Upper North Farming Systems

UNFS

Upper North Farming Systems

2012 Harvest Report

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RURAL SOLUTIONS SA

GRDC

Grains Research & Development Corporation

CARING FOR OUR COUNTRY

clean energy future

2012 Harvest Report Contents

UNFS Executive Summary

Seasonal Overview

For most of the district 2012 has been a very challenging year. The opening rains were late and very patchy, resulting in staggered emergence. Early sown and dry sown crops generally performed the best, despite some grass weed issues. Later sown crops (early to mid June) emerged well, but did not grow due to the cold conditions experienced during late June, July and early August. Very little rain was received after mid August and most crops relied on stored soil moisture from rains in March. Yields across the district have been very variable from well above average in the western part of the district to well below average in the north east. Barley performed above expectations with many crops yielding higher than expected, however wheat has generally been disappointing yielding less than expected. Grain quality has generally been good with low screening and reasonable grain protein levels. With the dry finish to the season reducing soil mineralisation, wheat protein levels were not as high as many growers would have expected, however most made either APW or H2 with a small percentage making H1.

Canola, mustard and peas have all been disappointing with yields well below average. The combination of frost, dry conditions and poor crop establishment has impacted on yield.

The UNFS group held its AGM at the CFS Complex in Booleroo Centre on 23 July 2012. Current Chairman, Ian Ellery continued for a further 12 months and the Vice Chair, which had been vacant for 12 months was filled by Jo Koch.

After the success in 2011 it was decided to again hold the UNFS field day at the Booleroo Centre, Athletics Complex. The theme for the day "Managing the opportunities, managing the risks". Topics included, impact of climate change on profitability, time of sowing and summer weed control, canola harvest management and smart phones and apps, Rabobank again provided lunch, however they were unable to cook the BBQ, but very generously paid the local Athletics Club to prepare lunch. Drinks after the field day were provided by Northern Ag. The afternoon included a bus trip to inspect the Crop Sequencing site and the National Variety Trial site.

The GRDC funded "Water Use Efficiency" project is coming to an end on the 30th June, 2013 and a new "Stubble Management" project was developed by GRDC through a tender process. UNFS completed a comprehensive tender application, during October and November and were fortunate to be invited to submit a full application. All successful applications did not receive their full funding; however the UNFS received a smaller cut than many other groups. This application was submitted in early February and we are still waiting to get feedback.

A special thanks to the sponsors:
Grains Research and Development Corporation
Caring for Our Country
Department of Environment, Water and Natural Resources
Sturt Grain (sponsors of "Yield Prophet" in the UNFS area in 2012)
Rabobank (sponsors of the field day lunch)
Northern Ag (sponsors of post field day drinks)

Michael Wurst
Upper North Farming Systems
Project Leader, Rural Solutions SA

National Variety Trials 2012- Booleroo Centre Wheat

Key Messages

- Further variety information and performance data is available on NVT online, www.nvtonline.com.au
- September rainfall was minimal, this significantly reduced wheat yield potential.
- If your property is similar to the Booleroo Centre site; the Emu Rock, Grenade CL Plus and/or Scout varieties would be worth trying due to their consistently high yield and reasonable protein content.

Background

The National Variety Trials (NVT) are a GRDC-funded program which compare the yield performance, disease tolerance and suitability of broadacre crops in farming areas in Australia. Crops include wheat, barley, oats, triticale, canola, peas, lupins, lentils, chickpeas and faba beans. The website also includes links to Sowing Guides with information for all crop types.

More information about specific varieties and comparisons between districts can be found online by visiting www.nvtonline.com.au. This site also includes fertiliser and herbicide treatments used for each trial.

Farmers who attended the Upper North Farming Systems annual field day took part in a bus trip around the district, which included a visit to the NVT site at Booleroo Centre.

Good rains in January and March resulted in good levels of stored soil moisture at the start of April. However, opening rains were relatively late 25th May. Reasonable falls were received in June and july, however, September rainfall was minimal (in the bottom 5% of years) and this significantly reduced wheat yield potential in 2012 (Figure 1).

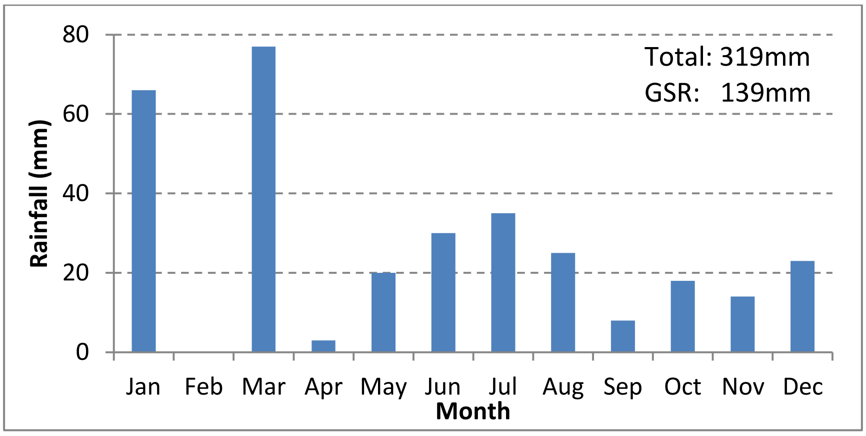


Figure 1: 2012 Monthly Rainfall totals for the Booleroo NVT sit

Results

Booleroo - Wheat - Main Season, 2012

Mean Yield:	1.62 (tonnes/ha)	**Sowing Date:**	28/05/2012
LSD:	0.11 (tonnes/ha)	**Harvest Date:**	27/11/2012
CV:	3.9 %	**Report Date:**	20/02/2013
Probability:	<0.001	**Trial Code:**	WMaA12BOOL5
		Trial Owner:	NVT

Despite the very dry finish, yields at the site were acceptable with low levels of screenings. Grenade CL Plus produced the highest yield, however this was not significantly different from the yield of Phantom (or any varieties between the two). There were are large number of varieties with very similar yields (1.6 to 1.7 t/ha) with only Lincoln and Young averaging less than 1.5t/ha.

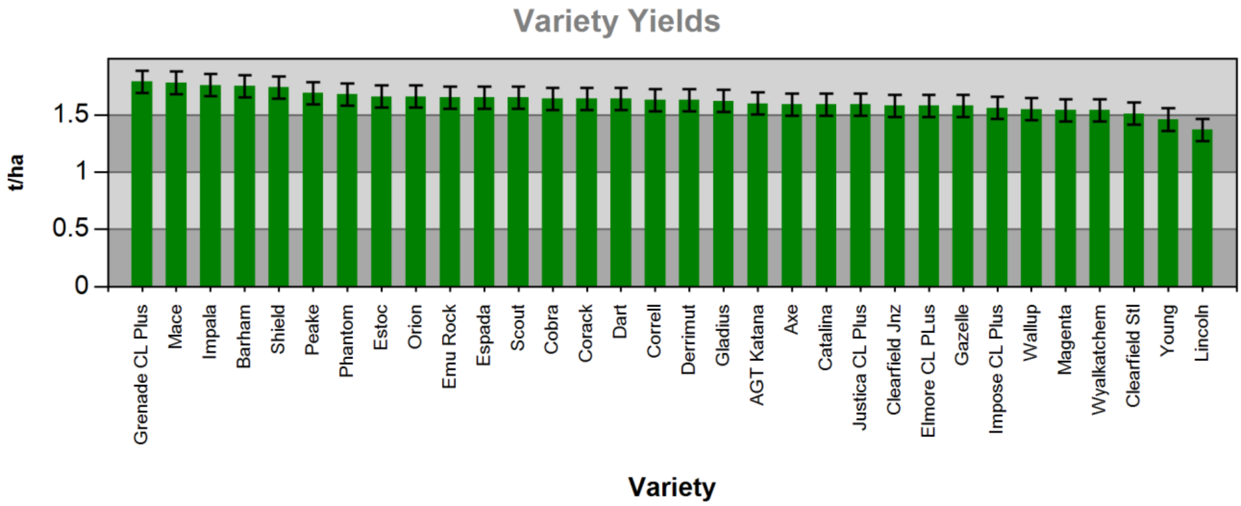


Figure 2: 2012 Booleroo wheat NVT yields. Source: www.nvtonline.com.au

In selecting the most appropriate variety it is important to look at variety yield rankings over a number of years, Figure 3 shows varietal yield rankings from 2009 to 2012 at Booleroo. Here Scout, Emu Rock and again Grenade CL Plus showed the highest yield production. It is important to note that although Emu Rock produces a high yield this yield is quite variable throughout the years in comparison to Scout and Grenade CL Plus (as shown by the large error range, whiskers at the top of the bar).
Emu Rock and Grenade CL Plus are AH quality wheat varieties. Grenade CL Plus is a Gladius derivative (but with good sprouting tolerance) and has been specifically bred to have tolerance to the Intervix® herbicide, offering an alternative for weed control; it's main disadvantage is susceptibility to yellow leaf spot and leaf rust (that are problems in good years). Emu Rock is a Kukri derivative with a high yield, it's disadvantage being susceptibility to CCN, yellow leaf spot and leaf rust. Scout is a Yitpi derivative with high yields, however it shows susceptibility to yellow leaf spot and black point.

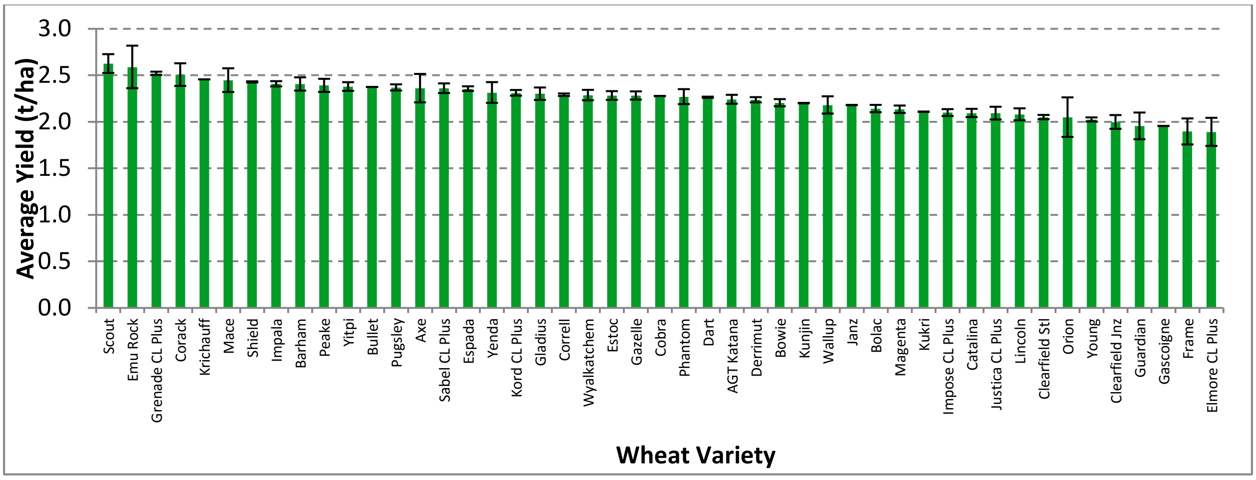


Figure 3: Ranking of wheat varieties at Booleroo 2009 to 2012. Source: www.nvtonline.com.au

Grain quality is also an important component of variety selection; the table below shows variation in hectoliter weight, Protein content, screenings and 1000 grain weight. Screenings were surprisingly low in 2012, with no varieties having enough for dockage upon receival. Hectoliter weights were all above the 2013 target 76kg/Hl. Protein contents were low in 2012, due to the dry spring reducing soil mineralization with no variety making the 13% cut off for AH1.

Corack
Early maturing APW variety derived from Wyalkatchem. CCN resistant and good yellow leaf spot resistance, but moderately susceptible to leaf and stripe rust and very susceptible to powdery mildew. High yield potential in SA, particularly in low to medium rainfall areas. Seed available through AGT.

Emu Rock
High yielding early maturing, AH variety released by Intergrain. Susceptible to CCN, but moderate resistance to stem and stripe rust and is MS/S to leaf rust and MS to yellow spot. Shown large grain and high yields in SA.

Grenade CL Plus
An imidazolinone herbicide tolerant (Clearfield type) replacement for Justica CL Plus. Early to mid season flowering with moderate resistance to CCN and useful rust resistance, but susceptible to yellow spot. Improved test weight and sprouting tolerance over Justica with seed available for sowing in 2013.

Shield
Recently released, early to mid season moderate yielding AH variety. Resistant to CCN, good resistance to all rusts, but susceptible to yellow spot. Good black point resistance and sprouting resistance, but slightly lower test weight. Seed available for 2013 sowing from AGT.

Table 1: 2012 Booleroo NVT Wheat Receival Standards

	Analysis	Receival Standards			
	16/12/2012	27/11/2012			
	Predicted Yield	Hectolitre Weight	Protein	Screenings (<2.0mm sieve)	1000 grain weight
	tonnes/ha	kg/hectolitre	%	%	g/1000 seeds
Grenade CL Plus	1.79	83.10	10.9	1.40	40.59
Mace	1.78	83.90	10.7	0.94	38.79
Impala	1.76	83.60	11.7	1.66	31.23
Barham	1.75	81.50	11.2	1.48	35.28
Shield	1.74	83.00	11.4	2.34	36.29
Peake	1.69	84.90	11.4	1.47	35.76
Phantom	1.68	82.90	12.4	1.17	40.34
Estoc	1.66	85.40	12.4	0.85	37.23
Orion	1.66	78.30	10.5	1.81	35.94
Emu Rock	1.65	83.90	11.7	1.63	40.46
Espada	1.65	82.10	12.5	1.32	36.13
Scout	1.65	85.10	11.7	1.19	36.77
Cobra	1.64	81.50	11.8	1.67	35.04
Corack	1.64	84.40	10.7	1.36	39.89
Dart	1.64	84.00	11.1	2.58	32.70
Correll	1.63	81.20	11.7	1.74	39.02
Derrimut	1.63	85.60	11.9	1.37	34.36
Gladius	1.62	82.20	11.9	1.85	37.98
AGT Katana	1.60	85.60	12.2	1.28	36.65
Axe	1.59	84.90	11.7	1.42	39.52
Catalina	1.59	85.20	11.4	0.77	36.79
Justica CL Plus	1.59	81.50	12.0	0.74	33.75
Clearfield Jnz	1.58	83.90	11.8	0.73	35.47
Elmore CL PLus	1.58	84.30	11.6	1.23	33.56
Gazelle	1.58	81.50	11.2	1.39	30.85
Impose CL Plus	1.56	83.60	11.3	0.79	40.41
Wallup	1.55	84.00	12.4	0.64	35.36
Magenta	1.54	82.90	12.6	0.88	38.31
Wyalkatchem	1.54	83.70	11.3	0.89	38.80
Clearfield Stl	1.51	84.00	12.6	0.82	39.36
Young	1.46	83.90	12.0	1.30	30.34
Lincoln	1.37	82.90	11.8	1.36	34.83

Source: www.nvtonline.com.au

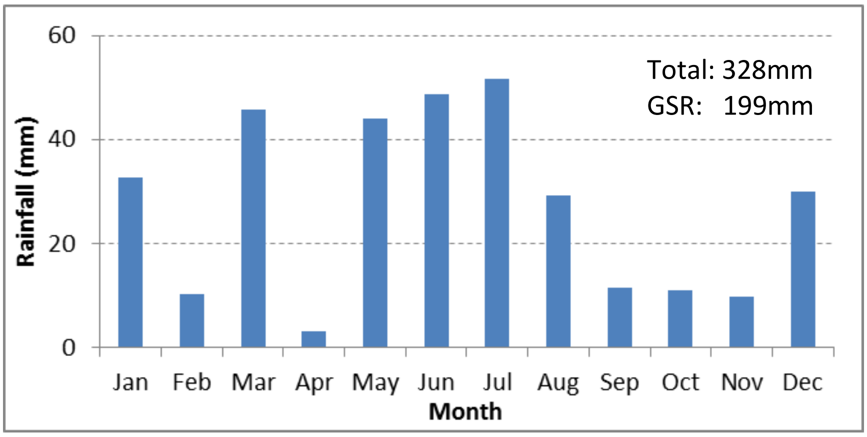
Emu Rock and Scout had better quality parameters (especially protein content) than Grenade CL Plus. And in general, lower yielding varieties had higher protein contents.

National Variety Trials 2012- Crystal Brook Barley

Key Messages

- Further variety information and performance data is avaliable on NVT online, www.nvtonline.com.au
- Crystal Brook had good May, June and July rains that set up a high yield potential in 2012.
- In general varieties that finished well were early maturing and had a good water use efficiency.
- If your property is similar to the Crystal Brook site; the Fathom feed variety, and Commander, Buloke and/or Navigator malting varieties would be worth trying due to their consistently high yield and low protein contents.

The NVT barley site closest to UNFS farmers is located just north of Crystal Brook. The trial received higher than average May, June and July rainfall (Figure 4) that set up high yield potentials and carried the barley varieties through the low September and October rainfall totals remarkably well in 2012.



4: 2012 Monthly Rainfall totals for the Crystal Brook NVT site

Results

Crystal Brook - Barley - Main Season, 2012

Mean Yield:	3.68 (tonnes/ha)	**Sowing Date:**	30/05/2012
LSD:	0.24 (tonnes/ha)	**Harvest Date:**	9/11/2012
CV:	3.9 %	**Report Date:**	20/02/2013
Probability:	<0.001	**Trial Code:**	BMaA12CRYS5

In 2012 Commander, Fleet, Keel, Hindmarsh and Fathom all produced a similar yield that was the highest of the varieties tested (Figure 5). Of these Commander is the only malting grade variety, although Hindmarsh can sometimes receive a slight premium as it is classified as a food quality variety. The later maturing varieties of Oxford and Wimmera produced the lowest yields in 2012.

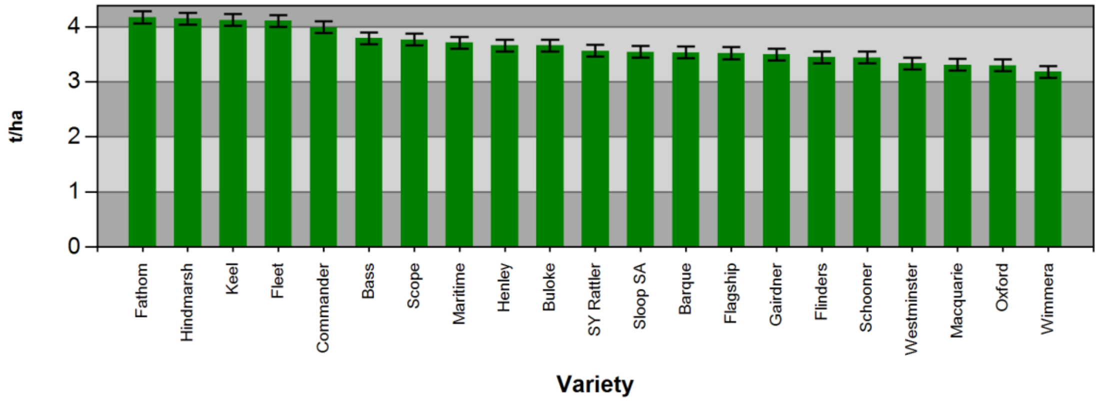


Figure 5: 2012 Crstal Brook barley NVT yields. Source: www.nvtonline.com.au

Again it is important to compare variety performance across a number of years, with Figure 6 showing the 2008 to 2012 average yield rankings. As with the 2012 year alone, Fathom produced the highest yield of all varieties tested in the Crystal Brook trial. Fathom is a feed quality barley derived from a wild barley cross, and it shows improved stress tolerance and water use efficiency; it is the best performer in the dryer environments of the state. It has good resistance to CCN, scald, powdery mildew and spot form net blotch; but it is succptible to net form net blotch.

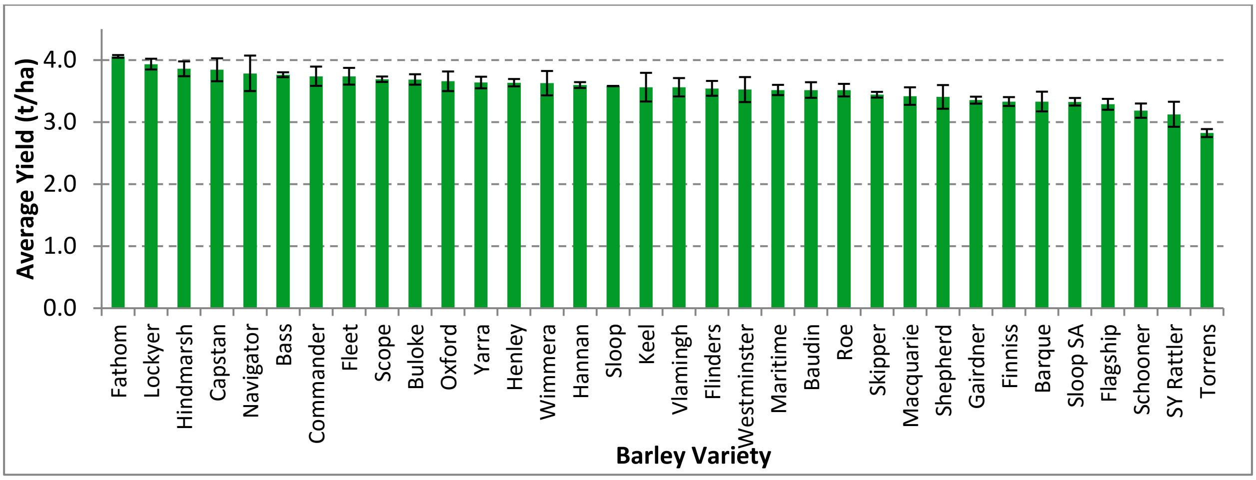


Figure 6: Average NVT barley yields for Crstal Brook 2008 to 2012. Source: www.nvtonline.com.au

Navigator, Bass, Commander and Buloke were the highest yielding malt quality varieties. Navigator is a high yielding domestic malting variety but care needs to be taken with it's extreme susceptibility to leaf rust. Bass is an export quality malting barley with moderate resistance to scald and leaf rust and no resistance to CCN or net blotch, and is not recommended for areas where either form of net blotch persists. Last year Commander was the variety most likely to achieve Malt 1 across SA, it is both a domestic and export malt variety that is CCN resistant and has a moderate resistance to foliar disease; it is not recommended for sowing into barley stubble. Buloke is an export quality malting barley that has good resistance to net form net blotch, but is succeptible to CCN, leaf rust, and black point; and requires shallower seeding (as does Hindmarsh).

Grain quality is also a significant factor in determining cropping profitability. In 2012 Bass had a very high protein content (refer table overleaf), the highest of all varieties in the trial. On the other hand Commander had the lowest protein content, Buloke had a slightly higher protein content than Commander and from prior years data Navigator had a slightly higher protein content than Buloke- although all were below the 12% malt 1 classification in 2012.

Hectolitre weight was good in the 2012 trial, screenings were low and Fleet had the largest grain size (refer table overleaf). Therefore it is recommended to sow Fleet at a higher density to receive adequate plant densities.

Table 2: 2012 Crystal Brook Barley NVT Receival Standards

	Analysis	*Receival Standards*				
	16/12/2012	*9/11/2012*				
	Predicted Yield	*Hectolitre Weight*	*Protein*	*Screenings (<2.2mm sieve)*	*Plump Grain (>2.5 mm sieve)*	*1000 grain weight*
	tonnes/ha	*kg/hectolitre*	*%*	*%*	*%*	*g/1000 seeds*
Fathom	4.17	70.80	12.2	1.6	82.4	44.20
Hindmarsh	4.14	71.10	11.9	5.7	50.5	36.37
Keel	4.12	70.40	11.1	3.7	72.2	41.55
Fleet	4.10	69.20	12.6	1.9	66.3	46.24
Commander	3.99	71.10	11.0	1.3	86.2	41.26
Bass	3.79	71.80	13.8	0.8	82.9	40.59
Scope	3.76	70.40	11.4	1.0	72.7	43.70
Maritime	3.71	70.00	12.7	1.2	87.9	45.51
Buloke	3.66	69.90	11.4	2.3	62.0	43.17
Henley	3.66	68.60	12.3	1.5	76.8	37.59
SY Rattler	3.56	69.60	12.0	5.3	44.6	33.52
Sloop SA	3.54	71.40	12.8	2.7	66.5	40.60
Barque	3.53	70.90	13.0	1.9	71.8	44.32
Flagship	3.52	72.10	11.7	4.3	54.5	40.93
Gairdner	3.50	70.20	12.1	2.0	67.6	41.77
Flinders	3.44	70.70	13.4	1.9	68.0	36.12
Schooner	3.44	72.70	12.4	2.0	68.1	39.53
Westminster	3.33	71.90	12.9	0.5	85.1	42.01
Macquarie	3.31	71.40	11.7	2.0	74.1	41.98
Oxford	3.30	72.70	12.6	2.2	63.7	36.50
Wimmera	3.18	71.10	13.4	1.7	74.6	39.20

Source: www.nvtonline.com.au

GRDC Grains Research & Development Corporation

SARDI South Australian Research and Development Institute

National Variety Trials A GRDC INITIATIVE

LRCG Profit/ Risk Project
2011/12 Report

Overview of the Project

The aim of this project is to improve participants understanding of their farming business in terms of profitability and risk to enable improved decision making for more resilient farm businesses. The importance of this approach is magnified by the high level of climate (and other) variability experienced in this region.

Activities undertaken in 2011/12

A farmer group based in the Orroroo/Morchard area was established. A total of 11 individual farm businesses have attended a series of 4 workshops (not all participants have been able to attend all workshops). The program has collaborated with Peter Hayman (SARDI Climate Applications Unit) to enhance delivery of climate information deemed appropriate for the improved understanding of seasonal risk in these environments. Work completed under a State NRM program looking at resilience in low rainfall farming systems has also been incorporated into the program.
Three workshops have been completed to date.

Workshop 1. Establishing the issues.
The workshop used an approach "borrowed" from Victoria DPI to establish where the primary concerns lay with the farmer group.
Five big questions were asked:

1. Are you and your family enjoying what you are doing?
2. Can you sustain the effort?
3. Are you satisfied with the return you are getting for your input?
4. Is your farming system sustainable (economically and environmentally)?
5. Have you enough to retire on?

Participants identified a number of issues which were of particular concern:

- Need more labour, not able to sustain current workloads
- Profitability- poor margins, particularly in poor years. Commodity prices and volatility. Lack of incentive for young people to return to farms.
- Need to improve economic sustainability- debts are too high, on-farm infrastructure is becoming rundown, lack of plant replacement
- Need to improve ability to store and maximize returns from moisture
- Succession planning, off-farm investments

Guest presenter Peter Hayman, from SARDI Climate Applications Unit discussed;

- Adaptational vs transformational change- most concentration at this stage on adaptational change
- Broad climate change projections for the Upper North- strong likelihood of warmer temperatures, not so certain on rainfall but best guess is a drying trend

This workshop also identified the broad characteristics of a representative case study farm to be used in analysing the local systems.

- Total farm size- 2000 Ha (1500 Ha arable, balance grazing)
- Standard program involves cropping 50% of arable land to cereals, balance self regenerating (medic?) pastures
- 800 Merinos Ewes for prime lambs
- Labour- One manager full-time plus half-time casual assistance

- Farm Assets

Land 2000 Ha @ $1000	$2,000,000
Machinery	$500,000
Livestock	$150,000
Total Farm Assets	$2,650,000

- Long Term Debt $530,000

This case study farm would then be used throughout the workshop series for analysis of various management settings and "what if" scenarios.

Workshop 2 Presentation of initial spreadsheet analysis on the local farming system .
Prior to the workshop, an initial analysis was completed on the case study farm. This was then presented for discussion. Seasonal risk was analysed in two ways

1. Using estimates of performance over different rainfall deciles to establish risk profiles across different seasons
2. Use the different phases over the past 20 years to test effects of different seasonal sequences.

Implications and conclusions drawn from this analysis:

1) Implications of seasonal variability.

The analysis confirmed the high degree of risk associated with mixed farming in these environments. Very poor years show operating losses of around $140,000 grading up to profits approaching $450,000 in very good years. Profitability of the case study farm in an average Decile 5 year was respectable at around $88,000 with break-even occurring at Decile 3.
The typical mixed farm program in the area is more sensitive to movements in grain pricing than it is to changes in livestock profitability. A 20% drop in grain pricing (from $220/tonne on farm) would place this case study farm in a very vulnerable position and relying on above average seasonal conditions for financial viability.

2) Implications of changes to enterprise balance.

The enterprise mixes which had a reasonable blend of both cropping and livestock were the best performing over the past two decades (and small variations within the mix had relatively little influence).
Cropping only performed satisfactorily during the early period of better seasons but would have crashed badly over the past 10 years. Good recovery occurred in 2010 but at least one more better season would be required to bring its performance up to the more balanced enterprise mix options.
Livestock only was the poorest performing enterprise mix over the period. Insufficient income is earned to adequately extinguish debt. In this circumstance, a livestock only mix could only be contemplated in high equity, low debt situations.
An analysis was also completed looking at the effect of changing annual sowing area based on Plant Available Water (PAW) at seeding, and the timing of the opening rains. The conclusion was that varying sowing levels based on seeding PAW and sowing opportunity can have substantial benefits in maximising returns in some better seasons, but has little impact in reducing the substantial losses incurred in poor yielding seasons. Changing other inputs (predominantly fertiliser) is likely to be of more beneficial in protecting against downside risk in poor seasons.
Discussions were also held on the perceived opportunities for transformational change in local farming systems. Participants did not support or envisage a non-reversible transformation of the current mixed cropping/ livestock landscape. As an example, even if they were to move to a full livestock system, they were reluctant to remove cropping as a possible alternative at some stage in the future.

Workshop 3 Further analysis of the profitability and risk of farming in the Morchard area.

The following aspects were discussed:

Cost of production analysis across different farm districts and relevance to Morchard area. This case study analysis of farm businesses located in widely varying productivity zones (average cereal yields varying from 4.5 tonne/Ha to 1.3 tonne/Ha) showed no significant differences in the cost of producing grain across the different regions when all costs (both fixed and variable) were taken into account.

In essence, farming at Morchard was quite profitable providing average yields could be obtained over time.

Return on Capital analysis and implications for risk management in lower rainfall districts. This analysis was completed in conjunction with the Cost of Production analysis mentioned above. It shows that even though the cost of producing wheat at Morchard could be competitive, the main difference between this lower rainfall district and the higher producing areas was the much higher risk profile being faced. This higher risk profile needed to be focussed on if sustainable and profitable farming systems were to be achieved in the lower rainfall farming districts.

Latest climate information for Morchard including modelling of possible yield effects of climate change. This showed a range of possible outcomes depending on the global model selected. Generally, the modelling is suggesting a decline in yields over time but, at least in the next 20- 30 years, this is likely to be overshadowed by normal climate variability.

The framework for "Practical Decision making for Resilient Farms" (a framework developed by Barry Mudge and Michael Wurst to aid in assessing resilience at farm level) was also introduced. The objective was to use this framework to allow improved understanding of the various components of the systems.

Workshop 4. Pulling it all together.

This workshop reviewed outcomes to date and further expanded on the "Resilient Farming Framework". This involves studying the various settings which make up the components of the farming system:

1) Whole of business
2) Strategic settings
3) Enterprise based tactical decision making

The case study farm was used to assess Cost of Production over different season types and under changes to business settings. The following was noted:

1) A change in equity from 80% to 100% reduced COP by $21/tonne. The difference in COP between 100% and 60% equity was $42/tonne.
2) Halving the machinery investment from a "normal" benchmark reduced COP by $18/tonne. It was considered by the group that this level of investment in machinery would create significant inefficiencies leading to likely yield loss. On the other hand, running a level of machinery 150% larger than the "normal" benchmark added $18/ tonne to the COP of wheat which is likely to have a significant adverse impact on profitability over time.
3) Cost of labour and management had a significant impact on COP which was accentuated in poor production years. Anything that could be done to reduce this impact in poor years would be of a strong advantage in this highly variable system.

It was noted by the workshop participants how relatively small changes in the business settings could accumulate into significant effects on COP and therefore long term financial viability.

To follow up earlier discussions on strategic settings for enterprise balance, an analysis was undertaken to assess the potential return from taking land which was marginal for cereal production and setting up a rotational grazing system including planting of perennial scrubs. This analysis showed a pay-back period of about 6 years.

To improve workshop participants understanding of machinery economics, a case study exercise was undertaken using a participant's actual situation in comparing the purchase of a harvester with using contractors to harvest his crop.

Assessment of the outcomes of this workshop program
At the completion of the final workshop, all participants were asked to complete a simple feed-back questionnaire to assess learning within the program.
Participants overwhelmingly found the workshops enjoyable, useful and thought provoking with new information which mostly motivated them to try something different. There was little uniformity about what the participants found most useful in the program. Most expressed confidence in their ability to evaluate their production system and key profit drivers and assess the economics behind machinery purchase decisions. When asked for suggestions regarding further training, there emerged a general theme about the economics of farm expansion using either land purchase or leasing or sharefarming.

Activities Planned in 2013

This project is combining with another project (Grain & Graze 2- Adaptive Management) to work with another group which includes farmers from the Booleroo/Appila and Port Pirie regions. The group has identified a number of areas which they regard as important in improving their understanding of profitability and risk in their farming systems. Workshops will focus on these issues over the next year. We are also keen to do more work exploring the profitability and risk currently being experienced by operators in some of the more marginal (usually) northern regions of the Upper North. In these areas, the extended poor run of seasons has seen operators question the future viability of mixed cropping/ livestock systems. The intention is to work with a group of farmers in the Quorn region to investigate this area in more detail.
Delivery in the future will also use the Excel spreadsheet add-in program @Risk. This program is seen as being beneficial for the business analysis component of the delivery. This will allow improved quantification of local farm business risks in a format which has been shown to have good acceptance by farmers.

General comments on the program to date

- Farmers who have been involved in the program have expressed good levels of satisfaction with the learning outcomes.
- The collaboration with Peter Hayman from SARDI Climate Applications has been a useful addition in exploring the implications of climate risk on farm profitability and resilience
- The current format of half day morning workshop followed by lunch appears to be working well
- Use of a case study farm works well although has the limitation of never being identical to participants own farms. Ensuring participants are involved in the establishment of the case study farm parameters is a necessary part of the process.
- The group discussions held under the workshop program have been a feature of the program and have contributed to successful outcomes. It is considered, however, that learning outcomes would be improved if some delivery could occur on an individual basis to participants.

Evaluating break options to cereal cropping in the Upper North

Key Messages:

- Canola and peas only produced half the yield of wheat, but barley performed very well.
- Ryegrass is becoming a problem in wheat on wheat plots.
- Pastures performed well where seed reserves had been increased in 2011.
- All options had good soil moisture (40mm) at the start of the season.

In low rainfall regions of south-eastern Australia, farmers have increasingly adopted continuous cereal cropping strategies as non-cereal crops are perceived as riskier than cereals due to greater yield and price fluctuations. There is a need for non-cereal crop and pasture options to provide profitable rotational crops, disease breaks and weed control opportunities for cereal production.

GRDC has funded a programme to address this issue and one of the projects within this programme will develop an improved understanding and implementation of management practices for Brassica, pulse crops, pastures and other options to reduce the risk of crop failure and improve whole farm profitability in low rainfall south-east Australia. The experiment at Ian Keller's at Appila is part of that project and is being run as a partnership between UNFS and SARDI.

The paddock has been in cereal for several years and while still being productive, has some rye-grass and wild oats building in patches across the paddock.

About the UN trial

The trial is testing nearly twenty different break options for wheat. These breaks are mostly two year breaks (aiming to overcome a grassy weed problem) but some one year breaks have also been included. The benchmark which all these breaks are being evaluated against is continuous wheat.

Every break is being managed in a way to optimise its potential productivity and profitability in a low rainfall environment (ie inputs are generally conservative). While pastures have been included in the break options, we are using mowing as a proxy for grazing as the plots are too small to effectively use sheep.

The trial was started in 2011 so we have just completed the last of the two break crop phases and are preparing to put wheat on all treatments in this season.

What has happened so far?

Growing season rainfall in both 2011 and 2012 were well below the average of 272 mm for Appila (about 200 mm in both years) but production was underpinned by a very wet summer preceding 2011 and a wet March preceding 2012.

The continuous wheat treatments averaged 2.0 and 1.7 t/ha in 2011 and 2012 respectively, with rye-grass becoming an increasing problem and requiring some expensive in-crop herbicides to keep them at bay (increasing the cost of inputs for this treatment to a risky $270/ha).

Frost wiped out grain yields of all break crops in 2011 (peas, lentils and canola) so the only possible income from these options was as a hay cut. Peas cut as hay would have matched gross margin with wheat as a crop in that year but for all other break options, the cost of hay cutting and freight would have erased all or most of any profit. In general, the costs of growing a break crop were no higher than for wheat (even if wheat inputs had not been inflated by the need for increased grass control).

Break crops in 2012 performed much better despite some frost damage again but they still struggled to perform relative to wheat. Canola and peas only produced more than one half of the grain yield of wheat if they were grown on a fallow in 2011.

Barley was sown on wheat in 2012 and performed very impressively, yielding almost double wheat on wheat.

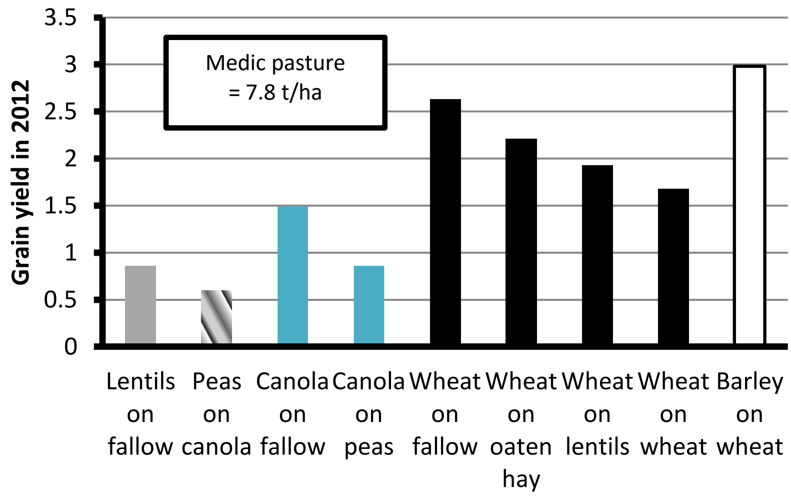
Pastures in 2011 performed very poorly because the medic seed bank was very low after a period of continuous cropping. However in 2012, those options which fostered a good seed set of medic in 2011 resulted in vigorous, medic dominant pastures which provided a lot of quality feed last year (up to 7 t/ha).
In terms of soil condition, all the productive legume options in 2011 increased soil mineral N levels preceding the 2012 crop by up to 50 kg N/ha but no more than a fallow.

For those treatments going into wheat in 2012, estimates of weed seed banks were taken over the summer of 2011-12. Rye-grass seed numbers were high following wheat (121 plants per sq m) and oaten hay (90 plants per sq m) but fallow and lentils in 2011 reduced them substantially (56 and 69 plants per sq m respectively). However, sow thistle and wire-weed seed numbers were high in all these options except for oaten hay and fallow which had lower numbers of sow thistle only.

All options which grew well in 2011 and were grown to maturity resulted in similar soil moisture levels at the end of 2011. The only options which had higher levels of stored water post harvest in 2011 were fallow and oaten hay. These two options increased stored water prior to the 2012 season by approximately 40 and 20 mm, respectively. All options accumulated about 40 mm of water over the summer of 2011-12 so the pre-seeding differences were largely due to water savings during the 2011 growing season.

Several one phase break options were chosen in 2011 so these were sown to wheat in 2012. Wheat yielded highest following a fallow, about 1 t/ha more than wheat on wheat. Wheat on oaten hay yielded 0.5 t/ha better and following lentils, 0.2 t/ha better. See figure 1 for a summary of all grain yields in 2012.

Figure 1: Grain yields for all crop options in 2012 at Appila.



What now?

The project team is now busy processing the performance data for all trials and large scale demonstrations in this project for the first two seasons. There are 5 trials in total in the project, all similar in scale to the one at Appila.

We are now approaching the last two seasons of the project which will monitor the impact of all break options on cereal production.

This type of information will be incorporated into a guide for selecting break options which will address developing problems in your intensively cropped paddocks for least risk and better outcomes.

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UNFS Time of Sowing Trial

Key Messages

- Slow maturing varieties sown early have potential to increase profitability, even in low rainfall areas.
- The late break to the season in 2012 in the UN, did not allow the long season variety to perform
- Dry sowing of wheat 5 weeks before the opening rains produced equal or higher yields to wheat sown on the break.

Why do the Trial?

The benefits of early sowing have been clearly demonstrated over the last few seasons with the early sown crops tending to yield the best and later sown crops performing poorly. Work conducted by James Hunt, CSIRO as part of the National Water Use Efficiency Initiative has shown that earlier sowing increases the frequency of planting opportunities, and allows more crop to be sown and flower on time. Modelling has shown the potential to increase average farm yield by 47% at Morchard (Table 1). Early sown crops yield more because less water is lost to evaporation, roots grow deeper, water is converted to dry-matter more efficiently and a longer stem elongation phase increases grain number. However, vegetative growth can be excessive, and early sown crops require specific genotypes and management to maximize reproductive growth, harvest index and grain yield. The use of long season slow maturing varieties may overcome this problem. The CSIRO believe the practice of sowing slow maturing varieties very early, could be applicable to approximately 30% of individual farm area, which is sufficiently free of grass weeds to allow early sowing.

Table 1. *Including a slow maturing wheat variety in a farm program that allows early sowing, increases average farm yield and reduces risk. Results are from APSIM simulation 1962-2011 with a frost & heat multiplier for yield and assume a farm wheat program takes 20 days to plant. (J Hunt, CSIRO)*

Strategy	**1. Mid-fast varieties only – sowing window opens 5 May**		**2. Very slow + mid-fast variety – sowing window opens 10 April**				
Location	**Average farm wheat yield (t/ha)**	**Paddock yields <1.0 t/ha (%)**	**Average farm wheat yield (t/ha)**	**Paddock yields <1.0 t/ha (%)**	**Average farm wheat yield increase (%)**	**Years in which very slow variety planted (%)**	**Average area of very slow variety planted (%)**
Condobolin	1.5	48%	2.2	34%	**42%**	71%	59%
Morchard	1.6	44%	2.3	32%	**47%**	29%	19%

How was it done?

In 2012 the UNFS attempted to validate this early work conducted by the CSIRO. Seed of a long season variety Eaglehawk was sourced. This variety is Prime Hard Quality in NSW and so would be AH in SA.

The aim was to conduct a time of sowing trial using three varieties at three times of sowing:- an early maturing variety (Axe), mid season maturing (Frame) and late maturing (Eaglehawk). Ideally the three sowing times were to be 1) mid April 2) early to mid May and 3) early to mid June.

Location: Ian Ellery, Coomoroo Vale — Average annual rainfall 312 mm
2012 Annual Rainfall 226 mm — Growing Season Rainfall 115.5 mm
Site sprayed with 30gm Logran and 1.2lt/ha glyphosate on12th April
Sown with a Shearer disc seeder using 18 cm row spacing.
Fertiliser DAP at 50 kg/ha

Variety	1,000 grain weight	Target Plant Density per m^2	Seeding Rate kg/ha
Eaglehawk	36	140	60
	36	100	40
Axe	36	140	60
Frame	40.5	140	66

Time of sowing

	Date	Comments
Time 1	20th April	Dry sown with forecast rain over the following few days, however only 2mm was received and plots failed to germinate
Time 2	5th June	Sown 10 days after 9 mm of rain, which germinated the first time of sowing
Time 3	25th July	Sown after further rain of 34mm in mid July.

What happened?

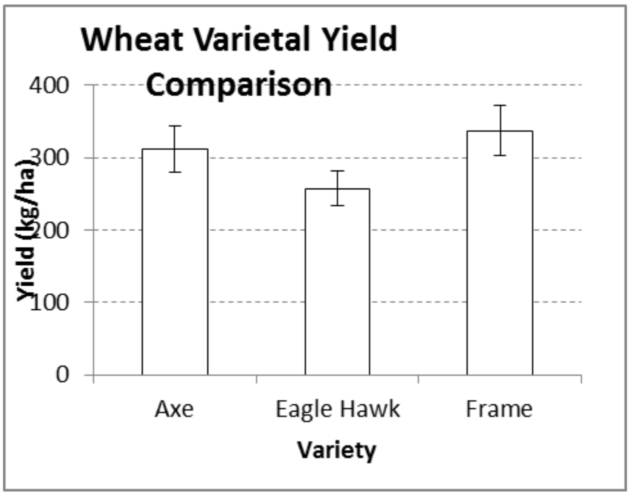

Figure 1: Yield of wheat varieties averaged over the three times of sowing

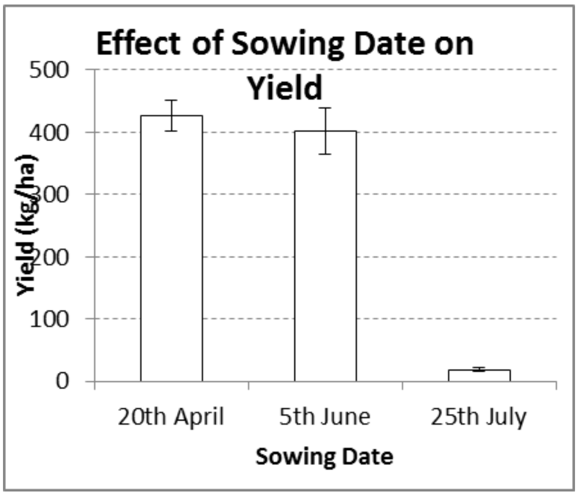

Figure 2: Wheat yield at three times of sowing averaged over the three varieties

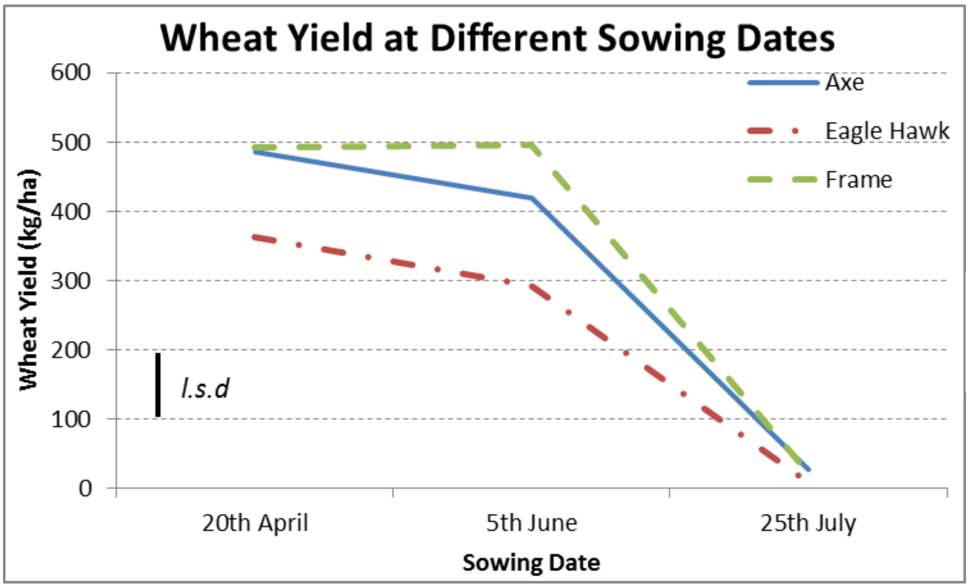

Figure 3: Wheat yield of three varieties at different sowing times

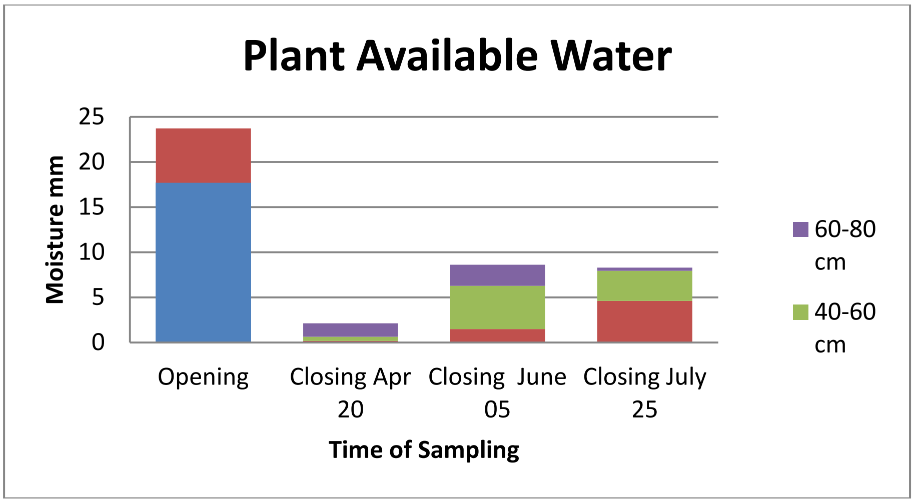

Figure 4: Impact of time of sowing on water use: “Opening” soil sampled April 20th; “Closing” soil sampled January, 2013

What does this mean?

The opportunity to see the benefits of early sowing (mid April) was not achieved, due to the later than ideal opening to the season. Cold conditions during July slowed growth, particularly of the late sown treatments as the dry spring did not allow them to recover and yield potential was poor.

The trial did however demonstrate the benefits of dry sowing. The first time of sowing (20th April) was sown dry following the application of Logran® and glyphosate to control summer weeds and despite forecast rain, insufficient was received to enable germination. The seed remained in the ground until reasonable falls were received between the 24th and 27th May, which germinated the grain. The second time of sowing was delayed so that there would be a reasonable time difference between the emergence of the first and second time of sowing. Despite there only being slightly over a week difference in the time of emergence the dry sown plots grew quicker and had a significant advantage over the second time of sowing. With the dry conditions in spring this advantage disappeared and the final yield advantage was relatively small and not significant (Figure 4). There was some varietal difference with the dry sown Axe and Eaglehawk yielding slightly higher, however this was not significantly different from the second time of sowing.

With the dry conditions in September and October, many of the plants in the late sown plots died and most of these plots were not worth harvesting.

The time of seeding trial was sown after good falls of rain in January and March had increased soil moisture levels in the top 40 cm. Soil testing completed after harvest showed that the earlier establishing dry sown crop had about 7mm less residual water in the soil profile. This is likely due to greater root development allowing increased exploitation of the soil water reserves. Dry sowing of suitable paddocks can ensure the majority of your crop is sown as close as possible to the optimum time. Dry sowing can only be contemplated where the weed burden is low or can be effectively controlled with selective herbicides. However, providing weeds can be controlled, there is very little risk of yield loss from dry sowing, even if opening rains are not received for four weeks or more after sowing.

Eaglehawk may still have a place in our farming systems when sown early. However, dry sowing of these later maturing varieties is a risk, particularly in seasons such as 2012, when opening rains are too late to achieve high yield potential.

Management of herbicide resistant Barley grass in pulse crops

Ben Fleet[1], Lovreet Shergill[1], Gurjeet Gill[1], & Barry Mudge[2]

[1]School of Agriculture, Food & Wine, University of Adelaide

[2]Upper North Farming Systems

Key messages

- Increasing incidence of barley grass in cropping paddocks in southern Australia is likely to be associated with selection of more dormant biotypes by weed management practices used by growers.
- In some districts, barley grass management is now being complicated by the evolution of group A resistance. However, there appear to be several effective potential herbicide alternatives for barley grass control in broadleaf crops.
- Integrated weed management strategies are critical to delay onset of herbicide resistant barley grass.

Why do the trials?

Feedback from growers and consultants in southern Australia has clearly shown increasing spread of barley grass. In a recent survey by Fleet and Gill (2008), farmers in low rainfall districts in South Australia and Victoria reported increasing incidence of barley grass in their crops. Research undertaken at the University of Adelaide has shown that barley grass has developed increased seed dormancy in response to management practices used in cropping systems. Presence of increased seed dormancy in this grass weed species has enabled it to escape pre-sowing control tactics used by the growers. This explains why barley grass is a problematic weed in cereal crops. However, in some locations like Port Germein and Baroota districts, it has now become largely impossible to control in pulse crops. This is likely due to the presence of group A (fop & dim) herbicide resistance. Currently in these locations barley grass control is reliant on growing Clearfield wheat and the use of imidazolinone (group B) herbicides. This management strategy is at high risk of collapsing from the additional development of group B herbicide resistance. Previous studies have shown that resistance to group B herbicides can develop relatively quickly. Presence of large densities and repeated exposure to group B herbicides could rapidly lead to group B resistance in such barley grass populations. The extent of this resistance needs to be understood and effective management strategies to manage resistant barley grass in pulse crops developed.

How was it done?

In 2012 a field trial was conducted at Baroota to evaluate possible herbicide options for controlling herbicide resistant barley grass in pulse crops (Kaspa peas). At the trial site, there was a very high background population of barley grass that was strongly suspected to be resistant to group A herbicides. Herbicide treatments were developed for experimental purposes only and many are not currently registered (Table 1.). Assessments included control of barley grass, crop safety and yield. Herbicide resistance at the site was confirmed in a pot study at the University of Adelaide.

Two random surveys were conducted to evaluate the extent of herbicide resistant barley grass. The first focused on cropping paddocks between Port Pirie and Port Augusta, where most reports of resistance have been. The second survey focussed on problem barley grass regions on Eyre Peninsula and included transects from Kimba to Wirrulla, Kimba to Buckleboo, Cowell to Smoky Bay via Elliston, and Darke Peak to Kopi via Port Neill and Tooligie. Samples from these surveys will be screened at the University of Adelaide for herbicide resistance during 2013.

What happened?

Barley grass collected from the trial site at Baroota, was screened for resistance. It is clear that the repeated exposure of the Baroota population to group A herbicides has resulted in high level of resistance (Figure 1). This population has confirmed resistance to quizalofop (Targa), haloxyfop (Verdict) and clethodim (Select).

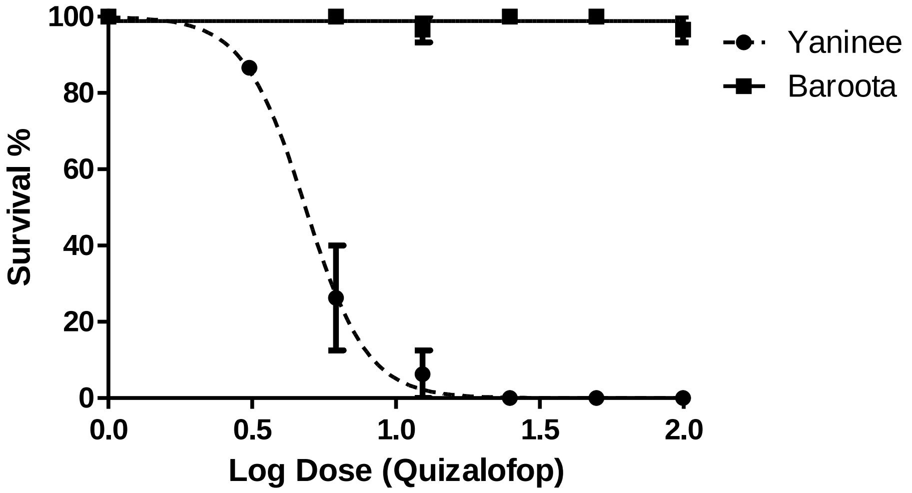

Figure 1. Effect of quizalofop (e.g. Targa) on the survival of barley grass field population from Baroota (Pt Germein) and the susceptible population from Yaninee. Herbicide rates are 0, $^{1}/_{8}$, ¼, ½, 1, 2, & 4 x field rate (300 mL/ha of herbicide)

The herbicide treatments trialled achieved various levels of barley grass control in field peas. Sakura, Raptor (imazamox) and Propyzamide provided excellent control of barley grass, which was reflected in significant increases in grain yield of field peas (Table 1). Outlook (dimethanamid) appeared to be relatively ineffective early in the season but its performance improved with time, so it may also have a useful role in field peas.

Table 1. Effect of different herbicide treatments on grain yield of field peas and reduction in group A resistant barley grass seed production at Baroota (SA) in 2012. Control treatment (knockdown alone) allowed seed set of potentially >65,000 seeds/m^2.

Treatments	Seed set reduction (%)	Pea yield (t/ha)
Sakura @ 118 g/ha IBS	99	2.29
Boxer Gold @ 2.5 L/ha IBS	74	1.41
Outlook @ 1 L/ha IBS	93	2.14
Raptor @ 45 g/ha + BS1000 0.2% PE	100	2.08
Trifluralin @ 2.0 L/ha + Avadex Xtra @ 2L/ha	71	1.32
Metribuzin @ 200 g/ha PSPE	46	0.82
Propyzamide 500 @ 1.5 L/ha	100	2.29
Diuron 900@ 1 kg/ha + Trifluralin @ 2.0 L/ha IBS	78	1.58
Trifluralin 2.0 L/ha IBS	68	1.19
Control	-	0.82
LSD (P=0.05)		0.33

What does this mean?

Barley grass, like annual ryegrass, has the capacity to become highly resistant to group A herbicides (Figure 1). Even though resistance takes longer to develop in barley grass, its proactive resistance management is still vital. An integrated weed management strategy, combining multiple control tactics to reduce seed set, is required to delay the development of herbicide resistance. For example in a non-group A resistant population, pre-emergent herbicide + post-emergent group A herbicide + crop-topping could be used to reduce the risk of selection for resistance.

Sakura (pyroxasulfone), propyzamide, and Outlook (dimethanamid) showed much promise for controlling group A resistant barley grass, pending their possible registration. Raptor (imazamox) also provided highly effective control of this barley grass population. As some farmers are already using Clearfield wheat to manage barley grass, it would be inadvisable to use Raptor which is also an imidazolinone herbicide. Such heavy reliance on group B herbicides could render them ineffective in relatively short time and this would be particularly bad news under situations where group A resistance has already developed.

Acknowledgements
Research on barley grass reported here was undertaken in a current GRDC funded project (UA00105). The authors would also like to thank Rob Dennis, for providing the field trial site and sowing the peas; Rupinder Saini, Amrit Riar and Malinee Thongmee for their technical assistance.

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THE UNIVERSITY of ADELAIDE

Category
2. “Searching for answers”- we know what the problem is and we’re trying to find out what we can do about it.

Trial Information

Location:	
Town or district:	Baroota
Farmer Name:	Rob Dennis
Group:	Neashaby Ag Bureau, Upper North Farming Systems
Rainfall:	
Av. Annual:	330mm
Av. GSR:	230mm
2012 Total:	390mm
2012 GSR:	230mm
Yield:	
Potential:	1.5 t/ha
Actual:	0.8 to 2.3 t/ha
Paddock History:	
2011:	Mace wheat
2010:	Morava vetch
2009:	Feed barley
Soil Type:	Mallee Loam
Plot size:	13.5m x 5m
Replicates:	4
Sowing details:	Sown 10th May 2012, Kaspa field peas @ 90 kg/ha with DAP @ 60 kg/ha, knifepoint press-wheel on 10” spacing
Yield Limiting Factors:	Barley grass very dense (why site selected) except plots with good control, and dry finish to season

Powdery mildew resistant medics for the EP and Mallee

Jake Howie, Ross Ballard and David Peck
SARDI, Waite Campus

Key messages

- We have identified a small group of material with excellent agronomic performance which exceed our benchmark strand medic cultivars, Herald and Angel, by up to 30% for dry matter production and seed yield.
- The lines are bred from a cross between Angel strand medic and a line originally selected for powdery mildew resistance. They also have SU herbicide tolerance, aphid resistance and a larger seed size.
- If the level of agronomic improvement of non-segregating lines can be confirmed at regenerating sites, there are excellent prospects for a future cultivar release.
- Unexpected responses to Rhizobium inoculation confirm some grower observations of poor medic nodulation in the Mallee, but the reasons for this remain unclear.

Why do the trial?

The broad aim of this SAGIT funded project is to assess the potential of a group of early generation “multi-trait” breeders’ lines for future commercial development.
More specifically the project is:

- Evaluating the agronomic performance of 27 early generation strand medic lines possessing various combinations of important new traits;
- Making in-situ field selections from segregating medic lines under evaluation at the field sites;

How was it done?

As part of this project, field selections and glasshouse screening for traits that are still segregating, have been regularly undertaken. Based on the excellent performance at multiple sites in 2010 and 2011 (EPFS 2010, pg 61-62; EPFS 2011, 68-70), a set of 17 non-segregating (stable) strand medic hybrids with various combinations of powdery mildew (PM) resistance, SU herbicide tolerance, aphid resistance and large seeds, was shortlisted for sowing in 2012. This included daughter lines for field testing to ensure they perform as well agronomically as the segregating PM parent lines from which they were selected. Also included were five benchmark cultivars and parents and, in response to farmer feedback at field days and measures of poor nodulation in 2010 & 2011 field trials, we also included some additional rhizobial treatments.
In addition to regenerating sites at Karoonda and Minnipa two experiments were established in the Murray Mallee at Lameroo and Netherton, enabling further evaluation of dry matter production, disease tolerance and seed yield.

What happened?

2012 sown trials – agronomic evaluation (Lameroo and Netherton)
Once again we were very encouraged with the agronomic performance of the PM lines with respect to dry matter (DM) production, seed yields are currently being processed and analysed. At Lameroo the top five PM lines (range: 84–95 of % maximum site yield (MSY); average 89% MSY) significantly out-yielded the benchmark strand medic cultivars, Herald, Angel and Jaguar (range: 55–71% MSY; avg. 66%). At Netherton the top five PM lines (88–95% MSY; avg. 91%) similarly out-yielded the strand medic cultivars (70-81% MSY; avg. 76%).

A feature of the new lines was increased early season vigour, possibly a benefit of the larger seed size inherited from the original PM resistant parent. Seed yields, which provide a critical measure of potential pasture persistence and future productivity, have been harvested and are currently being processed. The harsh spring finish should provide a good test of their ability to produce seed and persist under adverse conditions. In previous years they have been excellent; for example at Netherton in 2011 the PM resistant lines averaged 1100 kg/ha, 30% greater than Herald and Angel (Fig.1).

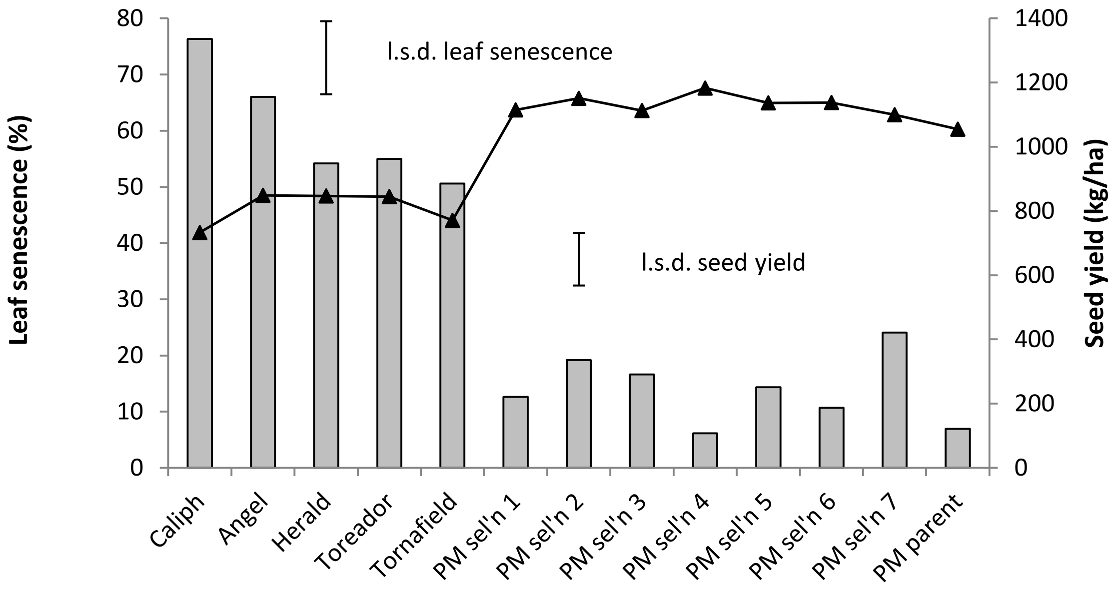

Figure 1. Leaf senescence (%) associated with the development of powdery mildew symptoms (bar), and kg/ha seed yield (line) of annual medic cultivars and PM-strand medic selections at Netherton, SA, 2011.

2012 regeneration of 2011 Karoonda site (powdery mildew resistance – field observations)

Despite the poor establishment at this site last year due to areas of non-wetting soil, there was enough seed-set to enable an adequate regeneration after early season rains in March. Although experimentally quite variable, this site as a whole responded very well to winter rains with the best plots producing an estimated 4 t/ha DM. At the time of the Karoonda MSF Field Day (GRDC Ground Cover #102, p. 14) the PM lines were still fresh and showing no signs of powdery mildew infection whereas Herald and Angel, although also growing well, were developing a heavy PM infection in the understory.

This is the second year we have been able to observe the impact of powdery mildew on the PM lines in the field (Netherton, 2011, Fig 1.) and we are very encouraged in that so far they support our results from greenhouse studies and field observations at the Waite Campus. However it is important to note that more fundamental research regarding the identification, pathogenicity and prevalence of different races of powdery mildew (if more than one) in SA is needed so that appropriate breeding strategies can be developed to ensure that the excellent levels of resistance in the current set of PM lines will be maintained.

2012 regeneration of 2010 Minnipa Agricultural Centre site

After growing very well in 2010, this site was sown to canola in 2011 and regenerated successfully in 2012 enabling two dry matter assessments to be made in August and September. As this was our first site regenerating after crop, it was pleasing to note the good performance (relative to the strand medic cultivars) of the parental PM lines which had subsequently been progressed (via their selected non-segregating progeny) into later trials.

Hardseed breakdown studies
Pods of short-listed PM lines and both parents (Angel and PM parent) were harvested from the Netherton 2011 site and taken back to the Waite Campus for hardseed breakdown studies conducted over 12 weeks from February to May 2012. At the end of the study Angel's hardseed content had declined from 99 to 88% and PM parent from 97 to 91%. The PM hybrid lines declined in hardseededness from 96-100% to 87-91% (i.e. very similar to both parents). This coupled with the Minnipa 2012 regeneration data, provides us with confidence that this material possesses an appropriate level of hardseededness for persistence in a ley farming system.

Nodulation responses in the field
Assessments of nodulation were made at Netherton, Lameroo and Karoonda where several additional rhizobia inoculation treatments were incorporated into the trial and demonstration plot designs in response to previous measures of inoculation response.

Large responses to inoculation in terms of nodule number were measured at Lameroo and Karoonda and improvements in legume vigour observed at the sites. The work again confirms that frequent grower reports of poor nodulation in the Mallee should be taken seriously and some work will continue to elucidate why this is occurring. Contrary to general practice, the findings show that medic should be inoculated to ensure good establishment and early vigour when sown on Mallee soils, even where there has been a recent history of medic in the paddock. Particular attention will be paid to ensuring PM medic lines are well inoculated in future trials to ensure their potential benefits are not limited by symbiotic constraints.

What does this mean?
The third year of field evaluation has so far confirmed our initial findings.
- We have identified a small group of material which exceed our benchmark strand medic cultivars, Herald and Angel, by up to 30% for dry matter and seed yield.
- The hybrid lines have powdery mildew resistance, SU herbicide tolerance, aphid resistance and larger seeds (cf Herald and Angel).
- Further selections have been made and there are excellent prospects for a future commercial release.
- Unexpected responses to inoculation confirm some grower observations of poor medic nodulation in the Mallee, but the reasons for this remain unclear.

Pending final harvest results from 2012 we will analyse all available data and further shortlist the PM daughter lines for final cultivar selection work in 2013-15, pending availability of future funding. These will be further seed increased at the Waite in 2013 to enable future cultivar developmental work.

Reference
RA Ballard, DM Peck, DL Lloyd, JH Howie, SJ Hughes, RE Hutton and BA Morgan (2012). *Susceptibility of annual medics (Medicago spp.) to powdery mildew (Erysiphe trifolii).* Proceedings of 16th Agronomy Conference 2012. University of New England, Armidale, NSW 14-18th October 2012. http://www.regional.org.au/au/asa/2012/pests

Acknowledgements
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Location: Minnipa Ag Centre **Rainfall** Av. Annual: 325 mm Av. GSR: 242 mm 2012 Total: 253 mm 2012 GSR: 185 mm **Yield** Potential: 5.5 t/ha Actual: Est. 3-4.5 t/ha **Paddock History** 2011: Canola 2010: sown medic **Soil Type** Red sandy loam **Plot size** 5 m x 1.5 m x 3 reps.	**Location:** Karoonda (Lowaldie) Peter & Hannah Loller **Rainfall** Av. Annual: 312 mm Av. GSR: 215 mm 2012 Total: 317 mm 2012 GSR: 231mm **Paddock History** 2011: Sown medic 2010: Cereal 2009: Sloop barley **Soil Type** Non-wetting sand, pH 8.1 **Soil test** Colwell P, 28 ppm; potassium, 110 ppm; sulphur, 2.4 ppm **Plot size** 4 m x 1.2 m x 3 reps **Yield Limiting Factors** Poor establishment in 2011 due to non-wetting soil, dry finish, frost, low soil K, S
Location: Netherton Lester & Kay Cattle **Rainfall** Av. Annual: 396 mm Av. GSR: 290 mm 2012 Total: 372 mm 2012 GSR: 232 mm **Yield** Actual: 3 t/ha (rising plate meter est. 16/10/10) **Paddock History** 2011: Oaten hay 2010: Schooner barley 2009: Oaten hay **Soil Type** Loamy sand, pH 6.7 **Soil test** Olsen P, 14 ppm; NO_3-N, 12.3 ppm; sulphur, 4 ppm; organic matter, 1.4%; copper, 0.3 ppm; zinc, 0.3 ppm; manganese, 1.3 ppm **Plot size** 4 m x 1.2 m x 3 reps **Yield Limiting Factors** Lodging, dry finish, frost, low phosphorus, sulphur, trace elements (Cu, Zn)	**Location:** Lameroo Trevor & Cath Pocock **Rainfall** Av. Annual: 330 mm Av. GSR: 235 mm 2012 Total: 275 mm 2012 GSR: 197 mm **Paddock History** 2011: Pasture 2010: Pasture 2009: Cereal rye **Soil Type** Loamy sand, pH 6.3 **Soil test** Colwell P, 20 ppm; potassium, 125 ppm; sulphur, 2.9 ppm; organic carbon, 0.89% **Plot size** 4 m x 1.2 m x 3 reps Yield Limiting Factors Difficult establishment due to clay spreading and rough terrain, dry finish, frost, low soil P, K, S

Avoiding crop damage from residual herbicides

Key Messages

- Increased risk of crop damage this season from herbicide residues, due to the dry spring and summer
- Plant back periods need to be checked and followed

Herbicide carry-over

This year, it will be even more important than normal, to take note of plant back periods of herbicides used over the previous few years. Herbicide residues may influence what crops are sown in particular paddocks.

There is not likely to be any margin for safety in plant back periods this year. This is due to the dry conditions experienced in most areas last year which reduced the breakdown of herbicides and so increased the length of time residues are likely to affect sensitive crops. Residues may carry over from herbicides applied one or two seasons earlier.

With minimal summer rain to help reduce residues, we will be relying on good autumn rains to enable the soils to remain moist for long enough for chemical and/ or microbial activity in the soil to be effective.

The re-cropping interval needed before a certain crop can be sown depends on the chemical and rate used, the rate of breakdown, and the sensitivity of the crop. Breakdown usually only occurs in moist soil.

Make sure your cropping and weed control plans consider:

- the plant back period for that herbicide and crop
- the sensitivity of the crop
- soil properties in the paddock
- rainfall received since application of the herbicide
- the reduction in herbicide breakdown due to below average rainfall after application
- the additive effect of the application of a herbicide this year, to residues of a herbicide from a previous application

Check and read the herbicide label thoroughly for residual activity and cropping restrictions following herbicide application.

What are the issues?

Some herbicides can remain active in the soil for weeks, months or years. This can be an advantage as it ensures good long term weed control. However, if the herbicide stays in the soil longer than intended it may damage sensitive crop or pasture species sown in subsequent years.

For example, chlorsulfuron is used in wheat and barley, but can remain active in the soil for several years and damage legumes and oilseeds.

A real problem for growers is the difficulty in identifying herbicide residues before they cause a problem. Currently, we are limited to predicting carryover based on information provided on the product labels about soil type and climate. Herbicide residues are often too small to be detected by chemical analysis, or if the testing is possible it is too expensive to be part of routine farming practice. Once the crop has emerged, diagnosis is difficult because the symptoms of residual herbicide damage can often be confused with and/or make the crop vulnerable to other stresses, such as nutrient deficiency or disease.

Which herbicides are residual?

The herbicides listed in the table all have some residual activity or planting restrictions. Product labels DO NOT use consistent terminology or put warnings in the same place so you need to read the entire label carefully. Selected residue issues for each of the herbicide groups are discussed in more detail further on.

Herbicide group	Active constituent
Group B: Sulfonylureas	azimsulfuron, bensulfuron, chlorsulfuron, halosulfuron, iodosulfuron, mesosulfuron, metsulfuron, sulfosulfuron, triasulfuron, tribenuron
Group B: Imidazolinones	imazamox, imazapic, imazapyr, imazethapyr
Group B: Triazolopyrimidines (sulfonamides)	flumetsulam, florasulam, metosulam, pyroxsulam
Group C: Triazines	atrazine, simazine
Group C: Triazinones	metribuzin
Group C: Ureas	diuron
Group D: Dinitroanilines	pendimethalin, trifluralin
Group H: Pyrazoles	pyrasulfotole
Group H: Isoxazoles	isoxaflutole
Group I: Phenoxycarboxylic acids	2,4-D
Group I: Benzoic acids	dicamba
Group I: Pyridine carboxylic acids	aminopyralid, clopyralid
Group K: Chloroacetamides	dimethenamid, metolachlor

N.B. New herbicides may be released after publication of this fact sheet.

How do herbicides break down?

Herbicides break down by chemical or microbial degradation or a combination of both. Chemical degradation occurs naturally, but the speed depends on the soil type (clay or sand, acid or alkaline), moisture and temperature. Microbial degradation depends on a population of suitable microbes living in the soil to consume the herbicide as a food source. Both processes are improved by heat and moisture. However, these processes are slowed by herbicide binding to the soil, and this depends on the soil structure (pH, clay or sand, and other compounds like organic matter or iron).

For these reasons degradation of each herbicide needs to be considered separately and growers need to understand the soil type and climate when trying to interpret re-cropping periods on the product label for each paddock.

When conditions are cold or dry, breakdown may be delayed. Warm moist soil conditions over autumn can favour breakdown. Careful assessment of the soil type, soil lime content, pH, rainfall distribution and other factors affecting the carryover of each particular herbicide is needed.

Additive effects

Accepted re-cropping intervals may not be sufficient after successive applications of certain herbicides. There is the danger of an additive effect where herbicides used are of similar activity to those used in the previous year.

If there are any signs in the crop of the effect of residues from a herbicide used last year, avoid using a herbicide of the same group and choose an alternative chemical.

How can I avoid damage from residual herbicides?

Keeping good records chemical application records, including weather conditions, can be invaluable in the case of unexpected damage, particularly spray dates, rates, rainfall and soil type.

If residues could be present, choose the least susceptible crops (refer to product labels). Optimise growing conditions to reduce the risk of compounding the problem with other stresses such as herbicide spray damage, disease and nutrient deficiency. These stresses make a crop more susceptible to herbicide residues.

Be wary of compounding a residue problem by planting a herbicide resistant crop and spraying with more of the same herbicide group. You may get around the problem with residues in the short term, only to be faced with herbicide resistant weeds in the longer term.
Rainfall received during autumn can greatly assist the breakdown of herbicide, but the amount of breakdown will depend on the length of time the soil is moist, particularly if microbial activity is required. Short periods of moisture of only a few days may give little or no chance for this to occur.

Delaying the sowing of a sensitive crop will be an option in some situations to allow herbicide residues time to break down. Legume pastures germinating on the opening rains do not have this option, so will be affected by herbicide residues that affect legumes. The effect will be more severe if there is little rain prior to the break in the season. Paddocks where legume pasture this year is liable to be affected by herbicide residues might be better sown to a crop that is unaffected by those residues.

Group B: The sulfonylureas (SU's).

The sulfonylureas persist longer in alkaline soils (pH > 7) where they rely on microbial degradation. Residual life within the sulfonylurea family varies widely with chlorsulfuron persisting for 2 or more years and not suitable for highly alkaline soils. Triasulfuron persists for 1-2 years, while metsulfuron methyl generally persists for less than 1 year. Metsulfuron is broken down by both chemical and microbial activity in the soil and there may be some problems in paddocks with higher pH and lime levels where the herbicide was applied later last year (August/September) and there has been minimal rainfall since. If we get early autumn rainfall when the soil is still warm this herbicide will breakdown quickly and the delayed sowing of sensitive crops will help reduce the risk of damage.

In situations where the carryover of metsulfuron methyl might be high, do not use Broadstrike® or Spinnaker® in a legume crop. Legumes and oilseeds are most vulnerable to SU's, particularly lentil and medic. However, barley can also be sensitive to some SU's - check the label.

Group B: The triazolopyrimidines (sulfonamides)

There is still some debate about the ideal conditions for degradation of these herbicides. However, research in the alkaline soils in the Mallee and Eyre Peninsula has shown that the sulfonamides are less likely to persist than the SU's in alkaline soils. Plant back periods should be increased in shallow soils.

Group B: The imidazolinones.

The imidazolinones are very different from the SU's as the main driver of persistence is soil type, not soil pH, and are broken down in the soil by microbes in wet aerobic conditions. Under conditions that DO NOT favour breakdown, such as low organic carbon soils, non-wetting sands, and prolonged dry periods, soil residues will persist longer and may affect susceptible following crops. If rainfall from application to the end of spring is less than 200mm and if single isolated heavy summer and autumn falls and break rains are required to achieve rainfall target of 250mm, it may not be safe to sow non-Clearfield cereals within 10 months of applications.

They tend to be more of a problem on acid soils, but carryover does occur on alkaline soils. Research has shown that in sandy alkaline soils, such as on the Eyre Peninsula, they can break down within 15 months, but in the heavy clay soils they can persist for several years.

Group C: The triazines.

Recent usage of the triazines has increased to counter Group A resistance in ryegrass and because of high rates used on Triazine Tolerant canola. Atrazine persists longer in soil than simazine. Both persist longer on high pH soils, and cereals are particularly susceptible to damage.

Group D: Trifluralin.
Trifluralin tends not to leach through the soil, but can be moved into the seed bed during cultivation or ridging. Trifluralin binds strongly to stubble and organic matter and is more likely to be a problem in paddocks with stubble retention. Be particularly careful with wheat, oats and lentils. Barley is more tolerant. Use knife points to throw soil away from seed and sow deep.

Group H: The isoxazoles.
Persistence in acid soils (pH < 7) has not been fully tested, but research has shown that isoxazole persistence is expected to be longer than the label recommendations for legume crops and pastures. Isoxazoles will also persist longer in clay soils and those with low organic matter. Cultivation is recommended prior to re-cropping.

Group I: The phenoxys.
Clopyralid and aminopyralid can be more risky on heavy soils and in conservation cropping as it can accumulate on stubble. Even low rates can cause crop damage up to two years after application. They cause twisting and cupping, particularly for crops suffering from moisture stress.

2,4-D used for fallow weed control in late summer may cause a problem with autumn sown crops. There have been changes to the 2,4-D label recently and not all products can be used for fallow weed control – check the label.

The label recommends you don’t sow sensitive crops, especially canola, until after a significant rainfall event. Oilseeds and legumes are very susceptible to injury from 2,4-D.

Group K: Metolachlor.
Metolachlor can be safely used for weed control in canola crops if sowing and herbicide application are carefully managed. However, the precautions on the label limit sowing of canola within 6 months of application. This essentially prevents re-sowing of canola if there is poor germination.

Yield Prophet in the Upper North in 2012

Key Messages

- Final yield results were heavily influenced by both opening Plant Available Water (PAW) and growing season rainfall
- Very low growing season rainfall on the northern sites was masked, in part, by good levels of opening PAW. Without this stored soil water, results would have been very poor.
- Sites with low levels of estimated opening PAW generally showed disappointing yields
- Sites where good levels of opening PAW combined with reasonable growing season rainfall all ended with good yields
- Final yields as predicted by the Yield Prophet model were generally close to the yields which were actually obtained.

What happened in 2012?

The Upper North Farming Systems ran Yield Prophet on 9 sites across the Upper North in 2012. Sponsorship from Sturt Grain is acknowledged in assisting with the costs of running these sites.

What is Yield Prophet?

Yield Prophet is the web-based interface which allows us to access outputs from the crop production model, APSIM. Inputs include detailed soil characterisation information along with measurements of soil water and deep nitrogen status at the start of the season. Specific crop information (sowing date, variety, fertiliser applications etc.) along with daily rainfall data are then entered for each site to provide us with updated estimates of yield expectations if historical rainfall patterns are repeated. So it is important to recognise that the results are very specifically location based- we can then extrapolate the results to other locations based on our knowledge of the particular characteristics of each location.

Yield Prophet can provide us with an estimate of yield expectations as we move through the season, which can be used to aid management decisions (e.g. value of fungicide applications) and possibly giving more confidence in forward marketing of grain. YP also provides an ongoing estimate of the Nitrogen status of the crop and can be used to assess the value or otherwise of applying additional N.

At the nine Upper North sites, deep soil sampling was completed in April and May and analysis undertaken to provide us with the details needed to run the model. Updates were then completed roughly every fortnight throughout the season (or as significant rainfall events occurred). To complete an update involved entering each locations actual rainfall details along with updating any additional nitrogen applications.

The cost to run Yield Prophet is an annual subscription of $155 (in 2012) plus the cost of the soil sampling. Once the subscription has been made, there is no limit on the number of times the information can be updated throughout the year. Normally, an individual using YP would access the reports from the Yield Prophet web site. The UNFS project distributed the information from each site as an e-mail with the reports as attachments.

Evaluating the Effectiveness of Yield Prophet

The normal report which we obtain from Yield Prophet is the “Crop Report”. This contains a multitude of information including:

- Crop and soil details of the selected site
- Grain and Hay Yield Probability Outcome charts
- Comparison of current growing season to date with historical deciles

- Estimate of crop stage and its potential vulnerability to frost and spring heat events
- Water and Nitrogen budgets including projected use and indications of stress
- Seasonal outlook information based on seasonal forecasts from main steam sources

It is also possible to receive numerous other reports addressing issues such as the profitability of applying more Nitrogen, profitability of cutting the crop for hay versus grain, potential effect of climate change on current crop growth, fallow monitoring etc.

The effectiveness of Yield Prophet can be assessed in two main areas:

- How accurately does it predict the yield for the location? During the crop growth period, potential yield in Yield Prophet is described in terms of a probability distribution using historical climatic records as a basis for seeing where yields might end up over the balance of the season. A useful reference point is to compare final yield with predicted yield at the end of the season once all seasonal rainfall data has been entered.
- What management decisions is it able to influence and does the information aid the decision making process?

Results of Yield Prophet in 2012

General growing conditions varied greatly across the Upper North in 2012. While all areas entered the growing season with at least some stored soil water, the actual amount as assessed by the Yield prophet model varied significantly between sites. The amount of growing season rainfall also varied substantially across the sites.

Table 1. Actual and Predicted Yields for all Yield Prophet sites including estimated Plant Available Water (PAW) at seeding and Growing Season Rainfall (GSR)

Paddock	Location	Date Assessed	Estimated PAW prior to seeding*	GSR (Apr-Oct)	Yield (tonnes/Ha)	
					Actual	Predicted
Barrie	Willowie	May 7th	48 mm	104mm	0.8	0.9
Berryman	Murraytown	May 7th	50 mm	212mm	3.5	3.1
Bottrall	Appila	May 10th	53 mm	166mm	2.2	1.7
Catford	Morchard	May 1st	28 mm	102mm	0.9	1.0
Dennis	Baroota	April 25th	37 mm	207mm	2.9	3.2
Heaslip	Appila	May 15th	1 mm	166mm	0.8	1.2
McCallum	Booleroo	May 7th	14 mm	149mm	0.8	1.1
Mudge	Mambray	April 25th	55 mm	207mm	2.7	3.0
Tiller	Port Pirie	May 10th	54 mm	233mm	2.8	3.2

**Note- Caution- While actual soil water content can be measured by oven drying soil samples, estimating PAW requires an estimate of Crop Lower Limit (i.e. the amount of soil water which will not be available to plants). This is achieved in the Yield Prophet model by making a judgement of soil type and characteristics. While every effort is made to make this as accurate as possible, we need to acknowledge the potential for errors in this assessment.*

Comments on individual paddocks in Yield Prophet in 2012

Barrie- Peter and Di Barrie's "Swimming Pool" paddock north of Willowie. Peas in 2011 and sown to Katana wheat in 2012. Site was showing good levels of soil water at sowing but sub-soil constraints are a problem. Very poor growing season rainfall.

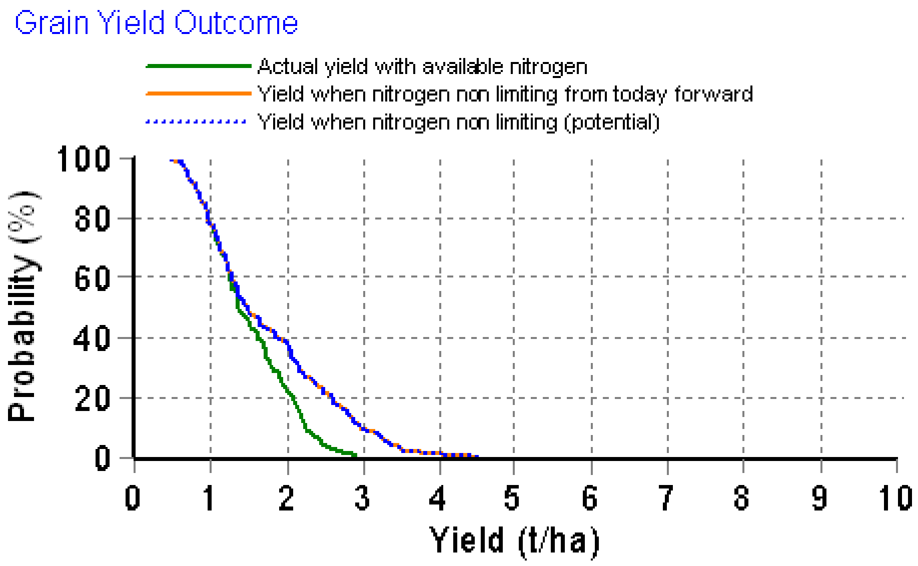

Figure 1. Yield Prophet predicted Grain Yield Outcome for **Barrie** as at 27 June, 2012

The model was indicating that Nitrogen supply was only likely to be a problem if above average rainfall was received for the rest of the growing season. There was no additional N applied pending further information on the season. This ended up being the correct decision.

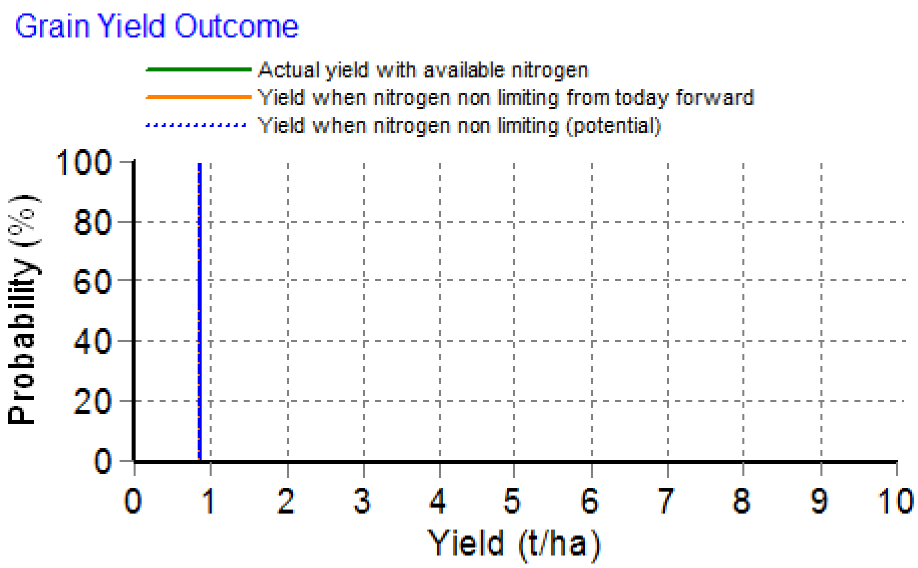

Figure 2. Yield Prophet predicted Grain Yield Outcome for **Barrie** at harvest.

With the continuation of poor growing season rainfall, grain yield at harvest ended up being in the lowest 20% of expected yields. Final yield was predicted by Yield prophet to be around 0.9 tonne/Ha. The paddock ended up averaging about 0.8 tonne/ Ha with grain protein about 14%. Given the results, the model has provided good decision support in this instance.

Berryman- Dustin's paddock near Murraytown. Canola in 2011, with Mace wheat in 2012.

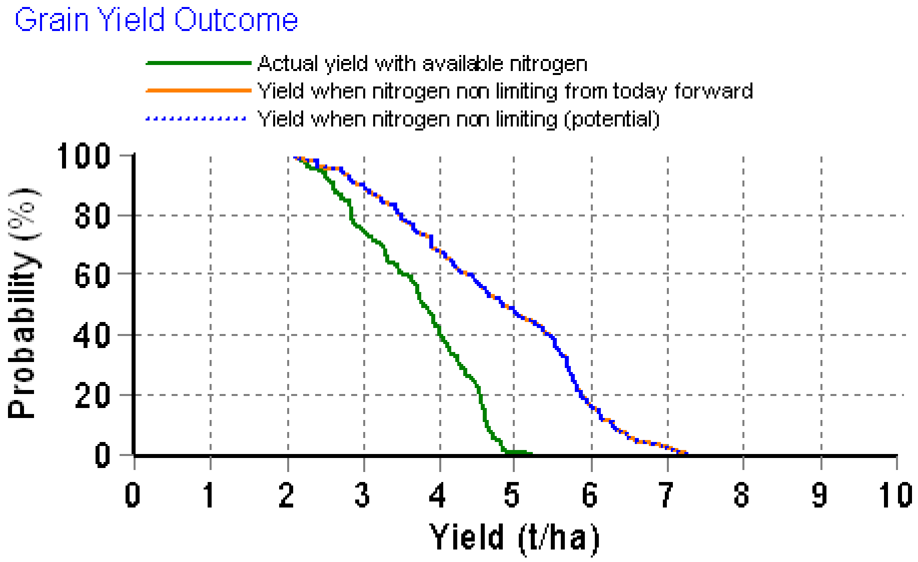

Figure 3. Yield Prophet predicted Grain Yield Outcome for **Berryman** as at 27 June, 2012

Model was suggesting a wide range of potential yield outcomes, but also showing that additional Nitrogen would be required to achieve good yields. Significant further N was applied (35 kg N)

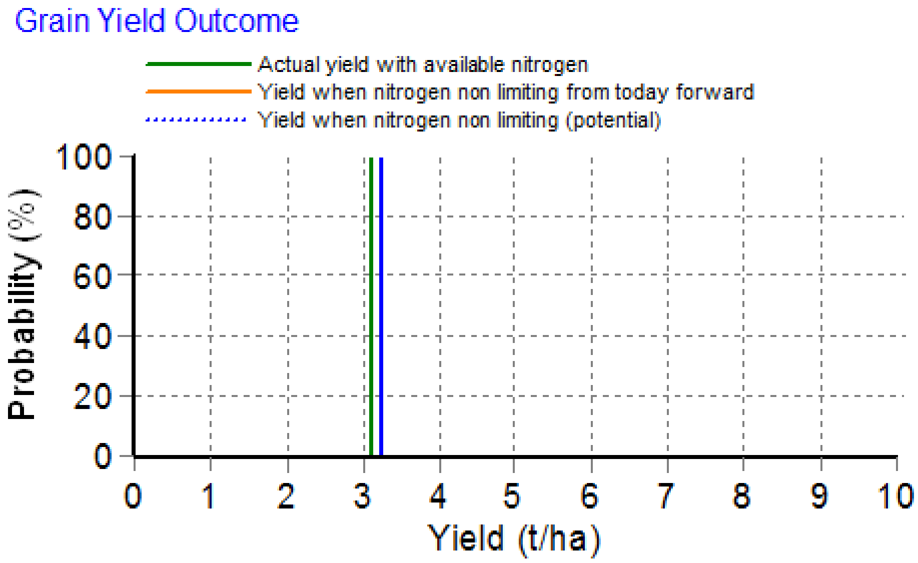

Figure 4. Yield Prophet predicted Grain Yield Outcome for **Berryman** at harvest.

The model is suggesting the crop still may have been a little short on Nitrogen. Final crop yield of 3.5 tonne/Ha was still a good result and slightly above the predicted yield.

Bottrall- Don and Heather's crop south east of their house. Site had a brief inundation over summer and was showing good levels of opening PAW.

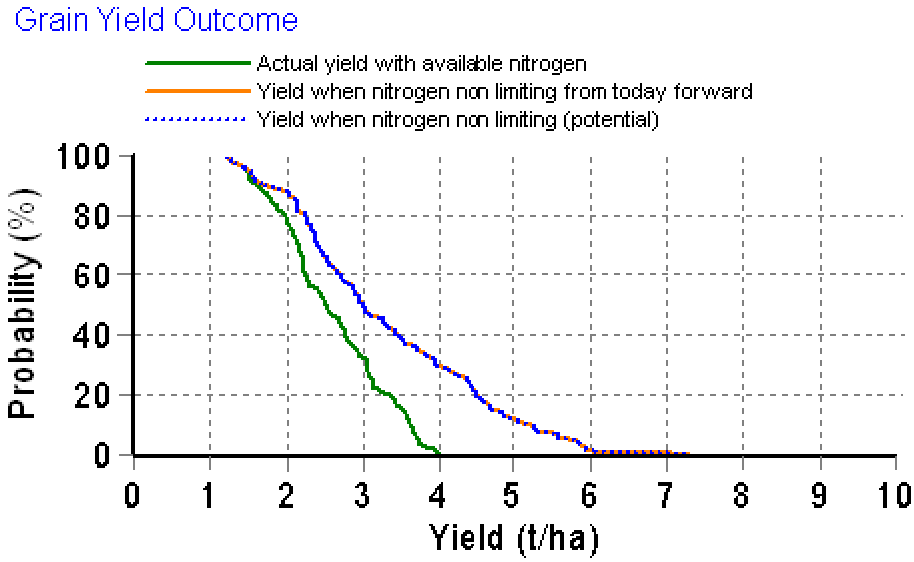

Figure 5. Yield Prophet predicted Grain Yield Outcome for **Bottrall** as at 27 June, 2012

Results were showing that Nitrogen supply may continue to be an issue in most years. No additional N was applied pending further seasonal information.

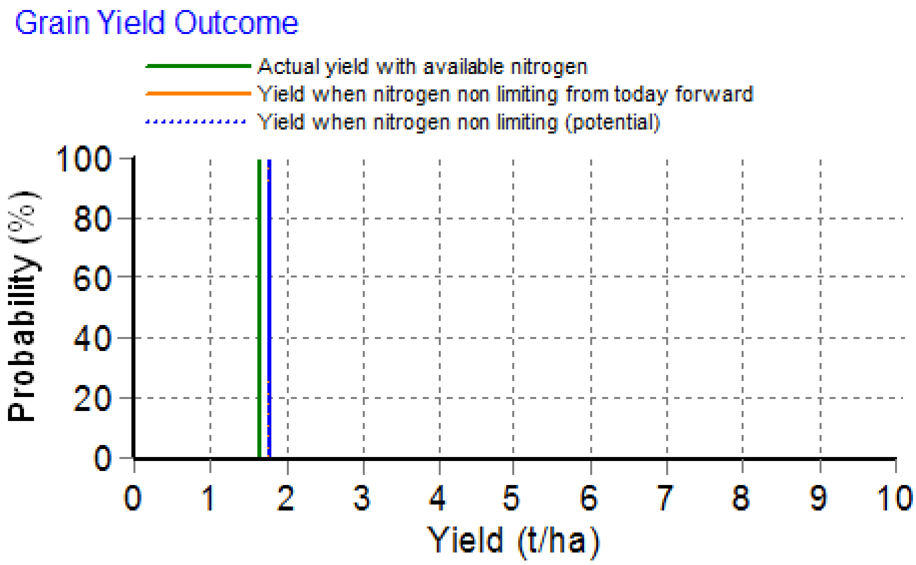

Figure 6. Yield Prophet predicted Grain Yield Outcome for **Bottrall** at harvest.

Actual yield was about 2.2 tonne/Ha against the Yield Prophet prediction of 1.7 tonne/ Ha. The difference is likely to be due to the model underestimating the amount of opening PAW in the soil profile. The model is suggesting that Nitrogen is still likely to have been limiting yield. Whether the application of additional N would have been economic is another question.

Catford- Gilmour and Michele's paddock near Morchard. Katana wheat back on 2011 wheat. Nitrogen was only going to be a limiting in this paddock in an above average year. Final yield of 0.9 tonne/Ha was close to the predicted yield of 1.0 tonne/Ha.

Heaslip- Paddock of Durum just north of Appila township. Similar situation to **Bottrall** with the model showing that N would become limiting in most years, even though opening PAW on this heavy soil type was estimated as being very low. Growing season did not provide any incentive (and limited opportunities) for additional N applications, and this was likely to have been the correct decision. Final yield was 0.8 tonne/Ha, significantly down on the predicted yield of 1.2 tonne/Ha due largely to some grass weed issues.

McCallum- Paddock of wheat north east of Richard's house. Similar to **Bottrall** and **Heaslip** model was showing the potential for Nitrogen to become limiting in an average or better season, but the poor season did not encourage any additional N applications. Final yield of around 0.8 tonne/Ha was down on the predicted yield of 1.1 tone/Ha and may have reflected an over estimation of opening PAW.

Dennis, Mudge and Tiller- All these sites were very similar- wheat back on wheat, with good levels of opening soil water. In addition, a rainfall event of up to 75 mm was received in late May which substantially increased potential yields.

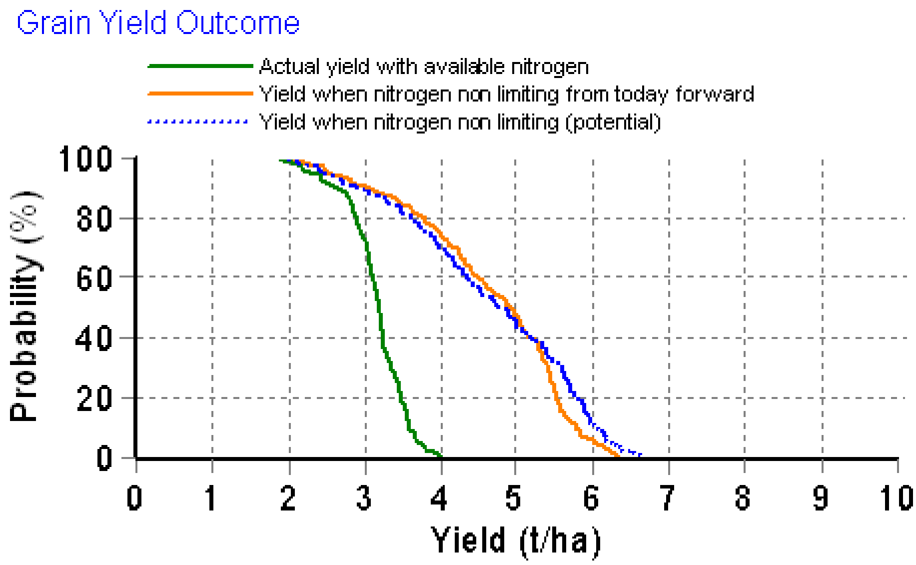

Figure 7. Yield Prophet predicted Grain Yield Outcome for **Dennis** as at 27 June, 2012

All three of these sites showed the strong likelihood that N would become limiting to yield in most seasons. In all cases, additional N was applied.

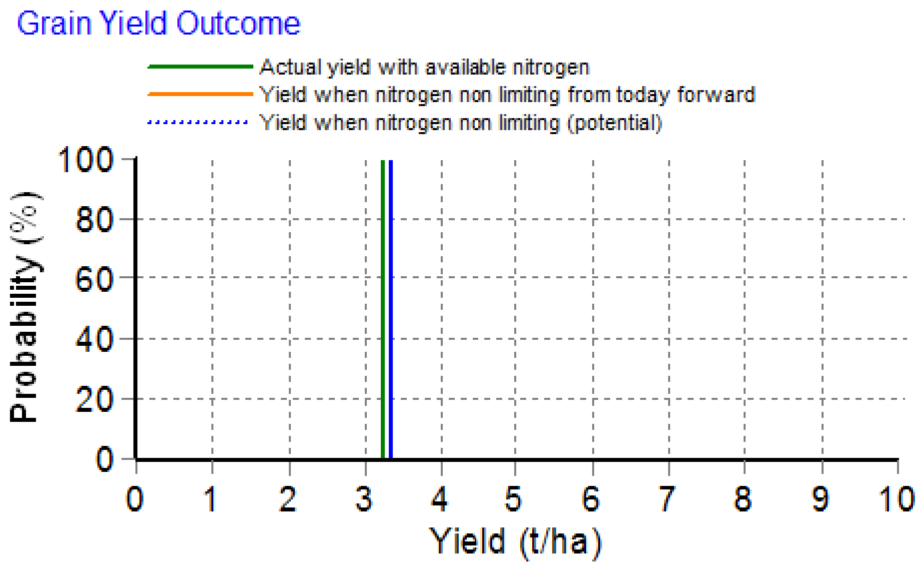

Figure 8. Yield Prophet predicted Grain Yield Outcome for **Dennis** at harvest
Even though additional N was applied, yields still may have been limited by the total Nitrogen supply. Both the Mudge and the Dennis sites reported lower proteins (ASW grade).

In all three cases, actual yields were down slightly on predicted yield, which may reflect some nutrition issues along with the possibility that yields were being limited by disease resulting from wheat being planted back on wheat.

In this case, it is important to remember that the Yield Prophet model is establishing only a water and nitrogen limited potential yield. It does not know anything about weed levels, pest and disease status, other nutrient deficiencies etc. Yields (particularly on crops sown back on cereals from the preceding year) may be being limited by other factors.

Summing up results from Yield Prophet in 2012

Overall, Yield Prophet again performed quite well in predicting yields over a wide range of circumstances. Much of the yield performance was due to the presence of stored soil water and the model has a good capacity to allow for this. The model performed well, even when yields of less than 1.0 tonne/ha were obtained.

Decision support for (mainly) post seeding Nitrogen management is a feature of the Yield Prophet model and it again showed its potential in this area. There is some debate whether the model calculates soil nitrogen mineralisation correctly. The fact that the model is showing good capacity to provide potential yield guidance still provides important information on which to base decisions throughout the season.

sturt grain

Carbon Farming

Key Messages

- There is considerable uncertainty regarding the future of carbon trading in agriculture
- The UNFS group is working on several project to help identify how growers might take advantage of the carbon market in the future
- Improved production and sustainability needs to be the key driver of any management changes with carbon credits being a bonus, not the drivers of change.

Carbon Farming Initiative

The Carbon Farming Initiative (CFI) is a carbon offsets scheme that will enable farmers and other land managers to access carbon markets. Farmers and land managers will be able to generate carbon credits for taking action to increase carbon stored in the landscape, or reduce emissions by changing farm practices.

Credits generated under the CFI that are recognised for Australia's obligations under the Kyoto Protocol can be sold to companies with liabilities under the **Carbon Price Mechanism**. This includes credits earned from activities such as reforestation, savanna fire management and reductions in emissions from livestock and fertiliser use.

The ongoing **CFI non-Kyoto Carbon Fund** will provide incentives for other activities, including revegetation and soil carbon projects.

Two types of offsets

1. Sequestration projects = projects to store C in living biomass, dead organic matter (dead wood or leaf litter) or soil
2. Emissions avoidance projects = reductions in emissions from agriculture (e.g. savanna burning, livestock (methane) fertilizer (nitrous oxide)) waste (i.e. legacy waste in landfill) and feral animals (camels and goats).

What is standing in the way of the CFI?

The obvious issues

1. Political uncertainty – prospect of termination of carbon pricing scheme with a new federal government
2. Carbon price – prospect of a low C price under the European Union model.

Legal obstacles

1. International climate rules
2. CFI rules
    - positive and negative list exclusions
    - project restrictions
    - methodologies (need to develop a complex methodology before a practice is included)
    - permanence requirement (100 years)
3. Project- level legal complexity

If CFI is going to work, there is a need for greater interest in ways of reducing the legal complexity and lowering transaction costs.

1. The current focus on science is good BUT science won't make the CFI work
2. There will be a need to sort out the economic and legal aspects.

What is happening in the Upper North?

The Upper North Farming systems group is involved in several Carbon Farming projects, which are trying to identify areas which have the greatest potential for soil carbon sequestration or reductions in greenhouse gas emissions.

1. Storing Carbon in the Soil

The Upper North Farming Systems is working with CSIRO to evaluate the impact of different pasture and grazing management systems on soil carbon stocks as well as identify the soil types and management practices most likely to give the largest gains in soil carbon stocks.
Clearing and cultivating native land for agriculture has typically decreased soil organic carbon (SOC) stocks by 40 to 60%. Recapturing even a small fraction of this through improved land management would significantly reduce greenhouse gas emissions.

There is currently a lot of uncertainty and debate within Australia, about the total potential of agricultural soils to store additional carbon, the rate at which soils can accumulate carbon, the permanence of this sink, and how best to monitor changes in SOC stocks. To help clarify some of these issues, the CSIRO have recently reviewed the mechanisms of carbon capture and storage in agricultural soils and analysed the evidence for SOC stock changes resulting from shifts in agricultural management.

On average, improved management of cropping land, through improved rotations, adoption of no-till or stubble retention has resulted in a relative gain of 0.2 – 0.3 Mg C ha-1 yr-1 compared to conventional management across a range of Australian soils. However, even the improved management often showed significant declines in SOC stocks, which, is most likely a direct result of the initial cultivation of the native soil. The traditional management practice often lost SOC at a greater rate and at the end of the trial there was a relative SOC gain in the improved management treatment. Therefore these improved agronomic practices may only be reducing losses in Australian soils and not actually sequestering additional atmospheric carbon. Also, sequestration rates were found to decline over time with the largest gains generally found within the first 5 to 10 years dropping to nearly 0 after 40 years.

The limited data available indicates that pasture improvements, including fertilisation, liming, irrigation and sowing of more productive varieties, generally have resulted in relative gains of 0.1 – 0.3 Mg C ha-1 yr-1. Larger gains of 0.3 – 0.6 Mg C ha-1 yr-1 have been found for conversion of cultivated land to permanent pasture.

Most of the trial data comes from a fairly narrow range of management options for the main agricultural systems of Australia and little data exists on numerous management options which hold potential to sequester large quantities of SOC. Within an existing agricultural system, the greatest theoretical potential for C sequestration will likely come from large additions of organic materials (manure, green wastes, etc…), maximizing pasture phases in mixed cropping systems and shifting from annual to perennial species in permanent pastures. Perhaps the greatest gains can be expected from more radical management shifts such as conversion from cropping to permanent pasture and retirement and restoration of degraded land. These options are summarized in the accompanying table.

Many of these management options that may increase SOC tend to also increase overall farm productivity, profitability and sustainability, and as such are being rapidly adopted in various regions of Australia. However, numerous other management shifts (for example, converting from annual crops to pastures) which may have the greatest positive impact on SOC stocks will likely need incentives, either in the form of direct government subsidies or credits from an emissions trading market, before wide-scale adoption is seen.
There is potential to store (sequester) carbon, however further research is required.

Summary of major management options for sequestering carbon in agricultural soils

Management	SOC benefit[a]	Conf.[b]	Justification
1. Shifts within an existing cropping/mixed system			
a. Maximizing efficiencies - 1) water-use 2) nutrient-use	0/+	L	Yield and efficiency increases do not necessarily translate to increased C return to soil
b. Increased productivity - 1) irrigation 2) fertilization	0/+	L	Potential trade-off between increased C return to soil and increased decomposition rates
c. Stubble management – 1) Eliminate burning/grazing	+	M	Greater C return to the soil should increase SOC stocks
d. Tillage –			1) Reduced till has shown little SOC benefit; 2) Direct drill reduces erosion and destruction of soil structure thus slowing decomposition rates; however, surface residues decompose with only minor contribution to SOC pool
1) Reduced tillage	0	M	
2) Direct drilling	0/+	M	
e. Rotation –			1) Losses continue during fallow without any new C inputs – cover crops mitigate this; 2) Pastures generally return more C to soil than crops; 3) Pasture cropping increases C return with the benefits of perennial grasses (listed below) but studies lacking
1) Eliminate fallow with cover crop	+	M	
2) Inc. proportion of pasture to crops	+/++	H	
3) Pasture cropping	++	M	
f. Organic matter and other offsite additions	++/+++	H	Direct input of C, often in a more stable form, into the soil; additional stimulation of plant productivity (see above)
2. Shifts within an existing pastoral system			
a. Increased productivity - 1) irrigation 2) fertilization	0/+	L	Potential trade-off between increased C return to soil and increased decomposition rates
b. Rotational grazing	+	L	Increased productivity, inc. root turnover and incorporation of residues by trampling but lacking field evidence
c. Shift to perennial species	++	M	Plants can utilize water throughout year, increased belowground allocation but few studies to date
3. Shift to different system			
a. Conventional to organic farming system	0/+/++	L	Likely highly variable depending on the specifics of the organic system (i.e. manuring, cover crops, etc…)
b. Cropping to pasture system	+/++	M	Generally greater C return to soil in pasture systems; will likely depend greatly upon the specifics of the switch
c. Retirement of land and restoration of degraded land	++ +++	H	Annual production, minus natural loss, is now returned to soil; active management to replant native species often results in large C gains

[a] Qualitative assessment of the SOC sequestration potential of a given management practice (0 = nil, + = low, ++ = moderate, +++ = high)
[b] Qualitative assessment of the confidence in this estimate of sequestration potential based on both theoretical and evidentiary lines (L = low, M = medium, H = high)

2. Nitrous Oxide

Nitrous oxide (N_2O)is a greenhouse gas with around 300 times the global warming potential of carbon dioxide (CO_2). A major source of N_2O emissions is the application of nitrogen fertiliser, however, limited research has been conducted around the grains industry's contribution to emissions, particularly in lower rainfall areas.

Farmers are already using nitrogen more efficiently by including legume break crops in their rotations and taking a more prescribed approach to nitrogen fertiliser applications that better match crop demand and the seasonal conditions. But how much N_20 is being emitted from soil remains unclear.

A number of demonstrations are being managed and coordinated by the Birchup Cropping Group, (BCG) across the low rainfall areas of southern Australia, including one in the Upper North that will attempt to measure N_2O emissions from soils under varying cropping regimes.

The first will compare the N_2O output when nitrogen is applied through synthetic fertiliser. The second will measure the N contribution made by a vetch legume crop that is terminated at various times in the establishment year and the corresponding effect of N_2O emissions from a non-legume crop in the subsequent season will also be measured.

If N_2O is released to the atmosphere; nitrogen has not been used by the crop, which ultimately means that input dollars have been wasted.

The main aims of this demonstration are to: increase farmer knowledge about the N_2O emissions made from fertiliser and legumes; reveal options available to reduce N_20 emissions; and to provide information about nutrient use efficiency that maximises productivity.

Additionally, growers and advisors will have a better understanding about how nitrogen application in the system can deliver the best result in terms of production per tonnes of carbon dioxide equivalents (CO_2e) emitted.

3. Methane from Livestock (R. Eckard, Primary Industries Climate Challenge Centre)

Methane makes up 68% of agricultural greenhouse gas emissions. Of this dairy cattle account for approximately 10%, beef cattle 47% and sheep 13%. Research on livestock methane production is not new, however research into reducing methane production (abatement) is new.

Animal methane production is a complex issue and research is likely to take decades to develop sustainable, practical and cost-effective solutions. The problem is the CFI wants options now and the research funding is only for 3 years.

Cost-effective abatement options are limited and the impact on production has not been fully measured. Most abatement options will only provide no more than 20% abatement and this is only from part of the system.

Livestock producers have been able to reduce emissions through improved productivity and sustainability.

- Increase growth rates, lower time to turnoff, improve perenniality and NRM outcomes
- Dual goals of adaptation to climate change and mitigation has been achieved

Incentives for producers to adopt new practices are currently low as CFI income is not sufficient to drive change alone and productivity gains must remain a focus.

The use of Fodder shrubs in the Farming System

Key Message

- New fodder shrub species have been successfully trialed in the UN
- Perennials, including fodder shrubs will increase pasture production on poor, degraded soils
- Grazing animals require a balanced diet with a variety of pasture species to ensure the correct balance of energy, protein and minerals
- High stocking pressure for short periods is necessary to maximize pasture production of both the fodder shrubs and inter-row pasture.

Background

Fodder shrubs, particularly Oldman saltbush have been used as a fodder source for many years. There have been mixed results and performance of the fodder shrub stands regarding, establishment production and utilization.
The Erich program has been researching alternative fodder shrub species to determine the most appropriate species, spacing's and management to maximize production and use of these fodder shrub systems. Data from the Enrich sites in the Upper North and Eastern Eyre Peninsula has identified a number of alternative species to Oldman saltbush. These may not necessary replace Oldman, but will provide an alternative, often more palatable feed source. Some of these fodder shrub species have been planted in larger demonstration areas with a range of row spacing depending on the situation and intended use of the fodder shrub systems. These demonstrations are part of a federal government funded "Caring for Our Country" project. This project is investigating where and how perennials, including fodder shrub species can fit into our farming systems and the benefits they can have on production and sustainability.
The greatest benefit has been obtained on poorer, degraded soils where crop and pasture production is very low. Often these areas are no longer viable to crop and landholders have decided to remove them from cropping; however pasture production is often also poor.

Fodder Shrub Species

Species	**Survival**	**Edible biomass**	**Palatability**	**Digestibility**	**Comments**
River saltbush (*Atriplex amnicola*)	~ 75%	Low - medium	medium	medium	Excellent edible biomass and ability to recover from grazing
Grey saltbush (*Atriplex cinerea*)	~ 75%	low	medium	medium	Readily grazed and performed well on saline areas
Oldman saltbush (*Atrilpex nummularia*)	~ 72%	medium	low	medium	Sheep avoid grazing when first introduced; excellent edible biomass and capacity to recover from grazing; good shelter.
Silver saltbush (*Atriplex rhagodioides*)	~ 95%	Low - medium	low	medium	Low grazing preference; excellent edible biomass and capacity to recover from grazing.
Creeping saltbush (*Atriplex semibaccata*)	~ 65%	low	medium	medium	Sheep readily grazed when first introduced; relatively short lived , but regenerates readily from seed
Ruby saltbush (*Enchylaena*	~ 95%	Very low	medium	low	Sheep readily grazed when first introduced; average

tomentosa)					edible biomass with good capacity to recover from grazing.
Mealy saltbush (*Rhagodia parabolica*)	~ 95%	Low - medium	low	high	Sheep avoid grazing when first introduced; average edible biomass with good capacity to recover from grazing; good shelter

Inter-row Pastures

Grazing animals require a balanced diet with a variety of pasture species to ensure the correct balance of energy, protein and minerals. In the past many fodder shrub systems were planted very densely to maximize fodder shrub production, however pasture production between the shrubs was significantly reduced.
Even in a shrub based system the bulk of the biomass eaten by livestock will come from a productive inter-row pasture or understorey. Shrubs typically only make up one-quarter to one-third of the dry matter intake of sheep. In autumn when inter-row pasture is of poor quality and in low quantity intake of shrub material may increase to half.

Selecting Inter-row Species

A range of inter-row species have been trialled in the Upper North and Eyre Peninsula. Cereals have given the most production and are relatively cheap and easy to establish. Annual legumes, such as vetch and annual medic provide high quality feed, however early growth is relatively slow. Dense regenerating annual medic stands can provide high early production in seasons with an early break. Mixtures of cereal and vetch provide good early feed or high production for later grazing.
Native perennial grasses (Curly windmill grass and Wallaby grass) provide reasonable quality feed and will respond to out of season rainfall. Early growth is very slow and most stands take 6 to 8 months to get established. Care is needed to ensure stands are not over grazed. Once established, stands can be over-sown with annual legumes to improve feed quality and quantity.
Lucerne has been used in areas with wide row spacing's (> 10m) between fodder shrubs and sown 1.5 to 2 m away from the fodder shrubs. When lucerne is sown close to fodder shrubs the plants tend to compete reducing the production of both the fodder shrubs and lucerne.
These sown pastures are generally far more palatable than the fodder shrubs and will be eaten out first. Moderate – high grazing pressure and moving animals into new areas allows them to adapt their grazing behaviour and incorporate shrub foliage into their diet before the inter-row pasture is grazed out.
When first introduced to fodder shrubs it may take 4 or more days before the shrubs become a significant part of their diet. Once stock have had experience grazing shrubs they will preferentially graze the shrubs much sooner, and within a few days it could make up 50 % or more of their diet.

Time of Grazing

When selecting the best inter-row species to sow, it is important to determine the time of year you intend to graze the fodder shrub system.
<u>Winter grazing</u>
Dry sow a cereal / legume pasture mix and graze early growth.
Dual purpose cereals could be grazed several times throughout the season and still be harvested.
<u>Late Spring grazing</u>
Early sown cereal or cereal / legume mix can be grazed when grain has developed, but before stubbles become available.
<u>Autumn grazing</u>
Cereals sown early (dry) and left as a standing crop.
Native grasses (C3 and C4 mix) would provide good feed.
These areas could be used as confinement feeding or for lambing in poor seasons with supplementary feeding.

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