GRDC Grains Research Update Jondaryan

Tuesday 4th August 2015, The Woolshed

Registration: 8:30am for a 9am start, finish 3:20 pm

Agenda

Time	Topic	Speaker (s)
9:00 AM	Welcome	GRDC
9:10 AM	Farming systems performance: A major new farming systems project on the constraints to performance and efficiency. What's planned, where and how to engage.	Lindsay Bell, CSIRO
9:25 AM	Summer pulse agronomy: plant population, row spacing, varieties and nitrogen fixation.	Kerry McKenzie, DAF Qld
9:55 AM	Tweaking sorghum agronomy for high yield targets	Trevor Philp, Pacific Seeds
10:20 AM	Disease management in summer crops to minimise loss: charcoal rot in sorghum, halo blight and powdery mildew in mungbeans and sunflower diseases.	Jo White, USQ
10:45 AM	Morning tea	
11:15 AM	Emerging insect threats - We see 'new' pests every season. What are they, where are they and what action is needed?	Melina Miles and Hugh Brier, DAF Qld
11:45 AM	Alternate end uses for sorghum.	Ross Naidoo, DAF Qld
12:15 PM	Weeds issues and action items: Group A's; sowthistle resistance and management; residual herbicides and their role in feathertop Rhodes management.	Michael Widderick, DAF Qld
12:50 PM	Lunch	
1:50 PM	Grower experience of deep phosphorus applications in Downs farming systems.	Bede O'Mara, IPF & John Cameron 'Kintyre'
2:25 PM	Managing barley and wheat diseases - priority issues and actions for 2015.	Greg Platz & Ryan Fowler, DAF Qld
3:00 PM	Mouse management; lessons from 2014/15 and preparing for a possible mice plague.	Julianne Farrell
3:20 PM	Close	

Contents

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Northern farming systems performance: can it be improved?

Lindsay Bell[1], David Lawrence[2], Kaara Klepper[2], Jayne Gentry[2], Andrew Verrell[3], Guy McMullen[3]

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Key words

Crop rotation, sequence, efficiency, system, economics

GRDC codes

CSA00050, DAQ00192

Take home message

GRDC is investing in research aimed at understanding how the performance of current farming systems can be improved.

Systems with different crop intensity (or frequency), crop sequences, system inputs and practices aimed at maintaining long-term soil resources are being compared experimentally.

System modifications and their interactions of these various modifications are being examined at a core experiment site on the Eastern Darling downs, and 6 regional sites across the northern region are examining locally relevant system modifications.

Experimental data and modelling are being used to assess changes and effects of the different farming systems on several attributes (e.g. water use efficiency, nutrient use efficiency, soil resource, pathogen and weed populations).

Rationale

Recent analysis suggests that there is potential to increase the efficiency of current farming systems. An analysis of surveyed crop sequences found that only 29% were achieving 80% of their potential water use efficiency. Similarly farming systems are facing emerging challenges of increasing herbicide resistance, declining soil fertility and increasing soil-borne pathogens all which require responses in farming systems in order to maintain system productivity.

The northern farming systems initiative aims to address these emerging challenges by investigating the question: Can systems performance be improved by modifying our farming systems?

The research aims to deliver information on the following issues:

- Key issues or areas where current systems are underperforming
- Benchmarks for, and gaps between, current and potential system water use efficiency (not just crop water-use-efficiency)
- What changes in farming systems enable further increases in system efficiency
- Benefits and costs of crop choices on various aspects of farming systems (water, nutrients, weeds, pests)
- Identify any possible future issues that are likely to arise in response to changes in farming systems

Experimental plans

The northern farming systems initiative will implement a co-ordinated experimental program to examine a range of modifications to farming systems and quantify their relative impact on a range of measures of system performance. These modifications have been chosen following consultations with growers, advisors and other researchers across the northern region and are targeted to address apparent current and emerging challenges to farming systems. The range of systems have been chosen to capture the range of possible cropping systems operating in the northern region.

The combined experimental program will consist of 1 core site located at Pampas on the Eastern Darling Downs and 6 regional sites located at Emerald Agricultural College (Central Queensland), Billa Billa (Western Downs/Border Rivers), Mungundi (Western NSW and Qld), Plant Breeding Institute, Narrabri (Northern NSW), Nowley Research Station, Spring Ridge (Liverpool Plains), and Trangie Research Station (Central West NSW).

The core site will compare 34 farming systems (see Table 1). These include 8 summer crop dominated systems, 8 winter crop dominated systems, 14 mixed summer-winter crop systems and 4 systems involving ley pastures. The cropping systems (not ley pasture systems) involve factorial combinations involving different crop intensity (i.e. the number of crops sown/yr), crop sequences (including the range of crops grown) and nutrient supply/balance. Each of these systems are based on differences in key decision points or rules which aim to bring about these distinct changes in the farming systems. The systems tested at the core site are common with systems being tested in the regional experimental sites.

At each regional site a ‘benchmark’ system, based on current decision rules used in the district, will be compared with a common set of 4 individual system modifications (i.e. higher crop intensity, higher crop diversity, high nutrient supply and high legume frequency) (see Table 2). Additional regionally relevant modifications to systems may also be included based on local demand for these treatments. Table 2 summarises the common set and different modifications to be tested at each region and the equivalent system in the core site.

Key metrics of systems performance

Over the life of the project each experimental farming system will be compared in terms of several attributes:

- Total grain production and quality
- Economics (inputs and returns)
- Efficiency of use of water and nutrients,
- Changes in soil nutrient stocks and soil health indicators
- Dynamics and populations of soil pathogens and weed populations

Together this information will be used to assess the relative performance of the farming systems against several metrics. This will help us understand the strengths, weaknesses and identify any future risks associated with particular system modifications.

Systems modelling and analysis

A combination of several modelling approaches will be used in the project to examine the performance of current farming systems across the northern region. These models will provide predictions of the likely effects of the various systems modifications over the time and extrapolate experimental information to compare system performance under a range of climatic conditions and predict the implications at other locations and/or other combinations of systems (e.g. different sequences of crops) across the northern region. In particular, the simulation modelling will enable climate and price risk factors to be analysed for each of the systems.

Table 1. List of key modification foci for changes to farming systems, their associated rationale and impacts and how the characteristics or decisions would be altered to achieve the desired outcome. System treatments in italics are those that make up the current 'benchmark' system; System treatments denoted with a ^ are included in a full factorial at the core site and denoted with a # are only singular treatments or partial factorials at the core site.

#	System modifications	Strategy	Anticipated impacts	Key characteristics & decision point change
1.	**CROP INTENSITY**			
1A	*Moderate crop intensity ^*	*Sowing on a conservative PAW threshold*		*Higher PAW requirement to trigger a crop sowing event (e.g. 150 mm)*
1B	High crop intensity ^	Increase the frequency of crops sown in order to maximise proportion of rainfall transpired by crops	- Reduced fallow herbicide use - Increased C inputs & soil OC - Increased soil biological activity & nutrient cycling - Reduce losses of water during fallows	Lower PAW requirement to trigger a crop sowing event (e.g. 75 mm)
1C	Low crop # intensity	Reduce the risk for a particular crop by maximising soil water at sowing by proceeding with a long fallow period.	- Greatly reduced number of crops - Higher profitability per crop - Long fallow periods requiring large herbicide program and low ground cover risks	Crops only sown when very high PAW or full profile Higher value/profitability crops are sown
2.	**CROP DIVERSITY**			
2A	*Limited crop options ^*	*Only crops with higher direct profitability are grown*	*- Soil-borne pathogens increase* *- Limited weed control & herbicide choices*	*Crop options limited to: wheat, barley, chickpeas, sorghum*
2B	Diverse crop options ^	Utilise a wider range of crops to manage the build-up and damage from soil-borne pathogens and weeds in cropping systems	- Increased soil biological activity & diversity - Alternate herbicide chemistry & hence slow HR onset	Crop choice altered to ensure 50% of crops are resistant to nematodes and no more than 2 non-resistant crops in a row. Two crops with same in-crop mode of action can't follow each other
3.	**NUTRIENT SUPPLY/BALANCE**			
3A	*Conservative nutrient supply^*	*Manage synthetic fertiliser input costs*	*- Soil fertility declining and likely crop yield penalties in good seasons*	*Crop fertiliser budget to achieve 50th percentile yield*
3B	High nutrient supply ^	Background soil fertility is boosted and crops provided with adequate nutrients to maximise yield potential.	- Soil chemical & biological fertility is maintained or increased - Crops able to maximise their seasonal yield potential	Initial organic amendments and subsoil P application Fertiliser budget to achieve 90th percentile yield.
3C	High legume ^	Increase inputs of biological N from legumes in system to reduce fertiliser N inputs	- Reduced N fertiliser requirements - Altered weed & pathogen populations	Legumes make up 50% crops sown High biomass legumes chosen in preference
4.	**SOIL QUALITY RESTORATION**			
4A	*No soil restoration*	*Non-grain crops are not included in crop sequences*	*- Soil quality declines and hence water capture and nutrient supply may limit system productivity*	*Grain crops only grown in crop sequences*
4B	Cover crops #	Cover crops used to restore soil cover, increase organic inputs and manage weeds and diseases	- Reduced herbicide use - Reduce N inputs for crops in rotation - Altered weed and disease populations	Cover crops after crops leaving low ground cover Brown manure (i.e. spray out) crops with yield < 50% of potential
4C	Ley pasture #	Perennial ley pastures phases to rebuild soil organic matter, nutrient levels and build disease suppressive soil biology.	- Reduced herbicide use - Reduce N inputs for crops in rotation - Altered weed and disease populations	A phase of grass and/or legume based pastures are sown in rotation with grain crops

Table 2. System modifications for experimental program at regional locations and the reference benchmark at the core site. Note the core site will also represent the Eastern Downs region farming systems.

Trt #	System	Regional sites					
		Emerald	Billa Billa	Mungindi	Spring Ridge	Narrabri	Trangie
1	‘Benchmark’	*	*	*	*	*	*
2	High nutrient supply	*	*	*	*	*	*
3	High legume	*	*	*	*	*	*
4	Diverse crop options	*	*	*	*	*	*
7	High crop intensity	*	*		*	*	*
14	Low crop intensity		*	*	*	*	*
15	Ley pasture (grass only)		*				
16	Ley pasture grass + N		*				
	Integrated weed mgnt	*					
No. of systems		6	8	5	6	6	6

Acknowledgements

The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC, the author would like to thank them for their continued support.

We would like to thank those growers and advisors who have given their time to be involved in focus group meetings, who shared their perspectives and provided their input into the design of this project.

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Summary pulse agronomy: plant population, row spacing, varieties yields and nitrogen fixation

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Key words

Mungbeans, soybeans, agronomy, row spacing, population

GRDC code

UQ00067

Take home message

- Reducing row spacing to 50cm and below will maximise summer pulse yields
- The improvement in yield is evident in differing environments and seasons
- Reducing row spacings may also increase the amount of nitrogen fixed
- Plant population has less influence on yield – continue with current recommendations
- Pulses should not be considered as only break crops but viable, profitable cropping options

Background and aims

Despite the potential environmental and economic benefits, the adoption of summer pulse crops in the Queensland Grains Region is around 4% of total cropping. To increase the share of pulses in the total cropping area, strategies are required to enable growers to more consistently realise the potential productivity and profitability of pulse cultivars in their farming systems.

One of the main aims of the project is to not only to get an increase in yields for summer (and winter) pulses, but to also improve the reliability of yields. When the risk in getting reliable yields in varied environments and seasons is reduced then pulses will not just be considered as a break crop in a cereal rotation or as an opportunistic cash crop but as a crop that can be considered a reliable and profitable part of the farming enterprise.

With mungbean yields averaging around 1t/ha in southern Queensland and a long term price of $750/t, an increase in yield of 10% could mean an extra return of $75/ha. Across a growing area of approx. 40,000ha this could mean an additional $3 million of returns to growers.

The Pulse Agronomy project has consulted widely within the pulse industry to determine the priorities to be investigated throughout the term of the project.

Mungbeans

Row spacing and population trials

The first summer pulse trials were established in the 2013/14 seasons and replicated again in 2014/15. The initial trials were based on a population trials with 3 varieties (Jade-AU Φ, Crystal Φ, and a pre release lines from the breeding program), planted at 10, 20, 30 and 40 plant/m^2, on 50cm rows with 3 reps of each. In the first season 2 sites were planted at Warra and Dalby on the Darling

Downs. In the season just gone 4 sites were planted, again at Warra and Dalby, with additional sites at Billa Billa and Miles.

Row spacing trials were planted with a target population of 25plants/m^2. The row spacing treatments were 25, 50, 75 and 100cm in 2013/14 and 25, 50 and 100cm in 2014/15.

The comparison of the weather between the 2 years of trials is quite stark with 2013/14 being very hot and dry, while the 2014/15 season was relatively mild for a summer plant mungbean crop. Figure 1 depicts the weather for Warra over the 2 seasons with above average high temperatures and limited rainfall (55mm in 11 falls) in 13/14, while milder high temperatures and much more in crop rain lead to a doubling of yields at this site.

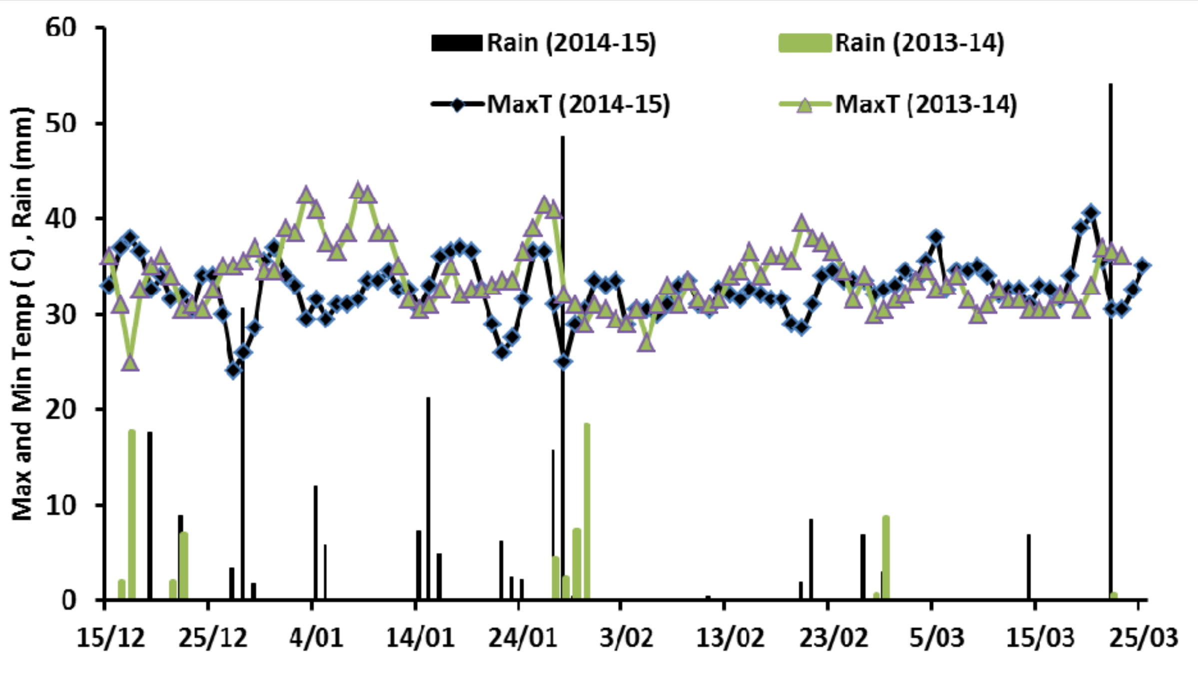
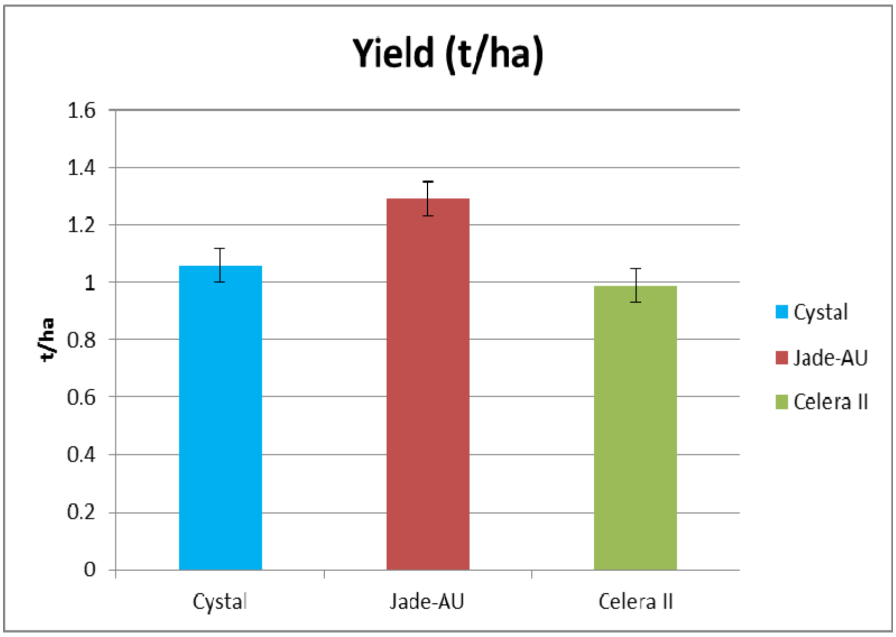


Figure 1. Comparison of 13/14 and 14/15 summers at Warra

In the 2 sites for 13/14 Jade-AU was the highest yielding variety across all row spacing treatments was Jade-AU, followed by the other commercial large seeded variety Crystal. The small seeded pre release variety MO9246 (since released as Celera II) was much quicker to flowering and maturity and prior to harvest a portion had shelled out of the pods, losses were estimated to be as high as 30% however the stated results are as harvested and not adjusted for loss.

a) Warra



b) Dalby

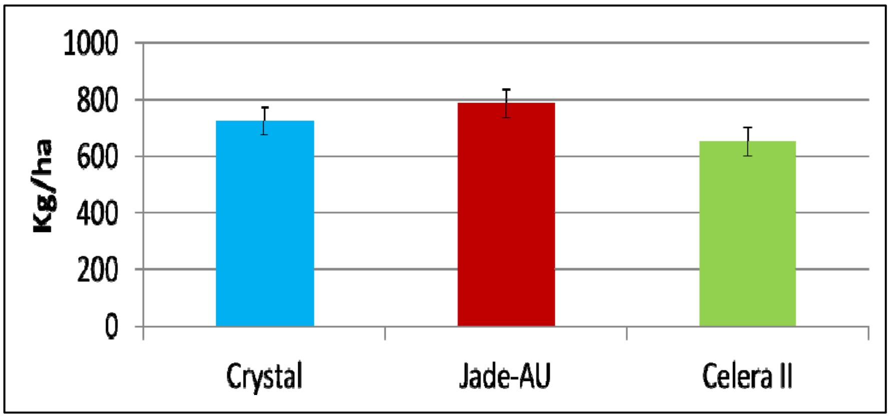


Figure 2. Variety grain yield for all row spacings at Warra (a) and Dalby (b) 2013/14 (LSD (5%) Warra: 0.119 t/ha Dalby: 101.2 kg/ha)

The highest yields at Warra were in the 25cm row spacing at 1.219t/ha, although this was not significantly better than the other row spacing treatment, with the lowest of 0.972t/ha for the 1m treatment.

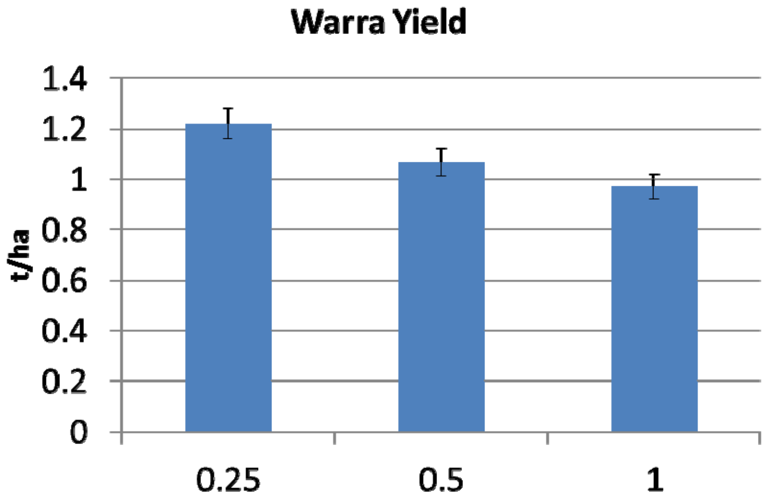


Figure 3. Warra row spacing yields for all varieties 2013/14 (LSD 5% 0.258)

The highest yield at Dalby in 2013/14 was from the 50cm row spacing treatment, but there was no significant difference between the 25cm and 50cm treatments, however there was a significant difference to 1m row spacing.

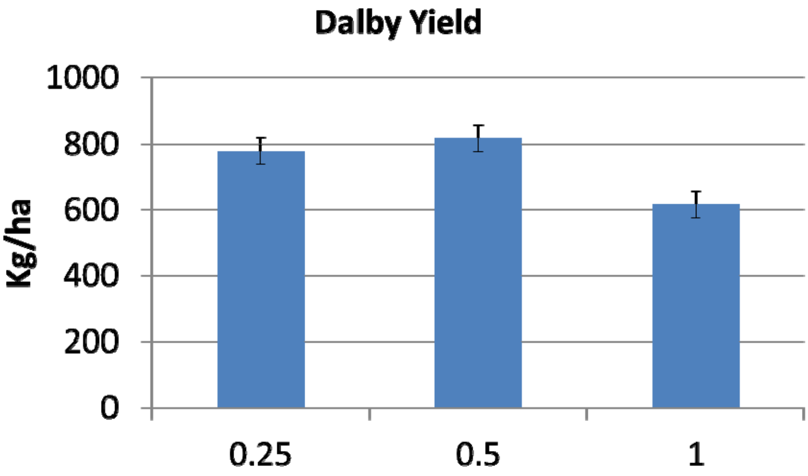


Figure 4. Dalby row spacing yields for all varieties 2013/14 (LSD 5% 81.6)

When the Warra row spacing by variety is graphed as in Figure , it can be seen that there is no effect of row spacing on the yield of Celera II. There is an effect on Crystal which is significant when row width is increased from 25cm to 50cm with a nearly 300kg/ha yield drop, with a further significant drop out to 1m rows.

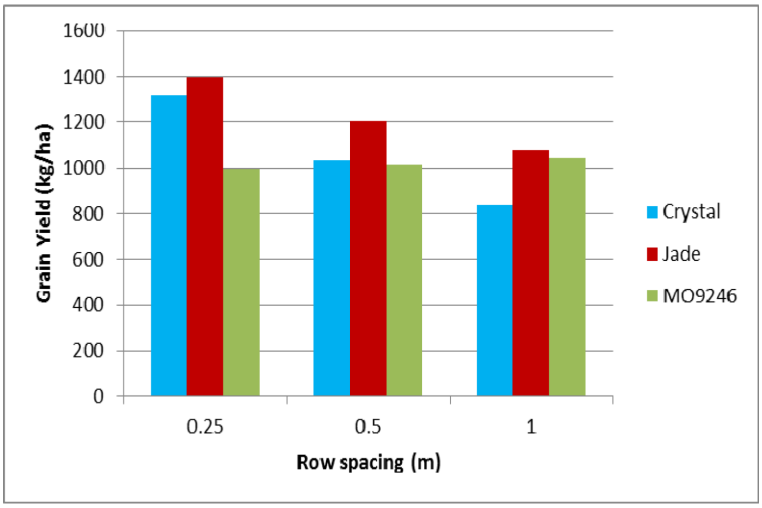


Figure 5. Grain yield of mungbeans at Warra by variety and row spacing treatment (LSD 5% 370)

As the plot size is the same and the plants on different row spacings had access to the same volume of soil the differences in yield are due to the narrower rows being more efficient at converting soil moisture to grain as in Table 1.

Table 1. Water use efficiency (WUE) of row spacing treatments at Warra 2013/14(kg grain/mm) (LSD 5% 2.3)

Row space (m)	**0.25**	**0.5**	**1**
WUE (kg grain/mm)	11.1	9.7	8.9

The 2014/15 results have not been fully analysed at the time of writing however some of the results from the Warra site have been included as a comparison to the much drier season before. In the much better weather conditions of 2014/15 yields were doubled that of the previous season.

The 2014/15 results have confirmed that Jade-AU ⓓ has performed better than Crystal and 2 pre release lines (discussion limited to the commercial available varieties).

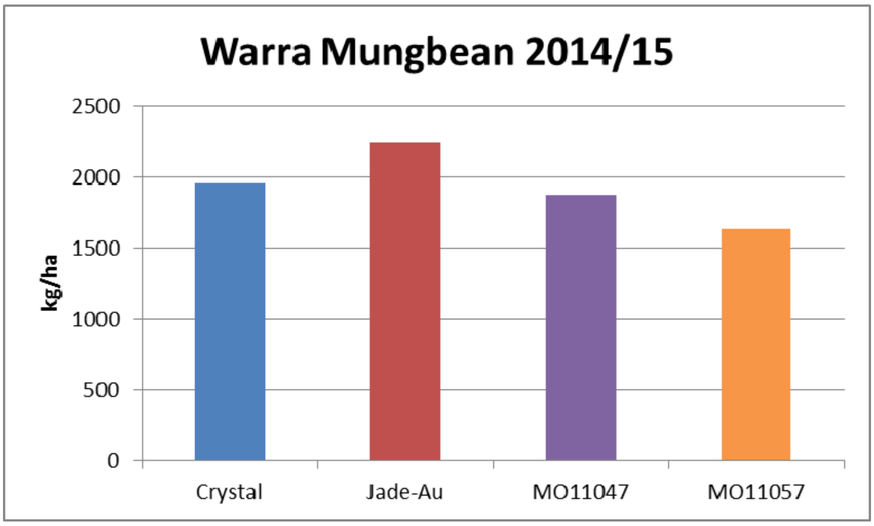


Figure 6. Warra 2014/15 mungbean variety yields, all row spacings (LSD 5% 562)

The yield differences between the varieties were not significant, there is significant difference between 0.25 and 0.5m and the 1m spacing. Crystal ᶲ was the only variety that had not significant difference across row spacings, the other varieties all had lower grain yields at 1m.

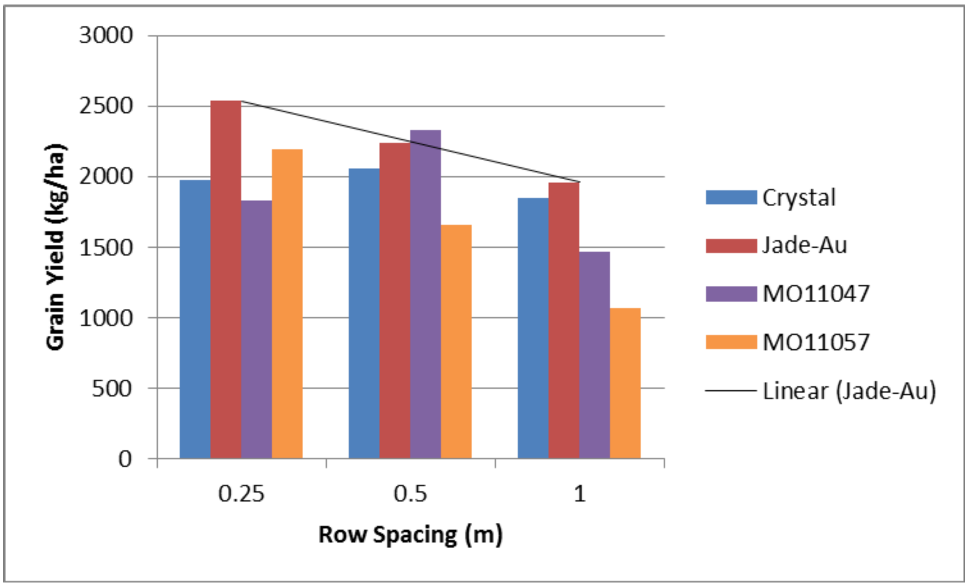


Figure 7. Warra 2014/15 mungbean grain yields variety x row spacing (LSD 5% 704)

In the first year there was no statistical difference in grain yield at the differing plant populations, however there was a trend for lower yields at 10 plants/m^2 and a flat yield response in 20, 30 and 40 plants/m^2. In the 2014/15 Warra results, which was a much higher yielding season, there appears to be yield increase in line with increases in the population across all varieties (not significant). This may suggest in high yielding environments that the target population should be above the current recommendation of 30 plants/m^2.

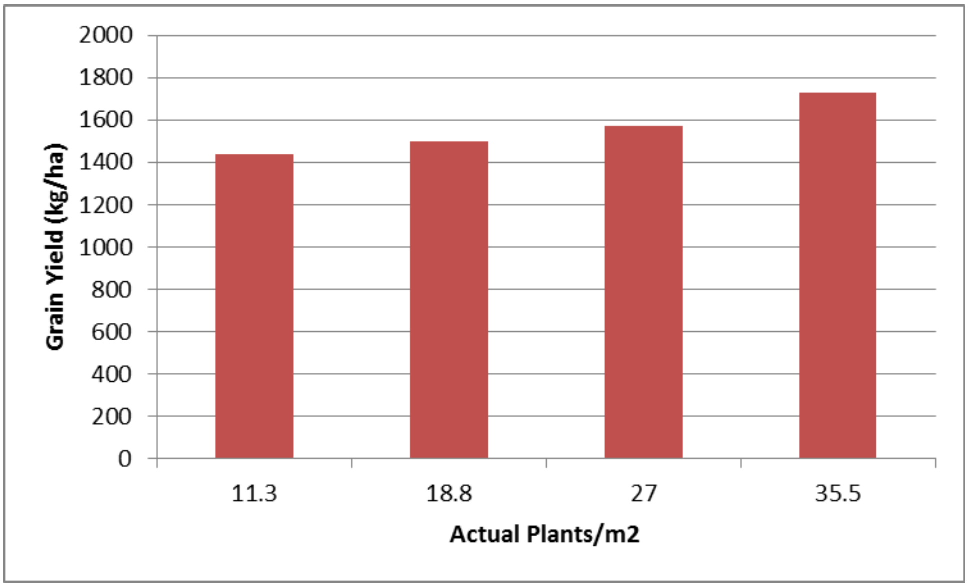


Figure 8. Warra 2014/15 plant population yields (LSD 5% 318)

Mungbean nitrogen fixation

It has been shown that agronomic practices can influence the amount of nitrogen fixed by pulse crops. The 2013/14 mungbean trial at Dalby was sampled for number of nodules per plant, nitrogen in dry matter and grain and the proportion of that nitrogen that was derived from the atmosphere

(%Ndfa). The site had an inherently high nitrogen of 150kg/ha and this in conjunction with the low yields at the site limited the amount of nodules to less than 1 per plant when sampled and the %Ndfa figures also showed that the amount of nitrogen in the plant from fixation by rhizobia varied from less than 9% to 16% with no distinct trends due to changes in row spacings.

This is in contrast to previous work at Kingaroy in the 2012/13 season. In this trial differences in the amount of nitrogen fixed was evident between varieties and the row spacings across all varieties (Figure 9).

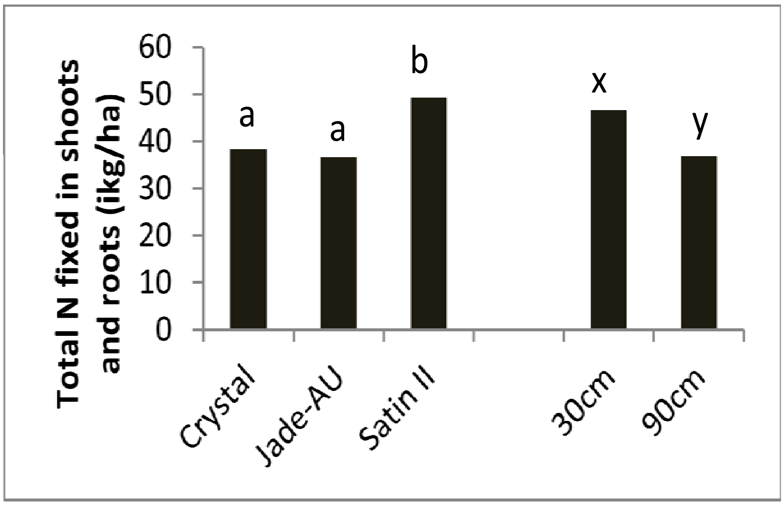


Figure 9. Differences in total shot and root nitrogen by variety and row spacing, Kingaroy 2012/13

The differences in the amount of N in the shoots and roots (Figure 9) can be influenced by the amount of total dry matter produced or the %Ndfa. It can be seen in Figure 10 that the amount of nitrogen derived from the atmosphere for Crystal and Jade-AU was different with changes in row spacings, however Satin II kept the amount of N from the atmosphere constant at the varying row spacings.

As we have shown with the other trial results narrower rows are producing higher yields which must be supported by higher dry matter production. The crop then has a higher nitrogen demand that is being met by an increase in the nitrogen fixed by rhizobia and provided to the plant.

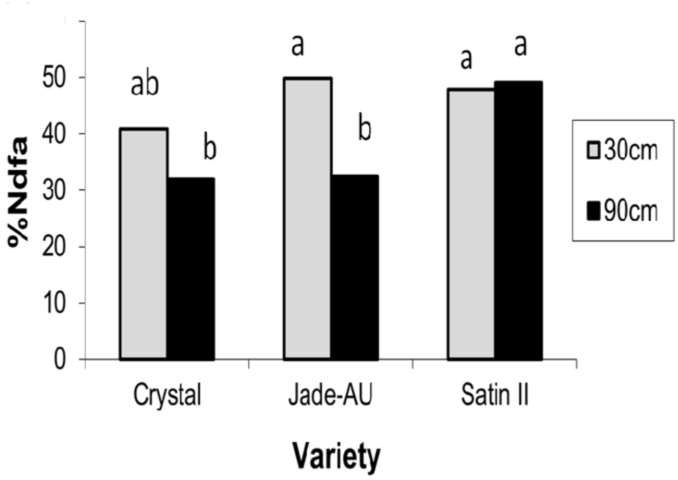


Figure 10. %Ndfa of different varieties at 2 row spacings, Kingaroy 2012/13

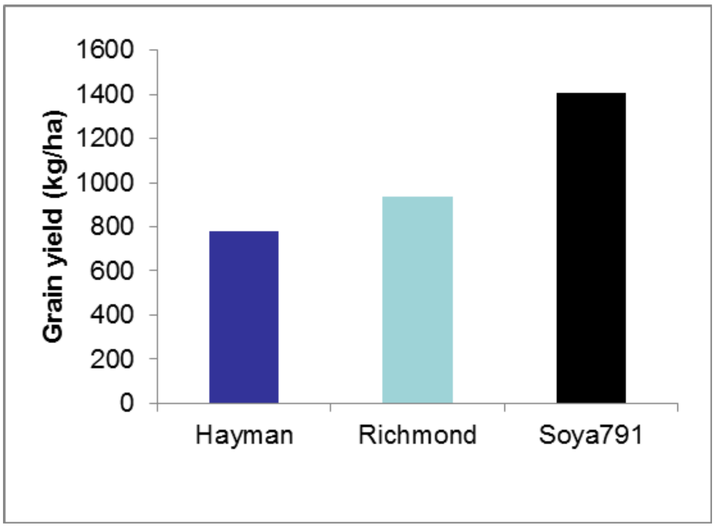
Soybeans

Row spacing and population trials

The first soybean trial was established in the 2013/14 seasons and again in 2014/15. The initial trials were based on a population trials with 3 varieties (Soy791 ⌽, Richmond ⌽, Hayman ⌽), planted at 10, 20, 30 and 40 plant/m^2, on 50cm rows with 3 reps of each. Row spacing trials were planted with a target population of 25plants/m^2. The row spacing treatments were 25, 50, 75 and 100cm

In the first season 1 site was planted at Kingsthorpe on the Darling Downs. In the season just gone 2 sites were planted at Warwick and Wooroolin (South Burnett). Only the 2013/14 results were available at the time of writing.

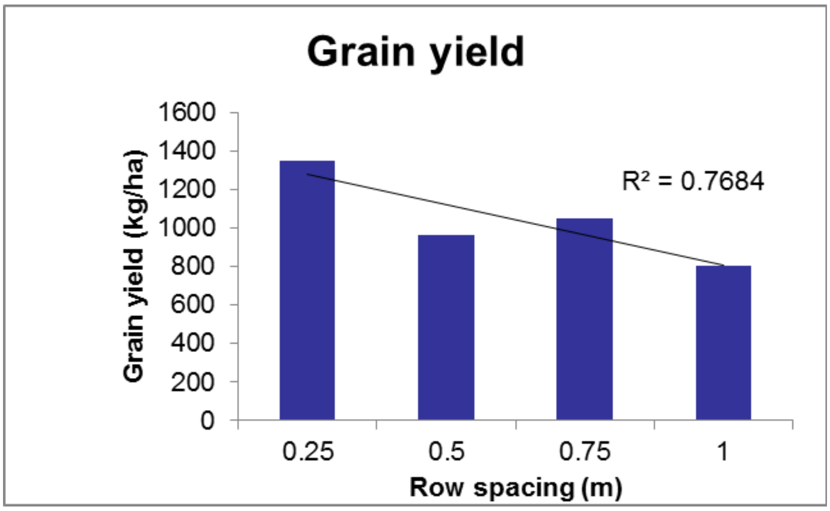
The yields were far from expected in a dryland situation on the Darling Downs due to the weather conditions. The highest yielding variety in the row spacing trial was Soy791 ⌽, almost 500kg/ha behind was Richmond ⌽ followed by Hayman ⌽ – Hayman's yield may have been reduced by not reaching full maturity due to it being a longer season type. This trend was not as evident in the biomass cuts with no significant differences between the varieties, however Soy791 ⌽ TDM was 6,303 kg/ha vs Hayman ⌽ and Richmond ⌽ 5,387 and 5,550 kg/ha respectively (LSD 1,426kg).



LSD 5% 240

Figure 11. Kingsthorpe soybean variety yields 2013/14

There is a distinct trend for grain yield to improve as you reduce row spacings with 25cm treatment yield significantly higher than all other treatments In a season with limited rainfall this goes against the perceived benefit of planting on wider rows to conserve moisture for later in the growing season, further testing of this in dryland situations to confirm or deny will certainly help the industry to improve yields.



LSD 5% 284.8

Figure 12. Row spacing treatment effect on soybeans at Kingsthorpe

Soy791 ⓓ was the best performer across most treatments with the exception of 1.0m row spacing where Richmond ⓓ provided the highest yield. All varieties produced their best yield with the 25cm treatment; however it was not necessarily statistically different.

The harvest index of this trial was quite poor with a site average of 0.186. There are several reasons for this:

- Early bulk of growth with reduced seed set due to drought effect
- Very low pod set with a 7-10% estimate of grain left in the paddock with mechanical harvest
- Crop not fully maturing and not converting assimilates into grain with leaf still on the crop at desiccation.

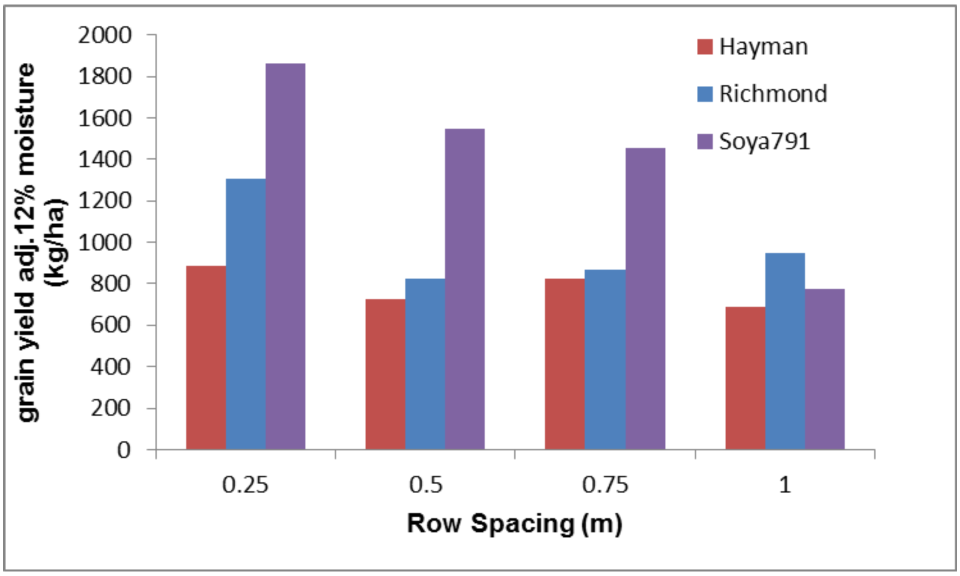


Figure 13. Effect of row spacing on yields of 3 soybean varieties at Kingsthorpe 2013/14 (kg/ha) (LSD 5% 458.4)

Summary and conclusions

With both summer pulses yields can be improved by planting at narrower row spacings. This has been evident in mungbeans in both a below average and above average seasons. The reasons are not fully understood but are suspected to relate to root morphology and how they explore the soil volume for water and also the larger crop canopy on narrow row spacings intercepting more of the light energy.

Populations are not as important in determining yields and the current industries recommendations should remain as the target populations. The fact that lower populations are not reducing yields significantly may help in making replanting decisions when establishment is effected by other factors.

Both of these factors and their effect on maximising yields in varied climates, along with improved varieties, will lead to greater confidence in the ability to grow a profitable crop and make mungbeans and soybeans viable crop options in the farming enterprise and not just break crops for the cereal dominated systems.

Acknowledgements

The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC, the author would like to thank them for their continued support.

The Queensalnd Pulse Agronomy group would also like to extend their appreciation to the trial co-operators who have hosted our trials; Wade Bidstrup, Glenn Milne, Tom Woods and family, Ben Moloney, Andrew Lester and John Champney.

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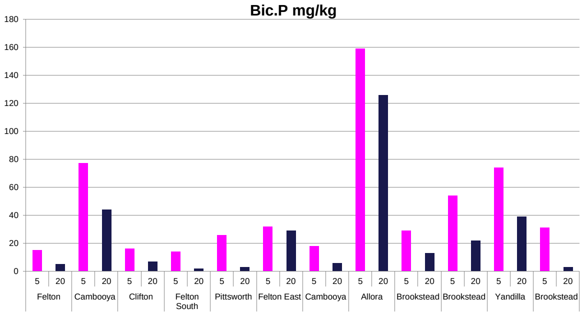
Hybrid Selection & Management for Better Yields

Trevor Philp
Pacific Seeds

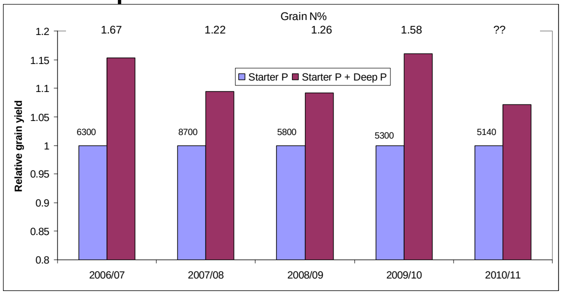
Good Farming Practice Still Key

- Soil Water
  - – Increasing infiltration
  - – Reducing compaction
- Nutrition
  - – Adequate N
  - – P&K at depth this needs to be checked
- Good weed control
- Precision planting

Is low P at depth limiting your Yield



Grain Sorghum response to Deep Banded P: Brookstead



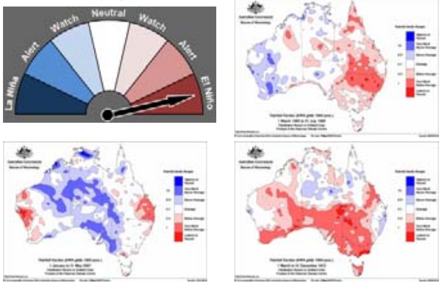
Professor Mike Bell 2011

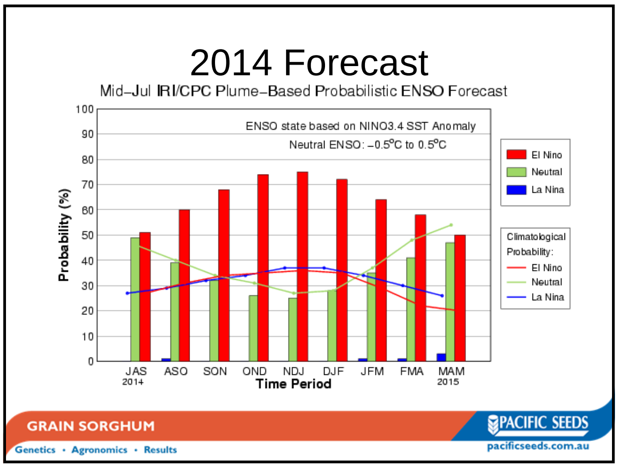
Planting Time decisions
G X E X M

- E= Soil water + rainfall + temperature
- G= Hybrid Mix
- M= Management
  - Row configuration
  - Population
  - Fertiliser
  - Planting date
- Risk Management

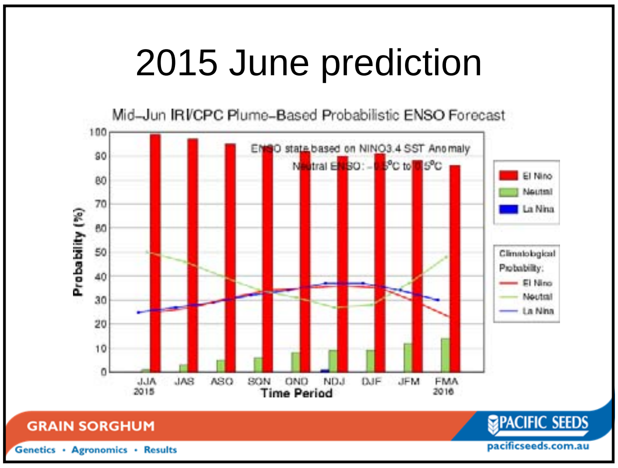
  How to manage the risk of my decision

What type of season will I get?

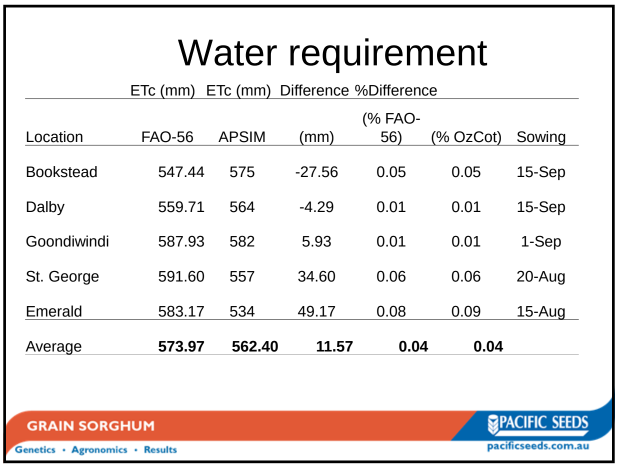




2014 Forecast

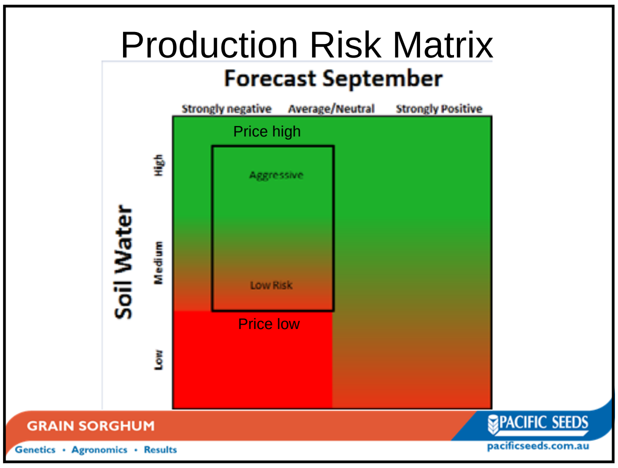


2015 June prediction



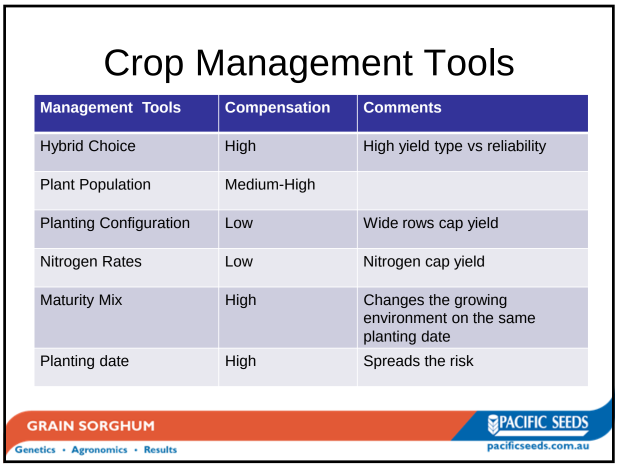
Water requirement

	ETc (mm)	ETc (mm)	Difference	%Difference		
Location	FAO-56	APSIM	(mm)	(% FAO-56)	(% OzCot)	Sowing
Bookstead	547.44	575	-27.56	0.05	0.05	15-Sep
Dalby	559.71	564	-4.29	0.01	0.01	15-Sep
Goondiwindi	587.93	582	5.93	0.01	0.01	1-Sep
St. George	591.60	557	34.60	0.06	0.06	20-Aug
Emerald	583.17	534	49.17	0.08	0.09	15-Aug
Average	**573.97**	**562.40**	**11.57**	**0.04**	**0.04**	



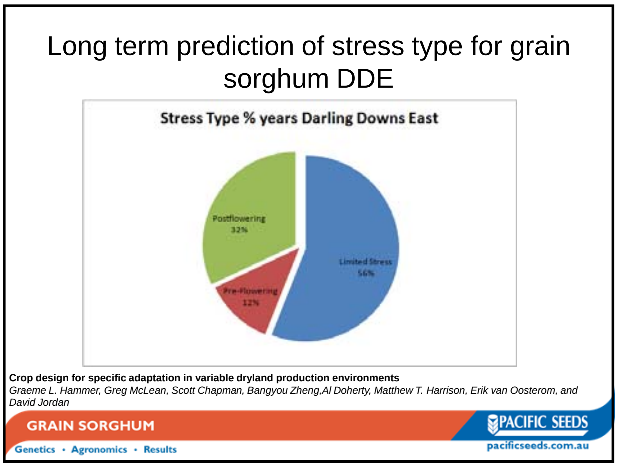
Production Risk Matrix

Forecast September



Crop Management Tools

Management Tools	Compensation	Comments
Hybrid Choice	High	High yield type vs reliability
Plant Population	Medium-High	
Planting Configuration	Low	Wide rows cap yield
Nitrogen Rates	Low	Nitrogen cap yield
Maturity Mix	High	Changes the growing environment on the same planting date
Planting date	High	Spreads the risk

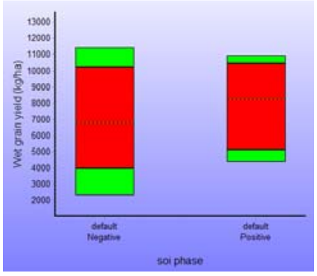


Long term prediction of stress type for grain sorghum DDE

Crop design for specific adaptation in variable dryland production environments

Graeme L. Hammer, Greg McLean, Scott Chapman, Bangyou Zheng,Al Doherty, Matthew T. Harrison, Erik van Oosterom, and David Jordan

What's the risk

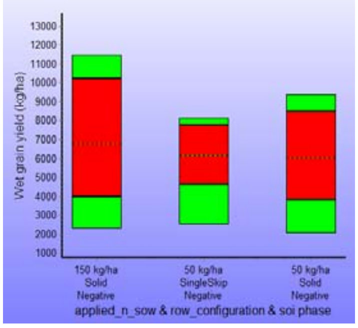


High yielding hybrid, 225-250 kg N
6 p/m>
Solid Rows

Reliable Hybrid, 120-150 kg N
Skip row ?

PAWC 240mm, Soil N 250 kg/ha 6 plants/m Medium maturity

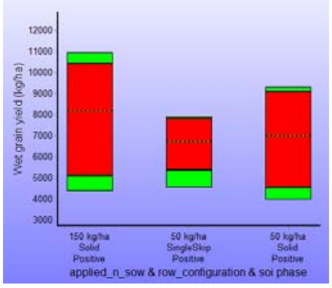
Too risk adverse ?



Statistic	Wet grain yield (kg/ha)
0%	2297
10%	3970
90%	10217
100%	11440
Mean	6805
0%	2489
10%	4624
90%	7771
100%	8147
Mean	6136
0%	2045
10%	3828
90%	8478
100%	9363
Mean	6034

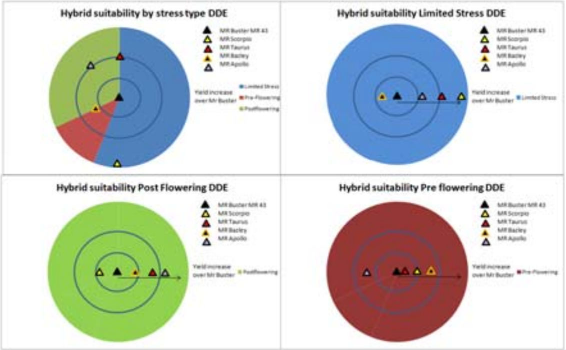
PAWC 240mm, Soil N 250-150 kg/ha 6 plants/m Medium maturity

How's a fixed strategy look

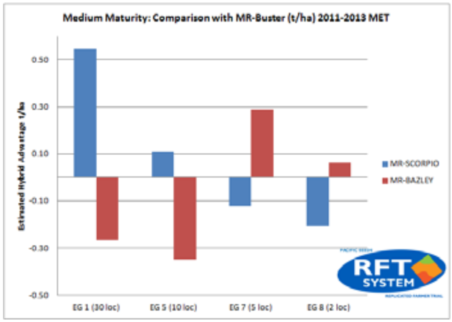


Statistic	Wet grain yield (kg/ha)
0%	4371
10%	5112
90%	10421
100%	10934
Mean	8222
0%	4531
10%	5370
90%	7808
100%	7911
Mean	6751
0%	3985
10%	4546
90%	9076
100%	9306
Mean	7015

Hybrid suitability to stress environment



Hybrid Selection by Environment



PAW$_{mm}$ Effect on Hybrid Rank

Table of ranked means

Variety	Mean (kg/ha)	s.e	subscript
MR Bazley	1928	88.3	a
MR Scorpio	1547	88.3	b

Planting Date: 07/02/2014
Row configuration: 150 cm
Starting wet soil depth: 55 cm
Incrop Rainfall mm: 15 mm (46 DAP)

Pairwise tests between means using LSD procedure
F-test is significant at the P = 0.050 level
NB: Means with same subscript are not significantly different at the P = 0.050 level
LSD = 255.9

Table of ranked means

Variety	Mean (kg/ha)	s.e	subscript
MR Scorpio	4854	137	a
MR Bazley	3997	126.8	bc

Comments
Planting Date: 18/02/2014
Row configuration: 150 cm
Starting wet soil depth: 85 cm
Incrop Rainfall mm: 35 mm (35 DAP)

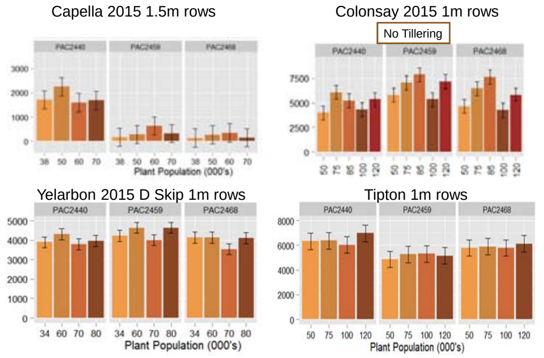
Pairwise tests between means using LSD procedure
F-test is significant at the P = 0.050 level
NB: Means with same subscript are not significantly different at the P = 0.050 level
LSD = 359

Plant Population ?

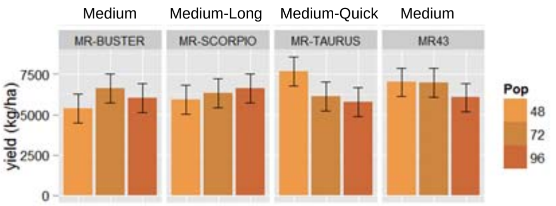
- 12 hybrid by population trials
  - 1 irrigated, 11 dryland
- Limited hybrid by population interaction
  - Limited effect on yield
  - Limited effect on lodging
- Uniformity and speed of dry down was improved with populations over 50000/ha

Grain Moisture at 1.00pm Double Skip Yelarbon 2014-15	
Plant Population	Grain Moisture
34000	17.35
60000	15.95
70000	15.3

Population Effects 2014-15

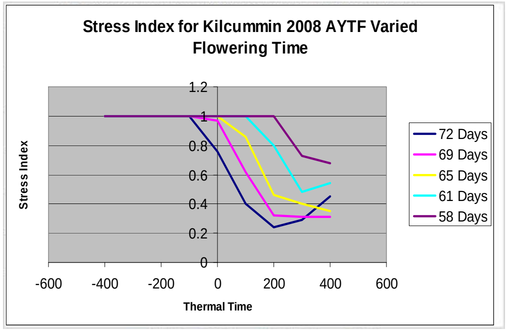


Maturity by population by Stress effect



Plant population trial Yallaroi NSW 2014-15
Planted 17/09/2014
Pre-flowering Stress, relieved at flowering in December
55 mm 19/09/2014-05/12/2015

Maturity effects on stress



Case Study Evanslea 2014

Soil Type	Black vertosol 300mm pawc	**Total Rain mm**	**234.5**
Farming System	Minimum Tillage with control traffic	**Pre-flowering Rain mm**	**183**
	3 meter wheel centres Track tractor	**Post Flowering Rain mm**	**51.5**
	9.02m planter width		
	12 row 76.2cm row spacing	**Starting water mm**	**300**
		Total water mm	**534.5**
Fallow	12 mth from failed Cotton		
Applied Nitrogen	98.4 kg/ha 18/06/2014	**WUE kg/mm**	**18-20**
Ending Nitrogen	93 kg/ha	**Check list**	
Phosphorus	15-30cm BESE 240 mg/kg	**Soil health**	☑
	15l/ha of Pillar water injected at planting	**Soil water**	☑
		Nitrogen	☑
Planted	17/12/2015	**Phosphorus**	☑
Hybrid	MR-Scorpio	**Precision Planter**	☑
Rate	77000 seeds/ha	**Good Agronomy/Agronomist**	☑
Planter	Maxemerge Precision Eset plates	**Own Header & Trucks**	☑
Flowered	18/02/2015	**Drier and Aerated Silos**	☑
Harvested	13/04/2015	**Luck**	☑
Yield	**9.7 t/ha**		

Summary

- Know your soil water
- Consider the forecast
- Identify limitations
- Manage you risk by paddock
  - – Develop a realistic yield target
  - – N budget to suit
  - – Hybrid that suits your goals Risk/Reward
    - Have a mix of Hybrid type and maturity
    - Spread you planting times
- Harvest Management
  - – High moisture grain drying ???

Disease control in summer crops - management strategies to minimise financial losses

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Key words

Charcoal rot, fusarium, stalk rot, powdery mildew, halo blight, sorghum, mungbean, sunflower, soybean, phomopsis, diaporthe, weeds

GRDC code

DAQ 00186 - Improving grower surveillance, management, epidemiology, knowledge and tools to manage crop disease – USQ/DAFQ

Take home messages

- Management of charcoal rot and fusarium stalk rot in sorghum relies on good agronomy, crop rotation, use of appropriate varieties and timely application of desiccants
- Management of powdery mildew in mungbean and sunflower relies on timely fungicide application(s) and the best available resistance (mungbean)
- Management of halo blight in mungbean relies on the use of seed with the lowest possible levels of infection, the use of clean harvesting equipment, weed management and crop rotation
- *Diaporthe* species which cause stem canker and other diseases in sunflower and soybean have wide host ranges including weeds; infected living plants and dead residues of these hosts act as “Green” and “Brown” bridges that need to be managed

Background

Surveys and field observations have revealed that stubble borne pathogens such as *Phomopsis*/*Diaporthe* (sunflower, soybean, weeds), charcoal rot (soybean, sorghum, sunflower, weeds), *Fusarium* species (sorghum, mungbeans, weeds), *Sclerotinia-spp* and *Sclerotium*-induced base rots (sunflower, soybeans, mungbeans, weeds) are increasing in incidence. Strategic tillage may have a future role to play in managing stubble borne pathogens. More research under Australian conditions is required.

The current GRDC funded project DAQ00186 focusses on the dominant diseases of sorghum, sunflower, mungbeans and soybeans in the northern region – these include the sorghum stalk rot pathogens, sunflower and soybean stem and pod pathogens, mungbean halo blight, neocosmospora on peanuts and the powdery mildews on sunflower and mungbean.

Ongoing changes in the disease spectrum of the northern region also indicate an increased incidence of the two *Sclerotinia* species across both cooler and warmer areas of the northern region plus sclerotium base rot (*Sclerotium rolfsii*) a warm weather pathogen favoured by conditions in Central Queensland, the eastern Downs and NNSW. These survey results reflect the concerning emergence of more stubble borne pathogens.

Charcoal rot and fusarium stalk rot in sorghum

Charcoal rot

Charcoal rot in sorghum is caused by the soil borne fungus *Macrophomina phaseolina* and is a major stalk rotting disease in sorghum which can lead to plant lodging. The causal agent, *M. phaseolina* can infect via the roots of sorghum plants at almost any stage of plant growth, but develops more rapidly in plants closer to maturity. Extensive colonisation of stem tissue generally occurs post flowering when plants are placed under a stress, such as unfavourable environmental conditions, particularly hot, dry conditions. This can be further exacerbated by the application of defoliants which also act as a stressor, further promoting growth and invasion of the stem.

The pathogen is easily identifiable when stems are split longitudinally. The characteristic appearance of black microsclerota (resting bodies) in the vascular tissue and inside the rind of the stalk results in a “peppered” look in conjunction with shredded internal vascular tissue which is grey/charcoal in colour. The fungus is widely distributed throughout Australia infecting the root and stems of over 400 plant species (all major summer field crops and many summer and winter weeds). The microsclerotes can survive in the soil and on stubble for 4+ years. It is uncertain what soil conditions are necessary to reduce the survival of microsclerotes in Australia but overseas studies indicate wet soil can significantly impede their survival.

Fusarium stalk rot

Fusarium stalk rot is predominantly caused by the pathogens *Fusarium thapsinum* and *F. andiyazi*. *Fusarium* is prevalent in all sorghum growing regions, with some geographical preference occurring depending on the species. The weather conditions conducive to infection and development of this disease are not well understood, however evidence suggests that infection can occur early in the crops development where it can remain latent and relatively asymptomatic during much of the vegetative stage. As with charcoal rot, extensive colonisation of stems occur when stress is initiated post flowering (induced by moisture stress or other factors such as application of desiccant), leading to possible lodging.

Diagnostic symptoms are easily identifiable when stems are split length-wise; visual symptoms include red – brown discolouration within the pith tissue of the stem, often initially concentrating at the base of the stem. *F. thapsinum* and *F. andiyazi* can survive in stubble for up to 3 years and possibly on alternative weed hosts. The host range for these pathogens is significantly more limited than *M. phaseolina*, however, given the saprophytic nature of the pathogen, survival on stubble of alternative crop and weed hosts is possible and is currently being researched.

Preliminary laboratory and glasshouse inoculations of alternative crop “non-hosts” (both live plants and dead stubble), have shown that possible infection of other crops such as mungbean, maize and wheat may occur. However, this initial work is under artificial inoculation conditions and may not reflect infield activity. Ongoing field work is being conducted to confirm the possibility of natural infection of alternative crop non-hosts in an endophytic or saprophytic capacity.

Yield losses

Determination of yield loss associated with either fusarium stalk rot or charcoal rot in Australia has not formally occurred. Quantification of yield loss through in-field assessments is difficult and varies depending on a number of factors including:

- weather
- time of infection
- cultivar susceptibility
- degree of lodging

Field surveys have demonstrated that the simultaneous invasion of both stalk rotting pathogens (*Fusarium* and *M. phaseolina*) occurs regularly making losses difficult to apportion to individual pathogens. Recent field trials artificially inoculated with *M. phaseolina* resulted in dual infection of both *Fusarium* and *M. phaseolina* due to the wounding nature of the artificial inoculation process.

Charcoal rot. Overseas yield losses have been estimated at more than 50%. Despite the lack of any formal quantification in Australia, significant yield losses have been associated with lodging over the last two seasons, where prevailing hot dry conditions have resulted in widespread high incidence of *M. phaseolina* and subsequent lodging.

Incidence and lodging were highest in Central Queensland where up to 30-40% total yield losses were associated with lodging, and patches of up to 90% in-field lodging was evident. Realised losses associated with lodging varied and was dependent on ability of individual growers to retrieve lodged heads with harvesting equipment available.

***Fusarium* species.** In Australia, yield loss in the absence of lodging has not been found, but does not preclude the possibility that it occurs. Although fusarium stalk rot can and has caused significant lodging, as was seen in 2009 season, more recent seasons have seen moderate incidence levels with low and sporadic associated lodging (less than 5%). Regions that appear to be more prone to *Fusarium* infection include SEQLD and NNSW.

Management

Management strategies for fusarium stalk rot and charcoal rot are closely related and have subsequently been dealt with in the following section simultaneously. There are no effective foliar fungicides for either disease. Management strategies that need to be taken into consideration include the following:

- Soil moisture – planting into adequate soil moisture and ensure row spacing and plant populations are suitable for the field and seasonal situation, to minimise possible post flowering moisture stress.
- Adequate nutrition – application of adequate fertilisers should be exercised to maintain plant health and vigour reducing nutrient related stress. More specifically, excessive Nitrogen and low levels of Potassium should be avoided.
- Crop rotations – rotating out of susceptible crop hosts can be effective in reducing the build-up of *Fusarium* and/or *M. phaseolina* which may have occurred in mono-cropping systems. Currently, the host range of *F. thapsinum* and *F. andiyazi* is thought to be limited, providing a number of options for rotations. However, alterations and additions to the list are possible as maize is thought to host *F.thapsinum* at low levels and more recently a survey overseas has found infection of *F. thapsinium* on soybean seed. In Australia, surveys and research into possible hosts, including the role of stubble from alternative non-hosts is still ongoing. Rotating out of susceptible crop hosts is more difficult with *M. phaseolina* due to its extensive host list. Overseas research suggests that the build-up of microsclerotes is less in some hosts than in others; in some U.S. trials the number of microsclerotes in the soil after several crops of sorghum was less than the numbers after maize or soybeans. This type of rotational farming systems work has not yet been conducted in Australia.
- Use of lodging resistant, drought tolerant, non-senescent varieties. In the absence of information regarding the genetics for resistance for *M. phaseolina* and *Fusarium,* which are not well understood, the use of cultivars which include some or all of the combined characteristics (drought tolerance, staygreen, standability) may reduce the development of disease, particularly charcoal rot. While evidence has previously shown that staygreen lines have a better tolerance to *M. phaseolina* invasion than senescent lines, there is no conclusive evidence yet to suggest that this holds true for *Fusarium* species. Preliminary results from field trials where cultivars

were colonised with both *M. phaseolina* and *Fusarium*, demonstrate that assessment of disease levels based on internal lesion lengths correlated well with assessments for lodging. However, the absence of lodging does not preclude high incidence levels of either disease, which means caution should be taken to avoid build-up of disease unknowingly, particularly in monoculture systems.

- Application and timing of desiccant and harvest. Timing of application of a desiccant must be assessed with a number of factors in mind. Early application of a desiccant can increase stress and lodging potential (if applied when <95% seed are at black layer) as much as a desiccant applied too late, particularly if lodging is already occurring and disease incidence is high. Timely harvest once application of the desiccant has been applied is essential. Preliminary results demonstrate some varietal differences in reaction to application of a desiccant which needs further investigation to determine its role, if any in affecting structural integrity of the stem.

Powdery mildew of mungbean

In Australia, powdery mildew of mungbean is caused by the fungus *Podosphaera fusca* which is found wherever the crop is grown. Powdery mildew most commonly appears around flowering time and is first evident as small circular powdery spots on the lower leaves, rapidly covering the entire leaf and spreading to younger leaves up the plant. Small powdery spots can also be found on stems and leaf petioles. The powdery growth consists of minute fungal threads on the leaf surface from which simple fruiting structures bearing spores develop. When mature, these spores become airborne and can spread in the wind for many kilometres. The powdery mildew pathogen survives in Australia on plants of volunteer mungbean and other legume hosts, including phasey bean; it does not survive in soil, stubble or seed.

Yield losses

Fungicide trials conducted at different localities in southern Queensland since 2000 have demonstrated that losses in mungbean yield due to powdery mildew can range from 2.7% to 46% (most commonly 10-15%), depending on the variety, plant growth stage at time of appearance of powdery mildew and the rate of development of the disease. These latter two factors are highly dependent on weather conditions, particularly air temperature and humidity, rainfall and leaf wetness. The available evidence suggests that disease development is favoured by mild temperatures (daily mean temperature of 22-26°C) and high humidity in the canopy, particularly after rainfall or irrigation. Overseas research has shown that yield losses in mungbean due to powdery mildew result from a reduction in seed size and pod number.

Management

The only viable options for management of powdery mildew are resistance and foliar fungicides. The black mungbean variety Regur has the highest level of resistance (moderately resistant – moderately susceptible), while cv. Berken and cv. Celera have the lowest (susceptible). All other varieties are considered to be moderately susceptible, although cv. Crystalⓓ and cv. Jade AUⓓ have slightly better resistance than the rest. It may be some time before varieties are released with powdery mildew resistance significantly better than either Crystalⓓ or Jade AUⓓ.

Although several formulations of sulphur are either registered or under permit for management of the mungbean powdery mildew pathogen, the systemic fungicide tebuconazole currently under APVMA permit (Permit PER13979 in NSW and Qld only) and sold as Folicur 430SC® or Hornet 500SC® is superior to sulphur. Trials conducted over many seasons indicate that good control will be achieved if the first fungicide spray is applied at the first sign powdery mildew on the lower leaves and another spray is applied 2 weeks later. Good control has also been achieved when the first spray is applied just prior to flowering even if powdery mildew is not present.

In a trial conducted in 2015 at Warwick, we tested 5 Folicur treatments on cv Jade AU. Folicur is permitted for use on mungbeans under APVMA permit number PER13979 expires 30th June 2017. A spray applied at the first sign of disease with or without a second spray 14 days later (FS, FS+1), a spray applied when powdery mildew was 1/3 – ½ the way up the plant with or without a second spray 14 days later (1/3C; 1/3C+1), and a spray applied before flowering (6 weeks after emergence), followed by two more sprays, 14 days apart (Be). The results are summarised in Table 1 and show that yield from Be (3 sprays) treatment was significantly greater than the unsprayed control ($P \le 0.05$). Yields from all other spray treatments were not significantly different from the unsprayed control.

Table 1. Yield data and predicted profits of fungicide sprays from the 2015 Warwick trial

Treatment (no. sprays)	**Yield (t/ha) and % increase [1]**	**$ value increase at $1200/t**	**$ Application costs [2]**	**$ Profit**	
				Trial yield	**1.5t/ha Yield [3]**
Be (3 s)	2.31**c**[4] (9.5%)	240	60	180	96
FS+1 (2 s)	2.25**bc** (6.6%)	168	40	128	69
1/3C+1 (2 s)	2.18**abc** (3.3%)	84	40	44	14
1/3C (1s)	2.13**ab** (0.9%)	24	20	4	-5
FS (1s)	2.04**a** (-3.3%)	-84	20	-104	-74
Unsprayed	2.11**ab**				

[1] % increase over unsprayed treatment

[2] Application costs are a total of $20/ha/application for Folicur 430SC at 145mL product/ha + ground rig application

[3] Calculations based on a yield of 1.5t/ha for the Be (3 s) treatment

[4] Yield means with the same lowercase letters are not significantly different at $P \le 0.05$.

Given the assumptions for the trial yields, selling price and application costs, the $ profits for the best two treatments ranged from $128/ha to $180/ha. For a target yield of 1.5t/ha with the same selling price and application costs, the profits range from $69/ha to $96/ha. For a target yield of 1.5t/ha, a selling price of $800/t and the same application costs the figures are $32-$44/ha. Profits would be even greater in years where fungicide applications resulted in higher % yield increases and if a fungicide spray was combined with an insecticide spray.

The results of this trial confirm that the timing of the first application is critical in controlling powdery mildew of mungbean – it should be applied either before or when powdery mildew is first seen, with one or two follow-up sprays (depending on disease progress).

Halo blight of mungbean

Although the cause of halo blight, the bacterium *Pseudomonas savastanoi* pv. *phaseolicola* (*Psp*), was recorded on mungbean many decades ago in Australia, it is only over the past 8 or so years that it has become a problem. The first symptom of halo blight is often a general yellowing on young developing leaves, followed by the appearance of small roughly circular spots a few days later. On older leaves the spots are dark, often shiny and water-soaked particularly on the lower leaf surfaces, and are surrounded by a yellow halo which disappears as the leaves age. Circular shiny spots may also develop on green pods and seeds which develop in these pods usually become infected internally. Seeds may also become externally infected during harvesting when they come into contact with infected leaf segments.

Under moist conditions bacterial cells ooze from these spots and are spread on the plant and between plants by water droplets from rainfall or overhead irrigation. Outbreaks of halo blight are favoured by wet weather and moderate temperatures. If these conditions occur early in the crop and symptoms of halo blight appear, the symptoms often become less obvious if the weather remains hot and dry for the remainder of the crop's growth.

Yield losses

Determining the actual and potential losses in yield are difficult because there is no effective bactericide which can be applied to either the seed or the foliage of mungbean plants. The National Mungbean Improvement program has identified sources with major genes for resistance (one large seeded and two small seeded lines) and incorporated these into their breeding program to develop more resilient varieties, the first of which, Celera II-AU was released in 2014. In-field assessments of nearly 140 breeding lines were conducted in 2013/2014 across a number of sites (Biloela 2013, Emerald and Warra 2014, Hermitage and Liverpool plains 2013, Hermitage 2014 and plant disease nurseries at Hermitage and Kingsthorpe. Halo blight pressure was high in 2013, 2014 in Southern QLD and NSW (Hermitage and Liverpool plains sites) and there was a strong pattern of lines with the highest yields having yield linked to disease resistance/pedigree under these conditions. Low/no disease pressure was observed in CQ sites where the majority of experimental genotypes yielded equivalent to Crystal. Some halo blight resistant pedigrees suffered a yield penalty at the Emerald site in the absence of disease pressure.

Plans are underway to collect data on potential yield losses by comparing the yields in plots which have been inoculated with the halo blight pathogen for various times with the yield of uninoculated plots.

Management

There are no effective chemicals for the control of the halo blight pathogen on infected plants or seeds, and all current green-seeded commercial varieties are either susceptible or moderately susceptible (the varieties Crystal and Jade AU have the best levels of resistance). The black gram variety cv. Regur is rated as moderately resistant – moderately susceptible. Although improved sources of resistance have been identified, the recent identification of new strains of *Psp* which can overcome this resistance means that the breeding effort in the National Mungbean Improvement program will need more resources.

Current management for halo blight relies on minimising the impact of the pathogen using a variety of strategies –

- Save planting seed harvested from a crop which did not display symptoms of halo blight during the season; AMA approved seed is sourced from crops which have been inspected for symptoms during the growing season
- If you plan to save some of your seed for planting, ensure that harvesting equipment brought onto your property is thoroughly clean of mungbean residues preferably with an antibacterial compound, as bacterial cells of *Psp* can be transferred from infested residues onto the surface of seed during harvest
- Harvest crops which did not display any symptoms of halo blight before crops which were infected with halo blight if you plan to save some of your seed for planting
- Other crops and weeds (including bellvine, cowvine, morning glory and native glycines) are known to host the halo blight pathogen so management of these plants in and near mungbean crops is warranted

- Although the importance of survival of the halo blight pathogen in infested crop and weed residues is unknown in Australia, mungbean crops should not be grown in succession in the same paddock to avoid any potential risk from this and other pathogens.

Powdery mildew of sunflower

In Australia, sunflower powdery mildew is caused by the fungus Golovinomyces cichoracearum, whose hosts are confined to the plant family Asteraceae, that is, the daisy family including noogoora burr, etc. The pathogen survives year round on living plants of volunteer sunflowers, wild sunflower and other hosts. It does not survive in soil, infested stubble or on seed.

The first sign of infection is the appearance on the lower leaves of small, white, round powdery colonies which rapidly expand to cover the entire leaf. Under cool, humid conditions powdery mildew spreads rapidly up the plant onto younger leaves, with colonies also developing on stems, leaf petioles and the green bracts on sunflower heads if infection is severe. Spores produced on the fungal growth give the powdery white appearance on the tops of the leaves and are spread from plant to plant in the wind, often for many kilometres.

As there is little known resistance in Australian sunflower varieties to the pathogen, practical management of sunflower powdery mildew relies predominantly on the strategic use of the fungicide propiconazole as Tilt 250EC Systemic Fungicide® (or other registered products) under the APVMA permit PER14777 which expires on 30 June 2016. Generally, infection risk is highest during cool and humid conditions early and late in the season.

Field trials conducted between 2010 and 2012 assessed the effectiveness of various combinations of fungicide rate (250 or 500mL of Tilt/ha), number of sprays (one or two) and time of first spray (at first sign of powdery mildew or at 5% ray floret emergence). This latter time is defined as when an average 5% of the ray florets (the 1st yellow petals) on a sunflower head are present. In the trials, powdery mildew infection was approximately ½ way up most plants in the unsprayed treatment at the 5% ray floret stage. The results of the trials show that a single spray of 500mL Tilt product/ha applied at 5% ray floret emergence can effectively control powdery mildew under moderate and late-appearing powdery mildew infections.

Based on three years of trial results, it is recommended that one application of Tilt 250EC (or other registered products) at 250-500 mL product/ha applied from budding up until no later than 5% ray floret emergence (RFE) (5 heads in 100 showing the first signs of yellow ray florets) will adequately protect the crop until physiological maturity.

Choose the rate of Tilt 250EC or other registered product after considering future weather conditions and the level of inoculum already present in the region. For instance, a late crop with a 'skirt' of powdery mildew in the bottom third at budding or at 5% RFE and finishing in cool conditions would benefit by the application of a 500mL product/ha rate as it is more likely that powdery mildew levels will increase in these conditions. An early crop finishing over the hotter conditions around December is less likely to suffer from late powdery mildew infection although cooler humid nights will increase risk.

Important Note: The current permit states that NO fungicide applications are permitted after 5% ray floret emergence; check the information on www.apvma.gov.au for the conditions of use of this fungicide on sunflower. Further residue studies are underway to enable later applications of fungicide, if necessary.

Yield losses.

Although yield differences between treatments in these trials were not statistically significant (due to only moderate infection levels and harvester issues), differences in seed weights indicated that all treatments showed a trend of increasing yields compared to the unsprayed treatment. Field observations also indicate that heavy powdery mildew infection in the top third of the canopy from flowering onwards as the seeds fill can cause pinched seed and subsequent yield loss.

***Phomopsis/Diaporthe* diseases of summer crops and weeds**

The fungal Phomopsis/*Diaporthe* species survive on stubble and cause stem canker on sunflower and soybean, pod and stem blight in soybeans and other crops in Australia, and a range of other diseases on a wide variety of plants. In sunflower, serious outbreaks of stem canker can cause lodging, while in soybean pod and stem blight causes premature senescence, pod death and yield losses from reduction in the number and quality of seeds.

Outbreaks of *Diaporthe* diseases are favoured by warm, wet weather, when spores produced in fruiting bodies in infected stubble or on alternative hosts are spread to the host plants.

A serious outbreak of stem canker on the Liverpool Plains in 2010 was the catalyst for investigations to quantify the diversity of *Diaporthe* species on summer crops in the northern region, to gain an understanding of the host range of these species and to study different modes of survival in northern farming systems. To date 13 *Diaporthe* species including many new species have been isolated from sunflower stem cankers, eight species from live soybean plants and three species from mungbeans. *Diaporthe helianthi*, a highly damaging species on sunflower in the United States, Argentina and Europe has not been found in Australia.

More than 25 new species of *Diaporthe* have been identified from various crops and weeds to date from this study, of which 11 have been described as new species and a similar number are yet to be formally described. Identifying the various species is of importance as the first step to looking at host range and virulence. Pathogenicity testing of many of these species is underway and a range of crop and weed hosts for many of these *Diaporthe* species have been identified.

Damaging outbreaks in the future will be influenced by weather conditions and the amount of inoculum surviving in crop and weed stubble as well as on live plants.

Some key findings from this research are (i) *D. gulyae* is highly virulent on sunflower, chickpea, soybean and mungbean, and has been isolated from naturally-infected, field grown plants of soybean, sunflower and mungbean, (ii) *D. kongii* is highly virulent on chickpea, sunflower and mungbean, and has been isolated from naturally infected plants of chickpea, sunflower and mungbean, and (iii) *D. masirevicii* is highly virulent on chickpea, soybean, sunflower, lupin, and mungbean in glasshouse trials, and has been isolated from field grown plants of all except lupin. Both *D. gulyae* and *D. masirevicii* have been isolated from symptomless, field grown plants of maize suggesting that these species may form an endophytic association with maize plants, which is highly significant from the context of aiding survival on 'non-host' crops in the rotation.

The role of weeds in aiding survival. The wide host range of many of these *Diaporthe* species also extends to live and dead plants and residues of common weeds in the northern region. For example *D. gulyae*, the most virulent of all species discovered during this study, has been isolated from lesions on live plants of the crops sunflower, soybean, and mungbean and the weeds bathurst burr, noogoora burr, saffron thistle and sesbania, and from dead plants of bathurst burr, bishop's weed, cobbler's peg, noogoora burr, thornapple and turnipweed. Another new species, *Diaporthe masirevicii,* which has moderate virulence on soybean and sunflower, has also been isolated from living plants of the weeds bitou bush, sesbania and turnip weed.

These findings are highly significant and have important implications for northern farming systems. Firstly, *Diaporthe* species have been shown to be capable of being (i) pathogens of a range of crop and weed species causing stem lesions (in mungbean, sunflower, soybean and weeds), lodging and yield loss in sunflower when conditions are conducive, and early senescence, pod infection and yield loss in soybean, lesions and early senescence in mungbeans in wet or irrigated conditions (2015 trial) (ii) saprophytes by invading dead plant residues of many crops and weeds, and (iii) potential endophytes which invade plants of certain hosts, eg., *D. gulyae* in maize without displaying symptoms.

'Green' and 'brown' bridges. Consequently, depending on the *Diaporthe* species, living volunteer plants of crop hosts and living plants of weeds in paddocks and adjacent areas can act as the "green bridge" between highly susceptible crops, while colonised dead plants and stubble of crop and weed hosts can act as the "brown bridge" between major crops. Almost 30 months after the severe *Diaporthe* lodging event in sunflower crops on the Liverpool Plains in 2010, *D. gulyae* was isolated from crop stubble lying on the soil surface after zero till farming practices and two cereal crops planted into the sunflower stubble.

Results of a 2015 stubble *Diaporthe* spp. trial in the Lockyer Valley are in the process of being collated – sunflower, soybean and mungbean planted into an irrigated site with treatments of infected stubble on the surface, stubble incorporated and a fallow. The aim of the trial is to investigate the effect of infected stubble on crop infection, early senescence and potential yield loss.

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.

The support of the private seed companies in providing seed, trial sites, planting, trial upkeep and background advice on genetics and maturity types has been invaluable – without this input much of this work could not have been done.

Molecular identification by DAFQ Ecosciences colleagues and other interstate and international scientists has also been essential to the findings of this research.

The authors also thank staff of Hermitage Research Station (Warwick), J Bjelke-Petersen Research Facility (Kingaroy) and staff of the Regional Agronomy Initiative (Toowoomba, Emerald) for their assistance with various field trials.

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Emerging insect threats in northern grain crops

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Keywords

Etiella, bean podborer, crown borer, planthoppers, soybean stemfly, scarabs

GRDC code

DAQ00196, DAQ00153

Take home messages

- Monitor crops frequently so as not to be caught out by new or existing pests.
- Look for and report any unusual pests/damage symptoms – photographs are good.
- Just because a pest is present in large numbers in one year doesn't mean it will necessarily be so next year – it maybe the turn of another spasmodic pest, e.g. soybean moth, to make its presence felt.
- However be aware of cultural practices that favour pests and rotate cops each year to minimize the build-up of pests and plant diseases.
- For Lucerne crown borer - Monitor and report any early beetle activity, Split stems to determine the first signs of larval feeding. Be aware of the damage symptoms of other stem borers, notably etiella and soybean stem fly.
- Soybean stemfly - Check plants regularly for any stem damage and distinctive stemfly exit-holes. Look out for and report any suspected stemfly activity. Be aware of other-stem tunnelling pests. Use crop rotations to avoid a build-up of soil borne diseases, the damage symptoms of which are often wrongly attributed to stemfly. Please contact project DAQ00196 entomologist Hugh Brier before spraying (0428 188 069).
- Etiella - Once larvae are inside pods or stems, they cannot be reached with insecticides. The thresholds are indicative therefore of what would be recommended if etiella behaved as *Helicoverpa*, i.e. if larvae were reachable by insecticides after they are first detected. However the indicative thresholds are useful as they show that what would be concerning levels of *Helicoverpa* attack (e.g. 5-6 larvae/m^2) are of no economic consequence for etiella. In practice, more emphasis needs to be put on early detection of the infestations. In vegetative crops, the early warning signs are damaged and dying auxiliary buds, as well as increasing moth activity. In lentils, there is a sweep net threshold of 1-2 moths per 20 sweeps. However lentils are a much shorter and softer crop than mungbeans and soybeans. In heavily infested mungbeans on the Downs, etiella moths were extremely difficult to catch in sweep nets, making it difficult to estimate moth density. The alternative would be to use traps, be they pheromone, bait or light traps. Further development is required to refine the design/use of these to make them more user-friendly. Agronomists and growers should monitor their mungbean and soybean crops this coming summer and report the first signs any suspicious activity.

Introduction

Recent seasons have seen a plethora of seemingly new pests and unusual damage in pulse and grain crops. The most notable examples are etiella up to 60/m^2 in vegetative and podding soybeans and mungbeans, severe scarab damage in sorghum and winter cereals, bean podborer west of the

Divide, the appearance of soybean stemfly in regions adjoining the Downs, well south of its ‘normal’ range, and plague numbers of a mystery planthopper in in mungbeans, sorghum and millet last summer. Key questions directed to GRDC’s Northern Gains IPM project DAQ00196 are:

(a) What damage are these pests doing?
(b) Is their damage economic?
(c) Will they continue to escalate? and
(d) Can they be economically controlled?

This paper describes each of these pest problems, and discusses possible management options, including the economics of doing so.

However before delving into specifics it is worthwhile reflecting on the bigger picture. These reflections can be put into context with the following questions; (a) “What have we done to deserve these pests”? and (b) “Will these pests decimate our industries”?

The answers to the first are “Maybe nothing, except growing crops that host these pests”. However in some cases we may have inadvertently adopted cultural practices that favour the pests, such as planting the same crop in successive years in the same paddock. It may also be (in some cases definitely so) that the seasons favoured the pests development, be it due to non-crop hosts, or a decline in the predatory and parasites insects (beneficials) that attack them.

The answer to the second question (Will these pests decimate our industries?) is “Hopefully not”! It should be remembered that pest populations can fluctuate widely, and that some major pests such as green vegetable bug and silverleaf whitefly, were conspicuous by their low activity last summer. Just because a pest is abundant one season, or for a number of season’s, doesn’t mean it will be a major issue every year. It maybe that some of the ‘crazy’ seasons (climatically) we have experienced lately have led to a disconnect between pests and the beneficial insects that normally regulate their numbers. This phenomena has often been observed with exotic incursions (e.g. with soybean aphid and soybean loopers), where massive populations observed during the early phase of the incursion were eventually stabilized (in most seasons) by native beneficials. On the other hand, it may be that warmer seasons have favoured pest development and in some cases, worsened their damage, as is the case with lucerne borer.

Etiella background

In the GRDC Northern Region, etiella (*Etiella behrii*) has (until recently) been regarded as a significant peanut pest, but only a spasmodic pest of other summer pulses. Etiella normally attack pods, but in 2013 and 2014, larvae caused significant damage to the auxiliary buds (precursors of the floral buds) and stems of vegetative soybeans in southern Qld and northern NSW. Similar but not as widespread stem damage was reported in mungbeans. In some South Burnett soybean crops in 2014, etiella activity continued well into late podfill, populations peaking at > 40 larvae/m^2. Significant etiella activity carried through into the spring/early summer of 2014/15, historically high pod damage being widely reported in spring-planted mungbeans from Central Qld to Central NSW. Fortunately, etiella activity was much lower in most 2015 summer-planted crops.

Etiella R, D&E

Then project DAQ00153 and now DAQ00196 responded to the etiella outbreaks by:

1. Documenting etiella activity and densities in commercial crops including describing (and photographing – see below) the damage in detail and differentiating the damage from that inflicted by other stemborers and podborers.
2. Quantifying the damage with the aim of developing economic thresholds
3. Evaluating a number of management options, including insecticides already registered or under permit in the crops in question, or registered in other crops against etiella. Note that because

they are not registered for etiella control in summer pulses, they cannot be identified in this paper.

4. Extending these findings where appropriate to industry, e.g. through GRDC Updates or the BeatSheet Blog.

Figure 1. (clockwise from top left) Damaged axilliary buds and stem in vegetative soybeans, Etiella larva in soybean pod showing only 1 seed nearly completely damaged, Etiella larvae in mungbean pod showing multiple seeds partially damaged per larva, Infested mungbean pod (magnified) showing microscopic Etiella entry hole, and damaged pod with clearly visible and much larger larval exit hole.

Etiella findings/ vegetative soybeans

- Assessments of soybeans severely damaged at the mid vegetative stage showed larvae initially feed inside the plants axilliary buds, before tunnelling in the plant's pith. About 75% of plants were infested in a Branchview crop, larval density in infested plants averaging 4 per plant, or 60 per square metre. The resultant damage killed a large proportion of the main stems, but the first signs of attack were the pale damaged and dying axilliary buds.
- Data from this site showed a significant (P <0.001) 70% reduction in main stem length but only a 21 % reduction in total stem length (main stem + side branches). This resulted in a commensurate but significant (P = 0.001) 20% reduction in total pod numbers, equating to (in this crop) 9 pods fewer per damaged plant.
- This suggests a theoretical threshold of approx. 2 infested plants per m^{2}or, for a plant density of 25 plants/m^2, a threshold of 10% infested plants. This assumes an etiella per plant

density as recorded in this trial site, namely 4 larvae/infested plant. In practice at lower % plant damaged levels, larval density per plant may well be less than 4/plant, resulting in less damage per plant, and therefore a higher tolerable % plants damaged threshold.

- Note that for grass blue butterfly larva e which also damage auxiliary buds, stems and vegetative terminals, the threshold is 25% of plants damaged.
- The term 'theoretical threshold' is used, because larvae would have to be controlled before move from the auxiliary buds into the stems, inside which they are safe from insecticides.

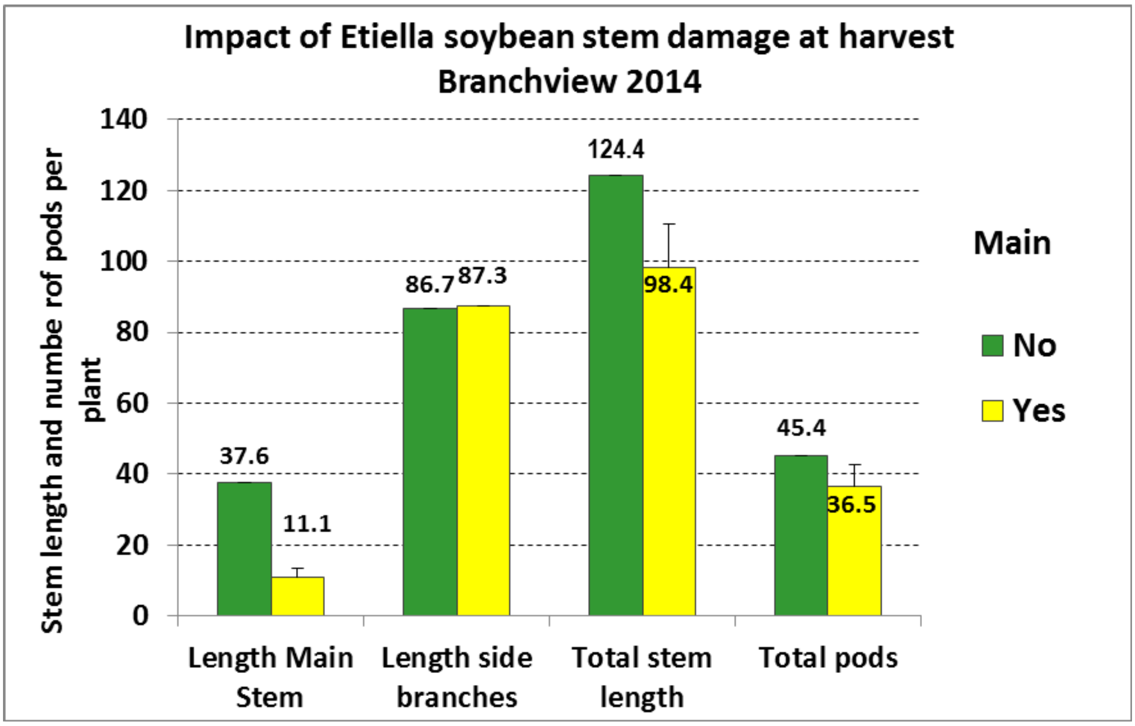

Figure 2. Impact of *Etiella* (E*tiella behrii*) damage to the final size (as measured by stem length and pod numbers) of vegetative soybeans at harvest. Note that total stem length and total pods were positively correlated (P<0.001).

Etiella findings/ podding soybeans

- etiella damage was also studied in a late podfill crop of South Burnett soybeans. The majority of larvae fed on only one (1) seed, consuming the seed totally, and confining their activity to one seed cavity. This means there is very little impact on seed quality as the seed remnants are lost at harvest. In soybeans, one seed totally eaten equates to 2kg/ha per larva/m^2. In contrast, the yield loss per *Helicoverpa* /m^2 is 40kg/ha
- Because the yield loss per etiella is so low the theoretical threshold is commensurately high. For example for a crop value of $600/t, and control costs of $36/ha, the respective thresholds for etiella and *Helicoverpa* in podfilling soybeans are 30 and 1.5 larvae/m^2 respectively.
- The term 'theoretical threshold' is used, because larvae would have to be controlled before they burrow into pods. Recent DAF trials show that once inside pods, larvae inside pods at the time of spraying are unaffected by insecticides.
- There is anecdotal evidence that when insecticides were applied under now lapsed permits, that the best results were achieved when they were applied at the first sign of significant moth activity. This agrees with the guidelines for etiella control in lentils in Southern Australia.

Etiella findings/ podding mungbeans

- Assessment of damaged pods from infested spring mungbeans shows that as in soybeans, each larva only damages one pod, but that on average, each larva partially damages nearly 4 seeds. Because seeds are only partially damaged they are therefore far more likely to end up in harvested seed, and therefore have the potential to downgrade seed quality.
- Harvested etiella seed damage was as high as 9% in some spring crops but was overshadowed by seed staining as high as 25% (due to weathering of the 1st pod flush). Nonetheless, growers still received $1000/t for manufacturing beans.
- Further samples are being assessed to determine the impact on seed quality for a crop where etiella damage is the quality-limiting factor.
- Regarding potential thresholds, an average 'good mungbean crop' with 10 pods/plant, and 9 seeds/pod, and 25 plants/m^2, would require 12 etiella larvae/m^2 to give 2% damage (@ a yield of 1.6t/ha). Critical etiella numbers to give 2 % seed damage (assuming all damaged seeds were retained at harvest) would be higher or lower in higher and lower yielding crops respectively. In practice, larval thresholds would be lower than that required to inflict the critical 2% damage level, as the potential quality downgrade would be much greater than the cost of control.

Conclusions and where to from here for etiella?

- Once larvae are inside pods or stems, they cannot be reached with insecticides. The above thresholds are indicative therefore of what would be recommended if etiella behaved as *Helicoverpa*, i.e. if larvae were reachable by insecticides after they are first detected. However the indicative thresholds are useful as they show that what would be concerning levels of *Helicoverpa* attack (e.g. 5-6 larvae/m^2) are of no economic consequence for etiella.
- In practice, more emphasis needs to be put on early detection of the infestations. In vegetative crops, the early warning signs are damaged and dying auxiliary buds, as well as increasing moth activity. In lentils, there is a sweep net threshold of 1-2 moths per 20 sweeps. However lentils are a much shorter and softer crop than mungbeans and soybeans. In heavily infested mungbeans on the Downs, etiella moths were extremely difficult to catch in sweep nets, making it difficult to estimate moth density.
- The alternative would be to use traps, be they pheromone, bait or light traps. Further development is required to refine the design/use of these to make them more user-friendly.
- Agronomists and growers should monitor their mungbean and soybean crops this coming summer and report the first signs any suspicious activity. As a final observation, the Peanut Company of Australia reported negligible etiella in their 2015 peanut intake, hopefully a good omen for next summer.

Bean podborer (*Maruca vitrata*)

Bean podborer is an example of a pest that fluctuates widely with the seasons. Huge numbers (>100/m^2) were observed in the wet summers of 2012 and 2013, but numbers crashed in the very dry summer of 2014 and were lowish again last summer. Then GRDC project DAQ00153 took advantage of these outbreaks and generated efficacy data that secured the registration of Altacor® (chlorantraniliprole) against this pest. Altacor is very effective against podborers, killing larvae hidden inside the buds. However larval death is not immediate. While feeding stops very quickly, larvae remain moribund for 3-4 days (shrunken and darkened), before dying. This moribund state is also observed in **Helicoverpa** and other caterpillars.

The key to successful control is to monitor the crops closely from early budding and target larvae before they move from the flowers to the pods. Cultural controls include getting rid of legume weed hosts such as sesbania. Other favoured hosts include pigeonpea and adzukis.

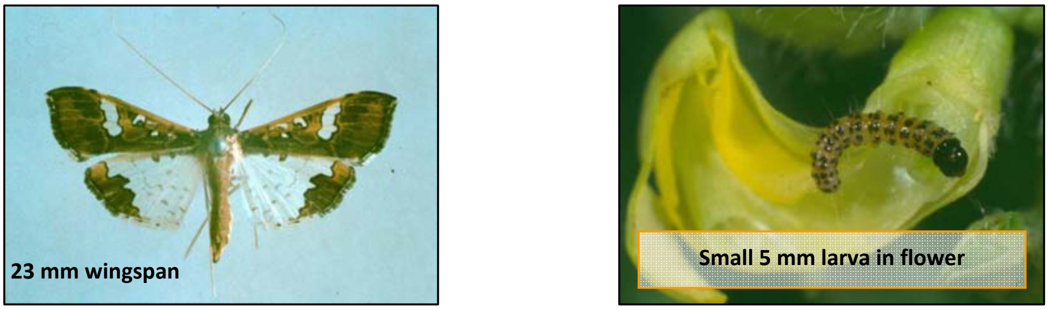

Figure 3. Adult and larva of bean pod border (*Maruca vitrata*)

Lucerne crown borer (Zygrita diva) (LCB)

Lucerne crown borer has been on the increase in recent years, with reports of up to 90% of plants infested and early plant deaths in some crops. Areas infested ranged from coastal Qld to Central NSW, and included the Downs. Damage was worse in early planted (Oct/Nov) crops. In some crops, larvae girdled plants prior to pupation as early as February when crops were only at the pod set stage. The resultant plant deaths severely reduced yield. This premature pupation was triggered by prolonged high temperatures and low rainfall, both of which lead to crop stress which is a major trigger for early pupation in crown borer.

Unfortunately because of its biology and feeding behaviour, there are no silver bullets for managing this pest, nor are there for very similar overseas beetle pests, e.g. the soybean stem borer (*Dectes tetanus*) in the USA.

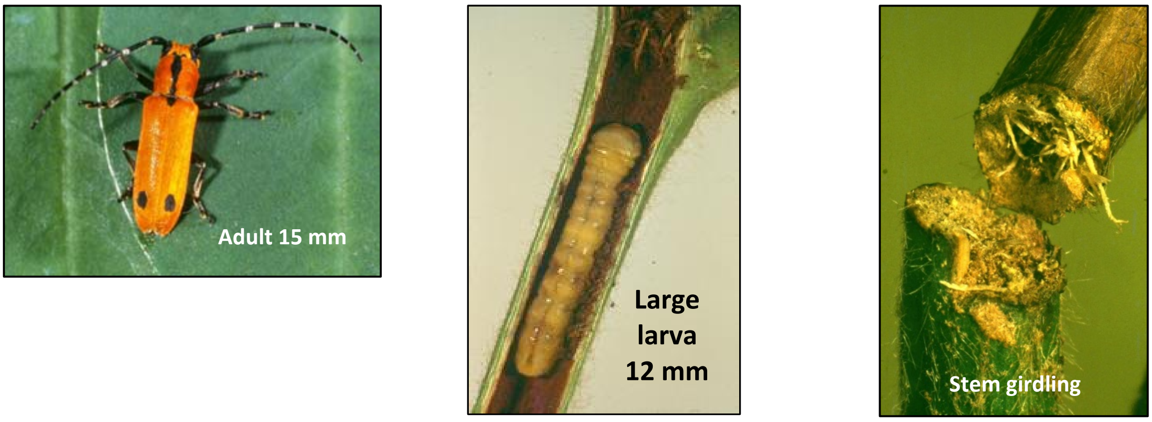

Figure 4. Adult, larva and effect of Lucerne crown borer (*Zygrita diva*)

Biology and damage

LCB overwinter as pupae in soybean stubble and beetles emerge in the spring/early summer. They are not strong fliers, and soybeans in paddocks planted to soybeans last year, or adjacent to such paddocks, are at greater risk. Proximity to other hosts such as lucerne or pigeon pea is also a risk factor. Adult LCBs lay eggs in the outer stems of young plants. Hatching larvae tunnel immediately into and feed on the stem pith, i.e. not the vascular tissue. Larval feeding in the pith by itself does not affect yield. However, the drying down of crops as they approach harvest maturity triggers LCB pupation, and early maturing cultivars are at increased risk. Heat stress earlier in the life of the crop can also trigger pupation, especially in early planted crops.

Larvae internally ringbark (girdle) the vascular tissue in the lower stem to plug the pith tunnel, before pupating in the tap root. If pods are not yet set or filled, yield losses can be severe. However, yield losses are far lower where pupation occurs when pods are nearly or fully filled, provided damaged plants do not lodge before harvest**.** Late pupation is the norm in cooler summers. ***Note that other pests can tunnel in soybean stems, notably etiella and soybean stem fly.***

Chemical control

Chemical control of LCB larvae is impossible, as they feed in the pith and cannot be reached, even by systemic insecticides or those with 'upwardly xylem mobility'. No insecticides are registered against LCB but dead LCG adults (beetles) have been reported in crops sprayed that are targeting *Monolepta* (a leaf-feeding beetle pest). However as crops are often invaded by LCB beetles over an extended period of time, multiple sprays would be required to give satisfactory protection.

Cultural control

Cultural control offers the greatest hope of managing this pest effectively and sustainably, without creating secondary pest problems. Specific strategies include.

- **Crop rotation:** Don't plant soybeans in the same ground as last year, and where possible, locate crops as far as possible from last year's plantings. Similarly avoid plantings into or close to lucerne. Crop rotation is also a key strategy to reduce the build-up of inoculum of soil bore diseases such as charcoal rot and phomopsis.
- **Weed control:** Eliminate weed hosts such as phasey bean, sesbania and budda pea.
- **Time of planting:** Avoid early plantings which greatly increase the risk of early damage.
- **Post-harvest cultivation:** Aim to split stems and burry stubble to a depth of at least 10 cm. Splitting tap roots destroys LCB's overwintering refuge, and burying stubble to reduce the emergence of beetles in the following spring. This is a key strategy as it attacks the pest at its most vulnerable stage. While any cultivation runs counter to zero till philosophy, strategic cultivations would also reduce the build-up of inoculum of key soil bore diseases such as charcoal rot and phomopsis.
- **Minimize lodging:** Have thicker plant stands in which girdled plants are more likely to be supported by adjoining plants.
- **Minimise water stress:** In irrigated crops, don't allow crops to become stressed, as stress can trigger early plant girdling. In dryland crops, potential crop stress is a major reason to avoid early plantings, as larger plants need more water.
- **Harvester set up.** Set harvester up to pick up any side branches that have drooped or plants that have lodged due to LCB damage.

Key crown borer messages

- Monitor and report any early beetle activity
- Split stems to determine the first signs of larval feeding
- Be aware of the damage symptoms of other stem borers, notably etiella and soybean stem fly.

Soybean stemfly (*Melanagromyza sojae*)

A major outbreak of this pest occurred in soybeans in the Casino region of NSW in 2013. To the author's knowledge, the only previous reported Australian outbreak was in the Proserpine region in 2009. Since 2013, stemfly populations have declined in the Casino region, most likely due to parasitism, significant levels of which were observed in late summer of 2013. Stemfly have also been detected in other soybean growing regions, including the South Burnett in SE Qld, but not in damaging numbers. It is likely that the pest will be always present in coming seasons, but hopefully only periodically in really damaging numbers. To date, there have had no reports from the Downs but it is possible the pest is present in this region in numbers not high enough to date to draw attention.

Soybean stemfly adults are small (2 mm) and black with reddish eyes and are very similar to bean fly (*Ophiomyia phaseoli*) which is a major navy bean pest. Eggs are laid in the leaves and larvae tunnel down the petioles to reach the stem. Unlike beanfly, stemfly larvae tunnel in the stem pith and make a distinctive exit hole before pupating. Note that stemfly damage look very similar to that caused by crown borer and etiella. Note also that the feeding in the pith has little if any effect on plant health.

Many infested crops near Casino exhibited a 'sudden death' syndrome during early podfill (leaf yellowing and plant death). However, the real culprit in many instances was most likely soil borne disease such as charcoal rot and phomopsis. These diseases are triggered by plant stress and inoculum build-up due to successive soybean crops in many paddocks.

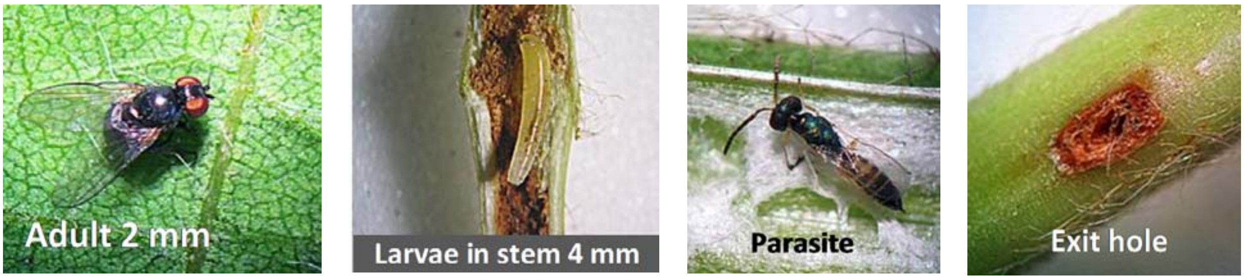

Figure 5. Adult, larvae, parasite and exit hole of Soybean stemfly (*Melanagromyza sojae*)

Control

There are no well-defined stemfly thresholds. In navy beans the beanfly threshold is one tunnel per plant in seedling plants. But in soybeans, stemfly normally attack older plants. Only spray if stemfly are present in 'reasonable' numbers (numerous larvae per plant) and there are increasing unhealthy plant symptoms that are NOT disease related. Note that diseases such as charcoal rot and phomopsis are manifested by poor root development, distinctive stem discolouration and leaf discolouration and death, and eventual plant death.

If you do spray, target the larvae before they reach the stems. Once inside the stems, larvae cannot be controlled as they are feeding on non-vascular tissue. Note that Casino crops that were sprayed with the beanfly rate of dimethoate (800 mL/ha) in 2013, experienced an explosion of white fly numbers, from already very high levels.

If you do spray, please leave an unsprayed strip to evaluate the efficacy of the spray on the pest and plant health, and its impact on secondary pests such as whitefly.

Take home messages

Check plants regularly for any stem damage and distinctive stemfly exit-holes. Look out for and report any suspected stemfly activity. Be aware of other stem tunnelling pests. Use crop rotations to avoid a build-up of soil borne diseases, the damage symptoms of which are often wrongly attributed to stemfly. Please contact project DAQ00196 entomologist Hugh Brier before spraying (0428 188 069).

Large mystery planthopper *Oteana lubra* (Cixiidae)

Very high numbers of a large planthopper *Oteana lubra* (no common name and formerly *Oliarus lubra*) were reported last summer in mungbeans on the Darling Downs and in North West NSW. The bulky hoppers are 9-10 mm long and pale brown/grey with a fluffy white rear end (see figure 6). They have been observed in previous years in low numbers (usually <1/m^2) in mungbeans and soybeans. However this year, populations in excess of 100 per 20 sweep net sweeps were observed in some crops. This most likely equates to an absolute population in excess of 20/m^2. All hoppers sampled were adults, i.e. there were no nymphs. This is because the nymphs of this planthopper group are root feeders, often of grasses.

Figure 6. *Oteana lubra* (Cixiidae)

Damage

Damaged pods suggest they are not as damaging as first feared. Close examination of mungbean pods from heavily-infested crops revealed numerous feeding stings on the external pod wall, but extremely few stings on the seeds, or on the inside pod wall (see figure 7). Plotting the data showed no relationship between the number of external stings, the number of stung seeds (the very few present may have been stung by podsucking bugs), and the total number of filled seeds per pod.

To further assess damage, caged mungbeans (2 rows x 1.5m) at the R4 stage were infested with *O. lubra* at a density of 20 adults/m^2. After 2 weeks, no live hoppers were present in the cage, suggesting mungbeans are not a suitable for *O. lubra,* or that the adults were short lived. Seed samples from this site are still being assessed for damage.

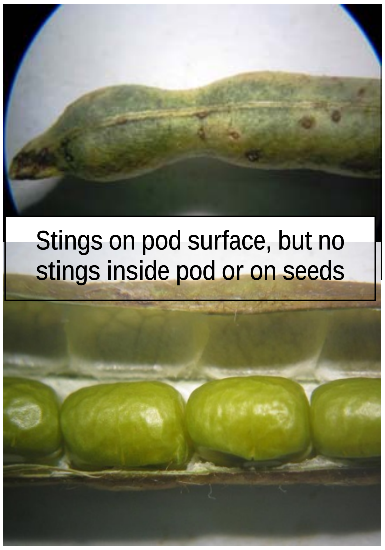

Figure 7. Damage by *Oteana lubra* showing stings on pod surface, but no stings inside pod or on seeds

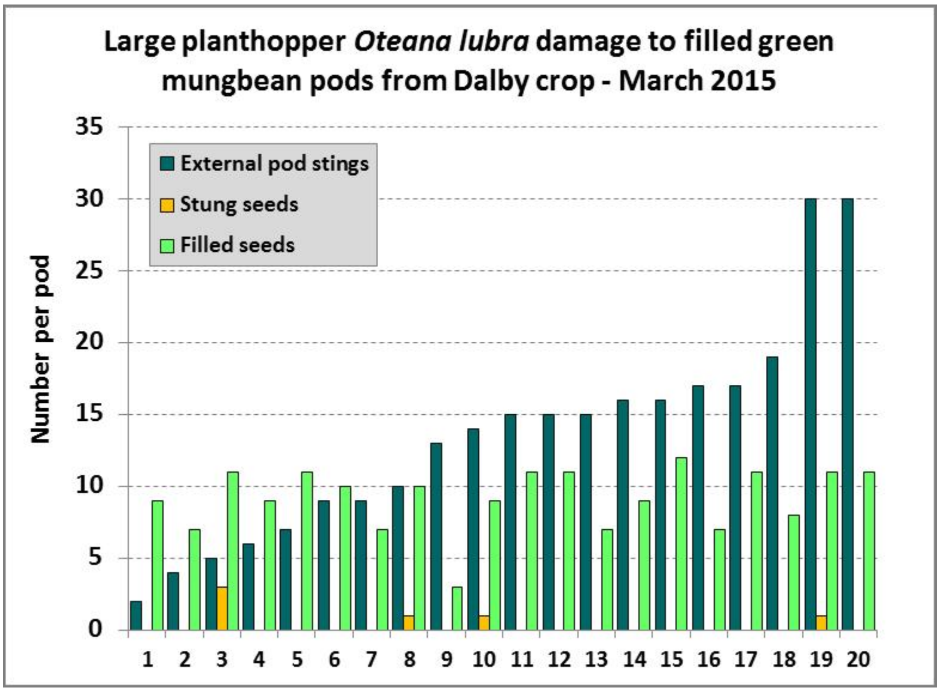

Figure 8. Number of external stings per pod made by planthopper *Oteana lubra,* ranked from lowest to highest, versus the number of stung seeds, and the total number of filled seeds per pod. Note the lack of correlation suggesting no impact on yield or quality.

Other hosts of adult large planthopper *Oteana lubra* include (DAF and other records):

- Chickpeas at Breeza, NSW
- Faba beans
- Ex cotton or lucerne (?) at Warren, NSW
- Sorghum & Millet – Downs 2015
- Sugarcane at Bundaberg, Qld
- Rice
- Potato at Gatton, Qld
- Sandalwood near Eulo and Pittsworth, Qld

- *Eucalyptus citriodora* near Moree, NSW

Control

Dimethoate at 800mL/ha is registered) for jassid/leafhopper control in mungbeans and a range of other grain legumes. In soybeans, the registered rate of dimethoate for Jassids/leafhopper is 340 mL/ha.

If any crops are sprayed next summer, please leave an unsprayed strip so that the impact of spraying can be assessed. In view of the assessments of damaged pods from heavily infested crops, spraying may be unnecessary. This is even more reason to leave unsprayed strips. Please also report any outbreaks to Hugh Brier or Melina Miles.

Take home observations for all above pests

- Monitor crops frequently so as not to be caught out by new or existing pests.
- Look for and report any unusual pests/damage symptoms – photographs are good.
- Just because a pest is present in large numbers in one year doesn't mean it will necessarily be so next year – it maybe the turn of another spasmodic pest, e.g. soybean moth, to make its presence felt.
- However be aware of cultural practices that favour pests and rotate cops each year to minimize the build-up of pests and plant diseases.

Acknowledgements for summer pulse research in DAQ00196

GRDC and DAF for providing financial support for Northern Grains IPM project DAQ00196. We are also grateful for the assistance and feedback provided by numerous agronomists, growers and Pulse Industry personnel (including Pulse Australia) throughout the GRDC Northern Grains region. Finally, we acknowledge the invaluable technical support of Joe Wessels, Wendy Sippel, Adam Quade and Kaela McDuffy, and of Scott Campbell and the Kingaroy Research Station farmhand staff.

Scarabs on the Downs, what do we know about them and can they be managed?

Overview of the problem to June 2015 (Melina Miles)

In February 2015, DAF Entomologists were contacted by several agronomists about the severity of damage to sorghum being caused by scarab larvae in the Jondaryan and Pampas areas. The agronomists reported that the problem had worsened over the past 5 years with persistently affected paddocks suffering up to 80% loss of sorghum. Losses in winter cereals have been recorded previously (Jondaryan, Jandowae and Clifton 2010). Anecdotally, cotton does not appear to be affected, but one record of severe damage to cotton in CQ was recorded in the mid-2000s. Sorghum and summer pulses and, in some seasons chickpea, are severely affected. The frequently observed pattern of crop loss in sorghum is that the crop establishes well, but within 4-6 weeks it is evident that plants loose vigour and show symptoms of wilting, yellowing and retarded growth are observed.

Figure 9. Scarab larva (left), in situ in the roots of sorghum (centre) and wheat (right)

Figure 10. Aerial view of scarab damage to sorghum (2015).

View video of affected fields at https://youtu.be/q6MptMKvT9U

Previous reports of scarab damage in the region have been sporadic. DAF entomologists have visited a number of farms over the past 3-5 years to inspect scarab damage. In all these instances there was a strong relationship between scarab damage and a recent history of pasture and/or grassy weed infestations in the affected fields. There is also anecdotal evidence that sorghum on sorghum rotations are more likely to have severe scarab problems in the affected regions. Historically, scarab damage in crops has been sporadic and associated with wetter than average seasons. Sustained scarab pressure in the same cropped fields over many years is unusual.

Between February and May 2015, DAF entomology in Toowoomba received reports of severe scarab damage in mungbean, maize, sorghum, and millet. During May, there was concern by agronomists, who had had significant crop loss in sorghum, in regard to the prospects of chickpea crop to be sown back into the affected fields. Reports were concentrated on the area between Macalister and Jondaryan, with a small number from further south into northern NSW.

Species status and biology of scarabs. (Coleoptera: Scarabaeidae)

At this point there is not a definitive identification of the species common in the affected fields.

Peter Allsopp (pers comm) has suggested that the species may be the Black Soil Scarab (*Othnonius batesii)*, based on the incidence of this species the 1960-1970s on the Downs. Adult beetles are needed to confirm the identity of the scarab.

If the species is *O. batesii*, then this is what is known about it from the work 40+ years ago:

- It is a native species, more commonly associated with damage to pasture.
- It has a 2 year lifecycle, which may be extended to 3 years if food quality or conditions are poor (fallow, no grasses, dry conditions)
- Beetles emerge from October to March. Females lay eggs into the soil. Eggs are present from November – March.
- There are 3 larval instars. 1st instar larvae feed on organic matter and are present from December to October. 2nd and 3rd instar larvae feed on plant roots and are present all year.
- Larvae feed on the roots, impacting plant vigour and root expansion. This limits access to soil moisture and nutrition and consequently plant survival and yield.
- Larvae pupate after 18 months and develop into beetles. The beetles remain in the soil until rainfall in spring-summer (13 mm+) which softens the soil making it possible for them to emerge.
- Beetles may disperse, or remain in/close to the fields from which them emerge; they mate and lay eggs.
- Cultivation (with a mouldboard plough) was found to reduce larval densities by 50-90%.

Management of scarabs in other crops, and options for the grains industry

The most comprehensive management plans for scarab pests in Australia have been devised by the sugar industry for the cane grub species. The sugar system is dominated by a need to minimise canegrub damage to cane crops for up to three to five years. Consequently it is comprised of a number of options designed to detect and assess risk, to suppress (trap cropping) and control (insecticide and fungal pathogen) canegrub populations. Management in cane integrates a number of options.

Current scarab research

Scarabs are not one of the priority pests identified for inclusion in the activities of the current GRDC investment in Northern Region entomology (DAQ00196). However, in response to the outbreak in 2015, the DAF entomology team has commenced research on this pest.

Current activities:

1. Species identification and clarification of lifecycle
    a. Collections of larvae from affected fields have been made and are being reared through to adult beetles in the laboratory so that the species/s can be identified.
    b. Survey larval populations through the year. Determine timing of larval development and risk to summer and winter cropping.
2. Mapping distribution of damage in affected fields using drone technology

   a. The use of the drone to inspect fields aerially at field scale has been invaluable in identifying affected areas of crop and the spatial distribution and infestation severity. A new drone with ground-link GPS capability has been purchased to further facilitate the mapping of affected areas so that long term monitoring of patches with different crop and management histories is possible.
   b. On a practical level, mapping patches of scarab infestation will assist in targeting strategic tillage or in-furrow insecticide application and may overcome the negatives associated with cultivating the entire field where only a portion is currently infested (potential application)

3. A small plot trial (in conjunction with Pacific Seeds) evaluating the efficacy of seed dressings and in-furrow treatments to protect establishing sorghum (completed May 2015).
   a. This trial has shown that there are both seed dressing and in-furrow insecticide treatments that result in significantly improved crop establishment and development. These products are currently not registered for scarab control, so data generated from this research will be used to support label extensions. These results will now be built on in 4.
4. Small plot chickpea and wheat trial to evaluate the impact of at-sowing treatments (seed dressing, sowing depth) on crop establishment. This trial will be sown into the same heavily infested field in the Jondaryan area in May 2015.
   The aims of this experiment are to:
   a. Determine the potential value of seed dressings in establishing chickpea – potentially generating data for permit/s and registration of products
   b. Evaluate the benefit or risk of deep sowing chickpea in scarab-infested fields
   c. Determine the susceptibility of wheat to scarab damage and characterise the damage caused to both wheat and chickpea seedlings.
5. Tillage trials that examine the impact of timing and implement (disc vs chisel/sweep) on larval survival. Planned for winter – spring 2015.

Acknowledgements for scarab research in DAQ00196

GRDC and DAF provide financial support for this research (DAQ00196). We are grateful to the assistance provided to undertake this research by agronomists and growers on the Downs, in particular Trevor Philp (PacSeeds), James Ryder, William Speed, John and Paul Griffiths. Trevor Philp (PacSeeds) sowed the sorghum seed treatment and in-furrow trial.

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Northern Region
GRDC Grains Research Updates-August 2015

TITLE - 'Alternative uses for Sorghum'

PRESENTER – Ross Naidoo (Qld DAF)

Sorghum Origin and use

CGAR

- Sorghum originated in north-eastern Africa, with domestication having taken place there around 5,000–8,000 years ago.
- The largest diversity of cultivated and wild sorghum is also found in this part of Africa.
- The secondary centre of origin of sorghum is the Indian Subcontinent, with evidence for early cereal cultivation dating back about 4,500 years. (CGAR)

Sorghum Human Food use

(Demand)

CGAR

- Traditional foods made from sorghum include:
- ***unfermented*** *and* ***fermented breads***, ***porridges***, ***couscous*** and ***snacks***, as well as ***alcoholic beverages***.
- ***Sorghum*** blended with ***wheat flour*** has been used over the last ***two decades*** to produce ***baked products***, including ***yeast-leavened pan***, ***hearth*** and ***flatbreads***, ***cakes***, ***cookies***, and ***flour tortillas***.
- ***Malt drinks*** and ***malt cocoa-based*** weaning food and baby foods are popular in Nigeria. Hard endosperm sorghum is used extensively in ***SEA for Noodles***.

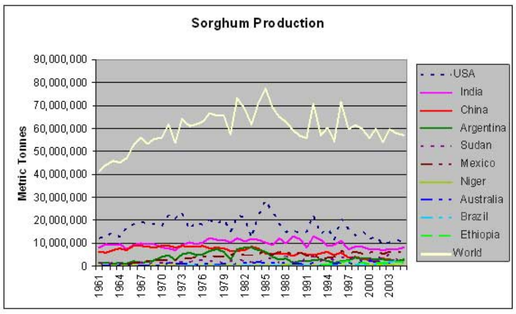
Sorghum Origin and Broader Use

(Demand) CGAR

- Sorghum grain is one of the major ingredients in ***swine, poultry and cattle feed*** in the western hemisphere, China and Australia.
- Sorghum is also ***grown for forage***; in northern India it is very common and fed to ***animals fresh or as silage or hay.***
- ***Sweet sorghum*** is used to a limited extent in producing ***sorghum syrup*** and 'jaggery' (raw sugar) in India and has recently gained importance in ***ethanol*** production.

Longitudinal Trend

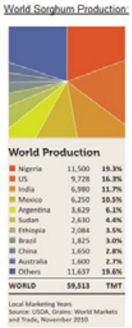
index mundi

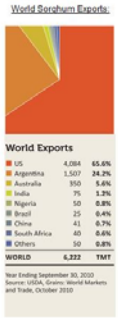


Global Snap Shot of production trends 60MT P/A

US Grain Council

-

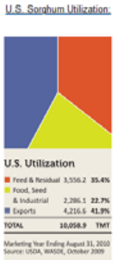




Global Sorghum Production

(US Grains Council)

- Sorghum production ranges from 40 MT/pa to 80MT/pa
- Approximately 16-32MT/pa used for human consumption.
- USA 30-40% energy production
- Leaving 1.5Mt Food & Seed



Market Map for Sorghum in South Africa and greater Africa (DAFFSA)

Figure 16: Sorghum Value Chain Tree: explaining its various uses.

Summary of uses

- ***Sorghum malt*** is used for the production of sorghum beer with an alcohol content of about 3%.
- ***Instant beer powder***: due to urbanization of the traditional users of home brewed sorghum beer.
- ***Sorghum meal***: also known as mabele is a very popular breakfast cereal. (It is processed in the same way as maize meal during the dry milling process.)
- ***Sorghum rice***: which compete with samp and wheat rice.
- ***Sorghum grits***: used in the industrial brewing process for the production of sorghum beer.

Quality Issues and technology opportunities (Grains milling.com)

- In a research paper entitled, “New Processing Alternatives for Production of Low Fat and Ash Sorghum Flour,” Florin Iva, a graduate student in the Department of Grain Science and Industry at Kansas State University, noted that most sorghum flour available in the market place is ***whole grain flour with inferior stability and baking characteristics.***
- ***“While the demand exists for high quality stable sorghum flour with low fiber and fat content, the current decortication step used for separating the bran from endosperm in sorghum milling is not economically viable”***
- The alternative techniques, which are based on abrasion and fractions, do a poor job and to increase endosperm loss.
- Success possible using a ***Buhler Experimental Mill***, a Great Western Gyratory Sieve and Quadrumat Brabender Sr. Experimental Mill.

Sorghum (Australia)

Qld DAF

- Grain sorghum is the ***main summer grain*** crop in most regions in ***Queensland***.
- Plays a key role in providing feed grains to the ***beef, dairy, pig and poultry industries***.
- Approximately ***60% of the Australian crop*** is grown in **Queensland** and the remainder in northern ***New South Wales***.
- Source Qld DAF

Sorghum (Australia)

Qld DAF and USDA

- The area of sorghum planted for grain in Queensland is normally **600,000-700,000 ha**.
- Average farm yields vary around ***2 -3 t/ha*** and reflects the ***severity of constraints***, such as water stress.
- USA **4.21 Mt/ha**
- World average is ***1.73 t/Ha***
- **Sorghum** grain production in 2014 is estimated at 433 million bushels (**10.98 million Mt**) , up 6 percent from the November forecast and up 11 percent from the revised 2013 grain production total. Planted area is estimated at 7.14 million acres (2.89 million Ha), down 11 percent from last year's revised planted acres. Area harvested for grain, at 6.40 million acres, is down 2 percent from the 2013 revised harvested acres. **Average grain yield**, at 67.6 bushels per acre (**4.21 Mt/Ha**), is up 1.5 bushels from the previous forecast and up 8.0 bushels from last year. (**USD Crop Production Summary 2015**). Abnormal claims up to 17Mt/ha
- Source Qld DAF and USDA

Sorghum (Australia)

Qld DAF

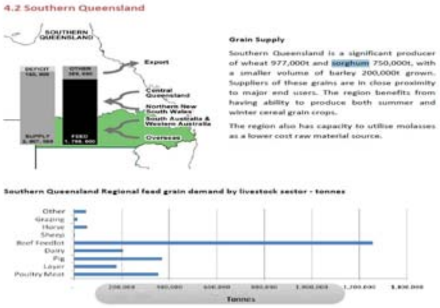
- ***None/ very little*** is used for ***human consumption*** and a ***significant market*** exists in the ***pet food industry*** (extruded)
- An ***export market*** of around **1Mt exists**, particularly to PRC and Japan, but the average long term amount exported is 300-500Kt*
- Around 29 species of sorghum exist though 25 are recognised and ***17 of these occur naturally*** in ***Australia*** (Source Qld DAF, UNSW)

Sorghum (Australia)

Qld DAF, UNSW, ABARE

- Species wise - ***Sorghum Bicolor*** appears to be the most mentioned in the commercial literature.(***Forage and Grain Sorghum***)
- Production range approximately ***1-2 million tonnes per annum***
- Value of the crop is estimated at between ***AUD500-600 million per annum***.
- Source: Qld DAF, UNSW, ABARE

Where the scale use of sorghum is in Australia (JCS Soultions)



4.2 Southern Queensland

Grain Supply

Southern Queensland is a significant producer of wheat 977,000t and sorghum 750,000t, with a smaller volume of barley 200,000t grown. Suppliers of these grains are in close proximity to major end users. The region benefits from having ability to produce both summer and winter cereal grain crops.

The region also has capacity to utilise molasses as a lower cost raw material source.

Southern Queensland Regional feed grain demand by livestock sector - tonnes

Sorghum (Marketing Possibilities)

CGAR

- Contains **11.3% protein**, **3.3% fat** and **56–73% starch.**
- It is relatively rich in iron, zinc, phosphorus and B-complex vitamins.
- Tannins, found particularly in red-grained types, contain antioxidants that protect against cell damage, a major cause of diseases and aging. (how do we leverage this for commercial outcome?)

Sorghum (Marketing Possibilities)

CGAR

- The protein and starch in sorghum grain are more slowly digested than those from other cereals, and ***relatively slower rates of digestibility*** are particularly beneficial for people with diabetes. Sorghum starch is gluten-free, making sorghum a good alternative to wheat flour for individuals suffering from celiac disease. (**resistant starch, levels 5-6 times* that of durum wheat potential exploitable point commercially??)**
- **Source: CGAR and Mereddy et al**

Sorghum (Marketing Possibilities)

CGAR

- Sorghum is a ***very good gluten-free energy*** source as many are allergic to gluten (**point commercially exploited**);
- Sorghum is apparently an important source of nutraceuticals such as antioxidant phenolics and cholesterol-lowering waxes. (**Phenolic content 3-7 times that of durum wheat potential exploitable point commercially??**)
- **Source: CGAR and Mereddy et al**

Sorghum (Marketing Possibilities)

- The average starch content of sorghum is 69.5% with 70 to 80% of this sorghum starch - ***amylopectin*** (*fast digesting associated with* ***insulin resistance**** *in rats*)
- The remaining 20 to 30% is ***amylose*** (*slow digesting associated with* ***normal rates of insulin resistance**** *in rats*); (***How to leverage this apparent fact to health advantage??***)
- **Source: Mereddy et al**

Sorghum Marketing Possibilities

Mereddy et al

- Building on health theme the **digestibility*** of isolated starch of sorghum cultivars ranged from **33 to 48 percent** (*proportionally lower*) as against **53 to 58** (*proportionally Higher*) percent for corn starches (61% starch content);
- (***How do we leverage this low digestibility as a positive commercial outcome???)***

Sorghum Marketing Possibilities

Mereddy et al

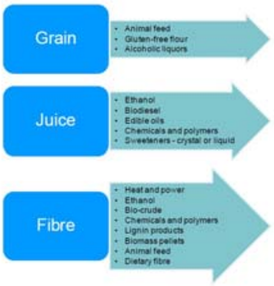
- The presence of **tannins** in the grain also contributes to the ***poor digestibility, increased resistance levels*** of starch in some varieties of sorghum;
- **Low digestibility** is a major negative issue in the use as animal feed but may be a **positive in human society where obesity/diabetes is a major concern, how do we leverage this fact commercially?**

Sorghum (Marketing Possibilities)

Mereddy et al

- Hopefully some interesting possible health facts and figures to drive your interest around, ***'resistant starch', tannins, high in low-amylose starch, etc.***
- Lets step back a little and look at what we could possibly pull out of sorghum from a ***whole grains approach***.

Sorghum (Whole Post Harvest Market & Business Perspective) RIRDCNo13/087



Sorghum (Marketing Possibilities)

RIRDCNo13/087

- Liquid and Semi Solid Sugar production – 'Jaggery', 'Gur' and 'molasses' – **Yes in market/non australian**
- Alcohol beverages – Beer, Mao Tai –**Yes in market**
- Sorghum flour (bakery-cereal style products) especially in *gluten free diets* or effectively as an ingredient in *small goods*, *deserts*, *anti-nutritional style snack foods*. **Infant to Emerging Industry Still Growing +**
- Animal/pets/ stockfeed extruded/flaked - **Yes products exist**

Sorghum (Marketing Possibilities)

RIRDCNo13/087

- *Ethanol* production modelling indicates 8130 L/ha possible –**Yes in market reality Dalby?**
- *Biodiesel* production-via microbial fermentation using heterotrophic algae –**No?, is there long term Market Opportunity?**
- *Hydrogen* and *Methane* production from anaerobic digestion from sorghum and waste sorghum- **No?, is there long term market opportunity?**
- *Cogeneration* ignition of waste in boilers –**No?, is there long term market opportunity?**

Sorghum (Market Possibilities)

RIRDCNo13/087

- Chemical Products ? (**more research required??**)
- Fibre and Textiles – **yes some use, possible more research in material sciences??**
- **Possibly examples of Sorghum products in the food, health and nutrition area might help to focus our investment focus as well.**

Jan 2015 -Sorghum Food Products Globally

- 2359 Products Listed for sale using Sorghum
- 2384 Variants of the above products

INNOVA MARKET INSIGHTS www.innovadatabase.com

Ingredients

Name	Count
Sorghum	2245
Rice	1397
Salt, Not Specified	1241
Calcium	940
Sugar	914

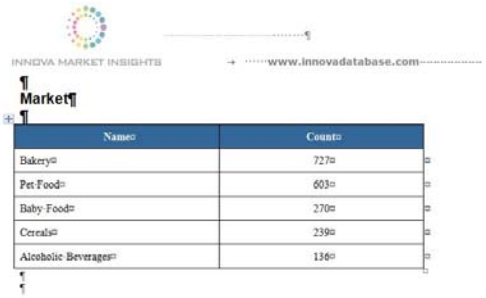
Jan -2015 Countries & Value Added Sorghum use

INNOVA MARKET INSIGHTS www.innovadatabase.com

Country

Name	Count
United States	805
China	210
Canada	121
Spain	118
Argentina	102

Jan 2015 -Markets



INNOVA MARKET INSIGHTS www.innovadatabase.com

Market

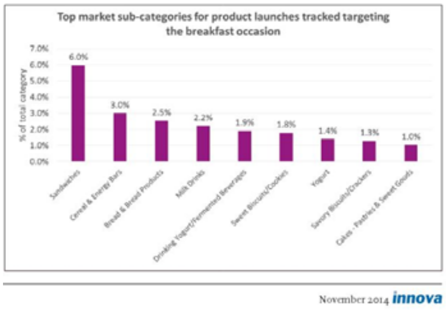
Name	Count
Bakery	727
Pet Food	603
Baby Food	270
Cereals	239
Alcoholic Beverages	136

Jan 2015 -Market category

Market Category

Name	Count
Dog Food	489
Sweet Biscuits Cookies	265
Baby Cereals & Biscuits	213
Baking Ingredients & Mixes	183
Breakfast Cereals	174

Ingredient wise this is the areas of use



Sorghum (Products in market)

innova database

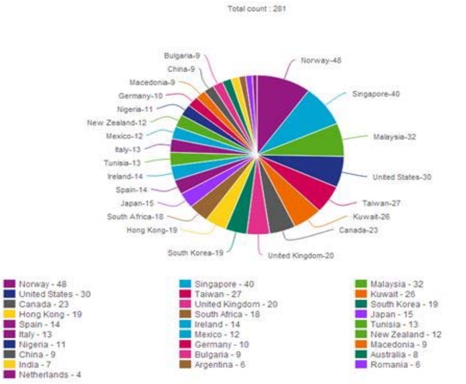
- **Lets see how many sorghum products are sold for clinical nutrition purposes**
- Sorghum and Clinical Nutrition sold globally - 0 products (***is this a possible future opportunity and how best should the science/technology be guided to achieve this outcome?***)
- Potential conclusion – **sorghum as ingredient is a current position**

Jan 2015 -Positioning

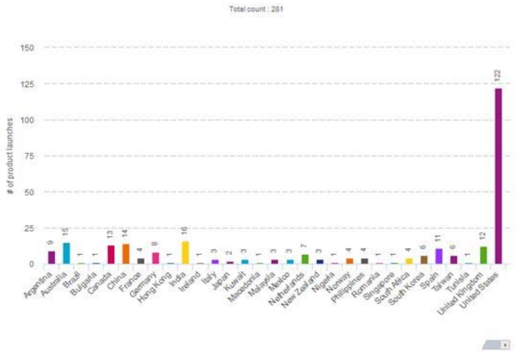
Positioning

Name	Count
Health (Passive)	1606
Convenience	1498
Health (Active)	934
Choice	536
Others	514

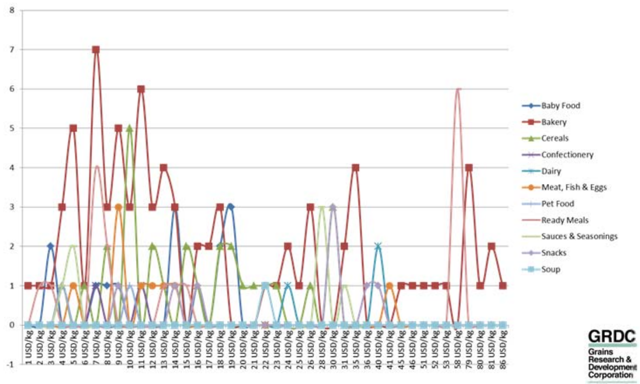
Jan-June 2015 -extra 281 Products Launched Globally –USD/kg

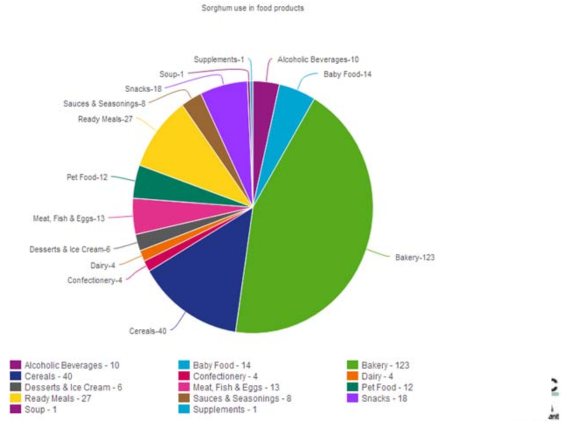


Jan-June 2015 USA still leading

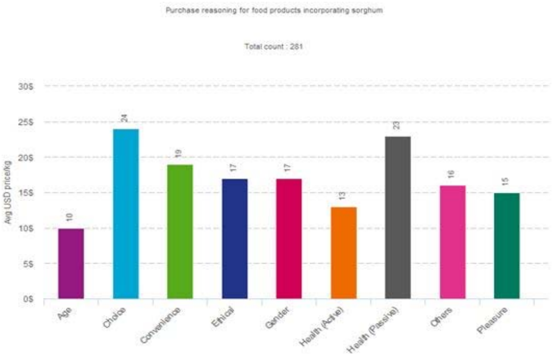


USD /kg Sorghum use in food





What drives spending sorghum products

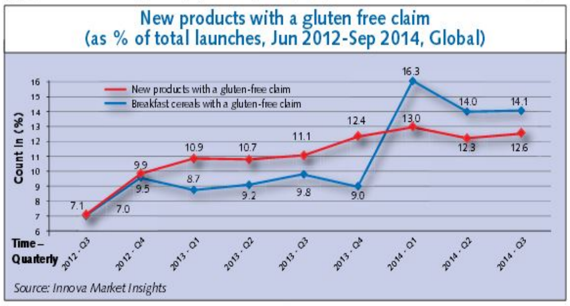


Sorghum (Products in market)

innova database

- **Lets see how many sorghum products are sold for sports nutrition purposes**
- ***Sorghum and Sports Nutrition*** sold Globally – ***9 products*** all launched since ***2012 (Canada/USA)***
- Market and product development stimulation ***North America last 2+ years***. None existed before this date.

Gluten free trend is on the rise



Source: Innova Market Insights

Jan -2015 Sorghum and Pet health high association

INNOVA MARKET INSIGHTS www.innovadatabase.com

Positioning¶

Name	Count
Health (Active)	331
Health (Passive)	283
Convenience	209
Others	78
Pleasure	38

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Hill's Science Diet Adult Small & Toy Breed Lamb Meal & Rice Recipe

Product ID:	1959888
Company:	HILLS PET NUTRITION
Brand:	Hills Science Diet
Country:	United States
Market:	Pet Food
Category:	Dog Food
Event:	New Product
Event Date:	Nov 2014
Region:	North America
Currency	USD
Price in US $:	11.99
Price in Euro:	9.23
Local Price:	11.99
Price / Kg in US $:	5.87
Price / Kg in Euro:	4.52

Product Description

Description: Hill's Science Diet Adult Small & Toy Breed Lamb Meal & Rice Recipe dry dog food provides 100% precisely balanced, easy-to-digest nutrition for small and toy breed dogs.

Extra Notes: Recommended For: Adult small and toy breed dogs ages 1-6 years. Not Recommended For: Puppies, pregnant or nursing dogs, or mature adult dogs.

Claims / Features: * Enhanced immunity to support long life expectancy * Key nutrients support healthy skin and coat * Easy to digest protein for strong, lean muscles

Ingredients and Nutrition

Ingredients: Lamb Meal, Brown Rice, Brewers Rice, Whole Grain Wheat, Whole Grain Sorghum, Corn Gluten Meal, Pork Fat, Cracked Pearled Barley, Chicken Liver Flavor, Flaxseed, Lactic Acid, Dried Beet Pulp, Soybean Oil, Potassium Chloride, Iodized Salt, L-Lysine, Choline Chloride, Vitamins (Vitamin E Supplement, L-Ascorbyl-2-Polyphosphate (source of Vitamin C), Niacin Supplement, Thiamine Mononitrate, Vitamin A Supplement, Calcium Pantothenate, Biotin, Vitamin B12 Supplement, Pyridoxine Hydrochloride, Riboflavin Supplement, Folic Acid, Vitamin D3 Supplement), Taurine, Minerals (Ferrous Sulfate, Zinc Oxide, Copper Sulfate, Manganous Oxide, Calcium Iodate, Sodium Selenite), L-Tryptophan, Mixed Tocopherols for freshness, L-Threonine, Phosphoric Acid, Beta-Carotene, Natural Flavors.

Nutrition: TotalCalories: 3728kcal, Protein: 24%, Calcium: 1%, fat: 16.4%, Magnesium: 0.100%, Phosphorus: 0.8%, Potassium: 0.83%, Sodium: 0.32%, Vitamin c(g/mg): 264mg, Vitamin e(g/mg): 529IU, Total carbohydrate: 51.8%, Crudefiber: 1.8%, Omega-6fatty acidsTotal: 3.39%

2015 Innova Market Insights www.innovadatabase.com

Sorghum and Human health recent market reality

Sanitarium Weet-Bix Gluten Free Breakfast Biscuits

Product ID:	2000762
Company:	SANITARIUM HEALTH AND WELLBEING
Brand:	Sanitarium
Country:	Australia
Market:	Cereals
Category:	Breakfast Cereals
Event:	New Product
Event Date:	Dec 2014
Region:	Australasia
Currency	Australian Dollar
Price in US $:	3.50
Price in Euro:	4.50
Local Price:	5.00
Price / Kg in US $:	9.33
Price / Kg in Euro:	12.00

Product Description

Description: Gluten free breakfast biscuits made with sorghum grains in a 375g plastic packet, held in a carton box.

Claims / Features: Low sugar. Gluten free. Made from red sorghum grains, not wheat grains. High in vitamins B1, B2, B3. Source of dietary fiber. Source of magnesium. High in folate. 3 times the antioxidants of oats. 96% wholegrain. Recyclable packaging.

Ingredients and Nutrition

Ingredients: Wholegrain sorghum, golden syrup, salt, vitamins (niacin, thiamin, riboflavin, folate).

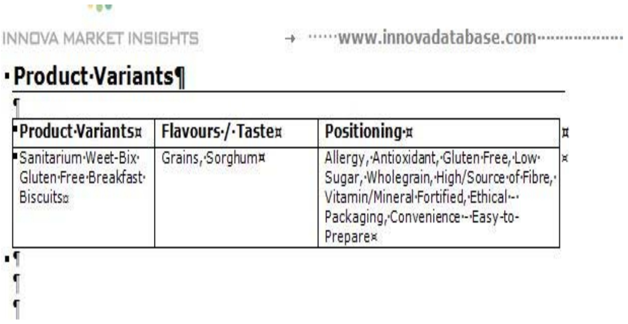
Nutrition: Per serving size: 100g, EnergyKJ: 1650KJ, Energy(kcal): 0.395Kcal, Protein(g/mg): 10.8g, Dietary fibre(g/mg): 6.8g, fat(g/mg): 3.5g, Magnesium(g/mg): 107mg, Potassium(g/mg): 320mg, Saturated fat(g/mg): 0.6g, Sodium(g/mg): 265mg, Total carbohydrate(g/mg): 75.5g, carbohydratesofwhichSugars(g/mg): 3.5g, Thiamin(Vitamin B1)(g/mg): 1.83mg, niacin(Vitamin b3)(g/mg): 8.3mg, Polyphenolstotal(g/mg): 221mg, Gluten(g/mg): 0.0g, riboflavin(Vitamin b2)(g/mg): 1.43mg, Folate(g/mg): 265ug

Fat: 3.5g; Protein: 10.8g; Carbohydrate: 75.5g

Product Analysis

Primary Package Type:	Packet
Secondary Package Type:	Box
Individual Pack Size:	0.375 kg
Total Pack Weight:	0.375 kg
Quantity Per Pack:	1
Shelving Details:	Ambient
Barcode:	9300652804874

Health positioning



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Product Variants

Product Variants	Flavours / Taste	Positioning
Sanitarium Weet-Bix Gluten Free Breakfast Biscuits	Grains, Sorghum	Allergy, Antioxidant, Gluten Free, Low Sugar, Wholegrain, High/Source of Fibre, Vitamin/Mineral Fortified, Ethical – Packaging, Convenience – Easy-to-Prepare

Up Date on Product

- Since my talk in January the gluten free 'Weet-Bix' product has been officially launched.
- **New Zealand**
- **Taiwan**

Gluten Free Growth 12 July 2015

- Products positioned on a gluten-free platform accounted for **10% of total global food and drinks launches** recorded by **Innova Market Insights** in the 12 months to the end of April 2015, rising to over **18% in the US**.
- Gluten-free launches in the cereals market is much higher than the average of the food and drinks market as **a whole at 21%, rising to an amazing 43% in the US.**

Gluten Free Growth 12 July 2015

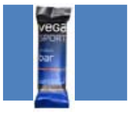
- **Biscuits** account for the largest number of gluten-free bakery launches, with over **40%**, equivalent to **8% of total biscuit introductions**, while **bread** has less than **16% of gluten-free bakery launches**, but this is equivalent to **9% of total bread** introductions.
- The **snacks market** is also seeing a relatively high proportion of launches **featuring gluten-free** claims, averaging **13% globally**, but **rising to over 42%** in the **US**.

Possible Future directions same as January

- Health and Nutritional supplements
- Extraction of resistant starch
- Extraction of antioxidants
- Extraction of oils
- Extraction of proteins
- Extraction of colouring agents
- Finer more consistent milled flour

The Future: Vega Sport Protein Bar: Chocolate Saviseed

Innova Database



Product Description
Description: Chocolate and saviseeds flavored protein bar in a 60g wrapper. A delicious, post-workout bar packed with 15g of complete, plant-based protein, Vega Sport Protein Bar is formulated to strengthen and regenerate muscles. Like Performance Protein, Vega Sport Protein Bars feature SaviSeeds, a rich, plant-based source of the amino acid tryptophan and omega 3.

Extra Notes: Made in a facility that processes peanuts, tree nuts, soy and dairy. May also contain fruit pit or nut shell pieces. Also available in Chocolate Coconut flavor.

Claims / Features: Provides 15g of complete, plant-based protein. Formulated to strengthen and regenerate muscles. Vega Sport protein bars feature SaviSeeds, a rich, plant-based source of the amino acid tryptophan and omega 3. Gluten free.

Product ID:	1752380
Company:	Sequel Natural
Brand:	Vega Sport
Country:	United States
Market:	Sports Nutrition
Category:	Sports Bars
Event:	Shelf SnapShots
Event Date:	Mar 2014
Region:	North America
Currency	US Dollar
Price in US $:	2.79
Price in Euro:	2.15
Local Price:	2.79
Price / Kg in US $:	46.50
Price / Kg in Euro:	35.80

Product Variants

Innova database

Product Variants	Flavours / Taste	Positioning
Vega Sport Protein Bar: Chocolate Saviseed	Chocolate, Not specified; Seeds, Not specified	Allergy, Gluten Free, High/Source of Protein, Omega-3, Sports & Recovery, Convenience - Consumption

Ingredients and Nutrition

Ingredients: Protein blend (sprouted whole grain brown rice protein, pea protein), dark chocolate coating (sugar, chocolate liquor, cocoa butter, sunflower lecithin, vanilla), dates, sorghum syrup, Saviseed (sacha inchi seeds), pumpkin seed butter, **sorghum crisps (sorghum**, quinoa, rice, tapioca), energy source (grape juice, natural rice dextrin), natural flavor.

Nutrition: Per Serving size: 60g, Protein, Total Calories: 230kcal, Calories From Fat: 60, Protein(g/mg): 15g, Calcium: 2%, Cholesterol (g/mg): 0mg, Cholesterol : 0%, Dietary Fibre(g/mg): 6g, Dietary Fibre: 24%, Fat(g/mg): 7g, Fat: 11%, Iron: 6%, Potassium(g/mg): 3mg, Saturated Fat(g/mg): 3g, Saturated Fat: 15%, Sodium : 65%, Sugars(g/mg): 14g, Total Carbohydrate(g/mg): 29g, Total Carbohydrate: 10%, vitamin A: 0%, Vitamin C: 2%, transFat(g/mg): 0g, PolyunSaturated Fat Fat(g/mg): 2g
Fat: 7g; Protein: 15g; Carbohydrate: 29g

Thank You For Your Time

- Questions??
- Ross Naidoo Food Science Liaison Officer Queensland Department of Agriculture and Fisheries.

Queensland
Government

Acknowledgement of Qld DAF and GRDC support

Thanks for making this event happen GRDC

Weed issues and action items

Michael Widderick, Annie van der Meulen, John Churchett & Andrew McLean, DAF Queensland

Key words

Herbicide resistance survey, common sowthistle, residual herbicides, Group A herbicides, feathertop Rhodes grass

GRDC code

UQ00062: Improving IWM practise in the northern region, NGA00003: GRDC Grower Solutions for Northern NSW and Southern Qld

Take home message

- The incidence of glyphosate resistance in common sowthistle is increasing. However no cases have currently been identified on the Eastern Darling Downs
- A range of double knock treatments which did not include glyphosate provided excellent control of small and large sowthistle plants
- Strategic tillage can reduce the emergence of common sowthistle, but some forms of tillage will bury weed seeds and increase their persistence
- There are a range of residual herbicides that provide effective control of feathertop Rhodes grass, but the efficacy can differ as a result of environment (eg rainfall)
- Using Group A herbicides for fallow control of summer grasses is a risky practice and poses a resistance and crop damage threat

Sowthistle resistance and management

Sowthistle glyphosate resistance survey

In 2014, researchers at the NSW DPI, Tamworth Agricultural Institute, confirmed glyphosate resistance in two populations of common sowthistle from Northern NSW. Identification of resistance followed application of glyphosate at 720 g.a.i. per hectare to sowthistle plants that had developed beyond the rosette stage, when the plants had commenced bolting or stem elongation. Since that time, researchers within the Queensland Department of Agriculture and Fisheries (DAF) have confirmed glyphosate resistance at the upper label rate (354 g.a.i. per hectare) for control of common sowthistle at the small rosette stage (less than 5 true leaves or ≤3cm diameter).

To benchmark how widespread this new resistance problem is, DAF is undertaking a random survey of common sowthistle growing in cropping fields across the northern growing region, as part of a GRDC funded project. The survey has been promoted through the grower solutions networks, including NGA, GOA and CQGS, and has involved the voluntary participation of agronomists and growers in collecting samples of common sowthistle for glyphosate resistance screening.

As shown in the map below, samples have been received over much of the northern cropping region. However, to date few samples have been obtained from cropping areas of Central Queensland, the Western Downs and Maranoa. In order to address these areas, we would particularly welcome sowthistle seed samples from growers and agronomists in these regions.

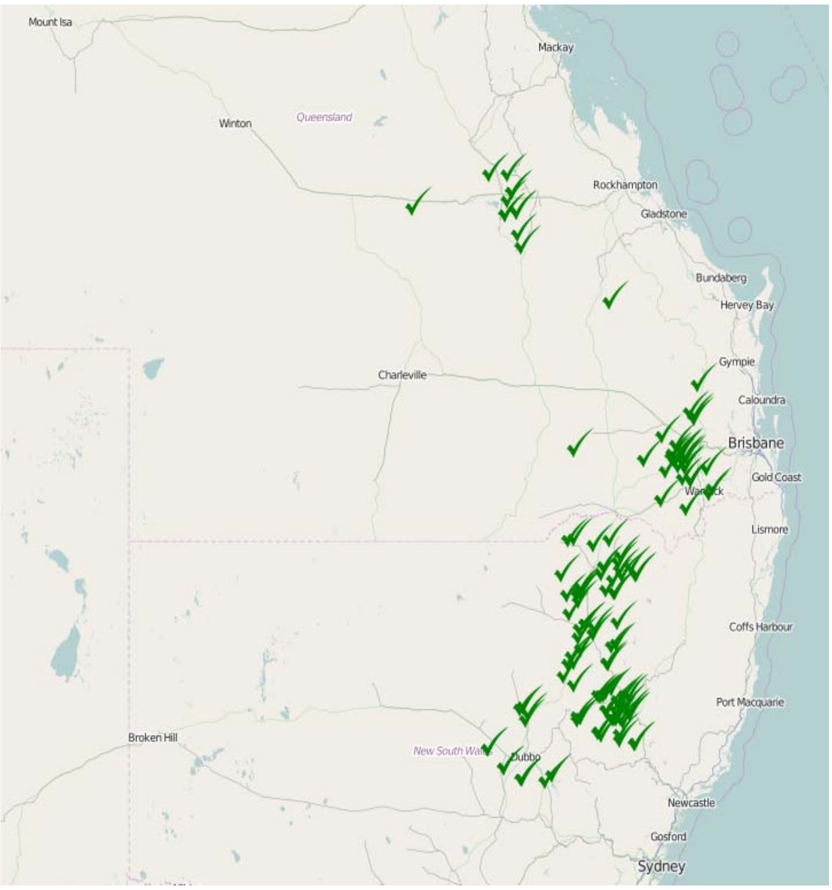


Figure 1. Map of the northern grin region showing the location (✓) of common sowthistle samples for glyphosate resistance testing.

Glyphosate resistance screening of the sampled sowthistle populations will be ongoing until early 2016, but preliminary results indicate the development of a resistance problem in the Liverpool Plains. To date, there have not been any populations from the eastern Darling Downs identified as having glyphosate resistance. However, it is not a question of if this will occur, but when. The choice of weed control options for control of your common sowthistle is critically important in ensuring glyphosate is retained as an effective herbicide for this weed.

If you are interested in becoming involved in the survey by sending in samples for glyphosate resistance screening, please contact Annie van der Meulen. Annie will provide information on collection methods, forms for gathering necessary information, and individually numbered bags to ensure correct identification of samples. You will receive a report on the resistance status of the sample(s) you provide (assuming good seed viability). Collecting samples is easily done when you are ‘out and about’ in the field, and samples will be accepted up to the middle of March 2016.

Sowthistle management

Due to the identification and increase in glyphosate resistance in this common weed species, alternative chemical and non-chemical options are required for its management. By including different management tactics as part of your weed management approach, the risk of resistance to glyphosate and other modes of action will be reduced, and management of already resistant populations will improve. Two such tactics are the double knock and strategic tillage.

The double knock tactic is a common tactic for the control of other weed species including flaxleaf fleabane and awnless barnyard grass. This tactic involves the sequential application of two different weed management tactics, where the second tactic is applied to control survivors of the first.

In a 2013 field trial located near Cecil Plains, double knock treatments were the most effective fallow treatments, and were equally effective on both small (<10cm diameter) (97-100% control) and large (>10cm diameter to elongating) (95-100% control) sowthistle plants. Most double knock treatments provided 100% control, thereby preventing any weed seed production.

Roundup® alone also provided very good control of both small and large sowthistle plants in this field. This helps explain why farmers continue to rely heavily on glyphosate for fallow control of common sowthistle. None of the single knock treatments were as effective as the double knock treatments in the control of large sowthistle plants, even at higher rates. Increasing the rate of herbicides did improve the control of small plants for Spray.Seed®, Tordon™ 75D + Roundup, Starane™Advanced + Roundup and Alliance®. However, even at the higher rates, these treatments only provided 88 – 97% control, thereby allowing survivors to grow and set seed.

By including a double knock as part of your fallow management approach, survivors will be controlled and seed set will be reduced. This will reduce weed density, and thereby the impact of weeds on crop production.

The impact of different forms of tillage on seed burial and subsequent emergence is being investigated in 4 field and 2 pot experiments. In all field experiments, harrows had the least seed burial (majority at 0-2 cm) and one-way discs had the most seed burial (majority buried below 5 cm). Glasshouse pot experiments have shown that emergence of sowthistle is greatest when seed is sown on the soil surface, and less when sown at 2 cm. For sowthistle, off set discs and one-way discs reduced emergence compared with zero tillage in all field trials (Figure 2), but in field trials 2 and 3, harrows and chisel ploughs increased seedling emergence. The timing and amount of rainfall during the trial can partly explain these differences.

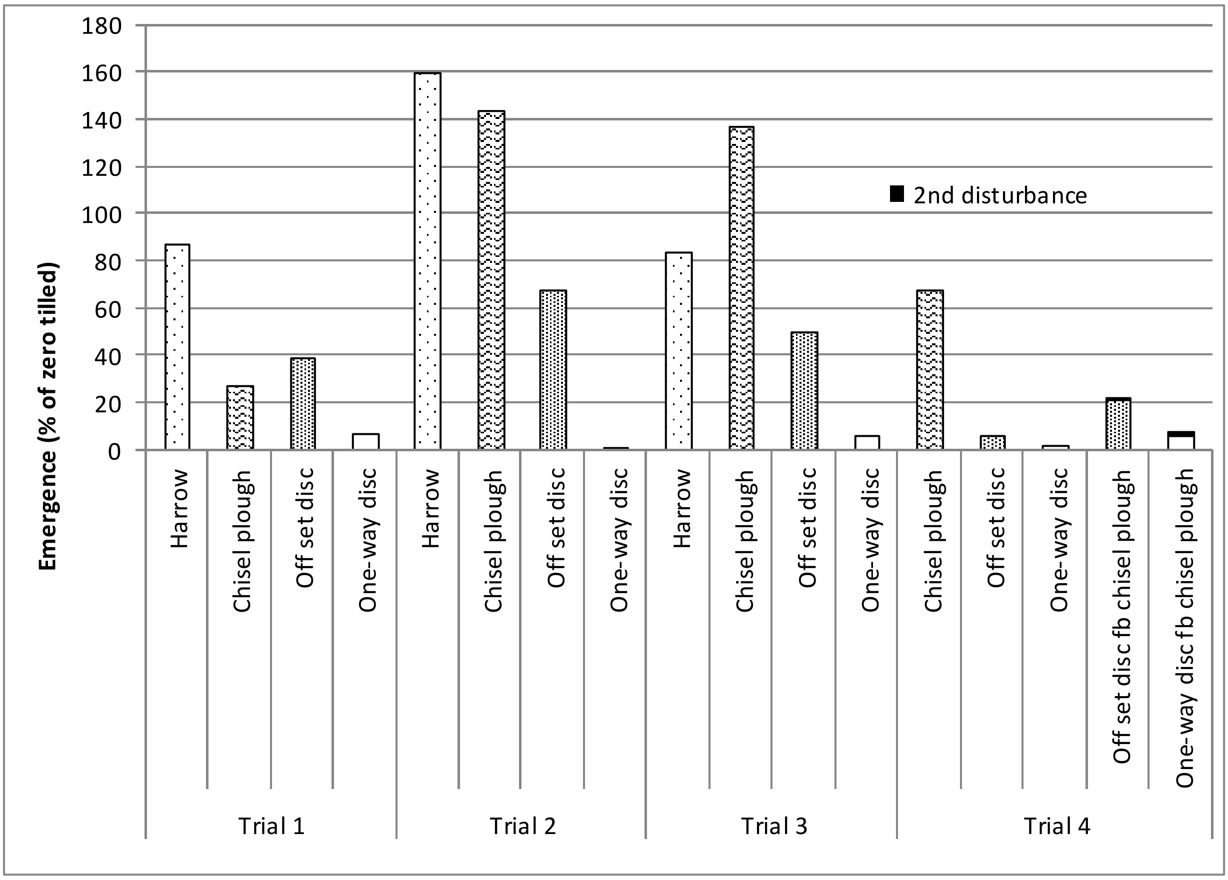


Figure 2. Impact of different forms of tillage on the emergence of common sowthistle as % of emergence in zero tilled plots.

Residual herbicides for feathertop Rhodes grass management

Feathertop Rhodes grass (FTR) is a difficult weed to control with knock down herbicides, especially once it grows past the early tillering stage. While the double knock tactic can provide useful control in fallow, the inclusion of residual herbicides can provide additional control in crop and fallow. Currently the only residual herbicide registered for fallow control if FTR is Balance®. However, other residual herbicides used in the cropping systems of the northern region may provide useful control of FTR.

The Northern Grower Alliance (NGA) and DAF have conducted multiple field trials to explore the efficacy of a range of residual herbicide for FTR with the aim of identifying herbicides to pursue for registration. Results differ across sites and seasons. However, results show that in addition to Balance, several other herbicides are consistent in their effective control of FTR.

Group A herbicide plantbacks

Typically, Group A, grass selective herbicides are designed for use in broad-leaf crops to selectively control grass weeds. However, the recent occurrence of difficult to control summer grass weeds including FTR and awnless barnyard grass (particularly with glyphosate resistance) has resulted in some growers choosing to apply Group A herbicides in fallow. Applying group A herbicides in fallow is a high risk practice for two reasons:

1) Previous research has shown that it only takes 6-8 years of repeated Group A use before resistance to this important herbicide group appears. Once resistance is present, the herbicide will no longer be effective as an in-crop herbicide and there are few alternative options. It is therefore important that Group A herbicides be preserved for their intended in-crop use.
2) There are plant back restrictions for cereal crops following the application of Group A herbicides. As such, Group A herbicides applied in fallow can result in crop damage.

Currently there is a minor use permit (Permit 12941), valid in Queensland only, allowing the application of Verdict™ and other registered products containing 530 g/L haloxyfop for the control of FTR in fallow. The permit stipulates that Verdict and other registered products containing 530 g/L haloxyfop can be applied once per season in fallow preceding a mungbean crop followed within 7-14 days by a treatment of paraquat applied at a minimum rate of 1.6 L/ha (using 250 g/L paraquat product).

Many Group A herbicides can persist in the soil and cause damage to monocot crops such as wheat, barley, cereals, sorghum and maize. As such, many Group A herbicides include plantback warnings on their labels (Table 1).

Table 1. Summary of the currently available crop rotational recommendations as per registered labels (at August 2014).

Herbicide	Crop rotational constraints
Butroxydim (e.g. Factor®)	Do not plant cereal crops for 4 weeks after application.
Clethodim (e.g. Select®)	*(No crop rotational information is provided on the label.)*
Fluazifop (e.g. Fusilade®)	Do not plant cereal crops for 12 weeks after application.
Haloxyfop (e.g. Verdict®)	Cereal crops or grasses planted within 12 weeks of application may be damaged.
Quizalofop (e.g. Targa®)	Do not plant cereal crops into the treated area for 18 weeks after application.

Table extracted from the publication 'Group A herbicide in fallow – GRDC Fact sheet' and used with permission from authors.

However, limited data exist on the persistence of Group A herbicides for the northern region conditions and proposed application practices. The NGA have done some work in this area and the DAF weed science team currently have two field trials exploring the impact of a range of Group A herbicides on wheat growth and yield. Results are not yet known.

Further information/resources:

https://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/07/Managing-herbicide-resistant-weeds-in-the-summer-fallow

https://www.grdc.com.au/Resources/IWMhub/Section-8-Profiles-of-common-weeds-of-cropping/Common-sowthistle

https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/weed-management-in-field-crops/herbicide-resistance/preventing-herbicide-resistance-in-at-risk-weeds

Acknowledgements

The research undertaken as part of these projects is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC, the author would like to thank them for their continued support.

The authors acknowledge those who have been involved in the sowthistle survey collection. Your participation is very important for the success of this survey, and for improving our ability to manage the development of glyphosate resistance in this species.

Many thanks to the Northern Grower Alliance for providing trial data for inclusion in this paper.

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Deep phosphorus placement – Research meets adoption
A case study integrating research into Darling Downs farming systems

John 'Cowboy' Cameron, "Kintyre", Bongeen Qld,
& Bede O'Mara, Incitec Pivot Fertilisers, Toowoomba

Key words

Deep P, farmer adoption, soil test, BSES, subsoil constraints, Central Downs Grower Group

GRDC code

CLI00001

Take home messages

- Soil test and monitor each paddock for P status to ascertain the Colwell P and BSES P numbers at 0-10cm and 10-30cm soil depths before commencing a deep P investment.
- Also have a good understanding of soil type, soil origin and any subsoil constraints in the profile to lower effective PAWC, through additional soil testing at 30-60cm, 60-90cm depths.
- Deep P can be applied without investing in new equipment; rather, adapting or simply using what is already on farm.
- Identify a time in your crop rotation aiming to minimise impact on your following crop and rotation.
- Any substantial applications of deep P will take more than 1 year to provide a return on investment, more likely 2-3 years.

Background

A small group of growers and agronomists formed the Central Downs Grower Group (CDGG) in 2014. The group meets every 1-2 months, discussing all things farming, and usually has a guest speaker attend each meeting. The local trial conducted by the Central Downs Grower Group, who was engaged by a GRDC Agribusiness Trial Extension tender to look at facets of grower adoption of deep phosphorus integration into Downs farming systems.

The purpose of the trial is to provide industry with more clarity on how to apply deep fertiliser and to provide growers with more information on the outcomes of investing in soil nutrition.

Methods

A low P farm site was identified with a CDDG group member on the Darling Downs. A selection of P applications were applied using a predetermined randomised trial design replicated three times, to identify and assess the P responses and the practicalities of applying Deep P using farmer equipment.

Five (5) different P applications (combinations of varying rates & application row direction) and one (1) Nil P application were compared. These consisted of:

- Farmer Practice
- Deep rip 0P in the row
- Deep 40P with row
- Deep 0P across the row
- Deep 40 P across the row
- Seed only no starter or deep P

Granulock® Z at 40kg/ha (8.7kgP/ha) was applied in furrow with the seed at the planting operation across all treatments, except the Nil P (Treatment 6) plots.

The field trial site was previously a grass paddock until August 2013, at which time it was offset disced followed by three passes with a John Deere chisel plough. Soil tests for fertiliser requirements were undertaken in September 2013, the soil tests identified the low phosphorus status of the paddock. Very little rain fell during the 2013/14 summer fallow. 280mm of rain was recorded at the site during late March 2014, which allowed a crop planting opportunity in June 2014.

The randomised plots size width was 24m wide and 48m long. The trial site area was calibrated and measured using the tractor GPS system (Trimble) and each treatment received an appropriate GPS coordinate to enable individual compilation of data from the randomised configuration.

Phosphorus and tillage (rip) treatments were applied using a tyne planter fitted with Flexicoil 550lb breakout and stealth points.

This was immediately followed by Urea applications of up to 46kgN/ha (100kg/ha) were applied on 50cm row spacing's with full disturbance (chisel plough) on 2/6/2014.

Lastly, the EGA Gregory⒟ wheat at 45kg/ha was planted the same day using the same Flexicoil adaptors. All tynes travelled in the same row. Granulock Z at 40kg/ha was applied in furrow with the seed at the planting operation across all treatments except the zero P (Treatment 6) plots.

Fuel consumption was noted from the tractor performance monitor during applications.

The trial site was soil cored for nutritional status and for soil moisture, taken early in the fallow (Sept 2014) at depths of 0-15cm, 15cm-30cm, 30cm-60cm, 60cm-90cm post planting.

Crop establishment counts were taken on 1/7/2014, 28DAS (days after sowing). The number of wheat seedlings established was counted at 10 sites per plot, each consisting of 1 metre of the row.

The EGA Gregory⒟ wheat trial site was tested for canopy density variations during the growing season using a hand held GreenSeeker® (3*10m of row scanned per plot). The scans were taken at GS 30-31 and GS 41. Dry matter cuts were also taken at GS 41.

The plots were harvested on 3/11/2014 and bin-weighed. From each trial plot the grain was tested for moisture, screenings, protein and test weighed kg/HL. Each grain sample was tested and categorised through the local grain handler in accordance to the national bin-grading standard. Grain samples from each plot were tested for their nutrient concentration and assessed for the nutrient removal per 1000kgs (1T) of grain/ha.

Each trial site treatment was soil tested post-harvest for its nutritional and moisture status within the row and inter-row. Each treatment was assessed for its nutrient removal and evaluated against the treatment costs.

WUE calculations were not completed, as rainfall records for the preceding fallow were unavailable, and growing season rainfall (GSR) was only 22mm in August 2014.

Monitoring of each site treatment for soil moisture, soil nutritional changes and grain removal will continue in 2015 and 2016.

Results

Grain yield

Decile 1 rainfall received during the 2014 wheat crop at 'Knapdale' delivered both disappointment and optimism. Whilst grain yields grown were well below average, the grain yield difference between the treatments was encouraging. In a more average season, it is expected that the base yield level would be significantly higher than in 2014, thus markedly increasing the returns from the treatments applied, and potentially reducing the number of crops required to break-even.

All grain yield figures are presented as moisture corrected to 12%, to allow comparison.

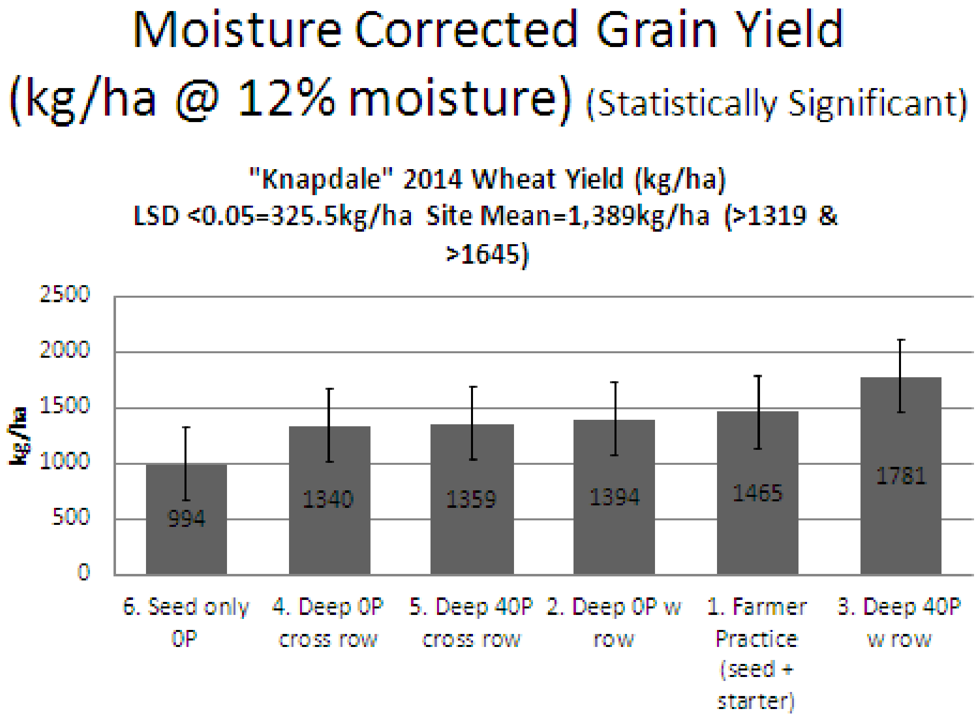

Figure 1. 2014 CDGG trial grain yield

Significant grain yield differences were observed (Figure 1) between treatment 6 (seed only-nil P applications) @ 994kg/ha grain-and all other treatments: treatment 4 (Deep rip 0P, cross row), treatment 5 (Deep rip 40P cross row), treatment 2 (Deep rip 0P with row), and treatment 1 (Farmer practice seed + starter) @ 1340kg/ha, 1359kg/ha, 1394kg/ha, and 1465kg/ha respectively.

Grain yield differences between treatments 4, 5, 2, and 1 (i.e. the lowest yielding treatment) were *not statistically significant*.

Grain yield differences between treatment 3 and 1 (i.e. highest yielding to the second highest yielding treatment) were *not statistically significant*.

However, grain yield differences were significant between treatment 3 (Deep rip 40P with row) @ 1781kg/ha grain yield, (i.e. the highest yielding treatment) to treatments 2, 4, 5 and 6 compared in the trial.

Grain yield results from 2014 indicate that application of deep immobile nutrients like phosphorus in bands close in proximity to the intended crop row is important for crop access, and thus provides maximum benefit for the first crop following application.

Grain quality

No statistically significant differences were observed in grain protein, screenings, and grain weight between treatments. Given the below average seasonal conditions experienced, no particular trends were observed.

Grain nutrient removal

Table 1. 2014 CDGG Trial Grain Nutrient Removal data

Trt	Treatment	Total Crop N removal (kg/ha)	*kg/ha of P removed per tonne of grain*	Total P removal (kg/ha)	Total K removal (kg/ ha)	**Total Zn removed per ha (grams/ha)
1	**Farmer**	**30.57**	***2.50***	**3.66**	**5.76**	**33.21**
2	Deep0Pwith	28.51	*2.53*	3.53	5.53	30.67
3	**Deep40Pwith**	**35.89**	***2.67***	**4.75**	**7.18**	**35.62**
4	Deep0Pcross	27.24	*2.63*	3.53	5.32	29.48
5	Deep40Pcross	28.69	*2.67*	3.62	5.30	28.54
6	**Seed only**	**20.81**	***2.30***	**2.29**	**3.55**	**24.85**

Table 1 compares the nutrient removal of the farmer practice (Treatment 1) against the highest and lowest yielding treatments (Treatments 3 and 6 respectively). It is noted that increasing yield generally drove a corresponding increase in grain nutrient removal.

Where any phosphorus was added (Treatments 1, 2, 3, 4 and 5) compared to none in the seed only (Treatment 6), a resultant increase in kilograms of phosphorus removal per tonne of grain was observed in Table 1. This increase in grain phosphorus concentration suggests that the applied phosphorus indeed made it into the plant, and into the grain and that the highest phosphorus removal rates per tonne of grain came from treatments 3 and 6, where the highest total phosphorus rates were supplied.

Further then, grain yield corresponded with the highest total phosphorus removal per hectare. The highest yielding Deep rip + 40P treatment (Treatment 3) removed significantly higher total phosphorus kg/ha, or 107% greater total P removal than the seed alone treatment (Treatment 6), with 79% additional yield.

The farmer practice (Treatment 1) also removed more total phosphorus per hectare than the seed alone Treatment 6. In fact, 60% greater total P removal per hectare in Treatment 1 from a 47% yield increase compared to Treatment 6 (seed only nil P).

From the 2014 trial season, it is noted that the farmer practice (Treatment 1) phosphorus application of starter @ 8.7kgP/ha, exceeded that of crop removal of 3.66kgP/ha for the same treatment by 5.06kgP/ha. It is suggested that additional yield contribution and thus additional total phosphorus removal per hectare was supplied from the additional with row Deep rip+40P from Treatment 3.

As mentioned earlier, given the well below average season and yield outcomes in 2014, it is expected that average seasonal property wheat yields under the same fallow treatment would be closer to 4t/ha, thus P removal rates from starter P would be in the vicinity of 10kgP/ha. This would mean that the applied Farmer Practice P rate of 8.7kgP/ha falls just shy of replacing removed P from wheat.

Higher nitrogen, potassium and zinc (removals per hectare) were observed where additional phosphorus was supplied (Treatments 1, 2, 3, 4 and 5) and all were greater than in the nil P seed only treatment (Treatment 6) nitrogen, potassium and zinc totals removed in kilograms per hectare.

Economics

Table 2. 2014 CDGG trial economics

Treatment	Treatment cost $/ha (net of pre-plant urea)	Mean Yield (t/ha) @ 12% moisture	Grain Price $/t (AUH2)	Total revenue $/ha	Net return (total rev - planting, deep rip & P fert costs) $/ha	$/ha net return variance (vs Farmer Trt)
1-Farmer Practice	$102.50	1.465	$315.00	$ 461.48	$ 358.98	$ -
2-Deep 0P with row	$171.50	1.394	$315.00	$ 439.11	$ 267.61	**-$ 91.37**
4-Deep 0P cross row	$171.50	1.340	$315.00	$ 422.10	$ 250.60	**-$ 108.38**
3-Deep 40P with row**	$315.50	**1.781**	$315.00	$ 561.02	$ 245.52	**-$ 113.46**
6-Seed only, nil starter or deep P	$70.50	0.994	$315.00	$ 313.11	$ 242.61	**-$ 116.37**
5-Deep 40P cross row	$315.50	1.359	$315.00	$ 428.09	$ 112.59	**-$ 246.39**

(*NOTE: Treatment costs: planting + starter @ $102.50/ha; planting nil starter @$70.50/ha; Deep cult 0P @ $70/ha; Deep cult + 183kg/ha Granulock®Z @ $213/ha)

Whilst the benefits from applied phosphorus as starter fertiliser to a responsive soil are well documented, these results clearly reinforce that benefit. This is demonstrated in Table 2 by the additional 0.471t/ha grain yield achieved from the farmer practice treatment (Treatment 1: seed + starter @ 8.7kgP/ha) which realised a $116.37/ha greater net return than that of the seed alone nil P treatment (Treatment 6).

The effects of deep ripping in treatments 2 and 4 (rip + zero P) regardless of rip direction, provided a negative economic return, despite additional grain yields and net returns of up to $25/ha greater than the seed only treatment (treatment 6).

Even when additional deep P was added with the deep rip in treatment 5 (deep 40P cross row), the grain yield remained similar at 1.359t/ha compared to treatments 2 and 4, with grain yields of 1.394t/ha and 1.340t/ha respectively. Further, the added cost of the deep fertiliser eroded the returns to the point that an additional $144/ha investment resulted in no additional return from this investment from this crop. Hopefully rip direction, fertiliser row direction and season were to blame here, and it is hoped that crop recovery of the deep applied P fertiliser is measured in future years.

Treatment 3 (deep rip + 40P) was the highest yielding treatment (as seen in Figure 1), and yielded an additional 0.316t/ha than the farmer practice treatment (Treatment 1: seed + starter @ 8.7kgP/ha). Treatment 3 also provided additional net revenue of $99.54/ha, better than the farmer practice (Treatment 1), however the additional fertiliser investment and application cost of $213/ha for Treatment 3, meant that a negative net return/ha of $113.46 was the result from this crop.

Summary

It is difficult to assess the overall benefits of Deep P in one season; further monitoring will provide a better understanding of the long term and economic benefits. The higher rates of Deep applied 40kg/ha P did not return an economic return in Year 1, however further assessments in future years from average seasons will enable a more informed evaluation.

Deep placement of P and tillage is expensive and any future benefit is still to be evaluated, a standard rate of 8.7kgs of P per ha (40kgs of Granulock® Z) has provided the most economic return as the farmer practice. Importantly, soil testing for nutrients and constraints, using relevant interpretation logic and paddock cropping history are critical tools for assessing the need for the deep placement of P.

Table 2 clearly indicated that **the practice of not applying any starter P to low P soils would provide negative economic returns.**

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:

- Mr John 'Cowboy' Cameron-Grower.
- Mr Jamie Innes-Agronomist, Landmark.
- Mr Michael T Burgis & Associates-Consultant.
- Mr Dale Jeude and all members of the Central Downs Grower Group.
- Mr John Piper and all members of the Clifton-Allora Topcrop Group.
- Dr Mike Bell-QAFFI
- Dr David Lawrence and Mr Brad Taylor-DAF Qld.
- Mr Howard Cox and Dr Andrew Zull-DAF Qld.
- Dr Alison Kelly-Statistics for the Australian Grains Industry (SAGI)-DAF Qld.

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Reviewed by

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Managing barley and wheat diseases – priority issues and actions for 2015

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Key words

Foliar diseases, leaf rust, yellow spot, net blotch, yield loss

GRDC code

DAQ00245; DUS0053

Take home message

- Sowing resistant varieties is the best means of avoiding serious yield losses to disease.
- Timely application of fungicides can be very profitable in susceptible varieties.
- Keep abreast of NVT disease resistance ratings. Changes in pathotypes in one growing season can have major implications for varietal selection in the following season.

Priority issues

1. A new pathotype of wheat leaf rust is likely to arrive in 2015.
2. New pathotypes of powdery mildew of barley in the Northern Region
3. Barley leaf rust will increase
4. Spot form of net blotch and yellow spot - to spray or not to spray

Introduction

Foliar diseases pose a constant threat to the productivity and profitability of winter cereals in Queensland. Given a combination of susceptible varieties, virulent pathogens and favourable weather, diseases will infect crops and may develop into widespread epidemics.

Seasons that are favourable for good crop growth are also favourable for the development of diseases like mildews, rusts and leaf spots. Consequently, when crops have high yield potential they are often exposed to high disease risk. The major effect of foliar diseases is a reduction in the effective photosynthetic leaf area; therefore to ensure crops are able to reach their potential, these diseases must be kept to a minimum.

Disease epidemics are more the exception than the rule and most can be controlled by in-crop application of fungicides; however an integrated approach of appropriate crop rotations; varietal resistance and fungicides will give the best control. Disease control by the application of foliar fungicides is an economic decision and can only be accurately determined by the availability of reliable yield loss data. The impact of diseases on yield and quality varies with the severity of disease, the duration of the disease epidemic, the levels of resistance in the host variety and environment. Under funding from GRDC, we have been investigating the response of varieties with different levels of resistance to the application of fungicides and to epidemics of different severities. The results of these trials might help guide your decisions on whether or not to apply foliar fungicides for disease control.

Trial results

Barley Leaf rust (Puccinia hordei)

In 2013 trials, an epidemic of leaf rust in the very susceptible (VS) variety Grout caused a loss in yield of 32%. Shepherd (moderately resistant (MR)) subjected to the same levels of initial inoculum recorded a non-significant loss of 6.1%.

In 2014, Grout lost 25.1% of its yield under a heavy epidemic while once again there was no significant difference in yield between the sprayed and unsprayed Shepherd treatments. To our surprise, the newly released variety Compass suffered a 38.5% loss in yield under the same epidemic conditions.

Fortunately, current levels of leaf rust inoculum in the region are low; however the popularity of Compass in the 2015 sowing season and its apparent susceptibility to leaf rust is likely to lead to an increase in the disease by the end of the season.

Trials in both years reinforced the principle that the best way to avoid losses in yield from rust is to sow resistant varieties; yet the application of fungicides to a susceptible variety can still be very profitable. In 2013, a single fungicide spray increased the yield in Grout by 29% resulting in a net return of around $250/ha.

Spot form net blotch (Pyrenophora teres f. maculata)

Shepherd barley is rated SVS to spot form of net blotch and the disease is often present in crops of this variety. In 2014, under a moderate to heavy epidemic "disease free" plots out yielded diseased plots by 18.7%. Two applications of a popular commercial fungicide gave a yield increase of 10.2% returning an extra $162/Ha. Failure of fungicides to completely control the disease in nil disease plots suggests losses could be even higher than those recorded.

Yellow spot (Pyrenophora tritici repentis)

As with other diseases the yield impact of yellow spot varies with varietal susceptibility. An epidemic of yellow spot in Kidman (S) reduced potential yield by 28.7% yet in the MR variety Leichhardt by only 10.1%. A two spray strategy on the same varieties increased yields by 21.6% and 14.2% giving net returns of $167 and $70 respectively.

Changes in pathotype

Most of our major foliar diseases are populations of different strains or pathotypes of that particular disease. When a variety that was once resistant becomes susceptible to a disease, it is usually a result of the disease gaining virulence for the particular resistance gene in that variety and we say the resistance has broken down. The strain (pathotype) that has developed additional virulence is a new pathotype.

In Australia, the compositions of our winter cereal rust populations are well documented; but less so for mildews and leaf spot diseases. With funding from GRDC, annual pathotype surveys of net form net blotch, spot form net blotch, powdery mildew, scald (*Rhynchosporium commune*) and spot blotch (*Cochliobolus sativus*) are being conducted across Australia. This allows early detection of new virulences in the disease populations and reporting of any changes in pathotypes before the new planting season. In Queensland, we are focussing on net form net blotch and powdery mildew of barley and have detected several shifts in virulence in recent years.

Wheat leaf rust

In August 2014, a new pathotype of wheat leaf rust was detected in South Australia. This subsequently spread to Victoria and into New South Wales. It has been isolated from as far north as

Narrabri, but as yet, not in Queensland. It is logical to assume it will arrive soon. The Australian Cereal Rust Control program has determined that this isolate is an exotic incursion and is virulent on several varieties that were resistant in 2014. The varieties Baxter, Sunvale, Mitch and Viking are either S or SVS to this new pathotype and should be monitored for the disease.

Net form net blotch

Currently, our leading barley variety is Shepherd which was released in 2009 when it was resistant to powdery mildew and to the net form of net blotch. In 2012, DAF detected virulence in powdery mildew for the resistance gene in Shepherd (*Mla3*) rendering the variety MSS to that disease. We have also detected virulence in the Queensland net form net blotch population on Shepherd.

This is not an immediate threat as the pathotype(s) that carry this virulence exist at only a low level in the net form net blotch population. However it does serve as a warning that increased levels of net form net blotch may be detected in the current and future growing seasons. This will be more conspicuous where environmental conditions favour infection events and where Shepherd is sown on the previous year's Shepherd stubble.

Powdery mildew

Nationwide surveys of powdery mildew of barley were conducted in 2010 and 2011. Those surveys identified a relatively simple population structure with apparently more virulences in the eastern states than in Western Australia. This was not surprising as there has been relatively little breeding for resistance to powdery mildew in Australian breeding programs so the disease has not been forced to develop new virulences to survive.

Within 12 months of these surveys, three previously undetected virulences (*Va3, Va9, Va12*) that were specific to resistance genes in Shepherd, Grout and Navigator respectively , were isolated in the Northern Region. In 2014, virulence for the resistance gene *MlLa* was detected in northern NSW and Queensland. Varieties such as Commander, Compass and Hindmarsh are now more susceptible to the disease than previously (Table 1) and may become infected in the 2015 season.

Table 1. Comparison of seedling and adult responses of commercial barley varieties to established and new pathotypes of powdery mildew.

	Shepherd pathotype	**Shepherd pathotype**	**New *MlLa* pathotype**	**New *MlLa* pathotype**
Variety	**Seedling**	**Adult**	**Seedling**	**Adult**
Commander	MSS	MRMS	VS	S
Compass	MSS	MS	VS	S
Granger	R	R	R	R
Grout	R	R	R	R
Hindmarsh	MS	MSS	VS	SVS
La Trobe	MS	MSS	VS	S
Mackay	MRMS	RMR	VS	MR
Oxford	R	R	R	R
Shepherd	VS	MS	MR	R

What does this mean for our barley growers?

Powdery mildew disease needs to be considered in context. In the Northern Region, powdery mildew is unlikely to cause losses in yield in excess of 10-15% in susceptible varieties. In crops with high yield potential, this can be significant and would justify fungicidal control. Despite having detected powdery mildew virulent on seedlings of Shepherd, Grout and Navigator the commercial impact to date has been minor.

Shepherd crops on the Downs are commonly infected with powdery mildew; yet severe infections are rare. We believe this is due to other minor resistances providing some protection. We are not aware that any commercial crops of Grout have suffered from significant infection of powdery mildew and the area sown to Navigator in the North is still very small.

A greater risk is posed by pathotypes that can attack varieties carrying the *MlLa* resistance gene. Commander and Compass are sown throughout the region and are considered susceptible to strains carrying virulence for this gene. Increasing levels of powdery mildew in either of these varieties would signal the need for application of fungicide.

Application of fungicides to control foliar diseases

It is now early August and the potential for diseases to become a problem in crops should be apparent. If you are contemplating application of foliar fungicides, there are a few rules of thumb to follow.

1. Foliar fungicides are far more effective as protectants than eradicants.
2. Do the maths. The economics of chemical control are a function of potential yield, potential loss, cost of application and commodity prices.
3. Most current commercial fungicides are very effective against mildews and rusts; but less so against leaf spots.
4. Good control of leaf spots is reliant on application pre-infection.
5. Application of commercial fungicides at recommended “full” rates can be expected to provide 3 – 4 weeks protection.
6. Two applications (one at GS31-32 and a second at GS49) will maximize control in barley.
7. Heed label warnings on fungicide resistance management

Acknowledgements

The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC, the author would like to thank them for their continued support.

We thank Clayton Forknall of DAFQ for analysis of the trial data used in this paper.

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

Surveillance and forecasts for mouse outbreaks in Australian cropping systems

Julianne Farrell & Peter Brown, CSIRO

Key words

mouse outbreak, plague, mice, mouse, crop damage, crop monitoring

GRDC code

IAC00002

Take home message

- Successful mouse management requires growers to be PROACTIVE rather than REACTIVE
- High numbers of mice are predicted on the Darling Downs during summer 2015-2016
- Use MouseAlert to record mouse activity

Mouse populations are monitored on a seasonal basis in grain farming systems in Qld, NSW, Vic, SA and WA. The monitoring provides data on the size (abundance) of mouse populations, their breeding status and activity in crops, fallows and roadside verges.

The Darling Downs transect, which runs between Mt Tyson and Cecil Plains is a benchmark site where live trapping data is collected for use in plague prediction models. The central Queensland (Callide and Dawson transects) and northern NSW (Moree transect) have been used as quantitative rapid-assessment sites using oil cards and active burrow counts.

A sustainable national monitoring network

The surveillance network has been designed to collect data using a variety of techniques, including kill and live capture trapping, oil cards, burrow counts and farmer/agronomist reports. The data set is now sufficient for a comparative assessment of these techniques during the final phase of the project. Evaluation of the rapid-assessment techniques (oil cards, burrow counts) is essential for future low-cost monitoring during periods with a high risk of mouse outbreaks.

Qualitative observations provided by growers, agronomists and other farm advisors will continue to provide up-to-date information and extensive coverage that is critical for an effective, sustainable monitoring network. The MouseAlert website and app were developed within the Invasive Animals CRC and launched in 2014. MouseAlert allows farmers and agronomists to record their observations of mouse activity. Recent reports can also be viewed, and it provides access to factsheets and forecasts of the likelihood for future high levels of mouse activity in each grain growing region.

Recent mouse monitoring results

Darling Downs: There was very little activity on the transect in June (Fig.1), apart from isolated paddocks of sorghum stubble at the Mt Tyson end. The early wheat and chickpeas appeared untouched. Mouse abundance is likely to remain low, however growers should be vigilant as crops mature.

Central Qld: No activity on either the Callide or Dawson transects.

Northern NSW: No activity north or south of Moree, and one paddock of barley in the Pallamallawa area with significant activity.

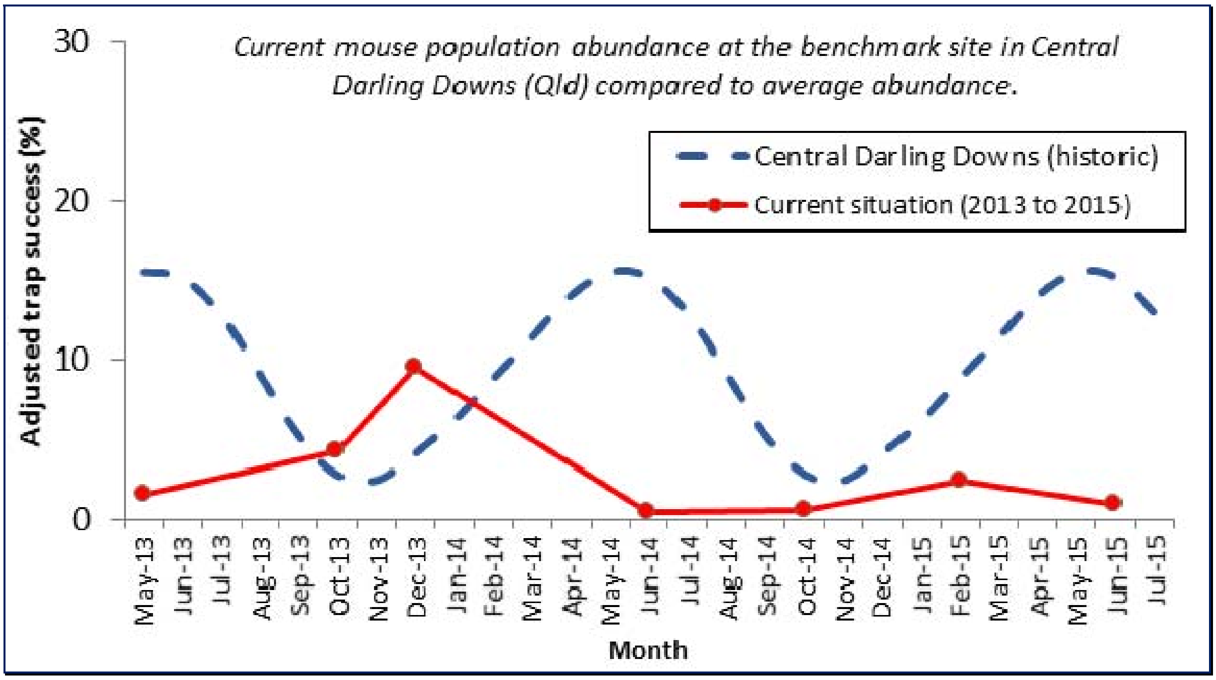

Figure 1. Recent trapping results for the Darling Downs (2013-2015) shown in red.

Currently, the project provides forecasts of the likelihood of mouse plagues using data from routine surveillance in models that have been developed progressively over the past 20 – 30 years. A new spatially-explicit model has been developed and tested with a data set representative of south-eastern Australia. The model translates current observations into consistent 'low', 'medium' and 'high' levels of mouse abundance. The model then predicts the likelihood that mouse abundance will stay at the same level or change during the next season. These predictions are made for 30km x 30km 'grid cells' and the model will initially be implemented for south-eastern Australia.

MouseAlert

MouseAlert is an on-line tool for recording and viewing recent mouse activity across all grain growing regions of Australia. *Mouse Alert* is a mobile phone app accessible by smart phones (Fig.2) or through the internet via desktop and tablet computers. Growers and advisors can access *Mouse Alert* through www.mousealert.org.au or download the FeralScan app which features *MouseAlert* (available in the iTunes store). The *MouseAlert* web site provides access to fact sheets about mouse control and forecasts of the likelihood for future high levels of mouse activity in each grain-growing region.

The first ever 'Mouse Census Week' was conducted in April 2015 to generate interest in *MouseAlert* and to get a snapshot of mouse activity across the main grain growing regions of Australia. This generated considerable interest, and there are now about 300 records of mouse activity.

Researchers will be using the data collected through *MouseAlert* to modify existing forecasting models and to explore whether such information can be used to monitor and forecast mouse problems in the future (Fig. 3). MouseAlert was developed by the Invasive Animals CRC through the GRDC mouse monitoring and modelling project in conjunction with Landcare Research and CSIRO.

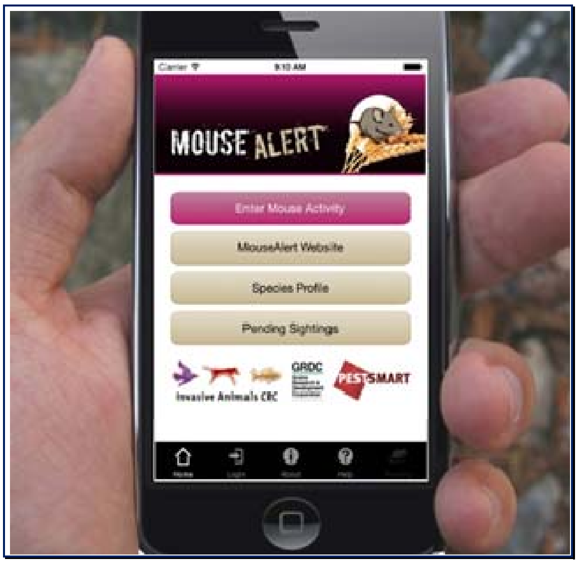

Figure 2. MouseAlert smart phone app www.mousealert.org.au

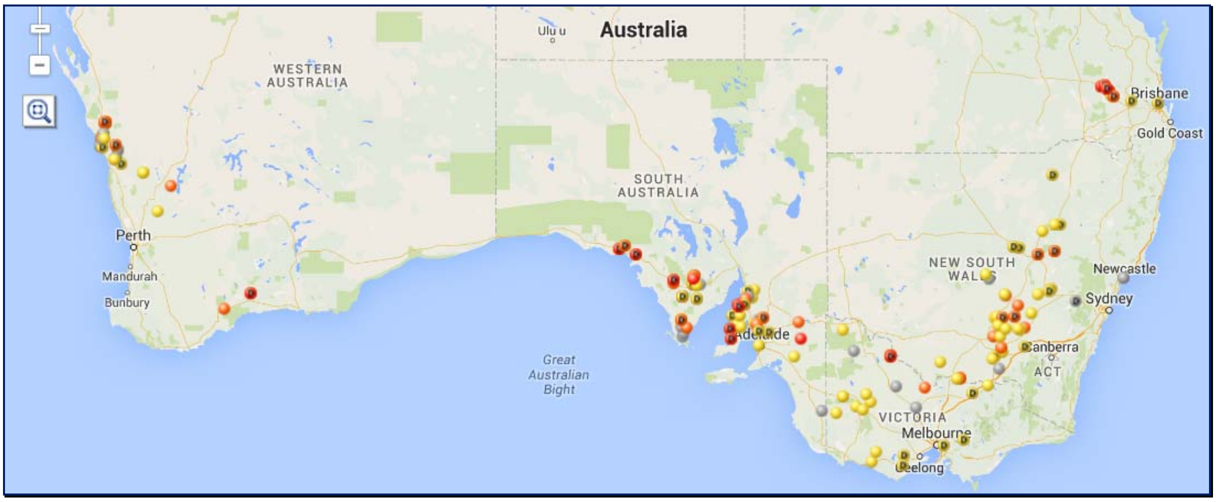

Figure 3. There are 300 records in MouseAlert showing low, medium and high mouse activity and locations where damage is evident (D).

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.

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