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MARCH 2024

# GRAINS RESEARCH UPDATE

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# GRDC 2024 Grains Research Update Welcome

Welcome to our summer series of northern GRDC Grains Research Updates for 2024.

We are pleased to bring growers and advisers another series of Grains Research Update events tailored to deliver the latest research, development and extension (RD&E) to enhance the profitability and reliance of grain production.

The past year has continued to present unique challenges and opportunities, building on our experiences from 2023 where we faced below-average rainfall in parts of Queensland and northern New South Wales and close to average rainfall in southern NSW. To date, we have seen higher than expected December and January rainfall in many regions despite an initial dryer than average outlook.

These conditions highlight the importance of our ongoing RD&E efforts in developing resilient and flexible farming practices, allowing growers to adapt to the diverse weather and climate changes we see in our region.

Sustainability within the profitable farming systems framework continues to be front of mind for our sector and an important consideration when it comes to future market access, government policy and community expectations. One quarter of GRDC's current RD&E investment portfolio has been identified as having direct environmental outcomes, with a significant portion contributing indirect environmental research outcomes. GRDC's Sustainability Initiative articulates our focus on emerging interests in sustaining and improving our soil resource and working to better understand and manage greenhouse gas emissions. We look forward to sharing further results from these investments at future Grains Research Updates.

2023 was a significant year for GRDC. After extensive consultation with growers and the grains industry we announced our RD&E 2023-28 plan and a commitment to invest more than a billion dollars in research, development and extension to deliver improved outcomes for Australian grain growers.

Across our regions, this strategic investment involves addressing critical concerns highlighted by growers and advisers through the National Grower Network (NGN) and RiskWi$e forums.

In the northern region, GRDC and NSW DPI have entered a strategic partnership *Unlocking Soil Potential* aimed at developing novel products to capture, store and use more soil water in grain production. Other major strategic investments include the National Risk Management Initiative, known as *RiskWi$e*, and work designed to quantify the response of deep phosphorus placement and means of improving phosphorus use efficiency, farming systems research comparing and improving crop sequence gross margins and of course our ongoing, extensive and well known National Variety Testing program.

These represent just a few of the investments designed to ensure the most pressing profitability and productivity questions are addressed from paddock to plate. GRDC places a high level of importance on grower and adviser engagement and we encourage you to look for opportunities to participate in regional NGN forums that capture insights for future RD&E.

While we're pleased to be able to facilitate plenty of face-to-face networking opportunities across this Updates series, we have also committed to continuing to livestream and record the main events for anyone who is unable to attend in person.

For more than a quarter of a century GRDC has been driving grains research capability and capacity with the understanding that high quality, effective RD&E is vital to the continued viability of our grains industry.

Sharing the results from this research is a key role of the annual GRDC Updates, which bring together some of Australia's leading grains research scientists and expert consultants. We trust they will help guide your on-farm decisions this season and into the future.

We would like to take this opportunity to thank our many research partners who have gone above and beyond this season to extend the significant outcomes their work has achieved for growers and advisers.

If you have concerns, questions or feedback please contact our team directly (details on the back of these proceedings) or email northern@grdc.com.au. Please enjoy the Update and we look forward to seeing you again next year.

Gillian Meppem
Senior Regional Manager – North

# BURREN JUNCTION
# GRDC Grains Research Update
## Thursday 7 March 2024

**Burren Junction School of Arts Hall, 17 Waterloo Street,**
**Burren Junction NSW 2386**
*Registration: 8:30 AM for a 9:00 AM start, finish 2:40 PM*

**AGENDA**

| Time | Topic | Speaker(s) |
|---|---|---|
| 9:00 AM | GRDC welcome | *GRDC* |
| 9:10 AM | Integrating soil moisture sensors on sowing equipment to optimise seed depth & establishment | *David Finlay (MPT AgTech)* |
| 9:35 AM | Where AI adds value to agronomic and crop decision-making now, and where might this technology be in 5 years? | *Jacob Humpal (GRDC)* |
| 10:00 AM | Finding profit in the face of increasing input costs, interest and land value. | *Simon Fritsch (Agripath)* |
| 10:45 AM | MORNING TEA | |
| 11:15 AM | Farming systems risk and profit over time in wet and dry seasons with a dive into nitrogen and pulse impacts - risks and rewards of running a higher soil N balance west of the Newell | *Jon Baird (NSW DPI)* |
| 11:55 AM | Nitrogen strategy discussion | *Jon Baird (NSW DPI), Greg Rummery (Outlook Ag) & Brad Coleman (Coleman Agriculture)* |
| 12:20 PM | Fallow efficiency - how much impact does stubble height, crop type and plant population have? | *Richard Daniel (Northern Grower Alliance)* |
| 12:45 PM | LUNCH | |
| 1:35 PM | Crop competition effects on weeds and crops | *Michael Widderick (DAF Qld)* |
| 2:05 PM | Achieving cool grain temperatures in storage through well designed aeration systems | *Alex Conway (Control Unlimited)* |
| 2:40 PM | CLOSE | |

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# Integrating soil moisture sensor technology into seeding equipment to optimise seeding depth and crop establishment

*David Finlay & Gordon Howard, Moisture Planting Technologies Pty Ltd trading as mpt.ag*

**Key words**

seeding, emergence, in-furrow soil sensors, moisture sensors

**GRDC code**

SEN2312-001RTX

**Take home message**

- A common objective in seeding is to have all seeds placed into a uniform soil moisture profile to achieve a uniform emergence. This may involve scenarios involving both moisture seeking as well as dry sowing
- Traditional seeding equipment is generally focused on providing a seeding outcome where a consistent depth outcome is achieved
- Whilst acknowledging that uniform depth is a desirable outcome, it does not necessarily result in a uniform emergence outcome if there is soil moisture profile variability across a field
- The aim of this project is a semi-autonomous seeder that uses in-furrow soil sensors to determine the status of soil moisture, such that hydro-electric row units can be adjusted in real-time within field.

## Introduction

Over the course of many years, manufacturers of seeding and tillage equipment have consistently endeavoured to introduce innovative solutions designed to address specific challenges encountered during the seeding process. These solutions encompass a range of features, including consistent depth, breakout, trash flow, and press wheel functions, among others. While these features are undeniably important, a limitation lies in their ability to deal and react to variabilities within the soil.

The evolving landscape of agricultural technology has witnessed significant progress in both proximal and remote sensing. These advancements hold the potential to offer valuable insights into areas where variability is occurring within soils, however they often require ground truthing to validate their findings or may overlook regions with alternate soil properties.

An alternate approach to address these challenges involves the integration of sensors directly into the in-furrow arrangement of the seeder. This strategic placement allows for the real-time mapping of soil properties as the seeder traverses a field. The utilisation of this data during the seeding process allows the potential for optimising seed placement in-field by enabling adjustments to various mechanical aspects of the seeder mechanism.

## Non-uniform crop emergence

The occurrence of uneven crop emergence is often attributed to variability in soil moisture levels within the seed zone during or shortly after planting. The moisture present at seed depth might be sufficient for germination and emergence in certain sections of a field but insufficient in others.

When planting seed into dry soil, seeds may not germinate and emerge until a rainfall event occurs, which could be weeks after the initial planting. Consequently, a field may exhibit a mix of more and less established crop, with the discrepancy aligned with the duration from planting to the onset of rainfall.

Uneven emergence often leads to non-uniform maturity within a crop. The earliest emerging plants may reach maturity sooner than later-emerging plants This non-uniformity can complicate harvest timing and reduce overall yield.

Areas with delayed crop emergence may provide opportunities for weed growth before the crop canopy is established. Weeds can compete with crops for essential resources, further increasing the negative impact on crop yield.

### In-furrow soil sensing

During the 2010's deep seeding crops became common, partially due to seasonal conditions, and partially due to the increased production of chickpea, which can handle emerging from greater depths than many crops.

Whilst 'moisture seeking' was a proven method to improve crop establishment in marginal soil moisture conditions, it resulted in significantly higher fuel use, and was often related to structural fatigue of seeding equipment.

By embedding soil moisture sensors into an autonomous row unit with automatic depth control, a more optimised seed placement could potentially be achieved across an entire field, thus improving plant establishment, whilst potentially reducing fuel use in areas where soil moisture profiles were more favourable.

### Technology trials

In the preliminary phases of implementing this technology, trials were initiated using a single-row unit mounted on a trailer (Figure 1). This experimental setup served as a platform for testing various sensor types and gaining insights into the operational requirements of the hydraulic control, software, and mechanical requirements for the effective functioning of the row unit.

The utilisation of a single-row unit provided a valuable testing ground for different sensor types. It facilitated a hands-on exploration of the hydraulic control system, allowing for a comprehensive understanding of its intricacies in ensuring the optimal performance of the row unit. This initial testing phase played a pivotal role in refining the technology and establishing a foundation for further advancements.

**Figure 1**. First single row trial unit.

Despite the informative nature of these trials, a limitation arose due to the generation of only a single data set from the soil sensor. This singular dataset presented challenges in comprehensively assessing the performance of the specific sensor type, especially in comparison to alternative sensor types. The absence of multiple datasets limited the ability to conduct robust comparative analyses, impeding a refined evaluation of each sensor's advantages.

In essence, the single-row unit trials, while instrumental in determining the functionality of the hydraulic control system and testing different sensor types, highlighted the need for a more comprehensive approach to data collection.

To overcome the limited testing capacity of the single row machine, a 3-row unit was constructed (Figure 2). The transition from a single row unit to three introduced a more complex requirement to the hydraulic control system and the control software. This sophistication was essential to ensure the seamless coordination and functionality of multiple row units simultaneously. The expanded setup not only allowed for a comprehensive evaluation of the hydraulic control software's adaptability but also enabled a concurrent assessment of different sensor types.

However, beyond a seeding depth of approximately 100 mm, ground slippage became significant, particularly as a conventional road-going vehicle was used as the driving source. This limitation posed a hurdle to achieving full optimal performance.

The incorporation of three row units outlined the interplay between hardware and software components. The hydraulic control system needed to navigate the complexities of managing multiple row units, ensuring uniformity in seeding operations while accommodating the nuances introduced by different sensor types. This phase of development served as a baseline for refining not only the mechanical aspects but also the software algorithms that controlled the system's responsiveness.

Despite the challenge posed by ground slippage, the utilisation of three row units presented a unique opportunity for comprehensive testing and refinement. The concurrent evaluation of different sensor types allowed for a better understanding of each sensor's strengths and weaknesses under field conditions. This process contributed to the improvement of the technology, bringing it closer to achieving the desired outcome of the product.

**Figure 2**. Second trial unit with 3 rows.

After the initial trailer arrangement, the machine was rebuilt onto a linkage frame (Figure 3). This adaptation not only allowed for better trials but also extended the operational capacity of the machine, enabling it to reach a maximum working depth of 250mm.

The mounting on a tractor allowed integration in the tractors hydraulic system. This integration not only streamlined the overall hydraulic functionality but also offered the advantage of freely adjustable flow rates. Moreover, the seamless connection to the tractor's hydraulic system ensured a readily available fluid source, eliminating the need for electronic on/off fluid control. This on-tap fluid availability increased the machine's efficiency, allowing for dynamic adjustments and responsive control during various phases of operation.

Within this refined setup, a comprehensive network of pressure and load sensors was strategically incorporated. These sensors were positioned to cover the entire row unit, capturing data across various seeding depths. This arrangement allowed for the measurement of force settings throughout the entirety of the row unit, offering a detailed understanding of the forces experienced at different depths during the seeding process.

The integration of pressure and load sensors enabled the quantification and analysis of forces exerted by the row unit at different seeding depths. This data set not only provided valuable insights into the machine's performance but also facilitated the fine-tuning of force settings to achieve optimal outcomes across different soil conditions.

**Figure 3**. Third trial unit with 3 rows on a linkage toolbar.

During product development we had made substantial progress in defining the mechanical, hydraulic, control software, and sensor components. However, a critical phase remained – validating the system's functionality at scale. The existing 3-row machine, while informative in early trials, had limitations in its hectare-per-hour rate and faced challenges in discerning significant changes in soil properties over small areas.

To address these limitations, a strategic decision was made to acquire an existing 12-meter seeder frame. This larger frame offered the potential to scale operations and rapidly evaluate the technology over more extensive areas. The frame was retrofitted with 36 row units spaced at 333 mm intervals (Figure 4).

A trial site was selected in Tullamore, central New South Wales, providing a diverse and representative location for testing. The 120-hectare site offering a suitable area to assess the system's performance under more realistic conditions.

Whilst the large-scale trials proved successful, it involved significant works in commissioning the machine, primarily involving changes to the operational software in modifying the routine on how the rows engage and disengage as required during the course of performing the seeding tasks. On top of this, was the various ancillary requirements of engaging the seed cart, and in-field guidance.

**Figure 4**. 12-metre-wide frame, with 36 rows fitted during the 2023 winter cropping trials.

### What's next?

With an operational full-scale seeder in place, the validation and ROI works are the key priority.

During 2024, the key project objectives include:

- ISOBUS integration
  The seeder is currently operating under its own control suite, however upgrading to an ISOBUS control will not only simplify operation of the seeder but will potentially allow for an integrated semi-autonomous operation of the seeder with minimal user input. This development is aimed at allowing for both the current deskilling of the agricultural workforce and the future automation of both tractors and implements.
- New sensor development
  Currently working with a Sydney based university to improve the sensor array. This research is intended at improving both sensor accuracy and sensor wear resistance.
- Crop trials
  Increased cropping trials in a variety of zones, running in conjunction with standard seeding equipment to determine performance of the technology when compared to conventional seeders. These trials will allow the continued development and optimisation of the sensor technology, the automatic control of the seeder functions, and the simplification and refinement of the seeder user interface.

### 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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# Where AI adds value to agronomic and crop decision-making now, and where might this technology be in 5 years?

*Liam Ryan, Jacob Humpal, Darren Plett, John Rivers, Tom Giles,*
*Grains Research and Development Corporation*

**Key words**

AI, agronomy, technology, decision making, artificial intelligence

**Take home message**

- Artificial intelligence (AI) will add value to different agronomic decisions differently
- Prioritise quality-assuring yield and management data from on-farm experiments to help enable AI in agronomy
- Expect some AI-enabled beta (test) agronomy products from GRDC projects to be available in 2024 and keep an eye on the May-June Groundcover supplement for more information.

## Background

GRDC has a significant portfolio of R&D in AI in agronomy. The intent of this paper is to provide a practical and non-exhaustive overview of where AI currently adds value to agronomic decision making and where the technology is likely heading in the Australian market in the near to midterm based on scientific, commercial, and regulatory factors.

This paper is brief and qualitative in nature because a Groundcover supplement scheduled for release in May-Jun 2024 will discuss this subject in more depth, along with results from GRDC's broader portfolio in 'on-farm' applications of digital agriculture and automation.

## Where does AI add value to agronomic decision making?

AI is likely to add value to different agronomic decisions differently. That's a key message from this paper. A helpful way to think through the contribution to AI in agronomic decision making is in one of three categories:

1. Informing decisions
2. Guiding decisions
3. Prescribing decisions

This is not meant to be used as a formal or fixed distinction, but to provide some guard rails for understanding how AI can add value to decision making now and into the future.

## Where does AI add value now?

### *Informing decisions*

Some forms of AI are adept at retrieving, synthesising, and summarising vast amounts of information. Large Language Models (LLMs) such as Chat GPT by Open AI, Bard by Google, and Llama 2 by Meta AI are popular examples. For example, sourcing information on the optimum planting time for a specific variety in your location, its disease ratings, and its certifications to inform variety selection. Most LLMs have multi-model capabilities, meaning they can ingest and analyse multiple types of input data such as text, images, numerical data, etc. The capabilities of LLMs are evolving rapidly and their future influence on agronomic decision making could be profound. For now, they're worth experimenting with to make the job of sourcing and synthesising information much easier, but note they have biases, errors, and their terms of use need to be carefully understood.

### *Guiding decisions*

Many agronomic decisions can be guided by access to good data, as in accurate biophysical data provided at the right spatial resolution in a user friendly and cost-effective manner at the right time. For example, information on the flowering time of a given variety for a given location and emergence date; the PAWC and depth to constraints across a paddock; plant available water at *x* depth in *y* paddock or zone; spatial distribution of weed emergence in fallow and to some extent, in-crop, etc. These are all examples of current capabilities enabled by the coupling of AI with relevant domain expertise.

Sometimes the influence of AI is easily apparent, but often it's used 'behind the scenes' within a broader workflow for sourcing, processing, and analysing multiple sources of data. Here are some examples of AI at work across the GRDC portfolio developing agronomic data layers to guide decision making (Table 1). Note this is a just a snapshot and by no means an exhaustive list.

**Table 1.** Examples of how AI is used to create insightful agronomic data that can guide decisions.

| GRDC project code | Domain | Use-case | Example of how AI adds value |
|---|---|---|---|
| UOM1806-001RTX | Crop phenology | Predicting variety-specific flowering time | To predict parameters required for APSIM Next Gen to simulate flowering time using genetic data |
| UOS2205-006RTX | Frost and heat (Abiotic stress) | Predicting yield loss from frost and heat events in major crop types | To develop analytics methods that use historical precision ag, crop physiological, environmental, and remotely sensed data to predict the impacts of frost and heat events at different stages of development in different crop types and environments |
| UOS2206-009RTX | PAWC and soil constraints | Mapping spatial variations in PAWC and the depth to soil constraints | To develop analytics methods that use soil sampling data, soil surveys, environmental and remotely sensed data in combination with digital soil mapping techniques to map spatial variations in PAWC across a paddock and map the 'effective' rooting depth based on the depth to soil constraints. |
| UOS2002-001RTX | Plant available water (PAW) | Mapping and monitoring plant available water at different depths in the profile and across zones | To develop analytics methods that use soil sampling data, soil surveys, environmental and remotely sensed data (optical and microwave) in combination with soil water balance models to estimate the PAW content at different depth profiles at different points in time across a farm, paddocks, or zones in a paddock |
| BCS2307-001RTX | Weed management | Mapping post-emergent weeds for site-specific herbicide applications | To detect the location of weeds from drone-based imagery for input into sprayers with section control or individual nozzle control for site-specific application of post-emergent herbicides |
| DFL2304-001RTX | Disease management | Detecting the occurrence of foliar diseases | To analyse satellite imagery for the purpose of mapping the incidence of crop foliar diseases to inform fungicide management |

A few of these projects are just getting started, but many will have initial protypes/beta products made available in the spring of 2024 following 4-6 years of applied research and development and ongoing engagement with growers and agronomists across Australia. Keep an eye on the May-Jun Groundcover supplement for more information.

### *Prescribing decisions*

This is where AI in agronomy is most frequently hyped and perhaps most infrequently realised. A pertinent example is with mid-season nitrogen decisions in winter cereals across Southern Australia. It can be a complex decision given there are multiple variables interacting in different ways across different sites and seasons. Nonetheless, AI can have significant, strategic impacts in prescribing a course of action, but there's often a requirement to couple large volumes of quality on-farm data with relevant domain expertise, precision agriculture technologies, and a long-term outlook. The experience with the Future Farm project (CSP1803-020RMX) is a good example.

Working with leading growers across Australia to implement and sample large-scale strip trials and analyse multiple data layers in different ways, the team developed a method to predict the economically optimum N-rate that more than halved the recommendation error associated with a simplified mass balance approach (*Colaço et al., 2024*). See Figure 1 for a summary figure sourced from *Colaço et al., 2024*. This method is being evaluated further at scale in multiple crop types and environments with growers across Australia in partnership with a private company. While the results are very impressive, the requirement for data is intensive and the approach is contingent on implementing N-rich and N-nil strips using precision agriculture technology.

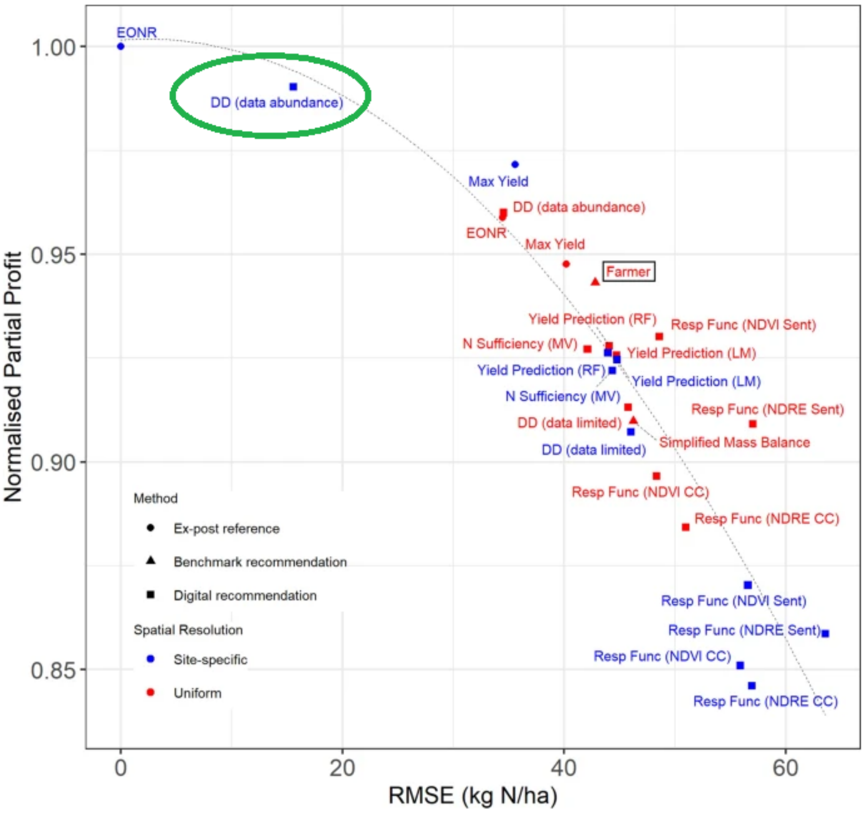

**Figure 1.** Error by profit biplot showing the average results of various N recommendation methods across 21 large scale on-farm trials in Australia, sourced directly from Colaço *et al.,* (2024). The RMSE stands for root mean squared error is a measure of accuracy. The lower the RMSE the better. Normalised partial profit is a relative measure of how profitable the N recommendation was. The higher the better. The method circled in green is the best-performing one and enabled by AI. Again, see Colaço *et al.*, (2024) for more information.

In summary, AI for prescribing complex decisions is doable and very powerful, but it's not easy. A key enabler of this approach is collated on-farm data and easy to use digital tools for collating yield and agronomic management data as well as results from large-scale on-farm experiments like strip trials. There are prior, powerful examples of this at work.

### The power of on-farm experimentation for enabling AI in agronomy

For example, Bayer's Fieldview$^{TM}$ platform has a powerful set of predictive agronomic tools for corn growers in the US. Fieldview provided digital tools for growers to implement simple strip trials and collect yield data from those strips alongside relevant agronomic management information. Aggregating that on-farm data at scale and combining it with their in-house small-plot database, genetic insights, and data science expertise provided an opportunity to build, test, and refine powerful predictive agronomic models that are both scalable and locally accurate. A blog post from the Climate Corporation (Bayer's Fieldview) back in 2018 provides a simplistic overview of the power or digital tools in the context of AI and agronomy (Eathington, 2018). For a more revealing description that highlights the power of collated on-farm data and on-farm experiments, it's worth reading through a patent filing from the Climate Corporation titled Digital modelling and tracking of agricultural fields for implementing agricultural field trials (Climate Corp, 2020).

Of course, many growers and agronomists already implement and learn from many types of OFEs. But quality assuring the yield data collected from those OFEs, collating it alongside management information, and creating a networked database of OFEs for analysis is often the missing piece. That's often key to realising the power of AI in agronomy. In addition to supporting product development in AI in agronomy, OFE provides a powerful basis to support peer-to-peer learning and fostering of farmer-researcher relationships (Lacoste *et al.,* 2022).

Digital tools are key facilitating both shared discovery between growers, agronomists, and researchers and collection of the quantitative geospatial data required to power AI-based agronomic models. There are many products available in the Australian market to help Australian growers implement and collect geospatial data from on-farm experiments, such as PCT Agcloud's strip trial tool and the Field Trial Module from SMS Advanced by AgLeader®. There are also different methods available to analyse treatment responses from large-scale on-farm experiments (e.g., Lawes et al., 2012 and Rakshit et al.) and published examples of the potential value of OFEs in different domains (Yan *et al.,* 2002; Virk and Witcombe, 2008; Kandel *et al.,* 2018).

### The impact of commercial drivers and market structure

While there's significant potential for AI in agronomy, commercial drivers often restrict the pace of development of AI in agronomy in the Australian market. Australia is a relatively small market on the global stage for digital agronomic analytics products and services. That mitigates the private investment into developing and scaling new innovations in AI and agronomy. While Australia has some excellent precision ag analytics companies operating in our market, the business case for investing in advanced agronomic analytics products for wheat, barley and canola in Australia often doesn't stack up the way it does for say corn and soy growers in North and South America.

### Where might this technology be in 5 years-time?

While this is difficult to predict given the pace of technological progress and some uncertain regulatory issues related to generative AI, there are some general observations worth noting:

#### *Expect new AI-enabled products and services to hit the market from GRDC investments*

GRDC has been investing in high-value use cases in agronomy and AI in multiple areas. By focussing on the high-value use-cases with a long-time horizon, GRDC's partners have able to couple their domain expertise in crop physiology, agronomy, soil science, nutrition, abiotic stress, and other areas to develop new products and innovations in AI and agronomy. We're excited to see many of them hit the paddock in and around spring 2024. Keep an eye on the May-Jun 2024 Groundcover supplement for more details on those projects, and where we're heading with our 'Grain Automate' program of RD&E that's focussed on machine autonomy and intelligent systems; areas heavily enabled by AI.

### *Expect data from on-farm experiments to have a strong influence in AI and agronomy*

Modern machine capabilities and data analytics tools make it easier than ever to implement large-scale on-farm experiments (OFEs) using precision agriculture tools. OFEs provide a rich basis of quantitative data across sites and seasons to help train and calibrate AI-based products for sub-paddock scale applications. As we head toward leveraging the power of AI for more complex agronomic decisions, OFEs are likely to be a linchpin in developing those products and services, and in helping growers and agronomists build confidence in those products.

### *Expect LLMs to advance rapidly barring regulatory and legal constraints*

The AI arms race among big tech companies such as Microsoft, Google, Meta (Facebook) is accelerating the pace at which AI tools become available to a wide breadth of users. At Agritechnica last year Bayer and Microsoft announced an update to Microsoft Azure Data Manager for Agriculture that included news of large language model APIs in Azure Data Manager for agriculture (Thomas, 2023). LLMs are also making coding tasks more accessible to non-software engineers, opening possibilities to easily automate bespoke data and/or agronomic analysis tasks, and many other applications.

## GRDC's investment strategy in AI and agronomy

GRDC has been focussing on high value use-cases that require complex science and commercial innovation to bring to market. That often involves investing upstream in applied R&D where the power of AI can be combined with relevant domain expertise, and where we can partner with companies that work closely with growers and agronomists to develop user-friendly AI products and services that really meet the need on-farm. We're excited to see the fruits of that long-term strategy deliver benefits on-farm and at scale in 2024 and beyond.

## Acknowledgements

GRDC staff get to collaborate with many innovative growers, researchers, companies and innovators in AI and agronomy. Many of which have contributed to the development and delivery of projects listed in the paper. We're thankful for their time, efforts, and ideation over the years and into the future.

## References

Colaço AF, Whelan BM, Bramley RGV *et al.,* (2024) "Digital strategies for nitrogen management in grain production systems: lessons from multi-method assessment using on-farm experimentation." *Precision Agriculture*, 230. [Online] Available at: https://doi.org/10.1007/s11119-023-10102-z

Climate Corp. (2020, February 21) "Digital modeling and tracking of agricultural fields for implementing agricultural field trials" [Patent EP3927137A1]. *Google Patents*. [Online] Available at: https://patents.google.com/patent/EP3927137A1?hl=en

Eathington S (2018) "The next evolution of digital farming technology." Retrieved from https://climate.com/blog/next-evolution-of-digital-farming/ Accessed 9/1/2024.

Kandel YR, Hunt CL, Kyveryga PM, Mueller TA, Mueller DS (2018) "Differences in Small Plot and On-Farm Trials for Yield Response to Foliar Fungicide in Soybean." *Plant Disease*, 102, 140–145. doi:10.1094/pdis-05-17-0697-re

Lacoste M, Cook S, McNee M *et al.,* (2022) "On-Farm Experimentation to transform global agriculture." *Nature Food*, 3(1), 11-18. [Online] Available at: https://doi.org/10.1038/s43016-021-00424-4

Lawes RA, Bramley RGV (2012) "A Simple Method for the Analysis of On-Farm Strip Trials." *Agronomy Journal*, 104, 371–377. doi:10.2134/agronj2011.0155

Rakshit S, Baddeley A, Stefanova K, Reeves K, Chen K, Cao Z, Evans F, Gibberd M (2020) "Novel approach to the analysis of spatially-varying treatment effects in on-farm experiments." Field *Crops Research*, 107783. doi:10.1016/j.fcr.2020.107783

Thomas S (2024) "Evolving Microsoft Azure Data Manager for Agriculture to transform data into intuitive insights." [Online] *Microsoft Azure Blog*. Available at: https://azure.microsoft.com/en-us/blog/evolving-microsoft-azure-data-manager-for-agriculture-to-transform-data-into-intuitive-insights/

Virk D, Witcombe J (2008) "Evaluating cultivars in unbalanced on-farm participatory trials." *Field Crops Research*, 106, 105–115. doi:10.1016/j.fcr.2007.10.017

Yan W, Hunt LA, Johnson P, Stewart G, Lu X (2002) "On-Farm Strip Trials vs. Replicated Performance Trials for Cultivar Evaluation." *Crop Science*, 42, 385. doi:10.2135/cropsci2002.0385

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# Finding profit in the face of increasing input costs, interest and land value

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## Notes

# Too little or too much; conservative and high nitrogen fertiliser tactics in northern farming systems

*Jon Baird[1], Lindsay Bell[2], Chris Dowling[3]*

[1] NSW Department of Primary Industries
[2] CSIRO
[3] Back Paddock Company

## Key words

Nitrogen, fertiliser strategy, farming systems

## GRDC codes

CSA00050, DAQ00192

**Take home message**

- Yield responses to high N & P fertiliser rates was variable across sites. At the Trangie red soil site, system yield was improved by 1.6 t/ha, while other sites showed little response ranging between 0.4 and 0.8 t/ha. Trangie Grey reduced system yield by 1.8 t/ha
- Dry matter production did improve in the Higher nutrient system by 1.7 t/ha, as did grain N export and cumulative cropping system N use was 80 k N/ha higher than the Baseline system
- Residual N improved in the *Higher nutrient* system compared to conservative fertiliser budgets (up to 60 kg N/ha), but losses due to weather events were larger and sometimes deleted the greater amounts of residual fallow N.

## Background

Seasonal variability within Australia's northern grain growing regions is increasing – from low rainfall seasons struggling to produce grain through to primed soil moisture levels producing high quality and high yielding crops. The challenge for growers is to ensure when these favourable seasons occur, the recovery efficiency of fertiliser is high and inherent conditions allow for optimum yield production.

Optimising nitrogen (N) fertiliser management in our cropping systems is critical to achieve acceptable yields and quality. Optimised rates are when the input of fertiliser is economically viable to achieve the highest possible gross margins. The challenge for growers is matching fertiliser usage with crop expectations in an environment that is highly variable. In addition, often fertiliser programs are focused on one crop and its requirements, rather than considering the legacy of previous crops and the requirement of future crops in the sequence.

Optimising application rates of N fertiliser will improve nitrogen use efficiency (NUE), especially when budgets include local contributions from other N pools/sources such as soil organic matter which have greater uptake efficiency than applied synthetic sources (Dowling, 2023).

The Northern Farming Systems project funded by GRDC, has explored differing fertiliser strategies since 2015, investigating the legacy implications on grain yield, economic sustainability and disease risk. The strategies include applying N and phosphorus (P) fertiliser rates aimed at achieving a 50th percentile modelled yield (*Baseline*) and high input strategy that provides the nutrition for a 90th percentile yield (*Higher nutrient*). We monitored the long-term N dynamics and the cropping system impact on NUE, crop N use and residual mineral N (nitrate-N and ammonium-N).

**Experimental setup**

Seven experimental sites were established in 2015 including Trangie (Grey and Red soil), Spring Ridge, Narrabri, Mungindi, Pampas, Billa Billa and Emerald. All sites contained a growers practice (*Baseline*) system, and a *Higher nutrient* system. APSIM modelling was performed to establish crop nutrient requirements specific to the location, crop choice, crop planting date and soil water content.

In the *Baseline* system, crops were fertilised to a nutrient budget targeting a predicted yield (APSIM) in the 50th percentile of seasons. That is, adequate N is applied for the crop to reach its yield potential in half of seasons (or an average yield outcome), while in seasons with higher yield potentials it is possible that the crop may not have sufficient N supply to meet its yield potential. In the *Higher nutrient* systems, crops were fertilised to a nutrient budget targeting a predicted yield in the 90th percentile of seasons. That is, the crops are fertilised so that they should never be limited by nutrient availability in any season, but this means that the crops are 'over-fertilised' in all but the best seasons. The crop N budgets are determined prior to sowing every non-legume crop. The rates applied are based on water limited predicted yield using well established N requirement calculations. An example for wheat is below (Equation 1). So, for the example crop situation in Figure 1, this would equate to a crop N fertiliser budget of 83 kg N/ha in the *Baseline* system and 185 kg N/ha in the *Higher nutrient* system.

Prior to each crop, the amount of fertiliser N to be applied was determined by deducting the amount of soil mineral N available in the top 90 cm (Equation 2) of the soil profile from the total crop budget (Equation 3). Hence, if there was sufficient mineral N available in the soil to meet the crop demand, then no synthetic N fertiliser was applied (other than starter to provide other nutrients). This method also did not assume or account for additional in-crop N mineralisation or adjust this based on crop history (e.g., following legumes). In the experimental locations in Queensland, all the fertiliser N was applied at sowing, while in NSW locations, a portion (up to 50%) was applied in-crop at the start of stem elongation.

***Equation 1: Wheat*** $_{N\ budget}$ ***= Predicted yield x 12% protein x 1.75 x 1.8***

***Equation 2: Soil Mineral N = (ammonium-N (-3 mg.kg) + nitrate-N) x bulk density x layer depth; summed to 90 cm depth***

***Equation 3: N to be applied = Crop*** $_{N\ budget}$ ***– Soil mineral N***

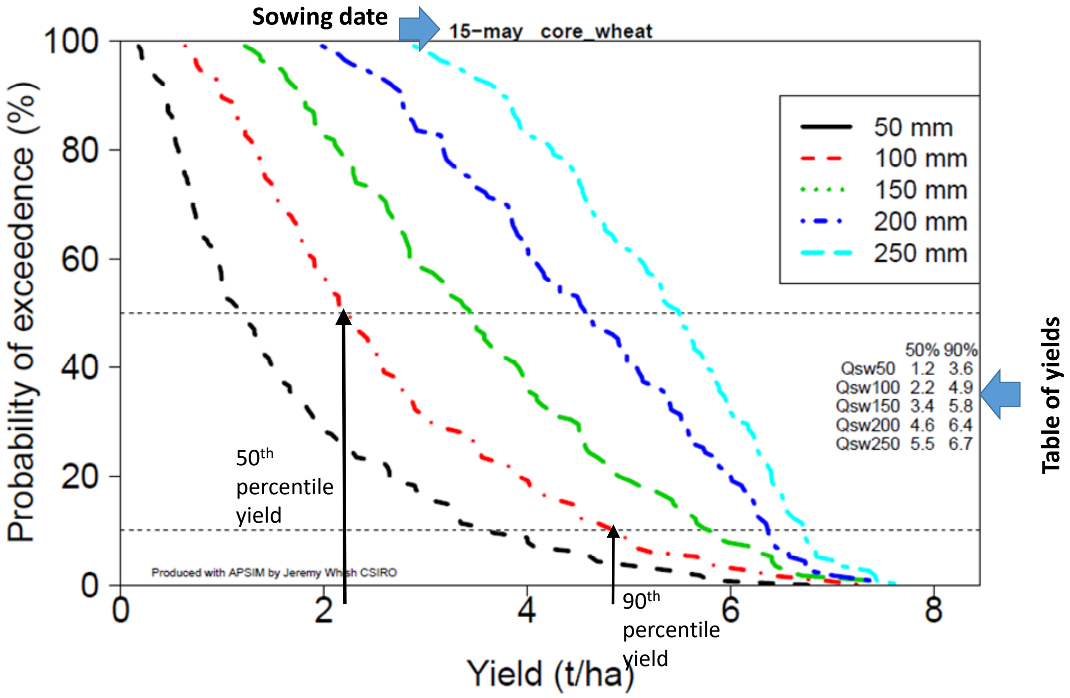

**Figure 1**. APSIM predictions of wheat yield probabilities with different starting soil water levels (50, 100, 150, 200 and 250 mm plant-available water). For 100 mm PAW at sowing (indicated by 2nd slotted line), the yield predictions for a 50th percentile season (1st vertical arrow) and a 90th percentile season (2nd vertical arrow) are shown; these are used to calculate the N budgets for the crop.

### System performance

A key objective when producers use a high input fertiliser strategy is to maximise productivity – particularly in favourable seasons. A yield gap analysis (https://yieldgapaustralia.com.au/) for wheat in the Coonamble district found that in the driest 20 % of years the water limited yield gap is around 46%, whereas in wetter years this rises to 60 %. Much of the gap in wetter years has been attributed to a lack of N, either low native soil N supply and or conservative fertiliser N rates. For our study, most sites had a number of below or average growing seasons in the last eight years. As expected during these low rainfall seasons there was minimal yield difference between the two farming systems. Seasonal growing conditions have improved since 2020 and higher grain yields were achieved for several individual crops when higher rates of fertiliser were applied, but the legacy did not result in a system difference. In saying that, we did achieve greater plant growth (dry matter production) at several sites. This shows that early plant growth may have been improved with the additional fertiliser N and P producing more plant biomass before late season moisture became limited and decreased yield potential. Considering the limited yield response to higher application rates of fertiliser N and P, growers should ensure the economic costs are sustainable, for this question we have applied dollar values to our results.

**Table 1.** Baseline and Higher nutrient productivity over multiple crops between 2015 and 2023

| | **System yield (t/ha)** | | | **System biomass (t/ha)** | | | **System income ($/ha)** | |
|---|---|---|---|---|---|---|---|---|
| **Region** | **Baseline** | **Higher nutrient** | diff | **Baseline** | **Higher nutrient** | diff | **Baseline** | **Higher nutrient** |
| **Billa Billa** | 27.4 | 28.2 | *0.8* | 67.1 | 70.0 | *2.8* | 8617 | 8596 |
| **Emerald** | 26.7 | 27.4 | *0.7* | 61.4 | 61.8 | *0.4* | 8423 | 8847 |
| **Mungindi** | 10.3 | 11.1 | *0.8* | 27.2 | 29.4 | *2.2* | 3219 | 3675 |
| **Narrabri** | 21.6 | 22.0 | *0.4* | 54.7 | 51.5 | *-3.3* | 7970 | 7860 |
| **Spring Ridge** | 36.8 | 37.5 | *0.7* | 79.6 | 81.8 | *2.2* | 12430 | 12539 |
| **Pampas** | 36.8 | 37.4 | *0.6* | 75.9 | 81.9 | *6.0* | 10738 | 10846 |
| **Trangie Grey** | 20.1 | 18.3 | *-1.8* | 41.5 | 43.5 | *2.0* | 6291 | 5650 |
| **Trangie Red** | 19.2 | 20.8 | *1.6* | 35.1 | 36.1 | *1.0* | 6679 | 7172 |
| *exp mean* | *22.6* | *23.1* | | *52.8* | *54.5* | | 7070 | 7156 |

## Is it economically viable to apply higher rates of fertiliser in northern grains regions?

When implementing a nutrient strategy containing higher rates of fertiliser for optimum productivity, growers should account for the higher costs and economic risks with the strategy. Extra fertiliser costs will vary according to starting soil fertility, mineralisation during fallow periods and seasonal conditions. Within the farming systems project, the extra costs ranged from $403/ha at Narrabri down to $18/ha at Emerald (Table 2, N fertiliser was costed at $1.30 per kg of N, which is lower than the current N fertiliser price). Please note, the rates of fertiliser were calculated to meet the projected yield modelled by APSIM dependant on sowing soil water, meaning budgets were built prior to planting and early crop development.

Applying greater fertiliser rates did improve levels of soil mineral N (nitrate-N + ammonium-N) by 20 kg N/ha on average across all the sites. When we place a value against the additional mineral N, the higher nutrient system is $25/ha in front of the *Baselin*e at the completion of the last harvested crop. In addition to extra mineral N, the value of exported grain N has allowed the higher nutrient system to generate greater N value of $54/ha per site.

The risk for growers is obviously the cost of the fertiliser, and the return on investment. If there is minimal difference in plant N use between systems, applying higher rates of fertiliser will leave greater levels of residual mineral N after the harvested crop. Mineral N when in the form of nitrate-N can be unstable in our farming soils and can be lost through various pathways. N losses did occur during the project, one instance at Spring Ridge saw a loss of >150 kg N/ha due to a severe summer storm in 2019 (Figure 2). A detailed paper by Graeme Schwenke (2022) highlights N loss pathways in grain cropping and options to reduce these losses. The study found N losses or un-accounted for fertiliser N was valued at $135/ha or $22/ha per planted crop, respectively. There is a possibility some of the un-accounted N is in organic form, and analysis planned at project closure will detail any changes in soil organic N.

**Table 2.** Economic viability of applying higher nutrients compared to the baseline system in the northern grains region (2015-2022)

| Region | Mineral N difference at final harvest | Additional N fertiliser cost | Additional min N value | System export N + soil N value | Value of additional N minus cost |
|---|---|---|---|---|---|
| | kg N/ha | $/ha | $/ha | kg N/ha | $/ha |
| **Billa Billa** | 34 | 76 | 44 | 124 | 48 |
| **Emerald** | -5 | 18 | -6.5 | 17 | -1 |
| **Mungindi** | 44 | 101 | 57 | 132 | 32 |
| **Narrabri** | 15 | 403 | 20 | 40 | -363 |
| **Spring Ridge** | 5 | 279 | 6.5 | 46 | -233 |
| **Pampas** | 19 | 250 | 24 | 44 | -206 |
| **Trangie Gray** | 5 | 130 | 6.5 | -71 | -201 |
| **Trangie Red** | 39 | 257 | 51 | 99 | -158 |

## Long term system legacy of higher application rates of fertiliser

On average across the eight years of study, the *Higher nutrient* system has applied 137 kg N/ha more than the typical growers practice system (*Baseline*) (Table 3). The additional application of fertiliser N may not have increased yield but there has been a slight improvement in exported N from the *Higher nutrient* system (+27 kg N/ha). When we add the legacy residual N, the overall system N use of the *Higher nutrient* system is 80 kg N/ha higher than the *Baseline* system. A basic system recovery calculation shows that of the additional N fertiliser, we have seen a recovery of 58% by the *Higher nutrient* system. This recovery rate is comparable to other agricultural industry values (Chen et al, 2008) and highlights the need for producers to understand their fertiliser use for the whole farming system and not a per crop or a single soil N pool basis.

The legacy of applying additional fertiliser N also led to greater residual mineral N across seasons. At Narrabri we found a difference between the *Baseline* and *Higher nutrient* system from 2017 through to 2021 (Figure 3). The difference ranged between 15 and 61 kg N/ha. The legacy lasted for a number of seasons, and was only diminished when grain yields exceeded 6 t/ha (2021).

**Table 3.** System fertiliser use and export rates in *Baseline* and *High nutrient* systems from 2015 - 2022.

| | **Cumulative applied N fertiliser** | | **Cumulative exported N** | | **Cumulative system N use** | | **System NUE** | | **Average summer mineralised N** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | kg N/ha | | kg N/ha | | kg N/ha | | kg/kg N | | kg N/ha | |
| ***System*** | *Baseline* | *High nutrient* | *Baseline* | *High nutrient* | *Baseline* | *High nutrient* | *Baseline* | *High nutrient* | *Baseline* | *High nutrient* |
| **Billa Billa** | 17 | 76 | 547 | 608 | 592 | 737 | 0.92 | 0.82 | 58 | 45 |
| **Emerald** | 96 | 120 | 568 | 586 | 549 | 516 | 1.03 | 1.14 | 70 | 60 |
| **Mungindi** | 83 | 161 | 213 | 271 | 297 | 310 | 0.72 | 0.87 | 37 | 6 |
| **Narrabri** | 257 | 567 | 502 | 517 | 346 | 665 | 1.45 | 0.78 | 20 | 23 |
| **Spring Ridge** | 384 | 599 | 738 | 768 | 326 | 481 | 2.26 | 1.6 | 26 | 51 |
| **Pampas** | 263 | 456 | 721 | 737 | 748 | 903 | 0.96 | 0.82 | 61 | 63 |
| **Trangie Gray** | 161 | 261 | 427 | 367 | 327 | 251 | 1.68 | 1.31 | 24 | 26 |
| **Trangie Red** | 186 | 384 | 295 | 332 | 288 | 150 | 1.02 | 2.21 | 15 | 10 |
| *exp mean* | *165* | *302* | *475* | *502* | *409* | *489* | *1.26* | *1.19* | *39* | *36* |

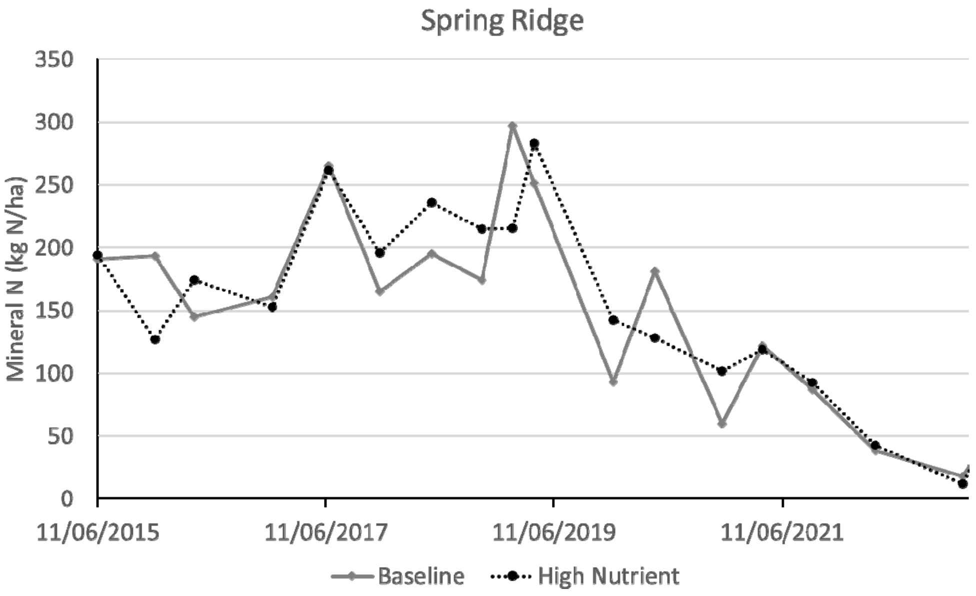

**Figure 2**. Long-term dynamic soil mineral nitrogen of a *Higher nutrient* and *Baseline* cropping system at Spring Ridge (2015–2022)

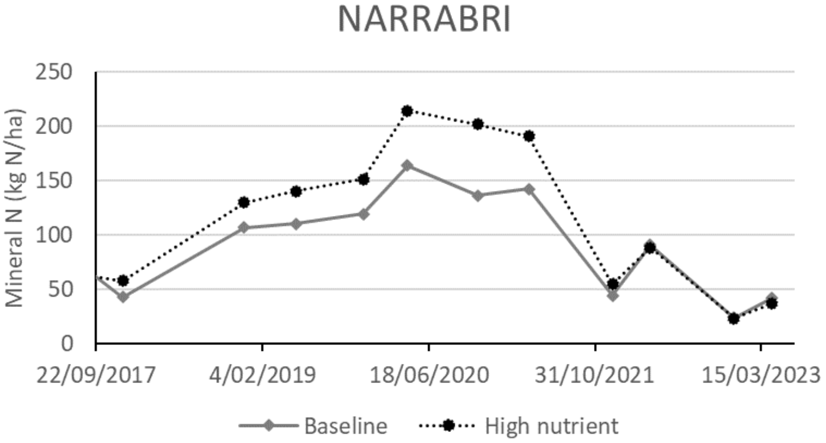

**Figure 3**. long-term dynamic soil mineral nitrogen of a *Higher nutrient* and *Baseline* cropping system at Narrabri (2017–2023)

## Conclusion

The importance of achieving a balance between input rates of fertiliser and fertiliser recovery is crucial for farming systems. There can be benefits to applying higher rates of fertiliser, but growers should always monitor their cropping soils and export levels to ensure non-productive losses are minimal. Evaluating fertiliser use across your cropping systems rather than on a per crop basis will further improve the understanding of the system sustainability. The cycling of N from past crop residue and organic sources is highly efficient and can be a significant source of nutrients for future crops. Practices that encourage build-up of N in organic matter should be a consideration when assessing soil fertility management options.

## References

Chen et al (2008). Prospects of improving efficiency of fertiliser nitrogen in Australian agriculture: a review of enhanced efficiency fertilisers. Journal of Soil Research, Vol. 46.

Dowling C (2023). Is it time to challenge current nitrogen strategies tactics and rules of thumb? https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2023/02/is-it-time-to-challenge-current-nitrogen-strategies-tactics-and-rules-of-thumb

Schwenke G (2022). Nitrogen loss pathways – how much do we lose and in what form under different situations. https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2022/06/nitrogen-loss-pathways-how-much-do-we-lose-and-in-what-form-under-different-situations

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# Nitrogen strategy discussion

**Notes**

# Fallow efficiency – impact of harvest stubble height

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**Key words**

fallow, stubble height, soil water

**GRDC code**

NGA00003, NGA00004 and NGA2009-001RTX

**Take home message**

- Fallow efficiency is a key driver of crop production in the northern grains region
- Increasing groundcover to 100% (i.e. a stubble mulch) can significantly increase fallow efficiency but how can it be done commercially ?
- Increase in adoption of stripper fronts allowed for an evaluation of the impact of harvest stubble height on fallow efficiency
- Paddocks harvested with a stripper front with extra treatments then imposed by 'harvesting' using conventional headers with dry matter spread in plots by straw spinners
- EM38 used to assess conductivity differences between treatments (as surrogate for soil moisture changes)
- No clear differences in soil moisture accumulation due to harvest stubble height in any trial
- No significant difference in yield of following crop in any trial
- Changing harvest stubble height may impact on other agronomic practices but did not provide a measurable impact on fallow efficiency or yield of the following crop.

## Background

The farming system in the northern region relies heavily on stored soil water for production, particularly during grain fill. Are there any approaches that could reliably increase water storage and then improve yields?

This project was initiated from the frequent observations of extra soil moisture under the increased stubble loads in header trials. Proof of concept validation trials commenced in January 2014 with small plot trials assessing the impact of added stubble on soil water in a low stubble situation. Results from these trials showed an increase in soil moisture with increasing ground cover (treatments added from 5-40 t/ha) with increases of up to ~50-60mm in gravimetric soil water in a number of the stubble-added treatments.

Given the magnitude of impact seen in these trials, the next step was to work with growers and try to find a practical way to apply the concept in commercial situations. One option proposed was to examine the impact of harvest stubble height on fallow efficiency.

## Aim

This paper summarises the impact of harvest stubble height on soil water accumulation and storage (~fallow efficiency).

**Trial details**

- All trials were carried out in commercial paddocks of wheat or barley stubble using commercial equipment
- Capacitance probes were used in the first 18 months of the Walgett trial to monitor impact on soil water
- EM38 assessment was subsequently used in all trials due to the high cost, inconvenience and poorer spatial representation from the capacitance probes.

An EM38 is a geophysical surveying instrument that provides a rapid measure of soil electrical conductivity. Factors affecting this measure are soil water and soil salt and clay content contents. Given that salt and clay contents remain largely stable in the soil, repeated measurements at a trial site allow for any changes in electrical conductivity to be attributed to changes in soil water. EM38 readings provide a conductivity measure at 3 depths: 0-37.5cm, 0-75cm and 0-150cm. Similar patterns of results were generally evident at all 3 depths in each trial.

**Figure 1.** Stubble height treatments: Bullarah February 2021

**Trial results**

***Walgett 2016***

- Trial in a paddock following Suntop⍉ wheat, grown on 40cm row spacings in 2016
- Paddock harvested in late November using a Shelbourne stripper, leaving tall stubble (~85 cm height)
- Additional treatments imposed approximately two weeks later using a conventional header
- Plots were 12 m wide x full field length with 5 replicates
- All straw 'cut' by conventional header was left in plots as spread by straw spinners
- Compared impact of stubble at three heights: short (~20cm), medium (~50cm) and tall (~85cm)
- ~14.5 t/ha of dry matter in tall stubble treatment
- Initial groundcover ranged from ~65% (short stubble) to ~50% (medium stubble) and ~35% (tall stubble)
- Next crop was unable to be planted until winter 2020 due to drought conditions

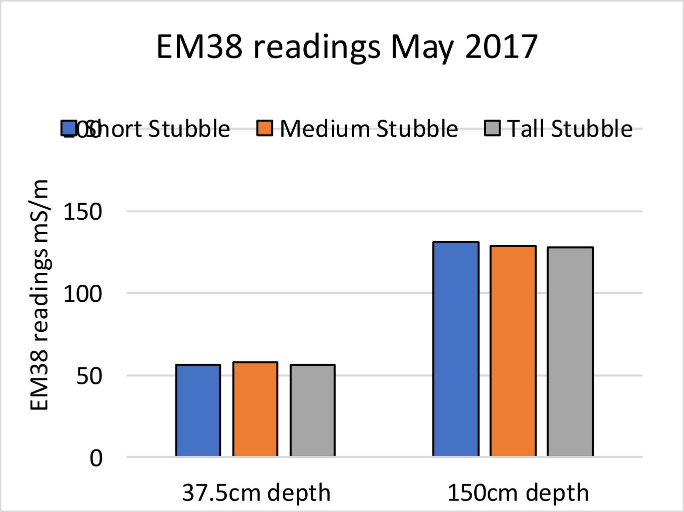

**Figure 2.** EM38 readings at Walgett May 2017

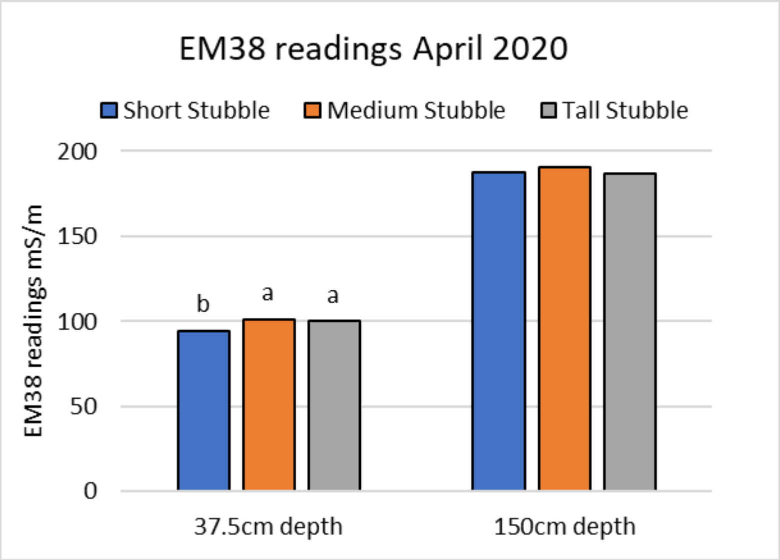

**Figure 3.** EM38 readings at Walgett April 2020

- Negligible difference in ‘soil water’ between stubble height treatments in EM38 readings throughout trial (NB only initial and final assessment dates shown)
- No clear difference in soil water from capacitance probe assessment between stubble height treatments (data not presented)

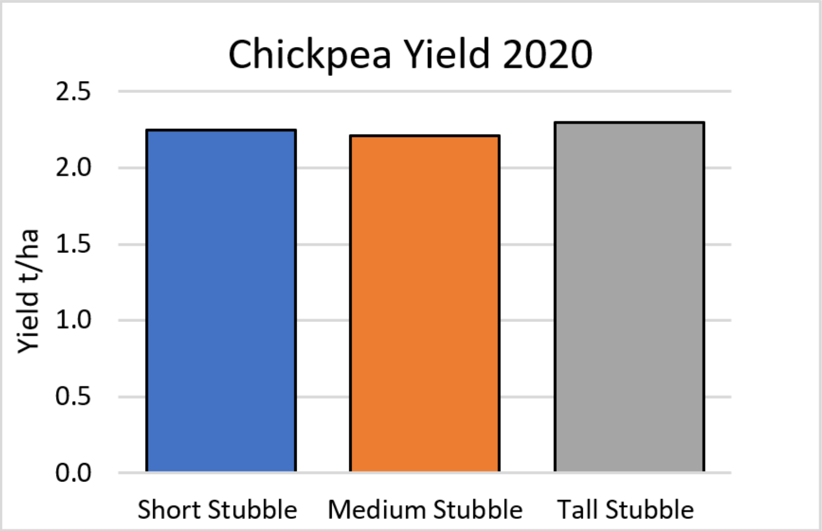

**Figure 4.** Chickpea yield at Walgett November 2020

- No significant difference in yield due to harvest stubble height

***Crooble 2019***

- Established following Planet⦷ barley, grown on 38cm row spacings in 2019
- Plots were 12 m wide x full field length with 6 replicates
- Treatments imposed in January 2020 using a conventional header
- Compared impact of stubble at three heights: short (~10cm), medium (~29cm) and tall (~51cm)
- All straw 'cut' by conventional header was left in plots as spread by straw spinners
- Only ~4.5 t/ha of dry matter in tall stubble treatment
- Initial groundcover ranged from ~49% (short stubble) to ~40% (medium stubble) and ~43% (tall stubble)
- Next crop sorghum planted in September 2020.

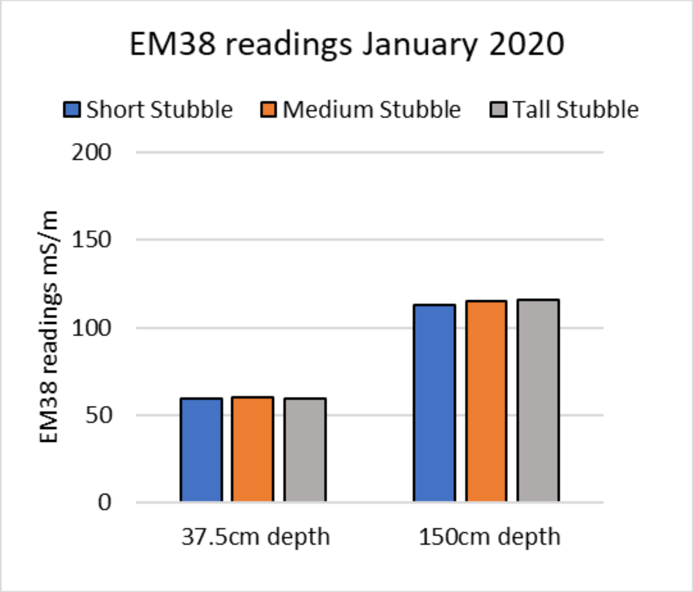

**Figure 5.** EM38 readings at trial initiation at Crooble Jan 2020

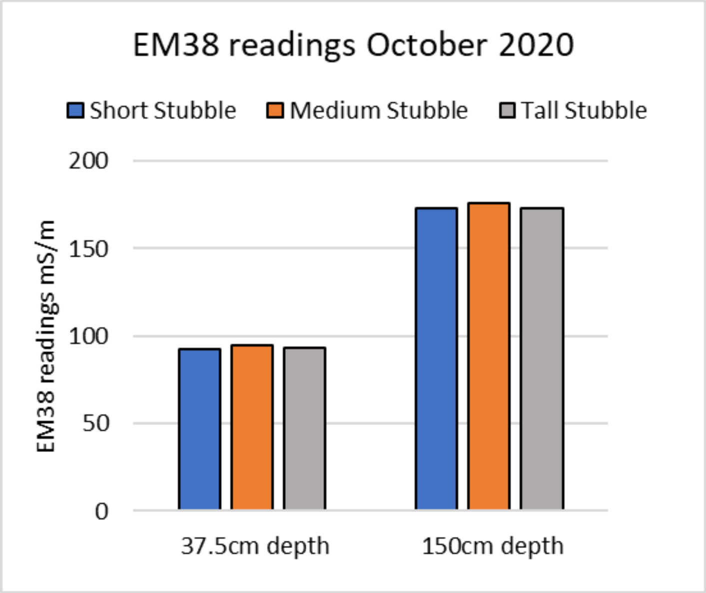

**Figure 6.** EM38 readings prior to sorghum planting at Crooble Oct 2020

- No significant difference in EM38 reading at any depth or assessment timing indicating no impact on soil water due to stubble height (NB only initial and final assessment dates shown)

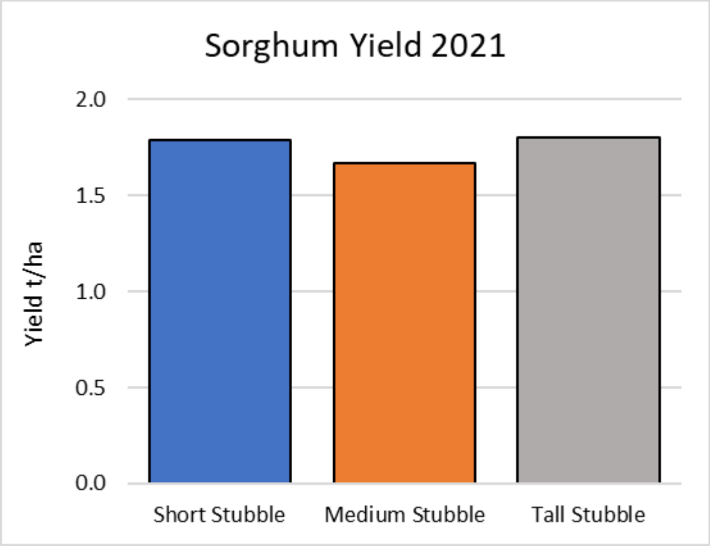

**Figure 7.** Sorghum yield at Crooble February 2021

- No significant difference in yield due to harvest stubble height.

***Bullarah, Mallawa and Crooble 2020***

- Nine trials established after the 2020 winter cereal harvest
- Plots 12 m wide x full field length with 6 to 9 replicates
- Initiation of trials was delayed due to the wet harvest, with treatments not imposed until Jan/Feb 2021
- Conventional headers or slashers used to create stubble height differences with straw remaining in plots
- All sites commenced with groundcover levels of greater than 60-70%
- Compared impact of stubble at three heights: short (~10-15cm), medium (~40-55cm) and tall (~85-95cm)

- Large rainfall totals were received at all sites in February and March 2021
- Interim EM38 assessments were not possible during that period and soil profiles may have been nearly full by April 2021
- One site abandoned due to flooding and yield data was compromised in three trials

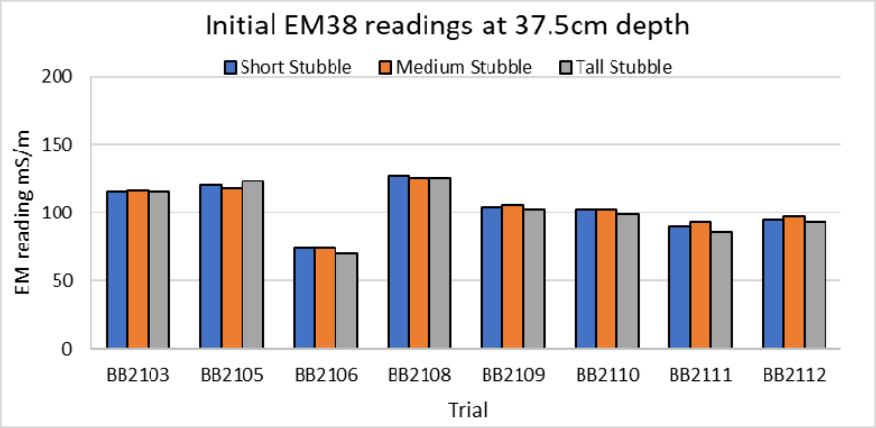

**Figure 8.** EM38 readings at 37.5cm depth at trial establishment across 9 trials (Jan/Feb 2021)

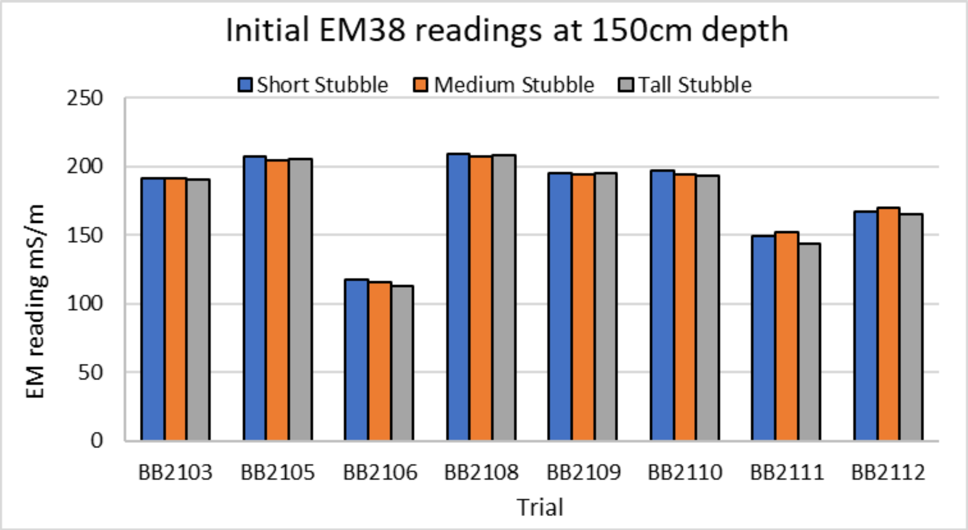

**Figure 9.** EM38 readings at 150cm depth at trial establishment across 9 trials (Jan/Feb 2021)

- No difference evident in EM38 between treatments at either depth, shortly after trial commencement

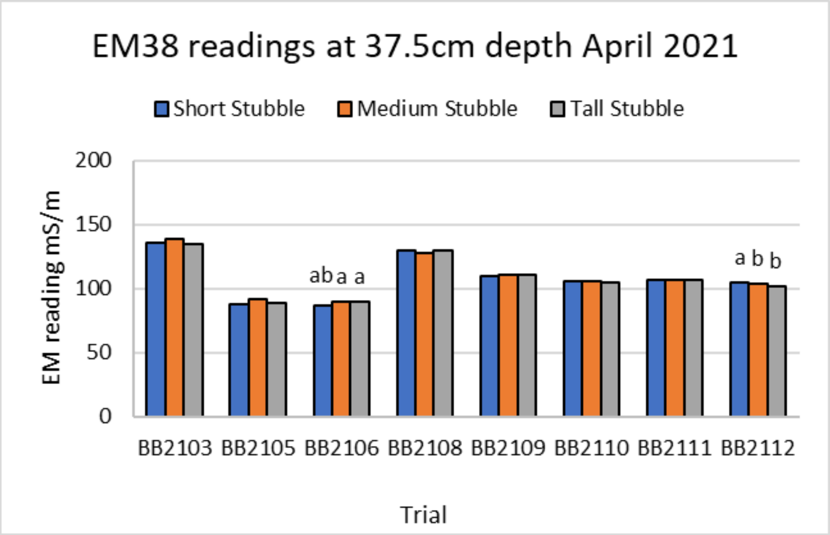

**Figure 10.** EM 38 readings at 37.5cm depth at end of summer fallow across 9 trials (April 2021)

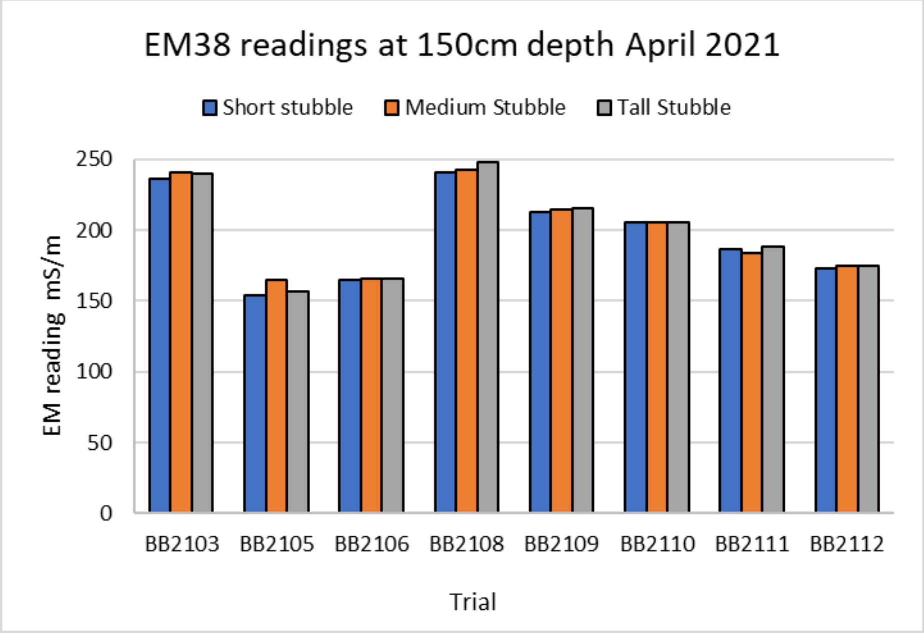

**Figure 11.** EM38 readings at 150cm depth at end of summer fallow across 9 trials (April 2021)

- Two trials had statistical differences at 37.5cm: one indicated a trend to **reduced soil water under short stubble**, the other indicated **increased soil water under the short stubble** treatment
- No significant difference in EM38 readings at 150cm depth in any trial indicating no impact evident on total soil water due to stubble height
- Two trials fallowed to dryland cotton in summer 2021/22

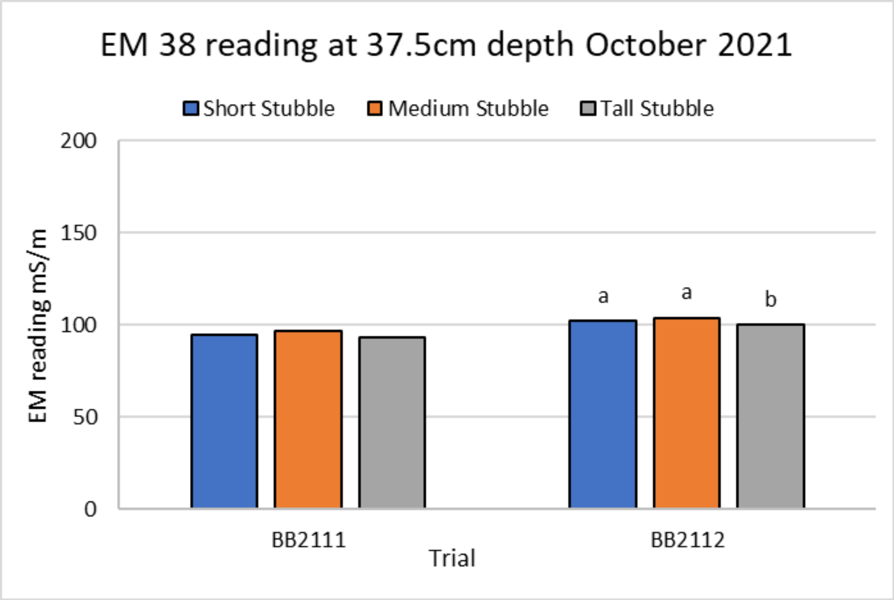

**Figure 12.** EM38 readings at 37.5cm depth prior to cotton (October 2021)

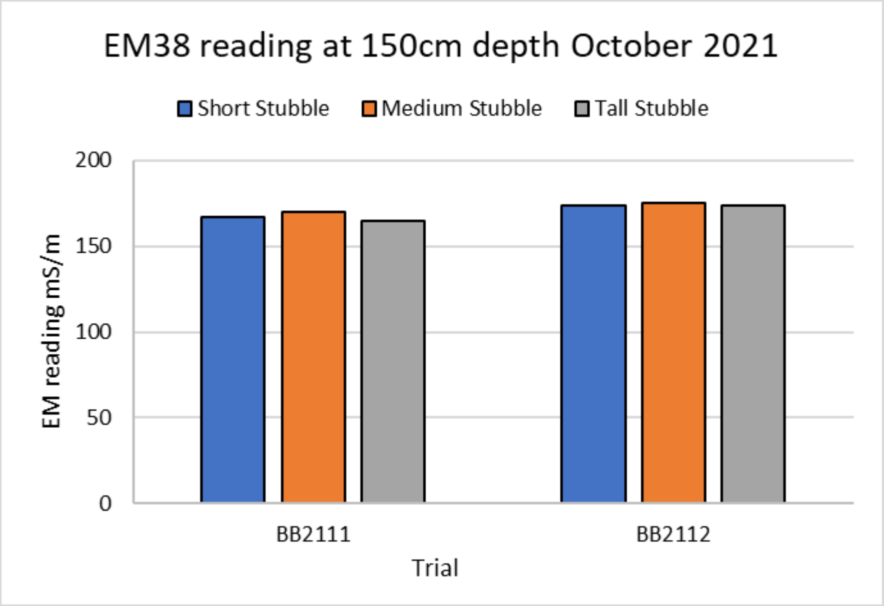

**Figure 13.** EM 38 readings at 150cm prior to cotton (October 2021)

- Trial BB2112 had significantly higher EM38 readings at 37.5cm in the short stubble at April 2021 and significantly higher for both short and medium stubble at October 2021
- No significant difference in EM38 readings at 150cm depth in either trial indicating no apparent difference in total soil water due to stubble height
- Header/harvest complications and wet weather impacted on yield data collection

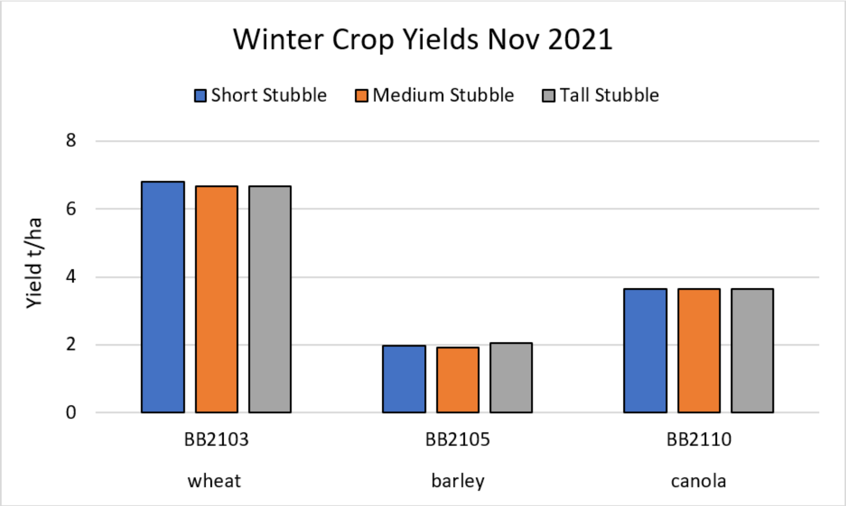

**Figure 14.** Yield (t/ha) from winter crop trials in 2021

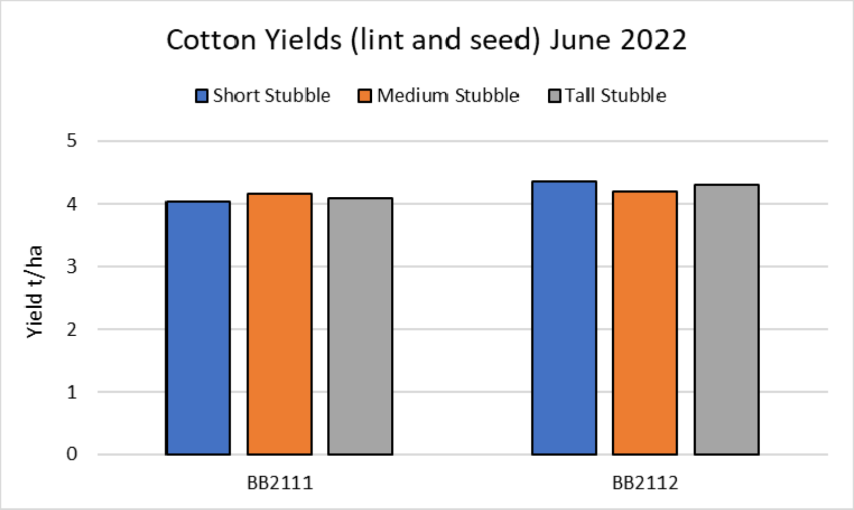

**Figure 15.** Yield (t/ha) from stripper picked cotton trials in June 2022

- No significant differences in yield at any site due to harvest stubble height

### Conclusions

This project was conducted to evaluate the level of impact of harvest stubble height on soil water or fallow efficiency. Trials were conducted under a range of conditions:

- Walgett 2016 started with good stubble loads but very poor fallow rainfall with the following crop not sown until winter 2020
- Crooble 2019 started with low stubble levels and experienced relatively low fallow rainfall
- Trials in 2020 started with high stubble loads and received large amounts of fallow rainfall shortly after commencement

Although none of the situations were considered ideal, the key messages to emerge from the trial series were:

1. **Harvest stubble height** - where the cut stubble was spread in the same treatment - **did NOT appear to provide any useful benefit in fallow efficiency as measured by EM38**
2. **There was NO indication of harvest stubble height impacting on the yield of the following crop**

**Did these results conflict with those from the pilot study in 2014 and 2015? In hindsight – NO.**

The pilot study assessed the amount of extra soil water that could be captured by ADDING stubble in a low standing stubble situation to achieve more than 100% groundcover. The harvest stubble height treatments DID NOT vary the amount of stubble in each treatment but just changed where it was located. Although a harvest stubble height approach would be relatively easy to implement on a commercial scale, it did not appear to be sufficient to result in a measurable impact on fallow efficiency.

It was clear that harvest stubble height can have other agronomic impacts:

1. Reduced weed emergence was noted in the tall stubble height plots at one site but knockdown weed control appeared more challenging due to poorer coverage
2. Short stubble height persisted longer in the Walgett 2016 trial as it appeared to remain 'anchored' in the soil despite over 3 years of fallow
3. Tall stubble height reduced canola emergence at one site with mouse damage suspected as the actual cause

In addition, recent studies from NSW DPI have shown that tall stubble height may increase the amount of crown rot infected stubble as the fungus can saprophytically colonise during the fallow.

Harvest stubble height can be influenced by a range of factors including header type, previous variety, growing conditions, presence of lodging or even by the intended following crop in the rotation. However, the data generated in this project would strongly suggest that harvest stubble height is unlikely to have any significant impact on the fallow efficiency achieved or on the following crop yield.

**Figure 16.** Stubble height treatments: Crooble April 2021

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

# Crop competition effects on weeds and crops

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**Key words**

crop competition, weeds, row spacing, crop density, yield stability

**GRDC code**

US00084

**Take home message**

- There is convincing evidence that increased crop competition in sorghum, mungbean, faba bean and chickpea resulting from narrower row spacing and/or increased crop density reduces growth and seed production of feathertop Rhodes grass and sowthistle
- Importantly, in most instances, narrower row spacing and increased plant density did not have a negative impact on grain yield. In situations where resources (e.g. water) were not limiting, more competitive crops resulted in higher yield
- In general, when there is low yield potential (usually due to limited resources) growing a crop at a narrow row spacing or increased crop density is more likely to result in yield loss. In contrast, when there is a high yield potential, crops grown at wide row spacing are likely to result in yield loss when compared to narrow row spacing.

## Background

In-crop weed control in the northern grain region (NGR) is heavily reliant on herbicides. However, this practice is not sustainable due to frequent and widespread herbicide resistance evolution. To prevent further resistance, and for herbicides to remain an important tactic for weed control, a combination of chemical and non-chemical weed control tactics is required.

An often overlooked weed management strategy is the use of competitive crops. Increased crop competition can be achieved by narrowing row spacing, increasing plant density or the use of more competitive crop species and cultivars. A competitive crop can compete against weeds to reduce weed growth (biomass) and seed production. However, a competitive crop will also need additional resources (water, nutrients) so that yield quantity and quality are not reduced.

Research was undertaken to quantify the effects of growing competitive summer (mungbean and sorghum) and winter (chickpea and faba bean) crops. This paper summarises research conducted at multiple sites over 6 years that focussed on the impact of row spacing, crop density and the combination of both on weed growth and seed production and crop yield.

## Methodology

Over the 2016 to 2021 growing seasons, replicated field trials were established across the NGR at three locations (Narrabri, Wagga Wagga and Hermitage). The impact of crop row spacing, crop density and a combination of row spacing and crop density was measured on weed growth (biomass), weed seed production and crop yield.

Awnless barnyard grass (data not presented) and feathertop Rhodes grass (FTR) were established in summer crops and common sowthistle was established in winter crops. The weeds were established either with the crop by sowing weed seeds, or by transplanting weeds into the crop. Exact crop and weed densities were established in fixed quadrats from which weed and crop measurements were taken. To measure weed growth and seed production, destructive samples were taken. Crop yield was also measured in each trial. No herbicides were applied in the crops and background non-target weeds were manually removed.

For chickpea and faba bean, the row spacings compared were 23/25cm and 46/50cm (differences due to available planting equipment). For chickpea, the crop densities compared were 15 and 30 plants/m$^2$, and for faba bean 20 and 30 plants/m$^2$. For sorghum we compared the row spacings of 50 and 100cm and crop densities of 5 and 10 plants/m$^2$. For mungbean, row spacings of 25 and 50cm were compared and crop densities of 20, 30 and 35 plants/m$^2$.

The growing seasons during these studies ranged from severe drought to flooding. In drought seasons, supplementary irrigation was applied, but only to ensure crop and weed establishment and survival. In some cases, crop establishment and survival were greatly impacted by the season and any compromised data has been excluded from analyses.

The research produced a large quantity of data with a total of 49 winter and 19 summer crop trials. To establish key trends in data, a combined trial analysis across sites and seasons was undertaken. Separate analyses were done for each agronomic factor (i.e. row spacing, crop density and row spacing × crop density) and each crop. For these analyses, separate 'environments' were considered and compared. Within each trial, an environment was where both levels of the crop agronomy were present (e.g. if 25cm x 30 plants/m$^2$ is the crop agronomy being analysed and we have 4 different cultivars within the trial, this creates 4 different 'environments' within one trial). By pooling data in this way, we have been able to assess the impact of different agronomic factors (row spacing and/or crop density) over a range of different growing conditions.

## Results

### *Faba bean*

A more competitive faba bean crop, achieved through narrower row spacing (23/25cm) and/or increased crop density (30 plants/m$^2$), consistently reduced sowthistle growth (biomass) and seed production, while maintaining grain yields in most cases (Table 1).

#### *Row spacing x crop density effect*

The greatest impact was evident when faba bean was grown at a combined narrower row spacing and increased density where reductions in sowthistle growth and seed production were not only more frequent, but greater (Table 1).

**Sowthistle biomass and seed production** – Highly competitive faba bean, combining narrow row spacing (23/25cm) with high crop density (30 plants/m$^2$), resulted in a lower sowthistle biomass in 60% of environments (Table 1). Similarly, the seed production of sowthistle was reduced in a highly competitive faba bean crop in 53% of environments and the reduction ranged from 45 – 95%.

**Faba bean yield** – Growing faba bean at the highly competitive configuration either maintained or increased faba bean yield in 96% of environments (Table 1).

**Table 1.** Impacts of different agronomic factors (row spacing, crop density and row spacing × crop density) in faba bean on sowthistle biomass and seed production and faba bean yield. A Reduction or Increase denotes a statistically significant reduction or increase.

| Agronomic factor | Sowthistle biomass | Sowthistle seed production | Faba bean yield |
|---|---|---|---|
| **Narrow row spacing**<br>25 vs. 50cm | Reduction in 44% of environments by 35 – 83%. | Reduction in 24% of environments by 36 – 71%. | Increase across all environments by 10%. |
| **Increased crop density**<br>20 vs. 30 plants/$m^2$ | Reduction in 33% of environments by 37 – 74%. | Reduction in 23% of environments by 44 – 89%. | Increase across all environments by 7%. |
| **Narrow row spacing × increased crop density**<br>25cm × 30 plants/$m^2$ vs. 50cm × 20 plants/$m^2$ | Reduction in 60% of environments by 47 – 87%. | Reduction in 53% of environments by 45 – 95%. | Increase at 25% of environments by 15 – 43%.<br>No difference at 71% of environments<br>Reduction at 4% of environments by 21%. |

### *Chickpea*

A more competitive chickpea crop, due to narrower row spacing (23/25cm) resulted in a reduction in sowthistle biomass but had no significant effect on sowthistle seed production (Table 2). Chickpea grain yields were either maintained or increased at this narrower row spacing. An increased chickpea density from 15 to 30 plants/$m^2$, resulted in a reduction in sowthistle growth (biomass) and seed production and an overall increase in chickpea yield across all environments.

#### *Row spacing x crop density effect*

When narrow row spacing and increased crop density were combined, sowthistle biomass and seed production were reduced to a greater degree than either alone, and yield was maintained in most cases.

**Sowthistle biomass and seed production –** Highly competitive chickpea grown at 23/25cm row spacing and density of 30 plants/$m^2$, reduced the biomass and seed production of common sowthistle in 44% and 30% of environments, respectively, compared to chickpea grown at the wider row spacing of 50cm and density of 15 plants/$m^2$ (Table 2). This is a lower percent of environments compared with faba bean (60% and 53%). Chickpea is known to be poorly competitive against weeds, and compared to the taller faba bean crop, this result is to be expected.

**Chickpea yield** – A competitive chickpea crop maintained grain yield in most environments (63%) and increased grain yield in 26% of environments (Table 2). In contrast, in only 11% of environments was there a decrease in crop yield in the highly competitive crop.

**Table 2.** Impacts of different agronomic factors (row spacing, crop density and row spacing × crop density) in chickpea on sowthistle biomass and seed production and sorghum yield. A Reduction or Increase denotes a statistically significant reduction or increase.

| Agronomic factor | Sowthistle biomass | Sowthistle seed production | Chickpea yield |
|---|---|---|---|
| **Narrow row spacing**<br>25 vs. 50cm | Reduction across all environments by 8 – 55%. | No difference across environments. | No difference at 90% of environments.<br>Increase at 10% of environments by 19 – 193%. |
| **Increased crop density**<br>15 vs. 30 plants/m$^2$ | Reduction in 36% of environments by 37 – 74%. | Reduction in 27% of environments by 39 – 74% | Increase across all environments by 20%. |
| **Narrow row spacing × increased crop density**<br>25cm × 30 plants/m$^2$ vs. 50cm × 15 plants/m$^2$ | Reduction in 44% of environments by 40 – 84%. | Reduction in 30% of environments by 39 – 85%. | No difference in 63% of environments.<br>Increase in 26% of environments by 11 – 154%.<br>Reduction in 11% of environments by 20 – 30%. |

### *Sorghum*

A more competitive sorghum crop, due to narrower row spacing (50cm) resulted in a reduction in FTR biomass and seed production (Table 3) and there was no difference in sorghum yield between row spacing treatments. An increased sorghum density from 5 to 10 plants/m$^2$, resulted in a reduction in FTR growth (biomass) and seed production and an overall increase in sorghum yield across all environments of 15%.

*Row spacing x crop density effect*

**Feathertop Rhodes grass biomass and seed production –** Highly competitive sorghum, combining narrow row spacing (50cm) with high crop density (10 plants/m$^2$), resulted in a lower FTR biomass in 35% of environments (Table 3) and the reduction ranged from 79 – 99%. The seed production of FTR was reduced in a highly competitive sorghum crop in 41% of environments (Table 3).

**Sorghum yield** – Growing sorghum at the highly competitive configuration either maintained or increased sorghum yield (Table 3). There were no reductions in yield across environments as a result of narrow row spacing and increased crop density.

**Table 3.** Impacts of different agronomic factors (row spacing, crop density and row spacing × crop density) in sorghum on feathertop Rhodes grass biomass (growth) and seed production and chickpea yield. A Reduction or Increase denotes a statistically significant reduction or increase.

| Agronomic factor | FTR biomass | FTR seed production | Sorghum yield |
|---|---|---|---|
| **Narrow row spacing**<br>50 vs. 100cm | Reduction in 32% of environments by 61 – 99%. | Reduction in 32% of environments by 49 – 91%. | No effect. Yield maintained. |
| **Increased crop density**<br>5 vs. 10 plants/m$^2$ | Reduction across all environments by 3 – 99%. | Reduction across all environments by 10 – 99%. | Increased across all environments by 15%. |
| **Narrow row spacing × increased crop density**<br>50 cm × 10 plants/m$^2$ vs. 100 cm x 5 plants/m$^2$ | Reduction in 35% of environments by 79 – 99%. | Reduction in 41% of environments by 56 – 97%. | Increase in 38% of environments by 45 – 67%.<br>No difference in 62% of environments. |

***Mungbean***

A more competitive mungbean crop, due to narrower row spacing (25cm) resulted in a reduction in FTR biomass and seed production at all sites (Table 4). Yield was not different between row spacing treatments at most (80%) sites, however there was an increase in yield at 10% of sites and a reduction in yield, also at 10% of sites. An increased mungbean density from 20 to 30/35 plants/m$^2$, resulted in a reduction in FTR biomass and seed production across all sites, however the magnitude of reduction differed greatly from 9-98% (Table 4). An increased mungbean density had no impact on crop yield.

*Row spacing x crop density effect*

**Feathertop Rhodes grass biomass and seed production** – Highly competitive mungbean, combining narrow row spacing (25cm) with high crop density (30/35 plants/m$^2$), resulted in a lower FTR biomass and seed production across all environments (Table 4).

**Mungbean yield** – Growing mungbean at the highly competitive configuration increased mungbean yield in all environments, with the yield increase averaging 7% (Table 4).

**Table 4.** Impacts of different agronomic factors (row spacing, crop density and row spacing × crop density) in mungbean on feathertop Rhodes grass biomass (growth) and seed production and mungbean yield. A Reduction or Increase denotes a statistically significant reduction or increase.

| Agronomic factor | FTR biomass | FTR seed production | Mungbean yield |
|---|---|---|---|
| **Narrow row spacing**<br>25 vs. 50cm | Reduction across all environments by 4 – 99%. | Reduction across all environments by 13 – 98%. | Increase in 10% of environments by 38 – 73%.<br>No change at 80% of environments<br>Reduction in 10% of environments by 40 – 55%. |
| **Increased crop density**<br>20 vs. 30 or 35 plants/m$^2$ | Reduction across all environments by 9 – 88%. | Reduction across all environments by 11 – 98%. | No effect. Yield maintained. |
| **Narrow row spacing × increased crop density**<br>25 cm × 30/35 plants/m$^2$ vs. 50cm × 20 plants/m$^2$ | Reduction across all environments, by 15 – 100%. | Reduction across all environments by 28 – 100%. | Increase across all environments by 7%. |

**Discussion**

Growing a competitive crop at a narrow row spacing and/or increased crop density is likely to reduce in-crop growth (biomass) and seed production of weeds, and this has been demonstrated for sowthistle and FTR in chickpea and faba bean, and sorghum and mungbean, respectively. Reducing weed growth via a competitive crop takes the reliance off herbicides for in-crop weed control. A competitive crop will provide complimentary weed control to herbicide application by reducing the growth and seed production on any survivors, thus preventing weed spread and persistence. This is important for keeping weed densities low and also for preventing the spread of herbicide resistance.

Favourably, the more competitive crop configurations maintained crop yield in most environments, and in some environments resulted in significant yield gains. In a minority of environments, competitive crop configurations resulted in crop losses due to less favourable seasonal conditions. A more competitive crop will require more resources (e.g. water) in order to retain or increase crop yield and grain quality.

### *Impacts on crop yield*

One of the key considerations for the adoption of growing a competitive crop via narrow row spacing and/or increased crop density is the impact on crop yield, especially in dry seasons or in low rainfall regions. In general, when there is low yield potential (usually due to limited resources), going to a narrow row spacing or increased crop density is more likely to result in yield loss. In contrast, when there is a high yield potential, crops grown at wide row spacing are likely to result in yield loss when compared to narrow row spacing.

A 3-year study undertaken by Kleemann and Gill (2010) investigated the effects of row spacing on growth and yield of wheat in South Australia. The study took place in three growing seasons with below average rainfall (286–361mm vs a long-term average of 434mm). Across the study, and despite the lower rainfall, there was a yield penalty for growing wheat at a wide row spacing compared to a narrow row spacing. Wheat yield declined by 5–8% as row spacing increased from 18 to 36cm and by a further 12–20% when row spacing increased from 36 to 54cm.

Modelling by Whish *et al.,* (2005) compared the production of sorghum at solid row configuration versus skip-row configuration using long-term weather records for a range of locations. They found that over the long-term, sorghum in a solid configuration produced a higher average yield.

In a comparison of 18 mungbean field trials from across NSW and Queensland, Moore and Dunn (2019) found a narrow row spacing of 25 – 40cm provided a significant grain yield advantage over a 100cm row spacing. Similarly, a publication by Gentry (2010) outlining the management of mungbeans, identifies that narrow row mungbean (15 – 40cm) have potential yield benefit as yield potential increases above 1 t/ha and that the yield margin increases to 10–15% in favour of narrow rows as yield potential approaches 2 t/ha. However, under severe moisture stress, the combination of wide rows and heavy stubble cover often results in a better yield than narrow rows.

To spread yield loss uncertainty, grow competitive crops when resources are likely to be plentiful or only in select paddocks rather than the whole property. A competitive crop may be used as a replacement for in-crop herbicides if weed densities are low, or in a situation of high weed density, combining a competitive crop with pre- and post-emergence herbicide will minimise weed survival and seed production.

### References

Gentry J (2010). Mungbean Management Guide 2nd Edition. Available online: https://era.daf.qld.gov.au/id/eprint/7070/1/mung-manual2010-LR.pdf .

Kleemann S and Gill G (2010) Influence of row spacing on water use and yield of rain-fed wheat (*Triticum aestivum* L.) in a no-till system with stubble retention. Crop and Pasture Science 61, 892-898.

Moore N and Dunn M (2019) Mungbean and soybean agronomy - time of sowing, row spacing and plant population: findings from combined trial analysis 2013-2018. GRDC Update Paper https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2019/08/mungbean-and-soybean-agronomy-time-of-sowing,-row-spacing-and-plant-population-findings-from-combined-trial-analysis-2013-2018

Whish J, Butler G, Castor M, Cawthray S, Broad I, Carberry P, Hammer G, McLean G, Routley R and Yeates S (2005) Modelling the effects of row configuration on sorghum yield reliability in north-eastern Australia. Australian Journal of Agricultural Research 56, 11-23.

### Additional/useful resources

Crop placement and row spacing fact sheet northern region. Available online: https://grdc.com.au/__data/assets/pdf_file/0018/210294/crop-placement-and-row-spacing-northern-fact-sheet.pdf.pdf

DAF Queensland Grains Research – 2016. Available online: https://www.publications.qld.gov.au/dataset/a103b315-253d-42ab-9a39-0051b1ed9739/resource/f564d65c-3bb8-425f-aabc-c0574243ca82/download/rantrials2016-24julylr.pdf

DAF Queensland Grains Research – 2017-18. Available online: https://www.publications.qld.gov.au/dataset/a103b315-253d-42ab-9a39-0051b1ed9739/resource/f4e08873-52bc-42c3-b81c-ec210646fef3/download/queensland-grains-research-1718-regional-agronomy.pdf

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# Achieving cool grain temperatures in storage through well designed aeration systems

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**Key words**

silo aeration systems, grain aeration, aeration controllers, optimising grain storage, aeration fans

**GRDC code**

PRB2011-001SAX

**Take home message**

- Aeration cooling is one of the most effective tools to combat stored grain insect pests and mould development in stored grain
- Grain storage aeration systems should be set up to achieve airflow rates of 2 to 4 litres of air, per second, per tonne of grain (L/s/t) for cooling or 15 to 25 L/s/t for drying
- Grain temperature under 23°C during summer storage and less than 15°C during winter are best to maintain grain quality and manage insect and pathogen incursion
- New research is assisting with aeration system design and fan performance to achieve the best results
- Monthly monitoring ensures aeration systems are operating effectively.

Grain is a living organism that deteriorates over time and this process is accelerated by heat and moisture. If left unattended this leaves grain more susceptible to mould and insect infestation. One of the most effective tools to protect grain quality is to use a well-designed aeration cooling system in grain storage facilities. When considering aeration systems there are several critical factors to consider that are discussed in this paper.

Until recently, grain storage aeration design was based on American research from 1951 and was used to guide manufacturers on key parameters relevant to design. Recent developments made possible through GRDC investment has resulted in updated information for aeration system design specific to Australian grain types, and conditions. As part of this development, fan performance testing has been conducted on a range of the most commonly used aeration fans and results are discussed here. The aim of this work was to provide improved outcomes to manufacturers and growers on performance and features necessary for Australian grain storage conditions.

## Aeration backpressure

Aeration backpressure is a key metric defining the performance of an aeration system and is a function of 3 major parameters: grain type (e.g., canola c.f., wheat), grain depth and airflow rate. The GRDC Grain Storage Extension Team recently tested 12 different grain types using these three criteria and are currently in the process of consolidating these results through an extensive array of on-farm field tests at storage facilities across the country. The effect that each factor has on the performance of an aeration system is illustrated below.

### *Grain type*

Grain type and size have a large impact on the performance of aeration systems. The grains tested (Figure 1) are presented in order from highest to lowest backpressure. Interestingly, canola indicates backpressures up to 2.4 times greater than wheat, which has a significant effect on the ability to move air through a parcel of grain.

| Backpressure ranking | Grain type |
|---|---|
| Highest backpressure | Canola |
| ↑ | Sorghum |
|  | Lentil |
|  | Wheat |
|  | Mung bean |
|  | Barley |
|  | Field pea |
|  | Oats |
|  | Corn |
|  | Chickpea |
|  | Faba bean |
| Lowest backpressure | Soybean |

**Figure 1.** Grain types ranked in order of backpressure level.

***Grain depth***

The interaction between the backpressure in an aeration system and how it increases non-linearly as the grain depth increases is shown in Figures 2. This means that higher airflow rates can be achieved by simply reducing the grain depth.

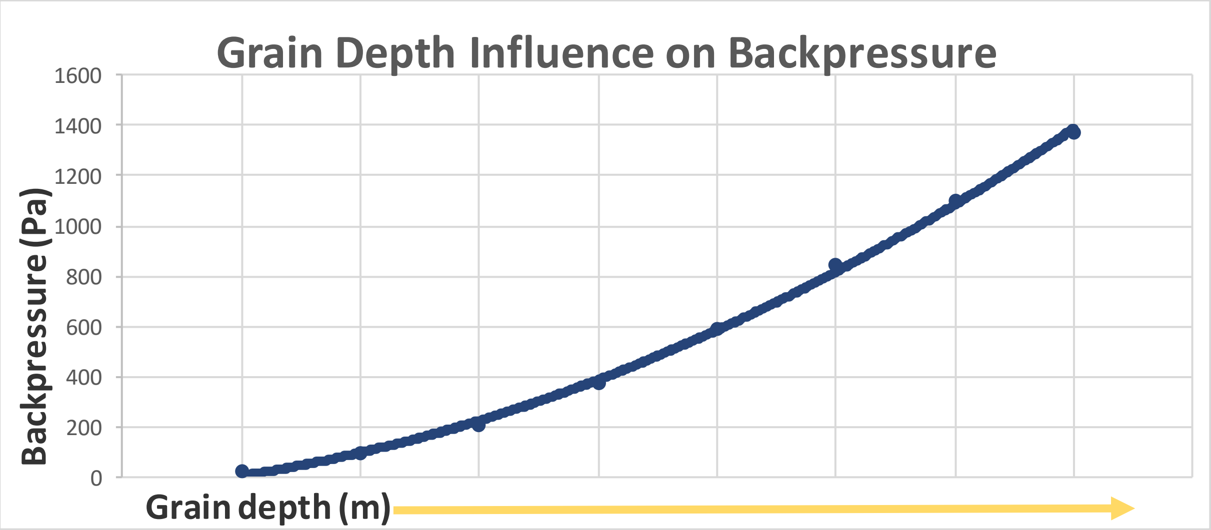

**Figure 2.** Relationship between backpressure and grain depth in stored grain.

### *Airflow rate*

The dramatic difference in backpressure between an airflow of 2 L/s/t (for cooling) and 15L/s/t (for drying) is shown in Figure 3. These results highlight the importance of ensuring that an aeration system is sized correctly to suit its desired application for cooling or drying.

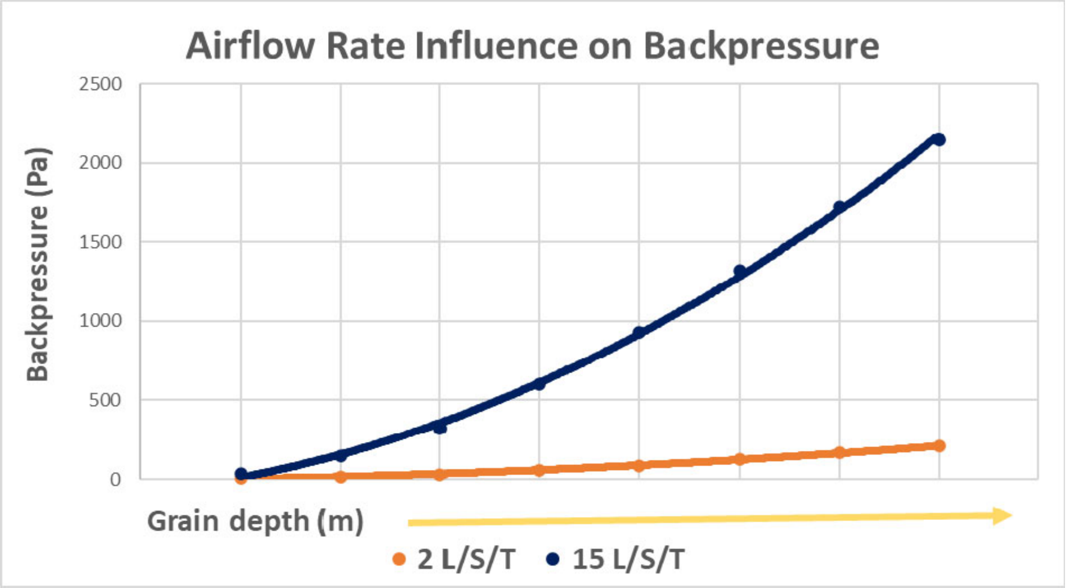

**Figure 3.** Relationship between backpressure and airflow rate in stored grain.

### *Aeration fan performance*

Another key factor in aeration system design is the correct aeration fan(s) and motor sizing. This is undertaken by cross checking the expected backpressure against a fan performance curve. The GRDC Grain Storage Extension Team has recently conducted performance testing on a range of aeration fans supplied by four silo manufacturers. The aim of this work was primarily to equip manufacturers with the data to ensure aeration systems supplied perform as the grower requires.

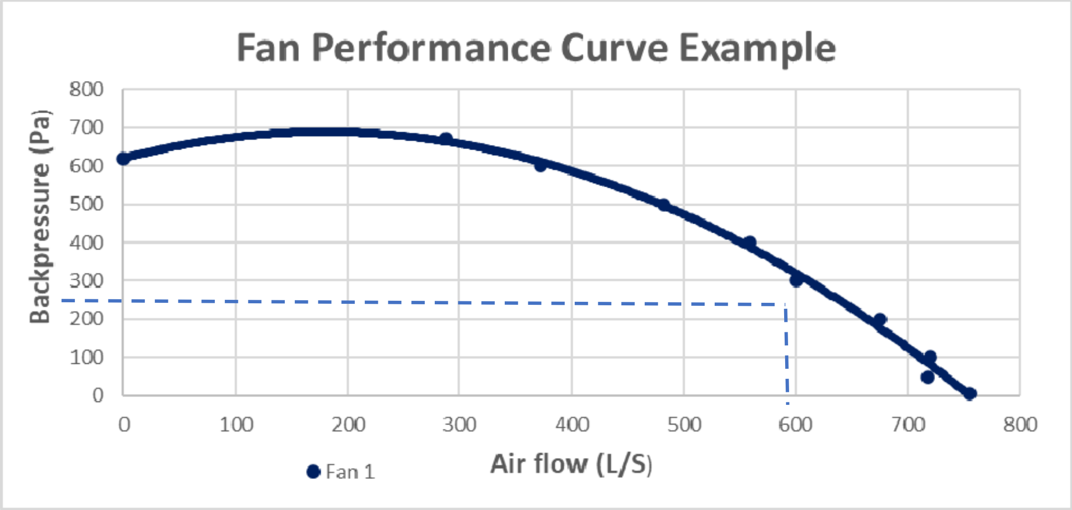

**Figure 4.** Comparison between various fan performance curves – a correctly sized fan is critical.

In the above example (Figure 4) the fan performance curve can be interpreted by interrogating a given fan backpressure point– for example 300 Pascals can operate at a corresponding flow rate of 600 litres per second. It's important to remember that adding multiple fans to a silo to increase airflow and even distribution, will also increase overall backpressure. So, the second and third fans won’t double and triple airflow, they may only add another 50% airflow depending on the fans performance curve and how many are added.

## Fundamental targets

### *Appropriate airflow rates*

Airflow rates measured in grain storage are most typically referred to in litres of airflow, per second, per ton of grain (L/s/t). Targeting the correct airflow rate is extremely important as without sufficient airflow the grain becomes increasingly susceptible to mould development and insect infestation. Measuring aeration fan airflow is not difficult and can be undertaken using the GRDC Grain Storage Fact Sheet ‘Performance testing aeration systems’. The optimal airflow rates for both long-term grain maintenance (e.g. cooling airflow rates) and ambient air grain drying (e.g. drying airflow rates) are as follows:

- Cooling airflow rate: 2 – 4 L/s/t
- Drying airflow rate: 15 – 25 L/s/t

### *Safe storage temperatures*

Regular monitoring of grain temperature is integral to ensuring seed stored for planting purposes maintains acceptable seed viability. Cool storage conditions also minimise the risk of mould and insect damage. This is most easily monitored using a grain temperature probe and should be checked monthly when checking for insect pests in stored grain. Grain storage aeration systems should target temperatures of:

- Summer: 18–23°C
- Winter: less than 15°C

## Monitoring & technology

Grain in storage requires regular and consistent monitoring, just as a crop does throughout the growing season. This allows any problems or equipment faults to be detected early before any significant damage can occur to the grain. A monitoring schedule performed monthly should involve:

- Fan testing: a well-equipped aeration controller will typically provide a ’test’ function that allows the operator to temporarily test each aeration fan for any faults
- Temperature testing: to ensure the grain mass is within the target range for the time of year
- Grain moisture monitoring: to ensure it is remaining constant
- Pest monitoring: check for pests in probe traps and sieve grain samples

## Conclusion

The grain storage extension team are providing ongoing test data to industry on both aeration fan performance and backpressures. This will assist both growers and silo manufacturers in ensuring the best aeration cooling results can be achieved through well designed systems targeting airflows of 2 to 4 L/s/t for cooling and 15 to 25 L/s/t for drying. Grain temperatures in summer should aim for between 18 and 23 degrees Celsius, and below 15 degrees in winter. The investment in quality on-farm storage with aeration can be maximised by regular monitoring and maintenance of the system over its lifespan. Our team has recently provided the following video production to assist grain growers manage grain quality and aeration systems.

The series of GRDC online videos for grain storage can be accessed here.
https://www.youtube.com/watch?v=SDwu98QomC0&list=PL2PndQdkNRHErDnJqZUsu2aj0Dd4GYgrb

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