FarmLink

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# 2015 Research Report

**FarmLink** 2015 Research Report
Published by FarmLink Research Limited
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Published by FarmLink Research Limited (FarmLink), a not for profit agricultural research and extension organisation coordinating research and development activities in the FarmLink region.

**ACKNOWLEDGEMENTS**
DESIGN: Blair Doherty - Snap Wagga Wagga
PHOTOGRAPHY: FarmLink Image Library
PRINTING: Snap Wagga Wagga

**FarmLink gratefully acknowledges the contributions of all project collaborators to this report and for the time and effort they have invested in ensuring the success of FarmLink.**

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# A Word from Chairman & CEO

It is with pleasure that we present you with the 2015 FarmLink Annual Research Report. 2015 has been a year of consolidation and stabilisation. The FarmLink team has focussed on delivering high quality R&D activities as well as hosting a range of events that have both entertained and informed.

We would like to take this opportunity to thank our major funding and project partners – GRDC, Riverina LLS, CSIRO, NSWDPI, ClearView Consulting, SARDI, Charles Sturt University, Kalyx, BCG and CropFacts. Without their recognition of the value that FarmLink creates and the importance of RD&E to the future of farming in southern NSW, none of the work of FarmLink would be possible. We also acknowledge our Partner organisations whose involvement with FarmLink creates enormous benefits for members and the organisation. We hope that your support of them continues.

We would also thank our volunteer Board members, who often go unnoticed, and who are contributing significantly with their time, expertise and passion to the success of FarmLink.

A significant highlight for the year was our Open Day, held in September at Temora Agricultural Innovation Centre, and attended by over 200 people. Combined with the presenters and companies' hosting trade displays there was quite a crowd on the day. Attendees were from all over southern NSW and included members and non-members alike, a demonstration of the value that FarmLink creates and shares with farmers across southern NSW.

Michael Bullen, Deputy Director General of NSW DPI, launched the Open Day and spoke about the revival and repositioning of agricultural innovation in NSW. Michael is part of the new team leading the department as it repositions itself to meet the future needs of agriculture in the state. We are pleased to think that FarmLink has an important grass roots role to play in helping to achieve some of the ambitious targets the department has set.

A feature of the Open Day, and in fact the FarmLink program in 2015 and going forward, is the renewed focus on livestock in the mixed farming context and as standalone enterprises. The livestock theme of the Open Day delivered information about genetic selection, enterprise performance, health and nutrition and handling technology.

Our livestock program with Murray Long, included a range of short term trials in 2015 looking at feeding supplements, genetic contributions to growth and lamb finishing. In addition, FarmLink partnered with Riverina LLS, Charles Sturt University and Murray to look at self regenerating hard seed legume pastures and to deliver workshops designed to improve livestock productivity. The information and events were very well received.

Looking forward, our livestock program will include a project, secured by Murray, to host a Satellite Flock under the Meat and Livestock Australia (MLA) Resource Flock Database, collecting data on DNA predictions, at TAIC. We will also be hosting the Federal Department of Agriculture funded, CSIRO project looking to develop an online system for estimating current and future soil water storage at the field scale using satellite and field-based measurement systems and simulation models. CSIRO will investigate the use of local automated and telemetered climate data stations to improve farmers' knowledge of the often large differences in conditions between their paddocks, and to develop a tool to assist in understanding the benefits and risks of fertiliser application at various crop stages. Also new in 2016 are two sites in the Galong and Harden areas with trials investigating amelioration of sub soil acidity and management of weeds seeds at harvest. Both of these projects are GRDC funded and we have partnered with NSWDPI and Southern Farming Systems respectively to deliver them.

We look forward to seeing you through 2016 and beyond.

*Darryl Harper*

*Chair*

*Cindy Cassidy*

*CEO*


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# The FarmLink Story

**Productivity, profitability and sustainability - securing the future of farming**

FarmLink is about the future of farming – productive, profitable and sustainable farms and farmers. We are committed to delivery of innovation for farmers in southern NSW and supporting them in the implementation of change on their farms and in their farm businesses. We believe that strong farm businesses create vibrant local communities.

### Our governance

FarmLink is a not for profit company limited by guarantee established in 2004. The constitutional objectives of the company are focussed on Research Development & Extension (RD&E) activities designed to achieve profitable and sustainable farming businesses in southern NSW. We have approximately 320 members involved in agriculture in SNSW representing 300+ farming, advisory, research and other agribusinesses

### Our Reach

The FarmLink region covers 1.2mil ha of arable land across SNSW. The region encompasses high, medium and low rainfall production zones and a range of farming enterprises from continuous cropping, livestock and mixed farming enterprises. Acidic red duplex soils are dominant in the cereal and canola production zones across the region.

FarmLink reaches over 3000 people annually through our media and social media presence, events, activities and communications. FarmLink's activities and region involves 15 different local government areas. These include Temora Shire Council, Junee Shire Council, Coolamon Shire Council, Cootamundra Shire Council, Young Shire Council, Wagga Wagga City Council, Cowra Shire Council, Boorowa Shire Council, Harden Shire Council, Gundagai Shire Council, Greater Hume Shire Council, Lockhart Shire Council, Narrandera Shire Council, Bland Shire Council and Weddin Shire Council.

### Our Business

FarmLink currently partners with GRDC, CSIRO, NSWDPI, LLS, UA, Bayer, DAFF, AgGrow Agronomy, St Anne's Central School, AGT, PacSeeds, CSU, Temora Shire Council and the Graham Centre to conduct RD&E activities at nine demonstration and/or field trial sites across our region including the TAIC. We have projects focussed on weed and herbicide tolerance management, soil micronutrient deficiency, carbon sequestration, stubble management, strategic tillage, crop sequences and early sowing.

FarmLink has 17 corporate partners across the agribusiness sector. Our partnership packages have been designed to appeal to businesses and organisations with values and aspirations aligned with FarmLink's. We see our partnerships as opportunities to introduce our members to the valuable skills and expertise of businesses operating in agriculture across our region and for our partners to meet and better understand our farms and farmers. A FarmLink Partnership allows our farmers and regional businesses to grow long term, beneficial relationships.

Recently FarmLink has established a Farming Systems Partnership with Charles Sturt University and three other farming systems groups to create a supply chain for agricultural training, research, development and extension in SNSW. Through this partnership, FarmLink contributes to RD&E priority setting, provides access to farmers, field trial capacity and industry work experience opportunities, and receives academic and scientific oversight of projects as well as gaining access to 4th year and PhD students working and located within the FarmLink business.

# 01

FarmLink Research Report 2015

# The effect of grazing and burning stubbles on grain yield and quality in no-till and zero-till controlled traffic farming systems in SNSW

GRDC Project code – CSP00174

## Project Partners

## Funding Partners

## Trial Site Location

5 km SSE of Temora

## Report Authors

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## Introduction

**Keywords: stubble retention, sheep, livestock, N cycling**

**Take home messages**

- Grazing stubbles with sheep speeds up N cycling and reduces N tie-up by the stubble. When yield is N limited, this increases grain yield and quality.
- Burning stubble decreased the amount of water stored over the summer fallow and the crops used by 8 to 21 mm, but this did not always decrease yield due to frost damage, N limitation or adequate subsequent recharge.
- Over the six year experiment, grazing and then retaining (not burning) stubble has been the most profitable treatment.

# Background

A livestock enterprise, particularly sheep, in conjunction with a wheat-based cropping enterprise has long formed the basis of mixed farming systems throughout south eastern Australia. This enterprise mix is symbiotic, with sheep able to consume and give value to otherwise wasted by-products from cropping (crop residues, weather damaged and spilt grain, early vegetative crop growth) whilst the legume-based pastures used for sheep production allow paddocks to be spelled from crop production, increase soil nitrogen and reduce crop weeds and diseases. The presence of both livestock and crops also diversifies the farm business, offsetting production and price risk and increasing resilience. In recent times much attention has been given to the potential for conservation farming practices such as no-till seeding with complete stubble retention and controlled traffic to increase crop yields and water-use efficiency. Advocates argue that the full potential of no-till and controlled traffic may not be realised if sheep are grazed on cropping country, remove residue cover and trample soils, but there is little contemporary research evidence to support this view. We report results from a long-term experiment designed to test whether sheep grazing in no-till and zero-till farming systems damage soil and reduce crop yields. Results from the first four years of this experiment (2009-2012) are available online (www.farmtrials.com.au/trial_details.php?trial_project_id=16648). In this paper we present results from the experiment for the years 2013-2015 where we expanded the experiment to compare a disc opener against two tine openers, and include a summary of gross income from 2010-2015.

# Methodology

The experiments were located on a red chromosol soil 5 km SSE of the township of Temora in SE NSW (519 mm average annual rainfall, 313 mm average Apr-Oct rainfall, 206 mm Nov-Mar rainfall) and consists of two stubble grazing treatments;

1. Nil graze
2. Stubble graze

These were applied in a factorial design with two stubble retention treatments;

i. Stubble retention
ii. Stubble burn

In 2013 these treatments were split for three different seeding furrow opener types;

A. Deep knife-point (AgMaster 12 mm - disturbs soil below seed)

B. Spear-point (Keech - does not disturb soil below seed)

C. Single disc (Excel with Arricks Wheel residue managers)

These treatments were applied in two different phases in adjoining areas of a farmer's paddock which had been in lucerne pasture since 2005. In Phase 1, lucerne was sprayed out in late spring 2008, in Phase 2 it was sprayed out in late winter 2009. Following lucerne removal, large plots (7 x 16 m – incorporating three individual plot-seeder runs of 1.83 m width and 1.5 m of permanent tram tracks) were established which allowed all operations to be conducted using controlled traffic. All plots were fenced so they could be individually grazed by sheep. Both tine openers were attached to FlexiCoil 250 kg break-out tines on a linkage mounted plot-seeder on 305 mm row spacing, and the discs were mounted on a trailing bar with air-seeder also on 305 mm row spacing.

Crops were sown from mid-April to early May in all years of the experiment and followed a canola-wheat-wheat rotation. Following harvest in each year (late November-early December), large weaner ewes grazed stubbles in treatment 2. The amount of stubble present in plots was measured before and after grazing to calculate how much sheep had consumed. Stubble was analysed for feed quality (metabolisable energy), and the number of grazing days was calculated based on one dry sheep equivalent (DSE) consuming 7.6 MJ of energy per day. Grazing value was priced assuming an agistment rate of $0.4/DSE/week. Sheep were not removed from the plots if it rained during grazing.

The stubble burn treatments were applied in mid- to late-March of each year. Summer weeds that emerged at the site were promptly controlled with herbicide.

Gravimetric soil water content and mineral N were measured from intact soil cores taken to 1.8 m in the knife point plots only in late March-early April. Soil water was measured prior to sowing and at harvest using a neutron moisture meter (NMM) (10 to 160 cm depth).

Grain yields was measured using a plot header harvesting only the inside 4 rows only of each seeder run to remove edge effects from rows adjacent to tram tracks. Grain yields were also measured by hand harvesting large areas (>1.0 $m^2$) of crop and threshing which also allowed total dry matter production, harvest index and amount of the residue returned to plots to be calculated. Grain protein, moisture and test-weight were estimated from NIR, and screenings as per receival protocols. Binned grades were determined from quality parameters, and prices determined using 2014 grain prices delivered Temora (Table 1). Inputs and non-tonnage dependent operations in all treatments were identical, therefore only gross income is calculated in the economic analysis.

| Binned grade | Price ($/t) |
|---|---|
| APH2 | $307 |
| H1 | $292 |
| H2 | $286 |
| AUH2 | $268 |
| APW | $267 |
| HPS1 | $258 |
| ASW | $256 |
| AGP | $250 |
| SFW1 | $237 |
| CSO1-A | $426 |

*Table 1. Grain prices used for calculating gross income for different treatments.*

# Results

## 2013

In 2013 there was 135 mm of summer fallow rainfall and 227 mm growing season rainfall. At the start of the growing season, there was no difference in mineral N between any of the stubble management treatments. Retained stubble treatments had an additional 21 mm of water compared to burning in Phase 2 (P=0.035) and there was no effect of grazing. In Phase 1 neither effect was significant.

All treatments were dry-sown between 24 April and 1 May, Phase 1 was sown to Hyola 575 canola and Phase 2 to Gauntlet wheat. Rain that germinated seed fell on 8 May. Phase 1 was top-dressed with 90 kg/ha ammonium sulfate and 160 kg/ha urea, Phase 2 was top-dressed with 160 kg/ha urea. Yield results were influenced by severe frosts on 15, 16 and 18 October during which screen temperature fell to -2.6°C, -1.8°C and -3.6°C respectively. In both phases of the experiment, treatments in which stubble was burnt suffered less frost damage and this translated into higher yields (Table 2). In both phases, treatments in which stubble was grazed yielded more than where it was not grazed, and this effect was greater in the unburnt treatments but still significant in the burnt treatments.

| | 2013 wheat yield (t/ha) | | 2013 canola yield (t/ha) | |
|---|---|---|---|---|
| | Burn | Retain | Burn | Retain |
| Treatment | (30% frost damage) | (59% frost damage) | (43% frost damage) | (59% frost damage) |
| Nil graze | 3.3 | 2.2 | 1.0 | 0.7 |
| Stubble graze | 3.6 | 3.0 | 1.1 | 0.9 |
| P value | <0.001 | | 0.014 | |
| LSD (P<0.05) | 0.2 | | 0.1 | |

*Table 2. Grain yield and frost damage for the different grazing and stubble treatments in Phase 1 and Phase 2 in 2013.*

There was a significant main effect of opener type in both Phase 1 (canola) and Phase 2 (wheat) with the single disc yielding more than the spear point which yielded more than the knife point (Table 3).

| | Grain yield (t/ha) | |
|---|---|---|
| Opener type | Phase 1 (canola) | (Phase 2 wheat) |
| Single disc | 1.05 | 3.1 |
| Spear point | 0.93 | 2.9 |
| Knife point | 0.85 | 2.8 |
| P-value | <0.001 | <0.001 |
| LSD (P=0.05) | 0.07 | 0.12 |

*Table 3. Grain yields for different opener types averaged across all stubble treatments in Phase 1 (canola) and Phase 2 (wheat) in 2013.*

There was a significant interaction between opener type and grazing on canola oil content in Phase 1 (Table 4).

| | Canola oil % | | |
|---|---|---|---|
| | Opener type | | |
| **Grazing** | **Disc** | **Spear** | **Knife** |
| **Nil graze** | 42.5 | 40.6 | 42.0 |
| **Stubble graze** | 42.2 | 40.0 | 41.0 |
| **P-value** | 0.005 | | |
| **LSD** | 1.1 | | |

*Table 4. Canola oil content for different opener types and grazing treatments in Phase 1 in 2013.*

In Phase 2 wheat protein content reflected yield results according to protein dilution and ranged from 12.4% in highest yielding treatments to 14.6% in lowest yielding treatments. There was no significant effect of any treatment on test weight (mean 77.4 kg/hL) or screenings (mean 14.4%).

**2014**

In 2014 there was 158 mm summer fallow rainfall and 238 mm growing season rainfall. There was no effect of grazing on stored soil water, but burning stubble decreased the amount of soil water the crop used by 14 mm in Phase 1 (P<0.001) and 13 mm in Phase 2 (P=0.002). Grazing stubble increased the amount of mineral N available prior to sowing in Phase 2 (Table 5), particularly when stubbles were not burnt, but there were no significant effects in Phase 1 (mean value 127 kg/ha).

| Graze | Burn | Retain |
|---|---|---|
| Nil graze | 137 | 104 |
| Stubble graze | 150 | 155 |
| P-value | <0.001 | |
| LSD | 10 | |

*Table 5. Soil mineral N measured to 1.75 m depth in Phase 2 of the experiment in 2014*

All treatments were sown into a moist seed bed on 1 & 2 May 2014. Phase 1 was sown to Lancer wheat and Phase 2 to Stingray canola. Both phases were top-dressed with 160 kg/ha urea on 23 July 2014. Due to a malfunction in the metering system of the disc seeder, crop establishment was not uniform across the opener treatments. In Phase 1 there were only 30 plants/m$^2$ of wheat in the disc treatment vs 125 and 129 plants/m$^2$ in the knife and spear point treatments respectively (P<0.001, LSD=7). In Phase 2 there were only 8 plants/m$^2$ of canola in the disc treatment vs 36 and 32 plants/m$^2$ in the knife and spear points respectively (P<0.001, LSD=4). Consequently, the disc treatment was excluded from all further analyses in 2014. All treatments suffered damage from stem frost in July and August but there was no effect of any treatment on extent of damage.

In Phase 1 machine harvest there was no significant effect of stubble treatment (either grazing or burning) or interaction with opener type on grain yield (mean yield 3.7 t/ha). However, based on hand harvests, burning stubble reduced yield from 4.4 t/ha to 4.0 t/ha (P=0.029) which reflects the observed difference in water use. Grazing stubble increased protein from 13.8 to 14.7% (P=0.016) and increased screenings from 4.3 to 6.0 % (P=0.006) but there was no effect of burning or opener type.

In Phase 2 burning stubble decreased canola yield from 2.1 to 2.0 t/ha (P=0.022) and there were no effects of grazing or opener type. Burning stubble and grazing stubble also decreased canola oil from 43.1 to 42.4 % (P<0.001).

**2015**

In 2015 there was 221 mm of summer fallow rainfall and 360 mm growing season rainfall. In phase 1 (wheat stubble) grazing decreased the amount of water stored during the summer fallow by 6 mm (P=0.006) and burning by 8 mm (<0.001) but there was no interaction between the two. However, despite having accumulated more soil water during the summer fallow, there was no significant effect on soil water use during the growing season. In Phase 2 (canola stubble) burning reduced the amount of water stored during the summer fallow by 20 mm, but there were no differences in seasonal water use.

Grazing stubble almost doubled the amount of mineral N available prior to sowing (Table 6) in Phase 1. This result was verified by surface N measurements taken immediately before and immediately after stubble grazing, which showed that mineral N in the Stubble Graze Stubble Retain treatment was twice that in the Nil Graze Stubble Retain treatment. When stubble was retained, burning increased the amount of soil mineral N available by 15 kg/ha. There were no significant effects of grazing or burning in Phase 2 (mean 157 kg/ha N).

Both phases were sown to Lancer wheat into a moist seed bed on 24 April 2015. In Phase 1 stubble grazing reduced plant establishment from 124 to 114 plants/m$^2$ (P=0.011) and plant density was also slightly lower in the disc (98 plants/m$^2$) in comparison to the knife point (126 plants/m$^2$) and spear point (134 plants/m$^2$, P=<0.001, LSD=9). In Phase 2 plant density was also lower in the disc treatment (99 plants/m$^2$) compared to the knife point (137 plants/m$^2$) and spear point (130 plants/m$^2$, P<0.001, LSD=10)

Most treatments in both phases had sufficient soil mineral N (allowing for in-season mineralisation of 40 kg/ha N) to achieve district average yield of 4 t/ha (Table 6), and given the El Nino that was in place during winter and associated dry spring forecast, neither phase was top-dressed. As a result, in Phase 1 grain yield and protein was driven by soil mineral N availability in the different treatments (Table 6) and grazing stubble increased both yield and protein. Likewise in Phase 2 grazing stubble increased yield from 5.1 to 5.4 t/ha (P=0.009) and protein from 8.9% to 9.4% (P=0.007) and burning had no significant effect. Opener type had no significant effect in Phase 1, but the disc yielded less (4.8 t/ha) than the knife point (5.5 t/ha) and spear point (5.4 t/ha, P<0.001, LSD=0.1).

| Graze treatment | Stubble treatment | Soil mineral N to 1.75 m (kg/ha) | Grain yield (t/ha) | Grain protein (%) |
|---|---|---|---|---|
| **Nil graze** | Retain | 77 | 4.0 | 8.7 |
| | Burn | 92 | 4.5 | 7.9 |
| **Stubble graze** | Retain | 151 | 5.2 | 9.2 |
| | Burn | 146 | 5.1 | 9.1 |
| **P-value** | | <0.001 | 0.005 | 0.006 |
| **LSD (p=0.05)** | | 4 | 0.2 | 0.3 |

*Table 6. Soil water depletion, soil mineral N to 1.75 m, grain yield and protein for Phase 1 in 2015.*

### Gross Income

Averaged across both phases for the six years of this experiment, the grazing and then retaining (not burning) stubble treatment has the highest gross income (Table 7). Even if no value is placed on grazed stubble, the stubble-graze stubble-retain treatment still grossed $45/ha per year more than the nil graze stubble retain treatment. Assuming the grazed stubble is valued as outlined in the methods section (averages $133/ha across both phases in all seasons), this economic advantage increases to $178/ha.

| Graze treatment | Stubble treatment | Gross income ($/ha/year) | |
|---|---|---|---|
| | | Assuming grazed stubble has no value | Assuming grazed stubble has value as per methods |
| **Nil graze** | Retain | $1,153 | $1,153 |
| | Burn | $1,179 | $1,179 |
| **Stubble graze** | Retain | $1,197 | $1,312 |
| | Burn | $1,193 | $1,307 |

*Table 7. Gross income per year averaged across both phases for all years (2010-2015) of the experiment*

## Conclusion

Over the six years that this experiment has been running, grazing and retaining (not burning) stubble has been the most profitable treatment. This is partly due to the grazing value of the stubble ($133/ha) and partly due to higher yields in that treatment which have largely been due to higher N availability. Since 2013 the graze and retain treatment has consistently delivered higher yields, whilst burning has only been of benefit due to frosts in 2013 and the wet growing season of 2015.

Based on these results, mixed farmers can safely continue grazing stubbles provided they control all weeds with herbicides promptly, and don't graze below 70% cover. N fertiliser inputs may be able to be reduced, and grain yields increased if measures are taken to ensure that stubbles are grazed thoroughly and evenly down to threshold levels e.g. strip grazing with electric fences etc.

In this experiment where in-crop weed populations are low, there has been no consistent advantage of either the disc or tine openers (with or without grazing). This will continue to be monitored over the next few years.

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# 02

FarmLink Research Report 2015

# Strategic Use of Tillage within No-Till Systems

GRDC Project code – DAN00152

## Project Partners

FarmLink, CSIRO

## Funding Partners

GRDC Grains Research & Development Corporation

## Trial Site Location

Harden, Daysdale, Thuddungra, Berthong

## Report Authors

Mark Conyers on behalf of the team ... Geoff and John Byrne, Chris Holland, Andrew Simpson (farmers), Peter McInerney, Sandy Biddulph, Greg Hunt (consultants), Cindy Cassidy (FarmLink), John Kirkegaard, Clive Kirkby, Andrew Bissett, John Graham (CSIRO), Vince van der Rijt, Albert Oates, Graeme Poile, Kurt Lindbeck (DPI NSW)

## Introduction

The project on the strategic use of tillage within no-till systems continued at the 4 sites in 2015: Harden, Daysdale (near Corowa), Thuddungra (near Young) and Berthong (near Cootamundra). Soil physical and chemical properties continued to be monitored throughout 2015. Establishment counts, dry matter and grain yields were also measured. The final harvest for the sites occurred in December 2015, except at the Daysdale site where we grew a vetch brown manure crop that was cut for dry matter in October. The final soil sampling at all sites will take place in autumn 2016.

While some soil properties were adversely affected by tillage that took place in 2011, 2012 or 2013, the effects of tillage on dry matter and grain yield have statistically either been neutral or slightly beneficial over the 4 or 5 seasons at each site. The example below shows the effect of treatments on the dry matter production of the vetch crop at Daysdale during 2015. The treatments at this site included:

- Year in which the soil was tilled: 2012 or 2013
- Application of additional nutrients to transform stubble into soil carbon: +/-
- Tillage: on going no-till, scarifying, or off-set discing.

There were 4 replicates of these 12 treatment combinations. The plots were 6m wide and 20 m long and contained two sown strips within each plot.

In 2015 the main effects of 'year of tillage' or of 'additional nutrient application' were not significant. However the mean impact of 'tillage' that had been undertaken 2 or 3 years earlier remained significant:

no-till 4.82 t/ha, scarification 5.99 t/ha, disced 6.24 t/ha s.e. 0.376 t/ha.

This means that the no-till soil yielded less vetch dry matter than either of the tilled treatments, even 2 and 3 years after that tillage. We are analysing the plant tissues to see if N or P nutrition contributed to this effect.

At the CSIRO site at Harden the canola grain yield was surprisingly high considering the finishing conditions (Table 1). The table shows that 25 years of ongoing stubble and tillage treatments had little impact on grain yield in 2015 (the upper 4 data cells). Of direct relevance to this project, there was no significant effect of strategic tillage in 2011 on grain yields in 2015 (the lower 4 data cells with s.e.m given in parentheses) and it is clear that the application of a strategic tillage in 2011 has not harmed yields in the no-till system.

In 2015 we undertook some soil biological tests at the Thuddungra site to compare the effects of tillage, stubble management and nutrients on biological functions within the soil. Following some additional tests in Switzerland, we hope to able to report some interesting findings later this year.

Grain data from the Thuddungra and Berthong sites were still being processed at the time of reporting.

After the final soil sampling in autumn 2016 we will have a large amount of laboratory work to complete and a large statistical task to complete. Final findings and recommendations from this strategic tillage project will be available in early 2017.

| | Burnt | Retained |
|---|---|---|
| Cultivated | 2.65 | 2.76 |
| No-till | 2.73 (0.18) | 2.49 (0.15) |
| No-till, | $268 | |
| Strategically tilled in 2011 | 2.86 (0.10) | 2.56 (0.18) |

*Table 1. Canola grain yields at Harden in 2015.*

# 03

FarmLink Research Report 2015

## Crop Sequencing

GRDC Project code – CSP00146

### Project Partners

A collaboration between CSIRO, NSW Department of Primary Industries (NSW DPI), the Victorian Department of Economic Development, Jobs, Transport and Resources (ECODEV; previously Vic DEPI, or Vic DPI) and leading Grower Groups in the Southern Region based in either the lower rainfall (Birchip Cropping Group [BCG], Central West Farming Systems [CWFS]), medium-high (FarmLink, Riverine Plains), or high rainfall zone (Southern Farming Systems [SFS], MacKillop Farm Management Group [MFMG]), or have a focus on irrigated systems (Irrigated Cropping Council [ICC]).

### Funding Partners

GRDC Grains Research & Development Corporation

### Introduction

The Grains Research & Development Corporation (GRDC) Crop Sequence Initiative was established to address concerns within the grains industry at the intensification of cereal cropping that occurred during the Millennium drought. Continuous wheat had become increasingly common in many grain production areas, despite a wide range of other crop options being available. In part the preference of wheat over other crops were based on the perception that cereals were less risky and more profitable; especially in the face of variable climatic conditions. However, in most areas there were growers who ran profitable farming systems that challenged this perception as they actively embraced broadleaf break crops such as canola and legume pulse crops, or routinely included a legume-dominant pasture phase as part of their cropping sequence.

Projects within the Crop Sequence Initiative aimed to generate new information on how crop choice and sequence could affect grain productivity and profitability, and to give growers necessary knowledge and confidence to appropriately and profitably integrate a greater range of crops into their system.  A sister project in the Crop Sequence Initiative in the Southern Region was undertaken by the Low Rainfall Cropping Group (project CWF00009) which represented an alliance of Grower Groups from the low rainfall grain production areas of NSW, Victoria and SA which included BCG, CWFS and Mallee Sustainable Farming Systems (MSFS)  See map below to indicate the general geographic locations of the Grower Groups participating in both these projects.

Specific project aims were:

1. To quantify the rotational benefits of broadleaf crops or pastures for cereals through participatory research in partnership with key agribusiness consultants and 7 leading grower groups from NSW, Victoria and SA.
2. To identify whether profitable broadleaf cropping sequence alternatives to continuous cereals are available for low, medium and high rainfall zones, and irrigated systems.
3. To provide grain-growers and their advisers with guidelines and economic data they can use to identify the circumstances when they can expect to derive the best outcome from the inclusion of different break crops and pasture options.
4. To increase the diversity of species grown in cropping sequences.

Much of the experimentation and on-farm trials undertaken by these two projects aimed at answering one or more of the following questions:

1. Can a break crop be as profitable as wheat?
2. Are sequences that include break crops more profitable than continuous wheat?
3. Can a weed problem be managed more cost effectively with a break crop than in a continuous cereal system?
4. What effects do break crops have on soil nitrogen availability?
5. What break crop should I grow?

The Crop sequencing project started in 2010 and is due to finish in March 2016.  One of the final outcomes of the project will be to produce an interactive on line web site that provides a summary of the key findings from GRDC projects CSP00146 and CWF00009 to assist growers and advisors on regionally specific results. Some of the key highlights will include:

What are crop sequences and why do we need to reconsider the management of them?

Break crop management considerations such as:

- Profitability of break crop sequences
- Managing weeds with break crops
- Managing nitrogen with break crops


Regional  specifics:

- Low rainfall (BCG, CWFS, MSFS )
- Medium rainfall (FarmLink, MFMG, Riverine Plains)
- High rainfall (FarmLink, ICC, MFMG, SFS)

Other Resources:

- Rules of thumb: Agronomist's cheat sheets to managing crop sequences;
- Decision support tool: using the timing of the 'break' to decide when it is best to use broadleaf options; and
- Reports, scientific and conference papers

**This report is to inform readers to "watch this space". We aim to have the interactive website up by June 2016 with grower groups notifying members when it occurs.**

# Profitable crop sequences to reduce ryegrass seed bank where herbicide resistant ryegrass is a major constraint to the sustainability of cropping systems

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*This paper/report was presented © 2015 "Building Productive, Diverse and Sustainable Landscapes "Proceedings of the 17th ASA Conference, 20 – 24 September 2015, Hobart, Australia. Website www.agronomy2015.com.au*

## Abstract

The profitability of cropping sequences involving pulse break crops (grain or brown manure-BM), canola and wheat high and low input (H & L), fallow and cereal hay and the respective effectiveness of each treatment in reducing the seed bank of an annual ryegrass (ARG) population resistant to multiple post-emergent herbicides, was investigated at Eurongilly in southern NSW between 2012 and 2015. Sequences that involved either canola or a spray topped lupin grain crop in year 1 followed by cereal hay or RoundupReady (RR) canola in year 2 provided high gross margins and significantly reduced ARG seed bank over the 3 year crop sequence. Cheaper double break combinations using a fallow or pulse BM in year 1 followed by RR canola in year 2 resulted in lower gross margins, but were the most effective in reducing the seed bank. The seed bank at the site changed from 1815 seeds/m$^2$ in year 1 to between 56 and 3140 seeds/m$^2$ at the conclusion of the experiment depending on crop sequence. RR canola in year 1 followed by high input wheat (Sakura® pre-em & post emergent Boxer Gold®) in year 2, and wheat (Sakura®) in year 3 was the most profitable sequence, but was less effective at reducing the seed bank (219 seeds/m$^2$) compared to most double break options (56-142 seeds/m$^2$) with the exception of triazine tolerant (TT) canola followed by cereal hay (300 seeds/m$^2$).

**Keywords: Canola, cereals, crop sequences, herbicide resistant ryegrass, pulse legumes, wheat.**

There is substantial evidence indicating wide-spread resistance or partial resistance of ARG (Lolium rigidum Gaudin) to a wide range of herbicide groups (Broster et al 2011) across south eastern Australia. Consultation with grower groups and agribusiness collaborators identified difficulties in managing grass weeds as a main constraint to wheat production, and the primary driver of decisions to grow broad leaf break crops. This paper outlines the main findings to date on sequence profitability and effectiveness

## Introduction

at reducing seed banks of herbicide resistant ARG from experiments that examined the impact of different inputs and herbicides applied to canola, pulse legumes, or wheat crops. The experiments address two key questions:

1. Do crop sequences that include a break crop improve the profitability of subsequent cereal crops in the presence of herbicide resistant ARG?
2. Can herbicide resistant ARG be managed more cost-effectively under break crops than cereals?

Experiments were established in 2012 in a paddock at Eurongilly in south-eastern NSW on red chromosols (Isbell, 1996) where herbicide-resistant ARG was known to be present with seed bank of 1815 plants/m2. The susceptibility/resistance of the ARG was tested by Plant Science Consulting SA. Results indicated that the ARG was resistant or partially resistant to group A herbicides Haloxyfop (70%), Clethodim (55%), Pinoxaden & Cliquintocet-methyl (65%), and Group B herbicides Iodsulfuron-

## Methods & Materials

methyl-sodium (95%), but 100% susceptible to one Group A herbicide, Butroxydim and to Group M (Glyphosate). The crops/treatments established in the each of the three years were:

- Year 1: Canola (RR & TT), legumes (pulse grain or brown manure), wheat (High & Low input) or fallow;
- Year 2: Canola (RR), wheat (high or low input) or cereal wheat (Hay);
- Year 3: Wheat.

Two input rates, high (H) or low (L) were included for wheat treatments with the (H) treatments used to examine a combination of effects including:

1) new but expensive pre- and post emergent herbicides 2) increased sowing density for increased competition 3) higher fertiliser rates (nitrogen and phosphorus) in canola and wheat for increased early vigour and competition. In the (H) treatment, the total input costs were significantly greater than (L) treatments, but they had the potential to return higher yields and gross margins (GM). Plant density aimed for in the canola, lupin and field peas (BM) were 40 plants/m2, lentils at 120 plants/m2, wheat (H & L) at 75 and 150 plants/m2. Canola was seed dressed with Jockey® & Gaucho® and fertilized with MAP @ 25 & 75kg/ha (TT & RR) with wheat (L & H) seed dressed with Raxil® or Dividend® and fertilized with MAP @ 25 & 75kg/ha, respectively. All treatments had an initial knockdown spray of Glyphosate 450 @ 1.6 L/ha. A brief outline of herbicides is summarised below. Detailed information is available on request.

**Year 1 treatments imposed, input/risk categories and input costs (2012):**

1. **TT Canola:** cv. Crusher open pollinated; NH4SO4 (100 kg/ha) pre-sow, urea top dressed (100 kg/ha). Triflur®X @ 2 L/ha + Atrazine 900 @ 1.1 kg/ha; Factor® @ 80 g/ha + Atrazine 900 @ 0.9 kg/ha. Total input cost = $249/ha.
2. **RR Canola:** cv. Hyola®505 hybrid; NH4SO4 (100 kg/ha) pre-sow, urea top dressed (200 kg/ha). Triflur®X @ 2 L/ha, Round-Up Ready® @ 0.9 kg/ha at 2-3 leaf & 6 leaf. Total input costs = $427/ha.
3. **Fallow:** fallow established in September 2012 with an application of Glyphosate 450 @ 2 L/ha, Ally® @ 5 g/ha, double knocked with Gramoxone® 250 @ 2 L/ha. Total input costs = $35/ha.
4. **Field peas & Lupin BM:** cv's Morgan & Mandelup. Triflur®X @ 2 L/ha + Simazine 900 @ 1 kg/ha; BM spray of Glyphosate 450 @ 2 L/ha + LontrelTM @ 150 ml/ha + Hammer® @ 25 ml/ha (early September); Glyphosate 450 @ 2.5 L/ha (mid October). Total input costs = $120/ha and $129/ha, peas and lupins, respectively.
5. **Lupin grain:** cv. Mandelup. Triflur®X @ 2L/ha + Simazine 900 @ 2.2 kg/ha; Factor® @ 180 g/ha; spray top with Gramoxone® 250 @ 400 ml/ha (mid November). Total input costs = $168/ha.
6. **Wheat (L):** cv. Spitfire; urea @ GS30 (100 kg/ha). Triflur®X @ 2L/ha + Diuron 500 @ 1 L/ha; Boxer®Gold @ 1.5 L/ha at 2-3 leaf stage. Total input costs = $169/ha.
7. **Wheat (H):** cv. Spitfire; urea @GS30 (200 kg/ha). Sakura® 850WG @ 118 g/ha + Avadex® Xtra @ 2 L/ha; Boxer®Gold @ 2.5 L/ha and Axial® @ 150 ml/ha at 2-3 leaf stage. Total input costs = $430/ha.

Two sowing times in 2012 were late April (canola and lupin) and mid May (field peas BM and wheat). All plots were kept weed-free during summer fallow period. Initial plots were 40m in length x 1.8 m with each treatment replicated four times.

**Year 2 treatments (wheat or second break crop) in 2013:**

All plots from year 1 were split into three sub-plots. Four treatments were sown in early May 2013 being RR canola, wheat (H & L) and cereal hay (wheat). Wheat (H & L) was sown into all year 1 treatments and RR canola was sown into pulse, wheat or fallow year 1 treatments only. Cereal hay was sown into canola year 1 treatment to act as a double break. Nitrogen as urea was differentially applied to all year 2 treatments to achieve a wheat grain yield of 7 t/ha in the wheat (H), 4 t/ha in the wheat (L) and 3.5 t/ha in canola based on mineral N concentrations measured prior to sowing. The herbicides used in year 2 were similar to those used in year 1 for the respective crop and input category.

**Year 3:**

All plots were sown to wheat cv. Suntop (Dividend®) + MAP + Impact® @ 75 kg/ha. Herbicides included Weedmaster®ArgoTM (1.9 L/ha), Hammer® (45 ml/ha), Sakura® 850WG (118 g/ha), Avadex®Xtra (2 L/ha). Urea was top dressed at GS30 between 87 and 187 kg/ha to achieve a target wheat grain yield of 5 t/ha for all treatments based on levels of mineral N measured prior to sowing in different treatments.

In late March year 1 (pre-experiment), forty surface soil cores (6cm in diameter x 5cm deep) were randomly removed across the trial area with eight surface cores removed per treatment in April of year 2, year 3 and year 4 to measure changes in ARG seed bank. The soil was put into trays and watered over the following three months and all emerged ARG counted. GM were calculated using input costs and operations from SAGIT/NSW DPI GM books and commodity prices on day of harvest from cash prices at GrainCorp terminal at Junee, NSW.

# Results

### Crop yields and gross margins

In year 1 the most profitable crops were RR and TT canola which returned grain yields and gross margins of 3.5t/ha (GM =$1259/ha) and 3t/ha (GM = $1166/ha), respectively. The next most profitable crops were lupins (H) @ $683/ha (yield = 3.1t/ha), wheat (H) @ $257/ha (yield = 3.2t/ha), wheat (L) @ $250/ha (yield = 2.0 t/ha), with the brown manure or fallow treatments having negative returns (-$45 to -$250/ha). In year 2, the treatments with the highest gross margin were canola following fallow or brown manure treatments (> $1000/ha, grain yield avg = 3.5t/ha) with canola following wheat (H) or lupins (H) returning ~$900/ha (grain yield = 3.2t/ha). Over the 3 years, the most profitable sequence was RR canola - wheat (H) - wheat, with an average GM of $883/ha/yr. Sequences with the highest average annual gross margins >$800/ha/yr were treatments that had canola (RR or TT) in year 1, with the next most profitable group having grain lupins in year 1 or canola year 2 (> $600/ha). The third group included sequences of fallow, combinations of wheat (H or L) or lentils in year 1, with the final group involving sequences with BM crops followed by wheat (H or L) (Table 1).

### Interaction between crop treatments and ryegrass plant populations.

ARG panicles (m2) in spring year 1 in untreated areas were 1042, significantly more than wheat (L) with 534 panicles/m2. All other treatments in year 1 had significantly less panicles than wheat (L), but the most effective ARG control was achieved by fallow, pulse BM or canola (H) (Table 1). By spring in year 2, there were significant differences in panicles/m2 with four distinct categories (0-8, 14-71, 192-388 & >643 panicles/m2) (Table 1). Main year 2 treatment effects continued into year 3 with significantly less panicles in order of: canola < hay = wheat (H) < wheat (L), and year 1 effects: fallow < pulses < canola = wheat (H) < wheat (L). Interactions were categorised into groups of (0-30, 60-166, 199-370, >536 panicles/m2) (Table 1). Generally, double break sequences or those where wheat (H) treatments were grown following treatments with bare soil or less stubble from year 1 had significantly fewer panicles.

By autumn year 2, there was a significant three-fold increase in ryegrass seed bank populations (5492 seeds/m2) following wheat (L) and by autumn year 3 a further significant 2.5 fold increase (13148 seed/m2) after a second wheat (L) treatment. Comparatively, seed bank numbers reduced to 124 seeds/m2 where canola (H) 2012 was followed by wheat hay (2013), and double breaks involving legumes, canola, fallow or hay resulted in the lowest seed banks following the 3 year sequences (Table 1). Main effects from year 1 and year 2 treatments were still apparent after the conclusion of the experiment in March 2015, with the year 2 treatments having a greater effect with significantly higher seed bank numbers remaining in order of: wheat (L) > wheat (H) > wheat (hay) > canola (meaned data not shown). The expensive herbicide costs ($142/ha) associated with consecutive wheat (H) treatments resulted in a significant reduction in seed bank by November 2014 (366 plants/m2), but was not as effective as sequences involving break crops or a fallow.

### Discussion & Conclusion

In the presence of a high population of herbicide resistant ARG, sequences that include a break crop were more profitable compared to continuous wheat (H or L). Canola was consistently the most profitable break crop, largely due to the high returns from canola itself, but legume grain crops were profitable and provided additional N in year 2. Although the TT canola / wheat (H) sequence was profitable, it was not as effective at reducing the ryegrass seed bank and any sequence with wheat (L) resulted in an increase in ryegrass numbers. Break crops or fallow provided cheaper and more effective ARG control options. Two consecutive years of complete ARG control were required to reduce seed banks to managable levels. The most profitable double break sequences were RR canola followed by a cereal hay or grain lupins followed by RR canola with these sequences also very effective at reducing the seed bank. Sequences involving fallows and brown manures reduced production risk in subsequent years due to enhanced yield in the following wheat crops, but were not as profitable as continuous cropping.

# Acknowledgements

We are grateful to the Grains Research and Development Corporation (GRDC project CSP000146) for financial support to undertake the investigation. We would also like to thank Alec Zwart from the CSIRO biometric division for his valued statistical advice.

| Crop x Input 2012 | Crop x Input 2013 | Ryegrass panicles Nov 2012 | SEED-BANK March 2013 | Ryegrass panicles Nov 2013 | SEED-BANK March 2014 | Ryegrass panicles Nov 2014 | SEED-BANK March 2015 | Average Annual 3yr GM |
|---|---|---|---|---|---|---|---|---|
| **(Year 1)** | **(Year 2)** | **(panicles/ m2)** | **(seeds/ m2)** | **(panicles/ m2)** | **(seeds/ m2)** | **(panicles/ m2)** | **(seeds/ m2)** | **($/ha/ yr)** |
| Fallow | Canola | 0 (NM)^ | 290 | 0 | NM | 2 | 56 | $603 |
| Lupin grain | Canola | 43* | 748 | 0 | 196 | 6 | 63 | $790 |
| Lupin BM | Canola | 0 (NM)^ | 152 | 0 | NM | 1 | 110 | $552 |
| Fallow | Wheat (H) | 0 (NM)^ | 290 | 2 | NM | 10 | 118 | $539 |
| RR Canola | Wheat (Hay) | 0 | 208 | 0 (537)^ | 124 | 23 | 122 | $834 |
| Pea BM | Canola | 0 (NM)^ | 464 | 0 | 210 | 4 | 142 | $513 |
| Lupin grain | Wheat (H) | 43* | 748 | 8 | 312 | 19 | 148 | $757 |
| Pea BM | Wheat (H) | 0 (NM)^ | 464 | 2 | 496 | 14 | 162 | $486 |
| RR Canola | Wheat (H) | 0 | 208 | 15 | 381 | 29 | 219 | $883 |
| TT Canola | Wheat (H) | 32 | 505 | 14 | NM | 82 | 252 | $844 |
| Wheat (H) | Canola | 78 | 777 | 0 | 259 | 20 | 267 | $636 |
| Lupin BM | Wheat (H) | 0 (NM) | 152 | 2 | NM | 11 | 279 | $463 |
| TT Canola | Wheat (Hay) | 32 | 505 | 0 (790)^ | NM | 23 | 300 | $844 |
| Wheat (L) | Canola | 504 | 5492 | 0 | 797 | 22 | 332 | $582 |
| Wheat (H) | Wheat (H) | 78 | 777 | 29 | 1379 | 60 | 366 | $585 |
| Wheat (L) | Wheat (H) | 504 | 5492 | 71 | 3412 | 121 | 523 | $537 |
| Fallow | Wheat (L) | 0 (NM)^ | 290 | 56 | NM | 100 | 970 | $530 |
| Lupin BM | Wheat (L) | 0 (NM)^ | 152 | 192 | NM | 308 | 1105 | $419 |
| Lupin grain | Wheat (L) | 43* | 748 | 200 | 6614 | 122 | 1167 | $715 |
| Wheat (H) | Wheat (L) | 78 | 777 | 294 | 5508 | 147 | 2158 | $513 |
| TT Canola | Wheat (L) | 32 | 505 | 383 | NM | 229 | 2222 | $800 |
| RR Canola | Wheat (L) | 0 | 208 | 388 | 7770 | 200 | 2387 | $845 |
| Pea BM | Wheat (L) | 0 (NM)^ | 464 | 237 | 7413 | 157 | 3118 | $397 |
| Wheat (L) | Wheat (L) | 504 | 5492 | 898 | 13148 | 943 | 3140 | $388 |
| **P value (2012)** | | **<0.001** | **<0.001** | **<0.001** | **<0.001** | **<0.001** | **<0.001** | |
| **P value (2013)** | | | **NA** | **<0.001** | **<0.001** | **<0.001** | **<0.001** | |
| **P value (interaction)** | | | **NA** | **0.004** | **0.105** | **<0.001** | **0.699** | |

*Table 1 Average annual gross margin over 3 years compared to ryegrass seedbank (April 2013, 2014, 2015) and ryegrass panicle number (November 2012-2014) in Exp 1 at Eurongilly, NSW. Crop 2012 pre-treatments are arranged in order of descending SEEDBANK March 2015 seed counts.*

**Lupins spray topped in Nov 2012 prior to ryegrass seed maturity*

*^Ryegrass panicles estimated at zero in 2012 and 2013 due to either spraying or cutting of hay prior to seed set*

*NM Not measured*

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# Legume effects on available soil nitrogen and comparisons of estimates of the apparent mineralisation of legume nitrogen

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*This paper/report was presented © 2015 "Building Productive, Diverse and Sustainable Landscapes "Proceedings of the 17th ASA Conference, 20 – 24 September 2015, Hobart, Australia, website www.agronomy2015.com.au*

## Abstract

Results from experimentation undertaken in southern NSW indicated that total soil mineral (inorganic) nitrogen (N) measured just prior to sowing wheat in 2012 (0-1.6m) was 42 or 92 kg N/ha greater following lupin grown for either grain or brown manure (BM) respectively, than following wheat or canola in 2011. The apparent net mineralisation of lupin organic N over the 2011/12 summer fallow was equivalent to 0.11-0.18 kg N/ha per mm rainfall and 7-11 kg mineral N per tonne lupin shoot residue dry matter (DM). This represented 22-32% of the total estimated lupin residue N at the end of the 2011 growing season. By the autumn of 2013, there was still 24-40 kg more N/ha after the 2011 lupin treatments than non-legumes. This represented an apparent mineralisation of a further 4-5 kg N per tonne of 2011 lupin's residue biomass and 14% of its N two years after the lupin had been grown. Data collated from four other experiments undertaken in different years and locations in NSW, Vic and SA generated similar increases in soil N availability in the year following legumes, and comparable estimates of N mineralisation. It was concluded that relationships averaged across all eight pulse crops grown for grain in the five separate studies (0.18 kg N/ha per mm; 10 kg N/ha per t shoot residue DM; 26% residue total N) could represent useful 'rules-of-thumb' to predict the likely affects of legumes on the N dynamics of dryland cropping systems.

**Keywords: pulses; canola; cereals; on-farm; grower group**

## Introduction

Even though elevated concentrations of soil mineral nitrogen (N) (i.e. nitrate+ammonium) are frequently observed after legume crops and pastures (Angus et al 2015), only a fraction of the N in legume residues remaining at the end of a growing season becomes available immediately for the benefit of subsequent cereal crops (Peoples et al 2009). The microbial-mediated decomposition and mineralisation of the N in legume organic residues into plant-available inorganic forms is influenced by three main factors: (i) rainfall to stimulate microbial activity, (ii) the amount of legume residues present, and (iii) the N content (and "quality") of the residues. Field data are utilised to estimate the apparent mineralisation of N from legume stubble, or brown manure (BM; where a legume is killed with "knock-down" herbicide prior to maturity to provide a boost in available soil N and/or to control difficult to manage weeds). The rate of mineralisation is expressed per mm of summer fallow rainfall, per tonne (t) of above-ground legume residue dry matter (DM), and kg total residue N (i.e. above-ground N + N estimated to be associated with the nodulated roots).

## Methods

The experiment was located at an on-farm field site at Junee Reefs, NSW, Australia and undertaken in partnership with the FarmLink Research grower group. Soil pH (CaCl2) was 5.50 in the surface 0-10 cm. Soil mineral N prior to the commencment of the experiment in April 2011 (0-1.6m) was 100 kg N/ha. The following crop treatments were replicated four times and were sown in a randomized design in 2.5 x 20m plots in either late-April (lupin and canola) or mid-May (wheat):

1. Lupin: cv Mandelup - for grain; inoculated at sowing + 75 kg kg/ha MAP (8 kg N/ha);
2. Lupin: cv Mandelup - for brown manure (BM); inoculated at sowing + 25 kg/ha MAP (3 kg N/ha), with the crop being terminated in September using knock-down herbicides (450 g/L glyphosate (Roundup CT) @ 2 L/ha + 300 g/L clopyralid (Lontrel) @ 150 ml/ha + 240 g/L carfentrazone-ethyl (Hammer) @ 25 ml/ha);
3. Canola: cv Crusher TT– for grain; (Jockey + Gaucho) + 25 kg/ha MAP (3 kg N/ha) + 100 kg/ha urea (46 kg N/ha) and 80 kg/ha ammonium sulphate (17 kg N/ha) in-crop;
4. Wheat: cv Lincoln – for grain; Raxil + 25 kg/ha MAP (3 kg N/ha) + 100 kg/ha urea (46 kg N/ha) in-crop.

Above-ground biomass was determined immediately prior to lupin BM termination, or 4 weeks later in the case of the grain crops at around the time of lupin mid-pod fill by removing all plants from 4 x 1m sections of row from each plot. Shoot DM was measured after drying subsamples at 70ºC. Grain yield was determined at maturity by the mechanical harvesting of the central 16m of each plot. Dried plant and grain samples were analysed for % N and 15N abundance using a 20-20 stable isotope mass spectrometer (Europa Scientific, Crewe, UK). At the end of April 2012, each of the replicated plots was sampled for soil mineral N analysis to a depth of 1.6m, and all treatments were sown to Spitfire wheat in mid-May. Further soil samples were again collected for soil mineral N analysis in April 2103.

Four additional studies similar to that outlined above at Junee Reefs, have been undertaken in collaboration with the Riverine Plains grower group, Birchip Cropping Group (BCG), Mackillop Farm Management Group (MFMG), NSW DPI, Vic DEPI and SARDI in NSW, Victoria and South Australia. These experiments are not described in detail here; however, summaries of estimates of apparent mineralisation of legume from these studies are included in the current paper for comparative purposes.

## Calculations

Estimates of total plant N were derived from the peak biomass shoot N data by assuming ~25% total plant N for lupin, and ~30% for wheat and canola N was associated with roots (Unkovich et al. 2010). The last 1m at each end of the canola and wheat plots received no fertiliser N and plants were collected from these areas at the same time as the lupin sampling and were used as "reference" plants to allow the determination of the proportion of the lupin N derived from atmospheric N2 (%Ndfa) using the 15N natural abundance technique, and these values were combined with lupin total N data to calculate inputs of fixed N:

**Amount of N2 fixed over the growing season (kg N/ha)**

= (total lupin N) x (%Ndfa/100)    Equation [1]

The total amounts of N remaining in crop vegetative residues and roots at the end of the 2011 growing season were calculated as:

**Total residue N**

= (total crop N) – (grain N removed)    Equation [2]

The net effect of lupin treatments on available soil N was calculated from the differences in soil mineral N data (0-1.6m) following lupin and wheat in April 2012 and April 2013. The apparent net mineralisation of lupin N was calculated in several different ways from mean treatment data by assuming negligible net N release from the 2011 wheat residues :

**Apparent mineralisation of legume residues (kg N/ha per mm fallow rainfall)**

= [(mineral N after legume) – (mineral N after wheat)] /(fallow rain)    Equation [3]

**Apparent mineralisation of legume residues (kg N/ha per tonne shoot residue DM)**

= [(mineral N after legume) – (mineral N after wheat)] /(legume shoot residue DM)    Equation [4]

Where shoot residue = (peak biomass DM) – (grain yield)

**Apparent net mineralisation of legume N (% 2011 total residue N)**

= 100x [(mineral N after legume) – (mineral N after wheat)] /(total legume residue N)    Equation [5]

Analysis of variance was undertaken on the DM, N and soil mineral N data to provide least significant difference (LSD) determinations. In each case P values were <0.001. However, no such statistical analyses were possible for the derived estimates of apparent mineralisation obtained using Equations [3]-[5], but as DM, N and soil mineral N provide the basis of the estimates, significant differences in these main factors should be sufficient to confer differences in apparent mineralisation.

## Results

### Crop growth in 2011

The 2011 growing season rainfall (GSR: April-October) was 216 mm which was lower than the 311 mm long-term average, but heavy rainfall in February 2011 (226 mm) resulted in an annual total of 639 mm, around 130 mm wetter than the long-term average (506 mm). The soil moisture profile at the beginning of the growing season was close to full which contributed to good crop establishment and growth, and respectable grain yields (Table 1). The lupin treatments were calculated to have accumulated a total of 290 kg N/ha (lupin BM) and 398 kg N/ha (lupin grain crop) of which 241 kg N/ha (83±3%) and 338 kg N/ha (85±4%) were estimated to have been derived from N2 fixation, respectively (LSD=35; P<0.001). The crop harvest indices (grain as % of above-ground DM) were 35% for lupin, 43% for wheat and 30% for canola. The N content of the stubble remaining after grain harvest was higher for the lupin crop (1.4%N; C:N ratio=28) than either canola (0.7%N; C:N=60) or wheat (0.3%N; C:N=130), but the shoot material in the lupin BM treatment had the highest "quality" (2.6%N; C:N=15). The total amounts of N calculated to be remaining in the vegetative residues and roots of the lupin treatments at the end of the 2011 growing season were between 3- to 5-fold higher than where wheat had been grown (Table 1).

| Crop grown in 2011 | Peak bio-mass | Above-ground N | Total crop N[b] | Grain yield | Grain N harvested | N remaining in residues |
|---|---|---|---|---|---|---|
| | (t DM/ha) | (kg N/ha) | (kg N/ha) | (t/ha) | (kg N/ha) | (kg N/ha) |
| Lupins BM | 8.4 | 218 | 290 | 0 | 0 | 290 |
| Lupins | 9.9 | 300 | 398 | 3.5 | 210 | 188 |
| Wheat +N[a] | 11.1 | 106 | 151 | 4.8 (10.4% protein) | 87 | 64 |
| Canola +N[a] | 10.6 | 164 | 207 | 3.2 (46% oil) | 94 | 113 |
| **LSD (P<0.05)** | **1.3** | **36** | **46** | | **11** | **22** |

*Table 1: Average annual gross margin over 3 years compared to ryegrass seedbank (April 2013, 2014, 2015) and ryegrass panicle number (November 2012-2014) in Exp 1 at Eurongilly, NSW. Crop 2012 pre-treatments are arranged in order of descending SEEDBANK March 2015 seed counts.*

*a N fertiliser was applied to wheat @ 49 kg N/ha and canola @ 66 kg N/ha.*

*b Above-ground data adjusted to include an estimate of below-ground N (Unkovich et al. 2010).*

**Trends in available soil mineral N, and estimates of N mineralisation in 2012 and 2013**

Soil mineral N measured in April 2012 were similar following the 2011 wheat and canola crops (76-77 kg N/ha), but were 42 or 92 kg N/ha greater than after wheat where lupin had been grown for grain or BM, respectively (Table 2). Apparent net mineralisation over the wet 2011/12 summer fallow (515 mm Sept 2011-April 2012 after BM, or 386 mm Nov 2011-April 2012 for grain crops cf 214 mm long-term average) represented the equivalent of 0.11-0.18 kg N/ha per mm rainfall, 7-11 kg N per tonne residue DM, and 22-32% of the 2011 lupin residue N. Soil mineral N was still 24 or 40 kg N/ha higher in soil in the lupin-wheat sequences than continuous wheat in April 2013 (Table 2), which was equivalent to a further 4-5 kg N per tonne of the 2011 residue DM, with 14% of the residue N subsequently becoming available.

| Crop grown in 2011 | Soil mineral N autumn 2012 | Apparent mineralisation of legume N | | Soil mineral N autumn 2013 | Apparent net mineralisation of legume N | |
|---|---|---|---|---|---|---|
| | (kg N/ha) | (kgN/t DM) | (% residue N) | (kg N/ha) | (kgN/t DM) | (% residue N) |
| Lupins BM | 169 | 11 | 32% | 167 | 5 | 14% |
| Lupins | 119 | 7 | 22% | 151 | 4 | 14% |
| Wheat | 77 | - | - | 127 | - | - |
| Canola | 76 | - | - | 115 | - | - |
| **LSD (P<0.05)** | **35** | | | **20** | | |

*Table 2: Concentrations of soil mineral N (0-1.6m) measured in autumn 2012 and 2013 following either wheat, canola and lupin grown for grain or brown manure (BM) at Junee, NSW in 2011, and calculations of the apparent net mineralisation of lupin N from 2011expressed per tonne shoot residue dry matter (DM), or as a % of total residue (above+below-ground) N.*

#### Comparisons of legume effects on soil mineral N and N mineralisation at other locations

Each of the four independent experiments undertaken in different locations, years, and soil types indicated improvements in soil mineral N after legumes, and comparable estimates of apparent net mineralisation of legume N (Table 3) were calculated to those obtained for Junee Reefs (Table 2).

| Location and year | Legumes grown for grain or BM in previous year | Additional soil mineral N | Apparent net mineralisation of legume N | | |
|---|---|---|---|---|---|
| | | (kg N/ha) | (kg N/ha per mm) | (kgN per t DM) | (% residue N) |
| Breeza, NSW | Chickpea | 38 | 0.14 | 12 | 30 |
| 1998 | Faba bean | 47 | 0.17 | 18 | 36 |
| Hopetoun, Vic | Field pea | 47 | 0.17 | 6 | 17 |
| 2010 | Vetch BM | 88 | 0.24 | 10 | 24 |
| Culcairn, NSW | Lupin | 61 | 0.10 | 11 | 30 |
| 2011 | Faba bean | 88 | 0.15 | 11 | 27 |
| Naracoorte, SA | Field pea | 28 | 0.23 | 6 | 18 |
| 2012 | Faba bean | 42 | 0.34 | 10 | 31 |
| **mean** | | **55** | **0.19** | **11** | **27** |

*Table 3: Examples of the impact of prior legume crops on additional autumn soil mineral N compared to following wheat, and estimates of the apparent net mineralisation of legume N at different locations in NSW, Vic and SA.*

## Discussion

In common with many previous field experiments where the accumulation of soil mineral N after legumes has been compared with wheat (Angus et al 2015), increased concentrations of available soil N were detected following all legume species grown at five different locations across south-eastern Australia (Tables 2 and 3). The estimates of apparent mineralisation of legume N calculated from these data represent the net effect of growing legumes for BM or grain on available soil N regardless of whether the mineral N was derived directly from above- and below-ground legume residues, arose from "spared" nitrate due to a lower efficiency of legume roots in the recovery of soil mineral N, and/or an additional release of N from the soil organic pool (Peoples et al. 2009). Although soil mineral N was not determined following grain harvest at the end of the 2011 growing season at Junee Reefs, given that lupin assimilated only 49-60 kg N/ha from the soil (calculated as: total lupin N - N fixed) while 151 kg N/ha was accumulated from the soil and fertiliser by wheat, it is likely that some of the additional available soil N measured after lupin represented unutilised nitrate carried over from the previous season.

The measured improvements in soil mineral N, and the derived estimates of apparent mineralisation of legume N, were similar across all five studies (Tables 2 and 3). As might be expected from the lower C:N ratio of the BM residues and the longer period available for mineralisation to occur (Peoples et al 2009), the calculated estimates of mineralisation were greater, for BM treatments than where pulses were grown for grain (Junee Reefs and Hopetoun). Apparent mineralisation also tended to be higher after lupin or faba bean than following chickpea or field pea (Breeza and Naracoorte average of 14 kg N/ha per t shoot residue DM and 33% residue total N cf 9 kg N/ha per t shoot residue DM and 22% residue total N; Tables 2 and 3).

## Conclusions

The relationships between summer fallow rainfall, legume residue DM, or total N, and soil mineral N measured the following autumn, were generally similar across five different experiments and were comparable to estimates previously determined for pasture legumes (Angus and Peoples 2012). This suggests that average estimates of apparent mineralisation might represent useful 'rules-of-thumb' to predict the likely additional mineral N provided by legumes in dryland grain production systems of south-eastern Australia. More experimental data are required to ensure the reliability of such determinations. This is especially important to confirm whether there are consistent differences between legume species and, in the case for legume BM treatments, to quantify the impact of timing of crop termination on the accumulation of mineral N. Of the three different measures of apparent mineralisation examined here, perhaps the estimate of around 10 kg additional soil mineral N/ha per tonne shoot residue DM might be the simplest for farmers and their advisors to apply. Since around one-third of the above-ground biomass is commonly harvested in grain in most pulse crops (i.e. Harvest Index = ~0.33), it should be relatively easy for farmers to calculate residue DM directly from grain yields (i.e. ~ twice the tonne grain harvested/ha). Consequently, 20 x tonne grain yield/ha could be a useful guide to the expected additional mineral N prior to sowing a following crop and provide a basis for modifying decisions on N fertiliser applications. However, it should be recognised that the end result will ultimately be mediated by rainfall over the summer fallow. There are potential negative implications of under-estimating available N using the proposed relationship as supplying too much fertiliser N to wheat in a dry cropping year could increase the risk of yield reductions due to haying-off.

## Acknowledgements

With the exception of the data from Breeza, all results were generated from experimentation initiated with financial support of the Grain Research & Development Corporation (GRDC project CSP000146).

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# 04

FarmLink Research Report 2015

# Farmers leading and learning about the soil carbon frontier

GRDC Project code – CRF00002

## Project Partners

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CSIRO

## Funding Partners

Australian Government Department of Agriculture

clean energy future

GRDC Grains Research & Development Corporation

## Trial Site Location

Temora Agriculture Innovation Centre

## Report Authors

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## Introduction

The soil organic matter content of Australian soils is either decreasing or remaining stable. Increasing soil organic matter content could be beneficial for improving soil water holding capacity, increasing nutrient supply (N and cations), better pH buffering capacity and improved soil structure).

**How can Soil Organic Matter be increased?**

The most active ingredient of SOM is humus, which consists of the remains of bacteria and other micro-organisms that consume and break down plant material returned to the soil from a crop or pasture. This plant material consists mainly of carbon (C). For soil microbes to consume this material they need nitrogen (N), phosphorus (P) and sulphur (S) otherwise they cannot thrive and multiply. Australian soils are inherently low in nutrients and in most soils there is insufficient N, P and S for soil micro-organisms to rapidly break down the plant material returned to the soil. To increase the stable humus fraction in the soil, we need to supply soil microbes with additional N, P and S; this may have to be supplied as extra fertiliser.

**How much N, P and S need to be supplied to stubble to form humus?**

Dr Clive Kirkby, from CSIRO, has been working on this question and found that:

- In humus, 1000 kg of C is balanced with 80 kg N, 20 kg P and 14 kg S.
- Dr Kirkby argues that for soil micro-organisms to breakdown stubble and form humus, we need to add sufficient nutrients (N, P and S) to feed these micro-organisms (Kirkby et al. 2011).
- For micro-organisms to efficiently break down wheat stubble to humus additional nutrients have to be added. Wheat stubble has a low nutrient:C ratio and 1t of cereal stubble needs to be balanced with 5.8 kg N, 2.2 kg P and 0.9 kg S.

The DAFF and GRDC funded trial is examining existing, new and alternative strategies for farmers in the cereal sheep zone to increase soil carbon. The trial will be used as base line data for carbon accumulation in soils and to:

- discuss the various forms of soil organic carbon (particulate, humus and resistant fractions),
- investigate how management affects each of these pools and how humus can be increased,
- communicate how soil organic matter affects soil productivity.

Identical trials are being run by eight farm groups in SE Australia (Victoria: Mallee Sustainable Farming, Birchip Cropping Group, Southern Farming Systems; NSW: FarmLink, Central West Farming Systems; SA: Hart and Eyre Peninsula Agricultural Research Foundation, both through Ag Ex Alliance; and Tasmania: Southern Farming Systems) so information can be collected on different soils and climates throughout the Southern Region.

# Methods

2015 was the fourth year of the trial. Soil samples were collected pre-sowing for Yield Prophet® (0-10, 10-40, 40-70, 70-100 cm) to determine soil available nitrogen, soil moisture and model in season crop N requirements.

In April the stubble management treatments were imposed: (i) stubble left standing, (ii) stubble worked in with off-set discs prior to sowing and (iii) stubble removed by raking and burning. Nutrient application treatments at seeding were: (i) base practice for P at sowing and N in crop as per Yield Prophet® and (ii) base practice PLUS extra nutrients (N, P, S) required to break down the measured canola stubble from the 2014 crop. Based on the 2014 stubble load, the extra nutrients (17.5 units N, 2.7 units P and 5.2 units S) required to break down the stubble were applied on 13 February with a rainfall event. The extra nutrients (Plus treatment) were applied as DAP (18:20:0:0) @ 14 kg/ha, ammonium sulphate (21:0:0:24) @ 22 kg/ha and urea (46:0:0:0) @ 37.5 kg/ha. Treatments were replicated 4 times.

The trial was sown on 28 May with Suntop wheat @ 50 kg/ha and a base fertiliser of MAP (11:22:0:2) @ 70 kg/ha. Summer knockdown chemical applications were 1.5l/ha Roundup, 700ml/ha Amicide, 80ml/ha Garlon plus an adjuvant. Pre seeding chemical applications were Roundup @ 2 L/ha, . On 22nd of August, MCPA LVE was applied at 1.0l/ha with 5g/ha of Ally at 70l of water/ha. No additional N was applied to the trial as very wet winter conditions saw some temporary waterlogging within the trial.

# Results 2015

### Yield

There was no significant effect on yield from the Stubble treatment but there was from the application of Extra nutrients (Table 1). This result implies that insufficient nutrients were applied to the Base nutrient treatments to enable the crop to reach its yield potential, and the nutrients applied in the Extra nutrient treatments were used by the crop rather than the intended soil micro-organisms to breakdown the stubble remaining from 2014.

| Stubble treatment | Nutrition treatment | Yield (t/ha) |
|---|---|---|
| Stubble removed | Base practice | 2.56 |
| Stubble removed | Base practice plus Extra N,P&S | 3.23 |
| Stubble standing | Base practice | 2.76 |
| Stubble standing | Base practice plus Extra N,P&S | 2.82 |
| Stubble worked | Base practice | 2.74 |
| Stubble worked | Base practice plus Extra N,P&S | 3.40 |
| P value Stubble treatment<br>Nutrient treatment | | NS<br>P<0.01 |

*Table 1 Grain yield as affected by stubble treatments and additional nutrients at Temora 2015*

**Soil Carbon 2012 to 2015**

Initial soil samples for soil Carbon analysis were taken prior to sowing in 2012 and again three years later prior to sowing in 2015. After three years of implementing the stubble and nutrient management strategies, soil C content at Temora ranged between 1.4 and 1.6% for the topsoil (0-10cm) and 0.5 and 0.7% for the subsoil (10-30cm). There was no significant difference in SOC content between the 2012 and 2015 measurements (Figure 2).

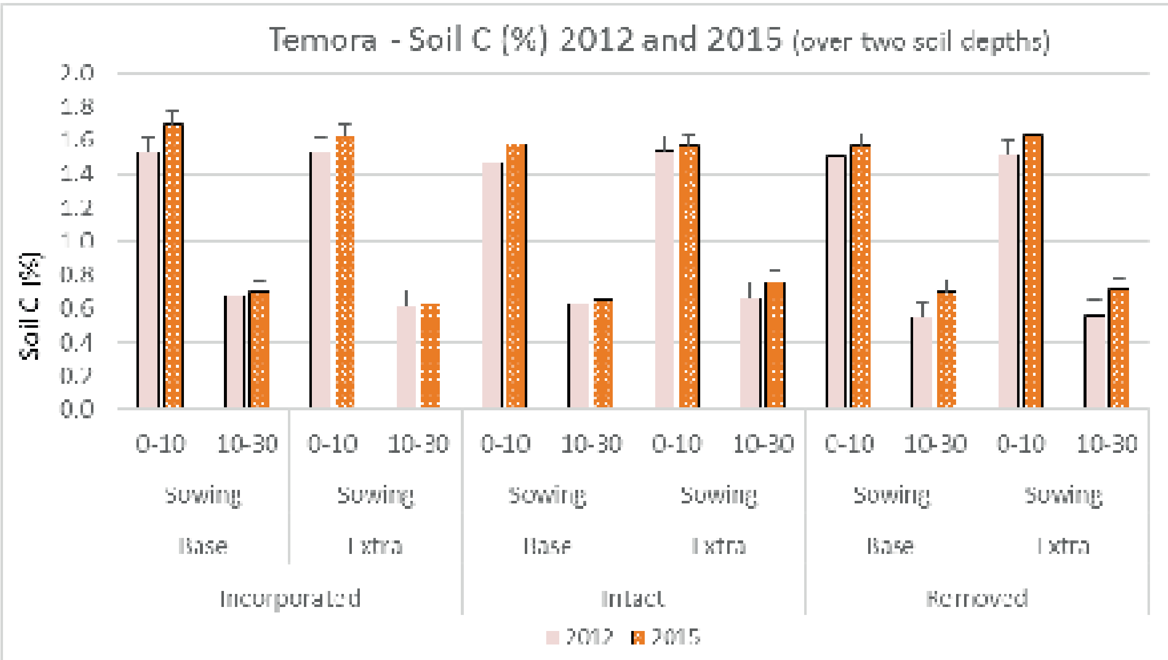


*Figure 2. Soil Organic Carbon content (%) for the top and subsoil after three years of stubble and nutrient application treatments.*

To measure the change in the amount of soil carbon over time, the soil mass per unit volume of soil has to be taken into account – in other words the amount of soil carbon is reported for a defined soil mass (ESM, Equivalent Soil Mass). The concept of ESM compensates for variations in the way samples were collected and also allows for variations in soil bulk density, resulting from different tillage practices.

Soil C stocks at Temora ranged from 40 to 45 t C/ha (Figure 3). There was no significant difference between soil C stocks for the different stubble and applied nutrient treatments between 2012 and 2015.

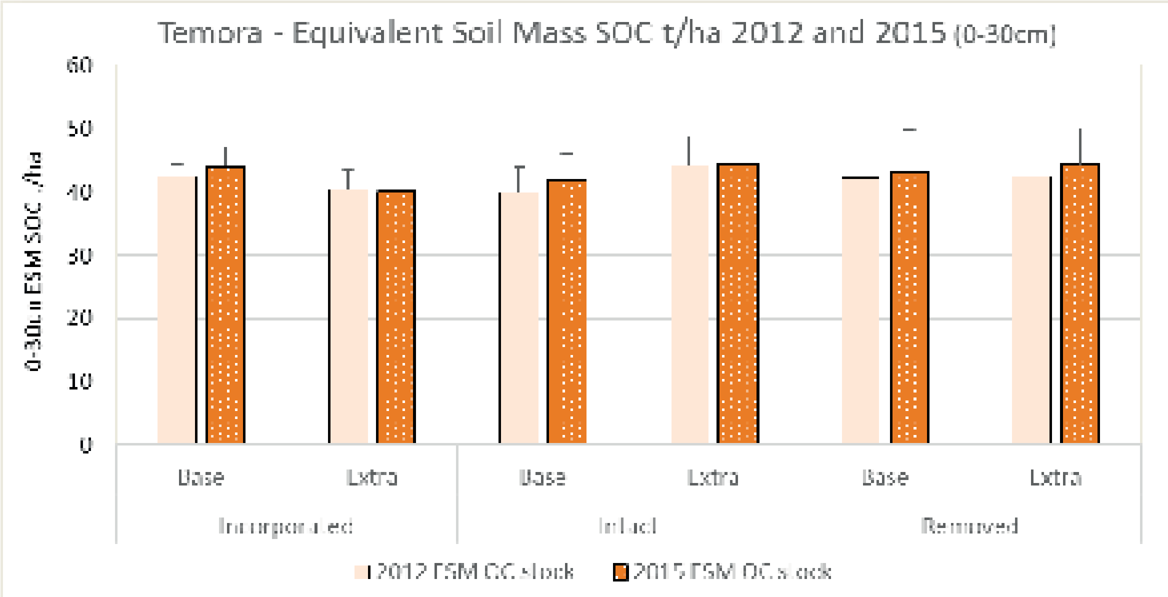


*Figure 3. Soil C stocks (t C/ha) in in 2012 (start of the trial) and 2015 after three years of stubble and nutrient application treatments at Temora.*

**What does it mean?**

It was expected that the imposed treatments to increase soil organic matter would take several years to become noticeable, especially in medium rainfall areas. Even after three reasonable seasons at Temora with good crop production there were no differences in Soil C stocks between the stubble and nutrient supply treatments.

The same result was found at the other seven trial sites located in SE Australia. This work shows that increasing soil C stocks is a long-term process, and three years was not long enough to measure significant changes with the practices selected. This is consist with a recent review indicating the largest gains in soil C stock were seen 5 to 10 years after adoption or change in practice (Sanderman et al. 2009). They also reported that improved management of cropland (eg. no-till or stubble retention) resulted, on average, in a relative gain in SOC of 0.2- 0.3 t C/ha/year compared with conventional management across a range of Australian soils. The Temora Soil C trial will be re-measured again on the completion of the 2016 season after five years of trial work.

## Acknowledgements

Funding for this trial is provided from DAFF and GRDC. Yield Prophet is an on-line modelling service based on APSIM that provides simulated crop growth based on individual paddock information and rainfall, and is registered to BCG.

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05

FarmLink Research Report 2015

# Detecting and managing trace element deficiencies in crops

GRDC Project code – DAS00146

## Project Partners

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## Funding Partners

GRDC Grains Research & Development Corporation

## Report Authors

Nigel Wilhelm and Sjaan Davey, South Australian Research and Development Institute, Waite Research Precinct, Adelaide, as presented at GRDC updates in Adelaide and Wagga.

## Introduction

**Keywords: trace elements, deficiencies, soil testing, plant testing, micronutrient deficiencies.**

**Take home messages**

- Zinc, manganese and copper are the three most important trace element deficiencies for crops in southern Australia.
- Diagnosis from soil testing or symptoms is often unreliable or too late to manage the problem well. Plant testing is the most reliable, if not fool proof tool to diagnose trace element deficiencies.
- Deficiencies can be overcome with cheap sulphate foliar sprays but boosting soil reserves for copper and zinc is a good investment.

Many soils in the cropping zone of southern Australia are deficient in trace elements in their native condition. Despite many decades of research into trace element management, crops can still be found to be deficient in one or more of these trace elements. Just because trace element deficiencies have not been prevalent in recent years, does not mean they will not return.

There is increasing concern in some districts that trace element deficiencies may be the next nutritional barrier to improving productivity. This is because current cropping systems are exporting more nutrients to the grain terminal than ever before.

## Why is there a need for trace elements?

Essential trace elements are nutrients which are required by plants and animals to survive, grow and reproduce but are needed in only minute amounts. Southern Australian cropping soils are more likely to be deficient in zinc (Zn), copper (Cu) and manganese (Mn) than the other trace elements.

Of these three, Zn deficiency is probably the most important because it occurs over the widest area. Zn deficiency can severely limit annual pasture legume production and reduce cereal grain yields by up to 30 per cent. Cu deficiency is also important because it is capable of causing total crop failure.

If these three trace elements are not managed well the productivity of crops and pastures can suffer valuable losses and further production can also be lost through secondary effects such as increased disease damage and susceptibility to frost.

Adequate trace element nutrition is just as important for vigorous and profitable crops and pastures as adequate major element (such nitrogen or phosphorus) nutrition.

## Zinc deficiency

Zn deficiency has been identified on many soil types. Acid sandy soils, sandy duplex soils, red-brown earths, 'mallee' soils, and calcareous grey and red heavy soils have all had either Zn responses confirmed or crops have been identified with Zn deficiency symptoms. Zn deficiency appears to be equally severe in both high and low rainfall areas.

## Symptoms

It is very difficult to diagnose Zn deficiency in pasture or grain legumes because the characteristic Zn deficient leaf markings are rarely produced in the field. Zn deficiency causes shortening of stems and the leaves fail to expand fully. This results in plants which appear healthy but are stunted and have small leaves.

In cereals, symptoms are usually seen on seedlings early in the growing season. An early symptom of Zn deficiency is a longitudinal pale green stripe on one or both sides of the mid-vein of young leaves (Figure 1). The leaf tissue in this stripe soon dies and the necrotic area turns a pale brown colour. Severely affected plants have a 'diesel-soaked' appearance due to the necrotic areas on the leaves, which generally start mid-way down the leaf, causing the leaf to bend or break in the middle.

Plant symptoms appear to be worst early in the season when conditions are cold, wet and light intensity is low. In spring, symptoms often do not appear on new leaves but grain yields will usually be reduced.

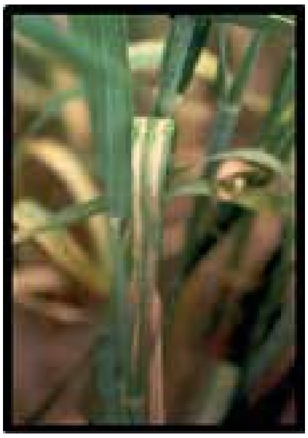

*Figure 1: Zinc deficiency symptoms as seen in wheat.*

## Diagnosis

Plant tests for diagnosing Zn deficiency are reliable and have been calibrated in the field under Australian conditions for wheat, barley, medic, beans and peas. In tillering plants of wheat and barley, YEB (youngest fully emerged blades) levels above 20-24mg/kg are considered adequate. The minimum value in YOLs (youngest fully open leaves) of medic is 15mg/kg and in beans and peas the figure is approximately 23mg/kg (although our information on peas is very limited). For lucerne, levels above about 20mg/kg in young shoots appear to be adequate.

## Correction

Correction of Zn deficiency in a way which provides benefits after the year of treatment is possible through the use of Zn-enriched fertilisers or a pre-sowing spray of Zn onto the soil (incorporated with subsequent cultivations). There is also the option of a Zn-coated urea product which can be used to supply Zn to the crop, and is most useful when pre-drilling urea before the crop.

Another option that will also provide long term benefits but has become available only recently is the application of fluid zinc at seeding. The advantage of this approach is that it will provide residual benefits for subsequent crops and pastures and has a low up-front application cost (providing you ignore the capital investment in a fluid delivery system!). At current prices, a typical application may cost about $6.00/ha (this is 1kg of Zn/ha).

Only Zn-enriched fertilisers of the homogenous type (fertiliser manufactured so that all granules contain some Zn) are effective at correcting Zn deficiency in the first year of application. A rate of two kilograms of elemental Zn per hectare applied to the soil is necessary to overcome a severe Zn deficiency and should persist for three to 10 years (depending on soil type). Short intervals between repeat applications of Zn will be necessary on heavy and calcareous soils in the high rainfall areas, while seven to 10 year intervals will be acceptable in the low rainfall areas. Following an initial soil application of 2kg Zn /ha repeat applications of 1 kg/ha will probably be sufficient to avoid the reappearance of Zn deficiency in crops and pastures. Most zinc-enriched fertilisers are now not sold as pure homogeneous types but providing a homogeneous fertiliser is used as part of the mix then the final product is still satisfactory for correcting Zn deficiency. For example, the company may produce a diammonium phosphate (DAP) Zn five per cent 'parent' product which has Zn on every granule which they will then blend with straight DAP to give 1 and 2.5 per cent products for the retail market. This option will currently cost approximately $17.00/ha.

Zn deficiency can be corrected in the year that it is recognised with a foliar spray of 250-350g Zn/ha but it has no residual benefits and is therefore not the best approach for a long-term solution. This option will currently cost approximately $1.00/ha (plus the cost of the operation). Zinc can be mixed with many herbicides and pesticides but not all, so check with your supplier for compatible tank mixes before you make the brew. Recent trials in eastern Australia suggest that chelated sources of trace elements are no more effective at correcting a deficiency than their sulphate cousin (see Figure 2 for an example of treating copper deficiency in wheat), although older results from WA showed that there are situations where they can be superior.

Seed dressings of zinc are another option for managing Zn deficiency. These products are effective and will supply Zn to the young crop but they will not completely overcome a severe deficiency, nor will they increase soil reserves of Zn. Seed with high internal levels of Zn can also be used in a similar way. However, both approaches should be used in conjunction with soil applications to correct and manage Zn deficiency in the long term. This option will currently cost approximately $3.00/ha.

## Copper deficiency

## Symptoms

Apart from shrunken heads in cereals, heads with gaps in them or 'frosted' heads, Cu deficiency rarely produces symptoms in plants in the field. The symptoms produced by Cu deficiency in the maturing cereal plant are due to poor seed set from sterile pollen and delayed maturity. However, under conditions of severe Cu deficiency cereal plants may have leaves which die back from the tip and twist into curls. Cereal stubble from Cu-deficient plants has a dull grey hue and is prone to lodging due to weak stems.

Cu-deficient pasture legumes are pale, have an erect growth habit and the leaves tend to remain cupped (as if the plant were suffering from moisture stress).

## Diagnosis

Leaf analysis to detect Cu deficiency in plants is a very important management tool because Cu deficiency can produce devastating losses in grain yield of crops and pastures with little evidence of characteristic symptoms.

Cu concentrations in YEBs of cereals above 3mg/kg are considered adequate and below 1.5mg/kg deficient. Pasture legumes including lucerne, have higher requirements for Cu and plants are considered deficient if YOL values are below 4.5mg/kg. Lupins are tolerant of Cu deficiency and levels above 1.2mg/kg are adequate.

Cu deficiency in livestock (steely wool in sheep; sway-back in lambs; rough, pale coats and ill-thrift in young cattle) is a continuing problem in some areas because livestock have a higher requirement for Cu than pasture plants. The low availability of Cu in the diet can be induced by high Mo intake which can be further exacerbated by high sulphur (S) levels. The introduction of Cu bullets which provide protection for 12 months has made treatment of the problem simple and cost-effective.

## Correction

Traditionally, Cu deficiency has been corrected by applying Cu-enriched fertilisers and incorporating them into the soil. Most soils require 2kg/ha of Cu to fully correct a deficiency, and this application may be effective for many years.

Due to the excellent residual benefits of soil-applied Cu, Cu deficiency in crops and pastures has been largely overcome in most areas from the use of the 'blue stone' mixes in the 1950s and 1960s.

However, Cu deficiency may be re-surfacing as a problem due to a number of reasons:

- The applications of Cu made 20-40 years ago may be running out.
- The use of nitrogen fertilisers is increasing and they will increase the severity of Cu deficiency.
- Cu deficiency is affected by seasonal conditions and farming practices, e.g. lupins in a lupin/wheat rotation make Cu deficiency worse in succeeding wheat crops.

Application of Cu by Cu-enriched fertilisers will currently cost approximately $19.00/ha. Cu deficiency in crops can also be corrected by fluid application at seeding with an application cost as low as $4.60/ha. Performance of soil applied Cu will improve with increased soil disturbance.

Although Cu deficiency is best corrected with soil applications, foliar sprays will also overcome the problem in the short term. A foliar spray of Cu (75-100 g/ha of Cu) is very cheap (approximately 90c/ha for the ingredient) but a second spray immediately prior to pollen formation may be necessary in severe situations. This was the case in a trial conducted on lower Eyre Peninsula in 2015 where a late foliar spray was necessary to completely eliminate Cu deficiency in an area that was extremely deficient for Cu and the problem was exacerbated by a dry spring when wheat was forming pollen ad setting grains (Figure 2).

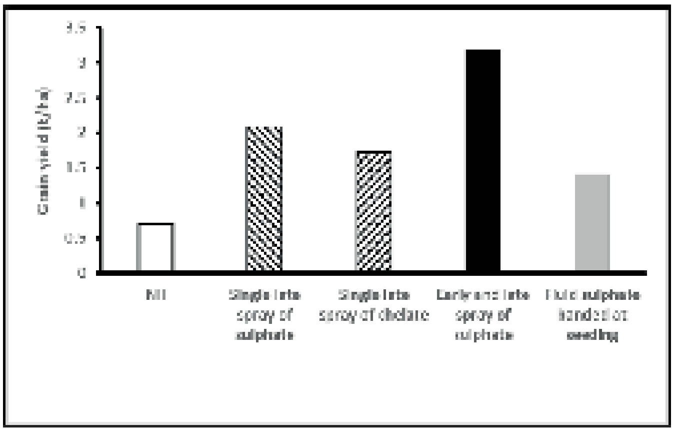


*Figure 2: Effectiveness of four application strategies for treating Cu deficiency in wheat. Foliar sprays were applied at 90g Cu/ha, the fluid at seeding at 1kg Cu/ha. Trial at Cummins, lower Eyre Peninsula, 2015.*

## Manganese deficiency

The availability of Mn in soil is strongly related to soil pH. Soils with higher pH have lower Mn availability than soils with lower pH. Mn deficiency is therefore more likely to be a problem on alkaline soils however, responses to Mn have also been recorded on impoverished, acid to neutral sandy soils.

The availability of Mn is also strongly affected by seasonal conditions and the availability is lowest during a dry spring. Transient Mn deficiency may also appear during cold, wet conditions but affected plants are often seen to recover following rains in spring when soil temperatures are high.

## Symptoms

Mn is poorly translocated within the plant so symptoms first appear in young leaves. Old leaves on plants severely affected by Mn deficiency can still be dark green and healthy because they acquired Mn from the seed and once Mn enters a leaf it cannot be shifted out.

Mn deficiency results in plants which are weak and floppy and pale green/yellow in appearance. Mn-deficient crops can appear to be water-stressed due to their sagging appearance. Close examination of affected plants can reveal slight interveinal chlorosis; the distinction between green veins and 'yellow' interveinal areas is poor.

In oats, Mn deficiency produces a condition known as 'grey speck'. Mn-deficient oats are pale green and young leaves have spots or lesions of grey/brown necrotic tissue with orange margins (this contrasts with Septoria lesions which have purple/

red margins). These lesions will coalesce under severely Mn-deficient conditions.

Mn deficiency delays plant maturity, which is a condition most marked in lupins. Mn-deficient patches in lupins will continue to remain green months after the rest of the paddock is ready for harvest. Delayed maturity in patches of the crop is frequently the only visual symptom of Mn deficiency in lupins. Mn deficiency will also cause seed deformities in grain legumes. Lupins suffer from 'split-seed' which is caused by the embryo breaking through a very weak seed coat. 'Split-seed' will reduce yields and also viability of the harvested grain. A similar condition in peas is known as 'marsh spot' due to a diffuse dark grey area within the seed.

## Diagnosis

Plant analysis will accurately diagnose Mn deficiency in crops and pastures at the time of sampling but Mn availability in the soil can change dramatically with a change in the weather condition. This means that the Mn status of the sampled crop or pasture can also change dramatically after sampling which must be allowed for when making recommendations on Mn deficiency.

Concentrations of Mn in YEBs greater than 15mg/kg are considered adequate for cereals at tillering. For legumes, the corresponding figure in YOLs is 20mg/kg. The Western Australia Department of Agriculture also advocates a main stem analysis of lupins for diagnosing Mn deficiency at flowering.

## Correction

Due to the detrimental effect of high soil pH on Mn availability, correction of severe Mn deficiency on highly calcareous soils can require the use of Mn-enriched fertilisers banded with the seed (three to five kg Mn/ha) as well as one to two follow up foliar sprays (1.1kg Mn/ha). In the current economic climate, growers on Mn-deficient country have tended not to use Mn-enriched fertilisers (due to their cost) but have relied solely on a foliar spray. This is probably not the best or most reliable strategy for long term management of the problem.

Neither soil nor foliar Mn applications have any residual benefits and must be re-applied every year. Another approach is the coating of seed with Mn. This technique is cheap and will probably be the most effective in conjunction with foliar sprays and/or Mn enriched fertilisers. Mn deficiency in lupins must be treated with a foliar spray at mid-flowering on the primary laterals. The use of acid fertilisers (e.g. nitrogen in the ammonium form) may also partially correct Mn deficiency on highly alkaline soils but will not overcome a severe deficiency.

Mn deficiency in crops can also be corrected by fluid application at seeding.

## Final Note

There are other trace element deficiencies which can occur in crops and pastures (e.g. boron, molybdenum, iron, etc). Deficiencies in these trace elements however are likely to be localised or not at all in many districts, and therefore, discussion wasn't included in this paper. If you do however, require any information on these please contact the author (nigel.wilhelm@sa.gov.au).

## Conclusion

Trace elements are as essential to productive and profitable crops as nitrogen and phosphorus. The difference is that crops only require them in minute amounts. Zinc, manganese or copper deficiencies are the most common and severe problems.

Trace element deficiencies are difficult to diagnose with soil tests or from plant symptoms. Plant testing is the most reliable, if not fool proof tool to diagnose trace element deficiencies.

Foliar sprays will usually correct a problem in crop. However, for long term correction of the deficiency boosting soil reserves is a sound investment.

## Useful Links

https://www.agric.wa.gov.au/mycrop

http://anz.ipni.net/topic/micronutrients

## Contact Details

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# 06

FarmLink Research Report 2015

# Optimising management of early sown EGA Wedgetail for either dual-purpose and grain-only production

GRDC Project code – CSP00178

## Project Partners

FarmLink, CSIRO

## Funding Partners

GRDC Grains Research & Development Corporation

## Trial Site Location

Hart Bros Seeds 2014 & TAIC 2015


## Report Authors

James Hunt, Brad Rheinheimer, Tony Pratt, Kellie Jones, Tony Swan, Laura Goward


## Introduction

Experiments in southern NSW have repeatedly shown the yield and WUE benefits from sowing early with slow developing cultivars. This practice is highly suited to SNSW where rainfall is evenly distributed throughout the year and early sowing opportunities are more frequent than they are in other locations in the Australian wheat belt with winter dominant rainfall. There is also a history of early sowing in the region, particularly of dual purpose crops, and Australia's only milling quality winter wheat breeding program was located at Wagga Wagga and Temora. Winter wheat cultivars are much better suited to early sowing and dual purpose grazing because of their vernalisation requirement which keeps them in a vegetative phase for much longer than spring wheats. The obvious cultivar of choice for early sowing in SNSW remains to the last cultivar released by the DPI NSW winter wheat breeding program in 2002 – EGA Wedgetail.

For much of its life EGA Wedgetail has been thought of as a dual purpose cultivar that 'needed' to be grazed so that excessive early growth did not hay-off the crop. However, its use as a grain only cultivar has been increasing. The area planted to EGA Wedgetail has increased in SNWS from just under 80,000 Ha in 2011 to over 120,000 Ha in 2014. The aim of this series of experiments was to determine if management of EGA Wedgetail should be different to that of spring wheats sown in May, and if grown for grain only or dual purpose use.

*High plant density, N broadcast at sowing*

*High plant density, N top dressed at Z30*

*Low plant density, N broadcast at sowing*

*Low plant density, N top-dressed at Z30*

# Methods

Two identical experiments were established in successive years at Junee Reefs (2014) and Temora (2015). The experiments were partially factorial split-plot designs with three different management factors designed to reduce the amount of pre-anthesis vegetative growth and improve harvest index;

1. Time of sowing x cultivar combination

   a. Winter wheat - EGA Wedgetail sown early-mid April

   b. Spring wheat - EGA Gregory and Suntop sown early-mid May

2. Nitrogen fertiliser timing

   a. Broadcast at sowing

   b. Top-dressed at Zadoks stage 30 (Z30 – start of stem elongation)

3. Target plant density (EGA Wedgetail only)

   a. 50 plants/m$^2$ (~25 kg/ha seed)

   b. 100 plants/m$^2$ (~50 kg/ha seed)

4. Defoliation at Z30 (EGA Wedgetail only, to simulate grazing with livestock)

   a. Defoliated

   b. Undefoliated

Timing of operations in both experiments were slightly different in both years (Table 1). Gravimetric soil cores taken to 1.6 m were used to determine plant available water and mineral N prior to sowing. All plots were direct drilled into standing previous crop residues using a six row plot seeder with spear points and press wheels on 305 mm row spacing.

Dry matter cuts were taken in plots to be defoliated before and after defoliation to determine how much dry matter was removed (forage yield). Dry matter cuts (0.5 x 1.2 m) were taken from each plot at crop maturity to determine total dry matter production, stem frost damage and harvest index. Grain yield was estimated by mechanically harvesting only the middle four rows of each plot, and all grain yields are reported at 12.5% moisture. Grain quality measurements were made on header harvest grain.

| **Previous crop** | **Junee Reefs 2014** Field peas | **Temora 2015** Lupins |
|---|---|---|
| **Summer fallow rain (Nov-Mar)** | 132 mm | 169 mm |
| **Growing season rain (Apr-Oct)** | 252 mm | 276 mm |
| **Soil mineral N to 1.6 m(kg/ha)** | 86 kg/ha | 208 kg/ha N |
| **Sowing date** | 8 April, 21 May | 20 April, 7 May |
| **Defoliation date (t/ha remaining)** | 2 July (0.9 t/ha) | 30 July (0.9 t/ha) |
| **Top-dressing date (N rate)** | 8 July (100 kg/ha N as urea) | 30 July (46 kg/ha N as urea) |

*Table 1. Paddock history and management details of the 2014 and 2015 experiments*

# Methods

### 2013

The season broke in late March and both the Wedgetail and spring wheat treatments were sown into seed bed moisture and established at target densities (Table 2). Temperatures in the first half of May were well above average, and EGA Wedgetail growth and development was extremely rapid. The warm conditions also allowed a large infestation of aphids that persisted beyond the control period provided by imidacloprid seed dressing, and despite application of foliar insecticide in late May the Wedgetail treatment was severely infected with barley yellow dwarf virus (BYDV). The spring wheats were sown late enough to escape both the warm weather and the aphid shower.

EGA Wedgetail reached Z30 on 2 July, about 3-4 weeks earlier than expected. Higher plant densities and N at seeding increased forage yield by an average of 0.4 t/ha and 0.8 t/ha respectively.

From mid-July through to mid-September there were 18 days during which minimum temperature fell below -2°C. The worst of these were during mid-July and early August which was during EGA Wedgetail stem elongation, but the spring wheats were still vegetative. This resulted in significant stem frost damage in the EGA Wedgetail, but not in the spring wheats. There was significantly less frost damage in the EGA Wedgetail treatments that were top-dressed (mean 26%) compared to those that had N at sowing (mean 32%), and top dressed treatments also yielded more (Table 4). The highest yielding treatments of EGA Wedgetail could not match the yields of the spring wheats due to stem frost damage and BYDV.

| | | Actual plant density (plants/m²) | |
|---|---|---|---|
| **Cultivar** | **Target plant density (plants/m²)** | **2014** | **2015** |
| **EGA Wedgetail** | **50** | 51 | 48 |
| **EGA Wedgetail** | **100** | 92 | 74 |
| **EGA Gregory** | **100** | 95 | 58 |
| **Suntop** | **100** | 98 | 64 |

*Table 2. Target and actual plant densities achieved in 2013 and 2014*

| | | Forage yield (t/ha) | |
|---|---|---|---|
| **Target plant density (plants/m²)** | **N timing** | **2014** | **2015** |
| **50** | **Broadcast at sowing** | 1.7 | 0.9 |
| **50** | **Top-dressed Z30** | 0.9 | 0.8 |
| **100** | **Broadcast at sowing** | 2.1 | 1.4 |
| **100** | **Top-dressed Z30** | 1.3 | 1.4 |
| | **P-value** | <0.001 | 0.004 |
| | **LSD (p=0.005)** | 0.3 | 0.3 |

*Table 3. Forage yield (dry matter removed during defoliation) for EGA Wedgetail at different plant densities and N timings*

| **Grain yield (t/ha) and stem frost damage (% stems)** | | **EGA Wedgetail sown 7 April** | | **EGA Gregory sown 21 May** | | **Suntop sown 21 May** | |
|---|---|---|---|---|---|---|---|
| Target plant density (plants/m²) | Defoliation @ Z30 | 100 kg/ha N broadcast at sowing | 100 kg/ha N top-dressed Z30 | 100 kg/ha N broadcast at sowing | 100 kg/ha N top-dressed Z30 | 100 kg/ha N broadcast at sowing | 100 kg/ha N top-dressed Z30 |
| 50 | Defoliated | 2.0 (27%) | 2.3 (24%) | - | - | - | - |
| 50 | Undefoliated | 1.6 (29%) | 2.3 (24%) | - | - | - | - |
| 100 | Defoliated | 1.9 (34%) | 2.6 (27%) | - | - | - | - |
| 100 | Undefoliated | 1.7 (34%) | 2.5 (29%) | 3.0 (1%) | 2.9 (0%) | 2.9 (2%) | 3.1 (6%) |
| P-value (yield) | | <0.001 | | | | | |
| LSD (yield) | | 0.2 | | | | | |
| P-value (frost) | | <0.001 | | | | | |
| LSD (frost) | | 9 | | | | | |

*Table 4. Grain yield and frost damage of experimental treatments in 2014.*

### 2015

The season broke on 7 April but sowing of EGA Wedgetail was delayed until 20 April. The seed bed in this year was compacted from grazing and came up cloddy which resulted in poor depth control and seed-soil contact. As a result, actual plant populations were well below target in all the 100 plants/m$^2$ treatments (Table 2). EGA Wedgetail reached Z30 on 30 July. Forage yield in the higher plant population was 0.5 t/ha more than the lower (Table 3) and there was no effect of N timing, probably due to the higher soil mineral N at the site (Table 1).

There was an interaction between N timing and plant density on grain yield, however effect sizes were small. At low plant density applying N at sowing decreased yield, but increased yield at high plant density (Table 5). There was no effect of grazing or interaction with any of the other treatments. Yield of EGA Wedgetail was not significantly different to yield of either EGA Gregory or Suntop with the same N timings (Table 5).

| Grain yield (t/ha) | | EGA Wedgetail sown 20 April | | EGA Gregory sown 7 May | | Suntop sown 7 May | |
|---|---|---|---|---|---|---|---|
| Target plant density (plants/m²) | Defoliation @ Z30 | 46 kg/ha N broadcast at sowing | 46 kg/ha N top-dressed Z30 | 46 kg/ha N broadcast at sowing | 46 kg/ha N top-dressed Z30 | 46 kg/ha N broadcast at sowing | 46 kg/ha N top-dressed Z30 |
| 50 | Defoliated | 3.5 | 3.9 | - | - | - | - |
| 50 | Undefoliated | 3.6 | 3.8 | - | - | - | - |
| 100 | Defoliated | 4.0 | 3.7 | - | - | - | - |
| 100 | Undefoliated | 4.0 | 3.7 | 3.8 | 3.8 | 4.2 | 3.8 |
| P-value | | 0.041 | | | | | |
| LSD (p=0.05) | | 0.3 | | | | | |

*Table 5. Grain yield of experimental treatments in 2015.*

## Conclusion

Despite being 14 years old, EGA Wedgetail can successfully be grown for grain only or dual purpose use and achieve yields competitive with recently released main season cultivars sown in May. Growers wishing to graze EGA Wedgetail should use high plant densities (at least 100 plants/m$^2$ on 305 mm row spacing, higher on narrower spacing) and some N fertiliser at sowing (particularly if soil mineral N is low) to maximise forage yield. Growers who wish to grow EGA Wedgetail for grain only should defer N fertiliser application until after Z30 to reduce early vegetative growth. Neither of these experiments or any others during the early sowing project have found a yield benefit from reducing plant populations, and target plant density should be kept at 100-150 plants/m$^2$ (less on wide rows, more on narrow rows) in order to better compete with weeds.

# 07

FarmLink Research Report 2015

# Short term rotations and herbicide selection for reducing annual ryegrass

## Project & Funding Partners

FarmLink change • adapt • prosper

Bayer CropScience

## Report Authors

Tony Pratt (FarmLink Research), Angus MacLennan (Bayer CropSciences)

## Introduction

Crop rotation and herbicide selection are important tools for managing weeds and in particular problematic weeds such as annual ryegrass (lolium rigidum) in wheat and canola crop rotations. This trial is a joint collaboration between FarmLink Research and Bayer CropScience.

## Objectives

- Examine the impact rotation has on the population of annual ryegrass under different systems.
- What is the effect of specific herbicides applied in the wheat crop in year one have on the annual ryegrass populations in year two before and after sown to canola (RR and TT) (something like this). How and where are herbicides best used in the rotation to maximise efficacy?

## Methodology

A small plot trial was established in 2013 that consisted of a wheat and canola phase. In 2014 these crops were rotated. The 2013 canolacrop was split into early season or mid season canola varieties with the most suitable selected to continue the trial in 2014. In both years the Roundup Ready system was evaluated using either a single spray timing (2 leaf crop growth stage) or a double spray timing (2 and 6 leaf crop growth stage) of Roundup Ready herbicide. In the TT system only atrazine was used with no post-emergent grass selective sprayed based on the assumption that group A "dim" resistance was well established.

All spraying was conducted using a 5m ATV mounted boom at sowing and harvest was conducted using specialised small plot equipment. Annual ryegrassplant populations were measured at 8 and 16 weeks after sowing (WAS).

Assessments were conducted by FarmLink Research across the trial throughout the two seasons to monitor ARG populations with Kalyx Australia providing trial research services along with harvest yield results

## Trial details


## Terminology

- BS – Incorporated by sowing
- PSPE – Post-sowing pre-emergent
- KPPW – knife point and press wheels
- RR – Roundup ready
- TT – Triazine tolerant
- WAS – weeks after sowing
- ARG – Annual ryegrass
- IWM – Integrated Weed Management

## Wheat phase 2013

Variety - Spitfire

Herbicide - a) Sakura® 118 g/Ha (incoporated by sowing) – (knife points and press wheels)

b) Triflur®X 2 L/Ha IBS – KPPW

## Canola phase 2013

| No. | Canola crop type | Herbicide | Variety |
|---|---|---|---|
| 1 | Roundup Ready | RR Plant-shield# 2 leaf | IH50RR |
| 2 | Roundup Ready | RR Plant-shield 2 leaf + 6 leaf | |
| 3 | Triazine tolerant | Simazine PSPE + Atrazine* 2 leaf | CB Atomic TT |
| 4 | Roundup Ready | RR Plant-shield 2 leaf | IH30RR |
| 5 | Roundup Ready | RR Plant-shield 2 leaf + 6 leaf | |
| 6 | Triazine tolerant | Simazine PSPE + Atrazine 2 leaf | Hyola 450 TT |

*# Roundup® Ready with Plantshield – 900 g/Ha*
**Gesaprim®900DF (Atrazine) – 2.2 kg/ha*

## Wheat phase 2014

Variety - Dart.

Herbicide - Sakura® 118 g/Ha IBS – KPPW, Triflur®X 2 L/Ha IBS – KPPW

## Canola phase 2014

| No. | Treatment | Herbicide | Variety |
|---|---|---|---|
| 1 | Roundup Ready | RR Plant-shield 2 leaf | IH30RR |
| 2 | Roundup Ready | RR Plant-shield 2 leaf + 6 leaf | |
| 3 | Triazine tol-erant | Atrazine 2.2kg 2 leaf | Hyola 450TT |

*# Roundup® Ready with Plantshield – 900 g/Ha*
**Gesaprim®900DF (Atrazine) – 2.2 kg/ha*

## Results

### 2013

Initial ARGplant populations measured pre sowing in 2013 (see Photo 1) were approximately 1700 plants per meter square. This initial high population was reduced by pre-sowing knock down sprays in 2013.

ARG plant populations at 8 WAS following two applications of Roundup Ready with Plantshield were significantly less compared to other treatments (RR @ 2 leaf stage only or Atrazine). Panicle counts conducted prior to harvest in 2013 (refer Graph 1) illustrated that Atrazine alone only gave a moderate level of control of ryegrass and in the absence of an effective post-emergent herbicide, could potentially result in a large seed set of ARG.

Panicle counts from the two Roundup Ready treatments showed that a 2 spray strategy at 2 leaf and then again at 6 leaf resulted in a 50% reduction in panicle numbers compared to a single application. However, there was no significant difference in canola grain yield (average 1t/ha) between the treatments following harvest.

Ryegrass control levels between TriflurX 2L/ha and Sakura 118g/Ha were very similar 8 weeks after sowing in 2013, however it is considered Sakura's longer residual activity resulted in an overall higher level of ryegrass control.

### 2014

ARG populations in the 2014 canola crops were lower following the two spray strategy of Roundup Ready Plantshield compared to the TT system and ryegrass plant populations were further reducted where Sakura had been sprayed in the previous year compared to Trifluralin (Figure 2). Photos 2 and 3 also give a visual observation of ryegrass populations in plots of RR 2 spray + Sakura and TT + Triflur X.

*Photo 1: 2013 pre-sowing ryegrass population.*

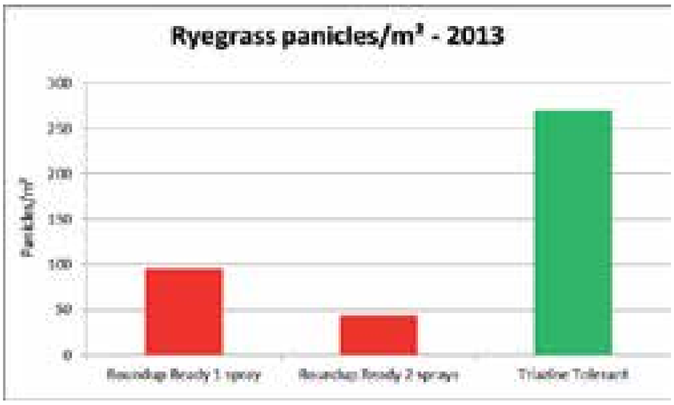



*Figure 1: 2013 pre-harvest ryegrass panicle numbers*

There was no significant difference in ARG populations at 16 WAS between treatments however again a positive trend is evident between a Sakura, two spray combination. Given the high populations of ARG at the site it could be argued that the high ARG counts that were recorded for the 1 spray treatment in both years may have been influenced by ongoing seed bank germinations.

The canola header grain yield for 2014 (Table 3) indicates that there was a significant difference between treatments RRcanola (sprayed once or twice) and between RRcanola sprayed twice

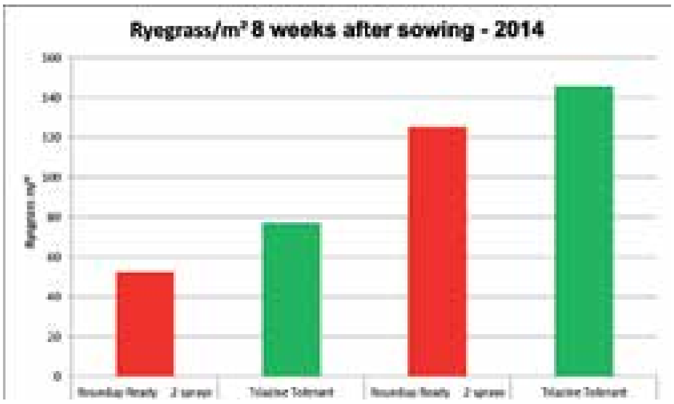



*Figure 2: 2014 8 WAS ryegrass counts*


*Photo 2*


*Photo 3*

compared TTcanola. Whilst no difference between spray regimes was detectable this data suggests that effective weed control is beneficial to canola yield in the following cropping season, which is a given.

| Crop x Herbicide | RR (2 leaf) (t/ha) | RR (2 & 6 leaf) (t/ha) | TT (t/ha) |
|---|---|---|---|
| | 1.46 | 1.59 | 1.37 |
| P value | | 0.007 | |
| est lsd (P<0.05) | | 0.105 | |

*Table 3. Header Harvest Grain Yields 2014*

# Discussion

Ultimately herbicide selection should be based on the suitability of that product to the sowing conditions, weed pressure and rotational fit while trying to completely control ARG in both single in consecutive years, managing for chemical groups. Annual ryegrass populations can increase rapidly if in any one year poor control occurs. Therefore careful rotational planning to include crop types, varieties and herbicide technologies is essential in an overarching control strategy.

From the results observed in this two year trial it is evident that effective weed control in year one results in a reduction in seed season are necessary to reduce weed seed bank numbers potentially making Roundup Ready canola systems more viable in a lower risk situation. Herbicides with low binding, moderate solubility and longer persistence such as Sakura tend to offer higher levels of weed control.

It is also clear that herbicide technology is not straight forward and attention to detail can mean the difference between a mediocre and first-rate result. Chemical efficacy can be influenced by a number of factors, especially when using pre-emergent herbicides in a combined chemical IWM strategy. Little things like stubble load, method of application, level of seedbed cultivation, incorporation timing and technique, rainfall after sowing and the suitability of that herbicide for the particular situation can add incremental gains for the overall result. For Roundup Ready canola and TT canola ensure to use every option available, don't settle for just 1 application of RR or rely solely on triazine chemicals for effective control of weeds.

Annual ryegrass control is a long term holistic proposition and no 1 or 2 control methods will solve your issues. It must be tackled with multiple techniques (both chemical and cultural) and in every corner of the paddock in every year.

Further details from this trial will be reported on in full at the conclusion of the season. For more information please contact Angus MacLennan from Bayer CropScience (0407 641 320) or Tony Pratt of FarmLink Research (0448 066 246)

*Sakura® is registered trademark of Kumiai used under licence by Bayer CropScience. Roundup® is a registered trademark of Monsanto, Gesaprim® is a registered trademark of Syngenta and Triflur®X is a registered tradmark of Nufarm Ltd.*

# 08

FarmLink Research Report 2015

# NPKS fertiliser responses - Field trial report for 2015 season

GRDC Project code – DAN00168

## Project Partners

## Funding Partners

This project is a part of the National More Profit From Crop Nutrition Project

## Trial Site Location

Various

## Report Authors

Mark Conyers, Jonathan Holland (NSW DPI); Cindy Cassidy (FarmLink)

## Introduction

The purpose of these GRDC funded trials is to provide soil test calibrations with fertiliser responses for situations where the national database has minimal data. For example there are very few response curves for K and S, particularly for pulses. Three projects are running: one in each of the western, northern and southern GRDC regions. NSW DPI and Farmlink, together with Southern Farming Systems, the Mackillop Farm Management Group, and AgGrow Agronomy, are responsible for the southern GRDC region.

Any fertiliser book will tell you how important NPK nutrition is to plant growth; these nutrients are the big 3. And in southern NSW we add lots of N and P to our crops, but rarely do we apply K, and then mostly it is in dairy areas on pastures or on potatoes.  Broadacre cropping in NSW rarely uses K fertiliser. Do we need to? Afterall, we thought that we didn't need limestone in our patch until the early 1980s.

If we search the national database (BFDC) on K responses for canola in NSW, we score zero trials over the 50 years that the database covers. If instead we search on our chromosol, dermosol and kandosol soil types, we now find just 17 trials on record in Australia, but they are all from WA. See figure 1 below. We therefore need more trials on K for canola, and we need at least some of these to be in NSW so we can be sure that the WA work is applicable to us. In the meantime, the critical soil test range for K for canola is about 50 mg/kg, a very low soil test value by our experience in the east.


*Figure 1. Soil test calibration for K on canola using WA soil types that are common in southern NSW.*

In 2015 we established 6 more trial sites under this project, three of which were on potassium.  The K trial sites were in SA, Victoria and Breadalbane in NSW. Low soil K is not common over most of the cropping belt in SE Australia.

## Breadalbane trial details

This trial is about 25 km west of Goulburn, on a yellow chromosol, and operated in conjunction with Richard Hayes and Matt Newell of NSW DPI. Canola, wheat and triticale were treated with 6 rates of potassium; dry matter and grain yield responses were recorded for the three crops. In addition, the effect of the K treatments on protein, digestibility and protein were measured, as these crops can be grazed or cut for hay or silage. The analyses of the samples will be completed during 2016.

*Figure 2. Aerial air photo of K response trial at Breadalbane, NSW*

# 09

FarmLink Research Report 2015

# Innovative approaches to managing subsoil acidity in the Southern Grain Region

GRDC Project code – DAN 00206

## Project Partners

FarmLink change • adapt • prosper

NSW GOVERNMENT Department of Primary Industries

## Funding Partners

GRDC Grains Research & Development Corporation


## Report Authors

Cindy Cassidy (FarmLink)


## Introduction

FarmLink has partnered with NSWDPI to deliver local trials as part of the Southern Region GRDC funded project "Innovative approaches to managing subsoil acidity in the Southern Grain Region.

This regional project includes a combination of paddock scale replicated experiments and establishment of a long term small plot experiment all in the high rainfall zone of the southern region. Over the next five years the project will investigate more aggressive ways, such as the deep placement of lime to the subsoil where it is most needed, with or without organic amendments to achieve more rapid changes to pH at depth. Other novel materials, such as calcium nitrate fertiliser, nano-lime and silicate-based materials, either separately or in combination, will be tested in different soils with difference crop species in both controlled environments and under field conditions. Detailed studies are essential to increase our understanding of these plant-soil interactions and the mechanisms involved.

## Objectives

FarmLink's role will be to establish paddock scale replicated experiments designed to -

- Increase awareness of subsoil acidity and,
- Demonstrate effectiveness of innovative technology to ameliorate and/or prevent subsoil acidity on farm scale.

## Method

FarmLink will establish two large scale on-farm experiments on highly acidic soils (pH about 4.0-4.5 at 10-20cm) in the high rainfall zone in the East of the FarmLink region. One trial will be established in each of two consecutive years in 2016 and 2017. Both sites will be maintained and assessed for three growing seasons after being established.

We are targeting sites with the following characteristics -

- Target sub-surface soil acidity
  - 0-10cm, prefer to acidic, but if limed pH < 5.0
  - 10-20cm, pH 4.0-4.3, Al% >20%
- Locations (rainfall >500mm)
  - Two separate sites in consecutive years
  - Each site to be sown to crop for at least 3 years
- Paddock selection
  - Preliminary soil tests (0-10 cm, 10-20 cm) to confirm sub-surface soil acidity
  - No resistant or problem weeds
  - Either crop or pasture in 2015
  - Three years cropping for next 3 years
  - The crop sequence to match the cropping program for the balance of paddock

In 2016 we have selected a site near Binalong but if you have a site you think would be suitable for 2017 please contact the FarmLink office.

Each experiment consists of at least four treatments with three replicates on a large scale. The core treatments include surface liming (control), deep ripping, deep ripping + lime at depth and deep ripping + organic amendment at depth (eg lucerne pellets, manure or composts). Additional treatments could be added as desired the options include –

| | Treatments | Description |
|---|---|---|
| 1 | Surface liming | Lime rate is depending on the current pH in 0-10cm and liming history, ideally to bring pHCa up to 5.5. The lime will be incorporated into 0-10 cm. Lime rate to be calculated based on preliminary soil test result and pH buffering capacity (NSW DPI) |
| 2 | Deep ripping only | Ripping depth 30cm and width 50 cm. Surface soils limed to pH 5.0, same as Treatment 3. |
| 3 | Deep ripping + lime | The soil will be surface-limed (to pH 5.0) and deep-limed to 10-30cm, but the combined lime rate will be same with Treatment 1 (surface liming). For example, if soil pHCa is 4.0, it will need ~ 4t/ha lime to increase pH to 5.5. For this treatment, we would apply 2.5t/ha to the surface to increase pHCa to 5.0, and place 1.5t/ha at 10-30cm to target subsoil acidity. |
| 4 | Deep ripping + organic amendment | As above with organic amendment (e.g. lucerne pellets) at 10t or 20t/ha (to be confirmed by Steering Committee based on results from incubation study and ash alkalinity titration test). |

Assessment will include –

- Initial and final soil sampling and assessment down to 100cm
- Agronomic data looking at plan establishment, growth and final crop yield over three years for each trial site.

## Outcomes

As results become available from the trials FarmLink will capture these in our Annual Research Report (the first set of data will appear in the 2016 edition) and these trial sites will be used for field events as and when it is appropriate.

# 10

FarmLink Research Report 2015

# Effect of Body Condition Score on Fertility and Fecundity in Non-Merino Ewes

## Project

Profitable & Sustainable Sheep Production in the Mixed Farming Zone

Project code – RV00595

## Project Partners

FarmLink change • adapt • prosper

GRAHAM CENTRE for Agricultural Innovation

CLEAR VIEW CONSULTING

NSW Government Local Land Services Riverina

## Trial Site Location

Temora Agricultural Innovation Centre

## Report Authors

Murray Long (Clearview Consulting)

## Introduction

The influence of Body Condition Score (BCS) across a range of manageable areas within sheep operations is well documented and promoted through programs such as Bred Well Fed Well and Lifetime Ewe Management. It should be a given practice for sheep producers to routinely assess the BCS of their ewes (in the yard, not from the ute window) and adjust management accordingly. Note that Body Score is different to Fat Score which is more commonly used to assess the fat cover on lambs at sale time. A BCS of around 3 – 3.5 is the figure that most programs promote as ideal for both joining and lambing and is generally regarded as a minimum safe level to avoid any potential problems.

In relation to conception rates, it has generally been promoted that higher body scores at joining will result in higher conception rates. The trial at Temora Agricultural Innovation Centre (TAIC) supported by FarmLink was designed to address the growing concerns of producers who are not gaining the benefits of high conceptions in ewes that are consistently above average (BCS 3) condition. These concerns were more prevalent in non-Merino ewes, especially Dorper and terminal breed types.

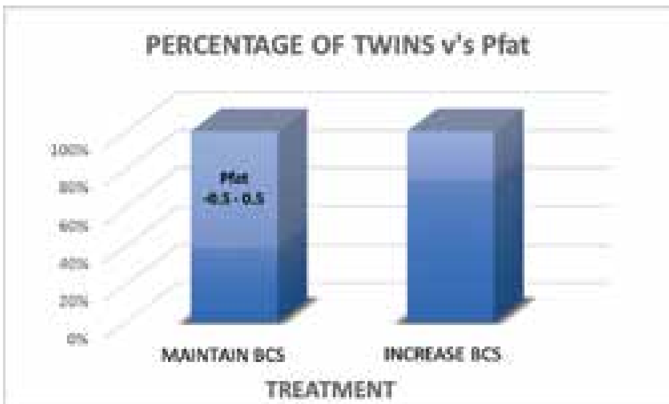
The trial involved around 175 White Suffolk ewes that were assessed for condition score when their lambs were weaned in October 2014 where they averaged between 3.2 & 3.6 BCS. They were then split into 2 groups; one treatment was held at BCS 3.3 until joining while the second group were allowed to increase in BCS to 4.5 before joining. The difference between the two groups was maintained during joining. Pregnancy scanning was conducted at 50 days after ram removal and the results evaluated against both the treatment and the known breeding values (ASBVs) of the ewes.

## Analysis

Maintaining condition score at 3.3 had a slight effect on the number of dry ewes (7% v's 10%), mainly due to a few ewes that had reared multiple lambs the previous year not recovering condition sufficiently. However, on analysis of the ewes that were scanned in lamb, there was an additional 9% lambs in utero for the ewes that maintained BCS compared to those allowed to increase BCS. This was due to an additional 9% of multiples in the BCS 3.3 ewes.

| TREATMENT | Dry ewes (%) | Singles (% SIL) | Twins (% SIL) | Total (%SIL) | Total (Joined) |
|---|---|---|---|---|---|
| BCS+ | 6.8% | 41% | 59% | 159% | 148% |
| BCS= | 9.9% | 32% | 68% | 168% | 151% |

Further analysis of the responses from the trial at TAIC indicated that for the ewes held at BCS 3.3 during joining, the fat breeding value (ASBV) of the ewe had only a slight effect on the multiple conception rate whereas in the group allowed to increase BCS to 4.5 pre- joining, it was the leaner ewes that had significantly more multiple conceptions (See Figure below). This comparison illustrates that for an average increase of 1 unit in genetic fat for the BCS= group, an extra 22% of twins were achieved whereas in the BCS+ treatment the same 1 unit increase appeared to impact negatively on twin conception rates. High genetic fat levels in high performance ewes appears to 'work against' multiple conceptions when ewes are joined in very good body condition but may enhance twin conception rates among ewes in lower BCS and/or on restricted feed. This tends to indicate that in non-Merino ewes, high condition scores at the commencement of joining may be counterproductive to conception of multiples therefore inhibiting the potential for higher lambing percentages.




**What does this mean for sheep producers?**

It is accepted that a rising plane of nutrition is desirable for best results at joining so it would therefore be desirable to have non-Merino ewes at a maximum BCS around 3 - 3.5 at the commencement of joining. A sheep producer running 1st cross ewes at Rankin Springs increased the BCS of his ewes from 3.5 to 4.2 during joining and achieved in utero conception rates of 183% so high conception rates seem more responsive to a rising plane of nutrition rather than just high values of Body Condition Score during joining.

While these trial results were observed in non-Merino ewes, there is little doubt that the higher the BCS of Merino ewes at joining, the better the potential conception rates will be. Merino genetics are inherently leaner than non-Merino types and the targeted selection for higher fleece weights and its negative impact in reproduction will mean that management of nutrition and BCS is essential to achieving high conception rates. The problem with Merino ewes is getting them to a BCS of 3.5 and not having them too light rather than any concerns of having them in too high BCS.

While the results of this trial don't actually show a penalty in lamb numbers from ewes at or above condition score 3, there is evidence that the incidence of twins in non-Merino ewes may increase within ewes having leaner (ie more negative Pfat) levels of genetic fat and there is potentially a twin conception rate 'penalty' for over fat ewes with higher Pfat ASBV's.

Given that many first cross or composite ewes do not have the potential for high levels of genetic leanness, relatively higher levels of genetic fat combined with excessively high condition scores at joining, may negatively impact on ewe fertility and, indeed, answer the question "can ewes be too fat to join". Such ewes may, in fact, perform better if maintained at an average condition score of 3 to 3.5 pre joining. Management may be better targeted to ensure non-Merino ewes reach minimum BCS's rather than pushing them to higher levels. Doing so may also lead to a saving on pasture/feed/supplement costs.

The practice of having your ewes on a rising plane of nutrition during joining is critical in achieving high conception rates...the next step is to ensure you keep most of those lambs alive.

# 11

FarmLink Research Report 2015

# Influence of Feed Quality on the expression of Growth ASBVs in White Suffolk Lambs

## Project

Profitable & Sustainable Sheep Production in the Mixed Farming Zone

Project code – RV00595

## Project Partners

FarmLink change • adapt • prosper

GRAHAM CENTRE

CLEAR VIEW CONSULTING

NSW GOVERNMENT Local Land Services Riverina

## Trial Site Location

Temora Agricultural Innovation Centre

## Report Authors

Murray Long (Clearview Consulting)

## Introduction

The use of ASBVs to select both rams and replacement ewes is now well entrenched in the Australian sheep industry. The advantages gained through the use of breeding values has been verified across many independent trials demonstrating significant increases in both performance and profitability across all sectors of the industry. So what impact does environment, if any, have on the expression of these ASBVs in a commercial environment? The effects of Post weaning Fat (Pfat) ASBVs has been shown to effect both conception and lamb survival although not equally across all environments with moderate levels of Pfat more advantageous to lamb survival in drier seasons. There has long been the question as to whether the expression of other ASBVs, especially growth, is affected by environment and what other considerations may be necessary if feed quality is likely to be limiting during the season.

One hundred and fifty-eight (158) mixed age (3-6 years) White Suffolk ewes with known ASBVs were randomly joined to either high growth (Pwt 13.7) or low growth (Pwt 10.3) sires with similar breeding values for fat and muscle. After a joining period of 6 weeks, the ewes were scanned at 92 days after ram introduction with an average of 163% lambs in utero and managed as a single mob to Condition Score (CS) 4.1 on Lucerne pasture until mid-way through the last trimester. They were then randomly split into treatment groups with equal numbers of Low growth and High growth joined ewes placed on either Lucerne pasture or low value native pasture to lamb down. These differing feed scenarios were maintained through lambing with the lambs kept on the different treatments for 4 weeks post weaning.

Individual lamb weights were taken at marking (day 60 from 1st lamb), weaning (day 141) and post weaning (day 167). Single and twin lambs were identified with this information allowing individual growth rates to be assessed and corrections for birth and rearing type. Condition Scores of the ewes from each treatment were assessed at weaning.

## Analysis

There was a marked difference in the Condition Score of the ewes from the two treatments at weaning with the ewes from the Pasture (native pasture) treatment averaging CS 2.45 compared to the Lucerne treatment where the ewes averaged CS 3.85. There was also a significant difference in the average weights of the lambs at weaning (day 141) from the two treatments with lambs from the Pasture treatment averaging 41.83 Kg compared to the Lucerne treatment average of 53.44 Kg.

The effect of the treatments on the expression of the Growth (Pwt) ASBVs (Table 2) was as expected on Lucerne with lambs from the High growth sires (H LUC) producing higher growth rates than those from the Low growth sires (L LUC). However, when feed quality was low (Pasture treatment) there was no advantage expressed in the High growth sired lambs (H PAST) over the lambs sired by the Low growth sires (L PAST).

| | Day 60 (Kgs) | Day 141 (Kgs) | Day 167 (Kgs) | Growth rate (gms/d) Day 60-141 | Growth rate (gms/d) Day 141 - 167 |
|---|---|---|---|---|---|
| H LUC | 26.81 | 54.87 | 62.22 | 346.43 | 282.92 |
| L LUC | 24.90 | 52.01 | 58.44 | 334.71 | 247.29 |
| H PAST | 20.69 | 41.78 | 45.86 | 260.34 | 157.21 |
| L PAST | 20.43 | 41.89 | 46.17 | 264.83 | 164.84 |

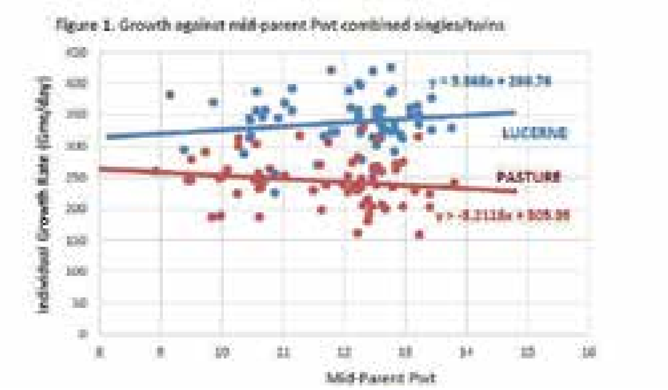
The White Suffolk ewes in this trial had ASBVs for all the traits being evaluated and this allowed the opportunity to evaluate the impact of not only growth against feed quality but other carcase ASBVs. By calculating a mid-parent ASBV for the progeny across all traits, a more detailed study of the impact of feed quality in relation to carcase ASBVs could be evaluated. The average ASBVs of both the High and Low growth sires were combined with individual ewes to give a mid-parent ASBV for Pwt, Pfat and Pemd for all progeny.

The calculation of individual mid-parent predictions of breeding values across growth, fat and muscle allowed the comparison of ASBVs against individual growth rates for the Lucerne and Pasture treatments. Figure 1 shows the relationships for Pwt against individual growth rate for combined rearing types.

The lambs born and raised on Lucerne realised weight gains commonly found under good commercial grazing conditions whereas the lambs born and raised on lower quality feed were not allowed to reach their expected daily weight gains despite the higher genetic potential for growth. This finding has long been suggested by many breeders and industry suggesting a more moderate and balanced approach to selection based on a mix of ASBVs with consideration to environment, especially in marginal areas.

The disparity in feed quality and quantity provided to the ewes and lambs across treatments in this trial was substantial. A times during the trial, the ewes and lambs on native pasture would have been in a situation where supplementary feeding would have been a consideration in a commercial operation. The response to higher growth ASBVs from lambs on Lucerne is what would be expected and has been shown in numerous trials relating to ASBVs.

The predicted weight advantage based on the

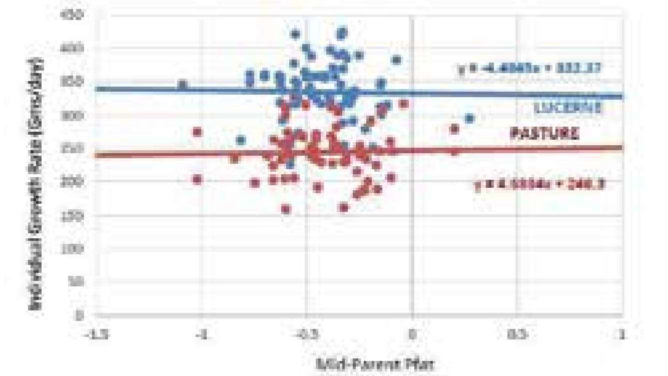



ASBVs at 225 days (Post weaning) across the range of sires used is the difference between average Pwt values of the sires used divided by 2.

That is; (High Pwt – Low Pwt)/2 = (13.7-10.3)/2 = 1.7 Kg @ 225 days

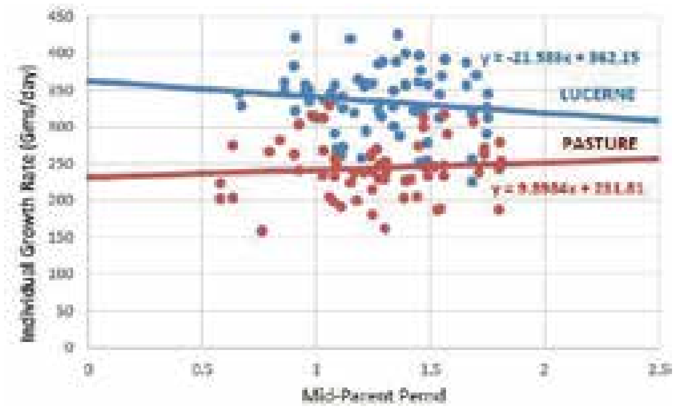
In this trial the difference between the high and low growth sires was significantly greater than the 1.7 Kg predicted; 4.6 Kg at 167 days. Even the difference between the treatments based on the mid-parent value of 2Kg underestimates the real gain in production. This finding has been the case for many "Proof of Profit" trials across a range of ASBVs and is further proof of the advantage that using ASBVs provides sheep producers. For lambs raised on Lucerne, growth was the predominant factor driving weight gain and the relationship with fat and muscle seemingly a negative one. This makes sense when we consider the negative genetic correlation that growth has with Fat and Muscle; Higher growth = less muscle and less fat. This correlation fully explains the apparent negative relationship seen in the Lucerne treatment when growth rate was plotted against either mid parent Pfat or Pemd. Under good nutrition, growth rate ASBVs drive the potential weight gain of the lambs. However, this does not suggest that fat and muscle are not essential considerations in selection criteria as the benefits to carcase value are substantial. Selection for growth alone is not an option for commercial lamb producers.

The interesting finding from this trial is that when lambs were unable to attain potential high growth rates due to nutritional restrictions, there was no advantage of high Pwt ASBVs when compared to lambs with lower Pwt values. However, when these growth rates were compared to the ASBVs for Pfat and Pemd, they seem to compensate providing some buffering for growth rate, or more than likely,




it is those lambs with more fat and muscle that are "protected" from weight loss. At first glance it would seem that this is minor but for the single lambs only (not shown), this effect was markedly greater than for the combined twins/singles. The response does follow the correlation between growth and both Pfat and Pemd given the slightly negative slope of growth rate per day against Pwt although the difference in the response of Pemd against growth is a higher magnitude.

This creates a different interpretation of the influence of Pfat and especially Pemd when feed is limiting. Assuming that the expression of growth potential is significantly curtailed when feed is




limiting as previously found in other studies and in this trial, why doesn't the response of fat and muscle against growth rate follow the pattern to the same magnitude as that produced on Lucerne? It could be argued that if the growth potential was reduced to the point of providing no advantage for high Pwt ASBVs, then the response observed against Pemd is the real effect it is having on growth. Hegarty et al (2006) found that the expression of Pemd (muscle) was not affected by level of nutrition therefore it would be expected that the lambs on Pasture with higher mid- parent Pemd values would have had higher levels of muscling. They also found higher carcase weights from sires with high Pemd values under low nutrition when compared to lambs from high growth sires. This is supported by the work of Cake et al (2006) who found that lambs grown out under low nutrition had a higher proportion of muscle than their counterparts grown under high nutrition for the same 20kg carcase weight. Further research has shown that selection for high muscling in sires, works against the deposition of fat under good nutrition resulting in higher yielding carcases under all conditions.

Despite the low quality of feed in the pasture treatment, these lambs still averaged a growth rate of around 250 gms/day to weaning. The combined effect of ASBVs for growth, fat and muscle and the balance of these traits is critical in achieving maximum potential gains across the range of potential seasonal challenges. It would seem that under feed limiting conditions, adequate levels of growth coupled with moderate fat and high muscle ASBVs are critical to achieving maximum flexibility of management and higher potential returns. This ties in with findings from a 2-year trial (Long unpublished 2006-07) where the Pfat of progeny was positively correlated with feed efficiency; more moderate levels of Fat, higher feed efficiency. If feed is to be limiting, more efficient genetics will make better use of those limiting resources.

The selection of genetics using ASBVs is a means to ensuring the best possible outcome in relation to, not only growth, but overall carcase shape and yield resulting in maximum profitability. While some knowledge of potential seasonal conditions and feed availability are possible, genetic selection has to take account of all probable situations and selection for extreme levels of growth (or any trait) may not the safest and best option. While there was no observed benefit from higher Pwt ASBVs in feed limiting conditions, there still remains to potential to take advantage of a change in the season or a response to supplementary feeding when there is genetic potential for faster growth rates. It has been shown that when feed limitations are eased, compensatory growth exceeds that of lambs on high nutrition and the advantages of using high growth ASBVs are realised. Getting the mix of ASBVs right is the secret to ensuring that all potential feed conditions are covered to ensure maximum production regardless of the seasonal variations. The importance of ensuring adequate nutrition is vital to allow the full genetic potential to be realised and provide maximum production and profitability.

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FarmLink Research Report 2015

# Effect of loose lick supplement on the growth rate of lamb grazing on Lucerne

## Project

Profitable & Sustainable Sheep Production in the Mixed Farming Zone

Project code – RV00595

## Project Partners

## Trial Site Location

Temora Agricultural Innovation Centre

## Report Authors

Murray Long (Clearview Consulting), Geoff Duddy (Sheep Solutions)

## Introduction

The real value of mineral supplements in sheep and lamb production systems has long been questioned. Provision of mineral blocks or a loose lick supplement is often provided as an insurance against any possible mineral deficiencies for either sheep grazing on stubbles or ewes during pregnancy and lactation. The use of a mineral supplement in feedlot finishing has arguably gained wider acceptance than grazing lambs on improved pastures. Apart from data generated by feed companies, there is limited information and still a question mark over the effectiveness of supplements in achieving higher growth rates.

# Background

To evaluate the impact of loose lick supplements, 188 White Suffolk cross lambs were drenched, inoculated, weighed and shorn prior to being divided into two equal size treatment groups and placed on actively growing dryland Lucerne pasture at Temora Agricultural Innovation Centre (TAIC). Within each group of lambs were three weight categories, Light Store (25-35Kg), Light Trade (36-45 Kg) and Trade (45-55Kg). One group was provided with a loose lick supplement (ad lib) and the weights of lambs and fat scores of all lambs regularly assessed. To further evaluate the effect of the loose lick mineral supplement, a crossover of treatments was conducted at day 42 with 50% of the lambs from each weight category transferred to the alternative treatment category.

The supplement provided was a commercially available product with the following analysis as per the label:

- Salt 34%
- Molasses 2%
- Calcium 12 %
- Magnesium 1.6 %
- Sulphur 3.1%
- Phosphorus 1.2 %
- Potassium 0.25%
- **Contents:** Salt, Agri-lime, Molasses, Vegetable Oil, Bi-Carb, Causemag, Di-Calcium Phosphate, Bypass Protein Meal, Magnesium Sulphate, Gypsum.
- **Trace Elements;** Cobalt, Iodine, Selenium, Methionine, Zinc, Manganese, Copper, Biotin, Chelated Zinc. Molybdenum Vitamins; Vitamin A, Vitamin B1, Vitamin D3 and Vitamin E

# Analysis

Lambs provided with a loose lick supplement achieved higher growth rates across all weight categories as shown in Figure 1. The effect was greatest in the light trade lambs with a difference of 101 gms/day in growth rate between the two treatments. The trade and light store lambs were showing similar differences in growth until day 42 when the trade category in the Control (no supplement) group actually lost weight on Lucerne that had dropped most its leaf due to lack of moisture. This resulted in a growth advantage to the supplemented group on day 42 of 85 gms/day and 48 gms/day for the trade and light store lambs respectively.

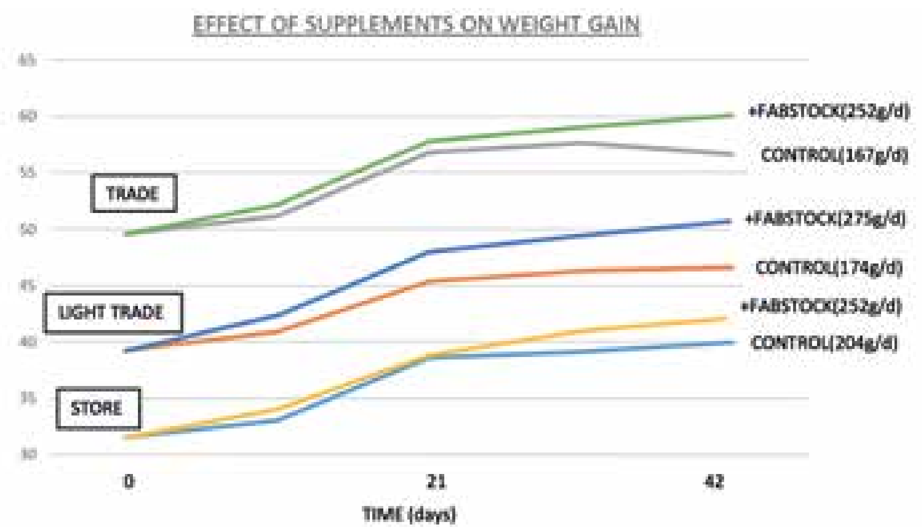


*Figure 1. Effect of supplement on live weight gains across weight categories*

The lambs on supplement appeared to settle faster after shearing/transporting and subsequently onto the Lucerne pasture and were noticeably less agitated at each weighing event. Despite a significant drop in the quality of the Lucerne stand, supplemented lambs continued to gain weight across all weight categories. The growth rates of the supplemented group were basically not adversely affected by further deterioration of the Lucerne stand once the leaf drop had commenced.

At day 33 lambs were shifted to a fresher Lucerne stand and at day 42, half the lambs from each group were transferred to the alternative treatment. When compared to the lambs that had been on the supplement for the duration of the trial, those lambs that went to the control after being on supplement showed a significantly lower weight gain while those that had previously been without supplement revealed a weight gain equal to, if not slightly better than, the lambs on supplement for the duration of the trial. The results from this can be seen in the Figure below.

The increase in weight gain from the lambs that were previously not on supplement was greatest in the trade and light trade lambs and not significantly different when compared to the reverse treatment in the lighter lambs. As these weights were attained just 10 days after the change of treatment, it confirms the positive effect of the supplement on the growth of lambs on Lucerne pasture. Continued weight measurements for another 3 weeks validated that the lambs on supplement continued to grow on average at faster rates than those without supplement (155gms/day compared to 103gms/day respectively) even on a depleted Lucerne stand.


The intake rates of the supplement were monitored for the duration of the trial. After an initial adjustment period where intake was 102 gms/hd over the 1st week, levels were initially high at 410gms/hd over the 2nd week, 205gms/hd for the 3rd week and settling on an average of 153 gms/hd/ week ± 25gms for the remainder of the trial. Intake did not increase as feed value of the Lucerne decreased.

As with growth rates, fat score evaluations were higher in the lambs on supplement than those not on supplement. Supplemented lambs finished the trial with an average of 2 mm more fat (10.4 v's 8.4) across all weight categories which was an increase of almost a full fat score (5mm) from the initial evaluations. The increase in fat score was more evident in the heavy trade lambs and this was consistent across both treatments.

**Analysis of the benefits of using a Supplement**

As the lambs with access to the supplement achieved higher growth rates and were on average half a fat score better, this elevated them into a higher price bracket at sale time for both the trade and light trade groups (now classified as heavy trade and light export).

An analysis (table right) of the cost-effectiveness of using a supplement was undertaken with the assumption that the lighter lambs theoretically consumed less of the supplement than the larger lambs with a ratio of 0.25, 0.35, and 0.40 used across the Light Store, Light Trade and Trade categories respectively.

The supplement is purchased in 25Kg bags @ $32.45 per bag, equivalent to $1.30/Kg.

| | | Sale $/head | Cost Supplement | Margin | Gain |
|---|---|---|---|---|---|
| LIGHT STORE | CONTROL | $98.78 | | $98.78 | |
| | SUPPLEMENT | $100.82 | $1.42/head | $99.40 | **$0.62** |
| LIGHT TRADE | CONTROL | $109.55 | | $109.55 | |
| | SUPPLEMENT | $123.98 | $1.57/head | $122.41 | **$12.86** |
| TRADE | CONTROL | $141.25 | | $141.25 | |
| | SUPPLEMENT | $152.21 | $1.65/head | $150.56 | **$9.31** |

In all weight categories, real dollar gains were achieved by the use of a supplement. The greatest gains were in the Light Trade category with an average gain across all lambs in the trial of $8.77 per lamb.

The results of this trial clearly indicated an economic benefit across all weight categories associated with the use of a supplement. The gains were significant with average growth rates per day increasing above the growth rates of the control groups by an average of 48 gms/day, 101 gms/day and 85 gms/day in the Light Store, Light Trade and Trade lambs respectively. This represented an increase in weight gain per day of 23%, 58% and 51% respectively across the weight categories when compared to the un-supplemented lambs for the 42 days of the trial. This advantage in growth rate per day resulted in an increase in the profitability of the lambs of up to $12.86/head or an additional 11.7% value in the Light Trade category and even in the Light Store category where weight gain was the least significant, a small advantage was gained with the use of supplement.

The Lucerne received minimal significant rainfall after the commencement of the trial and no Lucerne regrowth was observed. Despite this drop in feed quality, acceptable growth rates were still achieved from the lambs on supplement whereas at times, lambs without supplement actually remained static or lost weight. At no stage did the average weights of the lambs on supplement approach a situation where they stopped growing. The larger lambs seemed more prone to slow their growth rate when feed quality and quantity dropped more than likely due to higher requirements for maintenance energy. Obviously the decision to use Lucerne as a finisher for lambs is more unreliable than the use of a feedlot to provide constant feed quality and quantity but when available, is a suitable choice to achieve good growth rates. The reality that at times during the trial, lambs achieved average growth rates around 500 gms per day in the heavier category indicates that Lucerne pasture (when available) may be even more suitable than a feedlot. No deaths or shy feeders (poor performers) were identified and all lambs grew relatively even as a group. The management required to finish the lambs on Lucerne is significantly different to that required in a feedlot operation.

The issue of temperament is one that that was quickly identifiable as a difference between the two treatments. The lambs on supplement were noticeably less flighty and easier to handle both in the paddock and through the weighing crate. The supplement contained 1.6% Magnesium, an element well known to be effective in reducing stress levels across many species including horses and cattle. Deficiency symptoms in lambs may lead to excitability, convulsions, tetany and death in extreme cases. Magnesium supplement has been found effective in reducing stress levels in lambs prior to slaughter. The relatively high levels of K and N (crude protein) in Lucerne may therefore reduce the efficiency of with Mg absorption, most of which occurs within the rumen (www.organicvet.co.uk), limiting an essential element for energy reactions and nerve function. There is little doubt that stress affects weight gain and findings (Geoff Duddy, unpublished) indicate that even the practice of regular weighing of lambs can limit weight gain for 1-2 days after each weighing event. While additional research is needed in terms of the role of Mg in stress reduction and improving productivity, it appears cost beneficial to provide supplemental Mg based on these trial findings.

The decision concerning which opportunity to employ when finishing lambs following the purchase of store lambs or value adding lambs raised on property is one that requires good economic evaluation. Recent years have seen the relationship between the prices of store lambs compared to trade lambs at an unfavourable ratio, often with store lambs at a dearer price per kilogram. Every advantage is required to ensure that, when finishing lambs, the growth rate you achieve is one that will deliver maximum profitability. The faster the desired weight gains, the better the chance of being on the right side of the ledger. Based on the results of this trial, the use of a supplement is one way to achieve those desired gains within a shorter time frame when finishing on Lucerne. The calculation of the expected returns in a feedlot scenario did not return a profit in any of the lamb weight categories when all costs (real and opportunity) were taken into consideration.

The response to the change in treatment at day 42 was a clear indication of the effectiveness of the supplement in facilitating higher growth rates. Having already observed faster daily growth rates in supplemented lambs, the fast response to the supplement from previously un-supplemented lambs that was equal to if not higher than their contemporaries was clear evidence of the effect of the supplement. The fact that the lambs taken off supplement dropped their growth rate so quickly is confirmation that the provision of supplement needs to be constant and continuous to achieve maximum growth rates. The initial consumption rates of supplements often panics producers but we found a quick return to moderately consistent intake levels of around 150 gms/head/week or $0.20 /head/week. The return in additional income from accelerated weight gain due to the supplement was on average $1.46/head/week over the 42 days of the trial or an average 600% return on the cost of the supplement.

We conclude the effect of supplements when grazing Lucerne pasture has a significant positive effect on weight gain across a range of weight categories in lambs. The economics of using supplements was shown to be a significantly positive one however, the decision as whether to finish lambs or sell earlier as stores, always needs to be one that is fully investigated to evaluate whether justifiable gains can be realised.

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FarmLink Research Report 2015

# The value of hardseeded legume for forage and for competition with annual ryegrass

Project code – RV00595

## Project Partners

FarmLink change • adapt • prosper

Lear View Consulting

Charles Sturt University

## Funding Partners

mla Meat & Livestock Australia

awi Australian Wool Innovation Limited

NSW Local Land Services Riverina

## Trial Site Location

Temora Agricultural Innovation Centre

## Report Authors

Dr Belinda Hackney (CSU), Dr Jane Quinn (CSU)

## Introduction

This project is a component of two other projects, B.PSP.0013 Pasture legumes in the mixed farming zone of WA and NSW: shifting the baseline (funded by MLA and AWI) and B.AHE.0236 Understanding photosensitisation in livestock grazing the pasture legume Biserrula pelecinus (funded by MLA). In this component of the project, two mixed pastures (biserrula/subterranean clover and bladder/gland clover) have been sown and are being compared to subterranean clover sown for their ability to support livestock production and also to compete with the important cropping weed, annual ryegrass.

Reasonable seed-set of sown species has been achieved on all treatments and assessment of livestock production and sown pasture-weed competition will continue throughout 2016.

## Background

The integration of hardseeded legumes such as biserrula, bladder clover and gland clover has been underway in southern NSW since the mid 2000's. These legumes have been found to perform well in comparison to traditional legumes such as subterranean clover, particularly in years with average and below average rainfall. Development of rotation systems using these legumes as 'on-demand' breaks in the crop rotation has also been undertaken since 2012 with much success.

Our focus with hardseeded legumes has more recently moved towards quantifying livestock production on these legumes. Additionally, as a result of differences in palatability between the species there is capacity to use livestock to strategically reduce the population of problem weeds such as annual ryegrass during the pasture phase of the crop-pasture rotation. So far, hardseeded legumes used in an 'on-demand' capacity in the rotation are used as monocultures. Many producers cite ease of management, particularly with regard to herbicide selection as a key reason for using these species as monocultures. However, from an animal production perspective, monocultures rarely provide an optimally balanced diet with respect to energy-protein balance and exclusive use of a legume-based diet can result in metabolic disorders such as bloat. Additionally, biserrula, while extremely productive, when used as a monoculture, can cause issue with primary photosensitisation in non-pigmented grazing livestock.

Given these issues, we have designed this study to examine the use of mixed legume swards which incorporate a mix of hardseeded legumes or hardseeded legumes sown with traditional legumes. Our aim over the lifetime of the study is to quantify the effect of mixed legume swards on livestock productivity and health as well as the balance between sown species and weeds.

### Treatments

In late May 2015, the following treatments were sown in a replicated trial (n=3), with each plot 0.4 ha in area:

- Biserrula (cv. Casbah) plus subterranean clover (cv. Dalkeith)
- Bladder clover (cv. Bartolo) plus gland clover (cv. Prima)
- Subterranean clover (cv. Dalkeith)

### Results

Owing to dry conditions in early-mid spring, growth on all plots was slow and the decision was made to allow plants to set seed prior to any grazing occurring. All legumes appeared to have senesced and set seed by early November. Interestingly, following rainfall in November, biserrula initiated a further round of pod & seed production (Figure 1).

*Figure 1: Biserrula showing seed pods produced in early spring (brown pods) and second round of flowering and pod production following rainfall in November. Middle and bottom photo shows bladder/gland clover and subterranean clover plots taken on same day*

*Seed production varied significantly between the species sown (Table 1) with biserrula producing significantly more seed cumulatively (>5900 seeds/m2) compared to other species. Subterranean clover seed production was lowest of all species.*

| | Early spring seed set | | Late spring summer seed set | |
|---|---|---|---|---|
| | Species 1 | Species 2 | Species 1 | Species 2 |
| Treatment 1 Biserrula/subclover | 2715 | 189 | 3258 | 0 |
| Treatment 2 Bladder/gland | 760 | 2046 | 0 | 0 |
| Subclover | 250 | | 0 | |

*Table 1 Seed production (seeds/m2) produced by in the biserrula/subterranean clover, bladder/gland clover and subterranean clover only treatments at Temora, NSW in 2015.*

Grazing was undertaken for two weeks in late November. This grazing period was too short to allow assessment of livestock production on any of the species and in any case, feed availability, particularly on the subterranean clover only treatments was not adequate to assess livestock performance on this species. Monitoring of annual ryegrass seedhead number was undertaken over the grazing period and this showed greater removal of initial population of ryegrass seedheads (78% removal) on biserrula over the two week grazing period compared to bladder/gland clover treatments (47% removal).

### Discussion

Results from the initial establishment season have again confirmed the ability of hardseeded legumes to grow and set seed under adverse seasonal conditions. The value of indeterminate pattern of growth in facilitating additional seed set was also shown with biserrula where following late spring rain, an additional round of seed set resulted in a more than doubling of overall seed production. Bladder, with a slightly deeper root system, and gland clover which is early maturing also showed better capacity to produce seed in challenging conditions compared to subterranean clover. With production of a seedbank critical for pasture performance in subsequent years, the performance of hardseeded legumes was very encouraging. Additionally, the role of biserrula as tool in grazing-assisted removal of annual ryegrass offers potential to integrate with other tactical control measures to lessen the impact of this weed on cropping systems

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FarmLink Research Report 2015

# Does increase herbicide use impact on key soil biological processes?

Project code – DAN00180

## Project Partners

FarmLink
change • adapt • prosper

NSW Department of Primary Industries

Queensland Government Department of Agriculture, Fisheries and Forestry

Victoria State Government Economic Development, Jobs, Transport and Resources

Government of Western Australia Department of Agriculture and Food

Southern Cross University

The University of Sydney

The University of Adelaide

## Funding Partners

GRDC Grains Research & Development Corporation

## Trial Site Location

Temora Agricultural Innovation Centre & numerous sites

## Report Authors

Mick Rose (NSW DPI)

## Introduction

- A national soil survey found that residues of certain herbicides, including glyphosate and its break-down product AMPA, trifluralin and diflufenican, are often detected in soils prior to the winter cropping season.
- Analysis of international literature suggests that soil biological functions are generally resilient to short term impacts of single herbicide application at label rates. Negative impacts, if any, usually last for less than one month.
- However, impacts of herbicide residues after repeat applications are less well understood. The lack of readily available, soil-specific guidelines for herbicide residues causing damage to i) soil biological functions and ii) plant growth is a key knowledge gap to be addressed by future work in this project.
- Strategies to avoid herbicide residue accumulation and potential damage to soil functions and crops include: routine rotation of pre-emergent herbicides, reliable record keeping to help identify potential residue issues, and organic matter addition to help tie-up bioavailable residues and stimulate microbial activity.

# Background

The move to conservation tillage and herbicide-tolerant crop cultivars means that many farmers are relying on herbicides for weed control more than ever before. Despite the provision of plant-back guidelines on herbicide product labels, site-specific factors such as low rainfall, constrained soil microbial activity and non-ideal pH may cause herbicides to persist in the soil beyond usual expectations. Because of the high cost of herbicide residue analysis, information about herbicide residue levels in Australian grain cropping soils is scarce. In addition, little is known about how herbicides affect soil biological processes and what this means for crop production. Although a few tests are mandatory for herbicide registration, such as earthworm toxicity tests and effects on soil respiration, other services provided by soil organisms such as organic matter turnover, nitrogen cycling, phosphorus solubilisation and disease suppression are usually overlooked.

GRDC recently co-funded a 5-year project (DAN00180) to better understand the potential impacts of increased herbicide use on key soil biological processes. This national project, co-ordinated by the NSW Department of Primary Industries with partners in WA, SA, Vic and Qld, is focussed on the effect of at least 6 different herbicide classes on the biology and function of 5 key soil types across all three grain growing regions.

Here we report on the results of a field survey of herbicide residues in 40 cropping soils prior to sowing and pre-emergent herbicide application in 2015. We discuss the relevance of these residues to soil biological processes and crop health, with a focus on those herbicides most frequently detected. We also detail plans for future research and the development of management tools for growers to monitor and predict herbicide persistence in soils.

### Methods

- A soil survey was undertaken to provide a representative snapshot of herbicide residue levels in cropping soils at the beginning of the 2015 growing season (April-May), prior to the application of pre-emergent herbicides. Soil samples were taken from 40 paddocks around Australia, including 12 in WA, 15 in SA, 10 in NSW and 3 in Qld. Composite samples (12 subsamples) were taken from a randomly chosen 50 m by 50 m grid in each paddock, at two depths (0-10, 10-30 cm). Samples were analysed for 15 commonly used herbicides using advanced analytical techniques developed and validated specifically for this project;
- Herbicide impacts to soil biology were reviewed by searching the literature using the search terms including herbicides, soil, microorganisms and function. Over 300 peer-reviewed publications were analysed for potential impacts of herbicides on soil organic matter turnover, nutrient cycling and disease interactions;
- The potential for direct damage to crops was assessed by comparing herbicide residue to literature thresholds for herbicide sensitivity. Because such data are lacking for glyphosate residues in soil, we also conducted a bioassay to determine the effect of soil-borne glyphosate residues on wheat, lupin and canola growth in a sandy (tenosol) soil from Wongan Hills, WA. This soil has low phosphorus buffer index (for Colwell P) of 15 L/kg, indicating a low potential for P sorption. Glyphosate (as Roundup CT ®) was thoroughly mixed through topsoil (5 cm) at rates equivalent to 0.33, 1, 3, 9 and 27 times the label rate, and aged for 1 month in the glasshouse prior to sowing. In addition, we tested whether the application of 20 kg/ha of P (as potassium phosphate) would alter the toxicity thresholds by remobilising soil-bound glyphosate.  Root and shoot biomass was measured after 6-week growth.

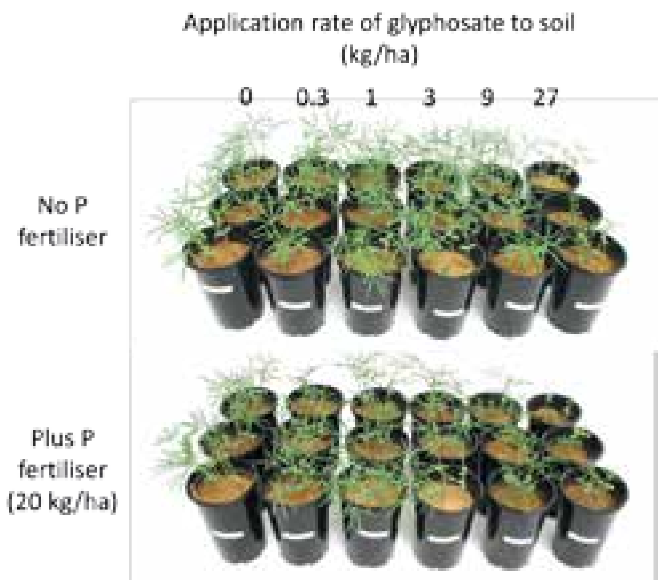


*Figure 1. Glasshouse dose-response trials.*

### Which herbicides are remaining in soil?

The soil survey of 40 different paddocks from around Australia (12 in WA, 15 in SA and 13 in NSW-Qld) detected residues of 11 chemicals out of the 15 analysed (Figure 1). Glyphosate and its primary break-down product (metabolite) aminomethylphosphonic acid (AMPA) were the most commonly detected residues, with AMPA residues present in every topsoil sample taken. Trifluralin residues were also detected in over 75% of the paddocks surveyed, both in topsoil and in the 10-30 cm soil layer, indicating some vertical movement despite the strong tendency of trifluralin to remain close to the site of application. This is possibly the result of cultivation, however, leaching or movement of particle-bound trifluralin may also occur on lighter textured soils with low organic matter content. Diflufenican and diuron residues were frequently detected in samples from WA paddocks, but less so in NSW-Qld and SA.

Interestingly, despite known application of triasulfuron and metsulfuron-methyl in many of the surveyed paddocks, neither of these residual herbicides was detected in any of the samples tested. This is probably a reflection of their low rates of application, close to the limit of analytical detection. It should be noted that sulfonylurea (SU) herbicides may still have some residual activity at levels below the limit of (currently available) analytical detection. By contrast, the lack of positive detections of frequently applied MCPA reflects its relatively short persistence.

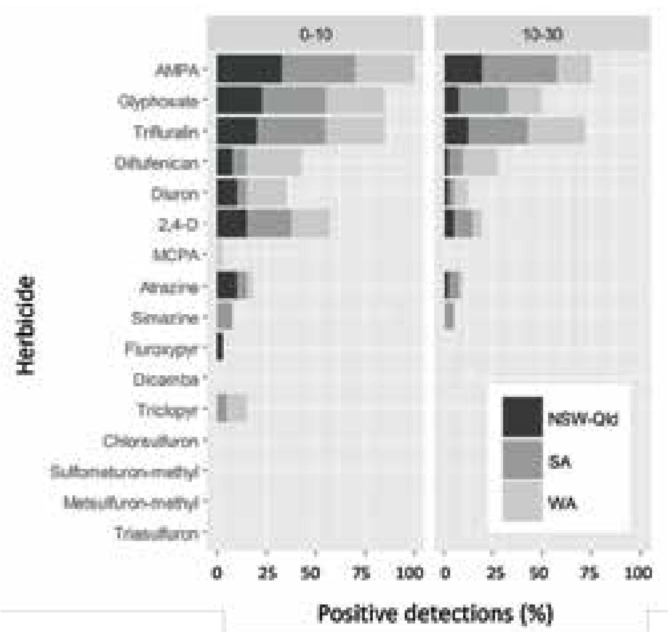


*Figure 2. Number of positive detections of herbicides and the glyphosate metabolite AMPA in soil samples from 40 grain cropping paddocks around Australia.*

By multiplying herbicide concentrations (mg/kg) by soil bulk density (kg/dm) and area, we estimated the total load of herbicide in the 0-30 cm soil profile for each paddock (Table 1). The average and maximum estimated loads of glyphosate, trifluralin, diflufenican and diuron were all significantly higher in paddocks in WA compared with those in SA, NSW and Qld. This likely reflects the lighter soil types, lower organic matter, dry summers and cool winters, which contributes to lower microbial activity and constrained herbicide breakdown. The higher load of atrazine in SA paddocks is probably a consequence of the higher persistence of s-triazine herbicides in alkaline soils; whilst the higher values for 2,4-D in the NSW-Qld soil profiles was due to a high value in a single paddock which had recently been sprayed.

Notably, in a number of paddocks (especially in WA but also in other states), we found a higher load of glyphosate than was applied in the previous spray, demonstrating a degree of accumulation of glyphosate and its metabolite AMPA over time. Although the half-life of glyphosate is relatively rapid (10-40 days), a significant portion of the glyphosate (and AMPA) is bound to soil and is much less accessible for continued degradation. This, combined with the high frequency of glyphosate use, can lead to a build-up of glyphosate and AMPA in soil. Accumulation of trifluralin was also apparent in a number of paddocks in WA. It should be reiterated that these levels represent the total loads, rather than the bio-available fraction. Aging of residues in soil results in stronger binding over time, and a reduction in bioavailability, so any biological effect can be difficult to predict. This is discussed in more detail in the following sections.

### How do soil functions respond to herbicide residues?

A literature review of over 300 published studies identified common themes with respect to herbicide impacts on soil function (Rose et al., 2016). The majority of papers reported negligible impacts of herbicides on beneficial soil functions when applied at recommended rates. Even in the cases where negative effects were observed, they were usually minor and only lasted for periods of less than one month.

However, some exceptions were apparent, especially regarding the effects of repeated herbicide application. For example, there is evidence that the accumulation of some sulfonylurea (SU) herbicides after repeat application can reduce plant-available N, by slowing down the processes involved in N-cycling. Persistence

| Herbicide | Estimated average load across all sites (kg a.i./ha)* | | | Estimated maximum load detected (kg a.i./ha)* | | |
|---|---|---|---|---|---|---|
| | NSW-Qld | SA | WA | NSW-Qld | SA | WA |
| AMPA | 0.91 | 0.95 | 0.92 | 1.92 | 1.97 | 2.21 |
| Glyphosate | 0.56 | 0.48 | 0.79 | 2.05 | 1.05 | 1.75 |
| Trifluralin | 0.08 | 0.11 | 0.53 | 0.14 | 0.26 | 1.34 |
| Diflufenican | 0.01 | 0.03 | 0.04 | 0.02 | 0.05 | 0.09 |
| Diuron | 0.14 | 0.05 | 0.17 | 0.16 | 0.05 | 0.29 |
| 2,4-D | 0.20 | 0.02 | 0.01 | 1.00 | 0.05 | 0.02 |
| MCPA | 0 | 0 | 0 | 0 | 0 | 0 |
| Atrazine | 0.02 | 0.03 | 0.02 | 0.03 | 0.05 | 0.02 |
| Simazine | 0 | 0.04 | 0 | 0.00 | 0.05 | 0 |
| Fluroxypyr | 0.03 | 0 | 0 | 0.03 | 0 | 0 |
| Dicamba | 0 | 0 | 0 | 0 | 0 | 0 |
| Triclopyr | 0 | 0.04 | 0.01 | 0 | 0.07 | 0.01 |
| Chlorsulfuron | 0 | 0 | 0 | 0 | 0 | 0 |
| Sulfometuron-methyl | 0 | 0 | 0 | 0 | 0 | 0 |
| Metsulfuron-methyl | 0 | 0 | 0 | 0 | 0 | 0 |
| Triasulfuron | 0 | 0 | 0 | 0 | 0 | 0 |

*Table 1. Residue loads (average and maximum) of herbicide active ingredients (a.i.) in the 0-30 cm soil profile of paddocks by region.*

*Calculated by multiplying mass concentration (mg/kg) detected by area and average bulk density (derived from soilquality.org) for each soil layer

of SUs in soil has also been linked with increased incidence of Rhizoctonia diseases in cereals and legumes. These effects are more likely to occur in alkaline soils, where SU herbicides are significantly more persistent. There are also cases in which other herbicides (e.g. glyphosate) can increase the incidence of disease, but these interactions appear to be site-specific and often occur under stressful growing conditions.

Based on this information and the herbicide residues detected in the soil survey, it is unlikely that SU residues are having ongoing negative impacts to soil functions in the paddocks surveyed. However, the high residue loads of glyphosate, its metabolite AMPA and trifluralin may be altering some soil functions or plant-pathogen interactions. The localised nature of interactions with glyphosate, and the lack of specific data on trifluralin, means that firm conclusions cannot yet be made with respect to the residues detected.

**How do crops respond to herbicide residues?**

Because the potential for each herbicide to damage crops varies according to soil, agroclimate and crop, comprehensive damage thresholds (given as soil residue concentrations) for assessing plant-back risk are not readily available. Here we focus only on the potential for glyphosate (+AMPA) or trifluralin residues to cause seedling damage, given their high frequency of application and detection in the residue survey.

It is generally accepted that glyphosate is deactivated when it reaches the soil and poses little risk to crops. However, recent research has shown that under certain circumstances glyphosate can be remobilised and become plant bioavailable, including:

1. In the event of P fertilisation, which can compete with glyphosate for binding sites on soil and remobilise bound glyphosate residues

2. In the event of glyphosate applied to a high density of weeds soon before sowing, such that dying weeds translocate glyphosate into the soil and act as a more soluble pool of glyphosate to the germinating crop

We used a sandy, low organic matter soil from Wongan Hills, WA, to construct dose-response curves for wheat and lupin encountering glyphosate residues applied one month prior to sowing. To demonstrate circumstance (1), half the test pots received a one-off application of 20 kg/ha P fertiliser (as soluble potassium phosphate) at sowing.

As can be seen in Figure 2, in soil not receiving P fertiliser, wheat and lupin biomass were was not affected by levels of glyphosate in soil resulting from a 27 kg/ha 9 kg/ha application rate, whilst lupin biomass was only significantly reduced at rates above 12 kg/ha (when upper 95% confidence level falls below 100% biomass). When P fertiliser was added at 20 kg P/ha, both wheat and lupin showed signs of phytotoxicity at lower glyphosate concentration – for lupin this occurred at levels of glyphosate > 3.5 kg/ha (Figure 2); and for wheat > 912.5 kg/ha (Figure 2). Previous research has shown that increasing levels of P fertiliser application will continue to lower the phytotoxicity threshold to glyphosate/AMPA residues in soil. We are currently analysing the soil samples from this experiment to determine the residue level of both glyphosate and AMPA in soil. This will give us a more accurate understanding of whether the residues found in the field survey are likely to cause crop growth impacts following P fertilisation.

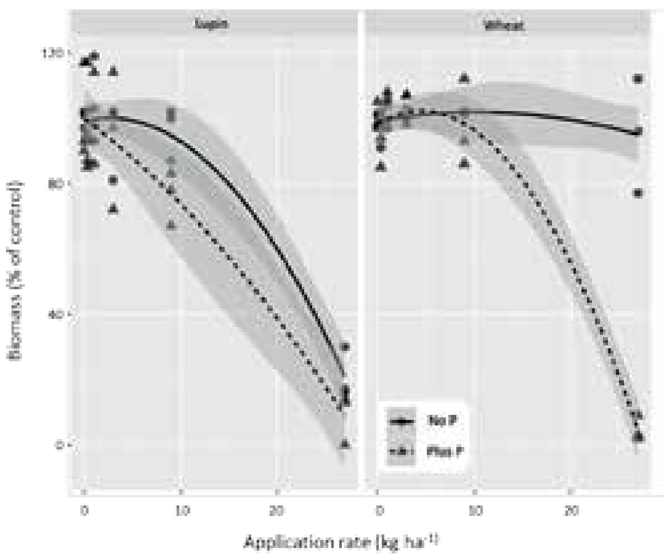


*Figure 3. Growth response of lupin and wheat to glyphosate applied to soil one month prior to sowing. P fertiliser (20 kg/ha) was added at sowing to half the pots.*

With respect to trifluralin, phytoxicity thresholds for oats vary from 0.1 – 0.2 mg/kg and wheat vary from 0.2 – 0.4 mg/kg depending on the soil type (Hager and Refsell, 2008). Table 2 shows the number of paddocks in which the topsoil trifluralin residue concentration exceeds the lower threshold for oats and wheat, respectively. Again, it must be stressed that the residues detected in our field survey constitute "aged" residues which are likely to be less bioavailable and hence less phytotoxic to crops. Nevertheless, considering that some of these paddocks will receive a pre-emergent application of trifluralin in 2016, the risk of some phytotoxicity is tangible.

**Where to from here?**

Ideally, growers and advisers would have tools available for rapid diagnosis of herbicide residues in soil, together with information of the biological relevance of these residues. Our current work is testing rapid in-field dipstick technology (similar to pregnancy test-kits) that can give a semi-quantitative indication of herbicide residue levels in soil within 30 min. We are also formulating improved models that can account for the effects of weather and soil type on herbicide persistence, to give growers and advisers the ability to estimate soil residue concentrations in a given paddock at a certain time after herbicide application. Output from current and future glasshouse dose-response experiments on herbicide impacts to soil functions and plant growth will be linked to model output in a handheld, 'App' format for quick reference.

**Conclusions**

- Glyphosate, trifluralin and diflufenican residues, plus the glyphosate metabolite AMPA, are frequently detected at agronomically significant levels at the start of the winter cropping season
- The risk to soil biological processes is generally minor when herbicides are used at label rates and given sufficient time to dissipate before re-application
- However, given the frequency of glyphosate application, and the persistence of trifluralin and diflufenican, further research is needed to define critical thresholds for these chemicals to avoid potential negative impacts to soil function and crop production.

| Region | Trifluralin > 0.1 mg/kg | Trifluralin > 0.2 mg/kg | Number of paddocks surveyed |
|---|---|---|---|
| WA | 10 | 5 | 12 |
| SA | 2 | 0 | 15 |
| NSW-Qld | 0 | 0 | 13 |

*Table 2. Number of paddocks exceeding trifluralin lower phytotoxicity thresholds for oats (0.1 mg/kg) and wheat (0.2 mg/kg) in topsoil (0-10 cm)*

**Acknowledgements**

The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC, the authors would like to thank them for their continued support. We would also like to acknowledge the generosity of all farmers participating in this survey for support, access and information regarding on-farm herbicide use. Special thanks to Cindy Cassidy, Tony Pratt and Kellie Jones from FarmLink, NSW; Greg Butler from SANTFA, SA; Clare Johnston and Elly Wainwright from Liebe Group, WA; Sarah Hyde and Georgia Oliver from Facey Group, WA; and Ashley Webb, Annabelle McPherson and Clarence Mercer, NSW DPI, for invaluable assistance with soil sampling and liaison.

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FarmLink Research Report 2015

# Field Evaluation of Allelopathy in Canola

## Project Partners

## Project Partners

## Trial Site Location

Temora Agricultural Innovation Centre and CSU Wagga Wagga

## Report Authors

Jim Pratley, David Luckett, Hanwen Wu, Deirdre Lemerle (Graham Centre), Md Asaduzzamam (Asad)

## Introduction

Research undertaken at the Graham Centre over many years has clearly indicated that there are differences between crop varieties in their abilities to 'control' associated weeds through both competitive ability and allelopathic capability. Laboratory and field trials have demonstrated proof of concept that some varieties can deliver weed free seedbeds without assistance from herbicides.

In 2015 field trials were established at two sites, Temora and Wagga Wagga to provide a wider geographic base for the evaluation of canola allelopathy. Varieties were chosen for their known positive and negative allelopathic capabilities and apart from glyphosate application to create the seedbed before sowing, no herbicides were applied during the growing season.

The trials experienced erratic weed behaviour with poor weed populations and late emergence. Nevertheless varieties performed to their expectations with allelopathic varieties inhibiting weeds and non-allelopathic varieties allowing weeds to flourish. The characteristics of allelopathy ought to be considered in crop breeding programs to reduce dependence on herbicides.

## Background

Crop plant interference against weeds involves the combined effects of plant competition and allelopathy. Allelopathy is the exudation of compound by plants that can suppress the growth of neighbouring plants. This exudation occurs from the roots and affects seeds and seedlings of other species located within a limited range (Rice, 1984). Although most plants species, including crops, are capable of producing and releasing biologically active root exudates (allelochemicals), relatively few have strong allelopathic properties. Recent research at Charles Sturt University has shown a large variation in the allelopathic potential of canola (Brassica napus) genotypes against weeds both in the laboratory and in the field (Asaduzzaman et al. 2014a; 2014b). In addition, several allelochemicals (sinapyl alcohol, p-hydroxybenzoic acid and 3,5,6,7,8-pentahydroxy flavone) have been isolated solely from the strongly-allelopathic canola genotypes (Asaduzzaman et al. 2014c). These phytotoxic or signalling chemicals presumably resulted in the observed inhibitory effects on annual ryegrass (Lolium rigidum) in the laboratory, and may also be responsible for the significant suppression of other weed species in the field (Asaduzzaman et al. 2014b). Despite the reports on genetic variability of allelopathy in several crops including canola, research on understanding the genetic control of allelopathy is still in its infancy. However, the reported variation in allelopathic strength in canola (Asaduzzaman et al. 2014a; 2014b) indicates that strong genetic control is involved.

Research at Charles Sturt University in seasons 2012 and 2013 clearly indicated that there is strong allelopathic capability within the available germplasm. The task therefore was to establish a series of trial sites where strongly and weakly allelopathic varieties could be tested, together with two current lines from Pacific Seeds for evaluation.

### Experimental

The objective of the field experiments was to evaluate the capability of the chosen varieties to suppress weeds in crop. Six sites were chosen, three at Wagga Wagga and three at Temora in southern NSW. The purpose of the range of trials was to canvas the responses in different environments and to ensure that at least some sites had weed burdens.

Choice of variety was based on known attributes for allelopathy and competitiveness. Two Pacific Seeds varieties of unknown allelopathy capability were included to evaluate their field performance against the varieties so classified. Details of variety inclusions are given in Table 1. It needs to be noted that Av-Opal, the most allelopathic variety, was only sown at two sites due to seed shortages, it being replaced at the other sites by PAK388-502, the next highest allelopathic variety as determined by ECAM. It should be noted that PAK388-502 is not a Pacific Seeds line.

Seedbed preparation involved a seedbed knockdown spray, glyphosate, but no other herbicides were used during the experiment. Seed was treated with Jockey®. Sowing occurred in early May with all plots receiving common fertiliser rates and common seeding rates (1500 seeds per plot). Weeds were allowed to emerge and develop and be monitored with weed free and weedy controls. All plots were sprayed twice with Prosaro® at 4-leaf and 8-leaf stages for protection against blackleg. The trials were destroyed in early October so as not to allow weed seed set. Six replicates were employed to account for variability of responses. with small plots.

Two quad measurements were made per plot (except at Temora experiments for emergence data where only one quad was recorded). Quads were placed at 'random' but obvious patches were avoided. One Temora site had many volunteer narrow-leaf lupins which were included in weed counts and biomass cuts.

| Entry | Wagga-1 | Wagga-2 | Wagga-3 | Temora-4 | Temora-5 | Temora-6 |
|---|---|---|---|---|---|---|
| 1 | AV-OPAL | PAK85388-502 | PAK85388-502 | AV-OPAL | PAK85388-502 | PAK85388-502 |
| 2 | ATR-409 | ATR-409 | ATR-409 | ATR-409 | ATR-409 | ATR-409 |
| 3 | AV-GARNET | AV-GARNET | AV-GARNET | AV-GARNET | AV-GARNET | AV-GARNET |
| 4 | RIVETTE | RIVETTE | RIVETTE | RIVETTE | RIVETTE | RIVETTE |
| 5 | BAROSSA | BAROSSA | BAROSSA | BAROSSA | BAROSSA | BAROSSA |
| 6 | ATR-BONITO | ATR-BONITO | ATR-BONITO | ATR-BONITO | ATR-BONITO | ATR-BONITO |
| 7 | HYOLA-600RR | HYOLA-600RR | HYOLA-600RR | HYOLA-600RR | HYOLA-600RR | HYOLA-600RR |
| 8 | HYOLA-725RT | HYOLA-725RT | HYOLA-725RT | HYOLA-725RT | HYOLA-725RT | HYOLA-725RT |
| 9 | CONTROL | CONTROL | CONTROL | CONTROL | CONTROL | CONTROL |

| Variety | | Allelopathic capability | Competitiveness |
|---|---|---|---|
| Av Opal | Superseded OP | ✓ | × |
| Av-Garnet | Superseded OP | × | ✓ |
| Barossa | Superseded OP | × | × |
| Rivette | TT | ✓ | ✓ |
| ATR Bonito | Current OPTT | ? | ✓ |
| ATR-409 | | × | × |

*Table 1. Variety inclusions at each of the experimental sites at Wagga Wagga and Temora and their categorisation on the basis of allelopathy and competitiveness*

## Results

The seasonal conditions of 2015 were difficult for experimental activities. There was variability in canola emergence which is a challenge with sowing small quantities of small seed. This however did not unduly effect experimental outcomes. The lack of weed germinations, despite annual ryegrass being sown in some trials, was a widespread phenomenon on south-eastern Australian trials this season. Our decision to sow on six sites to spread such risk paid off and we were able to continue with four of the six sites, two at Wagga (GC2 and GC3) and two at Temora (T4 and T6). The abandoned trial site at Wagga (DPI1) was used to grow Av-Opal seed for future experiments. At both Wagga and Temora there was a low weed site and a heavy weed site.

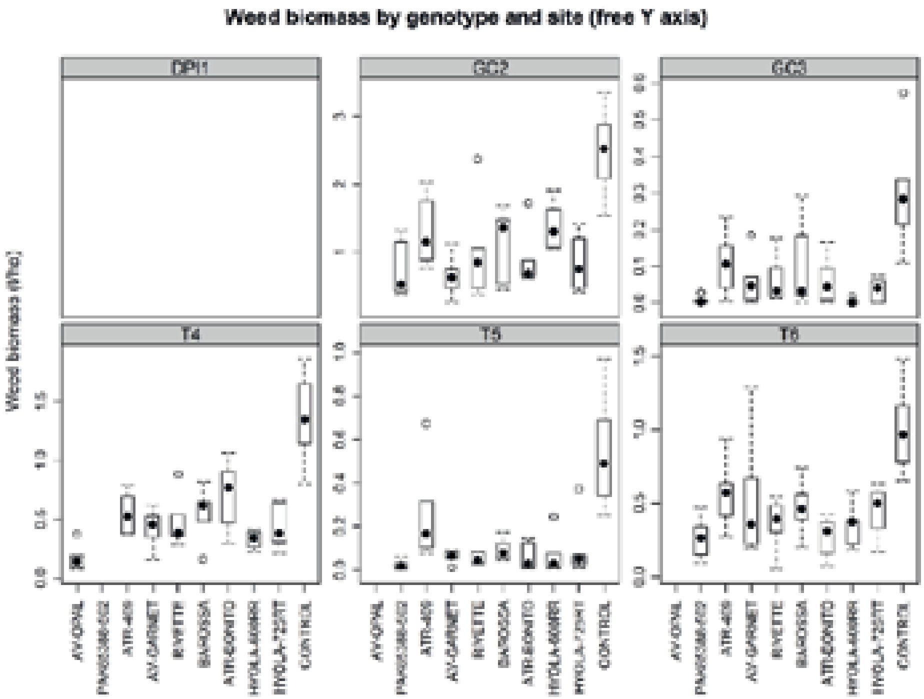


*Figure 1. Weed biomass (t/ha) using raw plot data. Crop free controls are at the right of each panel. Please note that the Y axes are on different scales.*

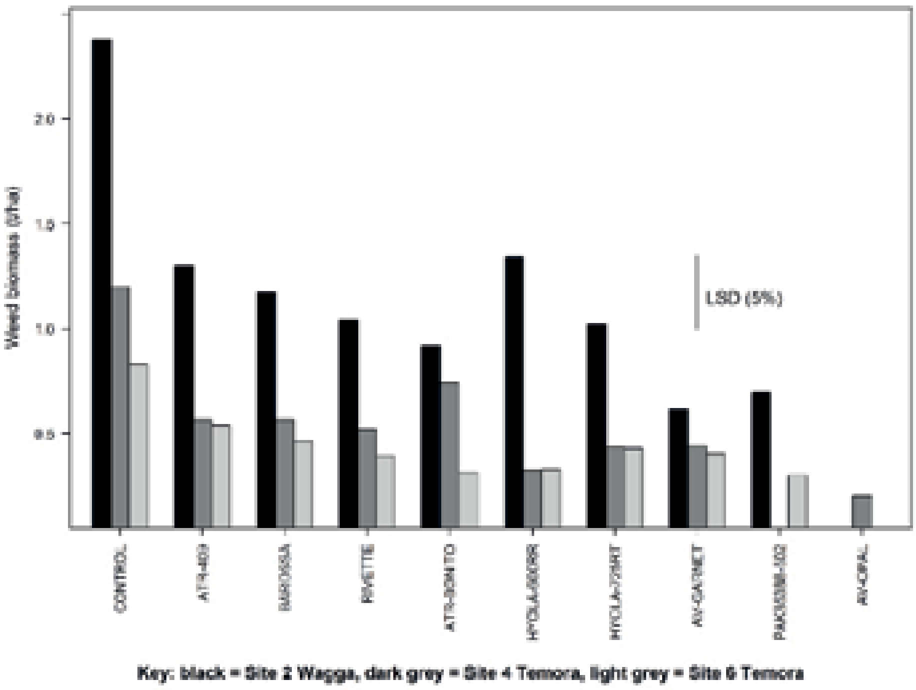


*Figure 1. Weed biomass (t/ha) using raw plot data. Crop free controls are at the right of each panel. Please note that the Y axes are on different scales.*

Figure 1 shows the weed biomass data against variety in September. All varieties reduced weed biomass relative to the crop-free controls as would be expected but the allelopathic varieties (Av-Opal, Pak85388-502) had reduced weed biomass burden at all sites relative to other varieties, in some cases near zero. Hyola varieties were generally at the lower end of weed biomass burdens except for Hyola 600RR in GC2 at Wagga Wagga.

Figure 2 dissects these data for individual sites including the crop free controls. This reveals the relative weediness of the sites.

## Conclusions

Despite a challenging season for weed studies, given the poor early germination of weeds, this research has provided confirmation of earlier studies showing the beneficial weed control capabilities of the allelopathic varieties Av-Opal and PAK85388-502. It also showed the poor impact of ATR-409 and Barossa. Other varieties were intermediate in response including the Pacific Seeds varieties Hyola-600RR and Hyola725RT.

The experiments re-enforce the need for the preservation of the older varieties like Av-Opal and PAK85388-502 (highly allelopathic) and Av-Garnett (highly competitive) so that these benefits can be incorporated into new cultivars. It also re-enforces the need for new varieties to be evaluated for their capabilities in the field without herbicides so that producers can broaden their armoury against herbicide resistance by choosing effective weed-inhibitive varieties

*Plate 1 The capability of AvOpal (left) to provide weed free conditions without herbicide in contrast to non-allelopathic variety (right)*

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FarmLink Research Report 2015

# FarmLink/St Anne's Agricultural Class

## Project Partners

## Trial Site Location
Temora Agricultural Innovation Centre

## Report Authors

Kylie Dunstan, Kellie Jones (FarmLink)

## Introduction

FarmLink partnered with St Anne's Central School Temora to offer a program of theory and practical hands-on lessons at Temora Agricultural Innovation Centre. FarmLink embraced the opportunity to link with potential farmers of the future and expose them to some of the research and other activities centred on improving the productivity and sustainability of farms in southern New South Wales. As a part of the school's Year 9 and 10 Agriculture elective, students visited TAIC throughout the school year and were taken through a variety of mixed farming operations including setting up and running a simple field experiment looking at the different surface application rates of nitrogen on the growth and productivity of wheat.

## Outline

FarmLink developed a comprehensive program in conjunction with St Anne's Central School ensuring subjects aligned with the curriculum requirements for the Year 9 and 10 Agricultural Elective.

| Learning areas throughout the course of the project | |
|---|---|
| **Soils 1** | Soil sampling & testing and farming practice |
| **Soils 2** | Impact of land use on soil structure and type |
| **Farm Safety 1** | Safe Machinery and Chemical usage on farm |
| **Soils 3** | Using soil test results to improve crop production |
| **Livestock 1** | Sheep identification and handling |
| **Crops 1** | Crop Identification – seeds, plants and end products |
| **Soils 4a** | Evaluation of impact of soil conditions on crop growth |
| **Crops 2** | Plant identification in the field |
| **Crops 3** | Identification of fertiliser, seed, and plants quiz |
| **Livestock 3** | Sheep husbandry II |
| **Livestock 4** | Sheep husbandry III |
| **Soils 4b** | Evaluation of impact of soil conditions on crop growth |

*Table 1. Course outline*

As well as learning different topics during their 13 visits to TAIC, the class also designed, executed and reported on their own simple field experiment, which was an ongoing trial spanning 2015 and culminated in students making presentations during FarmLink's Annual Open Day on September 11. This was an opportunity for students to share what they had learned during the year, as well as explaining the process of their simple field experiment.

Teaching the students in different aspects of the learning areas, were Tony Pratt of FarmLink Research, Murray Long of Clear View Consulting, Landmark Agronomist Andrew Lockley and St Anne's teacher Wendy Sutherland.

*Image 2. Andrew Lockley (Landmark) & Tony Pratt (FarmLink) demonstrating how to extract an intact soil core.*

## Impact of Various Nitrogen Application Rates

St Anne's Central School students conducted a field trial designed to determine the impact of nitrogen on crop growth and yield. This experiment was selected due to the importance of nitrogen management in broadacre crop production. The trial was designed to allow students to observe the impact of high, medium and low nitrogen levels on wheat when sown at Temora in May 2015. Students collected plant count, tiller number, final dry matter and grain production data.

### Treatment outline

Treatment 1: 0kg/ha of Urea.

Treatment 2: 50kg/ha of Urea.

Treatment 3: 150kg/ha of Urea.

Plot Area = 10x3m = 30m2

Convert to hectares = 30m2 / 10,000m2 = 0.0030 ha

Treatment 2 (50kg/ha) = 0.0030 x 50 = 0.150kg

= 150g

Treatment 3 (150kg/ha) = 0.0030 x150 = 0.450kg

= 450g

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | B | B | B | B | B | B | B |
| Rep3 | B | 2<br>301 | 1<br>302 | 1<br>303 | 1<br>304 | 2<br>305 | B |
| Rep 2 | B | 1<br>201 | 3<br>202 | 2<br>203 | 1<br>204 | 3<br>205 | B |
| Rep 1 | B | 3<br>101 | 2<br>102 | 3<br>103 | 2<br>104 | 3<br>105 | B |
| | B | B | B | B | B | B | B |
| | | Strip 1 | Strip 2 | Strip 3 | Strip 4 | Strip 5 | |

B = Buffer
1 = Treatment 1
2 = Treatment 2
3 = Treatment 3

*Table 2. Trial outline*

| Urea Rate | Establishment | Tiller Count | Dry Matter | Grain Avg |
|---|---|---|---|---|
| | Plants/m2 | tiller/ m2 | g/m2 | Grain/ head |
| 0 kg/ha | 58.3 | 348.7 | 708.4 | 53.2 |
| 50 kg/ha | 59.0 | 406.7 | 670.5 | 55.8 |
| 150 kg/ ha | 70.0 | 464.7 | 711.5 | 55.1 |

*Table 3. Average emergence rate, tiller counts, dry matter weights and grain numbers per head for each treatment.*

## Conclusions

From these results the students drew the conclusion that nitrogen can be used to improve plant growth and yield. However, there are boundaries and limitations, such as the timing of the nitrogen application and crop access to water and other nutrients.

The timing of the nitrogen application is crucial if you want to increase the yield and not just the biomass of the crop. The results in table 3 show the plots with 150kg/ha of urea applied to the surface prior to sowing had the highest plant counts, tiller counts and dry matter weight. But had a similar number of grains per head to the other two urea treatments of 0 and 50kg/t.

The average dry matter weights for treatment 1 (0kg/ha of urea) was higher than expected, relative to its tiller and plant emergence counts. There may have been an error that occurred during data collection that caused this. There were also visual differences that go against these results in table 3.

Applying nitrogen too early in the season may cause vigorous crop growth, draining the soil profile of moisture before the important flowering and grain filling stages. On top of this, the region experienced a short Spring, meaning there was little rainfall in September and October. In the future the class could think about adding an extra treatment of split application into their trial to observe the effects on the yield. If the soil profile seems to be fairly full and it's going to be a good spring, then the decision to top dress can be made.

Overall, the trial was successful in demonstrating to the students the effects of varying urea rates on plant growth throughout the season.

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FarmLink Research Report 2015

# Mirrool Creek Landcare Project 2015

GRDC Project code – CRF00002

## Project Partners

FarmLink, Mirrool Creek Landcare, Elders, Landmark, A.L. Chalmers & Son

## Funding Partners

Caring for our Country

## Trial Site Location

Mirrool Creek

## Report Authors

Kellie Jones and  Tony Pratt (FarmLink)

## Farm Host

Matthew & Sam Dart, Felix Farm. Michael & Renae Denyer, Bellevue.

## Introduction

Growers in the Ariah Park and Mirrool region of Southern New South Wales expressed an interest in developing knowledge and skills in improved soil moisture profile mangement to reduce yield loss and maximise profitability. In conjunction with the project partners three soil moisture probes and automatic rainfall gauges were installed at two sites. One on Felix Farm, North West of Ariah Park, and the other on Bellevue, South West of Ariah Park. The probes were installed twenty metres apart to allow a range of management options to be implemented over each probe. The probes were installed 18cm below the soil surface to allow normal machinery operations to occur without interuption. Each probe has six sensors at 28, 38, 58, 78, 98 and 118cm to measure the moisture levels at a range of depths. Temperature, daily rainfall, dew point, delta T and wind data was also recorded at both sites using weather stations.

The focus of the first site, Felix Farm, for 2015 was to evaluate the effect of different stubble treatments and varying nitrogen applications on soil moisture & yield over the growing season. The focus for the second site, Bellevue, was to compare nitrogen application rates & timings & view the impact it has on PAW use and rainfall infiltration between Lucerne/Clover pastures and wheat.

Moisture probes can be great decision making tool, as they can be used to track soil moisture use and remaining moisture levels at a range of depths throughout the growing season, allowing management decisions to be as informed as possible.

## Method - Felix Farm

The trial site was sown with 45Y84 canola on 22 April at 2.5kg/ha and with 50kg/ha of MAP (Impact treated) on 300mm row spacing's with a (Ultisow) disc seeder. A stubble burn treatment was implemented on 15 May and nitrogen treatments were pre-drilled on 20 April, two days prior to sowing. All three blocks were top dressed with 100kg/ha of urea on the 15th of June.

**Probe 1** canola sown into standing wheat stubble, Nitrogen rate of 50kg/ha of Urea pre-drilled (20/04/15) + additional 100kg/ha urea topdressed

**Probe 2** canola sown into burned wheat stubble, Nitrogen rate of 50kg/ha of Urea pre-drilled (20/04/15) + additional 100kg/ha urea topdressed

**Probe 3** canola sown into heavy standing wheat stubble load, Nitrogen rate of 200kg/ha of Urea pre-drilled (20/04/15) + additional 100kg/ha urea topdressed.

## Results - Felix Farm

| Probe number | 2015 Harvest Index | 2015 Estimated Hand Harvest Yield | SFU's 1st April 2015 | SFU's 31st October 2015 |
|---|---|---|---|---|
| 1 | 0.33 | 1.60 | 65.37 | 63.87 |
| 2 | 0.31 | 1.55 | 71.37 | 69.67 |
| 3 | 0.34 | 2.39 | 61.89 | - |

*Table 1. Yield and soil moisture data for Dart moisture probes, various stubble and urea treatments 2015. SFU = Soil fraction units*

The results in Table 1 show Probe 3 had the highest yield for 2015. Probe 3 had 150kg/ha more urea compared to probes 1 and 2. Whilst probe 1 and 2 yield is quite respectable at approximately 1.6t/ha given the shorter spring experienced in 2015, the extra 790kg's achieved by probe 3 highlighted a strong response to additional nitrogen. At $500/t for canola, the increased yield of 790kg/ha would bring in an extra $395/ha, there was a profit of $295/ha. NB: that doesn't include all fixed or variable costs.

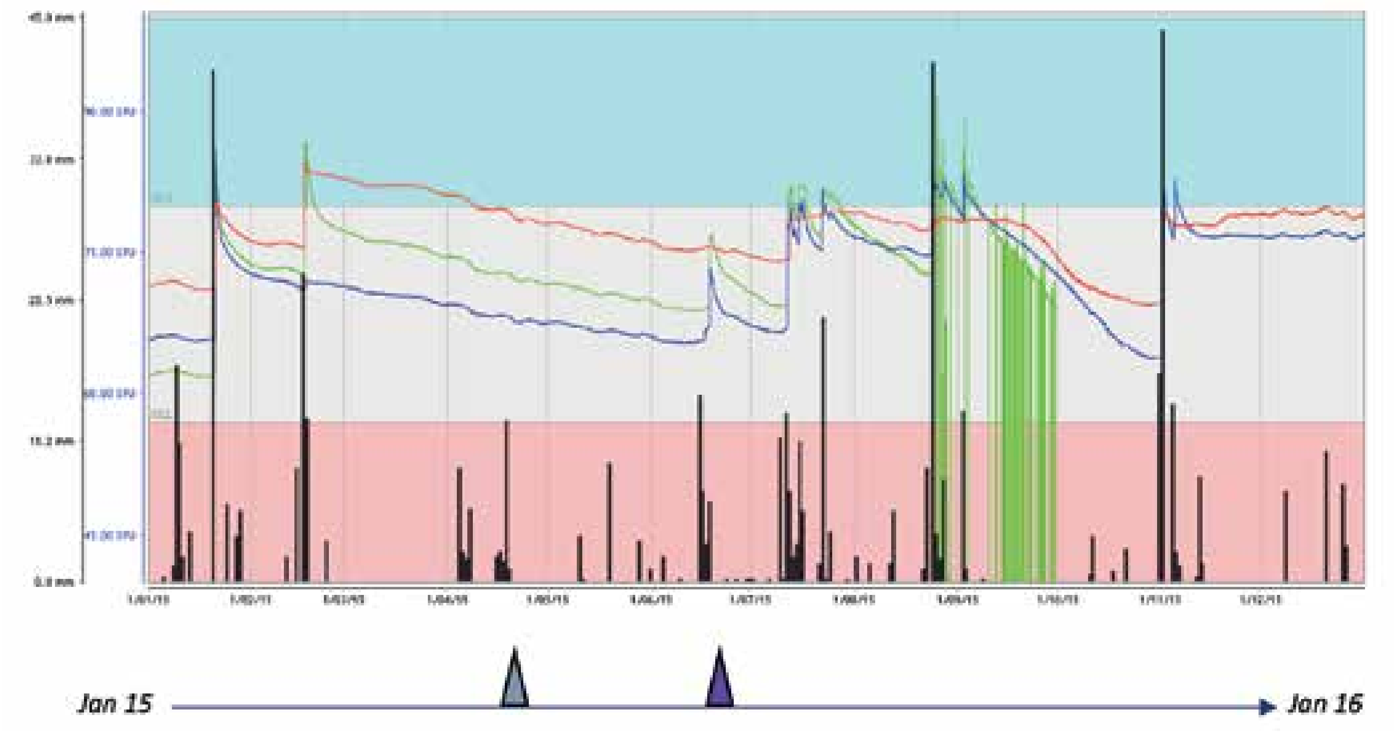


*Figure 1. PAW levels for 3 Dart probes January – December 2015. Blue = probe 1, Red = probe 2, Green = probe 3, black bars = rainfall (mm).*

Probe 3 began the season with the lowest PAW due to high moisture use and yield in 2014 from the preceding long fallow treatment in 2013. The moisture levels soon re-joined probes 1 and 2 (in the sum graph) after a major rain event in January. The three plots had an excellent start to the season with near perfect soil moisture conditions at sowing. From April 1st up until the day of sowing, the blocks received 38.8mm of rain. All probes show a steady decline in moisture levels from sowing onwards, indicating crop establishment and early growth. Despite the different nitrogen treatments and some differences in plant counts at each probe, all seem to be using moisture at an equivalent rate. Despite a lower plant count, probe 1 seems to be using up plenty of moisture.

Surprisingly during this period, probe 2, the burn treatment, has narrated high moisture levels. It might be expected that a bare cultivated surface would be prone to more evaporation than the other two treatments. It is also less influence by a rain event in mid -June which sees a small but sharp increase in probe 1 and 3.

A very wet winter sees all probes register DUL and field capacity, with probe 3 seeming to top out the graph readings. The site received 192mm of rainfall over winter, and a total of 530.4mm over 2015. Probe 3 has the highest stubble load out of all the treatments, this is aiding in increasing moisture infiltration as water movement over the plot is slowed giving more opportunity for it to enter the soil profile.

We can see during winter (early to mid-July) some small sharp falls in probe 3, indicating that the crop over that treatment has a well-developed root system and has started to access some of the 200kg/ha of nitrogen applied to that treatment. Consequently, from mid-August we see the green line dip below the blue and the red as the crop makes use of the moisture and nitrogen.

Rain events in late August and early September lift probe moisture levels back above DUL/field capacity. Probe 2 plateaus a little, indicating low moisture draw down. Probes 1 and 3 exhibit a moderate usage of soil moisture, especially probe 3 which now has a high biomass demand for moisture.

A short spring in 2015 saw little or no rainfall through September and October, but with well stocked profiles we see all treatments using up that stored moisture. Probe 3 unfortunately experienced some technical difficulties in late September and this has made for a dirty graph, but an underlying trend is still very evident and we can see this high nitrogen input treatment drawing down on the PAW moisture reserves. It ceases to function at the end of October, but the steepness of the graph indicates that moisture use is high and the yield achieved at that probe of 2.39t/ha would have used most if not all of the available moisture and converted it to yield.

By late October we can see that the two functioning probes have reached a CLL for the season, and these are similar to the preceding season.

Rain did eventually come at the start of November, but this was too late for any plant use and yield benefit. It did however quickly replenish the moisture levels back towards a DUL and they have remained relatively static into 2016.

| Probe number | Emergence | 2015 Estimated Hand Harvest Yield | SFU's 1st April 2015 | SFU's 31st October 2015 |
|---|---|---|---|---|
| 1 | 47 | 76.89 | 0.33 | 1.60 |
| 2 | 78 | 78.95 | 0.31 | 1.55 |
| 3 | 72 | - | 0.34 | 2.39 |

*Table 2. Treatment measurements for probes at Dart moisture probe site.*

The results in table 5 show that there was a large difference in canola emergence counts between the probe treatments. Probe 1 had the lowest count with 47 plants/m2, while probe 2 had the highest emergence count with 78 plants/ m2. Probe 3 followed probe 2 closely with 72 plant/ m2. Even though probe 2 had the highest emergence count, it still yielded approximately the same as probe 1 which had 31 less plants per square metre.

## Method - Bellevue

The focus for 2015 at this probe site was to compare nitrogen application rates and timings and view the impact it has on PAW use and rainfall infiltration between Lucerne/Clover pastures and wheat.

The probe site was sown with Stingray canola on the 20th of May at 3.5kg/ha with 60kg/ha MAP and 80kg/ha of Gran Am, with a knife point, press wheel seeder on 300mm spacing's. 100kg/ha of urea was applied on 31 July to probes 1 and 2 (Canola probes). The Lucerne/clover pasture crop is in its final year of pasture and will be sown to oats in 2016 in an attempt to open the ground up and will be sprayed out in the spring. It will be then put into a cropping rotation in 2017.

**Probe 0** Pasture, lucerne and clover.

**Probe 1** Stingray Canola, sown into roughly 2t/ha of standing barley stubble, targeted for 100kg urea topdressed to the area surrounding it.

**Probe 2** Stingray Canola, sown into roughly 2t/ha of standing barley stubble, targeted for a split application of urea added to the area surrounding it. How ever, only the first application was applied due to the paddock being too wet for the second application. Therefore, both probe 1 and 2 had the same treatments.

## Results - Bellevue

The probes at this site have experienced some data logging issues during the 3 years they have been collecting data and this affects the reliability of the data and interpretation of results. The probes have returned data but getting the 3 probes to conform to a common scale for interpretation has been an ongoing challenge. However individually it is still possible to track soil moisture levels and plot associated trends across the collection period despite this non standardized scale.

| Probe number | Yield | Emergence (Plants/m2) | SFU's 1st April 15 | SFU's 20th November 15 |
|---|---|---|---|---|
| 0 | Pasture | | 22.26 | 28.34 |
| 1 | 1.3t/ha | 44 | 30.33 | 35.80 |
| 2 | 1.3t/ha | 44.47 | 69.67 | 85.34 |

*Table 3. Yield and soil moisture data for Denyer moisture probe nitrogen treatments 2014. SFU = Soil fraction units*

# Discussion – Bellevue

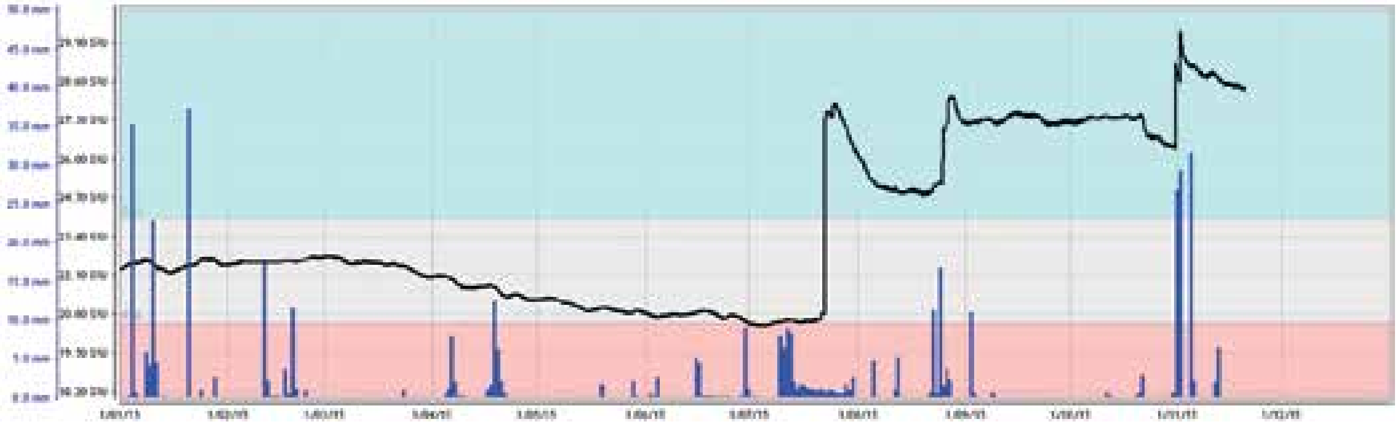

*Figure 2. Denyer probe 0, Paw levels sum graph. Lucerne and clover pasture, January-December 2015. Blue bars = rainfall (mm).*

Probe 0 at Denyer's gives us a good indication of the soil moisture variability and usage under a perennial dominated pasture over the three years of data logging. Large rainfall events are required to cause dramatic increases of moisture in the soil profile and fill it up towards its assumed DUL (light blue zone on graph). As we can see there was a major increase in moisture up to 27.58 SFU on 23 July, 2015. At first sight, this looks like an excessive amount to increase by with little rainfall. But the frequent small rainfall events received over a long period of time has allowed the water to infiltrate into the soil and not just wash away before having time to soak into the soil.

*Figure 3. Denyer probe 1, Paw levels sum graph. Canola crop, January-December 2015. Blue bars = rainfall (mm).*

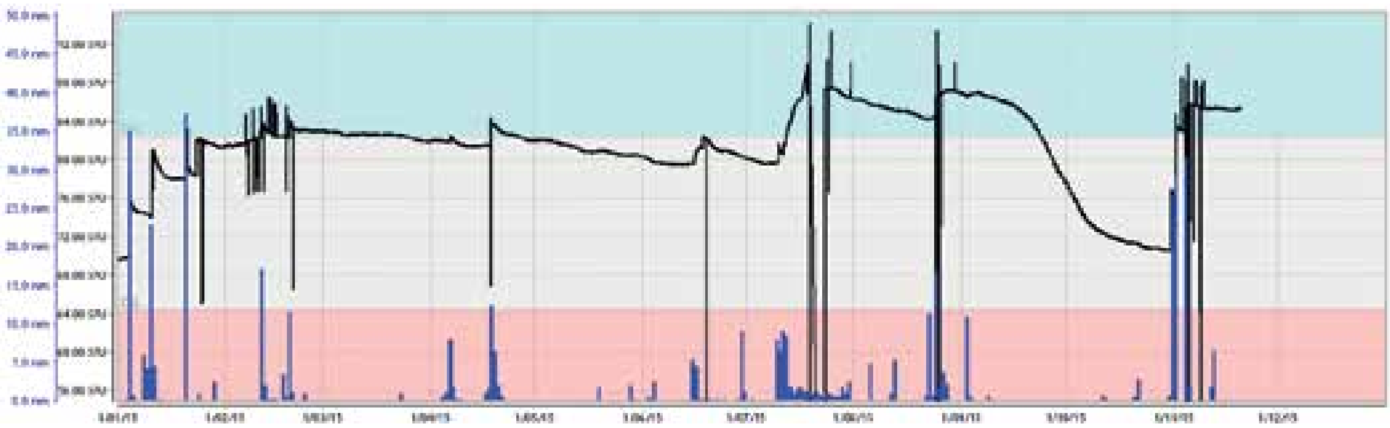

*Figure 4. Denyer probe 2, Paw levels sum graph. Canola crop, January-December 2015. Blue bars = rainfall (mm).*

While there have been issues with the three probes conforming to the same scale, probe 1 and 2 exhibit similar behaviour throughout the season. Both probes received the same urea treatments of 100kg/ha top-dressed, probe 2 never received the second top-dress application scheduled for later on in the season due to access to the paddock. Unfortunately, all three probes cut out on November 20, but most of the season's moisture data was captured.

# Conclusion

**Dart**

Many factors could have contributed to the extra yield that probe 3 produced, the main factor was the high nitrogen rate of 200kg/ha pre-drilled prior to sowing. The high nitrogen ensured good root establishment in the early stages of growth, allowing the roots to access moisture located deeper in the soil profile. However, this means more moisture was utilized and removed from the soil during the season compared to the other two probes, this is the trade-off between soil moisture and yield. Another factor contributing to the high yield is the high stubble load over probe 3, the stubble slowed down the movement/run off of water increasing water infiltration into the soil.

Unfortunately, probe 3 went offline in late September. Despite these problems, we can see the trend continued to decline before it completely cut off. The last reading was 69.93 SFU, while the readings at the point in time for probe 1 was 73.31 SFU and 75.46 SFU for probe 2. From this we can gather that there was less plant available water left in the soil under the high urea treatment (probe 3). There is a chance that the moisture levels dropped below the CCL, but how far the moisture declined is unknown.

It was expected that probe 2 would have a lower moisture levels due to increased evaporation from the bare soil and high plant establishment counts, however this was not the case. Probe 2 had the highest moisture levels throughout most of the season. The probe had the lowest yield, once again demonstrating the trade-off between yield and moisture use.

The moisture probe network has been a great tool to teach growers in the region how to read moisture graphs and use this data to make informed management decisions. Growers can see how various urea application rates and stubble cover effects soil moisture throughout the season. The effects on the starting moisture for the next season is also demonstrated.

**Denyer**

The aim of the project at the Denyer's site was to compare moisture infiltration in pasture and cropping paddocks and the effect of varying nitrogen applications on moisture usage and yield. These probes have given growers in the region the opportunity to learn about water infiltration in various crop types. There was no difference in the urea application rates over probe 1 and 2 to compare.

Although the graphs could not be compared directly to each other due to scaling problems, individually these graphs are still useful. From this data we can see the moisture supply and demand is clearly dissimilar for the crop types. The PAW is held under constant pressure to the demands of the deep tap rooted Lucerne species, whereas the moisture demand in the canola crop fluctuates throughout the season.

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FarmLink Research Report 2015

# Harvest weed seed control in the Southern region (paddock scale experiment)

Project code – 2015.03.06D

## Project Partners

## Funding Partners

## Report Authors

Paul Breust (Southern Farming Systems), Tony Pratt, Kellie Jones (FarmLink)

## Introduction

**Research Question - Can harvest weed seed practices be adopted to reduce soil weed seed banks in high yielding HRZ areas of the southern region to address herbicide resistance issues?**

A project is currently underway to look at a range of different harvest weed seed capture and pre sowing stubble management practices.  Capturing weed seed at harvest is becoming an increasing valuable tool in the fight against weed management and weed resistance management. Growers have been capturing and burning weed seed in windrows via custom made chaff chutes in canola and lupins for a few years now, but new research is aimed at looking for viable weed seed reduction options for cereal crops as well. SFS (Southern Farming Systems lead agency), AHRI (Australian Herbicide Resistance Initiative) along with FarmLink, Riverina Plains and MacKillop Farm Management Group have been tasked with implementing innovative trials aimed at delivering key herbicide resistance management messages to growers, agronomists and consultants to facilitate adoption of weed management tools and encourage crop sustainability.

### Trial Design

The projects trial design utilizes small plot and farm scale trials. The small plot trials will be three-way factorial randomized block design to give rigorous scientific data on weed seed collection rates for a range of crop phenology and harvest heights.

The on farm trials will be paddock long strips one header width wide for each treatment. The design will utilize modern precision agriculture (PA) techniques such as yield monitor data, NDVI imagery and photo examination for data collection to provide statistical data for analysis. PA analysis will be done on data generated from the treatment strips. Trials will be established, where possible, in paddocks with historical yield and soil information to further enhance the analysis.

FarmLink is conducting one of the on farm trials which was initiated prior to harvest in 2015. The trial site is located on Mark Bryant's property at Greenethorpe in NSW. There are 3 treatments x 4 reps which are in place at the trial site. They are as follows

1. Blanket burn harvested as high as possible.
2. Weed seed mill harvested at 15cm high.
3. Windrow burn harvested at 15cm high.

*Image 1. Treatment 3 Windrow burn harvested at 15cm high.*

*Image 2. Treatment 2 Weed seed mill harvested at 15cm high.*

## Methods

A thorough and detailed assessment schedule will be performed at the on farm trial sites which has been summarized in Table 1 below. Sampling of soil weed seed banks, weed counts and herbicide resistance sampling will be undertaken using established methodologies and again analysed to provide statistical rigor. Establishing initial base line weed seed densities, historical yield variability and mapping weed density variations within treatments will be critical to reliable data analysis.

| Assessments | Timing | units | Method |
|---|---|---|---|
| Trial planning | pre harvest 2015 | | |
| Weed seed bank | pre harvest 2015 | weed seeds/m2 | 40mm diameter x 5cm deep soil cores |
| Weed type, numbers & maturity | Just prior to harvest 2015 | weed seeds/m2 | Plants/m2 x weed seeds/plant |
| Harvest efficiency / heights | At harvest 2015 | kg/hr, km/hr, L/ha, t/ha | Yield monitor data |
| Weed seeds | Post harvest 2015 | weed seeds/m2 | Plants/m2 x weed seeds/plant |
| Weed seed bank | Pre sowing 2016 | weed seeds/m2 | 40mm diameter x 5cm soil cores |
| Windrow burning + blanket burn | Pre sowing 2016 | | Timing determined by seasonal conditions, farmer's management schedule |
| Weed establishment | Post emergence 2016 | weeds/m2 | 25cm x 25cm quad |

*Table 1: Assessment schedule for 2015 replicated on farm trials.*

## Weed seed bank methodology

Soil weed seed banks act as a repository from which weeds emerge to infest crops. Determining initial soil weed seed numbers will provide data on potential weed germinations from the soil in subsequent years. Seed dormancy can be overcome by extending the period of assessing germinations or implementing a cold temperature treatment that will satisfy species dependent germination requirements. For example, annual rye grass.

*Image 3 (above). Ryegrass seed bank germination tray.*

*Image 4 (right). Pre harvest Weed type, numbers & maturity assessment site.*

*Image 5. Post-harvest weed seed assessment site.*

As an added demonstration for the Harvest weed seed trial site FarmLink were fortunate to engage the services of Jamie Wright owner of Springfield Chaff Carts (www.springfieldgrenfell.com.au) to put in two demo runs alongside the trial. Chaff carts are an alternative method of weed seed capture which are popular in WA and becoming more popular in eastern states.


*Image 6 & 7. Springfield Chaff Cart.*

## Results

Results are currently being compiled and analysed and presented to project leaders for scrutiny and will be available for release prior to planned field day and paddock inspections pre sowing.

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FarmLink Research Report 2015

# Weed management in disc systems (paddock scale experiment)

Project code – GRDC CSP-00174

## Project Partners

FarmLink change • adapt • prosper

CSIRO

## Funding Partners

GRDC Grains Research & Development Corporation

## Trial Site Location

Ariah Park

## Report Authors

Tony Pratt, Kellie Jones (FarmLink), Tony Swan, James Hunt (CSIRO Agriculture)

## Introduction

Local growers in the Farmlink region have found that the addition of rotary harrows may improve pre-emergent herbicide efficacy of some disc seeding systems. There is also anecdotal evidence of stubble born disease, eg. black leg reduction from the use of rotary harrows. This could result in a cost-effective solution which allows full stubble retention but maintains efficacy of pre-emergent herbicides. However, rotary harrows may negate some of the perceived benefits of disc seeders i.e. zero soil disturbance with weed seeds kept on soil surface.

The aim of this experiment was to examine the effect of rotary harrows on crop establishment and herbicide efficacy in a retained stubble system using a disc seeder.

# Method

The experiment was located on Matt and Sam Dart's property at Ariah Park. The Dart's farm on a 9m controlled traffic no-till stubble retention system, using a Serafin Ultisow single disc seeder with 300m row spacing.

This farm scale experiment incorporates the sowing/harvesting swathes as 'plots' with each 8.9m wide by 200m long. Two stubble management systems were implemented in a randomized block design with 4 replicates. Treatments were;

1. Commercial disc seeder (Serafin Ultisow) with rotary harrows (K-Line) with best practice pre-emergent herbicide applications
2. Commercial disc seeder without rotary harrows with best practice pre-emergent herbicide applications

*Figure 1. Comparison of '+' (left) and '-' (right) rotary harrows in weed management in disc systems paddock scale experiment*

There were 2 phases to the experiment with phase 1 (2014), examining canola being established into a wheat stubble and in phase 2 (2015) examining wheat sown into a canola stubble.

Phase 1 (2014): A plus and minus (+/-) rotary harrow treatment were applied to a retained wheat stubble (approximately 5t/ha stubble) which had no post harvest stubble management from the previous cropping season. Two distinct zones of 2013 stubble residue were apparent with a large volume of this residue (chaff + straw) confined to a zone around and between the wheel tracks of the harvester and the balance spread outside this area. The level of disturbance and incorporation of the '+' rotary harrow treatment in comparison to ' – ' rotary harrow are illustrated in Figures 1-3.

*Figure 2. - Rotary harrows, high trash zone right of picture, low trash zone to the left*

*Figure 3. + Rotary harrow, high trash zone centre of picture, low trash zone either side*

The paddock was inter-row sown on the 17 April 2014 to a Clearfield hybrid canola cv. 45Y86 @ 2.5kg/ha (Jockey and Gaucho) with 50kg/ha MAP (Impact) following knockdown of Glyphosate @ 1L/ha and pre-emergent herbicides of propyzamide @ 1L/ha and Lorsban @ 0.5L/ha. Post emergent herbicides applied on the 19th June 2014 were Intervix @ 0.6L/ha, Select @ 0.5L/ha and Lontrel 750 @ 60gr/ha with Hasten @ 0.5%. The sowing equipment is illustrated in figure 4.

*Figure 4. Dart's Serafin disc seeder and trailing rotary harrows (not photographed in trial paddock)*

Crop emergence and crop vigor (NDVI scanning) were measured during the growing season with weed assessments measured pre sowing, 1 month after sowing and pre harvest. As there were two distinct stubble residue zones (high and low), plant and weed assessments were carried out in both zones. Grain yield was measured by machine header harvest following windrowing each treatment according to treatment readiness. The grain yield was measured by the header yield monitor and each 200m strip was weighed in a mobile weigh bin fitted with load cells.

## Results & discussion

In 2013, the farmer had identified the paddock to have an increasing number of ryegrass plants. An initial weed assessment on the 14th April 2014 found only 4 plants/m2 of broadleaf weeds (milk thistle, prickly lettuce, marshmallow, capeweed, clover), 2.9 plants/m2 of annual ryegrass but a high volunteer cereal population (59.1 plants/m2), in the high stubble residue zone (chaff rows from the previous harvest).

There was no significant effect of rotary harrow on canola emergence but a significant reduction in plant numbers in the high stubble residue zones (Table 1).

| | **Canola plant count (plants/m2)** | |
|---|---|---|
| Treatment | Low trash zone | High trash zone |
| + rotary harrows | 28.1 | 17.7 |
| - rotary harrows | 25.9 | 17.2 |

*Table 1: Canola emergence in +/ – rotary harrow treatments within high and low stubble residue zones.*

Early weed assessment (May 2014) found a 50% increase in emergence of volunteer cereals where no rotary harrows were used (Table 2), however, there was no significant difference in either ryegrass or broadleaf emergence with all populations being less than 2 plants/m2 (data not shown).

| **Treatment** | **Volunteer cereal/m2** |
|---|---|
| Harrows<br>No harrows | 5.4<br>10.5 |
| P value<br>lsd (P<0.05) | 0.005<br>2.503 |

*Table 2: Volunteer cereal counts for +/- rotary harrow treatments*

By October 2014, there was a significant interaction between the use of the rotary harrows and the amount of trash present in header rows from the preceding season. There was no significant difference in volunteer cereal plant numbers where trash levels are low, however there significantly more cereal plants behind the header (ie. high trash zone) and more again where no harrows are engaged (Table 3). There was a trend for higher ryegrass plant numbers where no harrows were used (P = 0.08) and in the high stubble zones (P=0.064) but there was no significant interaction (data not shown).

| | Canola plant count (plants/m2) | | | |
|---|---|---|---|---|
| Treatment | High Volunteer cereal (plants/m2) | Low Volunteer cereal (plants/m2) | High Ryegrass (plants/m2) | Low Ryegrass (plants/m2) |
| Harrows | 6.9 | 0.6 | 1.9 | 1.3 |
| No harrows | 13.8 | 0.0 | 6.3 | 0.0 |
| P value | 0.032 | | 0.114 | |
| lsd (P<0.05) | 4.306 | | NS | |

*Table 3: Weed counts for +/– harrow treatments and in high and low trash zones.*

There was no significant differences in canola grain yield (average = 1.08 t/ha) between the two stubble management systems.

## Phase 2 - 2015

An adjacent paddock was selected that had been sown to canola in 2014. Wheat was sown using the Serafin Ultisow single disc seeder with and without the K-Line rotary harrow on the 18th May 2015. A knockdown herbicide of Glyphosate and pre-emergent herbicide were sprayed before sowing.

The weed control in the canola phase of the rotation was very effective and the residual canola stubble that the wheat was sown into was evenly distributed.

**Results**

There was no significant difference in wheat emergence (average 70 plants/m2) between the two stubble management systems and there was no difference in weed numbers as entire trial had very few weeds. The combination of the weed control in the canola phase plus the pre emergent herbicides used in 2015 were very effective at keeping weed numbers to a minimum.

*Figure 5. 2015 crop residue, - harrows (left) and + harrows (right). Taken 27/07/2015.*

Estimated Dry Matter (DM) measurements from NDVI scans performed in late July resulted in no significant differences between treatments, again due to the even emergence and establishment of the crop in the relative absence of stubble (Table 4). There was also no significant difference in wheat grain yield at harvest between the +/- rotary harrow treatments (Table 5).

| Estimated DM (t/ha) from NDVI<br>Date: 27.7.15 | |
|---|---|
| | DM (t/ha) |
| Not Harrowed | 0.056 |
| Harrowed | 0.043 |
| P value | 0.111 |
| lsd (P=0.05) | ns |

*Table 4: Estimated dry matter (t/ha) using NDVI measurement for +/- rotary harrow*

| Header Harvest<br>Date: 4.12.15 | |
|---|---|
| | Avg Yield (t/ha) |
| Not Harrowed | 4.08 |
| Harrowed | 4.26 |
| P value | 0.26 |
| lsd (P=0.05) | NS (0.509) |

*Table 5: Wheat grain yield from header harvest for +/- rotary harrows in 2015*

## Conclusions

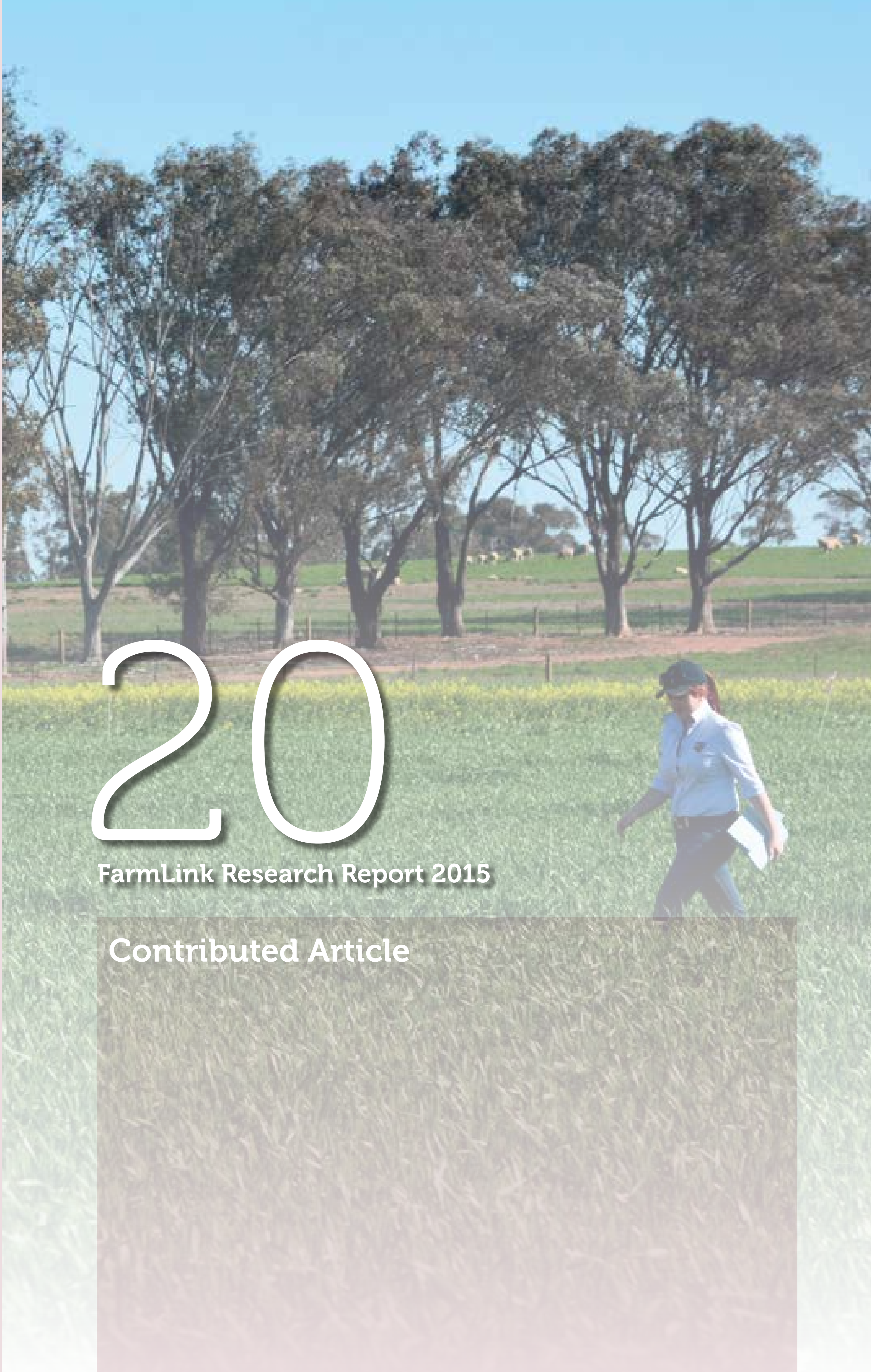
The addition of rotary harrows may have improved the pre-emergent herbicide efficacy at this site particularly by spreading the wheat stubble residue more evenly on the soil surface and in doing so more evenly spreading the pre emergent herbicide. Overall, there were low ryegrass plant numbers in any treatments, but there were fewer plants in the zones of high residual stubble and where rotary harrows had been used in canola in 2014. The main weed in the canola crop was volunteer wheat in high residual stubble zones, especially where rotary harrows were engaged, but this weed should have been removed by the grass herbicides sprayed in mid June 2014.

There was no improvement in crop establishment or increase in grain yield in either the canola or wheat crops when rotary harrows were used. The trade-off for using the harrows then comes down to the perceived benefits in increased weed control. What needs to be factored into the equation is that towing the harrows behind the sowing rig will use more fuel and require a higher horse power requirement and this will increase variable costs reducing net incomes.

One option to overcome some of the issues highlighted by this trial might be to spread the residue more effectively across the harvest width if this option or harvester setting is possible especially when harvesting cereal crops and if the rotary harrows are to be used at seeding.

## Acknowledgements

Thanks to Matt Dart for his assistance in setting up trial areas at sowing and for access to the header and yield data at harvest each year as well as providing paddock history information



# 20

FarmLink Research Report 2015

## Contributed Article

**Faba beans and acid soils – making it work with lime and forward planning.**

Growers have achieved high yields from faba beans, these are achievable if crops are effectively nodulated and root growth is not affected by subsurface constraints acidity. The 2015 observations have highlighted the impact of acid soils on growth and yield potential of faba beans.

**Key messages:**

- Faba bean and its specific Group F rhizobia are sensitive to $pH_{Ca}$ below about 5.0
- Faba bean rooting depth is limited by acid layers in the soil profile
- Unincorporated, surface-applied lime increases pH of the soil surface, but has limited effect on subsurface pH in the short to medium term
- Lime incorporation to 10cm is necessary to rapidly increase subsurface pH
- Check for pH stratification before using Group B SU herbicides – elevated surface pH slows the breakdown of herbicide residue and may extend re-cropping intervals for legume species on acid soils to 22 months – check herbicide labels

**Soil acidity and nodulation**

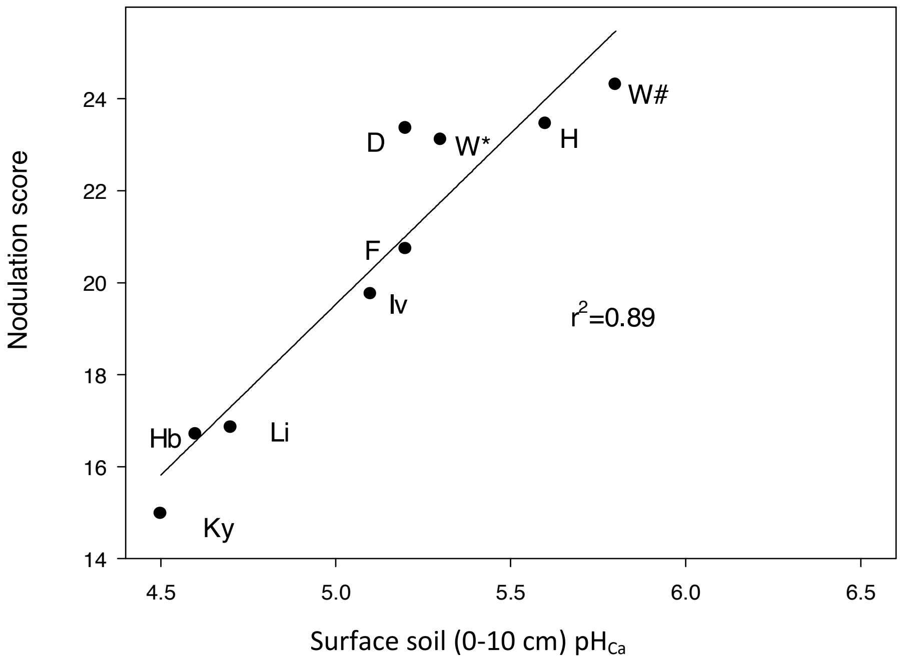
Faba bean crops sown by farmers on acid soils in SA, Victoria and NSW were monitored in 2015 as part of a joint NSW DPI/Grains Research and Development Corporation project aimed at improving the performance of legumes in the Southern Region high rainfall zone. Results from winter / spring crop inspections highlight the importance of liming and improving soil pH in the main root zone, particularly in the top 15cm.

The impact of acid soils on faba bean growth was similar across a range of soil types, from the loams of the Billabong Creek flats in NSW to the sandy loams of SA and south west VIC. The monitor crops fell into two clear categories: (i) vigorous, well-nodulated crops; and (ii) extremely variable crops, showing symptoms of nitrogen deficiency.

All crops were scored for nodulation in late winter / early spring and when these were checked against topsoil pH (0-10 cm) the connection between pH, nodulation and crop vigour was clear (Figure 1). In all cases soil tests for the crops with poor nodulation and vigour had a soil pH in calcium chloride ($pH_{Ca}$) below the recommended 5.2 for faba bean (Pulse Australia, 2015).

Analysis of the nodulation scores for faba bean crops and pH of 0–10 cm soil samples from the monitor paddocks showed a strong correlation ($r^2$=0.89) between soil acidity and nodulation scores (0 = nil nodules present, to a maximum of 25 = all plants with effective nodules). This indicates that nodulation is affected by soil pH.

**Figure 1.** The effect of topsoil pH (0-10cm) on nodulation of faba bean across the south eastern Australian high rainfall zone in 2015. Sites of sampling include Kybybolite, S.A. (Ky), Holbrook, NSW (Hb), Lismore, Vic (Li), Inverleigh, Vic (Iv), Frances, SA (F), Darlington, Vic (D), Willaura, Vic (W) and Henty, NSW (H). W* = after wheat, W# = after canola.




Representative plants from the monitor paddocks, and several others with reported variable nodulation, were dug up to also check for root growth. As can be seen from the photographs of plants from Wickliffe, Vic (Figure 2) and the Holbrook, NSW site (Figure 3), they were poorly nodulated and root growth was concentrated in the topsoil. The pH of the topsoil was tested at 5cm intervals and the results showed that at a sowing depth of about 4-5 cm faba bean seed and rhizobia were placed in an acid soil layer. This is likely to affected rhizobia survival, root growth and therefore nodulation. The effect of soil acidity on survival of faba bean Group F rhizobia is critical to the yield potential of faba bean. These rhizobia are sensitive to $pH_{Ca}$ below 5.0 – the optimal $pH_{Ca}$ is above 6.0.

**Figure 2.** Fully podded faba bean plants at Wickliffe, VIC sampled in late October were poorly nodulated and the roots did not grow below 10 cm. Lime was applied in 2013 and not incorporated.

**Figure 3.** Faba bean roots of plants at early flowering at the Holbrook, NSW site in early September, were poorly nodulated with root growth restricted by the acid subsoil (4.2 $pH_{Ca}$ at 10 cm), despite a history of 4t/ha of lime since 2009 (shallow incorporation with speed tiller).

The vigorous, well-nodulated faba bean monitor crops were growing in paddocks with a history of liming and / or effective incorporation. The benefit of lime incorporation on root growth is evident in the Figure 4 which shows a Wickliffe crop from a paddock where lime had been incorporated in 2012 to a depth of 10 cm in order to control slugs. This contrasted with poorly nodulated, variable crops with either no lime or recent applications of lime, which either had no incorporated (Figure 2) or shallow incorporation with a speed tiller (Figure 3).

**Figure 4.** Fully podded faba bean plants from the paddock next to the crop in Figure 2. Lime had been applied in 2012 and incorporated to a depth of 10 cm. The crop was even, well-nodulated and the roots extended beyond 30 cm, into the moist subsoil.

**Stratification of pH**

Standard soil testing procedures that use a bulked 0-10 cm soil sample may be misleading as unincorporated surface-applied lime moves very slowly into the subsurface layers. The pH stratification shown at the Wickliffe and Holbrook sites (Table 2) is to be expected if lime is not incorporated to the recommended 10 cm. Unless it is incorporated the lime is concentrated in the soil surface and while it has elevated the surface pH, there is limited effect on the subsurface pH.

Most growers have a minimum tillage farming program and rarely incorporate lime. If incorporation is not an option it is essential that lime is applied well before sowing sensitive species such as faba bean. The time for lime to impact on the subsurface layers will depend on soil type and rainfall. Growers should check for pH stratification before sowing sensitive crops such as faba bean.

**Table 1.** The $pH_{Ca}$ of soil samples taken from commercial monitor paddocks show that surface-applied lime with limited incorporation has had limited effect on increasing subsurface pH compared with incorporation to 10 cm.

| Depth (cm) | Wickliffe, Victoria | | | Holbrook, NSW# |
|---|---|---|---|---|
| | Lime not incorporated* | | Lime incorporated to 10cm** | $pH_{Ca}$ – representative of paddock |
| | Area of poor crop growth | Area of good crop growth | | |
| 0 – 2 | 5.3 | 7.3 | 6.8 | 6.5 |
| 5 – 7 | 3.8 | 4.8 | 5.3 | 4.9 |
| 12 – 14 | 3.8 | 4.3 | 4.8 | 4.3 |

*Lime surface-applied at 2.5t/ha in 2006 and 2013, not incorporated.
** Lime surface applied at 2.5t/ha in 2006 and 2012, not incorporated in 2006, incorporated to 10 cm in 2012.
# Lime surface-applied at 2t/ha in 2010, and 2t/ha in 2015 - shallow incorporation with a speed tiller.

### Impact of soil pH on herbicide breakdown

Be aware that surface-applied lime will also affect the breakdown of Group B sulfonyl urea (SU) residual herbicides. As shown in Table 1, liming may result in an alkaline surface layer, which, according to herbicide labels extends the re-cropping interval for legume species. For example the re-cropping interval for sulfonyl urea extends to 22 months when $pH_{Ca}$ is above 5.8. Check re-cropping intervals on herbicide labels!

Reference:
Pulse Australia, 2015 Southern Faba & Broad bean – Best Management Practices Training Course Manual

Acknowledgements:
Cooperating farmers in NSW, Victoria, South Australia and Tasmania

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