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Karoonda Information Booklet 2015

Mallee Sustainable Farming

About Mallee Sustainable Farming

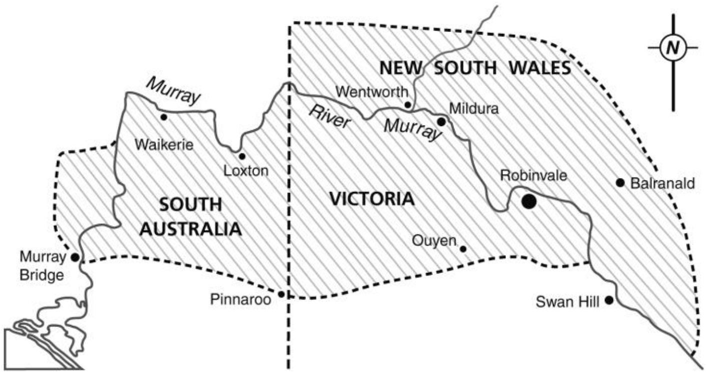
Mallee Sustainable Farming (MSF) Inc. is a farmer driven organisation delivering research and extension services to the less than 350mm rainfall Mallee cropping regions of New South Wales, Victoria and South Australia. MSF operates within a region of over four million hectares, extending beyond Balranald in the east to Murray Bridge in the west.

Our 18 year legacy

MSF Inc. formed in 1997 in response to recognition that conservation farming practices had not been widely adopted across the region. Therefore, there was a need to identify the issues restricting the adoption of technology that would enhance the development of profitable and sustainable farming systems. During its first 16 years of operation, MSF has achieved a great deal. Increases in farm profitability have been observed as a result of MSF activities, along with environmental and social gains. MSF continues to strive to be relevant to farmers' information needs, whether in the sphere of cereal cropping or livestock management.

Our members

The Mallee has approximately 2000 dryland farming families whose farming activities include cropping (wheat, barley, vetch, lupins and canola) and livestock (sheep for wool, lambs and cattle for meat). An increasing number of these families are members of MSF, receiving new and timely information on research and best management practices. Such activities include Farmtalk fact sheets, farm walks, trial sites, field days and research compendium publications.



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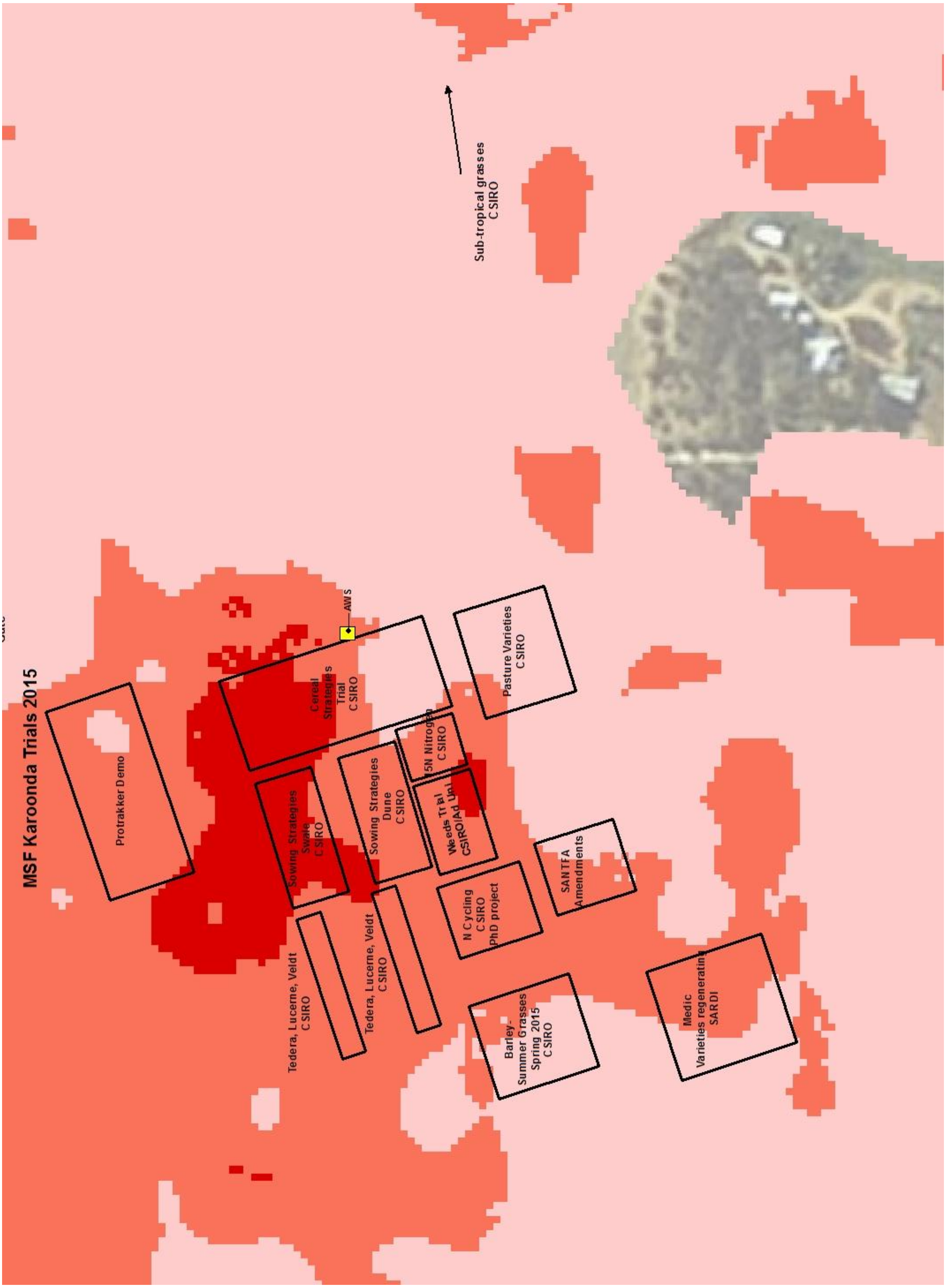
MSF Karoonda Trials 2015
Protrakker Demo
Cereal Strategies Trial CSIRO
AWS
Pasture Varieties CSIRO
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Sowing Strategies Swale CSIRO
Sowing Strategies Dune CSIRO
Weeds Trial CSIRO/Ad Uni
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Tedera, Lucerne, Veldt CSIRO
Barley - Summer Grasses Spring 2015 CSIRO
Medic Varieties regenerating SARDI
Sub-tropical grasses CSIRO

2015 Karoonda field day program

Time	Group 1	Group 2	Group 3
10:00	Welcome: Stuart Putland		
10:10	Paddock history: Peter Loller		
10:20	Plenary Session: John Kirkegaard “Innovations in Australian Agriculture”		
11:10	ProTrakker	CSIRO – Part 1	Pastures
11:30	Pastures	CSIRO – Part 2	Weeds
11:50	Weeds	Phosphate alternatives	CSIRO – Part 1
12:10	Phosphate alternatives	pH on the run	CSIRO – Part 2
12:30	pH on the run	Weeds	ProTrakker
12:50	Lunch		
1:35	Update from GRDC: Rob Sonogan		
1:45	Launch of MSF (GRDC) Stubble guidelines: Stuart Putland		
1:50	Plenary Session: Jack Desbiolles “Seeding Systems for the Mallee” James Barr “Bentleg openers”		
2:40	CSIRO – Part 1	ProTrakker	pH on the run
3:00	CSIRO – Part 2	Pastures	Phosphate alternatives
3:30	Evaluation & close		

Group 1 Facilitator: Andrew Biele

Group 2 Facilitator: Stuart Putland

Group 3 Facilitator: Lou Flohr & Jeff Braun

- CSIRO – Part 1 & 2: Sowing strategies, nutrient cycling, non-wetting soils – Therese McBeath, Gupta Vadakattu, Margaret Thorpe (CSIRO).
- ProTrakker & guidance systems – Rob Pocock (Lampata) & Grant Yates (Southern Precision)
- Brome grass management – Matt Elliot, Richard Saunders (Dodgshun Medlin) & Rick Llewellyn (CSIRO)
- On the go soil and plant sensing - Sean Mason (University of Adelaide)
- Phosphate alternatives – Andrew Bird (SANTFA)
- Pastures – Michael Moodie (MSF), Andrew Smith (CSIRO)

Innovations in Australian agriculture: Success from system synergies

John Kirkegaard (and colleagues)
CSIRO Agriculture

Take home messages

- Past (and future) agricultural "revolutions" are about systems, not silver bullets
- A sound sequence and good fallow management (weeds, residue) provide the platform for success
- Then, early sowing systems targeting optimum flowering windows can maximise farm productivity
- Grazing early-sown, dual-purpose crops can add flexibility, profitability and reduce risk on mixed farms

Introduction

The global food security challenge, and your farm profitability challenge, prompts many to propose "transformational" breakthroughs as the solution. These may be a new genetically modified crop, a more effective biological fertiliser or a new satellite-guided planter - often proposed by largely disconnected research disciplines.

In reality, and throughout history, few individual technologies have been singularly transformational either in the scale or the speed with which they influence productivity. Rather, step changes in productivity come when combinations of technologies, often a mix of old and new, synergise within a system. The first agricultural revolution arose from a combination of pre-existing, individual technologies most of which were centuries old, but it was the combination that made them so effective.

We need to deliberately foster the evolution of synergies to provide more rapid gains in productivity on-farm. I will provide examples from two recent national research projects in which a range of innovations from different scientific disciplines combined with direct grower collaboration to generate step-changes in productivity that have been adopted on farm. Mallee farmers and MSF have been involved in both....

National Water-Use Efficiency Initiative

Water is the limiting resource to higher productivity on most Australian farms, yet our crops rarely achieve the "water-limited potential". So how can we improve our performance?

"Catch more; Store more; Grow more"

We often think about in-crop management to improve yield and water-use efficiency (e.g. variety, N management, row spacing etc) – but it is often the pre-crop management that drives success. The 17 grower groups across Australia involved in the National Water-Use Efficiency project nominated a range of different pre-crop and in-crop management strategies to try to increase productivity. We divided these into 4 Themes, and some key outcomes are shown below.

1. Long-term soil management (over coming soil constraints with gypsum, spading, lime)

- Overcoming soil constraints (sodic, non-wetting, acid) increased productivity by 15 to 54%

2. Crop sequences (benefits of break crops)

- The 4-year gross margin was increased by up to 30% by the inclusion of a break crop

3. Fallow management (managing weeds, stubble and stock)

- Strict summer weed control was key, saving ~ 40 kg N and 40 mm water with a $5.70:1 ROI
- Sheep do more damage with mouths (i.e. by overgrazing) than with hooves (trampling)
- Maintain sufficient stubble cover to avoid erosion (70% cover)

4. In-crop canopy management

- Sowing early and targeting the optimum sowing window increased yield by 21 to 33%
- Including early-sown crops can scale-up to whole-farms yield increases of 11 to 47%
- Variable rate N (more on dunes, less on swales) could significantly improve productivity on Mallee soils

Impressive, but it's the combination that counts!
Individually, new management strategies can have measureable effects, but combined, each builds on the next to *"Catch More; Store More; Grow More"*

For example we used a model to predict the value of individual and combined effects of management improvements for a typical farm at Kerang. The baseline management is set out below and delivered average wheat yields of 1.6 t/ha. The individual and combined effects of new management are shown in the Table below:

Baseline Scenario (Kerang, Victorian Mallee)
Management - Continuous wheat, grazed weedy fallow, burn/cultivate, sow from 25 May.

Baseline Mean wheat yield = 1.60 t/ha

System change	**Mean Yield (t/ha)**	
	Individual Effect	Combined Effect
1. No-till	1.84	1.84
2. Strict fallow weed control	2.37	2.80
3. Pea break crop	1.76	3.45
4. Early sowing (from 25April)	2.10	4.01
5. New long-coleoptile wheat (Sow on 25 April)	1.45	4.54

Note that making any of the changes in isolation (Individual) made relatively small improvements above the baseline long-term wheat yield (1.6 t/ha). For example the benefits of a pea break crop alone is small (1.76 t/ha) if you let weeds grow in the fallow. But if you control weeds and use a pea break crop yield increased to 3.45 t/ha.

Sowing early made a small difference (from 1.60 to 2.10 t/ha) without a good rotation and fallow weed control (combined gave 4.01 t/ha). A new, long-coleoptile wheat allowing the crop to be sown into moisture on Anzac day every year was of no benefit without the right system to support it.

This example has been confirmed by the 5 years of field experiments (including many in the Mallee and by MSF) to demonstrate how combinations of individual improvements creates potentially large yield benefits.

We will explore some of those results and demonstrate how more efficient capture, storage and use of water (and nitrogen) drives the yield improvements

Dual-purpose crops – are they a "goer" in the Mallee?

Crops sown early in autumn to target the optimum sowing date will provide grazing opportunities without yield penalties if sound grazing guidelines are followed. This is because the crop will often grow more biomass then it needs to satisfy the grain yield potential.

The most critical management decision is lock-up time, which must occur BEFORE the developing heads elongate above the ground and are at risk of removal by the sheep. That stage is DC30, when the first node can be just felt or seen above the soil.

As well as a safe phenological stage, the residual biomass and calendar date can also be used to judge lock-up timing. A target yield is linked to a critical anthesis biomass – a 2.0 t/ha wheat crop needs about 3.6 t/ha of biomass at anthesis. So provided the crop is locked up with sufficient residual biomass to reach that critical flowering biomass, the target yield will not be compromised. Of course the spring conditions (which we cannot predict) determine the ultimate yield – but grazing, like N management can use target yields as a guide.

As winter feed availability can limit the profitability of the livestock enterprise, grazing crops without yield penalty provides an option to rest pastures and to build a wedge of late-winter/spring feed. Grazing provides an additional option to manage the biomass and flowering time of early-sown crops.

What about the Mallee

In the most comprehensive published studies in the Mallee, the grazing of spring and winter wheat and barley at various sites over 5 years showed 23 cases with no impact on yield (60%); 14 with yield decreases (36%) and 2 with yield increases (4%). Screenings increased in 3 of the 5 experiments.

Early sowing is crucial in the Mallee to achieve biomass for grazing. Slower-maturing wheat varieties suited to earlier sowing in the Mallee are under development with breeding companies which should reduce the risks of yield loss!

Sheep and soil

Good news – we have found no long-term impact of grazing stubble and/or crops on the soil or crop performance – in fact in some years grazing appears to turn-over the organic N more rapidly making it available to crops during early growth stages with some yield benefits.

Where will the N come from?

Shorter or non-existent pasture phases mean that crops rely more and more on fertiliser N which is likely to increase demand and as a result price. At average rates of 9 kg/ha N applied in some Mallee environments, and 20 kg/ha N removed per tonne of wheat, it is clear we are either mining organic N resources, or relying on as yet unclear biological processes to balance soil N.

Calculations of the fertiliser N required to make up the difference across the farm at current (or future) prices point to the need to have profitable legumes (pastures or crops) in the system.

Good planning and timeliness are the key

I have outlined some key strategies to lift whole-farm productivity and manage risk - many of which have been known for decades and some of which are new.

The principles are sound, but the logistics and detailed agronomic pieces of the puzzle on specific farm businesses require good planning and execution. New break crops, early sowing systems and dual-purpose cropping all require planning – for weed management, for stock movements, and for "Plan B's".

But many of these changes are within the reach of growers with moderate changes to current practice.

Further information

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Alternative phosphate

Greg Butler & Andrew Bird
SA No-Till Farmers Association

Take Home Messages

- Alternative Phosphorous sources that perform, transport and handle well are emerging.
- The efficacy of DAP can be improved with additions of Biochar at low rates.
- Commercial biochar to come on stream in Mt Gambier within the next year or two

The best management of phosphorous should consider the right type of phosphate, the right rate, the right placement and the right timing.

In this trial, varying types of conventional and alternative phosphate sources are compared at varying rates (Fig 1). The timing is at planting and the placement is banded with the seed.

TABLE 1 : Karoonda 2015 Sowing treatments

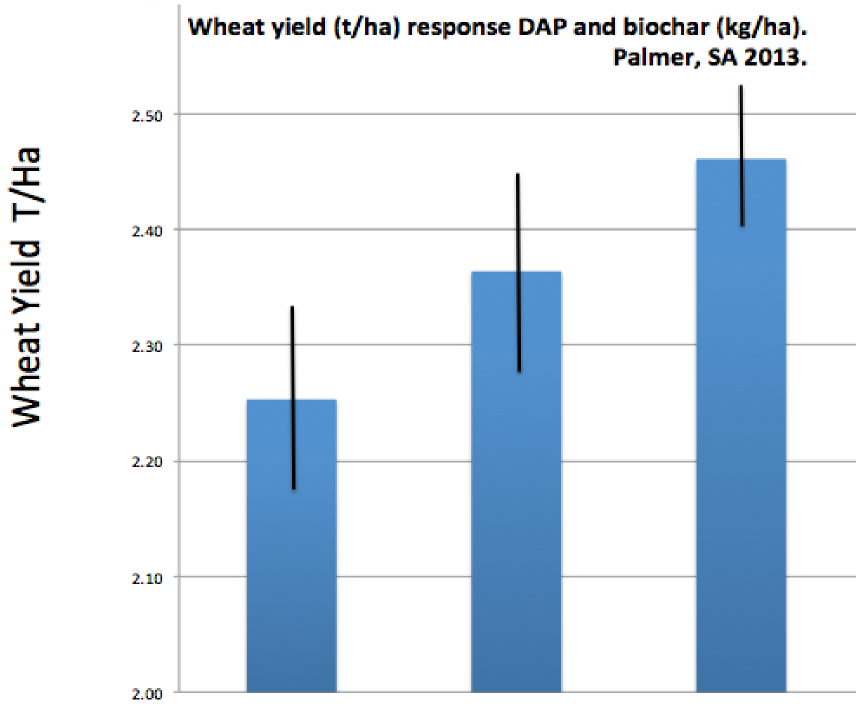
Treatment	DAP Kg/Ha	Biochar C Kg/Ha	Crystall Green + Urea Kg/Ha		PL Pellet + Urea Kg/Ha		PL&B Pellet + Urea Kg/Ha	
	18:20	Cool Terra	CG	Urea	PL Pellet	Urea	PL&B Pell	Urea
1								
2	50							
3	100							
4	50	35						
5	100	35						
6	50	100						
7	100	100						
8		35						
9		100						
10							50	15
11							50	30
12							100	15
13							100	30
14							200	15
15							200	30
16					50	15		
17					50	30		
18					100	15		
19					100	30		
20					200	15		
21					200	30		
22			50	15				
23			100	30				
24		35	50	15				
25		100	100	30				

About the treatments:

DAP
Di ammonium phosphate is an industrial fertiliser and used a reference in this trial.

Cool Terra Biochar
Cool Terra biochar is the first biochar in the world to receive quality certification from the International Biochar Initiative (IBI).

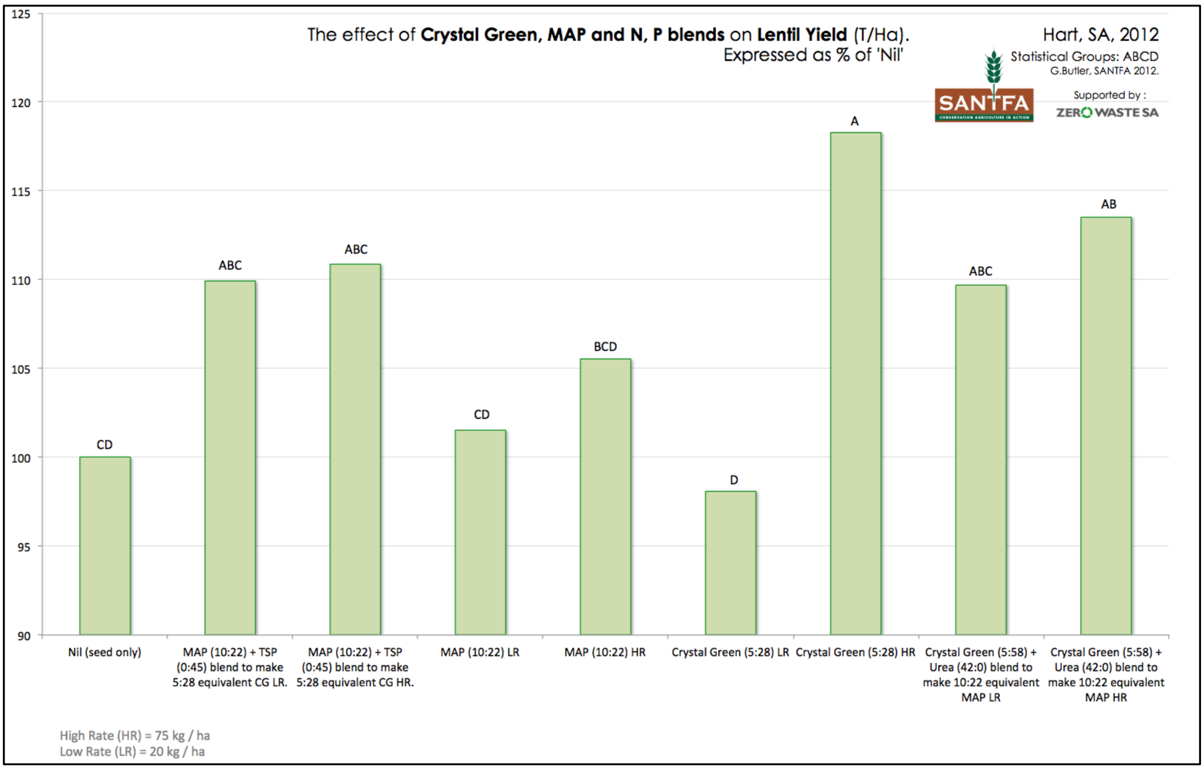
Biochar shouldn't be considered a fertiliser in its own right however, biochar has consistently shown a propensity to increase the efficacy of phosphate fertiliser when used at modest rates (Figure 2). New research also shows that biochar can reduce the leaching of nitrate.



Avg. Yield over 3 reps	2.25	2.36	2.46
DAP at sowing (kg/ha)	0	50	50
Biochar at sowing (kg/ha)	0	0	30

One of the first commercial scale biochar production plants in Australia has been proposed near Mount Gambier at the timber processing business *Roundwood Solutions*.
Once in production, the biochar produced at Roundwood Solutions will be able to meet commercial biochar objectives in terms of supply, affordability and quality control.

Crystal Green
Crystal Green is made by sustainably recovering phosphorus and nitrogen from nutrient-rich wastewater streams. The technology has been installed at some of the world's largest wastewater treatment plants including Chicago and London. It is hoped that the technology will be installed in Australia in the not-so-distant future.
Crystal Green is chemically known as Struvite or Magnesium Ammonium Phosphate.
It is white, hard, dust-free granule, with excellent transport and handling characteristics.
Crystal green has a very low 'salt index' and is unlikely to exhibit any fertilizer toxicity even in sandy soils using zero-till seeding systems.
In terms of N:P:K, it is a 5:12:0+10%Mg however in recent trials, it seems to perform well above expectation, particularly when used to fertilize legume crops. (Fig 3).



Granulated Poultry Litter Ash

There is interest from poultry farmers to create renewable energy both thermal heating and electricity) from their excess poultry litter. The nutrient rich ash that results from the energy production process has good amounts of Phosphorous (P) and Potassium (K), however Nitrogen is usually low due to its volatile nature relative to P & K.
(N:P:K = - : 9 : 13).

US field trial have demonstrated a good response to poultry litter ash, and it may be a way to reduce freight and allow better placement of P derived from poultry litter. The ash granulates well and should be reasonably good to handle and apply via banding during the seeding process.
One batch of the granulated poultry litter ash has been granulated with biochar in a ratio of 80 ash: 20 biochar.

This SANTFA project is supported by the Federal Government Caring for Our Country Innovation Program and the SA MDB NRM Board.
Cool Terra Biochar and Granulated Poultry Litter Ash are supplied by Clean Carbon Pty Ltd.

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Government of South Australia
South Australian Murray-Darling Basin Natural Resources Management Board

SANTFA CONSERVATION AGRICULTURE IN ACTION

CARING FOR OUR COUNTRY

CleanCarbon

On the go soil and plant sensing

Sean Mason
University of Adelaide

Take Home Messages

- Continued advancement of benchtop instruments towards smaller and portable units allows for the potential for these instruments to be tested out in the field.
- Portable X-Ray Fluorescence (PXRF) is able to rapidly measure selected nutrients in various crop types
- Mid Infrared Spectroscopy (MIR) has shown potential to accurately measure selected soil properties including Phosphorus Buffering Index (PBI), calcium carbonate ($CaCO_3$) content, organic carbon and soil texture.
- These two instruments offer inexpensive, rapid analysis on selected soil and plant parameters and allows for further refinement in fertiliser decisions on a paddock scale

Background

Portable X-ray fluorescence

X-ray fluorescence (XRF) analysis has the potential to measure selected nutrient (calcium, chloride, copper, potassium, magnesium, manganese, phosphorus, sulphur and silica) concentrations in plant material with previous studies showing good correlations with the more expensive and labour intensive laboratory method (acid digest of plant followed by ICP analysis). The technique works on the principle that all elements emit a secondary (fluorescent) X-ray when they are exposed to an X-ray of a higher energy, and the intensity of the emitted X-rays is used to determine elemental composition of the material exposed. To date there have been no studies that have assessed the performance of XRF to measure plant nutrient concentrations of agricultural crops applicable to southern broad acre agriculture region (wheat, canola, lupins, chickpeas and field peas). XRF is inexpensive to run, with consumable costs reported to be about $0.15 per sample, and has high sample throughput (around 160 per 8hr day). Once the instrument is calibrated, the analytical procedure is simple and does not require a highly skilled operator, increasing the potential number of users.

Through a SAGIT funded project we assessed the applicability of hand held XRF instrument to quantify element concentrations such as P on prepared plant tissue samples in the laboratory and also on plant samples in the paddock.

Mid infrared Spectroscopy

Mid-Infrared technology (MIR) has been shown to be a rapid method that accurately determines concentrations/proportions of major soil properties including texture, organic carbon and $CaCO_3$ contents. MIR technology assesses characteristics of a soil sample through the absorption of light which occurs at specific frequencies for a particular molecular structure.

Part of this rapid assessment is the determination of the major soil components that influence the soils ability to buffer applied phosphorus (P). MIR has been shown to accurately predict P buffering values across a large range of soil types. PBI values are an important indicator of P fertiliser efficiency, the greater the PBI value the greater the absorption/fixation of applied P fertiliser.

Recently MIR technology has advanced to include the production of hand held prototypes that provides the opportunity for it to be used in the field. Through another SAGIT funded project we had an opportunity to test the potential of using MIR as a tool for rapid assessment of PBI across a paddock. Paddock maps of variation in PBI can be produced to aid in variable rate technology to maximise P inputs on the basis of the likely availability of fertiliser applied P.

Results

XRF in the laboratory

XRF analysis on prepared (dried and ground) plant samples produced excellent correlations (typically R^2 >0.8) with selected nutrient concentrations (Ca, K, P, S and Zn) as measured by ICP and for a large range of crop types (canola, chickpea, field pea, lupin, rye, vetch and wheat) grown in southern Australian cropping regions.

XRF for P analysis in the field

Significant correlations ($p < 0.05$) between XRF and ICP results for wheat and barley tissue P concentration using youngest emerged blade samples were not obtainable. It appears that the water content of the plants severely affected the ability of XRF to measure counts of P in the leaf. This might be due to the reduced density of the leaf with the higher moisture contents. Additionally, P concentrations in many of the samples could not be determined by XRF as they fell below detection limits.

In contrast to wheat and barley, significant correlations ($p < 0.05$) were obtained for relationships between XRF and ICP for the determination of P contents in beans ($R^2 = 0.71$), canola ($R^2 = 0.9$) and field pea ($R^2 = 0.95$). Possible explanations for the excellent correlations obtained for these crop types and not wheat and barley are:

1) Overall plant P concentrations were higher potentially due to greater soil P levels at this site allowing improved detection of P by XRF
2) The more advanced growth stage of these crops meant that the moisture content in the leaves were lower further aiding detection ability by XRF.

Drying the leaf samples (wheat and barley) allowed for significant ($p < 0.05$) but moderate correlations between XRF and ICP determined P concentrations for both wheat ($R^2 = 0.6$) and barley ($R^2 = 0.49$) (figure 3). This is further evidence that removal of water content in the leaf improves the ability of XRF to measure P. Excellent correlations were also obtained for beans, canola and field pea with the relationship for beans increasing upon drying of the leaf.
Combining all crop data for samples that have been dried and analysed by XRF with ICP determined P concentrations produces and excellent correlation suggesting minimal matrix effects of each crop type on XRF P determination (figure 1).

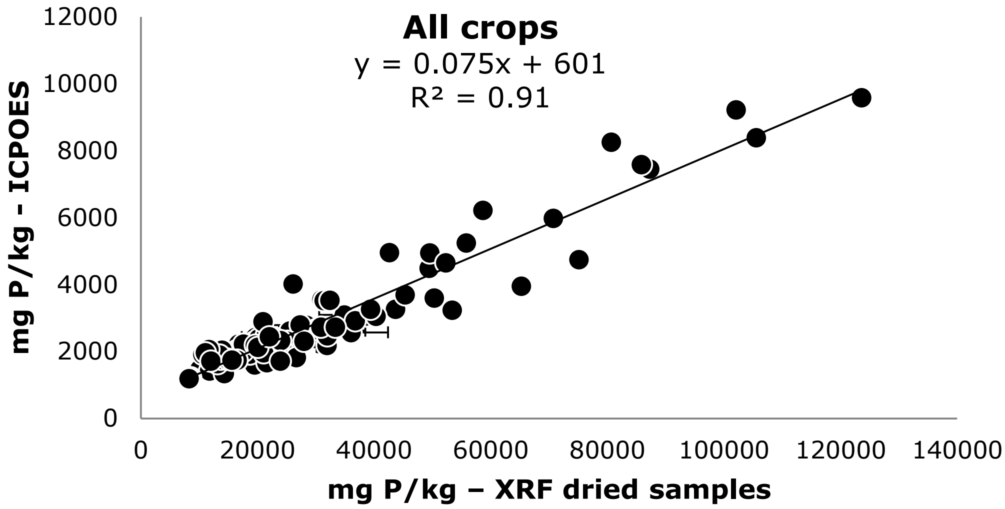

Figure 1. Relationship between P concentrations determine by XRF on dried samples in the laboratory and ICP analysis after acid digestion for all crop types combined.

PBI prediction by MIR in the paddock

An example of how MIR could be used to paddock map PBI was performed at a focus paddock near Karoonda which had a typical dune swale system and varying PBI values (Figure 2). Samples were taken in a grid format (120m x 60m) after significant rainfall events and therefore the effect of soil moisture on the IR determination of PBI could be evaluated (wet soil is particularly problematic for IR analysis of soils).

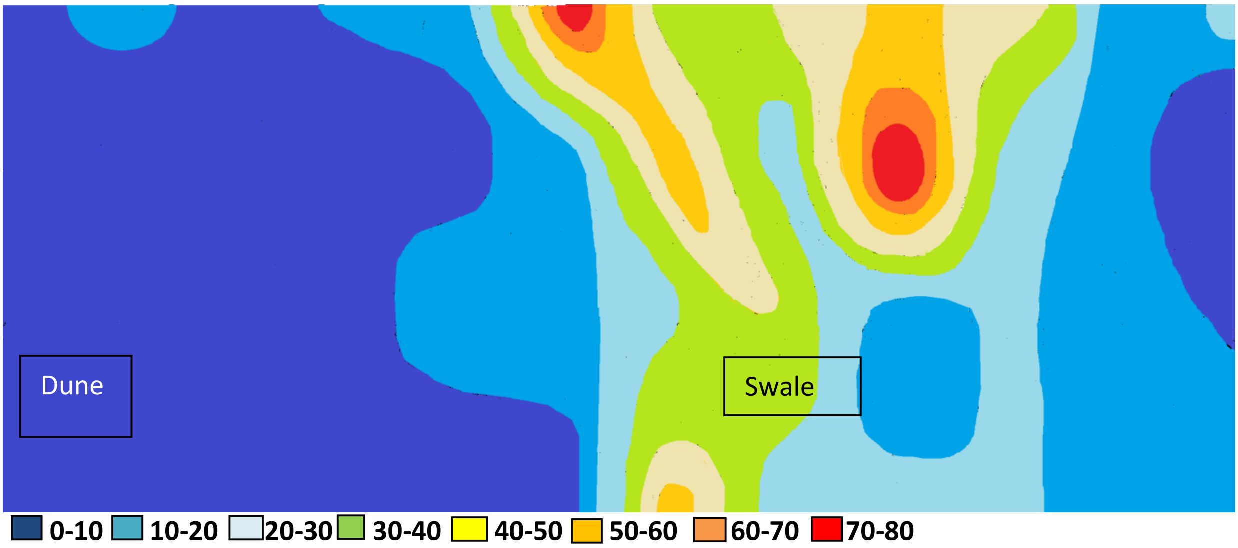

Figure 2: PBI values (measured in the laboratory) across a section in a paddock (120 x 60m) at Karoonda

PBI values were predicted with high accuracy (R^2 = 0.89). Furthermore, there was a strong relationship between PBI and soil moisture content at this site (R^2= 0.73). Thus, an additional model was built from a combination of MIR spectral information plus soil moisture as the independent input variable, improving the prediction of PBI (R^2 = 0.98, Figure 4).

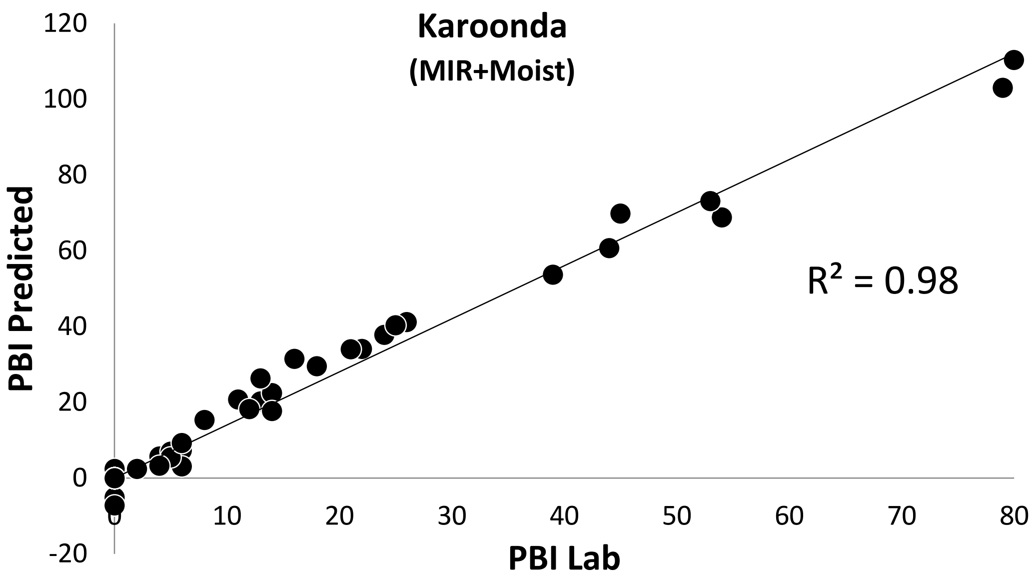

Figure 4: Site-specific validation of PBI values of field-moist Karoonda soils versus laboratory determined PBI. Calibration models derived from PBI data and MIR spectra plus soil moisture contents.

Summary:

Both XRF and MIR technologies have shown promise as tools for measuring plant nutrient concentrations and various soil characteristics in the paddock respectively. Further work is required to assess the impact of moisture in both plant and soil samples before adoption. On site analysis offers huge potential in terms of saving cost and time compared to taking plant or soil samples and sending them to laboratories for chemical analysis.

Further information

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THE UNIVERSITY of ADELAIDE

Nitrogen cycling in cereal stubble retained systems

Vadakattu Gupta[1], Therese McBeath[1], John Kirkegaard[2], Alan Richardson[2], Jonathan Sanderman[1], Stasia Kroker[1], Steve Szarvas[1], Bill Davoren[1], Claire Browne[3] and Rick Llewellyn[1]

[1]CSIRO Agriculture Adelaide,
[2]CSIRO Agriculture Canberra and
[3]BCG, Birchip

Take Home Messages

- The management of cereal stubble affects the microbial activity that influences the cycling of and supply of nutrients (nitrogen (N) and phosphorus) to growing crops.
- Cereal stubble management (standing vs incorporated) increased microbial biomass and N supply potential at sowing in the surface soil.
- The 2014 wheat crop at Karoonda had a harvest index of 0.4 and fertilizer N recovery was 35% which could be partly due to the dry spring conditions.
- Wheat stubble contained 16 kg N/ha and had a C:N ratio of 95 which is common for cereal crop residues in these environments .
- Mineralization during summer resulted in the accumulation of 18-33 kg/ha of mineral N in to 50cm depth across all the treatments.

Aim

To quantify the effect of stubble management on the timing, amount and availability of N released to subsequent crops under varying stubble loads, stubble management and soil environment.

Background

In low fertility agricultural soils of Southern Australia, crop residues are one of the major sources of carbon (C) for soil biota in low fertility agricultural soils of Southern Australia. As a result stubble retention can provide benefits through changes in soil physical, chemical and biological properties. However, the selection of stubble management strategy could have a significant impact on the potential benefits to be gained from the activity of soil biota in their role in carbon turnover, nutrient mineralisation, and subsequent availability of nutrients to crops.
As part of the GRDC project (CSP00186) we are conducting focussed studies at Karoonda in South Australia, Temora in New South Wales and Horsham in Victoria, to strengthen our knowledge on seasonal changes in the (1) biological value of stubble (2) mineralisation: immobilisation balance (ratio) and (3) the direct supply of N from stubble to crops as influenced by stubble management.

Field experiments

During the 2014 crop season wheat was fertilized with ^{15}N isotope labelled Urea applied in two doses (i.e. 2 weeks after sowing and at GS 32) @ 70 kg N/ha. Similar experiments were set up at Horsham, Vic and Temora, NSW (@ 100 kg N / ha). Labelling stubble with ^{15}N helps directly trace the transfer of N from wheat stubble into soil organic matter and to the crop in 2015.

Following the harvest of 2014 wheat crop, replicated stubble retention treatment plots representing nil (stubble cut low and removed), surface (stubble cut low and retained), standing (stubble cut at standard height and retained) and incorporated (cultivation to 10cm depth following harvest) stubble were established on 2014 wheat crop plots adjacent to the ^{15}N labelled area. A uniform mixture of ^{15}N labelled stubble and chaff samples was prepared using the ^{15}N residue collected after the 2014 crop harvest, e.g. stubble cut to 5-10cm length pieces, and applied in microplots (~2 sq M plots) in the 'Incorporated' and 'Slashed' treatments. At Karoonda, stubble was applied @ 2.5t/ha. The trial was sown with Mace wheat on the 21st of May with DAP at 50 kg/ha and Urea at 24 kg/ha.

Surface soil samples were collected during the summer and at sowing and were analysed for microbial biomass (MB) and activity, mineral N and N supply potential (the amount of N that could potentially be supplied through in-season mineralization). Soil and crop residue samples from the microplots were analysed for ^{15}N in the mineral N, decomposing residues and total soil N pools.

Results

Data on grain yield and total plant biomass indicated significant differences in the harvest index between the lower rainfall Karoonda and Horsham sites and the higher rainfall Temora site (Table 1). Crops at all the three sites experienced dry spring and grain filling periods (Figure 1) which had a significant effect on the overall crop performance. These conditions could also be attributed to the lower fertilizer Urea ^{15}N recovery, especially at Horsham and Karoonda (Table 1).

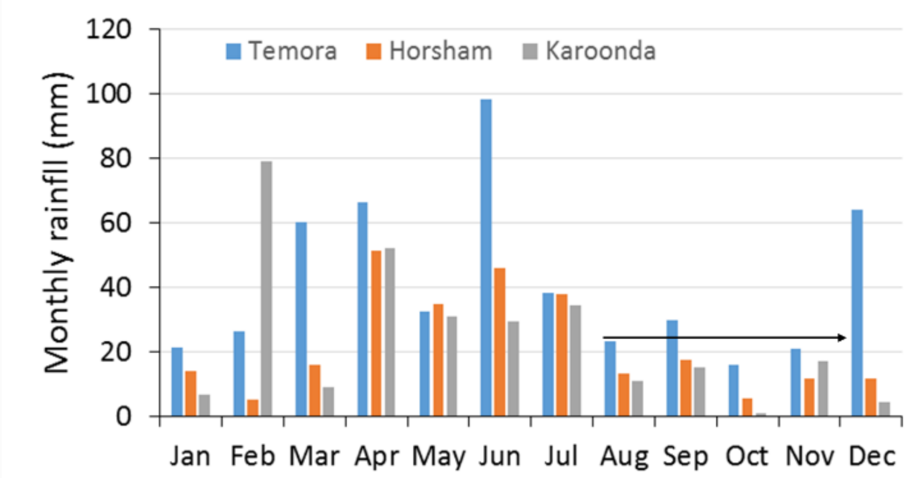

Figure 1. Rainfall distribution during 2014 season at the three field sites

Results from the ^{15}N analysis indicated that the level of ^{15}N enrichment in the stubble fraction (average atom% 5) would allow us to track the fate of stubble N in the 2015 crop season. At Karoonda, stubble at harvest contained 4.5% N which was 24% of the total N taken up compared to 38% at Horsham and Temora.

The large difference with C:N ratio of stubble fraction between Karoonda and Horsham/Temora could be attributed to the inherent soil fertility and seasonal conditions i.e. soil moisture in profile and rainfall. The wider C:N ratio at Karoonda is likely to cause relatively more immobilization (tie-up) of nitrogen during the early stages of stubble decomposition.

Table 1. Crop performance, N uptake and fertilizer N use efficiency the 2014 wheat crop

Location	Yield (t/ha)			N uptake (kg N/ha)		C:N ratio	Fert N
	Grain	Stubble	HI	Total	Stubble	Stubble	uptake*
Karoonda	2.51	3.31	0.41	66	16	95	35%
Horsham	2.19	4.70	0.32	97	38	56	31%
Temora	3.29	8.38	0.28	142	55	57	40%

HI – Harvest Index; * preliminary estimate of fertilizer ^{15}N uptake which doesn't include N in roots

At harvest at Karoonda in December 2014, 49 kg N/ha was found in the soil mineral N pool to 1 metre depth and at sowing the levels ranged between 67 to 83 kg N/ha. Biological mineralization following rainfall events in summer resulted in a significant increase in mineral N in the top 50 cm of the soil profile in all the treatments. Mineral N accumulated in the summer was lowest in the 'surface stubble' treatment (18 kg N/ha) with no significant difference between the other treatments (27-33 kg N/ha). Lack of difference between the different stubble treatments can be attributed to the generally dry summer conditions not supporting decomposition of crop residues, organic matter turnover and mineralization.

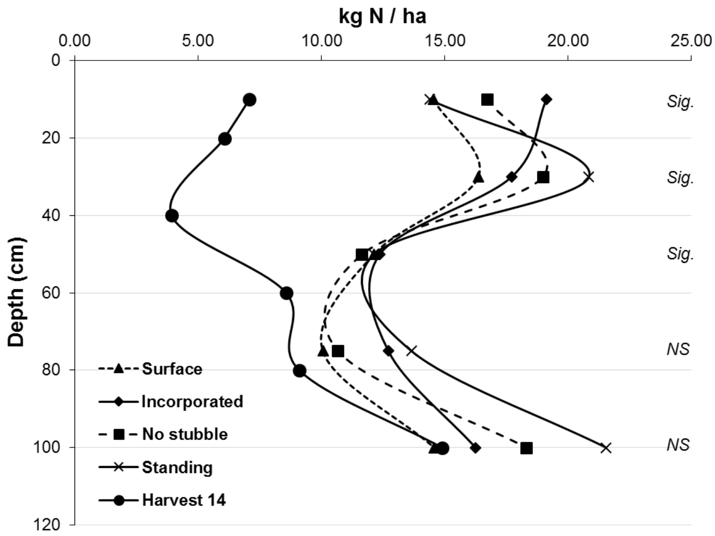

Figure 2. Effect of stubble management on mineral N in soil profile at sowing 2015 compared to that after harvest in 2014 at Karoonda, SA.

Stubble retention significantly increased the amount of microbial biomass C, N supply potential and soil water content in surface 0-10cm soils at sowing, especially in the standing and incorporated treatments compared to the treatment where stubble was removed at harvest (Table 2). There was no difference between treatments in the mineral N and dissolved organic carbon (data not shown, average 19 µg C/g soil) levels.

Stubble retention can influence microbial and nutrient supply properties by providing carbon (energy as MB-C) to support biological activity and also modify soil moisture levels. In the 'no stubble' treatment, root material from the previous wheat crop would have provided the required carbon source for biological activity.

Table 2. Effect of stubble management on microbial biomass and N supply properties in the top 10 cm of soil at sowing in 2015 at Karoonda, SA.

Treatment	MB-C	Min N	N supply potential	Field Moisture
	ug C/g soil			(%)
No stubble	**115.8**	**12.2**	**25.0**	**3.50**
Standing	**128.5**	**12.7**	**28.2**	**4.90**
Incorporated	**126.5**	**12.8**	**27.3**	**3.80**
Surface	**115.0**	**11.2**	**25.2**	**3.60**
LSD (P<0.05)	*10.2*	*NS*	*1.8*	*1.02*

Note: field moisture represent gravimetric water content

Further information

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Management of soilborne Rhizoctonia disease risk in cropping systems

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Take Home Messages

- In 2015, colder soil temperatures during May, June and July and drier soils are key factors for the greater observation of rhizoctonia disease incidence in the southern Mallee region.
- A significant variation in the rhizoctonia inoculum build-up exists between varieties of wheat and barley. Inoculum build-up was generally higher in the barley varieties compared to that in wheat. Observations from 2014 are being verified in 2015 season in field experiments in the Mallee (Karoonda) and in Eyre Peninsula (Nunjikompita).
- A number of soil physical, chemical (organic C and nutrients) and biological (activity and composition) characteristics and seasonal (temperature and rainfall) factors can influence the growth of *R. solani* fungi and the severity of rhizoctonia disease.

Background

Rhizoctonia rootrot is an important soilborne disease in cereal crops in the southern agricultural region (average annual cost $59 million with potential costs $165 million, Brennan and Murray, 2009), especially lower rainfall region. The pathogenic fungus *Rhizoctonia solani* AG8 is a good saprophyte (grows on crop residues and soil organic matter), adapted to dry conditions and lower fertility soils.

Recent research has shown that effective control of rhizoctonia disease impacts requires an integrated management program over multiple years to (i) reduce the pathogen inoculum levels and (ii) control infection and impacts on plant growth. The level of disease incidence is due to a combination of inoculum level, level of soil microbial activity, the amount of soil disturbance below seeding depth, N levels at seeding, soil temperature and moisture during the seedling growth stage. Some new generation fungicides when applied as liquid banding can provide greater efficacy in reducing rhizoctonia impact, however they need to be used as part of an integrated management strategy.

Although, non-cereal crops in rotation have been shown to reduce inoculum levels, reduction of inoculum build-up under cereal varieties is considered to be a useful trait in the cereal phase dominated cropping systems commonly followed in the rainfed regions of Southern and Western Australia.

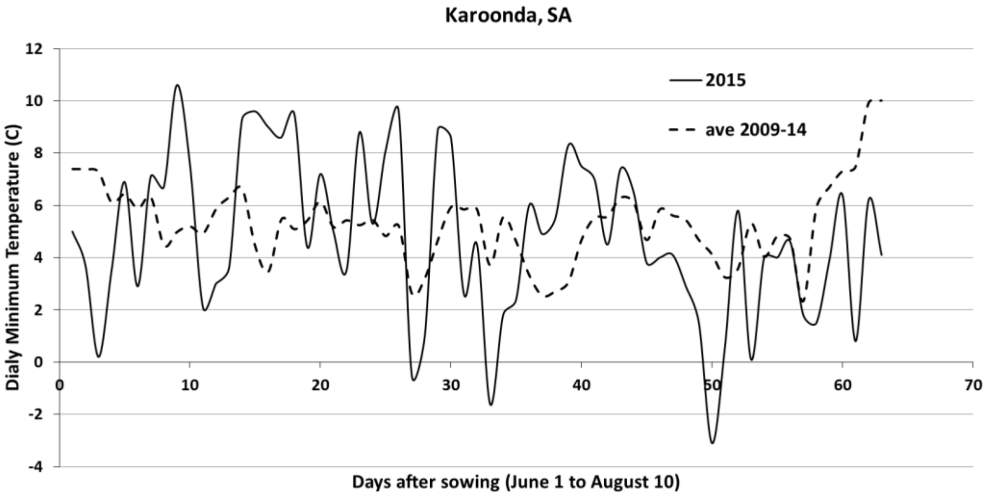
Aim

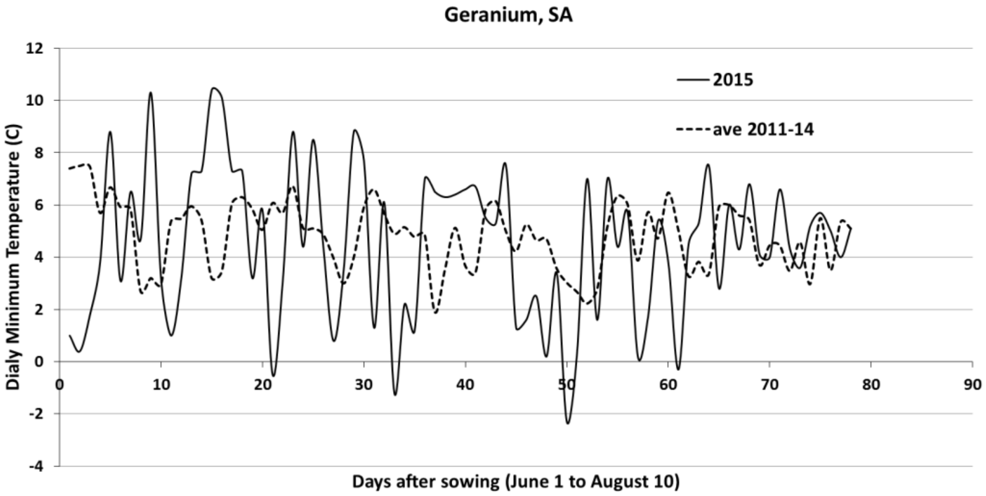
To determine the variation in the build-up of *R. solani* AG8 inoculum between wheat and barley varieties and any link with differences in root distribution using a DNA-based method.

Results

1. Rhizoctonia disease incidence in 2015 cereal crops

In 2015, colder soil temperatures during June and July and drier soils are the key factors for the higher rhizoctonia disease incidence observed in the southern Mallee region. In general, there have been more number of days where Minimum temperatures are below the averages for this time of the year (see the graphs below for Karoonda and Geranium, SA). The trend is similar for Maximum temperatures i.e. lower maximum temperatures. Also, soil moistures are generally on the dry side thus the roots are exposed to cold and drier soils and these conditions are known to slow the rate of root growth and exasperate rhizoctonia impact. These conditions also lead to lower microbial activity which otherwise helps negate rhizoctonia impact.





In spite of higher incidence of rhizoctonia disease, crops with moderate disease levels would benefit from good spring rainfall and soil moisture conditions coupled with adequate soil fertility in the effective root zone to reduce yield losses.

2. Rhizoctonia inoculum build-up in cereal crops

During 2014 crop season, *R. solani* AG8 inoculum and root growth measurements were made in field trials at Lameroo (Barley NVT trial, Rob Wheeler, SARDI) and Geranium (Wheat NVT trial, Rob Wheeler, SARDI) and Streaky Bay (Barley and Wheat experiments conducted by Andrew Ware, SARDI). Soil type at Geranium and Lameroo is Mallee sand loam and in Streaky Bay experiments it was alkaline calcareous sandy loam. Surface soil (0-10 cm) samples collected from the on-row and in-between row were analysed for *R. solani* AG8 and plant root DNA concentrations using the SARDI RDTS DNA methods. Plant samples collected at 8 weeks after sowing from the Streaky Bay experiments were analysed for root disease.

Root disease assessment in the Streaky Bay experiments indicated a very high level of rhizoctonia root rot incidence, e.g. average root disease score of 3.65±0.05 and % infected crowns 75±1.5%. In the NVT trials, above ground patch incidence and severity symptoms also indicated higher disease incidence at the Lameroo barley site; root disease measurements were not feasible in the NVT trials.

In general, *R. solani* AG8 inoculum DNA concentrations in both Wheat and Barley varieties were significantly higher (P<0.01) *on-row* compared to that in the soil from in between row (Table 1) and an overall 4-fold difference between lowest and highest values. Differences in rhizoctonia inoculum levels were generally higher in on-row soils compared to that in in-between-row soils for both wheat and barley. These results confirm our original hypothesis that a significant variation exists in terms of rhizoctonia inoculum build-up between varieties of wheat and barley.

Table 1. Differences in within crop *Rhizoctonia solani* AG8 DNA concentrations in surface soils as influenced by Wheat and Barley varieties during 2014 season.

Location	Crop	*R. solani* AG8 (pg DNA/g soil)	
		on-row	In between row
Lameroo	Barley	684 - 2283	573 - 1276
Streaky Bay	Barley	520 - 1403	289 - 850
	Wheat	485 - 1666	296 - 674
Geranium	Wheat	258 - 1409	106 - 553

Root DNA concentrations were generally lower in the alkaline calcareous soils at Streaky Bay compared to that in the Mallee soils at Geranium and Lameroo (Table 2). There was a significant variation in the wheat and barley root DNA levels between varieties of both wheat and barley supporting the previous evidence that root distribution is a highly variable trait in both wheat and barley crops. Although crop root DNA concentrations were also higher in on-row soils compared to that in in-between-row soils, there was no consistent and significant relationship between root DNA and rhizoctonia DNA levels at both locations (i.e. on-row & in-between-row) and for both crops (R^2 values 0.01 to 0.30).

Table 2. Root distribution differences between Wheat and Barley varieties in surface soils.

Location	Crop	*Root growth* (pg DNA/g soil)	
		on-row	In between row
Lameroo	Barley	33221 - 117967	5234 - 34277
Streaky Bay	Barley	14578 - 46716	5469 - 25534
	Wheat	9873 - 40715	3226 - 34415
Geranium	Wheat	35356 - 213227	17309 - 92071

Our measurements of root distribution was based on one time root DNA measurements only which indicate the DNA concentrations at the time of sampling and don't provide any indication about healthy and diseased roots or root growth pattern. This would require root growth measurements at multiple times during the crop season.

3. Crop and variety trials in 2015

A field experiment was established with different varieties of Wheat (5), Barley (6), Cereal rye (2) and Triticale (2) to determine the pattern of rhizoctonia inoculum build-up within the crop. The trial was established on May 26th using a one pass sowing equipment with knife points. Additionally, Wheat and Barley NVT trials in the Mallee and EP will also be sampled.

Conclusions and Implications

A significant variation in the rhizoctonia inoculum build-up exists between varieties of wheat and barley. Our observations on varietal differences for in-crop the rhizoctonia build-up are based on one year observations only. It is known that a number of soil physical, chemical and biological characteristics and seasonal factors can influence the growth of soil fungi including *R. solani* and the severity of rhizoctonia disease. In addition, soil type and seasonal factors also influence the performance of wheat and barley varieties. Therefore it is critical that these observations are verified in multiple seasons to identify the stability of such variation.

Overall, effective control of rhizoctonia disease in cereal crops requires both the reduction of the pathogen inoculum in the soil prior to seeding and control of the infection process in the crop itself. This has to be achieved through management practices spread over more than one cropping season and through an integrated management strategy.

Acknowledgements

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Further information

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GRDC Factsheet March 2012 (currently being updated);
http://www.grdc.com.au/Resources/Factsheets/2012/03/Management-to-minimise-Rhizoctonia-disease-in-cerals

Improved crop establishment through technological innovation

Robert Pocock
Lampata

Take Home Messages

- Demonstrate the ability of implement steering systems to accurately sow crops.
- Benefits of edge row seeding through increased emergence.
- Benefit to soil through increased stubble residues and cover.

The project is trialling innovative precision seeding technology which uses a steerable drawbar and customised seed boot to precisely place the seed in the moisture zone alongside the previous year's stubble row, while minimising stubble disturbance or blockage, thereby minimising soil erosion. The technology is a significant improvement on "current" 'guidance technologies used by farmers which only 'steer' the tractor. This technology has only recently been developed and there is scope for broad adoption within the Mallee region.

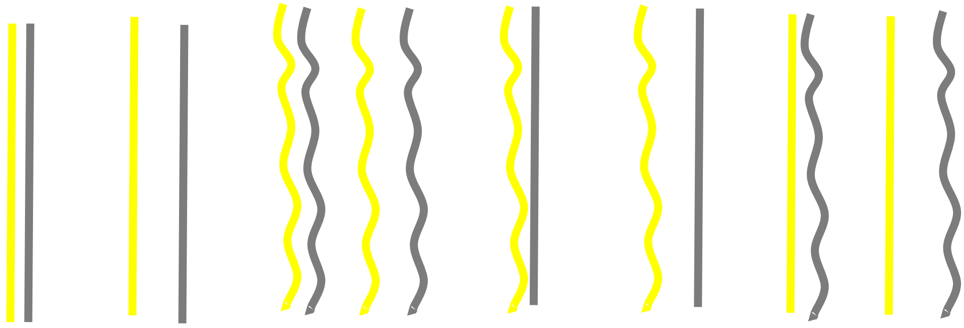
The project directly addresses the need within the low rainfall, non-wetting, sandy soil cropping systems of the SA Mallee for alternative seeding technologies which allow for maximum farm business profitability and environmental sustainability.
Figure 1 demonstrates the water pathways effect in non-wetting soil where this method is going to be of most advantage to many Mallee farmers.

Figure 1: Moisture below previous years crop in non-wetting soils.
Source: https://www.agric.wa.gov.au/water-repellence/effective-furrow-sowing-water-repellent-soils

The trial is sown to demonstrate the ability of implement steering to be used in consecutive years to enable planting against the previous year's crop residue/row to gain access to water and nutrients and therefore enhance seed establishment. The trial site has been sown with two different crops in separate machinery passes to enable a comparison of edge row and mid row sowing within the one season.

This method could be used to more reliably plant break crops in dryer soils than usual and also consider latticing legumes such as peas onto high cut cereals to aid with harvesting and increase ground cover post-harvest.

Demonstration Design:



Plot	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
Trial Site									North of Track
Canola	Pro Trakker Edge Row	Pro Trakker Mid Row	RTK Auto steer Edge Row	RTK Auto steer Mid Row	RTK Auto steer Edge Row	RTK Auto steer Mid Row	Pro Trakker Edge Row	Pro Trakker Mid Row	
Barley	Protrakker	Protrakker	RTK Auto steer	RTK Auto steer	Protrakker	Protrakker	RTK Auto steer	RTK Auto steer	

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Natural Resources Management Board

Seeder tracking and guidance considerations for guided row sowing

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Take Home Messages

- Accurate tractor guidance is not always sufficient for successful guided row sowing
- Specific seeder bar designs with contour following openers and sufficient weight on rigid wheels are important parameters for good tracking stability in operation
- Passive and active implement guidance systems offer various solutions ranging from more cost-effective seeding to quality guided row sowing in challenging conditions.

Ensuring the seeder maintains its intended pass to pass accuracy across a paddock, regardless of terrain, is needed to avoid sowing overlaps and underlaps and to maximise cost-efficiency. Being able to do this repeatedly, from season to season, opens the door for *guided row* sowing techniques (e.g. inter-row, centre-row or near-row). While there is a number of guidance technologies with various capabilities, implement tracking stability is the starting point often overlooked. This article provides an overview of relevant considerations on the subject.

Inter-row (LHS) and centre-row (RHS) crop sowing using precision guidance

1. Benefits of guided inter-row and centre row sowing:

Accurately sowing in relation to previous stubble rows can be critically important to successfully establish crops in challenging situations.

In high residue situations, **inter-row sowing** into standing residue with tine seeders will decrease or cancel residue clumping and interference over the seed rows. With disc seeders, it will control residue hairpinning, especially in combination with residue managers, to ensure good soil to seed contact. In both cases, inter-row sowing significantly improves the efficiency of crop establishment (enabling lower seed rates) while intact stubble rows can effectively shelter seedlings against wind damage and soil moisture loss. Inter-row sowing also reduces take-all and crown rot disease pressure, and improves harvestability of pulse crops.

In non-wetting soils and low fertility sands, especially in marginal moisture conditions, placing seeds in close proximity to the previous stubble row can be beneficial for crop emergence and early vigour, due to the improved moisture and nutrient status within existing furrows relative to the inter-rows.

This is particularly true with furrow sowing systems where localised moisture benefits early in the break are most obvious. **Near-row seeding** - rather than **centre-row seeding** - is generally best to maintain the integrity of furrow moisture (with tine seeders) and minimise residue hairpinning risks (with disk seeders). With a tine seeder, it is best obtained with a side banding attachment.

2. Basics on seeder tracking stability

As a starting base, accurate sub-inch RTK GNSS (GPS) guidance of the tractor - as well as a stable implement tracking ability - are both necessary to achieve guided row sowing. Accurate tractor guidance increasingly uses sophisticated softwares for 'terrain compensation' to accurately steer the tractor hitch to its guidance path, including on uneven or sloped ground.

Pull-type (towed) seeder bars however show variable tracking stability in operation, so accurate auto-steering of the tractor alone may not always be sufficient. Seeder **tracking stability** is influenced by the balance of forces applied onto the bar in relation to the tractor pulling force. The forces applied on the seeder bar include:

- forces at the implement hitch (including tractor pull)
- seeder bar self-weight,
- tyre reactions (including rolling resistance),
- opener draft, penetration and side forces and,
- drag force from a tow-behind air-cart, where applicable.

In a given context, an imbalance in horizontal forces creates a corresponding drift movement, arising from the implement centre of draft trying to line-up with the tractor centre of pull. This **implement drift** can be:

- *random*: in response to fluctuating operating depth and soil variability encountered across the bar or,
- *systematic*: such as due to a poor implement setting or a down-slope offset from weight related forces when operating along a side slope.

Random drift is a significant issue when trying to accurately inter-row sow, while **systematic drift** may sometimes be managed by following the same seeding pathway, season after season. The implement drift is measured by the extent of skew angle in relation to the travel direction. Under a skew angle, 'restoring' forces develop from the implement rigid wheels, as well as from many types of furrow openers (especially single disc openers), which automatically stabilise the bar under equilibrium, containing the implement drift to within a maximum skew angle.

Generally speaking, successful guided row sowing requires the bar to travel straight. With deep multi-rank bars, even a small skew angle (such as on a side slope) quickly becomes incompatible with guided row sowing as it results in highly variable seed furrow spacings. However, a small skew angle with very compact bars (1-2 ranks) is generally acceptable for guided row sowing, often facilitated by following the same seeding pathway, season after season.

3. Seeder bar design principles for good tracking

Awareness of the principles affecting the dynamics of pull-type implement tracking is important to understand how to best control implement drift and maximise the beneficial impacts of 'accurately guided row sowing':

A '**balanced bar**' design is the first requirement for a good tracking stability, this includes symmetrical layouts of both openers and wheels, as well as a uniform bar weight distribution (including in the wing sections). Strategic wheel positioning relative to tines can potentially affect depth gauging accuracy by riding into furrow during skewing, with the potential to either improve or worsen the force imbalance. Wide tyres on walking beam arrangements are typically least sensitive. A longer A-frame gives an advantage by stabilising drift at smaller skew angles. The rule of thumb often referred to -

that the draw-bar length should at least be half the implement width - is to give sufficient restoring power to the rigid wheels.

The need for **constant tillage depth** across the bar is critical, which is best obtained by ground contour following (wheel regulated) openers. This is especially important on wider bars (less stable) and undulating land (inducing larger force imbalances). A poorly set-up bar (both side to side and front to back), and/or inadequate floatation in soft soils, can create a constant force imbalance leading to a systematic drift, either to the left or right. The extent of such systematic drift when sowing up and back on flat land can be checked from the presence of alternate ‘closed’ and ‘open’ spaces between adjacent passes.

Rigid wheels, either singles or as walking beam arrangements on the bar act as rudders, providing restoring forces proportional to the extent of their skid angle (= implement skew angle). Their ‘restoring power’ is improved by a **greater loading weight**, a larger wheel skid angle and a greater distance behind the tractor towing point (i.e. rearmost wheels and long A-frames).

Tow-behind air-cart can add to seeder stability on the flat

The restoring forces of rigid wheels can be very limited on **disc seeders** operating in hard soils, due to the bar weight being absorbed in the main by the discs for penetration, making many disc seeders less capable to track accurately and prone to drifting more suddenly. On the good side however, disc seeder bars are often more compact and in practice a systematic skew angle will have no or reduced impact on seed row spacing variability, improving the chances of successfully inter-row sowing.

To improve the stability of a **tine seeder bar** by maximising the weight acting on the rigid wheels, steep inclined narrow openers should be avoided as they ‘absorb’ some of the bar weight by generating an upward soil reaction – especially when dry seeding in hard soils due to the higher soil forces involved. Conversely, shallow rake angle points (< 60 deg.) with optimum wear at the cutting edge (no underside smearing surfaces) can add to the existing frame weight as well as significantly decrease the seeder draught requirement. Castor wheels absorb frame weight with no capacity to stabilise the implement tracking and so are not helpful for implement stability.

A fully mounted air seeder box located near the rearmost supporting (rigid) wheels of a seeder bar, placing the openers close to the towing tractor (i.e. lesser drift at similar skew angle) should provide the basis for a more stable tracking configuration.

4. Effects of the air-seeder cart

For air-cart + seeder bar towing combinations, a **tow-BETWEEN air-cart** adds another 'link' to the tow-chain, and places the implement further behind an accurately guided tractor. When operating on a side slope, this combination tends to increase the extent of implement drift down-slope, amplified with a near-empty cart less able to resist any down-slope pull.

Conversely, a **tow-BEHIND air-cart** acts as a damping force which, when operating on the flat, tends to reduce the amplitude and suddenness of random implement drift by decreasing the impact of a force imbalance. However, when operating on a side slope, the tow-behind cart drag force contributes to further pulling the implement down slope and increasing its skew angle. To reduce this effect, twin axle air-carts with steerable wheels are preferred over single axle carts, especially when those are fitted with front castor wheels.

5. Field operation

Overall, keeping a slower operating speed is likely to improve guided row sowing accuracy on average. Inter-row sowing is always easier to achieve than near-row sowing as larger margins of error can be afforded with lesser repercussions, especially at row spacings of 300mm and beyond.

In practice, a common source of implement drift is the tendency for the openers to return to last years' row when inter-row sowing especially in harder soil conditions, whereby a force imbalance pushes the openers away from the harder inter-row zone into the weaker furrow side, making a return to the intended inter-row or near row position difficult and erratic. As this problem is more significant with lighter frame seeders, improving stability with a higher load on the seeder wheels can improve the effectiveness of restoring forces on stability. While stability in this case is difficult to obtain at narrow row spacing, an active correction via implement steering can be a solution, as highlighted next.

6. Implement guidance: An overview

Steering solutions focussed on guiding implements to targeted pathways enable the most accurate implement control in practice. These implement-focussed technologies fall under two categories:

Passive implement guidance: These systems rely on combining GNSS (GPS) data from two mounted receivers (tractor + implement) to auto-steer the tractor such that the implement always remains on the intended guidance path. This approach is the cheapest option but requires the tractor to move on and off track in the process of keeping the implement on the targeted path. This concept is best suited to gradual and systematic drift situations, thus should best be combined with stable seeder bars to minimise the impact of transient and sudden random drift. Example technologies include John Deere *IGuide*™, Trimble® *TrueGuide*®.

Active implement guidance: These systems can guide the implement independently of the tractor, which is guided separately. Active implement guidance is more expensive but its cost benefit should be assessed in light of the impacts of the extra accuracy achieved on the cropping returns. This technology comprises dedicated 'auto-steering' systems for the implement, which fall under two main concepts:

i) <u>HITCH CORRECTION</u>**:** Here, the tractor draw-bar or the implement hitch tongue is hydraulically adjusted side to side to guide a pull-type implement back on track. Options also exist for fully mounted implements with using a hydraulic side-shift fitted on the 3 point hitch. A system controller reacts to either GNSS (GPS) receiver position data from the implement itself or to local positioning data from a stubble row or furrow tracking sensor fitted to the implement. This approach adjusts for implement off-tracking only up to a maximum offset and without correcting any skew angle. With large offset drift, this approach may not be suitable. Example such guidance systems include SunCo Farm Equipment *AcuraTrak*™, John Deere hitch-based *iSteer*, Automatic Mfg *Navigator*™, MBW *Pro-Trakker*™ , Seed Hawk *SBR technology* and *I-till*™. In post-crop emergence applications, specific sensors can include camera based computer vision systems, reading 'green' row positions over background, such as with the Garford *Robocrop*™.

ii) <u>IMPLEMENT STEERING KIT</u>**:** Here, the implement frame is actively directed over the guidance path using steerable implement wheels or disc blade kits to generate a corrective force. Their action is controlled by GNSS (GPS) receiver position data from both the implement and the tractor. This approach corrects any implement skew angle down to zero in order to track behind an accurately guided tractor over a common guidance path. Provided they achieve sufficient penetration, piloted disc blades are able to generate larger restoring forces than steerable, surface running wheels. Example technologies Include John Deere wheel-kit *iSteer,* Orthman Agriculture *Shadow Tracker*™ and *Tracker IV*™.

7. Conclusion

Maximising implement tracking stability - via design, setting up and operational considerations - combined with accurate (2cm) tractor guidance should be the first port of call when aiming for guided row sowing. A number of tractor-path correction softwares and implement auto-steer technologies can further improve the reliability of guided row sowing across more challenging and variable paddock terrains. The returns on investment should be assessed in light of what each technology can actually deliver.

Further information

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Seeding systems for the Mallee: What's the latest?

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Take Home Messages

- Seeding system comparisons in Mallee soil types during 2014 suggest there is potential to improve crop performance in stony and sand hill areas of typical Mallee paddocks, where paired row and independent seeding systems performed better.
- In non-wetting sand this season, clearing top soil onto the inter-row was the most effective way to maximise wheat emergence, followed by centre-row sowing.
- In marginal moisture conditions, fertiliser toxicity can be significant with single shoot systems.
- 'Loose mulch' concept is useful to maximise seed germination in marginal moisture situations.

Getting the seeder set-up right is critical for rapid seed germination, uniform crop emergence and good early crop vigour. The role of the seeder is to establish an optimum and uniform plant density regardless of the crop, season and soil combination, but due to the diverse nature of Mallee soils and season openings, a 'one fits all' solution still remains a challenge.

Fig. 1: Seeding system suitability for the MALLEE integrates issues of technology design, setting up and field operation

1. Advanced seeding systems trial – Murrayville, VIC (2014)

Mallee farmer feedback from the Vic Mallee near Murrayville highlighted a strong interest in new seeding system solutions (e.g. Fig. 1), looking for better adapted technologies to the soil variability of Mallee environment. The greatest issue reported by farmers was the inability to maintain a consistent and accurate seeding depth across all soil types in dune-swale paddocks, with crops sown too shallow on stony soils and too deep on sandy rises. As a result, crop establishment is often highly variable, especially with canola, and thin/bare paddock areas become subject to wind erosion.

During 2014, a trial was implemented comparing 8 double shoot seeding systems across 3 soil types (e.g. from stones to mid-slope and sand hill, over a 205m length of plot), with sowing 2 crops (wheat, canola). The 4 ha trial site was characterized with EM38, surface stoniness, stubble cover and top soil moisture at seeding. Crop establishment, seeding depth, NDVI and grain yield were measured. Each seeding system treatments consisted of wheat and canola strips arranged in a randomised block design and encompassing 12 'soil type' subplots x 4 replications. Results for the wheat crop are reported below.

CL Plus Grenade wheat was sown at 65kg/ha (= 175 seeds/m^2) together with 65kg/ha Granulock Z14S (=13N+9P+5S) split or deep banded, into very moist soil conditions, benefiting from 29mm follow-up rainfall until 28 days after sowing. 2014 annual rainfall was 310mm (179mm GSR), following a significant rainfall deficit accumulating over Jul-Oct.

Table 1. Double shoot seeding systems evaluated in the 2014 Murrayville trial

T0 (Control)	<u>District system:</u> Agmaster knife point rubber boot 55mm V press wheels
T1	Agmaster knife point rubber boot 150mm wide V press wheel
T2	Flexible boot: Agmor UBV3 polyurethane boot
T3	Paired row 1: knife point *RootBoot* + 100mm flat press wheel
T4	Paired row 2: Flexi-Coil *Stealth* opener + 100mm flat press wheel
T5	Contour following: Triple disc Yetter/K-Hart
T6	Contour following: *Seedhawk* opener
T7	Knife point + contour following double disc split seeding system

The average wheat site establishment was 140 p/m^2 (= 80% emergence). Under the good moisture conditions, the seeding system variation was limited and ranged from 73-85% on average across all soil types. In contrast the measured variation due to soil-type was larger, ranging from 65-96%. Mean seeding depth data grouped the 8 systems into 'shallow' (n=3, d=18-24mm, stdev=5-6mm) and 'deep' (n=5, d=30-34mm, stdev=6-8mm).

While the best wheat establishment was obtained in the reference mid-slope soil, all seeding systems suffered some reduction in crop establishment in the other two soil types. Stoniness reached up to 27% in some subplots highlighting a significant negative correlation with plant emergence (e.g. -6.3% emergence loss per 10% stone cover). Emergence penalties in stones reached up to 21% (with T0 and T2), however were not significant under T3 (paired row) and T6 (Seedhawk).

Emergence loss on the sand hill reached up to 15% (with T0), but were least under paired row systems (T3, T4) and T6 (Seedhawk). Overall, paired row systems performed significantly better across the 3 soil types, by being least affected by emergence reduction in stones and on the sand hill (See Fig. 2). Similar benefits could be found with T6 (Seedhawk) in the stones only (see Fig. 3). All other systems showed similar crop emergence patterns across soil types to T0, while T2 (Agmor) performed consistently lower than T0, explained by its shallowest seeding depth (20mm).

At harvest, seeding system differences were largely reduced, while the effect of soil type remained very strong, recording a significant positive grain yield correlation with EM38 data (driven by water holding capacity under a tight season finish). While the control yielded the lowest (3-4% below site average), the independent systems (T6, T7) yielded best in stones (+4-7% above average), while paired row systems (T3, T4) yielded best (+4%) in the reference mid-slope soil. No significant differences between seeding systems eventuated on the sand hill.

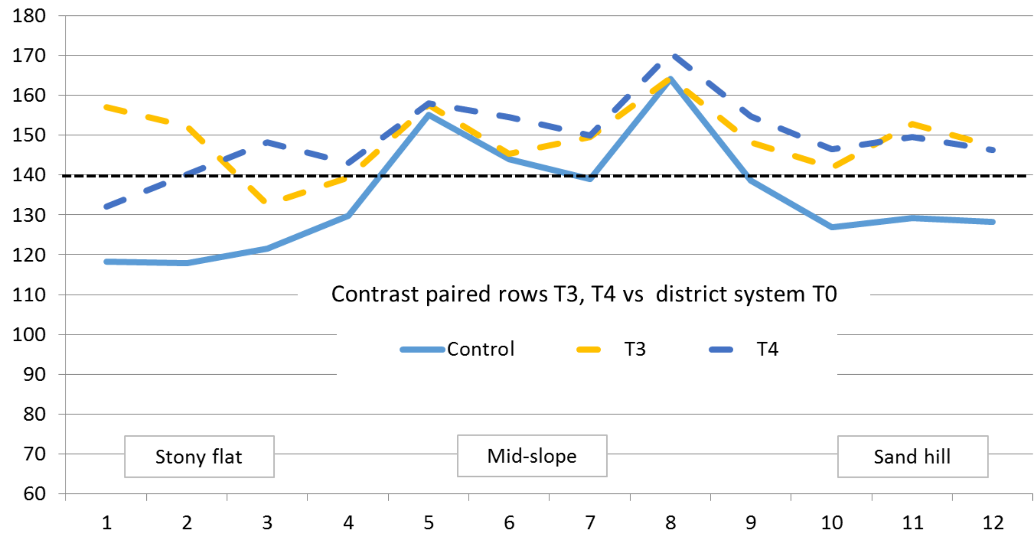

Fig. 2: Paired row system WHEAT plant density (p/m^2) patterns along 12 'soil-type' subplots and relative to the control (T0) (Data = running average n = 2)

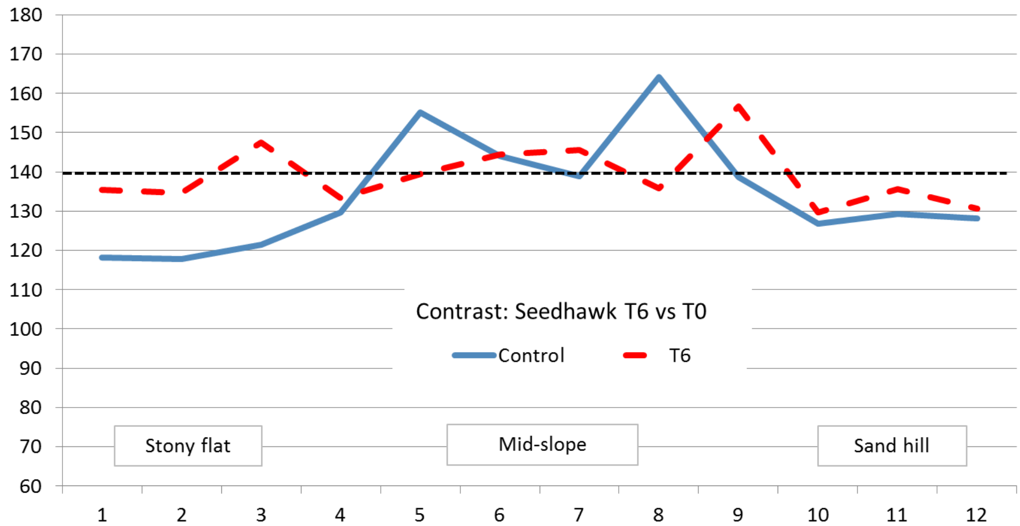

Fig. 3: Seedhawk system WHEAT plant density (p/m^2) pattern along 12 'soil-type' subplots and relative to the control (T0) (Data = running average n = 2)

The data suggest there is potential to improve crop response in both stony and sand hill areas of typical Mallee paddocks, and overall lift crop performance with improved seeding systems. Paired row and independent side banding systems showed a potential to improve crop performance, especially on the sand hill, possibly due to the combined effects of the seed placed on undisturbed ledge and a flatter furrow finish. More work is needed to validate these early recommendations.

2. Non-wetting sands: the benefits of soil disturbance at seeding

Non-wetting soils present great challenges with crop establishment due to their gradual and localised wetting patterns, leading to slow and patchy seedling emergence, staggered over time, sometimes continuing up to 3-4 months post-seeding, depending on rainfall and seed placement. Wheat crop establishment into non-wetting sands at Moorlands this season showed interesting responses to seeding system technology. The trial seeding context was as follows:

- *CL Plus Grenade* wheat sown at 85kg/ha (196 seeds / m2) on 21-24 May 2015
- Fertiliser applied at sowing: 13N+9P+12S+0.4Zn
- Low moisture and drying soil conditions at sowing

- Rainfall deficit post sowing (10mm rainfall in 6 events over 4 weeks)
- 1st significant rainfall post-sowing: 20mm at 52 days.
- Seedling emergence still occurring at 70-75 days after sowing (DAS)

The trial is part of a Rhizoctonia management project led by SARDI investigating the impact of liquid fungicides at sowing. The snapshot crop establishment data at 28 DAS showed the following – see also Fig. 4:

- The 'Mallee standard' double shoot knife point furrow opener (followed by twin disc sowing system) established reasonably well, recording 77-87% wheat emergence.

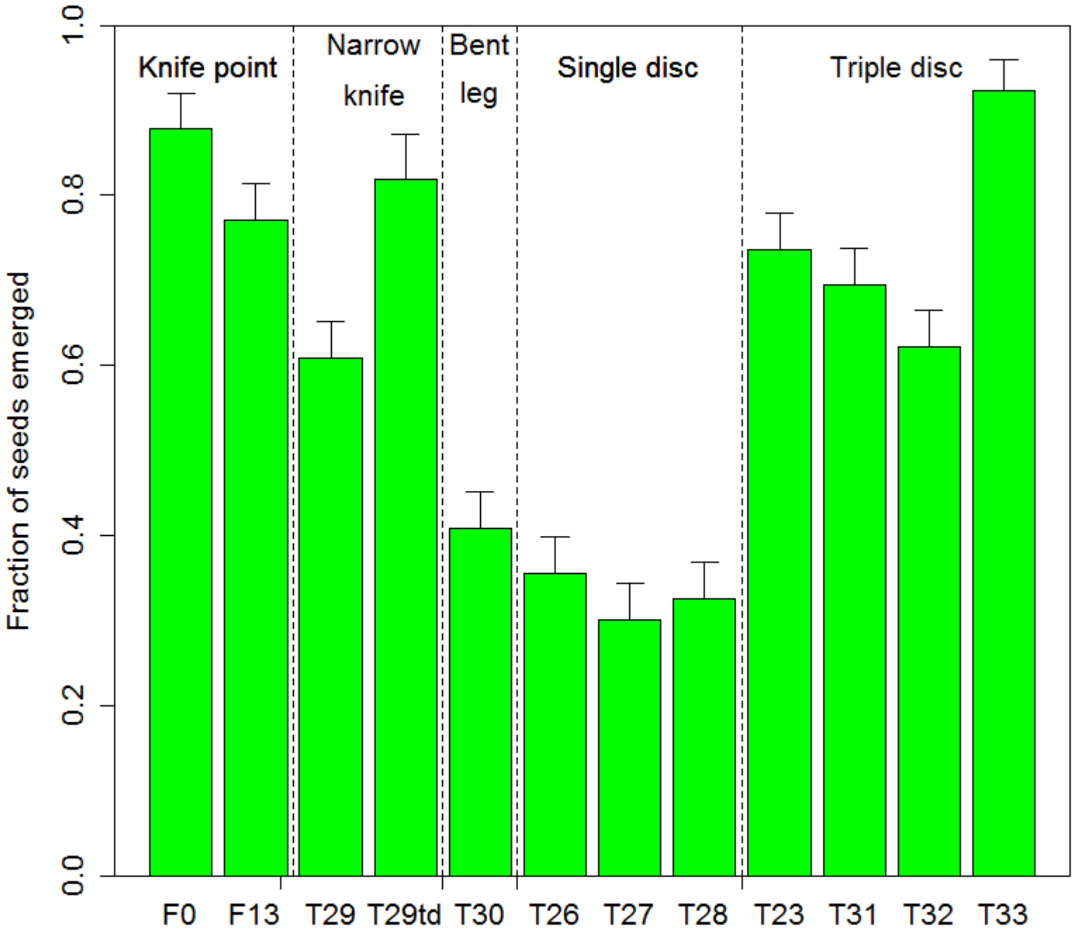

Fig. 4: Wheat crop establishment overview at 28 DAS at the 2015 Moorlands site (error bars = 1 std error)

- Wheat crop establishment significantly worsened under single shoot systems (due to fertiliser toxicity), especially when combined with lower soil disturbance, e.g.
  - single shoot, single disc system (30-35% emergence)
  - bentleg opener (e.g. furrow loosening without soil throw) + single shoot twin disc sowing system (40%)
  - single shoot, shallow till seeding point (61% with fertiliser, 82% no fertiliser)
  - double shoot, triple disc system, 6 vs 11kph speed (62-73% emergence, slightly better with higher speed).
- The best treatment (93% emergence –T33 in Fig. 4) was obtained by adding a shallow operating scooping share ('scoop' - see Fig. 5) ahead of the triple disc, to clear away the top 3-4cm soil layer onto the inter-row zone, and assist with placing seeds into moist soil. This scoop requires low operating speed (5km/h) at the 25cm row spacing. Paddock-ready 'scoop' solutions would need

testing but could include concepts based on modified front coulters or knife points to emphasize an effective surface soil clearing at common operating speeds.

Note: In this trial, neither *Sakura*™ pre-em herbicide (applied IBS) nor *Uniform*® liquid fungicide applied in-furrow had an effect on crop emergence.

Fig. 5: Triple disc with preceding scooping share (LHS) gave the best wheat crop establishment at the 2015 Moorlands site (RHS at 71 DAS)

3. Inter-row sowing - or NOT - in non-wetting sands

At the same Moorlands site this season, CENTRE-ROW sowing - using a triple disc seeding system, significantly improved wheat crop establishment (by up to 29%) - relative to inter-row sowing. This beneficial effect has been observed in many other trials (including interstate) and from paddock experiences and is explained by an improved wetting likely facilitated by existing root systems and water harvesting furrow shape, as well as a possibly a more active microbial activity in the furrow rhizosphere more effectively breaking down waxy compounds.
At this site, seed row establishment was also found best when coinciding with previous traffic lanes (whether across or along seed rows), acting as a depressed surface layer benefiting from water harvesting and possibly promoting a greater uniformity of wetting/moisture retention from the associated compaction.

Fig. 6: Wheat crop establishment at 28 DAS under inter-row (LHS) and centre-row sowing (RHS) at the 2015 Moorlands non-wetting site

Acknowledgements:

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- Farmer collaborators in SA and VIC Mallee
- Seeding system manufacturers and importers

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Making water repellent soils more productive

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Take Home Messages

- Zero/ no-till promotes water infiltration in water repellent soils
- On-row seeding benefits plant emergence and crop performance
- Dry seeding can worsen the effects of repellence. Where feasible leave water repellent paddocks to last in the sowing program to avoid dry soil

Causes of Water Repellency

- Plants produce waxes in their leaves and stems to create a waterproof coating that protects them from drying out and helps defend against environmental stresses. When plant matter breaks down, the hydrophobic waxes fuse onto soil particles to create water repellent soil.
- This is more commonly observed in sandy soils due to their large sand grain size and low clay content; a smaller soil surface area to volume ratio means a smaller amount of plant waxes create greater expression of repellency than in a finer loam or clay textured soil.
- Usually, water repellent soil layers form in the top 0-10 cm where the organic matter (retained stubble) is concentrated.
- Waxes can be broken down by wax-degrading microbes (e.g. *Actinobacteria*). A seasonal effect of increasing soil water repellency is observed during summer as plant waxes fuse onto soil particles in the heat, and the lack of soil water causes wax-degrading microbes to be dormant. Water repellency is reduced in winter months when microbes become more active with access to soil moisture.

Measurements

Soil water repellency

Soil is sampled at 0-5 cm and 5-10 cm within the crop row and inter-row. Soil is oven-dried at 105^{o}C and sieved <2mm. Severity of repellency is measured by MED (Molarity of Ethanol Drop). MED values of 0.2 – 1.0 are considered to be slightly repellent; an MED concentration of 1.2 – 2.2 indicates moderately repellency; severe repellency occurs between MED values 2.4 – 3.0; and an MED above 3.0 is considered to be very severely repellent.

Soil water

Volumetric soil water content is measured in the top 12 cm of each plot in the row and inter-row using a hand-held time domain reflectometer sensor (HHTDR) (HydroSense; Campbell Scientific, Logan, Utah). Permanent TDR probes have been set up in crop rows and inter-row in some trials to provide continuous soil water data under different treatments. Water infiltration patterns are visualised by spraying a strong blue dye solution on an area of the crop and digging a face across the soil profile.

Plant performance

Surveys of seedling emergence are done to determine any differences in germination rates between treatments. The numbers of grain heads are also surveyed, which can be used to estimate potential yield in the case of crop loss later in the season. Average plot yields are measured by contract trial harvesting.

Trial Sites and Treatments

Site	Year	Burn vs. Retain Stubble	Graze vs. Retain Stubble	No-till vs. cultivate	Dry vs. wet sow	On- vs. inter-row sow	Wetter	Liming	Innoculate & Irrigate
Munglinup	2008-	✓		✓					
Pingrup	2013-				✓	✓	✓		
Kojonup	2014				✓			✓	
Wanilla (SA)	2011-2014	✓	✓	✓					
Calingiri	2012-2013					✓			
Wharminda (SA)	2015				✓	✓	✓		
Hopetoun	2008-2012	✓		✓					
Munglinup	2008-2012		✓	✓					
Woogenellup	1996-2000							✓	✓

Findings

Zero/no-till promotes water infiltration in water repellents soils

Findings in Munglinup showed that under no-till and stubble retention, despite being more repellent due to higher stubble loads, soils were wetter and crops performed better than plots where stubble was burned and soil was cultivated.

- By not disturbing soil, old root pathways are preserved and act as a conduit ('bio pores') for water entry.
- Soil water pathways persist well into the next season, but are destroyed by cultivation.
- Following restoration of no-till and stubble retention in 2012 to plots previously burned and cultivated in 2008-2011, water infiltration and crop performance of burned plots had still not recovered by the end of 2014.
- Zero/no-till can be used following amelioration techniques such as mouldboard ploughing, spading and claying to help establish root pathways and reduce erosion.

On-row seeding benefits plant emergence and crop performance

- Trials at Calingiri and Pingrup have shown that seeding near the previous year's crop row ('on-row seeding') improves plant emergence due to more available soil water.
- The inter-row is consistently more repellent and drier than the preserved crop-row.

Dry seeding can worsen repellence

- Anecdotal evidence from farmers indicates that plants emerge poorly in dry-sown water repellent soils.
- Demonstrated in the laboratory: if non-wetting soils are disturbed when they are dry, soil structure collapses and repellency becomes worse. New research is visualizing the packing of particles at a micro-scale and is expected to lead to strategies to overcome the problem.

Bacteria can breakdown waxes responsible for repellency

- Wax-degrading microbes need water to function, however repellent soils restrict microbial activity because they resist wetting up.
- This was confirmed by a 4-year field trial in Woogenellup which demonstrated that irrigation improves microbial activity and reduces repellency over time.
- Liming of acid soils at Woogenellup improved water infiltration particularly after the break of season, and increased naturally-occurring populations of wax-degrading bacteria 10-fold, resulting in reduced water repellency for the duration of the 4-year trial.

Acknowledgements

It is gratefully acknowledged that this research is funded by the Grains Research & Development Corporation (GRDC). We also thank growers Doc Fetherstonhaugh, Stott Redman, Gavin Gibson, Grant Cooper, Paul Hicks, James Hope, John Taylor, Steve Waters and Caleb Prime for allowing us to conduct research on their properties.

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CSIRO

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Testing on-row and inter-row seeding across soil types

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CSIRO Agriculture

Take Home Messages

- At the time of sowing the previous crop row was able to accumulate significantly more surface soil water than the inter-row position.
- Water repellence on sandy soil has had a significant effect on crop establishment in 2015 and on-row (or near-row) sowing has measurably improved establishment and early biomass.
- Delayed and on-row sowing both reduced early crop N supply.
- Managing for temporary reductions in early crop N supply due to either on-row or delayed sowing are like to prove beneficial in sands.
- There were some measurable increases in disease risk as a result of on-row sowing.

Background

Trials at the Karoonda site over recent years have highlighted the benefits of strong early crop establishment and nutrition, particularly on sands. Non-wetting (or water repellent) sands have presented additional challenges. Global Positional System (GPS) guided seeding is increasingly common and presents the opportunity for strategic placement of seed in relation to last season's crop rows. In 2014, trials were established at Karoonda and Loxton to examine when and where on-row (or near-on-row) seeding may have benefits over inter-row seeding in stubble-retained systems.
In 2015 Plots were sown with Mace wheat at two times:

- TOS 1: 27th April
- TOS 2: 21st May

For each time of sowing, this year's crop was sown either on or very close to the previous year's crop row or between last year's crop row. The row spacing used was 28 cm. All plots were sown into cereal stubble and received DAP @ 50 kg/ha and Urea @ 24 kg/ha on two main soil types (swale and dune). Measurements will include disease risk, disease incidence, starting nitrogen (N) and water, microbial activity, N supply potential, crop emergence, biomass, weed density and biomass (to be reported separately) and crop yield.

Results

Weather

After a significant rain in January, conditions were dry for the remainder of the fallow. There was average rainfall in April (31mm) with deficiencies in May (30 mm), and especially in June (6 mm). Rainfall in July and August has returned the cumulative rainfall for the season (226mm) to close to average (Figure 1).

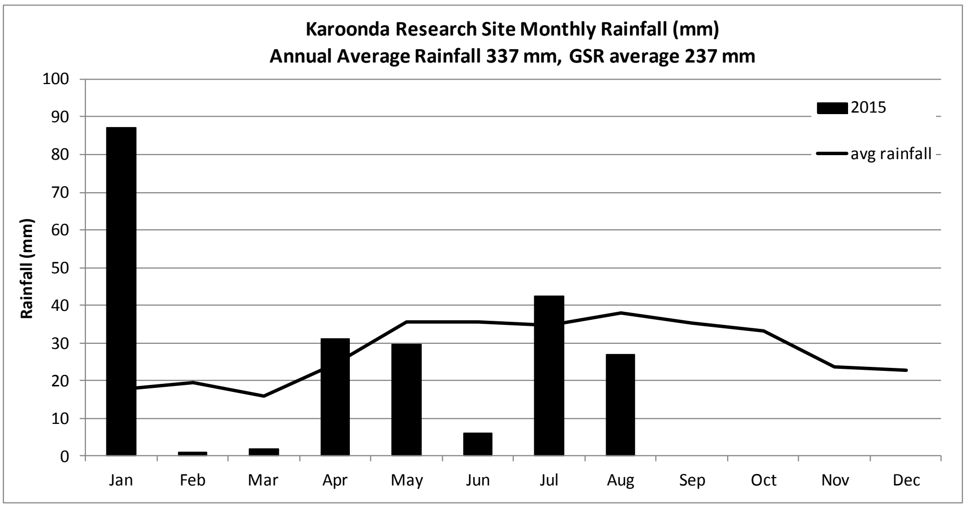

Figure 1. 2015 Monthly rainfall for Karoonda trial site (as of Aug 20th) compared with the average monthly rainfall.

Monthly rainfall data does not adequately represent the difficult conditions for crop establishment in early 2015, particularly for May sown plots. The expression of water repellence on sands was severe in places, which combined with small and infrequent rain events, led to variable wetting up of the surface soil. This has resulted in some of the patchiest, and in places poorest crop establishment on sands that we have measured at the site.

Soil Water

Measurements of surface (top 10 cm) soil water showed two important relationships. At both sowing dates, on-row sowing was into a higher level of surface moisture than inter-row sowing, and secondly that the on-row position accumulated more water than the inter-row position between the two sowing dates. In a season when water repellence expression has been quite marked, this difference has proven quite important.

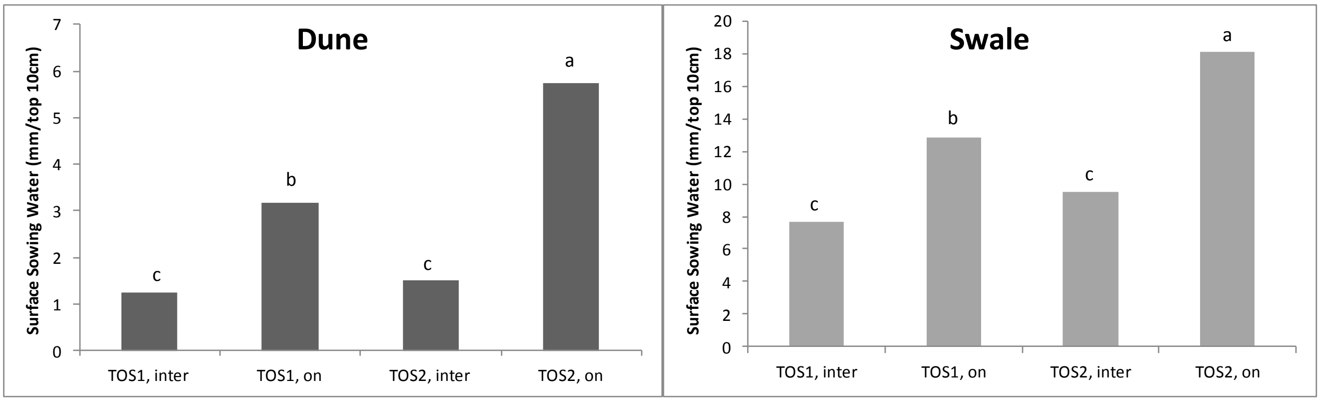

Figure 2. Soil water (mm) measured in the top 10cm layer at sowing at the first (TOS1) and second (TOS2) sowing date for plots sown on-row (on) and inter-row (inter). Within a soil type, a column annotated with a different letter has a significantly different amount of surface soil water.

Nutrition

There is a clear difference in the inherent fertility between the two soil types on which the sowing row placement strategies have been tested with higher levels of microbial biomass, mineral N and N supply potential on the swale (Table 1). The early sowing date had higher levels of mineral N and N supply potential with a lower level of microbial biomass. The increased level of microbial biomass without an increase in mineral N and N supply potential suggests that there was some immobilisation of N between the two sowing dates (Table 1). The wider ratio between dissolved organic C and N (DOC:DON) on the row is indicative of the presence of a higher load of wheat stubble on-row. Based on the wide DOC:DON and the increase in microbial biomass as the soil started to wet up early in the season it is likely that this stubble has not undergone very much decomposition during the fallow (Table 1). Managing for temporary reductions in early crop N supply due to either on-row sowing or a delay in sowing are likely to prove beneficial.

Table 1. Microbial biomass carbon (C), mineral N and N supply potential on-row and inter-row at the time of sowing in 2015. Within a treatment factor (Soil, row position, sowing date) and measurement a result annotated with a different letter is significantly different from another.

Sowing Treatment	Microbial biomass C	Mineral N	N supply potential	[1]DOC:DON
	µg/ g soil (0-10cm depth)			
Dune	136[b]	9.4[b]	21.4[b]	14[a]
Swale	314[a]	18.8[a]	48.4[a]	11[b]
Inter-row	203[b]	13.8	33.1	11[b]
On-row	246[a]	14.4	36.7	15[a]
TOS 1	205[b]	17.3[a]	38.2[a]	12[b]
TOS 2	245[a]	10.8[b]	31.6[b]	14[a]

[1]DOC:DON, dissolved organic carbon: dissolved organic nitrogen

Disease

Table 2. Soilborne disease risk ratings for Takeall (Ggt), Rhizoctonia (RsAG8) and Fusarium crown rot (*F. pseudograminearum*) in soil on last year's crop rows and in the inter-row at the time of sowing in 2015.

	Takeall (Ggt)		Rhizoctonia		Fusarium Crown Rot	
Sowing Treatment	TOS 1	TOS 2	TOS 1	TOS 2	TOS 1	TOS 2
Dune inter-row	Low	Low	Low	Medium	Low	High
Dune on-row	Low	Medium	Medium	Medium	Medium	High
Swale inter-row	Low	Low	Medium	Low	Medium	Low
Swale on-row	Low	Medium	High	Medium	High	High

Inoculum levels and resulting disease risk Takeall was generally higher on-row compared to inter-row for the later time of sowing while Rhizoctonia and Fusarium had higher disease risk on-row compared to inter-row in most treatments (Table 2). In most cases on-row sowing posed a similar or higher disease risk with the later time of sowing.

Crop Establishment and Biomass at GS31 (first node)

Establishment was influenced by time of sowing and row placement on the dune, but they were not found to interact. Earlier sowing on-row resulted in 2-3 times better plant counts than the alternative treatments. As expected, the biomass accumulated by GS31 was affect by sowing date on both soil types, with earlier sowing resulting in up to 3 times more biomass on the dune. Row placement only affected biomass production on the dune, but the effect was substantial with 2 times more biomass with on-row sowing compared with inter-row sowing (Table 3)

Table 3. Crop establishment (plants/m^2) and biomass at first node (GS31, t/ha). Within a treatment factor (Soil, row position, sowing date) and measurement a result annotated with a different letter is significantly different from another.

Sowing Treatment	Establishment (plants/m^2)	GS31 biomass (t/ha
Dune	44^b	0.37^b
Inter-row	20^b	0.22^b
On-row	69^a	0.51^a
TOS 1	60^a	0.59^a
TOS 2	29^b	0.15^b
Swale	129^a	1.13^a
Inter-row	121	1.15
On-row	137	1.10
TOS 1	127	1.44^a
TOS 2	130	0.81^b

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Six years of continuous wheat with variable rate nitrogen at Karoonda

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Take Home Messages

- Cereals grown on sands showed continued responses to N inputs at levels higher (40 kg N/ha vs.9 kg N/ha) while heavier soils on the swales maintained production with nil or low N input.
- A net N audit suggests the possibility of a significant decline of soil N reserves at low levels of inputs on the more productive soils.
- Break effects derived from legume based pastures are no longer present
- Maintaining N in the system using N inputs of fertiliser and/or legume based breaks is required on sandy soils to maintain production and profit.
- Higher N application (40 kg/ha) upfront on the sands has been most profitable but other constraints are still limiting N efficiency and yield on the sandy soils.

Background

A field experiment was established in 2009 at the Mallee Sustainable Farming on-farm research site near Karoonda (Lowaldie) to test soil-specific strategies for increasing the profitability of cereal-based rotations. A range of treatments were used across a heavy swale through to deep sand dune toposequence. Results have been reported annually through MSF. Only a limited set of measurements are now taken on the trial and the most recent results are presented here.

Treatments

Wheat crops have been sown each May from 2009-2015. The 2014 wheat variety was Corack. The 2015 wheat variety is Mace. The treatments applied across the soil types are:

- Nil fertiliser inputs
- Low fertiliser inputs (9kg N/ha and 10 kg P/ha applied as DAP at sowing)
- Higher N inputs at sowing (40 kg N/ha with 10 kg P/ha)
- Higher N inputs split (9 kg N/ha at sowing and 31 kg N/ha at tillering with 10kg P/ha at sowing).
- Volunteer pasture in 2010 followed by wheat managed with 9kg N/ha and 10 kg P/ha applied as DAP at sowing for the remainder of the experiment.

Key results

Higher rates of N were important for increasing yield on all sandy topsoils. On the least fertile sands, the addition of 9 kg N/ha at sowing was not enough to overcome N deficiency and provide a significant N response compared to the control (Table 1). Yield increases were up to 300% (0.5 vs. 1.5 t/ha at 40 kg N/ha applied). Yield on the swale has been maintained without fertiliser N inputs since 2010, but there have been some effects on protein (data not shown). Any yield benefit that has been measured as a result of a volunteer pasture in 2010 and associated N supply and disease break effects has now disappeared.

Table 1. Wheat yield in 2014 after same treatments on continuous wheat since 2010.

Soil	Nil Fertiliser	9kg N/ha Upfront	40 kg N/ha Upfront	40 kg N/ha Split	Volunteer Pasture 2010	LSD
Swale	2.7	2.8	3.0	3.0	2.8	NS
Mid-slope	2.0	2.5	3.5	3.5	2.6	0.4
Dune-crest	0.5	0.8	1.6	1.3	1.1	0.4
Dune	0.8	1.1	2.1	1.8	1.2	0.4

X shaded cells denotes significantly greater than Nil Fertiliser, X shaded cells denotes significantly greater than nil and district practice. LSD is least significant difference.

While yields have been maintained without fertiliser on the swale, the N balance was negative (i.e. more N has been exported than has been supplied) (Table 2). This means soil organic N reserves are probably falling. The low N input treatments (over the five year period) resulted in a negative balance for N on the mid-slopes with a neutral balance at 40 kg N/ha input. On the low yielding dune-crest, the N balance was positive for all levels of fertiliser N input and up to +117 kg N/ha (Table 2). This is indicative of the presence of other constraints to production on the sandy soils (e.g. soilborne diseases, poor fertility, physical constraints, increased weed competition) limiting the ability of the crop to use the applied N. On the dune, there was a positive N balance for high inputs of N at 54-60 kg N/ha over the five year period (Table 2).

Table 2. The net N balance (kg N/ha) following five year implementation of treatments (2010-2014).

Soil	Nil Fertiliser	9kg N/ha Upfront	40 kg N/ha Upfront	40 kg N/ha Split	Volunteer Pasture 2010
Swale	-210 d	-156 c	-82 ab	-61 a	-102 b
Mid-slope	-102 b	-81 b	-5 a	10 a	-92 b
Dune-crest	-22 c	23 b	91 a	117 a	-24 b
Dune	-64 c	-15 b	54 a	60 a	-21 b

Within a soil (row) at P 0.05, LSD between treatments was 34 kg N/ha and a treatment annotated with a different letter is significantly different from another. The N balance for a given year was calculated as N balance (kg/ha) = N input (kg/ha)-N Yield (kg/ha) where, N Input= N fertiliser (kg/ha) + N supplied from legumes (kg/ha) + 10 kg/ha N from free living N fixation. N Yield= grain yield (kg/ha) x grain N content (protein/ 5.7). The audit did not account for N losses through leaching, volatilisation or denitrification or differences in fertiliser use efficiency for different soils and seasons.

Over 5 years of continuous wheat, additional N (urea) at sowing has increased returns across the mid-slope and dune but most markedly in the dune soils (Table 3). Except for a 2009 pasture break nil fertiliser has been the most profitable strategy on the swale in all years but N reserves are now getting low (as suggested by a protein response to N in 2013 and 2014). The difference between a 2009 and 2010 pasture in the swale is important. A 2010 pasture, meant missing out on high cereal yields while a 2009 pasture break boosted 2010 cereal yields even higher. Applying N upfront gave a better gross margin than a split application across all sandy soil types, likely due to the effects of early N deficiency in some seasons that could not be addressed with the 9 kg N/ha applied at sowing. The substantive break effects of growing a pasture in the dune-crest soil in particular meant that it resulted in a similar or even better gross margin than applying 40 kg N/ha upfront every year (Table 3).

Table 3. Cumulative gross margins ($/ha) for period 2010-2014. Wheat was grown in all years in all treatments except the treatment with volunteer pasture in 2010 which was then followed by wheat in 2011-2014.

Soil	Nil Fertiliser	9kg N/ha Upfront	40 kg N/ha Upfront	40 kg N/ha Split	Volunteer Pasture 2010	Volunteer Pasture 2009
Swale	3456	3068	3296	3161	2493	3979
Mid-slope	2061	2374	3172	2885	2495	3142
Dune-crest	193	152	999	565	893	1154
Dune	909	876	1877	1598	1210	1598

Acknowledgements

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Low cost annual pasture legumes for sandy soils

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[2]CSIRO

Take Home Messages

- Well managed and productive pastures can provide rotational benefits equal to or greater than break crops,
- There are limited crop and pasture choices available to Mallee farmers for use on sandy soils,
- MSF has established research and demonstration trials to identify the potential of a range of annual regenerating pastures on Mallee sandy soils,
- Characteristics of the pasture options such as aerial seeding and hard seededness could be used to develop low cost pasture establishment systems ,

Why investigate pasture options

Research at Karoonda and at other sites in the Mallee has clearly demonstrated the benefits that break phases have on the productivity of long term crop rotations. Soil nitrogen benefits following legume crops and pastures are particularly important on sandy soils where organic matter levels are low and crop yields are often constrained by nitrogen.

Lupins are widely grown and increasingly vetch is used as a pasture or brown manure option on these sandy soils. However the cost of establishment of these crops is high; lupins: $160-200/ha and vetch: $60-100/ha. However very few other legume crop and pasture options are well suited to many of the Mallee's sandy soils. To reduce risk, low cost – high productivity pasture options are required for sandy soils, especially for farmers looking to use the pasture for grazing or brown manure.

Through the GRDC Grain and Graze Project, MSF has commenced a number of trials and demonstrations to investigate the potential of a wide range of regenerating legume pasture options on sandy soils. Trials have commenced at Karoonda and Walpeup and demonstrations have been established at MSF's Loxton and Waikerie research sites.

What potential pasture options are available?

Figure 1 is a diagram from the Western Australia Department of Agriculture of the suitability of annual regenerating pasture species to a range of soil types. After taking into account the minimum rainfall requirements and other traits, we have narrowed the list of pasture species to investigate down to six: medics, serradella, biserrula, rose clover, gland clover and baldder clover. Basic agronomic details and the strengths of each of these species has been provided in Table 1. This information has been sourced from the Pastures Australia Fact Sheet Index and full details for these and other pasture species can be accessed at the following website http://keys.lucidcentral.org/keys/v3/pastures/Html/index.htm#A.

Figure 1: Suitability of annual regenerating pastures to a range of soil types.

Table 1: Adaptability and strengths of annual pasture species to Mallee sandy soils. The varieties in bold are those sown in the trial.

Pasture species and Mallee suitable varieties	Soil type and minimum rainfall requirements	Strengths
Strand Medic ○ *Harbinger* ○ *Harbinger AR* ○ *Herald* ○ *Angel* ○ ***Jaguar***	Loamy sands to clay loams. Neutral to alkaline soils (pH ($CaCl_2$): > 5.8), which are not prone to waterlogging or salinity Min rainfall: 250 mm	○ Palatable at all growth stages including senesced dry matter and seedpods for grazing over summer. ○ High nutritive value with high protein content. ○ Hard seeded and once established will maintain a bank of seed reserves in the soil and will self-regenerate from that soil-seed bank over a number of years.
Hybrid disc medic ○ ***Torreador***	Sands to loams and clay-loams. Neutral to alkaline soils (pH ($CaCl_2$): > 5.8), which are not prone to waterlogging or salinity. Min rainfall: 250 mm	
Barrel Medic ○ *Parabinga* ○ *Caliph* ○ ***Sultan SU***	Sandy loams to clays. Neutral to alkaline soils (pH ($CaCl_2$): > 5.8), which are not prone to waterlogging or Sali.3nity. Min rainfall: 250 mm	
Serradella ○ *Cadiz* ○ *Erica* ○ ***Margarita***	Deep (more than 60 - 80 cm), well-drained sands and sandy loam soils. Adapted to soils with pH ($CaCl_2$) of less than or equal to 7.0 Min rainfall: 350 mm	○ Deep-rooting behaviour on deep sandy soils can extend the length of growing season. ○ Very productive in spring with high nutritive value (vegetative, silage, hay). ○ Highly palatable and low bloat risk. ○ Tolerant of aphids. ○ Ease of seed production. ○ Soft seeded cultivars like 'Cadiz' do not require dehulling ○ Compatible with summer growing grasses.
Biserrula ○ ***Casbah***	Well-drained fine textured soils (including sandy loams and clay loams). Adapted to acidic and alkaline soils. Min rainfall: 300 mm	○ Palatable and nutritious. ○ Tolerant of low soil fertility. ○ Deep root system capable of extracting water and nutrients from depth. ○ Tolerant of heavy grazing. ○ Low bloat risk. ○ Suppresses herbicide resistant weeds such as annual ryegrass and radish in cropping systems. ○ Seed spread by livestock.

		○ High hard seed levels (>99%) protect against false breaks and assist long-term persistence. ○ Few insect or disease problems. ○ Ideal species for ley farming systems (1:1 rotation)
Rose clover ○ ***SARDI*** ○ *Hykon*	Range of soil textures. Adapted to mildly acid to alkaline soils (pH ($CaCl_2$) 5 to 8) Min rainfall: 400 mm	○ High seed yields are easily harvested, handled and cleaned using common multi-crop machinery ○ Productive annual forage and tolerant of heavy grazing in medium-low rainfall areas ○ Suited to self-regenerating ley systems or short-term phase farming ○ Protection against false breaks
Gland clover ○ ***Prima***	Range of soil textures and well drained to mildly waterlogged soils. Adapted to mildly acid to alkaline soils (pH ($CaCl_2$) 4.5 to 8). Not suited to poor infertile sands. Min rainfall: 350 mm	○ Suited to low rainfall environments ○ Resistant to red-legged earth mites and blue green aphids ○ Excellent regeneration ○ Easy to harvest for conservation ○ Ease of seed production ○ High level of hard seed for protection against false breaks ○ Low courmarin levels in the plant.
Bladder clover ○ ***Bartolo***	Range of soil textures (sandy loam-loam). Adapted to mildly acid to alkaline soils (pH ($CaCl_2$) 5 to 8) Min rainfall: 325	○ Productive annual forage tolerant of heavy grazing in medium-low rainfall areas ○ Suited to self-regenerating ley or short-term phase farming systems ○ Protection against false breaks ○ High seed yields, which can be direct headed and cleaned using crop harvesting machinery. ○ High level of hard seed
Sothis Eastern Star Clover, Losa Sub Clover, Akurra Sulla have also been sown at Karoonda		

Pastures systems for Mallee farms

The pasture options being trialled have traits that will enhance their alibility to integrate with Mallee cropping systems. For example, many of these pasture options have high levels of hardseededness which safeguard against false–breaks, but also allow the pasture seed bank to persist through multiple cropping phases before the paddock needs to be returned to pasture.

Many of the pastures listed in Table 1 are aerial seeded which allows the pod or seed to be collected and cleaned using conventional harvesting equipment. By harvesting seed on farm, pastures can then be re-sown at high seeding rates while minimising establishment costs.

Establishment systems using farm retained pasture seed has been extensively researched in Western Australia using serradella and bladder clover. Both of these species have high levels of hard seed and this trait is used to advantage by twin sowing or summer sowing systems:

- Twin sowing refers to sowing pasture seed with the preceding crop where little of the pasture will emerge in the crop because of the hard-seed dormancy, but seed will gradually soften and reduce dormancy over the following summer and autumn (Nutt, 2013)
- Summer (dry) sowing works on a similar principle where the pasture is sown soon after harvest and seed softens over the summer and autumn period.

One of the advantages of both of these techniques is seed costs are reduced as expensive seed cleaning and scarify costs to break dormancy is avoided. Furthermore, twin and summer sowing have the advantage of making full use of rainfall and can have improved production as pastures emerge early when soil temperatures are warm (Nutt, 2013). Twin sowing reduces establishment costs as the crops and pasture is sown simultaneously and only one machinery pass is required (Nutt, 2013). Moreover, as the pasture seed is located in the previous year's crop row, twin sowing may provide an advantage on sandy soils were water harvesting can be achieved and crop residues remain intact.

Acknowledgement
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Testing new perennial pasture options for low rainfall areas

Andrew Smith, Bill Davoren, Rick Llewellyn, Damian Mowat;
CSIRO Agriculture

Take Home Messages

- Sub-tropical grasses continue to persist at the Karoonda site after 6 years and respond rapidly to summer rain with Petrie Panic looking the most promising at this stage.
- Tedera is a perennial legume developed in WA that is now being trialled for the first time in this region.

With decent wool and prime lamb prices, and the increasing interest in diversifying beyond cereal crops, there is widespread interest in increasing production from the livestock side of mixed-farming businesses in the low rainfall zone (LRZ). However, a major limitation to increasing production continues to be the lengthy and costly feed gaps that often occur across the LRZ once stubble grazing has finished through to when annual pasture or crop forages becomes available in autumn. GRDC have funded the EverCrop project to investigate alternative perennial pasture options that may alleviate constraints in mixed farming systems including new forage shrubs, grasses and a new legume. At the MSF Karoonda site there are a number of perennial pasture trials and experiments currently underway.

Subtropical Grasses

Photo: Panic grass summer 2015.

The capacity of warm-season perennial grasses to establish grow, persist and be a reliable and valuable source of animal feed has been assessed in a replicated field experiment since 2010. The species we have been closely following are Petrie Panic (*Panicum maximum*), Bambatsi (*Panicum coloratum*), Rhodes Grass (*Chloris gayana*) and Digit Grass (*Digitaria eriantha*). These pastures have evolved and flourish in tropical environments but the Karoonda trial is the first of its type in the SA Mallee. The total biomass produced on an annual basis since establishment in October 2010 is shown in Figure 2.

It is worth bearing in mind that these pastures have not received fertiliser since they were sown in 2010.

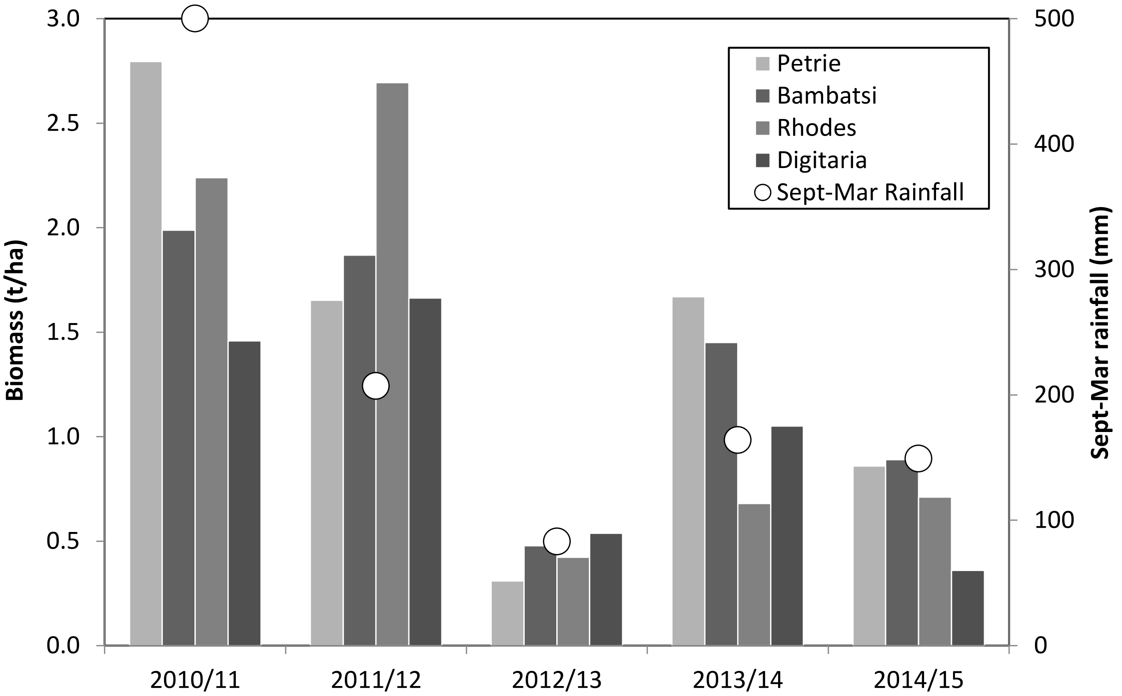

Figure 2. Total annual biomass in the subtropical grass experiment (t DM/ha) – dry matter results to date

The experimental results are confirming what was found after 6-years of trials at Hopetoun – these pastures can grow, provide a worthwhile source of feed in summer and persist through dry years. The grasses are known to be very responsive to summer and early-autumn rainfall. With around 25 mm of rainfall being enough for a growth response, at Karoonda since Spring 2010, in 4 out of 5 years we recorded at least two 25 mm events from November to April. How well set up is your farm feed base to capitalise on the out-of-season rainfall?

In the summer 2013 and autumn 2014 we did some assessment of the pasture quality. The best feed quality was Petrie followed by Digit and Bambatsi and lastly Rhodes Grass. In addition to its favourable nutritional profile, Petrie also produces a decent amount of nice green leafy material following summer rainfall and therefore is the most attractive of all the species for livestock production. Rhodes grass quickly becomes rank and so is best grazed soon after rainfall – however its most beneficial characteristic is its prostrate growth.

This spring we will make a one-off application of nitrogen fertiliser to some of the plots in the current subtropical grass experiment and then monitor the response over the ensuing months.

Tedera

Photo: Tedera after grazing at Dandaragan, WA (Daniel Real, DAFWA)

On the 24th May 2015 we established an experiment to evaluate a new perennial forage legume called Tedera that has the most off-putting botanical name: *Bituminaria bituminosa*. Tedera is native to the Canary Islands, and has been under evaluation since 2006 through the Future Farm Industries CRC and DAFWA but is largely untested in the Mallee environment. In Western Australia it has held green leaf even over the harsh summer period. The experiment also includes perennial Veldt Grass (*Ehrharta erecta*) and SARDI-Grazer - a recently released winter active lucerne (*Medicago sativa*) variety (rating 6) – released in 2013. The trial is repeated on the swale and on the sand-hill.

Dry conditions leading up to sowing in 2015 meant that the pastures were sown into almost dry soils and over the following 45 days only 11 mm of rainfall was received. Also since sowing, there has been 64 hours of frost over 13 days and air temperatures falling as low as -3 °C. Considering these very adverse conditions for seed germination and plant growth we are happy with the establishment recorded almost 3 months after sowing (Table 1).

Table 1. Plant numbers (number/m^2) recorded on 13 August (81 days after sowing)

	Average	St Dev
Swale		
Lucerne	23.1	8.5
Tedera (T15)	12.9	2.8
Tedera (T47)	11.0	2.9
Veldt	16.4	6.2
Hill		
Lucerne	17.6	8.1
Tedera (T15)	12.9	2.4
Tedera (T47)	12.2	3.6
Veldt	4.2	1.5

Over the next few months we will monitor the soil moisture in order to assess plant rooting and water use efficiency of the different treatments. The aim being to better understand the potential scope for Tedera in the southern agricultural region.

Further information

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Towards a profitable brome grass strategy on Mallee sands

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Take Home Messages

- On-row or near-row seeding on sands can lead to reduced brome grass seedbanks.
- Pre-emergent herbicide options are effective but not even the more costly mixes can be relied upon to maintain low brome populations.
- The potential for harvest weed seed control practices to control brome is more limited than for ryegrass due to early shedding.
- Piecing together clever combinations of practices is needed to profitably maintain low brome grass numbers while reducing dependence on Group B herbicides in crop phases.

Background

Brome grass is already rated the most costly weed to grain production in the Mallee region. This is despite herbicide resistance in brome still being relatively low. The cost of managing brome will increase further as resistance to key herbicides increases over the next decade.

An increasingly strategic approach is needed to manage brome populations and the available herbicides. However, compared to ryegrass in other regions, brome control options are more limited and less is known about their efficacy and reliability. A range of trials on brome are being conducted in the Mallee that are informing what combination of control practices are likely to be the most economic over the longer term.

Trials

On-row Vs inter-row seeding

Last year our trial on the dune soil at Karoonda showed that brome grass plant numbers and brome seed production were both almost 80% lower ($P<0.05$) where the crop was sown on the previous year's crop row compared to inter-row (Table 1).

Table 1. Brome grass numbers at maturity in wheat sown on-row and inter-row in 2014 (McBeath et al 2015).

	Brome plants/m2	Brome seeds/m2
On-row	14	389
Inter-row	64	1859

This year we have similar on-row / inter-row treatments in place again with late April and late May seeding dates. Early brome emergence counts have been taken, but late-season measures after the effect of differences in crop competition are needed to confirm whether on-row seeding has led to another significant reduction in brome.

Pre-emergent herbicide options

The Karoonda site has hosted three previous years of pre-emergent herbicide trials targeting brome grass on sands (Griffith 2015). These highlighted the potential for greater than 75% brome control but also the potential for variability (Figure 1).

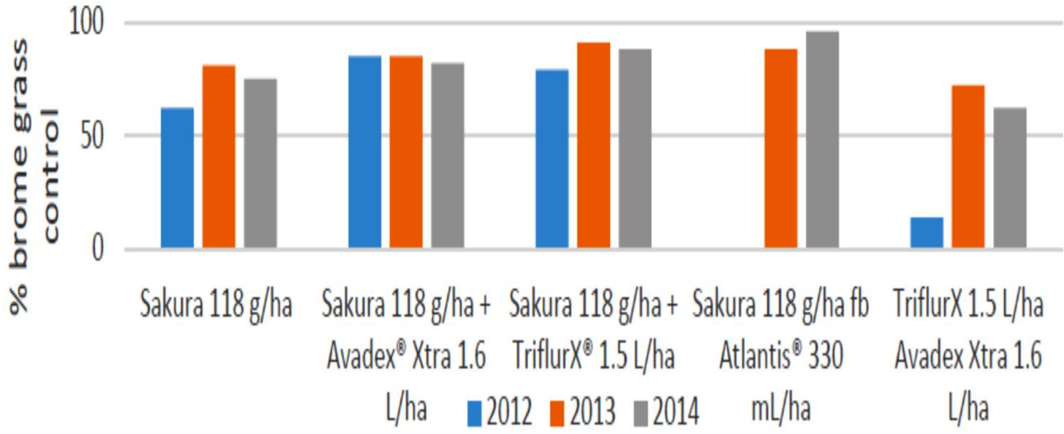

Figure 1. Three seasons of pre-emergent herbicide results on brome plant numbers at Karoonda comparing herbicides and a nil herbicide control (Griffith 2015). nb no Sakura + Atlantis treatment was applied in 2012.

This year, in partnership with the University of Adelaide, we have applied the following treatments of widely varying costs to control brome sown on retained cereal stubble. One question is whether extra investment in pre-emergent herbicide mixes can lead to longer-term payoffs through reduced brome seedbanks.

Treatments applied at 2 seeding times (30 April and 20 May 2015):

1. Trifluralin (control) at standard local rate (1.5 L/ha)
2. Trifluralin + Metribuzin (1.5 L/ha + 150 g/ha)
3. Trifluralin + Metribuzin + post emergence Avadex Xtra (1.5 L/ha + 150 g/ha + 2.0 L/ha)
4. Trifluralin + Avadex Xtra (1.5 L/ha + 2.0 L/ha)
5. Sakura (118 g/ha)
6. Sakura + Avadex Xtra (118 g/ha + 3.2 L/ha)
7. Sakura + Metribuzin (118 g/ha + 150 g/ha)

The difficult dry topsoil conditions on non-wetting sands led to patchy wheat (Kord) establishment. Early plant counts do not show significant differences in brome plant numbers between treatments, but any differences are more likely to show in later plant and seed production assessments.

Harvest weed seed control

A study of brome grass seed retention at harvest in 2014 by MSF and Vic DEDJTR at Ouyen measured the potential for harvest weed seed control practices such as seed catching and narrow windrows to capture brome seeds (Korte et al 2015). While the figures will vary by season, the results indicate the potential limits of harvest weed seed control methods that rely on brome seed entering the harvester (Figure 2).

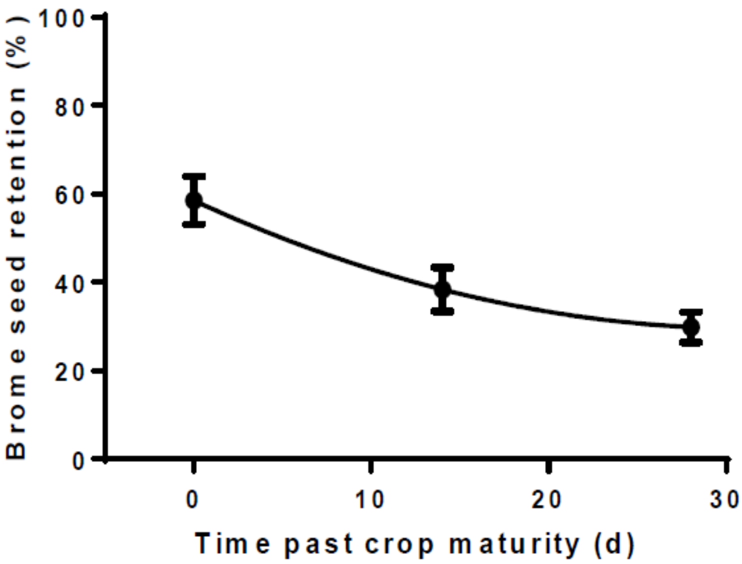

Figure 2. Seed retention above harvest cutting height (>15 cm) of brome grass at 0, 14 and 28 days after barley crop maturity (Korte et al 2015)

Further information

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Available at http://msfp.org.au/resources/research/2014compendium/ :

Griffith (Bayer) 2015. Sakura® 850 WG herbicide for grass weed control in water repellent soil.
McBeath et al 2015. Sowing strategies to improve productivity on sandy mallee soils.
Korte et al 2015. Brome grass seed retention declines over harvest.

GRDC fund the 2015 trials at the Karoonda Field Day site

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Brome, brome on the range

Richard Saunders
Dodgshun Medlin Ag. Management

Take Home Messages

- Grass control must be an integrated strategy.
- Brome and Barley grasses are being selected for later germination.
- We may need to think and aim for 3 – 4 years of 100% control.
- It is vital to make Pre-emergent chemicals for grass control work well.
- Pre-emergents are inconsistent in their effectiveness from season to season.

Integrated Grass Control

We cannot afford to rely on one or two strategies if we seriously aim to reduce grass weed numbers and keep them low. How do we tackle it? Firstly we must examine our rotation and ask ourselves the following questions:

- Why is there grass in this paddock?
- What level of grass control is going to drive weed numbers down?
- What chemicals have been used here for grass control?
- What has been the effectiveness of those chemicals? And therefore …
- What are the resistance levels of the various chemicals used in this paddock?
- How do I confirm if I have resistance? And finally …
- What do I do if have resistance?

Later Germination, Multi Year Control

Numerous trials and anecdotal evidence have show that barley and brome grass are migrating towards later germinations. The standard knockdowns and pre-ems are not as effective on these populations; a single grass spray will not pick up these grasses, and these populations are now present and developing in the Mallee; we are inducing later and later germinating grasses. Are we also inducing greater levels of hard seededness?

Red Brome *Bromus rigidus* and Great Brome *Bromus diandrus* prefer to germinate in dark conditions, and germination is often stimulated by cultivation or treading by livestock that buries the seed. How often have you got two knockdowns on a late sown paddock prior to sowing and then realised a large number of brome grass plants have appeared in the established crop.

Red Brome also naturally has about 20% hard seeds, and up to 30% in some situations, meaning a large number of seeds can be carried over to germinate in following seasons. Getting 100% Brome grass control in one year does not eliminate the problem because there is still significant numbers of seeds ready for germination next year along with a percentage from the year before.

We need to serious start thinking about rotations and strategies that allow us to effectively control Brome for a continuous phase of three to four years. We need to use and protect the effective Group A chemicals – both fops and dims, and also Glyphosate (Group M).

Pre-emergent Control

It is vital to make the pre-emergent chemicals work well. We need to know how to get the best out of each chemical and spike. These chemicals must be part of an integrated grass control strategy. The pre-emergent chemicals are generally much cheaper than the shrinking range of effective post-emergent chemicals. However, pre-emergents are not a magic bullet but part of the integrated solution.

Conclusions

Experience tells us that pre-emergent chemicals can be inconsistent and influenced by many factors:

- Rate of pre-emergent
- Soil moisture
- Amount of stubble
- Speed of seeding and therefore sow throw
- Type of seeding system – knife point or disc, etc.

Matt Witney (Dodgshun Medlin) has been conducting brome grass trials for the University of Adelaide for a number of years and from these trials derives the following conclusions:

- When choosing a pre -emergent herbicide for Brome grass control, results will vary given seasonal conditions. This variance in results achieved is due to both the chemistry of the herbicide, the brome pressure and the straw residue level in the paddock.
- Sakura appears to work best in wetter starts, and this has been confirmed over three years of trial work.
- In high residue situations (< 50% ground cover), soluble herbicides (Avadex, Sakura) provide significantly better control than the non-soluble Trifluralin.
- Chemicals with good residual (8-12 weeks after sowing) are showing greater benefits as we select for later germinating Brome grass.
- Pre-emergent herbicides appear to be more inconsistent on Brome grass compared to Ryegrass. Pre-emergents alone cannot be relied upon to provide consistent Brome control.
- Don't expect pre-emergent chemicals to control large grass populations, but need to be part of the multi-year strategy.
- We need to be aiming for a minimum of 80% control to be driving the grass population down.

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CSIRO Karoonda Field Experiments

Sowing Strategies Trial

2015: Trial sown with Mace wheat on two occasions, 27th of April (Early) or 21st of May (Later), either near previous year's row (On row) or between rows (Inter row). Fertiliser DAP @ 50 kg/ha and Urea @ 24 kg/ha. Trifluralin applied pre-sowing @ 1.5 l/ha.

Treatment	Position/sowing time	Plots
1	On row/Early	21,28,33,38
2	Inter row/Early	24,25,30,36
3	On row/Later	22,29,34,39
4	Inter row/Later	23,26,31,35

Cereal Strategies Trial

2015: Trial sown with Mace Wheat on the 14th of May.

Treatment	Plots	Crop/Variety	Fertiliser
1	1,14,17,31	District practice phase 1 - winter pasture (2009) followed by cereal (2010-14)	DAP @ 50 kg/ha@ sowing
2	5,10,24,30	District practice phase 2 – cereal (2009) followed by winter pasture (2010) and cereal (2011/14)	DAP @ 50 kg/ha@ sowing
3	8,13,23,26, 4,9,19,25, 2,11,18,28	Control -Continuous cereal-district practice fertiliser inputs	DAP @ 50 kg/ha@ sowing
4	6,12,21,32	Continuous cereal –no fertiliser	Nil fertiliser
5	7,15,22,29	Continuous cereal –high N inputs upfront	DAP @ 50 kg/ha + 67 kg/ha Urea @ sowing
6	3,16,20,27	Continuous cereal – high N inputs split	DAP @ 50 kg/ha @ sowing + 67 kg/ha Urea (top dress @ GS22)

Brome grass management (Weeds trial)

In collaboration with The University of Adelaide

2015: Trial sown with Kord wheat on two occasions, 30th of April (early) or 20st of May (later). A range or pre sowing herbicide applications were applied. Fertiliser DAP @ 50 kg/ha and Urea @ 45 kg/ha.

1. Trifluralin (control) at standard local rate (1.5 L/ha)
2. Trifluralin at standard local rate (1.5 L/ha) then **hayfreeze** using glyphosate to prevent all brome seed set.
3. Trifluralin + Metribuzin (1.5 L/ha + 150 g/ha)
4. Trifluralin + Metribuzin + post emergence Avadex Xtra (1.5 L/ha + 150 g/ha + 2.0 L/ha)
5. Trifluralin + Avadex Xtra (1.5 L/ha + 2.0 L/ha)
6. Sakura (118 g/ha)
7. Sakura + Avadex Xtra (118 g/ha + 3.2 L/ha)
8. Sakura + Metribuzin (118 g/ha + 150 g/ha)

Nitrogen cycling in cereal stubble retained systems (^{15}N trial)

To quantify the effect of stubble management on the timing and amount of N release & availability with varying stubble loads, treatment and soil environment. Stubble treatments applied during the summer of 2014/15, incorporated treatment applied with rotary hoe.

Trial sown with knife points to Mace wheat on the 21st of May with DAP at 50 kg/ha and Urea at 24 kg/ha.

Treatment	**Plot No.**
Treatment 1 Surface stubble (cut low and retained)	2,5,9,13
Treatment 2 Incorporated stubble (cultivated in fallow to 10 cm depth)	3,6,10,15
Treatment 3 Standing Stubble (cut normal and retained)	1,7,11,16
Treatment 4 No stubble (cut low and removed)	4,8,12,14

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