Fodder for the Future
FINAL REPORT

Fodder for the Future

Australian Government
Department of Climate Change, Energy, the Environment and Water

Murray DAIRY

Dairy Australia

Contents

Executive summary

The Fodder for the Future project is a cross-sectoral collaboration designed to support the development of complementary farming systems that optimise the use of both irrigated and dryland resources across the southern Murray-Darling Basin. Led by Murray Dairy, the project was delivered under a partnership model with Agriculture Victoria, Birchip Cropping Group, Irrigated Cropping Council, The University of Melbourne, Riverine Plains and Southern Growers. The program was funded by the Australian Government through the Murray–Darling Basin Economic Development Program.

Its aim was to assist communities in developing strategies to maintain and increase economic activity through a participatory approach. The project engaged 2,016 farmers and service providers.

The project established 6 trial sites to showcase the economic and biophysical performance of different winter cereal, vetch and other legumes. Summer forages were also examined at one site. Other sites were supported by a comprehensive range of extension and communication activities. The project also developed legacy to engage farmers and service providers with strategies to improve their business performance.

The trial sites delivered a range of technical data to increase industry knowledge about how to improve yield and quality of fodder produced by key winter cereal and summer forages. It also identified a range of additional extension messaging to support dairy farmers and fodder producers increase the performance of their fodder production.

A key output of the project is the development of the Fodder for the Future Network, spanning key organisations involved in the delivery of project activities. This Network has emerged as a critical vehicle to share technical knowledge on how to improve fodder production, as well engage an extensive number of farmers and service providers effectively.

The project has contributed significantly to industry knowledge, and identifies a number of areas for future work including:

1. Support to continue the Fodder for the Future Network as a key mechanism for sharing technical knowledge around how to improve fodder yield and quality, as well as engage large numbers of farmers and service providers effectively.

2. Future research into the role of break crops in intensive cropping rotations to support dairy feedbase systems. This includes how to achieve the natural resource benefits of break crops such as weed and pest control whilst balancing the need to produce high quality fodder for lactating cows cost effectively.

3. Integration of best management practices relating to site preparation, weed control and nutrient management into standard dairy extension programs relating to feedbase. There remains significant potential to adapt common best management practice principals from the cropping industry into dairy extension packages as winter & summer cereals are continued to be adapted for dairy feedbase systems.

4. Sharing of information on fodder storage and handling developed by dairy industry to grain, fodder and other livestock producers particularly in the context of dry conditions. Similarly, grain and livestock stakeholders identified the opportunity to integrate common best management practice principals from the dairy industry around fodder quality testing, storage & handling into their extension delivery.

5. Updating current and future research projects, particularly those focusing on physical and economic modelling, with yield and quality results from this project to ensure realistic assumptions are being made around yield and quality targets. The variability of performance across years and species demonstrated by this project shows the importance of using current up to date data to inform modelling and economic analysis. This information could also benefit other regions when looking into future climate models and the impact on dairy feedbase performance.

Background

The Murray region has experienced an extremely volatile operating environment since the Millennium drought. This has been driven by water policy reforms, climate change, rising input costs, seasonal conditions and challenging commodity markets. Changes in production systems are driving changes in timing and volume of water demand across the season, presenting a challenge for irrigation district infrastructure planning. More recently, the industry has suffered a string of significant shocks, including high temporary water prices in 2015/16, milk price crash and extreme wet conditions in 2016, extremely high temporary water prices in 2018/19 continuing into 2019/20 and widespread flooding in 2022. This has had a significant impact on farm profitability and farmer confidence.

As a result of these drivers, the irrigated dairy industry has already undergone significant change and farm businesses are typically exemplified by the following characteristics:

- Limited access to irrigation water and/or high irrigation prices particularly high security water rights.
- Significant reduction in summer irrigation of direct grazed forages (e.g., perennial ryegrass and lucerne) due to high cost of production and increased production risk. Only ~30% of dairy businesses graze all year round.
- Significant reduction in traditional grazing systems and increase in partial mixed ration (PMR) and total mixed ration (TMR) systems in order to deal with feed gaps over summer and extreme events (heat waves, dry conditions, wet conditions).
- Flat calving patterns.
- Increase in alternative forages for fodder conservation to underpin PMR and TMR systems and increase water use efficiency e.g., winter cereals, vetch & legumes, maize and sorghum.

Transformation of feedbase systems

Dairy farms in the Murray dairy region have historically relied on low input, intensively irrigated, perennial pasture-based feed systems. Productivity and profitability of these systems were driven by access to abundant, cost effective and secure irrigation water and milder historical summer temperatures. Water policy reform, combined with volatility in climates as well as markets has significantly impacted the suitability of these feedbase systems. The Accelerating Change project (funded through the Murray Darling Basin Diversification Fund 2015-18) found that the cost of traditional perennial ryegrass feedbase systems increases significantly when water price increases, up to $679/t in 2015 when water price was approximately $180/ML[(2)]. In response, transformative change of dairy feedbase systems is occurring across all irrigated communities. Farmers are looking for strategies to increase their water use efficiency and to opt in and out of the irrigation market dependent on water availability and price. One strategy to achieve this is through the integration of alternative feedbase sources including winter cereals and summer forages.

The use of summer forages in dairy systems in southern Australia under limited water has been closely examined in a modelling exercise by University of Melbourne[(3)]. With less water available for irrigation, the spatial and temporal pattern of water use for growing feed must change to maximise the amount of feed produced for each megalitre of water available. Strategies that were successful in doing this included growing C4 crops such as maize, which can produce large tonnages of forage cost effectively during summer.

Winter cereals provide a much higher water use efficiency option for autumn and spring irrigations than traditional perennial ryegrass species, increasing water use efficiency from 1t/ML to up to 3t/ML[(4)]. Importantly winter cereals can also be grown as a dryland crop. Winter cereals provide a twofold approach at reducing reliance on irrigation; a) they can be grown without irrigation when water availability is low, and b) they are also conserved and fed back to dairy herds over the summer period, further reducing the volume of irrigation water required to sustain milk production compared to systems that rely on summer irrigation. Winter cereals have been modelled under the Dairy Directions – Analysing Farm Systems for the Future project. The project found that cereals perform better under drier conditions as metabolisable energy yields are maintained compared to other crops, and cereals have a relatively lower water cost component as a percentage of total cost[(5)].

Dairy feedbase systems that are now emerging are increasingly complex both in terms of agronomic management and breadth of crop types and species grown. Due to the rapid pace of industry change, farmers are trialling new practices and innovating on the go. In the last 5 years 99% of dairy farmers have tried a new crop, 50% have grown winter cereals and 40% have grown sorghum[(6)]. The need to support on-farm decision making with high quality, up to date and targeted research, development & extension is critical in order to assist efficient transformation of these systems.

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[1] Murray Dairy (2021), Murray Region Trends Report

[2] Murray Dairy (2018), Final Report-The Accelerating Change Project, funded by Regional Development Victoria, Dairy Australia, Agriculture Victoria & Murray Dairy (2015-2018).

[3] University of Melbourne, School of Land And Environment (2011) Forage based dairying in a water limited future: Use of models to investigate farming system adaptation in southern Australia

[4] Murray Dairy (2018), Final Report-The Accelerating Change Project, funded by Regional Development Victoria, Dairy Australia, Agriculture Victoria & Murray Dairy (2015-2018).

[5] Agriculture Victoria (2013) *Dairy Directions-Analysing Farm Systems for the Future project technical note.*

[6] Murray Dairy (2021), Murray Region Trends Report.

Overview of Project

Project Objectives

The Fodder for the Future project is a cross-sectoral collaboration designed to support the development of complementary farming systems that optimise the use of both irrigated and dryland resources across the southern Murray-Darling Basin (MDB). Led by Murray Dairy, the project was delivered under a partnership model with Agriculture Victoria, Birchip Cropping Group, Irrigated Cropping Council, The University of Melbourne, Riverine Plains and Southern Growers.

Its aim was to assist communities in developing strategies to maintain and increase economic activity through a participatory approach. The project engaged 2,016 farmers, service providers & other stakeholders delivering communication and engagement activities, extension resources, workshops, and other initiatives to share information and support community adaptation to a water-limited future.

The Project Objectives were to:

1. Increase economic activity to support regional communities in a variable water future.

2. Increase collaboration, coordination and information sharing between communities and industries in the Southern MDB.

3. Enhance opportunities for broader community engagement through the development of locally generated meeting sites, information, knowledge, and support services for agricultural stakeholders.

4. Improve the quality and quantity of fodder produced in the MDB, including increasing water use efficiency, water productivity, and reducing reliance on irrigation.

5. Foster the development of a 'closed loop' fodder production system within the Southern MDB to retain the value of fodder production locally.

6. Enhance risk management, diversity and resilience of farm businesses by establishing long-term complementary relationships between fodder producers and end-users in the basin.

Activities

Project Partners

The partnership model of the project focused on coordination and collaboration between organisations that have both technical expertise in fodder production and large farmer networks. Project partners included:

Birchip Cropping Group (BCG)

BCG is an agricultural research and extension organisation based in Birchip, Victoria, Australia. BCG focuses on addressing the challenges and opportunities faced by farmers in dryland cropping systems. Their primary objective is to enhance farm profitability and sustainability through research, knowledge transfer, and adoption of best practices.

Irrigated Cropping Council (ICC)

The ICC, based in Kerang, Victoria, is a farmer driven, not for profit, independent research organisation, committed to providing the latest research in irrigated grain production and connecting growers with local, state and national research and extension. ICC have recently changed their name and are now known as Irrigated Farmers Network (IFN).

Riverine Plains

Riverine Plains is an independent farming systems group dedicated to improving the profitability and prosperity of broadacre farming systems in north-east Victoria and southern New South Wales. Riverine Plains specialises in farmer-driven research and extension that delivers on-the-ground benefits to members.

The University of Melbourne-Dookie Campus

Dookie plays an important role in development of agriculture and agricultural teaching and learning. It has a key focal point on forward looking research, teaching and technology development.

Southern Growers

Southern Growers is a member-based organisation in the Murray Irrigation Region. It is a non-for-profit organisation that focuses on assisting irrigation farmers to increase their return per megalitre of water they use. Southern Growers membership base includes irrigated dairy farmers and grain growers.

Agriculture Victoria Tatura

Agriculture Victoria delivers policy, research, development, extension, regulation and market access, and regulation services to long established and mature agricultural industries such as beef, sheep and dairy, as well as new and emerging industries. The Tatura team speciality is in dairy agronomy and irrigation Research.

Project Activities

Project activities were multifaceted and were designed to both increase the technical knowledge available to farmers and service providers about how to improve quality and yield of key fodder products, but also encourage relationship building between different industries and partners.

Project activities involved:

1. Trial and demonstration sites to test the impact of different management strategies on key fodder species specifically to improve yield and quality. These sites were spread across geographical areas, soil types and irrigation and dryland systems to demonstrate the impact of seasonable variability but also to improve relevance to a wider range of farmers.

2. Extension and communication activities to engage stakeholders with project learnings and encourage cross sectoral collaboration and information sharing.

3. Development of information resources to support learning and provide legacy products for the project. This included technical reports from each site and a suite of videos showing the progress of each site across the seasons.

Each partner organisation delivered a set of trial activities to cater to their specific farmer network needs as well as their geographical challenges and opportunities. The partner organisations were responsible for the design, implementation and measurement of their own trial sites. Collaboration and coordination were managed through a Technical Committee which shared learnings, expertise and feedback to review and refine trial activities. Each partner delivered two winter trial sites over two years, with the Irrigated Cropping Council delivering an additional summer trial site. More information about the trial sites and their outcomes is in the Trials section of this report.

Similarly, each partner organisation designed and implemented a set of communication and engagement activities tailored to their individual audiences. Murray Dairy coordinated engagement activities and resource development across the breadth of the project to further disseminate project learnings.

The project's extension and engagement activities were hugely successful and far exceeded expectations in terms of stakeholder engagement. It was a challenging environment to deliver extension and engagement activities due to ongoing COVID restrictions and then an extremely busy and competing calendar that emerged across all organisations when restrictions were lifted.

To overcome this, the project focused efforts on small, standalone local activities. These activities had smaller number of attendees, less travel time, were mainly held outdoors, and involved less organisations to coordinate. This meant that these events were more agile and could be rescheduled or reformatted quickly if necessary.

The project also partnered with larger events to leverage engagement and to ensure that cross sectoral audiences were reached directly. This included premier industry events such as the Birchip Cropping Group Main Field Day and Murray Dairy's Murray Muster. Unfortunately, a number of cross sectoral events designed to link trial sites together such as a bus trip and an overall results day were cancelled due to COVID restrictions which did decrease the opportunity for farmers and service providers to network across industries. Despite this, the majority of trial sites reported a cross sectoral audience at each event which assisted with networking and sharing of knowledge.

To further extend reach, the project delivered a set of complementary digital activities and resources which included videos, booklets and a podcast. Through the combination of all activities, the project reached 2016 farmers, service providers and industry stakeholders.

A list of communication and engagement activities is outlined in Table 1 (next page).
Table 2 lists the communication material produced as part of this project (page 11).

Table 1: Extension & Engagement Activities 2020-22 (Part 1 of 3)

DATE	EVENT	ORGANISATION	ACTIVITY	LOCATION	#FARMERS	#SERVICE PROVIDERS	# OTHER	ADDITIONAL VIEWS (ONLINE)	TOTAL
10/12/20	Agronomy network - SIP2 and FFtF updates	workshop	Moama			16			16
17/08/21	FFTF BCG field day	Birchip Cropping Group	field day	Mitiamo	44	3	7		54
31/08/21	FFTF Melb Uni virtual field day-students		field day	online			90		90
09/09/21	FFTF Riverine Plains Field Day	Riverine Plains	field day	on-line	12	8	7	counted below	27
21/09/21	FFTF Melb Uni virtual field day	Murray Dairy	field day	online	1	8	10		19
23/09/21	FFtF AgVic virtual field day	Murray Dairy	field day	online		10	2	counted below	12
13/10/21	Integrated Field day	Southern Growers	field day	Finley Site	86				86
03/10/22	Lecture	Murray Dairy/ Melbourne University	Lecture	Online			60		60
08/09/22	Vetch Field Walk	Riverine Plains	Field Walk	Youarang Trial Site	10	7			17
10/03/22	Summer Crop Walk	Irrigated Cropping Council	Field Walk	Kerang Trial Site	40	20			60
15/09/22	Spring Field Day	Southern Growers	Field Day	Finley Trial Site	65	20			85
16/09/22	Research Field Day	Irrigated Cropping Council	Field Day	Kerang Trial Site	60	30			90
17/08/22	Mitiamo Crop Walk	Birchip Cropping Group	Field Walk	Mitiamo Trial Site	20	5			25

Table 1: Extension & Engagement Activities 2020-22 (Part 2 of 3)

DATE	EVENT	ORGANISATION	ACTIVITY	LOCATION	#FARMERS	#SERVICE PROVIDERS	# OTHER	ADDITIONAL VIEWS (ONLINE)	TOTAL
18/05/22	Murray Muster: Focus on Fodder	Murray Dairy	Conference	Yarrawonga	42	46	12		100
24/08/22	Vetch Crop Walk	Southern Growers	Field Walk	Finley Trial Site	25	10			35
24/10/22	Site Visit - UoM Ag Undergrads	University of Melbourne	Field Walk	Dookie Trial Site			80		80
25/02/22	BCG Trial Review Day	Birchip Cropping Group	Conference	Birchip	100	50			150
31/03/23	Travelling Trial Review Day	Birchip Cropping Group	Presentation	Dingee	15				15
04/08/22	Vetch Crop Walk	Southern Growers	Field Walk	Finley Trial Site	5	2			7
July - September	Discussion Group Network (3 meetings)	Riverine Plains	Discussion Group	Murray Region	30	0			30
Ongoing	Video Updates	All	-	-				958	958
					# Farmers	# Service providers	# Other	Additional views (online)	# Total
				Total	555	235	268	958	2016

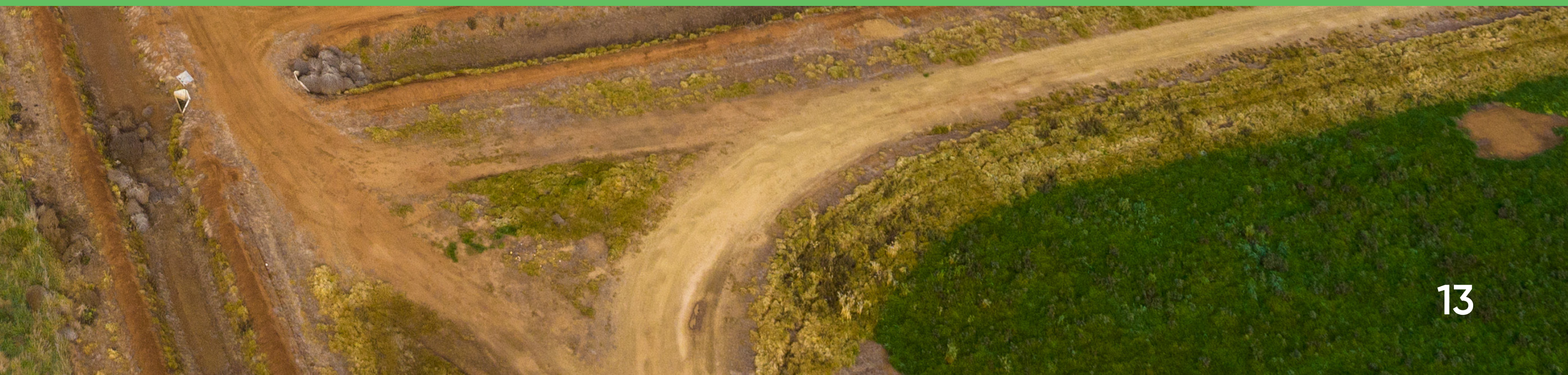
Table 2: Communication Material 2020-22 (Part 1 of 2)

DATE	PARTNER	COMMS MATERIAL	DESCRIPTION
August	Murray Dairy	FFTF Booklet	Booklet describing trial activities for Winter 2021
June	Murray Dairy	FFTF Trial Updates	One page update on winter trial activities June 2021
August	Murray Dairy	FFTF Trial Updates	One page update on winter trial activities August 2021
October	Murray Dairy	FFTF Trial Updates	One page update on winter trial activities October 2021
September	Murray Dairy	FFTF Trial Videos	Videos detailing trial activities and partnership arrangements for 2021
September	Murray Dairy	Media release FFTF Videos	Media release highlighting project activities & videos
17.08.2021	Birchip Cropping Group	FFTF BCG field day	Trial sheet
09.09.2021	Riverine Plains	FFTF Riverine Plains Field Day	Presentations from individuals
21.09.2021	Murray Dairy	FFTF Melb Uni virtual field day	Flyer & presentation
23.09.2021	Murray Dairy	FFtF AgVic virtual field day	Flyer & presentation
15.06.2022	Murray Dairy	Article	*"Fodder for the Future Trial Update"*
28.06.2022	Murray Dairy	Article	*"Fodder Trials bust some myths"*
16.11.2022	Murray Dairy	Article	*"Murray Dairy partners with grains industries to boost Fodder for the Future"*

Table 2: Communication Material 2020-22 (Part 2 of 2)

DATE	PARTNER	COMMS MATERIAL	DESCRIPTION
Ongoing	Murray Dairy	Video	Video Updates (x 6 partners)
Ongoing	Irrigated Cropping Council	Website	Fodder for the Future
Ongoing	Riverine Plains	Website	Fodder for the Future
	Riverine Plains	3 Articles	Emailing list
September 2022	Riverine Plains	Trial Article	Trials Booklet
23.10.2022	Riverine Plains	Article	*"Fodder for the Future"*
01.10.2022	Riverine Plains	Article	*"Hay and Silage" - Finding a secure market and understanding quality*
17.08.2022	Birchip Cropping Group	Flyers	Mitiamo Trial Site
24.08.2022	Southern Growers	Flyers	Finley Trial Site
08.09.2022	Riverine Plains	Flyers	Youarang Trial Site
16.09.2022	Irrigated Cropping Council	Flyers	Kerang Trial Site
23.02.2023	Birchip Cropping Group	Article	*Vetch Agronomy in a Decile 10 year*
23.02.2023	Birchip Cropping Group	Article	*Oat and Barley Hay Agronomy, Mitiamo*
23.03.2023	Riverine Plains	Article	*"Fodder for the Future"*
24.04.2023	Irrigated Cropping Council	Podcast	Podcast summarising learnings form Kerang Trial Site

Overall Forage Outcomes

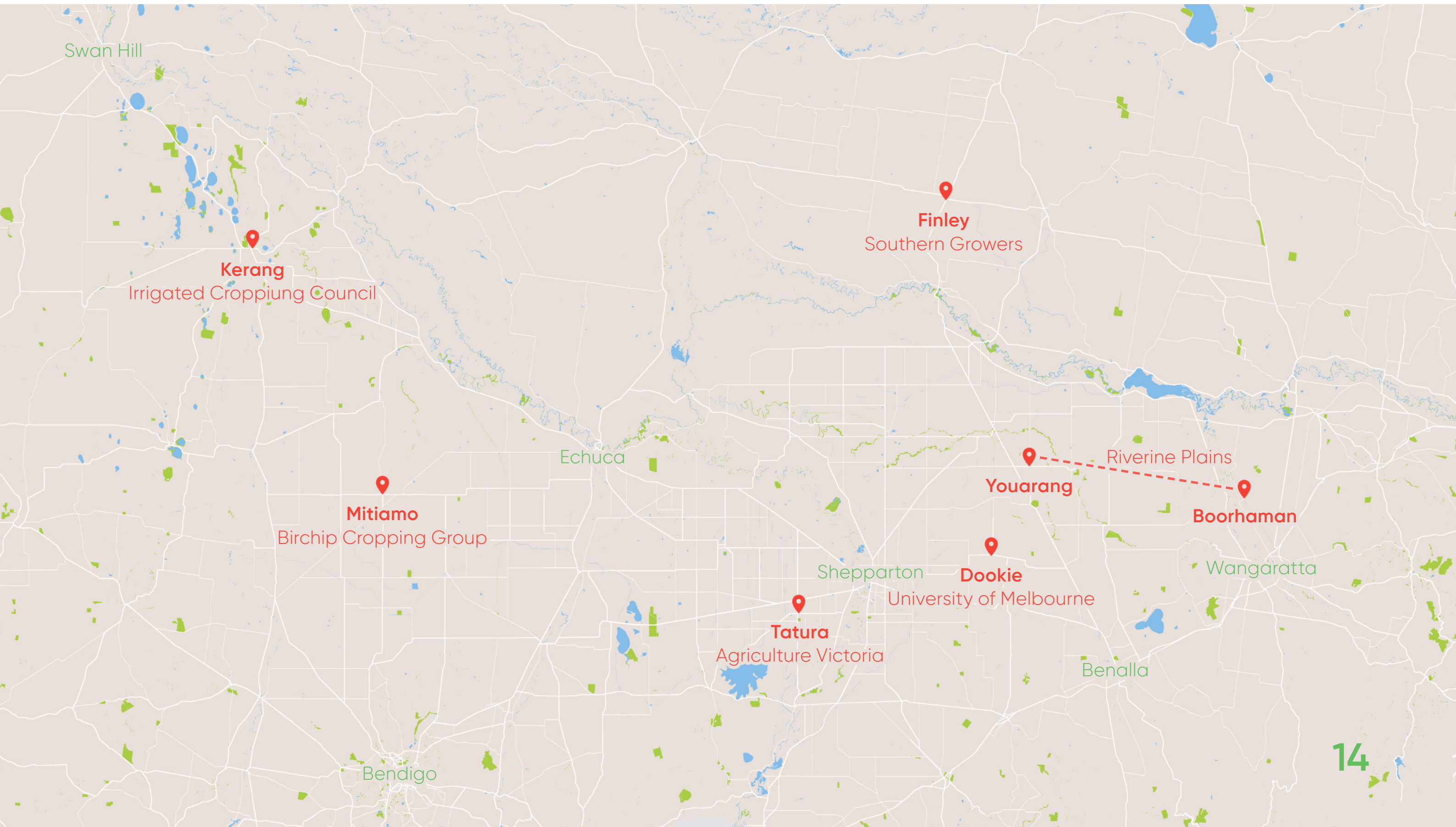


Summary

The project successfully delivered 2 years of cropping trials at 6 locations spread across the Murray Dairy region – 5 of these sites were winter only cropping activities and 1 trial site had both winter and summer activities. These sites were representative of climate and soil type as well as geographic spread of both dairy and livestock producers and grain farmers who also produce fodder for target markets. Each trial site delivered a set of field trials or demonstrations outlining management practices to improve yield and quality of key fodder species for dairy consumption. The second year of trials built on learnings from the first year as well as feedback from researchers and growers. Collaboration between the Technical Committee and the partner organisations allowed trial protocols to be refined for Year 2. A key focus of each site was management practices that demonstrated optimal commercial relevance. Each Partner Organisation delivered a final report outlining their findings from Year 1 and Year 2.

One trial site was terminated early in 2022. Due to a restructure of Agriculture Victoria, the agronomy team that were delivering the Fodder for the Future site were made redundant. Although the site provided some quality extension learning opportunities around weed control and soil nutrient management during the year, harvest data was not available from this site for Year 2 and the contract between Murray Dairy and Agriculture Victoria was terminated.

The project was seriously impacted by the widespread Northern Victorian Floods in October-November of 2022. Sites at Mitiamo and Kerang were completely inundated, and all other sites had access compromised, and a number of people working on the project were directly impacted by floods either at work or home or both. Fortunately, most of the harvest was completed across all sites with only a small loss of harvest data unavoidable. Each partner organisation collected sufficient samples to analyse and review. Murray Dairy enacted their emergency response plan across all project areas during the flood period which included minimising non-essential travel and activities in flood affected areas. This included directions to partner organisations about prioritising safety and wellbeing above project activities in affected areas. The floods led to a delay of the Final Report due to the extra time required to submit partner final reports and data for overall analysis.



Outcomes from each trial site were assessed individually and are outlined in a following section, *Trial Sites Activity and Results* (page 27). An overall analysis of all data, particularly yield and quality aspects, is presented below.

Yield vs quality

One of the challenges of growing fodder for dairy cattle is effectively managing the competing parameters of forage quality and yield. It is well known that post-flowering the quality of many crops, particularly cereals, declines quite rapidly while dry matter (DM) yield continues to increase. This is demonstrated in the project's data (Figure 1), with the observations consistent with current industry knowledge. The yield and quality relationships with crop growth stage also highlight the variations within and between crop species, and the DM yield penalty required to achieve conserved forage with high quality specifications.

Lactating cows require forage with a high metabolizable energy (ME), good crude protein (CP) concentration and relatively low, but highly digestible, neutral detergent fibre (NDF) concentration to enable high daily DM and nutrient intakes to meet milk production and other metabolic requirements and optimise feed conversion efficiency. Recommended overall diet specifications for lactating dairy cows eating partial- or total mixed ration diets include: a minimum NDF of 27-33%, with about 75% of the NDF coming from forages and having a high digestibility; minimum ADF% of 19-21%; 14-18% CP, depending on stage of lactation; minimum ME of 11 MJ/kg DM. While conserved fodder generally doesn't make up the entire ration for lactating cows, the greater proportion of the diet that is fodder the better it is for rumen health, hence why high-quality specifications are sought after. Also, the more forage that can be used for feeding cows, the less need for purchased concentrate products which can be expensive.

While the focus is on feed quality for lactating cows, there are a range of stock classes on a dairy farm that lower quality forage is suitable for (e.g. young stock), but these animals consume a relatively small proportion of the farms overall feed requirements. A key area for investigation going forward is the economics of fodder growing and fodder use by both fodder growers and dairy farmers to gain more understanding of the extent of trade-offs around yield and quality that are possible for both farm enterprises. Total nutrient yield (Figure 2) may be an important decision-making factor in some businesses and will drive the overall quality of the forage products, and therefore which stock they are fed to e.g. heifers can tolerate a lower quality feed compared to lactating cows.

The fodder end-product, i.e., silage or hay, impacts how the nutrient profile of the harvested forage changes during the forage preservation process. There are more quality losses in the field during harvesting with hay compared to silage such that if hay and silage were cut from the same crop on the same day, the silage would be a higher quality product, assuming ideal preservation conditions. Samples of forage crops collected in this project were oven dried as soon as possible after collection, so are likely to be slightly better quality than if the forage was preserved as hay, and similar or slightly lower quality than if the forage was preserved for silage.

Further analysis of the data collected in this project will attempt to determine which management strategies were linked with the higher quality crops. An important aspect that also needs investigating is the economics around crops with different harvest stages, yields and qualities and how that impacts businesses of both dairy farmers and forage growers.

Figure 1. Effect of crop growth stage on yield and quality attributes of different winter forages. Decimal-based scales are used for growth stage: Zadoks scale for cereals and the BBCH scale for the legumes.

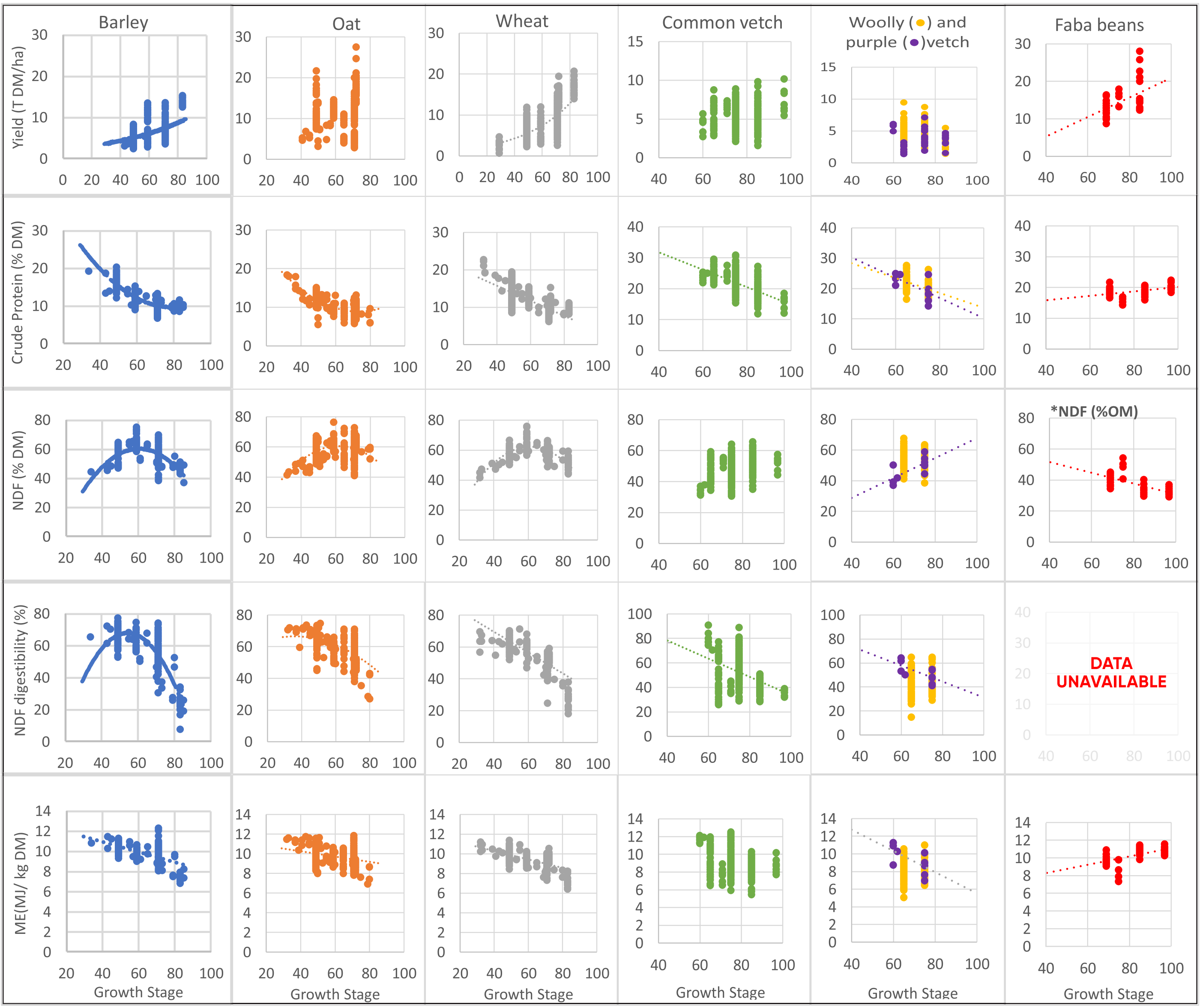
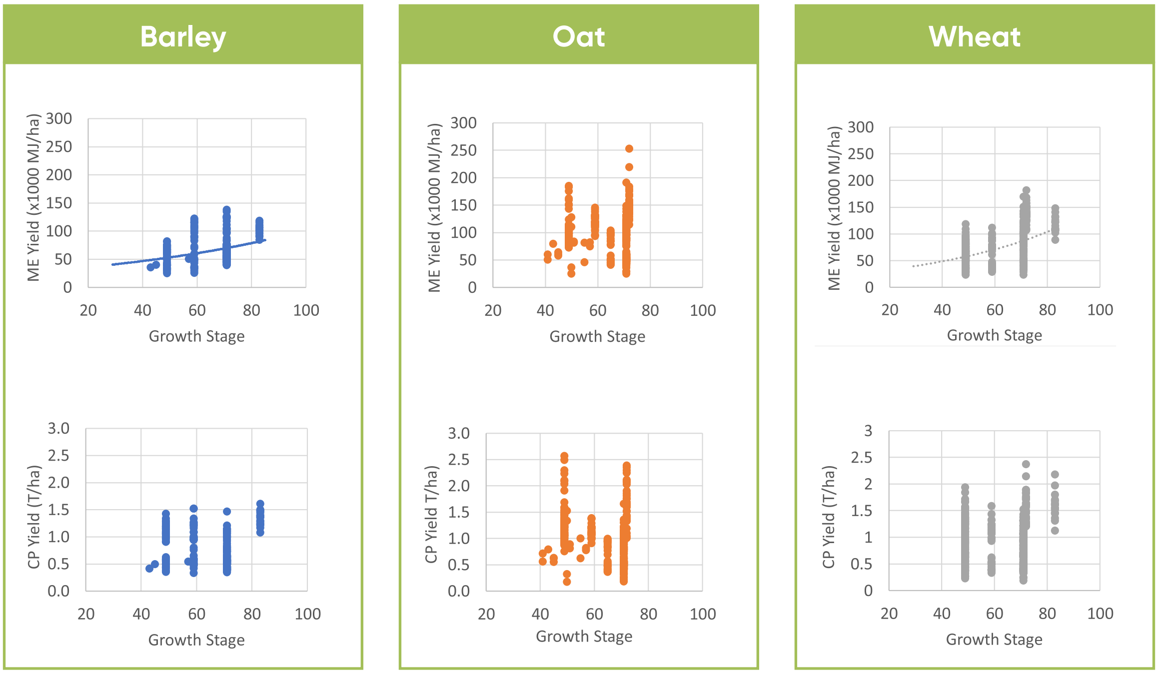


Figure 2. Total yield (units/ha) of metabolisable energy (ME) and crude protein (CP) from cereal crops harvested at different growth stages in northern Victoria.



Yield and quality of winter cereals

Large variations in yield and quality were apparent across all sites demonstrating the impact of site seasonal conditions, time of sowing effects and crop type and variety (Figure 3, page 18). The combination of strategies, crop selection and seasonal conditions all impacted yield and quality demonstrating that the practical implementation of managing crops to meet yield and quality targets can be extremely difficult. Complex interactions between all these factors led to hugely variable results in yield and quality across both years of trials and sites. This further emphasises the opportunity that exists to improve yield and quality of fodder produced based on current commercial practice that the trial sites reflected, but also the extent of the challenge to do so.

Cereal crops are often used for hay production and hays that meet the specifications for the export cereal hay market(7), or the Grade A1 or Good to Excellent specifications of the AFIA(8) and Feed Central(9) rankings respectively would generally be suitable for milk production. The AFIA forage grades are based on ME and CP concentrations and a third of the cereal forage samples from the project met AFIA grade A1 (Table 3, page 19).

7 Gilmac (2016), referenced within AEXCO (2016) 'Producing quality oat hay', p15.

8 AFIA & GTA (2015) 'Section 5 Fodders trading standards' In Guide to the GTA grain trading standards 2022/23 season. (Grain Trade Australia: Royal Exchange, NSW).

9 Feed Central (2023) Quality certificate explanation notes, p13. (Feed Central: Toowoomba, QLD).

Export market grading is more stringent with specifications for ME, CP, acid detergent fibre (ADF), NDF and water-soluble carbohydrate (WSC) needing to be met. Only 19% of the cereal hay samples from the project met the export specifications (Table 3, page 19). The hay assessment and trading company, Feed Central, also has a hay grading system of which the Good and Excellent grades have higher specifications than the export market grade and are aimed at the dairy production market. Only 12% of the project samples met Feed Central's 'good' specifications and 3% met the 'excellent' specifications.

Although it is acknowledged that some of the project samples, by design, were harvested at growth stages that are not conducive to high quality forage products the vast majority of samples (89%) were harvested between GS 49 and 72 which is considered the 'window of opportunity' for quality forage[10]. Our results highlight the variation in quality that is achieved when growing fodder under relatively controlled trial plot conditions, the challenges that are amplified at commercial paddock scale and the opportunity that exists to improve quality of fodder products on the market. There is also opportunity to produce higher quality cereal fodder products through ensiling, rather than hay production[11].

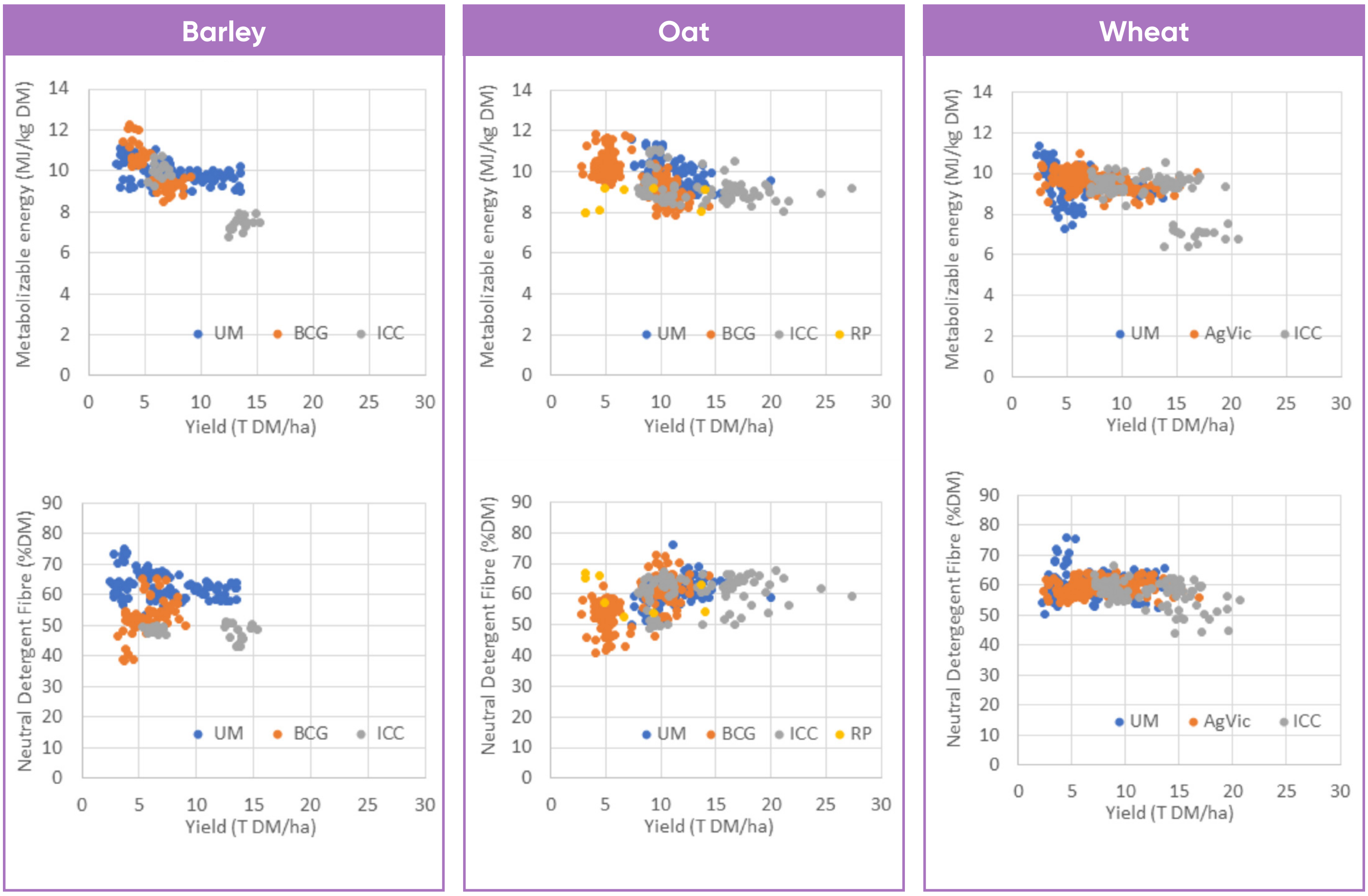


Figure 3. Relationship between yield and metabolizable energy and neutral detergent fibre concentrations in barley, oat and wheat forage crops grown by multiple research partners across the Murray Dairy region as part of the Fodder for the Future Project.
UM – University of Melbourne; **BCG** – Birchip Cropping group; **ICC** – Irrigated Cropping council; **RP** – Riverine Plains; **AgVic** – Agriculture Victoria.

[10] AEXCO (2016) 'Producing quality oat hay', p13.

[11] Griffiths et al (2004) 'Crops and by-products for silage' In Top Fodder Successful silage (NSW DPI and DA: Orange NSW).

Table 3. Classification specifications for high quality cereal hays and silages used by different companies or organisations and the proportion of project samples that met these specifications.

COMPANY AND CLASSIFICATION	SPECIFICATIONS—CEREALS					SAMPLES MEETING SPECIFICATIONS (%)
	ME (MJ/kg DM)	CP (%DM)	ADF (%DM)	NDF (%DM)	WSC (%DM)	
AFIA – Grade A1	>9.5	>10				34
Gilmac - Export (2016)	>9.5	4–10	<32	<57	>18	19
Feed Central - Good	≥9.5	≥10	≤45	≤54	≥18	12
Feed Central - Excellent	>10.5	>12	<40	<50	>25	3

1. Stage of cutting. Results confirmed that increasing growth stage at cutting time led to increased yield trends for barley and wheat crops however not for oats. There was also a general decline in ME and CP concentrations as growth stage increased however some observations were inconsistent.

2. Crop type and variety. Variability of crop type and variety on yield and quality was also apparent across all sites (Figure 1). Oat was usually higher yielding than wheat or barley –double or triple that of barley. This demonstrates the attractiveness of oats to fodder and grain producers who typically sell fodder based on tonnage. Varietal differences were influenced by cutting stage, time of sowing and seasonal conditions. Differences between wheat and barley yields were variable between sites and years. Quality parameters such as ME, CP and fibres were impacted by crop type, varieties, site seasonal conditions, harvest stage and time of sowing.

3. Time of sowing, sowing rate and nutrient input.
Time of sowing and sowing rate had variable effects on yield and nutritive characteristics and also varied between sites and with crop types and varieties and harvest stages. Yield increased with increasing nitrogen input but did plateau at the higher levels. There was no consistent effect of nitrogen applied on ME. CP was highest at highest nitrogen input levels and NDF was variable.

Yield and quality of vetch forage

The challenging growing conditions for vetch crops in both years of the project resulted in a large proportion of samples that were of relatively low quality. Only a quarter met the AFIA A1 specification for legume hays and a very small percentage met the more stringent Feed Central specifications for 'Good' and 'Excellent' classification (Table 4). When the results from the two main vetch growing sites were analysed for the impacts of management strategies on yield and quality, the between year variations were most obvious. The large variations generated meant there were no obvious relationships between yield and quality in the vetch crops (Figure 4).

Table 4. Classification specifications for high quality legume hays and silages used by different companies or organisations and the proportion of project vetch samples that met these specifications.

COMPANY AND CLASSIFICATION	SPECIFICATIONS—LEGUMES					SAMPLES MEETING SPECIFICATIONS (%)
	ME (MJ/kg DM)	CP (%DM)	ADF (%DM)	NDF (%DM)	WSC (%DM)	
AFIA – Grade A1	>9.5	>19				26
Feed Central - Good	≥9.5	≥19.5	≤32	≤41	≥11	3
Feed Central - Excellent	>10.5	>22	<29	<38	>15	1

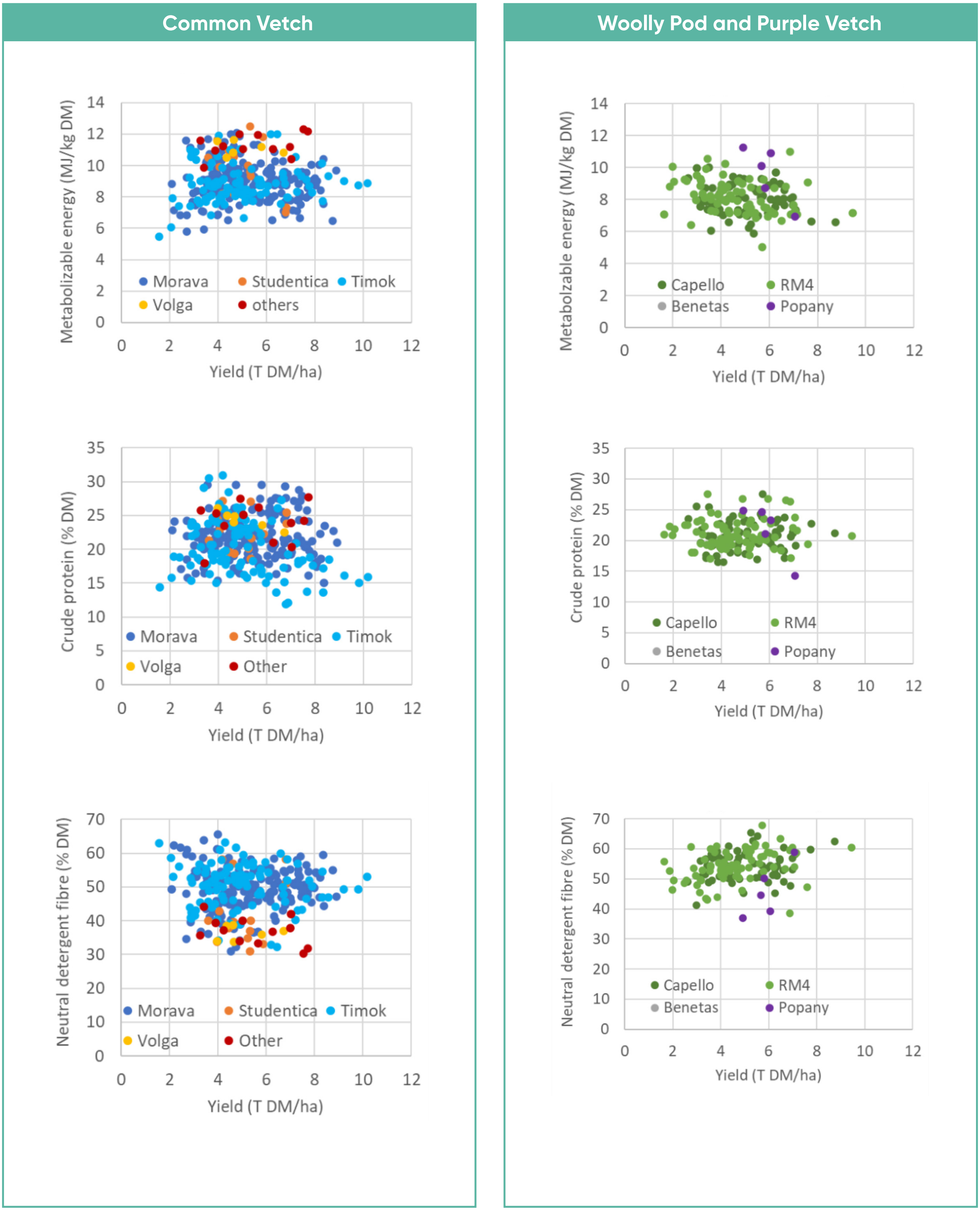


Figure 4. Relationship between yield and metabolizable energy, crude protein and neutral detergent fibre concentrations in different varieties of common, woolly pod and purple vetch crops grown across the Murray Dairy region. Crops were harvested at varying growth stages and the sample proportions were - Common vetch: 50% R4, 25% R6, 13% R2; Wooly vetch: 50% R2, 50% R4. Vetch fodder crops are usually targetting hay as an end-product.

Management strategies for impacting yield and quality of vetch for forage:

1. Stage of cutting. While the overall data shows no strong relationships between cutting stage and hay yield or quality, a strong relationship between time of cutting and quality was found in BCG's year 2 trials which also showed that the maturity type of the plant also interacts with hay quality e.g. early maturing types can be cut at a more mature stage than late maturing types while still maintaining forage quality. Southern Growers trials in year 2 also found quality parameters were higher at earlier growth stages, but in their year 1 work there was no strong relationship between cutting stage and yield or quality.

2. Vetch type and variety. Common vetches did tend to have better quality parameters than the woolly pod or purple vetches. Impact of variety on yield varied across the two growing sites with BCG recording more variety impact than Southern Growers.

3. Time of sowing and sowing rate. These variables were not tested at both sites so overall data is limited. Southern Growers saw no or minimal impact of sowing rate on yield and quality parameters in year 1 and BCG found that earlier sowing increased yield with some varieties but didn't affect quality parameters.

4. Irrigation timing. Irrigations treatments had minimal to no effects on outcomes due to the timings and volumes of rainfall across the two years.

Yield and quality of faba bean forages

Faba beans produced large fodder yields with very good nutritional characteristics. Forage quality improved as maturity progressed, which is the reverse of what is observed for most forages. However due to high lodging tendency and high water content there are likely to be practical challenges around harvesting and ensiling, which are a major barrier to widespread commercial adoption.

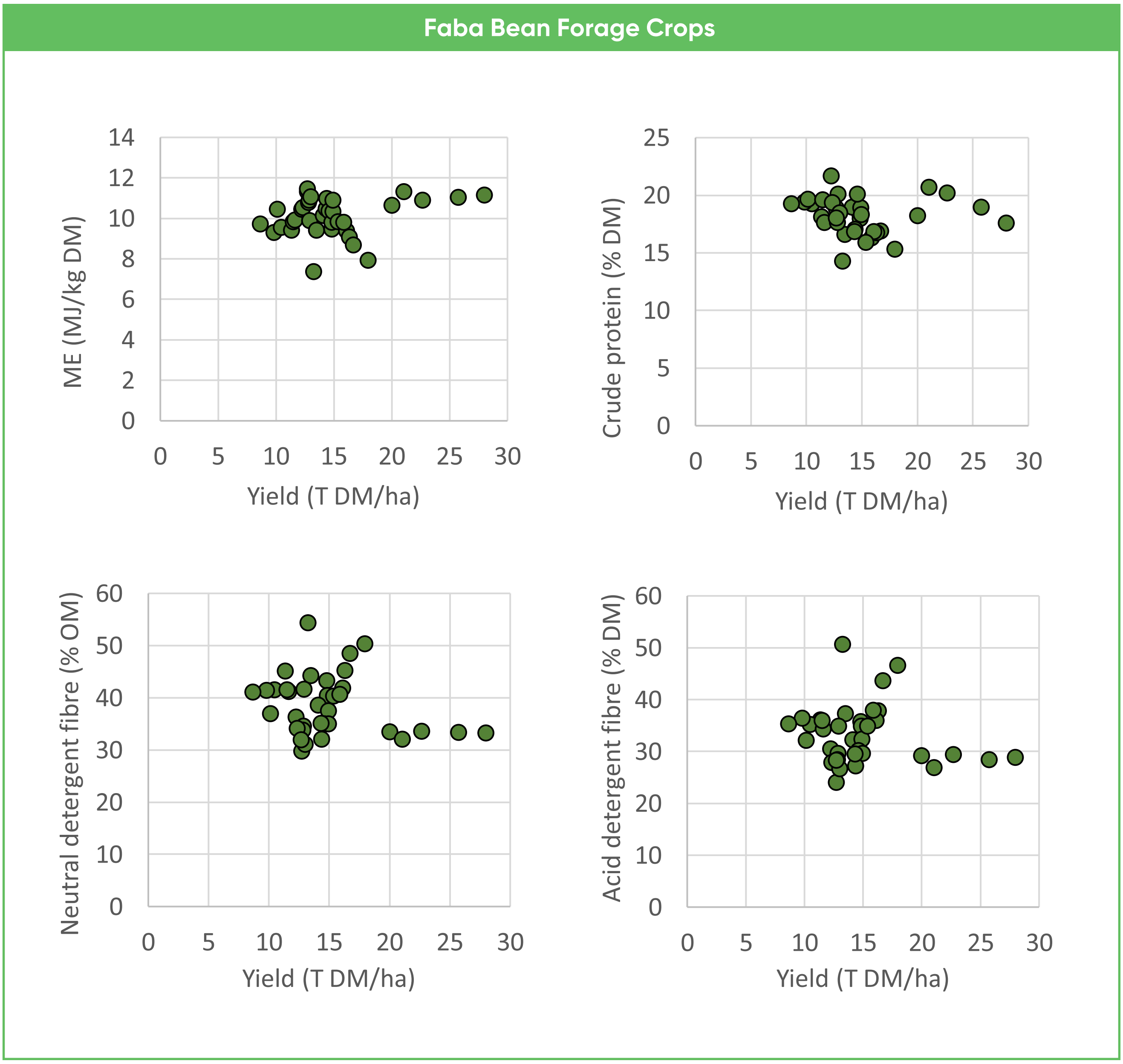


Figure 5. Yields and nutrient characteristics of faba bean forage crops grown at Kerang.

Yield and quality of maize and sorghum forages

The project demonstrated that forage harvested from the selected grain and forage sorghum varieties could achieve quality characteristics comparable to maize, in the context of seasonal conditions experienced during the project. However, maize was still a higher yielding crop than the grain sorghums and also had better water use efficiency (WUE; kg DM/mm applied), even under mild to moderate deficit irrigation strategies. Forage sorghum had comparable yield and WUE to the maize. Starch concentration in the maize crops was lower than expected.

Table 5. Nutrient characteristics of maize and sorghum crops grown for ensiling at Kerang.

	SENTINAL RED GRAIN SORGHUM	LIBERTY WHITE GRAIN SORGHUM	MEGASWEET FORAGE SORGHUM	PAC440 MAIZE	PAC606IT MAIZE
DM% at harvest	34.4	34.7	30.0	41.0	43.3
Starch (%DM)	33.2	31.1	20.0	24.3	23.7
NFC (%DM)	46.2	38.6	41.7	40.5	43.7
NDF (%OM)	33.1	42.3	40.3	42.2	40.2
ADF (%DM)	22.5	26.0	24.8	26.7	24.2
CP (%DM)	9.3	8.2	8.2	7.3	6.9
ME (MJ/kg DM)	10.1	9.6	9.6	9.2	9.1

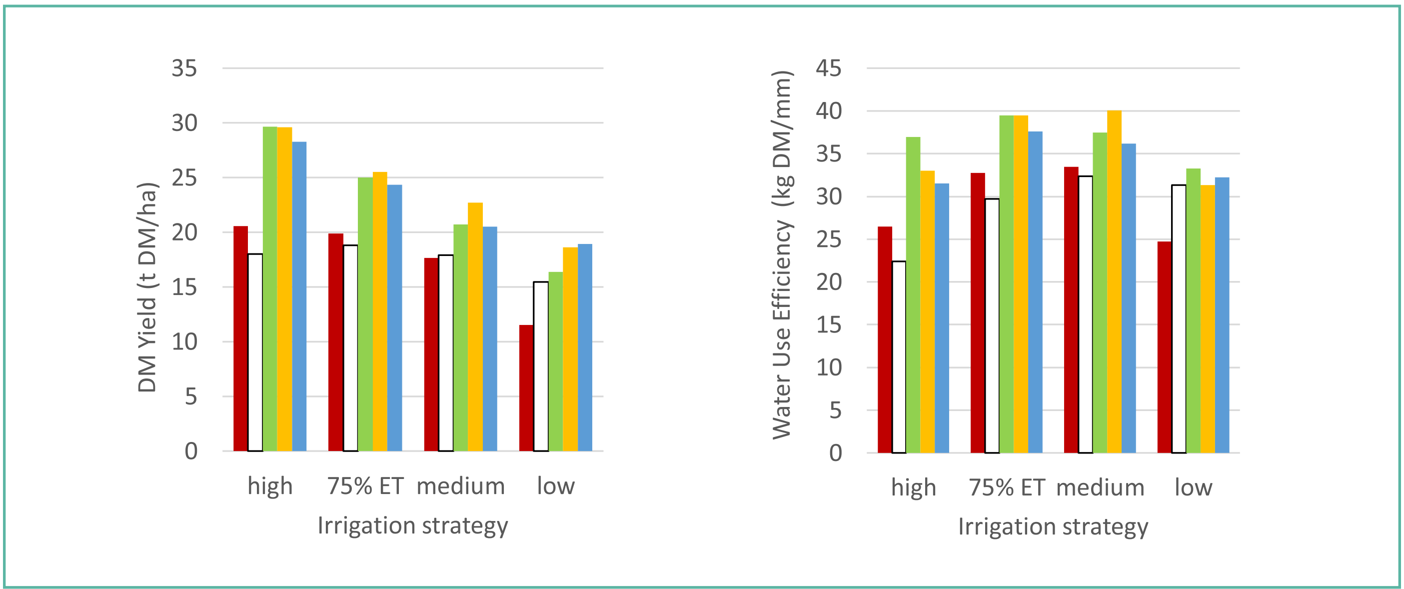
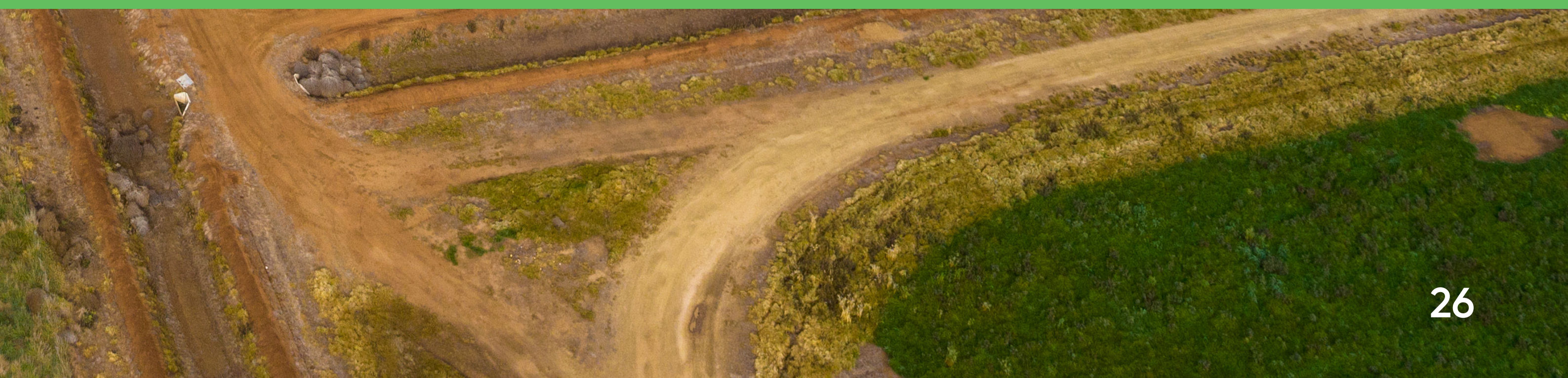


Figure 6. Yield and water use efficiency of maize and sorghum forage crops grown under different irrigation strategies at Kerang.

Sentinal red grain sorghum Liberty white grain sorghum Megasweet forage sorghum PAC440 maize PAC606IT maize.

Trial Sites Activity & Results



Partner: Birchip Cropping Group

Year 1 activity & results

The first year of trials conducted at Mitiamo focused on the performance of oaten hay. This is a commonly grown fodder species on dryland grain farms in the area. A couple of barley cultivars were included for comparison. The site also included a vetch component however due to an incorrect herbicide application the trial had to be abandoned before results could be measured. The study aimed to investigate the effects of variety and time of sowing, nutrient inputs (nitrogen, phosphorous, and potassium), sowing rate, and cutting time on oaten hay production.

The site involved a replicated field trial design. The treatments included cereal variety and time of sowing, nutrient inputs, sowing rate, and cutting time. The trial assessed establishment scores, normalized difference vegetation index (NDVI), hay biomass cuts at GS71, stem diameter, and feed test quality for energy, protein, and fibre metrics.

The key findings of the site in year 1 included:

1. Hay yield was highest for the oat varieties Kingbale, Mulgara, Brusher, Yallara, and Wintaroo.

2. Cutting at growth stage 71 (GS71) to optimise yield and quality resulted in increased profitability.

3. The barley variety *RGT Planet* was identified as a good dual-purpose option for both grain and hay production.

4. The oat variety *Brusher* had the highest crude protein content, followed by Bannister.

5. Soil testing was important for appropriate nutrient management. At this site, 60kg of urea was found to be the most economical nitrogen input. Higher nitrogen rates did not provide additional benefits. Additional phosphorous and potassium applications did not provide benefit to yield.

The trial results highlighted that time of sowing did not significantly affect hay yield, but varieties and cutting times had an impact. Stem diameter was influenced by time of sowing, with earlier sowing resulting in larger stem diameter. Different varieties showed variations in CP, ADF and water-soluble carbohydrates (WSC). However, NDF levels did not differ significantly among varieties.

The trial also examined the effects of nutrient management. Increasing urea application up to 60kg/ha improved hay yield and crude protein content, but further nitrogen application did not have significant benefits. Phosphorus and potassium rates did not show significant effects on hay yield or stem diameter.

Year 2 activity & results

In the second year of the trial at Mitiamo, cereal species were expanded to include barley and vetch as a result of feedback from the Technical Committee on the value of those fodder types for milking herd diets.

The trial again aimed to investigate the impact of variety, time of sowing, nutrient management, sowing rate, and cutting times on the yield and quality of oat and barley hay.

The trial measured various parameters, including establishment counts, NDVI, hay cuts at GS71 stem diameter, and feed quality tests using NIR for CP, ADF, NDF & ME. The trial also examined the impact of nitrogen treatments on hay yield, protein, and fibre content for both oat and barley crops.

Key findings of year 2 included:

1. Hay yields were higher than 2021, but the quality was affected by the wet spring conditions in 2022.

2. *Wintaroo* and *Yallara* were consistently the highest yielding varieties across both sowing times, with yields of 11-12t/ha. Kingbale and Bannister also performed well in the early sowing time but lost their yield advantage when sown later. RGT Planet was the highest yielding barley variety.

3. Additional nitrogen (30kg N/ha) applied in-crop increased hay yield by 1.7-2t/ha.

4. Timely cutting of hay crops between head emergence and watery ripe stage maximised biomass and minimised curing time before hay quality declined.

5. Oaten hay is lower in energy and protein but higher in fibre compared to other feeds like grain, silage, and legume hay.

The quality characteristics of the hay varied among the varieties and time of sowing. Crude protein levels were affected by variety but not the time of sowing. ADF & NDF increased with delayed sowing time in most varieties, except for Wintaroo and Yallara. ME either performed similarly or decreased with delayed sowing time.

The study also examined the impact of nutrient management, showing that in-season nitrogen applications increased hay yield and CP levels. Late applications of liquid nitrogen at stem elongation yielded similar results to early applications of urea at growth stage 24.

Overall, the study highlights the importance of variety selection, timely cutting, and nutrient management in optimising the yield and quality of oat and barley hay crops. While hay production was limited due to extreme weather events, the research outcomes still offered insights for decision-making for farmers in the area. The extension messages emphasised the significance of good management practices and the need for collaboration between growers and end users to achieve high-quality fodder production.

Vetch

After discussing results and outcomes from other Fodder for the Future sites in year 1, the Mitiamo site included a trial in year 2 to investigate the yield and quality of vetch hay under different management strategies. The trial aimed to evaluate the impact of variety and time of sowing, disease management, sowing rate, and cutting time on vetch hay production.

Various treatments were applied, including different vetch varieties, plant densities, cutting times, time of sowing, and disease management techniques. The trials were managed following best practices for weeds, pests, and diseases, except for the disease management trial.

Key findings from the trial included:

1. A strong relationship was observed between cutting time and hay quality. Early-mid varieties cut earlier in the season exhibited higher quality compared to later maturing varieties cut later.

2. The maturity of a vetch variety was found to be the most important consideration when choosing between varieties. The choice of maturity depends on the end-use targets, such as grazing or hay production.

3. Sowing vetch earlier in the season resulted in increased hay yield, as early sown crops could take advantage of the timely break and had a longer growing period. However, early sowing also increased the risk of disease, impacting hay yield and quality.

4. A single-pass disease management strategy did not provide full-season control of pathogens, particularly botrytis grey mould (BGM). Disease levels varied among different time of sowing treatments and grazing initially reduced disease levels but had limited long-term impact.

5. Varieties that matured later had increased ADF & NDF impacting digestibility. All varieties exhibited adequate levels of CP suitable for feeding lactating cows.

The trial highlighted the challenges faced during the wet season, including access, cutting, and disease issues. It emphasised the importance of considering time of sowing, variety selection, cutting time, and disease management strategies to maximise vetch hay yield and quality

Partner–Irrigated Cropping Council

Year 1 trials and results

Cereals

In year 1, the Irrigated Cropping Council's trial at Kerang evaluated yield and quality of irrigated oats and wheat for fodder production in a replicated, randomised complete block design. The trial assessed two long season oat and wheat varieties, considering different sowing rates and two different times of sowings. The trial analysed the feed quality of oats and wheat. Various quality parameters such ME, CP, ADF & NDF were assessed. Key outcomes of year 1 included:

1. Yields were generally higher in oats compared to wheat.

2. Feed quality was slightly better in wheat compared to oats

3. Stem density was higher in wheat compared to oats

4. Sowing rates had minimal impact on yield and no significant impact on feed quality, but higher rates did increase stem density of the crops and reduced the stem diamete.

5.Vernalisation response in wheat and oats negated the influence of time of sowing

6. Lodging rates were higher in oats due to their tall nature, while wheat showed no lodging issues.

Overall, the trial concluded that oats had higher yields of fodder but were more prone to lodging. Wheat, on the other hand, had the advantage of easy harvest due to no lodging and a smaller stature. Wheat also exhibited slightly better feed quality compared to oats.

Faba Beans

The ICC site also included a faba bean trial which aimed to evaluate the dry matter production and feed quality of irrigated faba beans for fodder production. The trial utilised the faba bean variety PBS Bendoc and focused on assessing the impact of sowing rate, sowing date, and cutting time on fodder production and feed quality. The trial design included two sowing rates (15 and 25 plants/m2) and two sowing times (2 April and 17 May). Measurements were taken for plant establishment, stem numbers, dry matter yield, and feed quality parameters. Key outcomes from year 1 included:

1. Plant establishment was higher for the second sowing time compared to the first.

2. Dry matter yields at both the end of flowering and mid-pod fill stages was higher for the early sowing (late April) compared to the later sowing (late May).

3. Fodder yields exceeded 20 t DM/ha for some treatments at the mid-pod fill stage.

4. Lodging issues at physiological maturity prevented accurate yield measurements.

5. Feed quality parameters improved with maturity, from the end of flowering to physiological maturity, with higher ME and CP contents and lower ADF content.

6. Time of sowing did not affect ME or CP contents, but ADF content was slightly lower at the second sowing time.

7. Sowing rate and plan population had little influence on yield or feed quality.

8. Challenges for forage conservation in faba beans include lodging issues and a high-water content at physiological maturity

There was significant interest from dairy farmers in the faba bean trial given the high yields and high quality that can potentially be achieved. However practical challenges around fodder conservation including lodging impacting 'harvestability' and high-water content impacting the ensiling process were deemed to be a major barrier to widespread commercial adoption.

Summer Forages

The ICC also implemented an irrigated summer forages trial in year 1. The trial built on a previous study funded by Dairy Australia and delivered by the ICC in 2019-20. The trial was established to evaluate a range of summer forage crop (sorghum and maize varieties) under various irrigation strategies, to understand crop performance based on both yield and quality of the forage (silage) produced. The previous study saw some teething problems with irrigation management that may have impacted crop yields and production efficiency. This trial implemented some modifications to agronomic management and the introduction of a fourth irrigation strategy based on calculated crop evapotranspiration for determining irrigation timing.

The trial design was blocked by irrigation strategy, and within each irrigation block the crop types were randomised and each crop treatment was replicated 4 times. Plot size was 7m by 4.2m. The trial was established on a surface irrigated border check layout. The initial irrigation of the site post sowing was via surface irrigation, but subsequent irrigation was applied by Netafim Streamline X 16080 FL dripper tape which could deliver the equivalent of 80mm of water in 4 hours and 30 minutes, adequately simulating flood irrigation. No issues with infiltration was noted. Irrigation strategies were based on the following assumptions and specifications:

Irrigation strategy 1 'High'.

Maximum maize production would occur when the crop was irrigated following best practice recommendations for maize sown for grain. Using daily evaporation data, the crop evaporation was estimated and irrigation scheduled when it was predicted the crop had used 80mm of soil water. When irrigation was triggered, 80mm of water was applied.

Irrigation strategy 2 '75%'.

To apply some drought stress to the crop, daily crop evapotranspiration was estimated as per the 'high' treatment, but only 75% of this value was used to estimate crop water use (ie. water use was purposely underestimated). Irrigation was triggered when the (underestimated) accumulated crop water use reached 80mm and then 80mm of water was applied.

Irrigation strategy 3 'Medium'.

Increased drought stress would be applied to the crops if irrigation was triggered when Watermark soil moisture sensors reached -140-160 kPa and then only 80mm of water was applied.

Irrigation strategy 4 'Low'.

Further increased drought stress would be applied to the crops if irrigation was triggered when Watermark soil moisture sensors exceeded -200 kPa (the maximum negative reading the sensors are capable of) and then only 80mm of water was applied.

Key outcomes of the trial included:

1. The highest yields were achieved with either maize or sweet (forage) sorghum under the 'High' irrigation strategy.

2. White and red sorghum yields did not benefit from the extra water in the 'high' strategy.

3. The best water use efficiency (WUE) for each crop type occurred under the '75%' and 'medium' deficit irrigation strategies. Maize and sweet sorghum achieved higher WUE than the white and red grain sorghums.

4. Lower plant numbers in the 'low' strategy reduced dry matter production and due to the amount of water used in the 'low' and 'medium' strategies being very similar (thanks to a timely rainfall event) WUE was lower in the 'low' strategy compared to the 'medium' strategy.

5. Maize yield reduced with reduced irrigation (75% and medium) but WUE was higher and forage quality slightly better.

6. Less water was required by the grain sorghums but the overall lower biomass produced at lower irrigations did not compensate for the water saved and WUE at the lower irrigations was therefore comparable with maize and sweet sorghum. Differences in WUE between the red and white grain sorghums also varied between irrigation treatments.

7. Higher quality feed was achieved with the grain sorghums, particularly the red grain variety

The results of this trial challenged the assumption that maize is typically a higher quality crop than grain sorghum. It did however confirm the assumption that maize is unforgiving of poor irrigation practices. But the results did suggest that that maize may be more forgiving of a small amount of moisture stress. This could lead to some potential to save total irrigation water applied when growing maize, but this is still not recommended as it will most likely reduce total dry matter produced. Similarly, even though grain sorghum used less water overall, reducing total water applied also reduced total dry matter produced. Overall, this trial site demonstrated that in terms of yield and quality maize is the preferred crop type and that a deficit irrigation strategy will reduce overall yield but result in a higher WUE (kg DM/mm) and a slightly better quality will be achieved.

Year 2 activity & results

In year 2, the Irrigated Cropping Council continued to look at assessing the yield potential and feed quality of longer season varieties of oats and wheat, as well as exploring ways to improve fodder quality through sowing rates and cutting dates. Barley was also included based on feedback from dairy farmers and the Technical Committee. Two varieties of oats, wheat, and barley were sown at two sowing rates to evaluate dry matter production and feed nutrient quality at two important growth stages. The experiment aimed to determine the impact of sowing rate, assess fodder production at different cutting dates, compare crop types and varieties, and evaluate changes in feed quality across growth stages.

The trial design involved 12 plots with different varieties and sowing rates, with four replicates. The crops were subjected to soil tests and received a single irrigation event prior to sowing. Nitrogen management was conducted based on the estimated dry matter yield. The measurements included phenological growth stages, dry matter yield, stem diameter, tiller number, and nutritive characteristics assessed via NIR at the Feed Test laboratory. Key results included:

1. Sowing rate had little impact on fodder yield or quality.

2. Higher sowing rates resulted in higher stems/m^2 and lower stem diameter, but this did not generally equate to improved feed quality.

3. Variety choice and cutting stage tended to play a more significant role in determining feed quality than sowing rates.

4. Forester oats had the highest yield at GS49 but were more likely to lodge by GS83, making conservation more difficult than for wheat or barley.

5. Yield of wheat and barley forages doubled between Gs49 and GS83.

6. Quality deteriorated as the cereals progressed from GS49 to GS83. There were more differences in quality between varieties at GS49 compared to GS83.

Faba Beans and Legumes

The ICC also continued to assess the suitability of various legumes and pulses in year 2, expanding on the faba bean trial in Year 1. Four legume crops were chosen: field peas, faba beans, a high-density legume mixture (HDL) with two seeding rates, and vetch. The HDL was a mixture of clover species. The trial measured dry matter yield and feed quality at different cutting dates for each crop. The influence of cutting time on feed quality was also examined. Soil tests were conducted, and fertilizer and irrigation were applied based on the results. Flooding of the trial site prevented some assessments and delayed cutting dates. Key outcomes included:

1. Dry matter yield exceeded 16 t DM/ha from the faba beans, and was 13.0-13.5 t DM/ha for HDL mixes

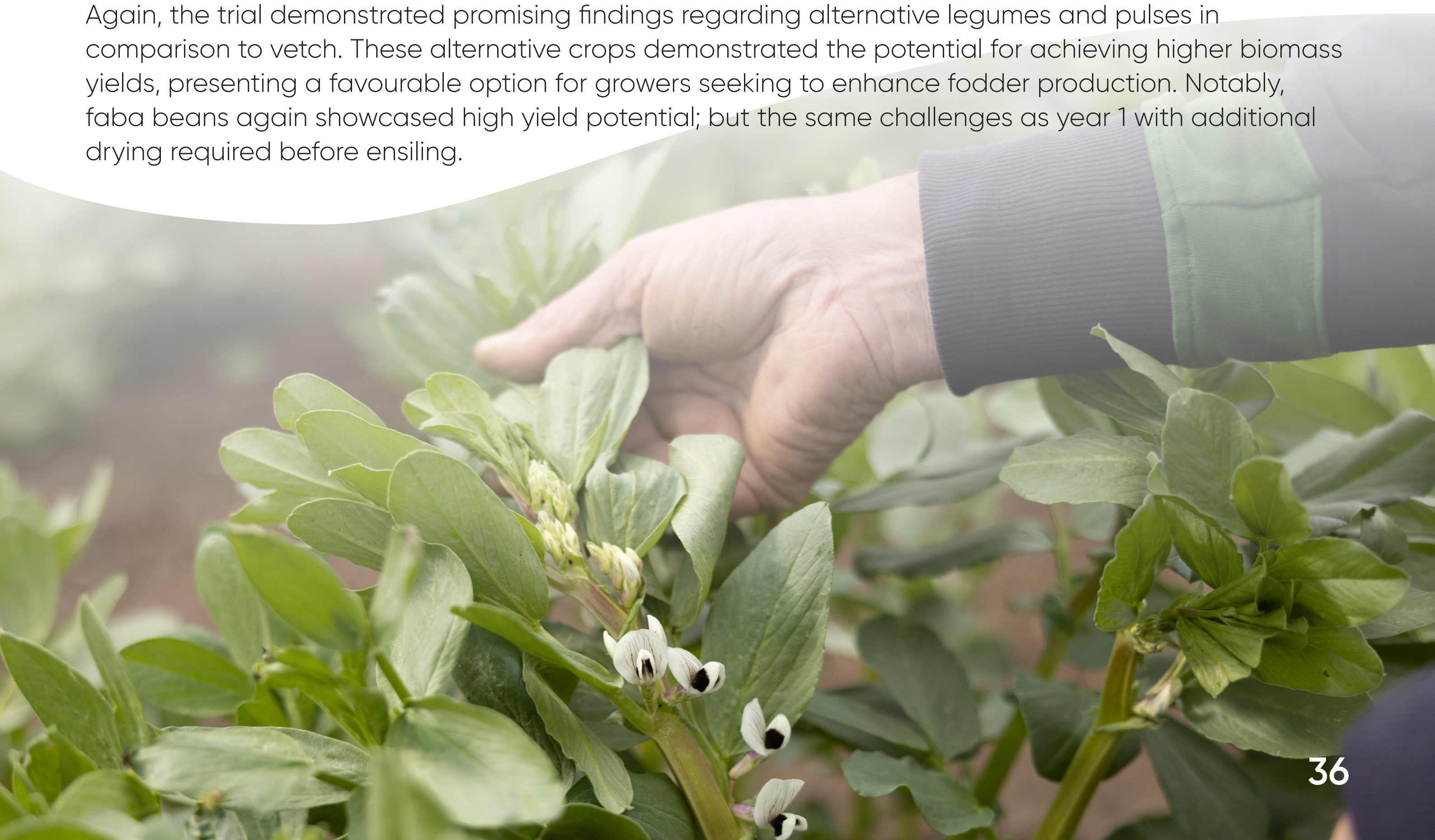
2. Sowing rates of the HDL had little impact on fodder production.

3. Crude protein content was highest in Twilight peas (20.8%) and in the mid- to high teens for the other legumes/pulses.

2. Metabolisable energy was lower in the pulses than in the HDL (8.5 vs 10 MJ ME/kg DM approx.) and may be due to the long stems with minimal leaves in the pulses.

3. NDF and ADF content was lower in HDL compared to the pulses.

Again, the trial demonstrated promising findings regarding alternative legumes and pulses in comparison to vetch. These alternative crops demonstrated the potential for achieving higher biomass yields, presenting a favourable option for growers seeking to enhance fodder production. Notably, faba beans again showcased high yield potential; but the same challenges as year 1 with additional drying required before ensiling.



Partner–Southern Growers

Year 1 trials and results

The trial conducted as part of the project by Southern Growers aimed to assess the influence of irrigation schedule, cultivar, and seeding rate on vetch production. The trials were conducted on four adjoining irrigation bays at the Southern Growers Irrigation Complex in Finley NSW, Australia. Delivery of the trials was done in collaboration with FAR Australia.

The trials consisted of four cultivars of vetch (Timok, Morava, Capello, and RM4) measured at two seeding rates, with different irrigation schedules. The trials were defoliated at different development stages, and the measurements included dry matter production, CP, ME, ADF & NDF. Key outcomes included:

1. **Dry matter production** tended to be higher in treatments featuring autumn irrigation compared to spring-only or dryland treatments, due to little rainfall occurring in April that season.

2. **Full irrigation** resulted in approximately 2t/ha more DM production, within a variety, compared to dryland.

3. **Common vetch cultivars matured faster** than woolly pod vetch varieties.

4. **Timok cultivar** had higher levels of ME & CP compared to other cultivars, but lower DM production compared with Morava.

5. **Seeding rate** had little influence on dry matter production and forage quality.

6. **Early defoliation** timings generally resulted in higher CP content.

Year 2 activity & results

In year 2 Southern growers continued to evaluate the effect of irrigation versus dryland conditions under the same experiment design.

Due to significant rainfall and saturated soil conditions during the trial period, the impacts of the treatments were reduced and detailed results on water productivity and water use efficiency were not obtained in the 2022 trial. Key outcomes included:

1. Poor dry matter production overall compared to the previous year, with mean yields around 50% of the 2021 trial season.

2. No significant differences in yield between the vetch varieties with overall yields ranging from 3.0 to 4.9 T DM/ha.

3. The irrigation treatment was not applied due to saturated soil conditions, so there are no irrigated vs dryland treatment comparisons.

4. Common vetch cultivars matured faster than woolly pod and purple vetch varieties.

5. ME and CP content was higher in early cuts, except for Benetas which had significantly lower ME than other varieties.

6. Benetas had higher ADF & NDF percentages compared to other varieties, across all cuts.

7. No interaction between yield and quality for the 2022 trials.

8. Quality of all vetches was hindered by wet conditions, with the later maturing varieties, Benetas and RM4, impacted the most.

The second year of this trial outlined the risks associated with growing vetch in challenging seasonal conditions. Vetch offers benefits such as disease breaks, integrated weed management, nitrogen fixation, and comparatively low water use. However, risks include inability to actually produce hay, maintain feed quality, and find a suitable end market when growing conditions are wet.

Partner–The University of Melbourne

Year 1 trials and results

As part of the project The University of Melbourne aimed to evaluate and demonstrate the agronomic best management practices for growing wheat, oats and barley to produce hay and silage for the dairy industry in northern Victoria. The trial took place at the Dookie Campus of the University of Melbourne. Different cultivars and sowing rates were tested, and various measurements were taken, including crop yield, stem diameter, and crop quality parameters such as ME, CP, ADF & NDF. The trial followed a randomized complete block design, with four replication plots per crop per sowing date. Two sowing rates (standard and high) and two sowing dates were tested for each crop. Various agronomic practices, including fertilization, insecticide application, and fungicide application, were implemented during the trial. Key outcomes included:

1. Cultivar had a significant effect on crop yield and stem diameter.

2. Eurabbie oat had the highest yield, while Kittyhawk wheat had the lowest yield.

3. Oat had a higher stem diameter compared to wheat and barley.

4. Sowing rate had a significant effect on yield at the earliest harvesting time and did not have a significant effect on crop quality parameters.

5. ME varied between cultivars at all three harvesting stages.

6. ME was highest at the earliest growth stage (GS 49) and lowest at the latest growth stage (GS71).

Overall, the trial demonstrated that the choice of cultivar and sowing rate can impact crop yield and stem diameter, while the timing of harvesting can affect crop quality.

Year 2 activity & results

The University of Melbourne continued to evaluate wheat, oats and barley for fodder production in year 2. The crop yield was measured at three growth stages (GS 49, GS 59, and GS 71), and forage quality parameters. Plant height, stem diameter, and weed quantification were also measured. The results showed significant effects of species, sowing date, and sowing rate on plant height and crop yield. Key outcomes included:

1. Oats produced higher fodder yields than wheat and barley.

2. Oats consistently had the tallest plant height which also corresponded with higher rates of lodging.

3. Very little difference in feed quality between oats, barley and wheat.

4. Yield was negatively correlated with ME for oats and wheat and with CP for all crop types.

5. Yield was positively correlated with NDF for oats with no correlations for wheat and barley.

6. Sowing date did not affect yields in wheat, but earlier sown oats had higher yields at both early and late harvests compared to later sown oats.

7. Sowing rates had little impact on yield or feed quality.

8. Higher sowing rates resulted in higher stems/m2 and lower stem diameter, but not improved feed quality at late harvesting stage.

9. Stem diameter negatively correlated with ME (oats and wheat) and CP (all species) but there were no relationships with NDF.

10. Weed infestation was lower in oat crops compared to wheat crops.

This trial demonstrated the importance of sowing date, sowing rate, and species selection for winter cereals. The results provided insights into the agronomic management practices that can optimise crop yield.

Partner–Riverine Plains

Year 1 trials and results

As part of the project, Riverine Plains ran a demonstration site to illustrate the impact of sowing date, sowing rate, and cutting time on the quality and yield of fodder when vetch was grown in combination with oats..

The demonstration site was located in a 4-hectare paddock in North Boorhaman, previously sown with a clover-based pasture. The site consisted of four plots with two different sizes. Two sowing dates were used, early (April 16, 2021) and late (May 14, 2021). The sowing rates varied between low and high for oats and vetch.

Various measurements were taken, including plant counts, silage and hay cuts, and soil samples. Plant counts were conducted to determine plant density. Harvest dry matter cuts were taken to measure yield per plot. Samples of silage and hay were analysed for nutritional characteristics.

The results showed that the soil at the site had slightly acidic pH values. Weed control was limited due to inadequate site preparation, and the combination of pulse and cereal crops restricted post-sowing spray options. The early-sown plots showed better development and advanced growth compared to the late-sown plots. The presence of vetch decreased as the oats overshadowed and suppressed its growth. The overall quality of the forage was suitable for dry stock or as a supplement for high-quality grass but not ideal for a milking herd.

Key outcomes from the demonstration include the importance of site preparation, the need to balance the ratio of cereal and legume in mixed fodder crops, the influence of sowing time on yield, and the potential benefits of cereal hay or silage as a supplement when the mix and timing are appropriate.

Year 2 activity & results

Riverine Plains continued their demonstration approach in year 2. A new demonstration site was developed at a 60-hectare paddock in Youarang, Victoria. Two vetch varieties, Morava and Benetas, were sown individually as well as in combination with oats. Fungicides were applied during the season to minimise disease risks. Soil samples were taken prior to sowing, and the pH and chemical analysis results were recorded.

Due to unfavourable weather conditions, the demonstration site was not suitable for hay or silage production. The Morava vetch plots were sprayed out and used as brown manure, while the Benetas vetch plots were harvested for grain. The height and overall stature of the vetch plants differed between the vetch-only and vetch-with-oats plots, with the oats providing support and keeping the vetch off the ground. Feed analysis indicated good quality forage samples.

Key findings revealed that the oats and vetch emergence counts were slightly below the target rates. The estimated yield for Morava vetch was 7.5 tons per hectare, while Benetas vetch yielded 8.5 tons per hectare. The vetch-only plots exhibited a wet mat on the ground, making harvest challenging, whereas the vetch-with-oats plots remained standing, facilitating cleaner cutting. The Benetas variety had a higher stem-to-leaf ratio, resulting in a higher yield but potentially lower nutritive value compared to the Morava variety.

Overall, the demonstration highlighted the importance of considering the purpose of fodder production and the desired quality or quantity. Growing vetch with a small amount of cereal can improve harvestability, especially in wet seasons, but makes both in crop and between crop weed control difficult. Matching the maturity of the cereal with that of the vetch is crucial for optimising fodder quality to balance growth stage of each species at cutting time. Collaboration and understanding between dairy farmers and grain producers is essential to ensure that fodder crops are planned and managed to mutual benefit.

Partner-Agriculture Victoria

Year 1 trials and results

Agriculture Victoria conducted a trial site at Tatura to investigate the effects of sowing rate and nitrogen application rate on winter wheat grown for fodder production.

The treatments included different sowing rates, nitrogen application rates, and defoliation treatments. Measurements were taken for dry matter yield, phenological development, tiller number, nutritive characteristics, and stem diameter.

The key findings from year 1 included:

1. Yield nearly doubled from early harvest (GS 49) to late harvest (GS 71) and was not affected by sowing rate.

2. Yield responded to increased nitrogen application up to 240 kg N/ha, with no further increases at higher rates.

3. Defoliation in the late vegetative stage (GS 29) resulted in the removal of around 2.5 t DM/ha, with greater removal at higher sowing rates, especially with high nitrogen rates.

4. Tiller density was highly responsive to nitrogen application but unaffected by sowing rate or early defoliation.

5. Tiller diameter increased from early to late harvest but was not consistently affected by sowing rate, nitrogen rate, or early defoliation.

6. ME & CP decreased from early to late harvest, while NDF did not change.

7. Nutritive characteristics were not consistently affected by sowing rate, nitrogen rate, or early defoliation. CP was increased by higher nitrogen rates but unaffected by sowing rate or early defoliation. No relationship was found between measured concentrations and stem diameter.

Unfortunately, the trial site was abandoned in Year 2 due to restructure of Agriculture Victoria.

Outcomes-Extension

In addition to the specific technical messages generated by each trial site, the project also identified several additional extension messages to support farmers to adopt practices on farm to improve the quality and yield of their fodder. These messages focused on the practical application of technical outcomes and took into consideration current and future seasonal and market conditions. They included:

1. Relationship building

The project emphasized the importance of building relationships between the dairy and grains industries. By understanding each other's needs, both industries can work together to create mutually beneficial outcomes, promote collaboration, and enhance long-term sustainability. An example of this was the role of oaten hay. Grain industry stakeholders involved in the project had a high emphasis on oaten hay given its high yield and potential high value market for export. It was assumed that the dairy industry saw it as an equally valuable product. By bringing the two industries together through the Technical Committee and at project events, dairy farmers were able to share their preference for wheat and barley hay and the quality benefits which helped grain growers understand what species suited different uses in the dairy industry. Having a clear target end product in mind enables fodder growers & dairy farmers to select the correct species, varieties and managements strategies including cutting time in advance in order to optimise the chances of growing a high quality, high value and cost-effective fodder product.

2. Diversification and income generation:

The project delivered trials in extremely challenging and diverse seasonal conditions. Year 1 was largely dry across the region apart from the east, and Year 2 was extraordinary wet with flooding impacting the majority of trial sites. Results from the trials show that seasonal conditions had the biggest impact on quality and yield, which was to be expected in such extreme growing conditions. In order to manage this on farm, farmers need to take a risk management approach to selecting the type, volume and desired end market for their fodder. The project demonstrated a wide variety of fodder options and the relative pros and cons of each one in different seasonal conditions. For example growing vetch in cereal rotations was identified as a beneficial practice for diversifying income streams for farmers as well as having significant agronomic benefits as a break crop. However it was also the most difficult to grow, particularly in wet conditions. Not one fodder species emerged as the highest performing, however the results across sites and years demonstrated that different species performed differently in different conditions. This highlights the need to diversify species and products in order to optimise success in a given year.

3. Yield and quality trade-off

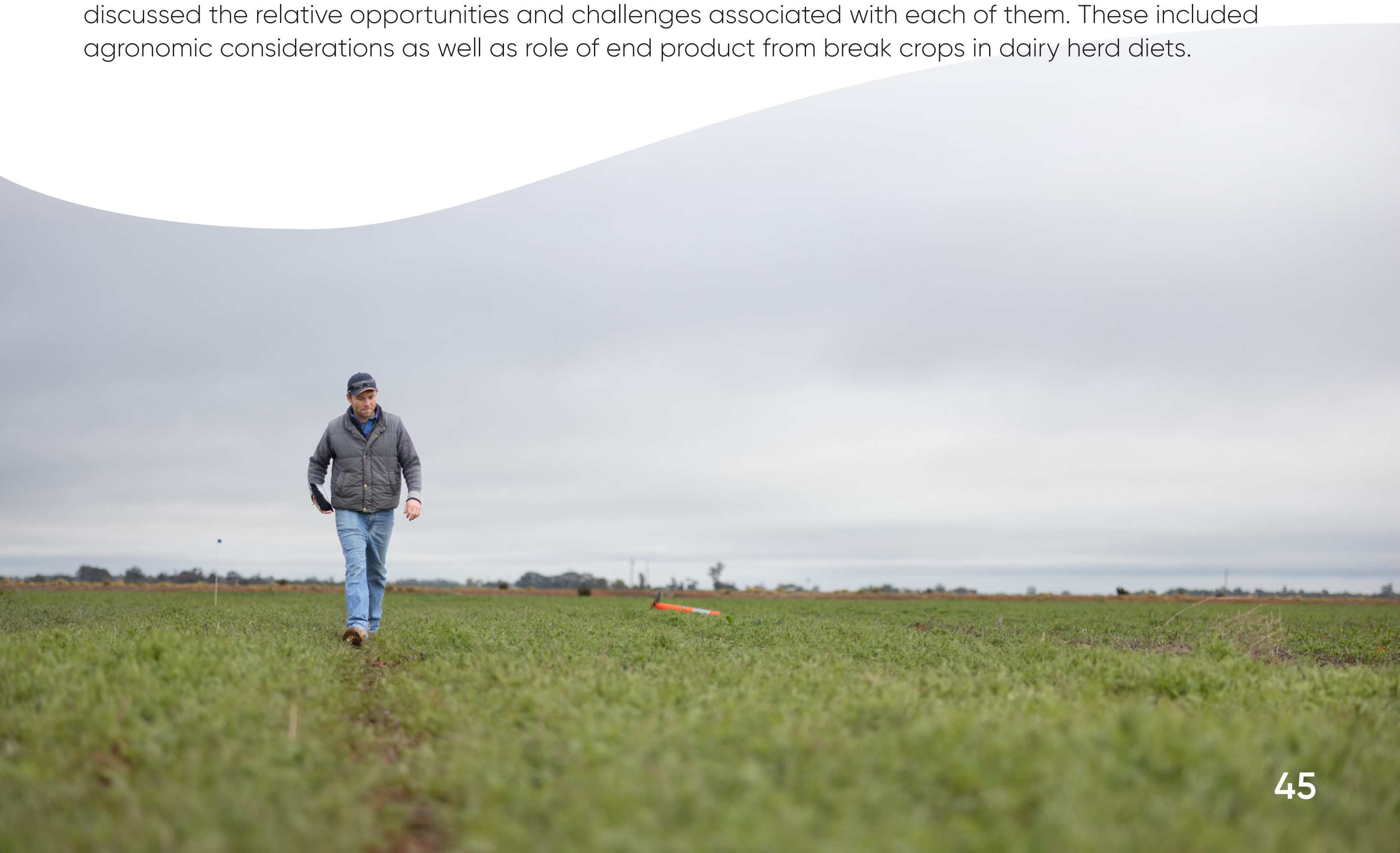
It is well known there is a direct trade-off between quality and yield in most fodder species. The project demonstrated that within that there are often complex decisions to be made in practice to balance seasonal conditions and harvestability with target yield and quality. The project reiterated the importance of having a clear end product with target yield and quality in mind from the beginning, in order to plan ahead for in crop management, particularly target cutting times. The project also demonstrated the importance of problem solving and being flexible with decision making in order to be realistic about what is possible to achieve depending on seasonal conditions. A number of times target yields and quality had to be abandoned as they were not possible to be achieved due to seasonal conditions or harvestability.

4. Importance of proactive weed control

In traditional dairy feedbase systems based on perennial ryegrass, targeted weed control is less critical to feedbase performance given the natural weed suppression from intensive grazing and continuous ground cover that perennial ryegrass provides. In contrast, dryland fodder and grain areas surrounding irrigated dairy farms generally have a sophisticated integrated weed management approach to reduce impact of weeds on target crop emergence and conserve soil moisture and nutrients over the summer fallow periods. Through cross collaboration, the project identified a number of critical improvements that dairy farmers should implement to reduce impact of weeds on fodder crop performance including the importance of rotations that break up continuous cereal and grass species with broadleaves (e.g., brassicas or legumes), pre-emergence and post-emergence chemical options and summer fallow spraying. The current uptake of these best practice options varies significantly between individual businesses.

5. Importance of break crops in dairy rotations

In addition to assisting in long term weed control, particularly the avoidance of herbicide resistance in grass weeds, the project demonstrated the role of break crops in intensive fodder and grain systems. This is already an established practice on dryland grain and fodder systems in the region, but implementation on intensive fodder rotations on dryland and irrigated dairy feedbase systems is mixed. The project demonstrated various break crop options from legume and broadleaf species, and discussed the relative opportunities and challenges associated with each of them. These included agronomic considerations as well as role of end product from break crops in dairy herd diets.



Building Relationships

Riverine Plains also delivered a pilot program as part of the project focusing specifically on building relationships between the dairy industry and other fodder growers. The aim of the pilot was to establish long-term relationships between dairy and fodder producers to increase risk management options, the diversification of income and resilience in business management. The pilot delivered a series of four workshops to bring together stakeholders to gain insight into the challenges and opportunities within the industries and knowledge gaps that could be addressed through relationship building. A common goal identified by all participants was to reduce risk to both fodder buyers and growers.

Understanding the value of fodder products was a key outcome from the workshop. Better communication and increased transparency about what make a 'quality' fodder product and what it takes to produce this would assist both fodder producers and dairy farmers purchasing fodder on the market manage their business risk more effectively. A desire to better value fodder products and built trust was a clear mutual priority for all stakeholders involved in the pilot.

Figure 7. A SWOT analysis demonstrates both the unique and mutual perspectives dairy farmers and fodder producers bring to the fodder market.

	DAIRY FARMERS (BUYERS)	MUTUAL	FODDER PRODUCERS
STRENGTHS	Storage and delivery when needed. Knowing product history.	Security and reliability. Consistency. Saves time/peace of mind. Price negotiation.	
WEAKNESSES	Inconsistent buying so grower not loyal. Narrow quality specifications for animal nutrition. Transparency could open growers eyes to better opportunities.	Trust	Buyer having too much input. Price negotiations – buyer has max, grower has min, sometimes there's a gap. Large risk due to climatic influence on quality. Fodder competing ha for product, harder to market than selling grain.
OPPORTUNITIES	Collective bargaining. Work with people heading in same direction. Price advantage. Transparency into quality.	Building firm relationship. Trust. Input into product. Build further networks.	Value the quality rather than the quantity. Educate in the input required to produce quality product.
THREATS	Quality – complacency: could end up with wrong product. Supply and demand: supplier moves on, changes direction. Pricing. Pushed out of relationship due to size. Indecisive so miss out. Overstepping relationship boundary with grower – being too pushy. Storage insurance. Pest and disease being brought in.	Trust. Verbal contracts. Becoming too reliant. Loss of crops – seasonal challenges.	Payment. Covering costs to produce product (otherwise there is more value in brown manuring it).

Contribution to industry knowledge & networks

A key legacy of the project is the Fodder for the Future network of partner organisations. It spans 6 key organisations that work directly on ground with farmers and service providers from the dairy, cropping and livestock industries.

The Network has created extremely effective communication and information sharing channels between farmers, industries and organisations. The Network was maintained by the project's governance structure.

The Technical Committee contained members from each organisation as well as additional expertise in agronomy and animal nutrition. This committee met regularly to design trial sites, review activities, and discuss key technical messages. This was a critical process to share technical knowledge between the cropping and livestock areas in both the agronomy and animal nutrition space, a key gap identified as part of the project development.

This information sharing led to increased knowledge and understanding of the drivers of quality and yield for fodder species and translated into high quality demonstration activities and coordinated, consistent key messages to farmer audiences in all industries.

The Network was also supported by the Advisory Committee, which contained members from each organisation's executive. The role of this committee was to ensure project activities were aligned to milestones, were completed to a high standard and were connected to other activities outside the project to avoid duplication. The Advisory Committee also oversaw the delivery of extension and communication activities.

The Network, and specifically the cross sectoral approach employed by the project, has been critical to ensuring collaboration and consistency of technical messages regarding the production and purchasing of fodder. This collaborative approach also enabled the strengthening of networks between farmers directly. By designing events to capture both fodder producers and end users, the mix of attendees were able to share information about the challenges and opportunities for producing high quality forage and what success looks like in terms of not only an end product, but also long term business relationships. This has been key to facilitating greater information in commercial markets, to assist to 'close the loop' of fodder produced in the southern Murray Darling Basin.

Evaluation

The project developed an evaluation plan in order to ensure continuous improvement and review of the project activities. A range of evaluation activities were conducted to ensure that the project delivered to its objectives and activities could be tailored to feedback throughout the life of the project. An important mechanism for monitoring and review was the Technical Committee and the Advisory Committee. The Technical Committee provided an important mechanism to share technical knowledge between the grain, fodder and dairy industries, review trial activities and discuss trial outcomes. The Advisory Committee reviewed and made recommendations for the overall strategy of the project including communication and engagement activities.

Partner organisations also tracked the effectiveness of the trial sites and extension activities through engaging with participants as part of their overall engagement and evaluation mechanisms. This included seeking feedback from events, input from farmer consultation mechanisms and reviews with board and staff members. Overall the project received highly positive feedback on the value of the Fodder for the Future network between organisations and the 'touch and feel' sites in local regions that accurately reflected the opportunities for improvement based on specific seasonal contexts and agronomic challenges. Feedback also focused on the benefits of the geographical spread of the trial sites, the value of improving understanding of both dairy farmers and fodder producers needs and highlighted a number of opportunities to further leverage the value of the project through additional data analysis and extension activities.

Literature review & desktop study

A literature review was completed at the start of the project in order to consolidate existing information on how to improve yield and quality of fodder for dairy herd diets and to guide activities. After on-ground activies were completed, an updated literature review was commissioned to consolidate technical learnings from the project. The literature review was undertaken by the Queensland Department of Agriculture and Fisheries and the C4Milk research team and updated to reflect key data collected as part of the project, as well as farmer and agronomist feedback and experience and expanded to include economic modelling. The review focused on optimising fodder in rotations which has been identified as a significant limiting factor to increasing yield and quality in the project. The literature review clearly reflects the extent of the knowledge that has been created and consolidated as part of this project.

Recommendations & areas for future work

The project delivered a comprehensive set of activities to engage stakeholders with a range of information in order to improve yield and quality of fodder produced by cereal species. A number of areas for future work were identified in order to build on the outcomes of this investment. These include:

1. Support to continue the Fodder for the Future Network as a key mechanism for sharing technical knowledge around how to improve fodder yield and quality, as well as engage large numbers of farmers and service providers effectively.

2. Future research into the role of break crops in intensive cropping rotations to support dairy feedbase systems. This includes how to achieve the natural resource benefits of break crops such as weed and pest control whilst balancing the need to produce high quality fodder for lactating cows cost effectively.

3. Integration of best management practices relating to site preparation, weed control and nutrient management into standard dairy extension programs relating to feedbase. Their remains significant potential to adapt common best management practice principals from the cropping industry into dairy extension packages as winter & summer cereals are continued to be adapted for dairy feedbase systems.

4. Sharing of information on fodder storage and handling developed by dairy industry to grain, fodder and other livestock producers particularly in the context of dry conditions. Similarly, grain and livestock stakeholders identified the opportunity to integrate common best management practice principals from the dairy industry around fodder quality testing, storage & handling into their extension delivery.

5. Updating current and future research projects, particularly those focusing on physical and economic modelling, with yield and quality results from this project to ensure realistic assumptions are being made around yield and quality targets. The variability of performance across years and species demonstrated by this project shows the importance of using current up to date data to inform modelling and economic analysis. This information could also benefit other regions when looking into future climate models and the impact on dairy feedbase performance.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