research update

Cassandra Schefe.

Riverine Plains Inc.

GRDC project codes: RPI00013, DAN00206, RPI0009

Keywords

- canola, sulphur, subsoil acidity, precision agriculture.

Take home messages

- Riverine Plains Inc conducts a range of research activities to provide local information to its members.
- Large farm scale trials provide farmer-relevant information.
- Understanding in-paddock variability can refine input use.

Background

Riverine Plains Inc is a progressive farmer group dedicated to improving the productivity of broadacre farming systems in north-east Victoria and southern New South Wales (NSW). The group provides relevant and unbiased research and information to its members and acts as a conduit for information flow from credible research sources to its membership.

During 2018, Riverine Plains Inc contributed to a range of research projects. This report will summarise the key information from these projects over the past year, including subsoil acidity, canola nutrition and plant available water (PAW) variation within paddocks. Results and key findings are to be presented at the February 2019 GRDC Grains Research Update at Corowa.

Project information

Optimising sulphur and nutrition in canola – a GRDC investment

The aims of this project were to identify if nitrogen (N) supply is limiting the uptake of sulphur (S) in canola crops of the Riverine Plains and to determine if S uptake and yield are increased when N is non-limiting.

The objectives of this project were to assess the response to N and S in canola crops of the Riverine Plains by determining:

- The influence of N and S application on canola tissue content, yield and oil content.
- The fluctuation in N and S content and N/S ratio in the plant from stem elongation to harvest, and
- The optimum N level of canola in the region at variable levels of S application.

Two trial sites were established at Howlong, NSW, and Yarrawonga, Victoria, in both 2017 and 2018 through a partnership with the Foundation of Arable Research (FAR) Australia, which managed the field research component.

A replicated randomised block design was used with four replicates, with plot sizes of 3m width x 18m length. The trial sites were sown with canola in April 2017 and 2018, after which combinations of the following treatments were applied.

Nitrogen was applied as urea in a split application between 6-8 leaf stage and green bud at five rates (0, 40, 80, 120, 160kg N/ha), with the first 40kg N/ha applied between 6-8 leaf stage, and the remainder applied at green bud.

Sulphur was applied as sulphate of ammonia (SOA) at four rates (0, 10, 20, 30kg S/ha). This was applied with the first application of in-crop N, with urea added to balance the N. These treatments were applied across the suite of N treatments to determine the interaction between N and S (Table 1).

Soil sampling was done across the sites pre-sowing (incremented to depth) to determine existing nutrient levels, and at the end of the season, in the nil and highest S treatments, to determine extraction of S from depth.

The trial site was managed as part of the surrounding commercial crop, except for the S and N applications.

The crop was monitored through the season, with tissue S samples at early flowering, dry matter (DM) sampling at first flower, pod set and harvest, yield and oil content, and % S content of biomass and seed.

Results from the 2017 season will be shown. Limited results from one site from 2018 season will be shown. Collection of a full set of data from the second site during 2018 was not possible due to the second site having to be abandoned due to poor and patchy growth and establishment.

Innovative approaches to managing subsoil acidity in the southern grains region – GRDC investment

Aim — To quantify the yield limitation caused by subsoil acidity and evaluate innovative soil amendments which act to ameliorate subsurface acidity.

Riverine Plains Inc is managing two farm-scale trials in the region for this project led by NSW DPI. A site at Rutherglen was established in February 2018, and one is currently being established near Devenish. Both will continue to be monitored for several years.

These trials are evaluating deep placement of lime, lucerne pellets and other products, compared to surface application of lime.

Results from the 2018 season will be shown for the first site.

Understanding subsoil acidity in cropping enterprises of the productive plains – Goulburn Broken Catchment Management Authority (GB CMA)

Aim — To understand the extent to which subsoil acidity may be limiting productivity of cropping systems in the Goulburn Broken cropping region.

Table 1. Treatment list: N applied as urea (46% N) and S applied as ammonium sulphate (21% N and 24% S)

No.	6-leaf stage GS1.06	Green bud (pre bolting) GS 3.3	Total S kg/ha S	Total N kg/ha N
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	40N 0S	0	0	40
6	40N 10S	0	10	40
7	40N 20S	0	20	40
8	40N 30S	0	30	40
9	40N 0S	40N	0	80
10	40N 10S	40N	10	80
11	40N 20S	40N	20	80
12	40N 30S	40N	30	80
13	40N 0S	120N	0	160
14	40N 10S	120N	10	160
15	40N 20S	120N	20	160
16	40N 30S	120N	30	160
17	40N 0S	200N	0	240
18	40N 10S	200N	10	240
19	40N 20S	200N	20	240
20	40N 30S	200N	30	240

n.b Treatments at 6-leaf stage (GS 1.06) applied as ammonium sulphate with residual N application applied as urea; The first 40kg N/ha of all N treatments applied at 6-leaf stage, remainder applied at green bud; Treatment list excludes monoammonium phosphate (MAP) applied at sowing with the commercial crop.

Soil acidification is a growing problem in the productive plains, which, if left unchecked, will reduce the productive potential of the region. While surface soil acidity (less than 10cm depth) is an ongoing issue, which some farmers are already aware of, acidification of the subsurface (greater than 10cm depth) is becoming a significant issue in the region, although largely undetected. Even if farmers conduct regular soil testing, most tests are only done in the 0-10cm, with no measurements at depth.

This project is looking for interested farmers across the region to participate in a free soil sampling survey to measure soil pH down to at least 20cm. The results from this sampling survey will be used to understand the extent of subsoil acidity and determine if further research or awareness activities are needed to reduce the incidence and spread of subsoil acidity.

Maintaining profitable farming systems with retained stubble in the Riverine Plains region – GRDC investment

Riverine Plains Inc has recently completed the stubble project titled 'Maintaining profitable farming systems with retained stubble in the Riverine Plains region'. This was a GRDC investment as part of a National Initiative (RPI0009) and conducted in partnership with FAR Australia.

A side research focus from this work was to understand in-paddock variability, specifically how PAW potential may change across paddocks due to soil type and/or soil constraints. Four focus paddocks were selected for this work — from Howlong, Rutherglen, Telford and Yabba South.

Examples of how potential water storage changes within these paddocks will be shown, corresponding to soil moisture probe data. Such information could assist in supporting decision making in a water-limited season, such as seen in 2018.

Conclusion

Riverine Plains Inc continues to conduct research on behalf of its members. To broaden the delivery of research to members, Riverine Plains Inc also collaborates with other organisations on a range of research projects, from crop nutrition to soil constraints. This supports the ongoing establishment of on-farm trials within the region, ensuring that the results obtained are immediately relevant to local farmers.

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.

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Nutrition decisions following a dry season

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GRDC project code: UQ82

Keywords

- crop nutrition, drought, nitrogen recovery.

Take home messages

- Fertiliser savings after drought or failed crop are possible with phosphorus (P) where there has been an extensive P fertiliser history and Colwell P values are at or above crop critical requirements. As a guide, one third of average crop P replacement can be applied down to a base level of 3-4kg P/ha.
- Savings in nitrogen (N) are likely to be less substantial than savings in P. Nitrogen savings are likely a result of higher spared N (mineral N carryover from last season), lower immobilisation due to lower crop residues and higher mineralisation rates assuming adequate late summer and early autumn rains.
- To better assess spared and mineralised N, deep soil cores should be taken to 60cm and split at 30cm to determine the amount and timing of mineral N availability.

Background

Fertiliser costs represent 20-25% of variable costs for growing grain crops. This proportion is likely to increase with the continued decline of soil organic matter and corresponding reduction in annual soil mineralisation of N (e.g. Angus and Grace 2017). In approximate terms, the N mineralisation potential in cropping soils is declining by 50% every 25 to 30 years (Helyar et al. 1997, Heenan et al. 2004). Soil mineralisation of N is not enough to meet crop demand, consequently N fertiliser is typically applied pre and/or post sowing. The in-crop efficiencies of fertiliser N retrieval in the year of application vary greatly, with approximately 44% in above-ground plant parts, 34% in soil and 22% not recovered, which is presumably lost (Angus and Grace 2017).

Soil mineral N at the start of the growing season still has a large impact on fertiliser N budgeting. Soil mineral N is a function of a number of variables including: [(spared N) + (total N mineralised)] – [(N immobilised) + (weed N uptake) + (N lost)]. On the plus side of the equation; **spared N** is the carryover of mineral N from the previous year and **total N mineralised** is N from mineralised plant residues and mineralisation of the soil organic N pool by microbes. On the negative side of the equation; **N immobilisation** is the N used by microbes to break down crop residues, **weed N uptake** represents another means of N tie up, and **N lost** considers leaching, denitrification (nitric and nitrous oxide and nitrogen gas), erosion and other gaseous losses (ammonia). After drought it is possible that spared N is higher due to lower exports of N in grain. Other considerations after drought include lower immobilisation rates due to lower quantities of crop residues and higher rates of mineralisation after the drought breaks.

Phosphorus is the other substantial annual fertiliser input for crop production in southern NSW. The extensive history of P application and mostly adequate to high soil Colwell P values in this region allow many growers some flexibility in managing P inputs, particularly where cash flow maybe limited following a dry season. The flexibility in P management is also made possible as crop uptake of P is primarily from the soil reserve with a smaller but important component coming from starter P applied at sowing.

In this paper we discuss both P and N considerations after drought. In the N section we consider an experiment examining the recovery of spared N in a 2018 canola crop where the N was applied to a wheat crop in 2017.

Nitrogen with an emphasis on spared nitrogen

Methods

2017 nitrogen experiment

This experiment was sown at Wagga Wagga Agricultural Institute, NSW on 14 May and included one wheat variety (cv. Beckom⁽ᴰ⁾), nine N rates and four N application methods with N applied as mono-ammonium phosphate (MAP) and/or urea (Table 1) in a fully randomised complete block design with four replicates.

The soil at the experimental site was a Red Kandosol with a starting mineral N content of 42kg/ha to a depth of 1.5m (May 4). The previous crop was barley which was burnt late prior to sowing. Soil pH ($CaCl_2$) was 5.8 (0–10cm), 4.7 (10-20cm) and 5.5 (20-30cm) and Colwell P was 57mg P/kg soil (0-10cm). The experiment was direct sown using Ausplow DBS tynes spaced at 250mm. At sowing, 100kg MAP (22kg P/ha and 10kg N/ha) was added to all treatments except the nil N treatment which received triple superphosphate at 22kg P/ha to balance all treatments for P. In plots receiving MAP, various amounts of urea were added to provide the N rates 35kg N/ha through to 185kg N/ha. Mean plant density at DC14 was 127 plants/m^2 and was not significantly different between treatments. In crop weed control was undertaken by applying the pre-emergents Sakura® (pyroxasulfone 850g/L) at 118g/ha and Logran® (triasulfuron 750g/L) at 35 g/ha on 14 May and was incorporated at sowing. Precautionary disease control was implemented, seed was treated with Hombre ® Ultra [Imidacloprid (360g/L) and Tebuconazole (12.5g/L)] at 200mLs/100kg and Prosaro® (Prothioconazole 210g/L and Tebuconazole 210g/L) was applied at 300mL/ha at DC 31.

The experiment was harvested on 30 November. Grain protein and seed quality were estimated using near infrared (NIR) (Foss Infratec 1241 Grain Analyzer) and Seed Imaging (SeedCount SC5000R), respectively. Nitrogen offtake was estimated by protein (%)/5.7 (conversion constant) x grain yield (t/ha). The proportion of apparent fertiliser N recovery in grain was calculated by (GrainN+N – GrainN-N)/N rate where GrainN+N is the grain yield with fertiliser N, GrainN-N is grain yield with no fertiliser N and N rate is the amount of fertiliser N applied. Economic returns after N costs were determined on 2017 prices (e.g. Junee 11th Dec) were calculated by multiplying grain yield (t/ha) by $210 for AUH2, AUH2, AGP1, $250 for AWP1, $265 for H2 and $280 for H1. Pre- and post-rain grain price was only influenced by test weight, protein and falling numbers. Grain discolouration was not significant enough to impact on price.

2018 nitrogen experiment

This experiment was sown into last year's wheat stubble on 5 May over the exact location of the 2017 wheat by N and N application method experiment described above using canola variety 43Y92 sown

Table 1. Variety, N rates and N application methods.

Variety	x	N rate (kg/ha)	x	Application method
Beckom⁽ᴰ⁾		0		Mid-row banding at sowing (May 14) [**MRB**]
		10		Spread and incorporated by sowing (May 14) [**IBS**]
		35		Deep placement under each row at sowing[**DP**]
		60		Broadcast at DC30 (July 28) [**BSE**]
		85		
		110		
		135		
		160		
		185		

at 4.5kg/ha. The aim of the experiment was to determine grain yield and N recovery (recovery of spared N) in 2018 from N applications made in 2017. The experiment received 20mm of irrigation immediately after sowing (5 May) and had 32mm of stored soil water as well as growing season rainfall (May to October) of 154mm providing a total of 196mm.

At sowing 100kg MAP (22kg P/ha and 10kg N/ha) was added to all treatments except the nil N treatment which received triple superphosphate at 22kg P/ha to balance all treatments for P. In-crop weed control was undertaken by applying the pre-emergent herbicide Treflan at 2.0L/ha prior to sowing. Precautionary disease control was implemented with Prosaro® (375mls/ha) at 20% flowering.

The experiment was harvested on 15 November (hand harvest by cutting 2/m^2) to determine 2018 seed yield, protein and oil response to 2017 N rates and application methods. Seed protein and oil content were estimated using NIR (Foss Infratec 1241 Grain Analyzer). Nitrogen offtake was estimated by protein (%)/6.25 (conversion constant) x seed yield (t/ha). The proportion of apparent fertiliser N recovery (spared N) in seed was calculated by (SeedN+N – SeedN-N)/N rate where SeedN+N is the seed yield with fertiliser N, SeedN-N is seed yield with no fertiliser N and N rate is the amount of fertiliser N applied. Economic returns after N costs were determined on 2018 canola prices (e.g. $600/t) and adjusted for oil premiums using a 1.5% increase or decrease in price for every 1% increase or decrease in oil content above or below 42%.

Results

Seed yield and protein measured in 2018 from 2017 N application

Seed yield and protein of canola harvested in 2018 increased with increasing rates of N applied in 2017 (Figure 1). All rates of N application increased seed yield although yield increases were more responsive above 85kg N/ha. The highest 2018 seed yield was achieved by the highest 2017 N rate using the MRB application method. No yield plateau occurred in any treatment, except for 2017 in the BSE treatment for the 160 and 185kg N/ha rates (Figure 1A). As with seed yield response, seed protein increased with increasing N rate however the protein levels were lower for the IBS method of application at the three highest 2017 N rates (Figure 1B).

Recovery of spared N and oil content measured in 2018 from 2017 N application

Recovery of spared N in 2018 increased with increasing rates of N applied in 2017, particularly at rates above 85kg N. The recovery of spared N was higher in MRB and DP compared with IBS for the highest three rates. Mid-row banding returned the highest recovery rate of spared N at the highest N rate (Figure 2A). Oil content of seed measured in 2018 declined with increasing 2017 N rate and MRB, DP and DC30 methods of application declined further than the IBS method (Figure 2B).

The percentage of spared N recovery in 2018 from 2017 N application ranges from 1% to 18% and increased with increasing N rate (Figure 3A). When

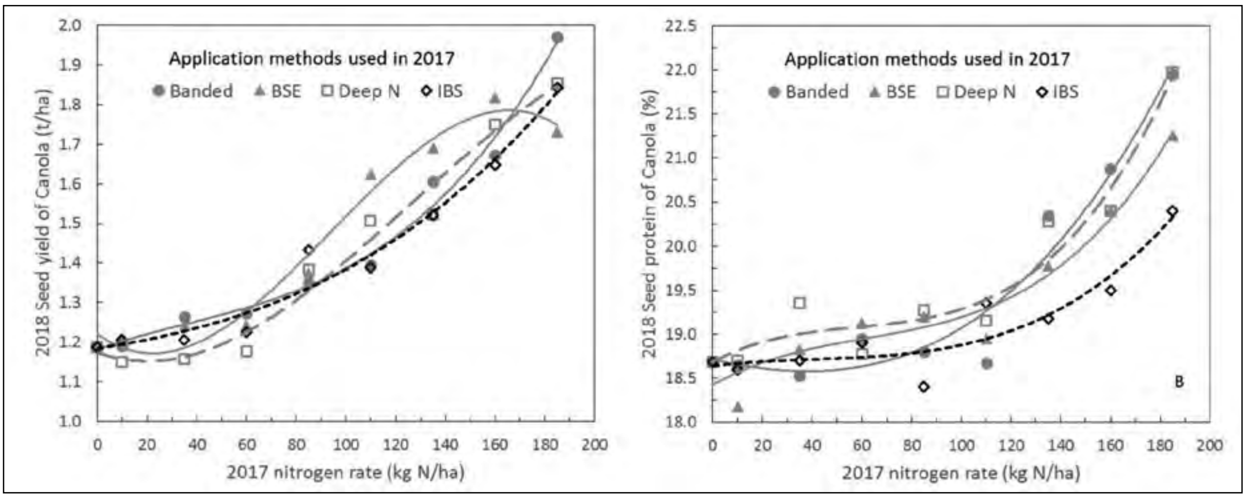

Figure 1. Responses of seed yield (t/ha) (1A) and seed protein (%) (1B) in 2018 to N applied in 2017 using four different methods of N application. Methods of application included (i) surface broadcast and incorporated by sowing (IBS), (ii) mid-row banding (MRB) at sowing (8cm deep) between every second row, (iii) deep placement (DP) at sowing under each wheat row (16cm), and (iv) broadcasting at stem elongation (BSE).

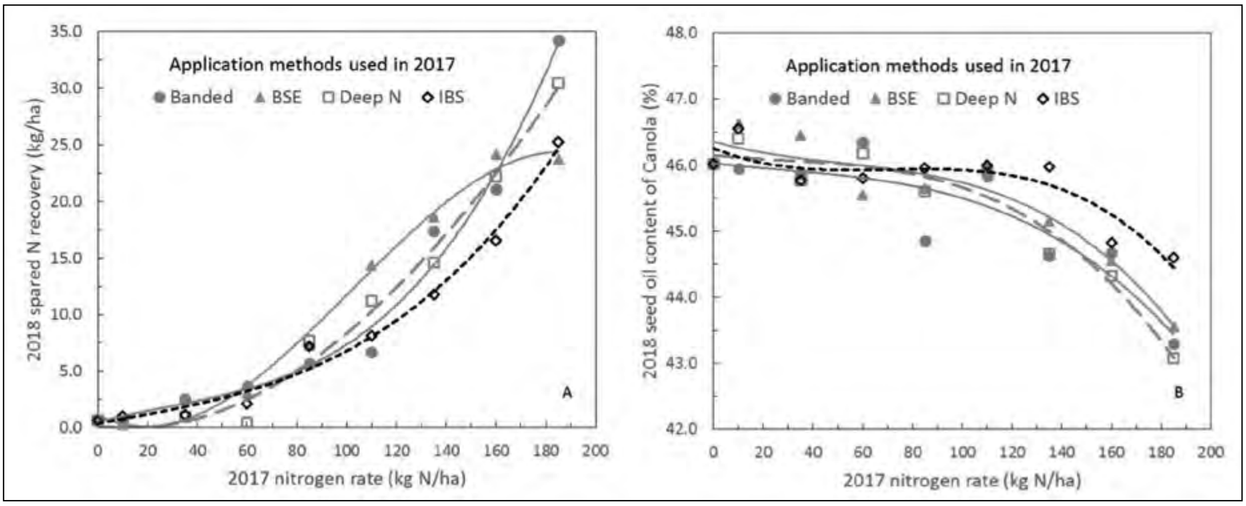

Figure 2. The recovery of spared N (kg/ha) (2A) and oil content (%) (2B) in 2018 from the N applied in 2017 using four different methods of N application.

the percentage of apparent fertiliser recovery and spared N recovery was summed over 2017 and 2018, there was a common rate of recovery of between 55% and 60% recovery across all methods of application when applied at 110kg N/ha (Figure 3B). At rates lower than 110kg N/ha, N recovery rates varied between methods of application although MRB tended to show higher and more stable results. Recovery rates above 110kg N/ha showed a consistent decline, although MRB had higher recovery rates than IBS while the other methods (BP and DC30) were intermediate (Figure 3B).

Net returns after fertiliser costs

Figure 4A indicates that 110kg N/ha produced 95% of maximum return on fertiliser N investment when considered on a single year response using Beckom⁽ᵈ⁾ wheat (2017). However, Figure 4B indicates that when considering returns over two years, the optimal N rate increases to 135kg N/ha.

Discussion

Spared N

In this experiment, spared N recovery in grain the year after N application was found to be low (1-18%) and for commercially used rates of N it is estimated at 6% (±5%) of the previous year's application rate (Figure 3A). This approach used the difference method to estimate spared N captured in grain and agrees with 15N studies that show spared N in the following crop from N fertiliser is 5.4% (±4.5%) (Smith and Chalk 2018). Spared N measured in soil the year after fertiliser N application is estimated at 24%

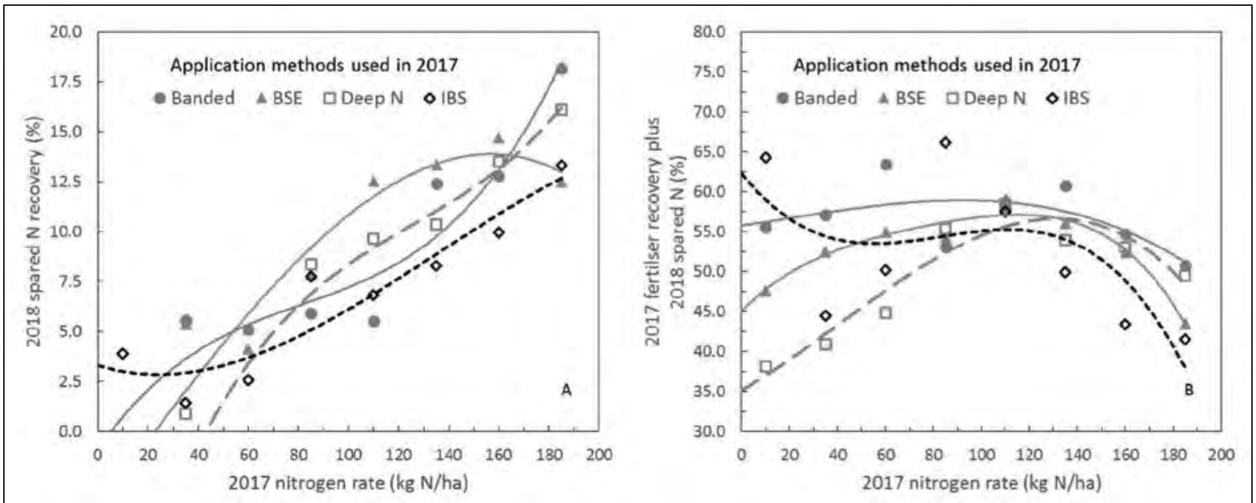

Figure 3A. The percentage of spared N recovery in 2017, and Figure 3B total recovery of fertiliser N and spared N over the years 2017 and 2018.

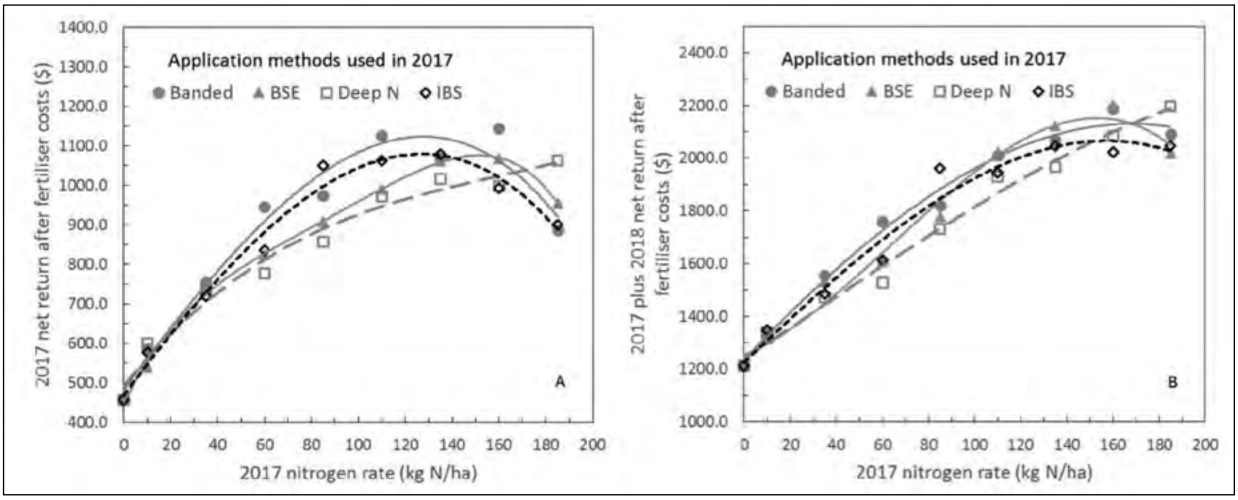

Figure 4. Net return after fertiliser costs for 2017 (Figure 4A) and combined values for 2017 and 2018 (Figure 4B).

(±15%) (Smith and Chalk 2018) suggesting a soil recovery for spared N of 25%. These results suggest N savings for 2019 sowings from spared N may be limited.

N immobilisation

Other considerations apart from spared N will be more important when N budgeting for example N immobilisation in stubble residues from the previous season. Microbes break the stubble down and to grow, these microbes use about 12 units of carbon (C) to 1 unit of N while wheat straw contains about 80 to 120 units of C for every unit of N. Consequently, the bacteria utilise soil N to break down the stubble residue. As an estimate, 1000 kg/ha of wheat grain produces about 1660 kg/ha of stubble. This stubble is made up of approximately 40 to 45% C (747kg/ha assuming 45% carbon) and has approximately 6.2kg N/ha, assuming a 120:1, C:N ratio in wheat stubble. As an estimate, 30% of the stubble is used by microbes for growth while approximately 70% is respired as carbon dioxide. Therefore, the microbes would consume 224kg C/ha (i.e. 30% of 747kg/ha) for growth and at a C:N ratio of 12:1 that would mean they require 18.6kg N/ha of which 6.2kg N/ha is already contained in the stubble. This suggests that for every tonne of last year's grain yield, 12.4kg N/ha (18.6kg N/ha – 6.2kg N/ha) is required to break down last year's stubble residue. Where this N is not supplied, the grain yield loss from immobilisation in wheat would be 250kg/ha/t of last year's wheat yield or 250kg/ha/1.66 t of residual stubble. With high stubble loads and low C:N ratios, N immobilisation can be substantial. For example, a 4t/ha wheat crop that was broken down (approximately 50% only) over the following year would immobilise an estimated 25kg N/ha or approximately55kg/ha of urea (note wheat stubble usually takes more than one year to break down in southern NSW). In a drought year assuming the stubble residue is halved so will be the immobilisation of N providing a calculated potential saving in this example of 12.5kg N/ha.

Pre-sowing mineralisation

Mineral N prior to sowing is best estimated by deep cores to 60cm. These can be split into 30cm sections to identify if the mineral N will be available early in the season or later in the growing season. In droughts mineralisation is slow due to low soil moisture and rapidly increases after the drought breaks. It's possible increased mineral N will be evident after the 2018 drought and this will be more likely expressed in paddocks with an extensive and recent pasture history.

Phosphorus budgeting after drought

P budgeting and take-off in grain

Starter P, often applied as MAP, is very important for; (i) early root development which assists the plant in exploring the greater soil P reserve and (ii) early head development when potential grain number is set (e.g. at or just prior to DC30).

Many phosphorus experiments have shown responses to starter P however, P savings can be made after drought especially where (a) December P export in grain is lower than P inputs at sowing and (b) soil Colwell P values are equal to or greater than soil critical values for the target species. In these circumstances one third of historical average annual P inputs can be applied down to a base level of 3-4kg P/ha. As an example, if our wheat target yield for 2019 is estimated at 3t/ha and the P budget is estimated to be 3.6-5.5kg P/t of grain production then we have a P budget of 10.8-16.5kg P/ha or 49-75kg/ha MAP. If a medium value of 62kg / ha MAP (13.5kg P/ha) was assumed as our standard P budget, we would reduce this by two thirds down to 18.6kg /ha of MAP or 4.1kg P/ha. At this rate the MAP granules are placed in-row at approximately 3.5-4.5cm spacings when using 25cm tyne spacing. Wheat sowing rates (50-65kg/ha) are likely to place seed at every 2-2.5cm in-row while the full MAP rate of 62kg/ha provides an in-row granule spacing of approximately 1.0-1.2cm.

The more detailed approximations used for P budgeting in wheat include grain P export (2.7-3.6kg P/t) plus stubble P not accessible to the following crop (0.4-0.8kg P/t) plus soil losses (0.3-0.7kg P/t grain production) which provides an estimated 3.6-5.5kg P required/t of grain production. Similarly, for canola seed P export (4.0-6.5kg P/t) plus stubble P not accessible (0.6-1.0kg P/t) plus soil losses (0.3-0.7kg P/t grain production) provides an estimated 6.1-10.2kg P required per tonne of seed production. On a per hectare basis the export of P for wheat and canola is approximately the same assuming canola has half the water use efficiency for grain production as wheat.

In the longer-term, P inputs should be adjusted by tracking soil P values to determine if soil test values are increasing (over estimate of P budget), decreasing (under estimate of P budgeting) or remaining within the critical 90 and 95% range (P budget balance). After several year of soil testing and adjusting P inputs it is possible to ensure relatively stable soil P test values for optimising economic returns.

Figure 5 shows the average Colwell P decline between P applied and measured in 2017 and measured again in 2018 when no P was applied in 2018. The Colwell P decline is estimated by regression analysis that included soil samples taken from plots growing four different crop species (wheat, lupin, field pea and lentil). Crop species were sown in a P deficient soil that was fertilised prior to being sown in 2017 with 11 P rates. The decline shown here, is an average over the different crop species and highlights that Colwell P decline is larger in higher P soils. This represents a greater reduction in soil P which is likely due to stronger bonding of P in the soil reserve and higher P removal in grain and stubble. The take home message from this is to ensure Colwell P values are within the 90 to 95% of maximum grain yield but not above these values as the high P levels will not increase grain yield and will decrease P use efficiency. For another supporting perspective on this point see Simpson et al (2014).

The exception to the above reduction in P budgets after drought applies to calcareous soils with high pH. Phosphorus savings in this example are not possible as the excess lime (calcium or magnesium carbonate) will not readily dissolve at high pH and it serves as a P sink for surface adsorbed calcium phosphate precipitation. In

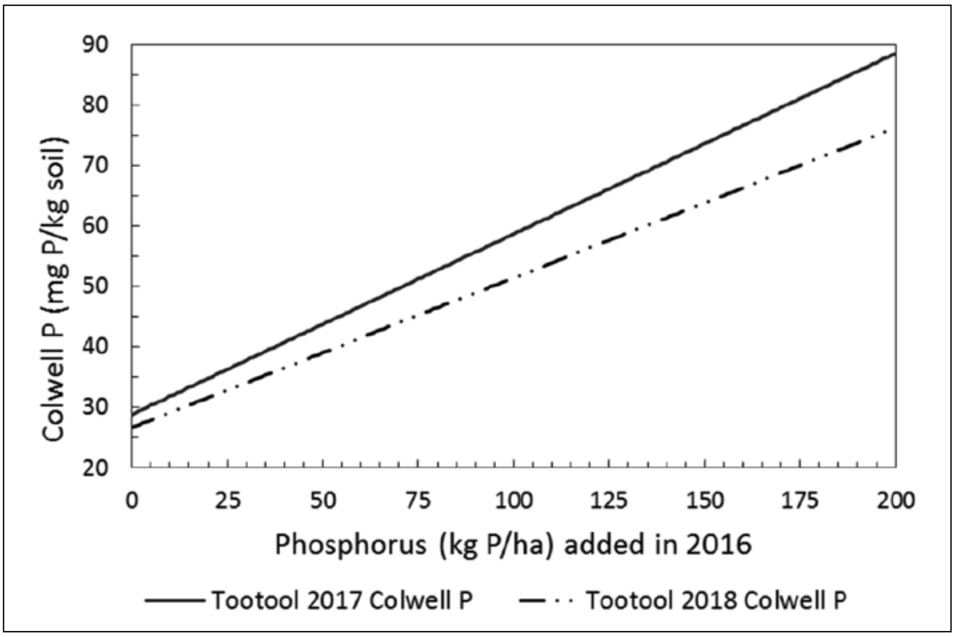

Figure 5. Average Colwell P decline between P applied in 2017 (solid line) and 2018 (dashed and dotted line) where no P was added in 2018.

addition, the lime in calcareous soil reacts with P in soil solution to form calcium phosphate at the surface of the lime. The first process of P bonding occurs in dry conditions and consequently P availability is low even in circumstance where P take-off has also been low. In these soils, advantages in P supply are achieved with application via highly concentrated P bands with minimal soil mixing.

P budgeting and take-off in hay

Phosphorus off-take in hay per ha is higher than for grain production. Previously it was estimated that a 1t/ha wheat crop would remove 2.7-3.6kg P/ha while a hay crop is estimated to remove 1.0-2.0kg P/ha/t. The same comparison for canola indicates a 1t/ha grain crop exports 4.0-6.5kg P/ha in seed while the hay exports an estimated 3.0-4.0kg P/ha/t. In some circumstance where substantial hay yields are achieved large amounts of P are removed. Large variations in P off-take in hay are also likely due to hay quality as well as the proportion of unbaled straw and leaf remaining in the paddock. Note the unbaled leaf component for canola can be large and rain on cut hay can leach plant available P into the soil.

Hence, P savings in 2019 after hay cut in 2018 needs to be considered in a more conservative light. With higher P off-take, Colwell P values will decline more substantially and consequently slightly different P saving rules apply. These include (a) soil Colwell P values greater than 95% of critical for the target species and (b) half of historical average P inputs can be used down to a base level of 5 kg P/ha.

Cash flow approach to P budgeting

One-off P savings after drought or failed crop production are made possible because most P for crop production is drawn from the soil reserve. Because of this P budgeting can be somewhat retrospective. As an example this 'somewhat retrospective' approach firstly estimates the P budget based on long term rainfall and water use efficiency to produce likely average grain yield for wheat and the subsequent P budget (e.g. stored soil water = 30mm, in season rainfall = 230mm, plant available soil water = 260mm, soil evaporation = 110mm, water use efficiency of grain production = 20kg grain production per mm of crop transpired water, grain yield therefore = 3 t/ha, P budget = approximately 16.5kg P/ha is the long term average). The second component of the budgeting exercise requires the same approach as described but applied to the season just passed. In this case let's assume last year's grain yield was 1.5t/ha and a retrospective P budget of 8.25kg P/ha is estimated (e.g. half the long-term average). The final step is to average the two estimates for the unsown crop and in this example that is estimated at approximately 12.4kg P/ha. The advantage of this approach is it considers both long term P budgeting to maintain soil P reserves and last year's retrospective P budget which is most likely to reflect cash flow. This simple model adds more P after higher yielding years and less P after low yielding years. The underlying assumption is that the soil Colwell P starting point is between 90 and 95% of crop critical P. Phosphorus inputs should always be assessed against soil test values to ensure input assumptions are maintaining Colwell P values in the critical range.

Conclusions

Fertiliser savings after drought are possible with P and less likely with N. This is because the extensive history of P application in southern cropping systems of NSW combined with low soil phosphorus buffering indexes ensures that P can be supplied to crops from the greater soil reserve. In addition, the soil reserve supplies most of the P requirements of crops while fertiliser P only directly supplies a much smaller proportion (<30%).

Drought is likely to cause slightly higher rates of mineralisation and lower rates of immobilisation compared to an average season. Spared N from the following crop is likely to be higher however, its recovery in the following crop is low. The combination of higher spared N and higher potential rates of mineralisation (assumes average or above average March and April rain) may result in lower 2019 N budgets, although this is best measured with deep soil cores.

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Angus, J. (2016) Budgeting crop nitrogen supply better estimation better decisions. https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2016/02/budgeting-crop-nitrogen-n-supply-better-estimation-better-decisions

Useful resources

https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2017/02/a-test-of-nitrogen-fertiliser-use-efficiency-in-wheat-using-mid-row-banding

https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2017/08/improving-nitrogen-use-efficiency-of-cropping-systems-of-southern-australia-by-mid-row-banding-nitrogen-fertiliser-in-season

Acknowledgments

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Canola agronomy – consistent messages on canola agronomy hold strong in a Decile 1 season

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GRDC project codes: CSP00187, DAN00213

Keywords

- canola, phenology, biomass, sowing date, flowering date, frost, nitrogen.

Take home messages

- Ensure flowering date is matched to the environment and grow enough biomass for the targeted grain yield.
- High biomass was necessary for a high yield potential. There is no advantage in utilising management strategies that reduce growth in order to increase harvest index and grain yield.
- Select two or three varieties with differing phenology or one single variety with flexible phenology to capitalise on variable sowing opportunity dates.
- Early sowing of slow developing spring canola varieties was successful in experiments in 2018 but is best suited to eastern regions with a higher frequency of late March to mid-April rainfall.
- The performance of hybrid canola continues to improve across all herbicide tolerance groups and across diverse environments.
- Nitrogen (N) response was modest in 2018 due to lower grain yield potential. Choosing a paddock with high starting N levels reduces the risk in growing canola in dry seasons as large upfront inputs of N are not required.

Introduction

The consistent recommendations from the Optimised Canola Profitability (OCP) project to date have been:

- Ensure canola flowering date is matched to the environment (i.e. target optimal flowering times as outlined in 10 Tips to Early Sown Canola -https://grdc.com.au/10TipsEarlySownCanola)
- Maximise the conversion of plant available water into crop biomass using tactical management of sowing date, hybrids and N.

With low in-crop rain and frosts across southern NSW, 2018 was the year to put the system to the test, particularly point 2. The 2018 season more than reinforced the above recommendations – it gave full confidence that the recommendations will hold over highly variable and risky seasons.

Matching flowering date to the environment is an ongoing challenge as the date of the autumn break is highly variable. Based on the sowing rule developed by Unkovich et al. (2015), 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 43% chance in the second half of March at Wallendbeen and a 41% chance in the first half of April. Therefore, sowing opportunities will influence varietal phenology choice. There are only limited opportunities to sow a slow or mid-slow canola variety before mid-April at Condobolin, therefore fast or fast-mid varieties are recommended. At Wallendbeen, there would likely be a more than 50% chance of canola before mid-April, therefore the slow and slow-mid varieties should be considered.

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.

To ensure flowering date targets are met, while also responding to variable seasonal breaks, growers need to either

- have access to two or three canola varieties with contrasting phenology (e.g. a slow and a fast-mid) or
- select a canola variety with relatively flexible phenology, specifically a variety that is relatively slow from early sowing, but faster from later sowing – some examples of these are highlighted below.

2018 phenology results

To determine the phenology of recently released canola varieties, a phenology experiment was established at Wagga Wagga in 2018 with 30 spring varieties sown in late March and early May and three winter varieties sown in late March only. The early sowing was done following 7mm of rain and was provided with an extra 7mm through dripper lines to ensure even establishment. There was approx. 100mm plant available water in the soil at sowing and 160mm rainfall from April to October.

There were subtle development differences between the winter varieties. Phoenix CL was slightly quicker to flower than the more widely grown Edimax CL and Hyola®970CL (Figure 1). There was still a large gap (32 days) in flowering date between the fastest winter variety (Phoenix CL) and the slowest spring variety (Victory 7001CL).

There were also large differences in the development of the spring varieties, particularly from early sowing. Fast varieties included Hyola®350TT, Hyola®506RR, ATR Stingray⁽ᵇ⁾ Diamond and 43Y23 (RR). In 2018, early sowing of these fast varieties resulted in early flowering and significant frost damage, with a resultant machine harvest yield of <0.5t/ha. However, commercial varieties that were relatively slow from early sowing included 45Y25 (RR), 45Y91 (CL), Victory 7001CL, InVigor® 5520P, ATR Wahoo⁽ᵇ⁾, GT-53 and SF Ignite. These varieties yielded in a range from 1.1t to 1.7t/ha from early sowing. The fast varieties had higher yield sown in early May, while the slow varieties had reduced yield from later sowing (1-1.4t/ha vs 0.4-0.8t/ha).

A key tactic to stabilise flowering date across and within seasons is to select a variety 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 varieties to yield >1t/ha from both sowing dates.

2018 biomass results

A continuation of the 'Biomass' series of experiments at Wagga Wagga (with a combination of two sowing dates, two N rates and eight varieties) reinforced the recommendations of the OCP project. High biomass (combination of early sowing and hybrids) was necessary to generate a high yield potential, but optimising flowering date was important to realise the potential yield. For example, Diamond sown on 4 April produced similar biomass as 4 April sown 45Y91 (CL) (approx. 11t/ha), but Diamond flowered in mid-July, one month before 45Y91 (CL) and yielded 30% less (1.7t/ha vs. 2.6t/ha) due to frost damage. Diamond produced only 7t/ha biomass from the 27 April sowing date, but flowered in mid-August, and with less frost damage yielded 1.9t/ha. There was no response to increasing N from 30kg to 180kg/ha as the starting soil N at the site

Table 1. Chance (%) of a canola sowing (germination) opportunity within defined date ranges in autumn in southern NSW. A sowing opportunity is defined as when rainfall > pan evaporation in a 7-day period (Unkovich et al. 2015).

	16-31 March	1-15 April	16-30 April	1-15 May	16-31 May
Canowindra	33	31	52	53	67
Condobolin	21	17	33	43	57
Corowa	29	26	50	57	79
Wagga Wagga	30	30	45	50	83
Wallendbeen	43	41	55	67	81

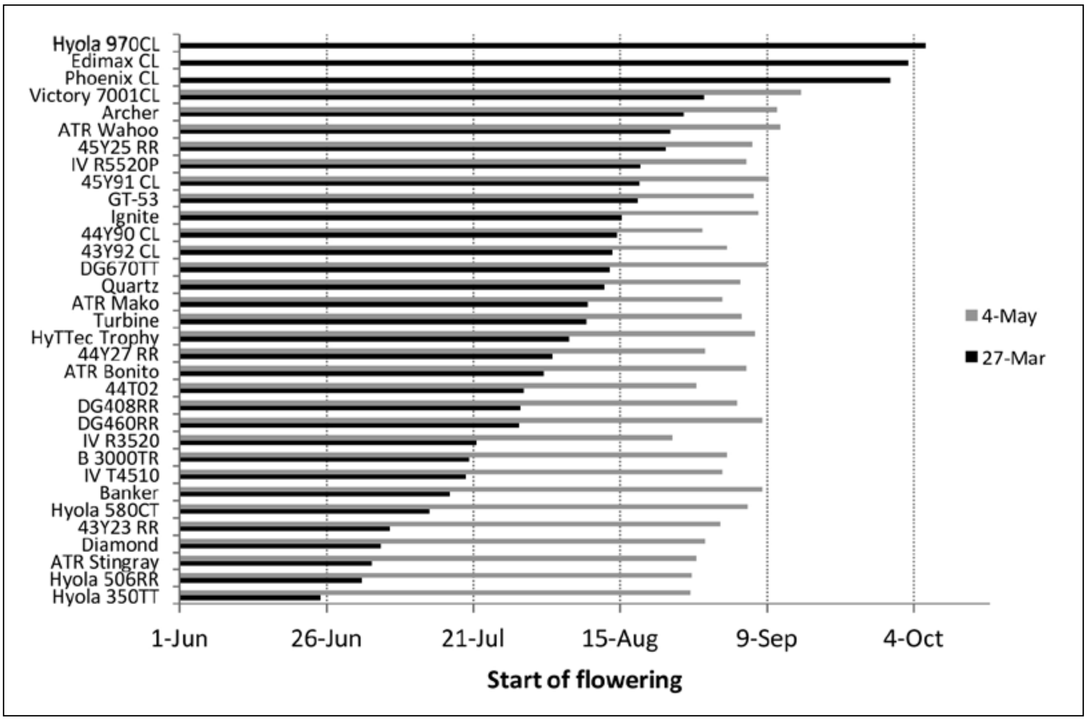

Figure 1. Phenology (start of flowering) of 30 spring varieties from two sowing dates and three winter varieties from one sowing date at Wagga Wagga in 2018.

was 227kg/ha. This highlights the value of stored N for canola, reducing the risk of applying high rates of N early in the season.

A comparison of similar phenology pairs of hybrid Clearfield® and open-pollinated (OP) triazine tolerant (TT) varieties sown within their highest yielding window highlighted the advantages of hybrids even in a very dry year. On average, the hybrid Clearfield® varieties yielded 40% more than the OP TT varieties (Table 2) largely due to their higher biomass.

High yielding canola

Over the past two seasons, a collaborative project (NSW DPI and GRDC) named 'High Yielding Canola' has been running in southern NSW, aiming to determine management strategies to achieve 5t/ha canola. One site has been at Wallendbeen with 210mm in-crop rainfall (April to October) and approx. 120mm plant available water at sowing in 2018. The second site has been at Leeton, which has been fully irrigated.

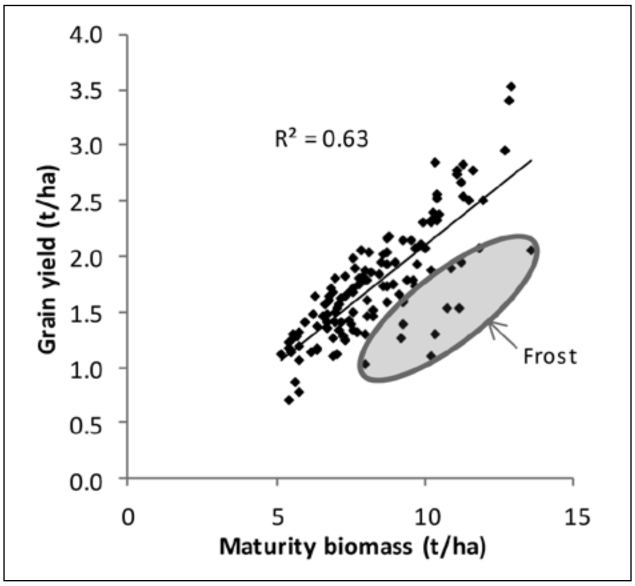

Figure 2. Relationship between maturity biomass and grain yield at Wagga Wagga in 2018. Treatments with high biomass, but relatively low grain yield, were generally early flowering and damaged by frost.

Table 2. Comparative yield of canola phenology pairs (hybrid Clearfield® versus OP TT) from their highest yielding sowing date at Wagga Wagga in 2018 (l.s.d. $P<0.05$ = 0.32t/ha).

Phenology	Sow date	Hybrid CLF	OP TT	Hybrid CLF Yield (t/ha)	OP TT Yield (t/ha)
Mid-slow	4-Apr	45Y91 (CL)	ATR Wahoo⁽ᴾ⁾	2.6	1.9
Mid-fast	4-Apr	44Y90 (CL)	ATR Bonito⁽ᴾ⁾	2.5	1.6
Fast	27-Apr	Diamond	ATR Stingray⁽ᴾ⁾	1.9	1.5

Table 3. Grain yield of 11 canola varieties sown at their recommended sowing date at Wallendbeen in 2018 (l.s.d. *P*<0.05 = 0.44t/ha) and Leeton (l.s.d. *P*<0.05 = 0.76t/ha) in 2018.

Sowing date	Variety	Phenology	Grain yield Wall. (t/ha)	Grain yield Leeton (t/ha)
30-April	Diamond	Fast spring	3.4	5.3
13-April	44Y90 (CL)	Mid-fast spring	3.9	4.4
13-April	ATR Bonito⸸	Mid-fast spring	2.8	4.2
13-April	45Y91 (CL)	Mid spring	3.6	5.0
13-April	45Y25 (RR)	Mid-slow spring	3.2	5.4
13-April	ATR Wahoo⸸	Mid-slow spring	2.6	4.1
27-March	Archer	Slow spring	3.7	5.1
27-March	Victory 7001CL	Slow Spring	2.6	4.1
27-March	Phoenix CL	Winter	2.7	3.2
27-March	Edimax CL	Winter	2.9	3.6
27-March	Hyola®970CL	Winter	2.5	3.5

In 2018, highest yields came from sowing spring hybrid canola varieties, with lower yields from the winter varieties at both sites. The hybrid varieties 45Y25 (RR) and 44Y90 (CL) were on average 28% and 19% higher yielding than the OP TT varieties with matching phenology, ATR Bonito⸸ and ATR Wahoo⸸, respectively.

In an adjacent trial at Wallendbeen, an extra 100mm of irrigation was applied to 45Y25 (RR) to determine the water unlimited yield potential. This resulted in a 9% grain yield increase compared to the non-irrigated 45Y25 (RR), suggesting that even in a relatively dry year, management factors such as variety choice (especially hybrids vs. OP TT) can have a larger impact than rainfall quantity.

Conclusion

A very dry 2018 (Decile 1 in-crop rainfall) did not alter the consistent messages from the OCP project. Matching flowering date to the environment and generating as much growth as necessary for the target yield is important to maximise grain yield. Where the date of the autumn break is highly variable, it is recommended to select more than one canola variety, each with differing phenology, or select a variety with flexible phenology. Early sowing of mid and slow spring varieties was successful in 2018 as they generated high biomass and delayed pod-fill till after the severe frosts. This strategy should especially be considered by growers in the eastern part of southern NSW where autumn rainfall is higher, especially those with management practices (stubble retention and strict fallow management) that maximise seedbed moisture retention.

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. Thanks to Cameron Hazlett (Wallendbeen) for cooperation with the 2018 site. Thanks also to technical staff, especially Danielle Malcolm, John Bromfield, Warren Bartlett and Daniel Johnston for assistance throughout.

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Further Reading

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

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Notes

Emerging management tips for early sown winter wheats

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GRDC project code: : (GRDC Management of Early Sown Wheat 9175069)

Keywords

- winter wheat, crop development, frost, dual purpose, vernalisation.

Take home messages

- Highest yields for winter wheats come from early to late April establishment.
- Highest yields of winter wheats sown early are similar to Scepter⁽ᴰ⁾ sown in its optimal window.
- Slower developing spring varieties are not suited to pre-April 20 sowing.
- Different winter wheats are required for different environments.
- Flowering time cannot be manipulated with sowing date in winter wheats such as spring wheat.
- 10mm of rainfall was needed for establishment on sands, 25mm on clays - more was not better.

Background

Winter wheat varieties allow wheat growers in the Southern Region to sow much earlier than currently practised, meaning a greater proportion of farm can be sown on time. The previous GRDC Early Sowing Project (2013-2016) highlighted the yield penalty from delayed sowing. Wheat yield declined at 35kg/ha for each day sowing was delayed beyond the end of the first week of May using a fast-developing spring variety.

Sowing earlier requires varieties that are slower developing. For sowing prior to April 20, winter varieties are required, particularly in regions of high frost risk. Winter wheats will not progress to flower until their vernalisation requirement is met (cold accumulation), whereas spring varieties will flower too early when sown early. The longer vegetative period of winter varieties also allows dual-purpose grazing.

The aim of this series of experiments is to determine which of the new generation of winter varieties have the best yield and adaptation in different environments and what is their optimal sowing window. Prior to the start of the project in 2017, the low to medium rainfall environments of SA and Victoria had little exposure to winter varieties, particularly at really early sowing dates (mid-March). Three different experiments have been conducted in the Southern Region in low to medium rainfall environments during 2017 and 2018, and one of these has been matched by collaborators in NSW for additional datasets presented in this paper.

Method

Experiment 1

Which wheat variety performs best in which environment and when should they be sown?

- Target sowing dates: 15 March, 1 April, 15 April and 1 May (10mm supplementary irrigation to ensure establishment).
- Locations: SA - Minnipa, Booleroo Centre, Loxton, Hart. Victoria - Mildura, Horsham, Birchip, Yarrawonga. NSW - Condobolin, Wongarbon, Wallendbeen.
- Up to 10 wheat varieties:- The new winter wheats differ in quality classification, development speed and disease rankings (Table 1).

Experiment 2

How much stored soil water and breaking rain are required for successful establishment of early sown wheat without yield penalty?

- Sowing dates: 15 March, 1 April, 15 April and 1 May.
- Varieties: Longsword⁽ᴰ, Kittyhawk⁽ᴰ and DS Bennett⁽ᴰ.
- Irrigation: 10mm, 25mm and 50mm applied at sowing.
- Locations: SA - Loxton. Victoria Horsham, Birchip.

Experiment 3

What management factors other than sowing time are required to maximise yields of winter wheats?

- Sowing date: 15 April.
- Varieties: Longsword⁽ᴰ, Kittyhawk⁽ᴰ and DS Bennett⁽ᴰ.
- Management factors examined: Nitrogen (N) at sowing vs. N at early stem elongation, defoliation to simulate grazing, plant density 50 plants/m^2 vs. plant density 150 plants/m^2.
- Locations: SA - Loxton. Victoria - Yarrawonga.

Results and discussion

Experiment 1

Development speeds

Flowering time is a key determinant of wheat yield. Winter varieties have stable flowering dates across a broad range of sowing dates. This has implications for variety choice as flowering time cannot be manipulated with sowing date in winter wheats like spring wheat. This means different winter varieties are required to target the different optimum flowering windows that exist in different environments. The flowering time difference between winter varieties is characterised based on their relative development speed into four broad groups — fast, mid-fast, mid and mid-slow for medium to low rainfall environments (Table 1 and Figure 1).

Table 1. Summary of winter varieties, including Wheat Australia quality classification and disease rankings based on the 2019 SA Crop Sowing Guide.

Variety	Release Year	Company	Development	Quality	Disease Rankings#			
					Stripe Rust	Leaf Rust	Stem Rust	YLS
Kittyhawk⁽ᴰ	2016	LRPB	Mid winter	AH	MR	MR	R	MRMS
Longsword⁽ᴰ	2017	AGT	Fast winter	Feed	RMR	MSS	MR	MRMS
Illabo⁽ᴰ	2018	AGT	Mid-fast winter	AH/APH*	RMR	S	MRMS	MRMS
DS Bennett⁽ᴰ	2018	Dow	Mid-slow winter	ASW	R	S	MRMS	MRMS
ADV08.0008	?	Dow	Mid winter	?	-	-	-	-
ADV15.9001	?	Dow	Fast winter	?	-	-	-	-
LPB14-0392	?	LRPB	Very slow spring	?	-	-	-	-
Cutlass⁽ᴰ	2015	AGT	Mid spring	APW/AH*	MS	RMR	R	MSS
Trojan⁽ᴰ	2013	LRPB	Mid-fast spring	APW	MR	MRMS	MRMS	MSS
Scepter⁽ᴰ	2015	AGT	Fast spring	AH	MSS	MSS	MR	MRMS

**SNSW only*

AH=Australian Hard, APH=Australian Prime Hard, ASW=Australian Standard White, APW=Australian Premium White

R=resistant, MR=moderately resistant, MS=moderately susceptible

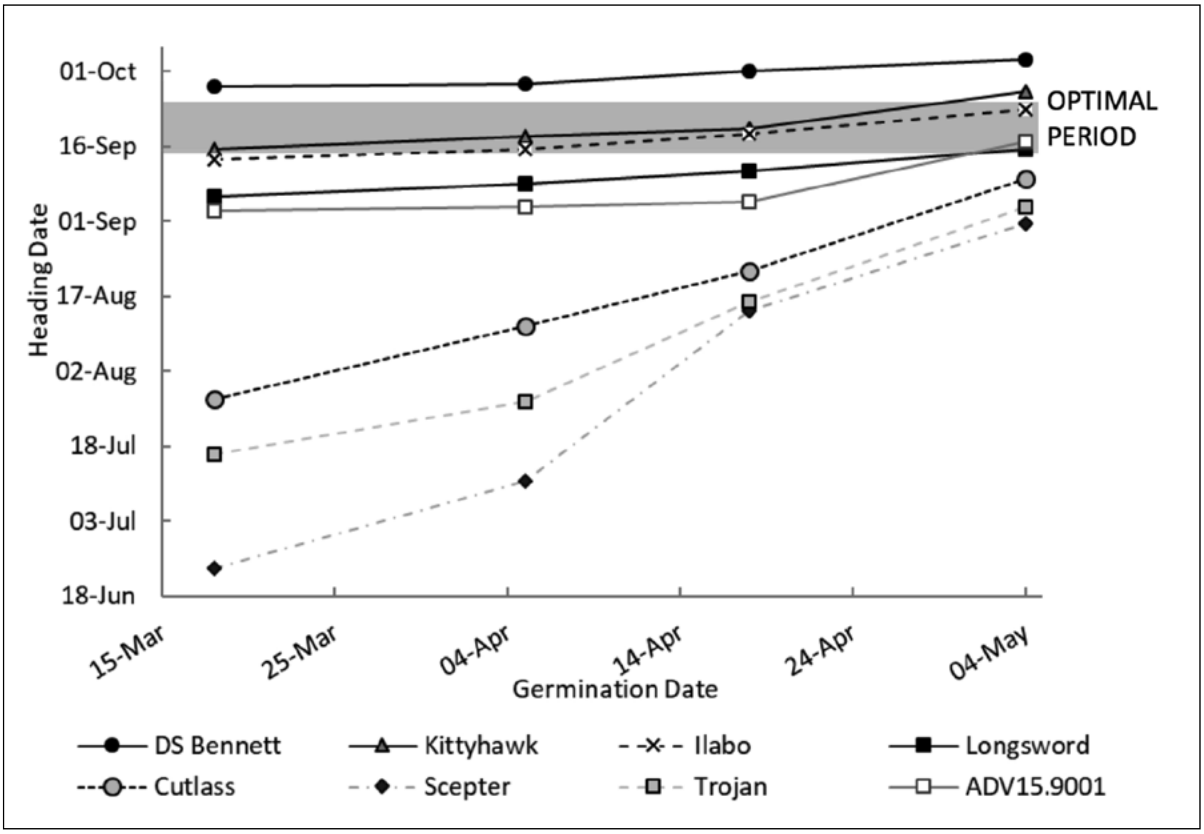

Figure 1. Mean heading date responses from winter and spring varieties at Hart in 2017 and 2018 across all sowing times — grey box indicates the optimal period for heading at Hart.

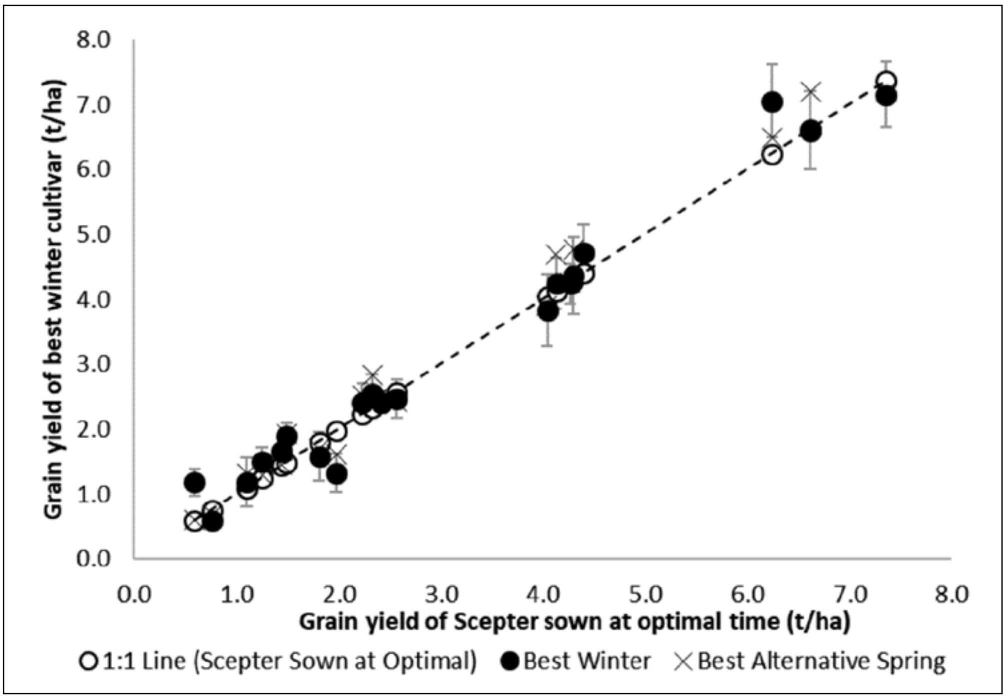

Figure 2. Grain yield performance of Scepter⦶ wheat sown at its optimal time (late April-early May) in 20 environments compared to the best performing winter wheat and best alternative spring wheat. Error bars indicate LSD (P<0.05).

For example, at Hart in the Mid North of SA, each winter variety flowered within a period of 7-10 days across all sowing dates, whereas spring varieties were unstable and ranged in flowering dates over one month apart (Figure 1). In this Hart example, the mid developing winter wheats such as Illabo(b) and Kittyhawk(b) were best suited to achieve the optimum flowering period of September 15-25 for Hart. In other lower yielding environments such as Loxton, Minnipa and Mildura, the faster developing winter variety Longsword(b) was better suited to achieve flowering times required for the first 10 days in September.

Winter versus spring wheat grain yield

- Across all experiments, the best performing winter wheat yielded similar to the fast developing spring variety Scepter(b) sown at the optimal time (last few days of April or first few days of May, used as a best practice control) in 16 out of 20 sites, greater in three and less than in one environment (Figure 2).
- The best performing winter wheat yielded similar to the best performing slow developing spring variety (alternative development pattern) at 14 sites, greater at four and less than at two sites.

Sowing time responses

- Across all environments, the highest yields for winter wheats generally came from early to late April establishment. The results suggested that yields may decline from sowing earlier than April and these dates may be too early to maximise winter wheat performance (Table 2).
- Slower developing spring wheats performed best from sowing dates after April 20, and yielded less than the best performing winter varieties when sown prior to April 20. This reiterates slow developing spring varieties are not suited to pre-April 20 sowing in low to medium frost prone environments.

Table 2. Summary of grain yield performance of the best performing winter and alternate spring variety in comparison to Scepter(b) sown at the optimum time (late April-early May). Different letters within a site indicate significant differences in grain yield.

Site		Year	Scepter(b) sown at optimum Grain Yield (t/ha)	Best Winter Performance			Best alternate Spring Performance		
				Grain Yield (t/ha)	Variety	Germ Date	Grain Yield (t/ha)	Variety	Germ Date
Yarrawonga*	Vic	2018	0.59 a	1.18 b	DS Bennett(b)	16-Apr	0.61 a	Cutlass(b)	16-Apr
Booleroo	SA	2018	0.77 a	0.59 a	Longsword(b)	4-Apr	0.69 a	Trojan(b)	2-May
Loxton	SA	2018	1.10 a	1.19 a	Longsword(b)	19-Mar	1.32 a	Cutlass(b)	3-May
Minnipa	SA	2018	1.25 a	1.50 b	Longsword(b)	3-May	1.29 a	Trojan(b)	3-May
Mildura*	Vic	2018	1.44 a	1.66 b	DS Bennett(b)	1-May	1.46 a	LPB14-0293	1-May
Mildura	Vic	2017	1.49 a	1.90 b	Longsword(b)	13-Apr	1.93 b	Cutlass(b)	28-Apr
Horsham*	Vic	2018	1.81 a	1.58 a	DS Bennett(b)	6-Apr	1.70 a	Trojan(b)	2-May
Booleroo	SA	2017	1.98 a	1.33 b	DS Bennett(b)	4-May	1.61 b	Cutlass(b)	4-May
Minnipa	SA	2017	2.23 a	2.42 a	Longsword(b)	18-Apr	2.52 a	Cutlass(b)	5-May
Loxton	SA	2017	2.33 a	2.55 a	Longsword(b)	3-Apr	2.83 b	LPB14-0293	3-Apr
Hart	SA	2018	2.41 a	2.42 a	Illabo(b)	17-Apr	2.52 a	LPB14-0293	17-Apr
Rankins Springs	NSW	2018	2.57 a	2.47 a	DS Bennett(b)	19-Apr	2.42 a	Trojan(b)	7-May
Birchip	Vic	2018	4.04 a	3.83 a	Longsword(b)	30-Apr	3.90 a	Trojan(b)	30-Apr
Hart	SA	2017	4.13 a	4.25 a	Illabo(b)	18-Apr	4.70 b	LPB14-0293	18-Apr
Yarrawonga	Vic	2017	4.27 a	4.24 a	DS Bennett(b)	3-Apr	4.26 a	Cutlass(b)	26-Apr
Wongarbon	NSW	2017	4.30 a	4.37 a	DS Bennett(b)	28-Apr	4.77 a	Trojan(b)	13-Apr
Tarlee	SA	2018	4.40 a	4.71 a	Illabo(b)	17-Apr	4.62 a	LPB14-0293	17-Apr
Wallendbeen	NSW	2017	6.24 a	7.05 b	DS Bennett(b)	28-Mar	6.49 a	Cutlass(b)	1-May
Birchip	Vic	2017	6.62 a	6.60 a	DS Bennett(b)	15-Apr	7.20 a	Trojan(b)	15-Apr
Horsham	Vic	2017	7.36 a	7.15 a	DS Bennett(b)	16-Mar	7.19 a	Trojan(b)	28-Apr

**repeated frost during September followed by October rain.*

Which winter variety performed best?

The best performing winter wheat varieties depended on yield environment, development speed and the severity and timing of frost (Table 2). The rules generally held up that winter varieties well-adjusted to a region yielded similar to Scepter⍉ sown in its optimal window. These results demonstrate that different winter wheats are required for different environments and there is genetic by yield environment interaction.

- In environments less than 2.5t/ha, the faster developing winter wheat Longsword⍉ was generally favoured (Table 2, Figure 3).
- In environments greater than 2.5t/ha the mid to slow developing varieties were favoured — Illabo⍉ in the Mid North of SA, and DS Bennett⍉ at the Victorian and NSW sites (Table 2, Figure 4).

The poor relative performance of Longsword⍉ in the higher yielding environments was explained by a combination of flowering too early and having inherently greater floret sterility than other varieties, irrespective of flowering date.

Sites defined by severe September frost and October rain included Yarrawonga, Mildura and Horsham in 2018. In these situations, the slow developing variety DS Bennett⍉ was the highest yielding winter wheat and had the least amount of frost induced sterility. The October rains also favoured this variety in 2018 and mitigated some of the typical yield loss from terminal drought. Nonetheless, the ability to yield well outside the optimal flowering period may be a useful strategy for extremely high frost prone areas for growers wanting to sow early.

Experiment 2

2018 had one of the hottest and driest autumns on record and provided a good opportunity to test how much stored soil water and/or breaking rain is required to successfully establish winter wheats and carry them through until winter. The 10mm of irrigation applied at sowing in the sowing furrow was sufficient to establish crops and keep them alive (albeit highly water stressed in most cases) until rains finally came in late May or early June at seven of the eight sites at which Experiment 1 was conducted in 2018. The one exception was Horsham, which had very little stored soil water and a heavy, dark clay soil. At this site, plants that emerged following the first time of sowing in mid-March died after establishment and prior to the arrival of winter rains. Plants at all other times of sowing were able to survive. Experiment 2 was also located at this site, and 25mm of irrigation was sufficient to keep plants alive at the first time of sowing. A minimum value of 25mm for sowing in March on heavier soil types is supported by results from Minnipa in 2017, which

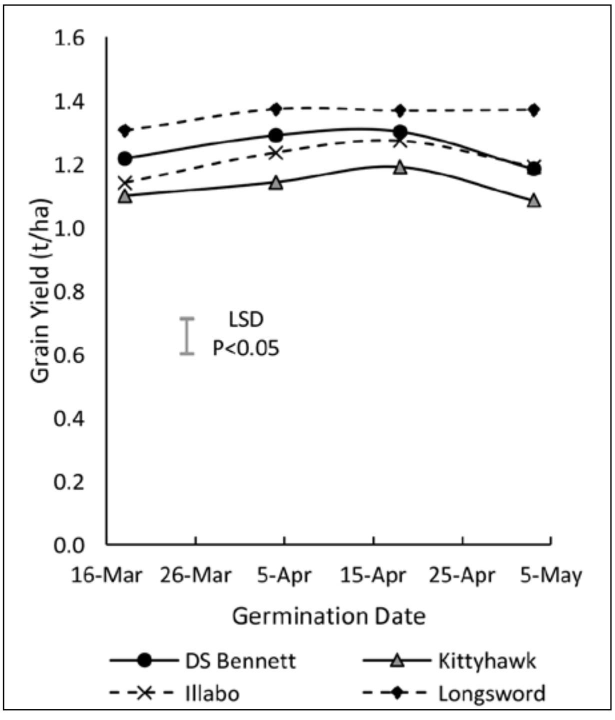

Figure 3. Mean yield performance of winter wheat in yield environments less than 2.5t/ha (11 sites in SA/Victoria)

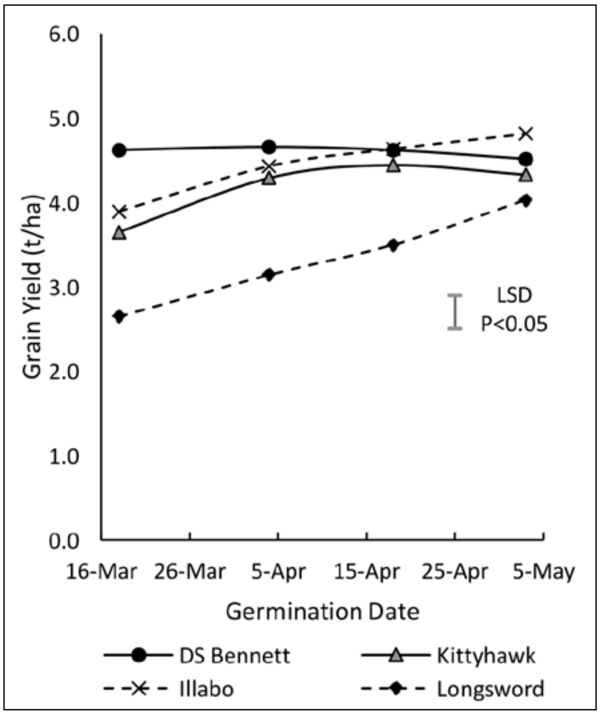

Figure 4. Mean yield performance of winter wheat in yield environments greater than 2.5t/ha (five sites in SA/Victoria)

also experienced a very dry autumn. In this case, approx. 30mm of combined irrigation, rainfall and stored soil water was sufficient to keep the first time of sowing alive. On lighter soil types, less water was needed and 10mm irrigation at sowing with 8mm of stored water plus an accumulated total of 13mm of rain until June allowed crops to survive on a sandy soil type at Loxton in 2018.

Based on these observations, it is concluded that when planting in March on clay soils, at least 25mm of rainfall and/or accessible soil water are required for successful establishment. Once sowing moves to April, only 10mm (or enough to germinate seed and allow plants to emerge) is sufficient.

Experiment 3

Yield responses to changes in plant density, N timing and defoliation have been small (Table 3). There have been limited interactions between management factors and varieties. The results from Experiments 1 and 3 confirm selecting the correct winter variety for the target environment and sowing winter varieties on time (before April 20) increase the chances of high yields. The target density of 50 plants/m^2 is sufficient to allow maximum yields to be achieved, and there is no yield benefit from having higher densities in winter varieties. Deferring N until stem elongation had a small positive benefit at Yarrawonga, and a negative effect at Loxton. Grazing typically has a small negative effect in all varieties, however the mean percentage grain yield recovery from grazing has been higher in Longsword⏀ (95%) compared to DS Bennett⏀ (87%) and Kittyhawk⏀ (82%), respectively.

Conclusion

Growers in the low to medium rainfall zones of the Southern Region now have winter wheat varieties that can be sown over the entire month of April and are capable of achieving similar yields to Scepter⏀ sown at its optimum time. However, grain quality of the best performing varieties leaves something to be desired (Longsword⏀=feed, DS Bennett⏀=ASW). Sowing some wheat area early allows a greater proportion of farm area to be sown on time. Growers will need to select winter wheats suited to their flowering environment (fast winter in low rainfall, mid and mid-slow winter in medium rainfall) and maximum yields are likely to come from early to mid-April planting dates. If planting in April, enough rainfall to allow germination and emergence will also be enough to keep plants alive until winter. If planting in March, at least 25mm is required on heavy soils. Reducing plant density from 150 to 50 plants/m^2 gives a small yield increase, while grazing tends to reduce yield slightly.

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. The project is led by La Trobe University in partnership with SARDI, Hart Field-Site Group, Moodie Agronomy, Birchip Cropping Group, Agriculture Victoria, FAR Australia and Mallee Sustainable Farming. Collaboration is with NSW DPI, Central West Farming Systems and AgGrow Agronomy & Research.

Table 3. Mean main effects on grain yield (t/ha) from management factors at Loxton and Yarrawonga (2017 and 2018 = 4 sites).

Management Factor (Grain Yield t/ha)						Mean Management Effect (t/ha)
Variety choice	DS Bennett⏀ (2.21) & Kittyhawk ⏀	(2.10)	Vs.	Longsword⏀	(2.40)	+0.30***
Seeding Rate (target density)	150 Plants/m^2	(2.14)	Vs.	50 Plants/m^2	(2.35)	+0.21***
Nitrogen Timing	Seedbed applied N	(2.32)	Vs.	N Delayed to Stem Elongation	(2.21)	-0.11 ns
Grazing^	Ungrazed	(2.38)	Vs.	Grazed	(2.11)	-0.27***
Sowing Date#	Early May Germination	(1.70)	Vs.	Mid-April Germination	(2.19)	+0.49***

*^grazing was simulated by using mechanical defoliation at Z15 and Z30, # Sowing date effect derived from Experiment 1 at Loxton and Yarrawonga. Level of significance of main effect indicated by ns=not significant, *** = P<0.001.*

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THE 2017-2019 GRDC NORTHERN REGIONAL PANEL

JANUARY 2019

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

CHAIR - JOHN MINOGUE

John Minogue runs a mixed broadacre farming business and an agricultural consultancy, Agriculture and General Consulting, at Barmedman in south-west NSW. John is chair of the district council of the NSW Farmers' Association, sits on the grains committee of NSW Farmers' Assn and is a winner of the Central West Conservation Farmer of the Year award. His vast agricultural experience in central west NSW has given him a valuable insight into the long-term grains industry challenges.

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DEPUTY CHAIR - ARTHUR GEARON

Arthur is a grain, cotton and beef producer near Chinchilla, Queensland. He has a business degree from the Queensland University of Technology in international business and management and has completed the Australian Institute of Company Directors course. He is a previous vice-president of AgForce Grains and has an extensive industry network throughout Queensland. Arthur believes technology and the ability to apply it across industry will be the key driver for economic growth in the grains industry.

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Roger Bolte is a fourth-generation farmer from the West Wyalong area in NSW, operating a 6500 ha winter cropping program with his wife and family focussing on cereals, legumes and hay. During his 35-years in the industry, Roger has been involved in R&D in various capacities and has had the opportunity to travel abroad and observe a variety of farming systems. He believes that R&D and education are the cornerstones of the industry and feels privileged to be afforded the opportunity to share his experiences.

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Roy Hamilton operates a 4400 ha mixed family farming enterprise near Rand in NSW's Riverina. He was an early adopter of minimum till practices and direct drill and press wheel technology and is currently migrating to CTF. The majority of the property is cropped while the remainder runs ewes and trade lambs. He has held roles on the south east NSW Regional Advisory Committee, the GRDC's southern region Regional Cropping Solutions Network and was a founding committee member of the Riverine Plains farming systems group.

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Tony is a grower from Forbes, NSW and managing director of an integrated cropping and livestock business. He is a director of the Rural Industries Research and Development Corporation. He has worked as an agricultural consultant in WA and southern NSW. With a Bachelor of Agricultural Science and a PhD in agronomy, Tony advocates agricultural RD&E and evidence based agriculture.

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Andrew is a grower and private agricultural consultant near Lake Cargelligo NSW with more than 17 years agronomy and practical farm management experience. He is an active member of the grains industry with former roles on the Central East Research Advisory Committee, NSW Farmers Coolah branch and has served on the GRDC northern panel since 2015. He is also a board member and the chair of Grain Orana Alliance.

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Peter operates a private agronomy consulting business based in Quirindi NSW. Prior to this he was facilitator/agronomist for AgVance Farming group, a communications conduit between industry and growers. He is a passionate supporter of research and has been active in extending weed management research information to industry, particularly in central west NSW, is a former director of Conservation Farmers Inc., a former member of the North East Regional Advisory Committee and a participant in Northern Growers Alliance local research group on the Liverpool Plains.

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GRAHAM SPACKMAN

Graham has been Managing Director of a private agricultural consultancy at Emerald, Queensland, for the past 28 years, providing advice on the agronomy and management of summer and winter, dryland and irrigated crops in grain and mixed farming systems. He has extensive involvement in RD&E having participated in two decades of GRDC and DPI-funded farming systems research, particularly in weed management, soil fertility and adaption of agronomic practices in CQ farming systems. Graham was a member of the CQ Research Advisory Committee for over 10 years and Chairman for five years.

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BRUCE WATSON

Bruce and his family operate a 3400 ha family grain growing business near Parkes NSW, which produces a mixture of dryland winter cereals, pulses and oilseeds as well as summer dryland cereals, pulses and cotton grown on a 12m zero till CTF platform with full stubble retention. Bruce holds a Bachelor of Agricultural Economics from the University of Sydney and previously worked with PricewaterhouseCoopers in its Transfer Pricing practice. He is an active member of the grains industry and was awarded a Nuffield Scholarship in 2009.

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DR JO WHITE

Dr Jo White is an experienced researcher with over 15 years' experience in agricultural research programs based at the Department of Agriculture and Fisheries in Queensland (DAFQ) and the University of Southern Queensland (USQ), including 10 years' experience in the field of plant pathology of broad acre summer crops. Jo has a keen interest in developing and delivering on-ground practical research solutions to growers which improve productivity and profitability of their farms and is now working as a private consultant based in Queensland.

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DR NICOLE JENSEN

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

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NORTHERN REGION GROWER SOLUTIONS GROUP AND REGIONAL CROPPING SOLUTIONS NETWORK

JANUARY 2019

The Northern Region of the Grains Research and Development Corporation (GRDC) encompasses some of the most diverse cropping environments in Australia, ranging from temperate to tropical climates – it has the greatest diversity of crop and farming systems of the three GRDC regions.

Implemented, to provide structured grower engagement, the GRDC Grower Solutions Group projects and the RCSN project have become an important component of GRDC's investment process in the northern region. The Northern Region Grower Solutions Group and the RCSN have the function of identifying and, in the case of Grower Solutions Groups managing short-term projects that address ideas and opportunities raised at a local level which can be researched demonstrated and outcomes extended for immediate adoption by farmers in their own paddocks.

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Northern Grower Alliance (NGA) was established in 2005 to provide a regional capacity for industry-driven, applied agronomic grains research. NGA is currently working on a five year Grower Solutions project, fully funded by the GRDC, focussing on cropping areas from the Liverpool Plains to the Darling Downs and from Tamworth and Toowoomba in the east to Walgett, Mungindi and St George in the west. A network of six Local Research Groups, comprised of advisers and growers, raise and prioritise issues of local management concern to set the direction of research or extension activity. Areas of focus range from weed, disease and pest management through to nutrition and farming system issues.

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Grain Orana Alliance (GOA) is a not for profit organisation formed in 2009 to help meet growers research and extension needs in the Central West of NSW to support their enduring profitability. Currently operating under the GRDC Grower Solutions Group - Central NSW project, one of the key priorities is to identify and prioritise R,D and E needs within the region through engagement with local growers and advisers. This grower engagement helps direct both the GRDC investments in research projects and GOA's own successful research programs. GOA's research covers a wide range of relevant topics such as crop nutrition, disease management and weed control. The structure of the project allows for a rapid turnaround in research objectives to return solutions to growers in a timely and cost effective manner whilst applying scientific rigour in the trial work it undertakes. Trials are designed to seek readily adoptable solutions for growers which in turn are extended back through GOA's extensive grower and adviser network.

CENTRAL QUEENSLAND GROWER SOLUTIONS GROUP

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The Central Queensland Grower Solutions project, is a GRDC and DAF Queensland investment in fast-tracking the adoption of relevant R,D & E outcomes to increase grower productivity and profitability across central Queensland. Covering approximately 550,000 ha and representing 450 grain producing businesses, the central Queensland region includes areas from Taroom and Theodore in the south to Mt McLaren and Kilcummin in the north, all of which are serviced by the project staff, located in Biloela and Emerald. Team leader Rod Collins is an experienced facilitator and extension officer with an extensive background in the central Queensland grains industry. He was part of the initial farming systems project team in the region throughout the late 90's and early 2000's which led the successful adoption of ley legumes to limit nutrient decline and wide row configurations in sorghum to improve yield reliability across central Queensland. He has more recently led the development and delivery of the Grains Best Management Practices program.

COASTAL HINTERLAND QUEENSLAND AND NORTH COAST NEW SOUTH WALES GROWER SOLUTIONS GROUP

The Coastal Hinterland Queensland and North Coast New South Wales Grower Solutions project was established to address the development and extension needs of grains in coastal and hinterland farming systems. This project has nodes in the Burdekin managed by Dr Steven Yeates from CSIRO; Grafton managed by Dr Natalie Moore from NSW DPI; Kingaroy managed by Nick Christodolou (QDAF) and Bundaberg managed by Neil Halpin.

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Neil Halpin is a principal farming systems agronomist with the Queensland Department of Agriculture and Fisheries. He has over 30 year's field trail experience in conservation cropping systems, particularly in the sugar-based farming systems of the coastal Burnett. His passion is for the integration of grain legume break crops, reduced tillage, controlled traffic and organic matter retention in coastal farming systems. Maximising the productivity and profitability of grain legumes (peanuts, soybeans and mung beans) is a common theme throughout the various production areas and systems covered by this project.

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Nick Christodoulou is a principal agronomist with the Department of Agriculture & Fisheries (QDAF) on Qld's Darling Downs and brings over 25 years of field experience in grains, pastures & soil research, with skills in extension application specifically in supporting and implementing practice change. Nick has led the highly successful sustainable western farming systems project in Queensland. Nick was also project leader for Grain & Graze 1 Maranoa-Balonne and DAF leader for Grain & Graze 1 Border Rivers project, project leader for Grain and Graze 2 and was also Project leader for the Western QLD Grower Solutions project. Currently he is the coordinator for the Grower Solutions Southern Burnett program.

BURDEKIN QUEENSLAND:

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The Burdekin & tropical regional node of the Coastal and Hinterland Growers Solution Project is led by CSIRO research agronomist Dr Stephen Yeates and technical officer Paul McLennan, who are based at the Australian Tropical Science and Innovation Precinct at James Cook University, Townsville. The Burdekin & tropical Grower Solutions node has a committed and expanding advisory group of farmers and agribusiness professionals. Due to the rapid increase in farmers producing mungbean in the region an open door policy has been adopted to advisory group membership to ensure a balance in priorities between experienced and new growers. The node is focused on integrating grain crops into sugar farming systems in the lower Burdekin irrigation area in NQ and more recently contributing to other regions in the semi-arid tropics that are expanding or diversifying into grain cropping. Information and training requests for information and training from the Ord River WA, Gilbert River NQ, Mackay and Ingham areas necessitated this expansion. Recent work has focussed on the introduction of mungbeans in the northern Queensland farming systems in collaboration with the GRDC supported entomologists Liz Williams and Hugh Brier, Col Douglas from the mungbean breeding team, the Australian Mungbean Association and Pulse Australia. Both Stephen and Paul have many decades of experience with crop research and development in tropical Australia.

GRAFTON NEW SOUTH WALES:

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The NSW North Coast regional node of the Coastal and Hinterland Grower Solutions Project is led by NSW DPI research agronomist Dr Natalie Moore and technical officer Mr Nathan Ensbey, who are based at the Grafton Primary Industries Institute. The NSW North Coast Grower Solutions node prioritises and addresses issues constraining grain production via an enthusiastic advisory group comprised of leading grain growers, commercial agronomists from across the region and NSW DPI technical staff. In this high rainfall production zone (800-1400mm pa), winter and summer grain production is an important component of farming systems that also includes sugar cane, beef and dairy grazing pastures, and rice. The region extends east of the Great Dividing Range from Taree in the south to the Tweed in the north. Both Natalie and Nathan have many years experience with research and development for coastal farming systems and are also currently involved with the Australian Soybean Breeding Program (GRDC/CSIRO/NSW DPI) and the Summer Pulse Agronomy Initiative (GRDC/NSW DPI).

REGIONAL CROPPING SYSTEMS NETWORK (RCSN) SOUTHERN NSW

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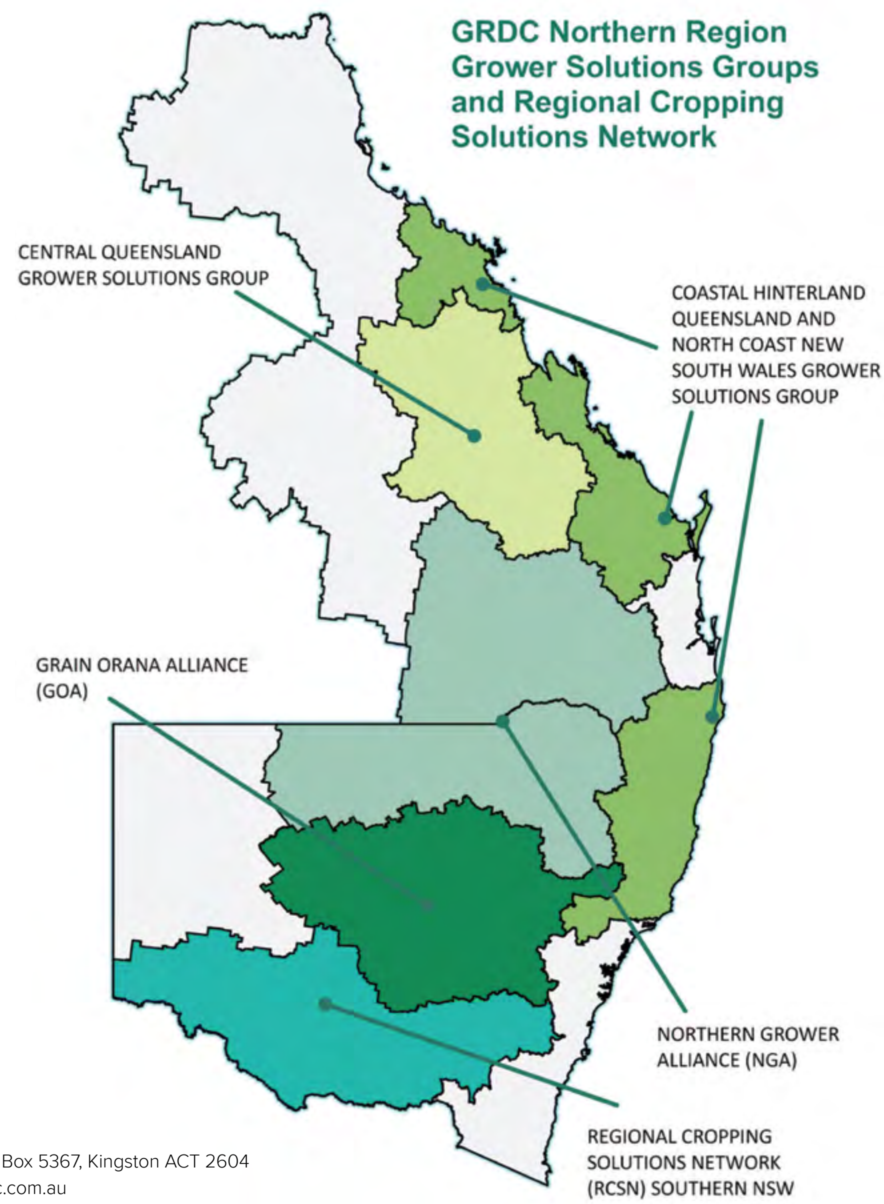
The Southern New South Wales Regional Cropping Solutions Network (RCSN) was established in 2017 to capture production ideas and opportunities identified by growers and advisers in the southern and western regions of New South Wales and ensure they translate into direct GRDC investments in local R, D & E priorities. The SNSW RCSN region covers a diverse area from the southern slopes and tablelands, through the Riverina and MIA, to the Mallee region of western NSW and the South Australian border. The region is diverse in terms of rainfall and climatic zones, encompassing rangelands, low, medium and high rainfall zones, plus irrigation. The SNSW RCSN is facilitated by Chris Minehan. Chris is an experienced farm business consultant and a director of Rural Management Strategies Pty Limited, based in Wagga Wagga, NSW. The process involves a series of Open Forum meetings which provide an opportunity for those involved in the grains industry to bring forward ideas, constraints and opportunities affecting grain grower profitability in their area. These ideas are reviewed by an RCSN committee comprises 12 members, including grain growers, advisers and researchers from across the region that meet twice per year to assist GRDC in understanding and prioritising issues relevant to southern NSW.



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Acknowledgements

The ORM team would like to thank those who have contributed to the successful staging of the Corowa GRDC Grains Research Update:

- The local GRDC Grains Research Update planning committee that includes both government and private consultants and GRDC representatives.
- Partnering organisation: Riverine Plains Inc.

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Prefer to provide your feedback electronically or 'as you go'? The electronic evaluation form can be accessed by typing the URL address below into your internet browsers:

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- You can start and stop the survey whenever you choose, **just click 'Next' to save responses before exiting the survey**. For example, after a session you can complete the relevant questions and then re-access the survey following other sessions.

2019 Corowa GRDC Grains Research Update Evaluation

1. Name [ ]

ORM has permisssion to follow me up in regards to post event outcomes.

2. How would you describe your main role? *(choose one only)*

- ❑ Grower
- ❑ Agronomic adviser
- ❑ Farm business adviser
- ❑ Financial adviser
- ❑ Communications/extension
- ❑ Grain marketing
- ❑ Farm input/service provider
- ❑ Banking
- ❑ Accountant
- ❑ Researcher
- ❑ Student
- ❑ Other* (please specify)

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For each presentation you attended, please rate the content relevance and presentation quality on a scale of 0 to 10 by placing a number in the box (**10 = totally satisfactory, 0 = totally unsatisfactory**).

3. National Paddock Survey – closing the yield gap and informing decisions: *Harm van Rees*

Content relevance [ ] /10 Presentation quality [ ] /10

Have you got any comments on the content or quality of the presentation?

4. Observations from the 2018 Saskatchewan Young Farmer of the Year Award winners: *Jordan Lindgren*

Content relevance [ ] /10 Presentation quality [ ] /10

Have you got any comments on the content or quality of the presentation?

5. Riverine Plains Inc research update: *Cassandra Schefe*

Content relevance [ ] /10 Presentation quality [ ] /10

Have you got any comments on the content or quality of the presentation?

6. Nutrition decisions following a dry season: *Graeme Sandral*

Content relevance [ ] /10 Presentation quality [ ] /10

Have you got any comments on the content or quality of the presentation?

7. Canola agronomy – consistent messages on canola agronomy hold strong in a Decile 1 season: *Rohan Brill*

Content relevance ☐ /10 Presentation quality ☐ /10

Have you got any comments on the content or quality of the presentation?

☐

8. Emerging management tips for early sown winter wheats: *James Hunt*

Content relevance ☐ /10 Presentation quality ☐ /10

Have you got any comments on the content or quality of the presentation?

☐

Your next steps

9. Please describe at least one new strategy you will undertake as a result of attending this Update event

☐

10. What are the first steps you will take?

e.g. seek further information from a presenter, consider a new resource, talk to my network, start a trial in my business

☐

Your feedback on the Update

11. This Update has increased my awareness and knowledge of the latest in grains research

Strongly agree	Agree	Neither agree nor Disagree	Disagree	Strongly disagree
❑	❑	❑	❑	❑

12. Overall, how did the Update event meet your expectations?

Very much exceeded	Exceeded	Met	Partially met	Did not meet
❑	❑	❑	❑	❑

Comments

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13. Do you have any comments or suggestions to improve the GRDC Update events?

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14. Are there any subjects you would like covered in the next Update?

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Thank you for your feedback.