Northern Grains Region Trial Results Autumn 2014

RESEARCH & EXTENSION – INDEPENDENT RESEARCH FOR INDUSTRY

Editors: Loretta Serafin, Steven Simpfendorfer, Mike Sissons, Andrew Verrell and Guy McMullen

Grains Research & Development Corporation

www.dpi.nsw.gov.au

NSW GOVERNMENT | Department of Primary Industries

Northern Grains Region Trial Results Autumn 2014

RESEARCH & EXTENSION – INDEPENDENT RESEARCH FOR INDUSTRY

GRDC
Grains Research & Development Corporation

www.dpi.nsw.gov.au

ISSN 1839-1192

Published by the NSW Department of Primary Industries, a part of the Department of Trade and Investment, Regional Infrastructure and Services.

Disclaimer

The information contained in this publication is based on knowledge and understanding at the time of writing (April 2014). However, because of advances in knowledge, users are reminded of the need to ensure that the information upon which they rely is up to date and to check the currency of the information with the appropriate officer of the Department of Trade and Investment, Regional Infrastructure and Services or the user's independent adviser.

The product trade names in this publication are supplied on the understanding that no preference between equivalent products is intended and that the inclusion of a product name does not imply endorsement by the department over any equivalent product from another manufacturer.

Recognising that some of the information in this document is provided by third parties, the State of New South Wales, the author and the publisher take no responsibility for the accuracy, currency, reliability and correctness of any information included in the document provided by third parties.

Always read the label

Users of agricultural chemical products must always read the label and any permit before using the product, and strictly comply with the directions on the label and the conditions of any permit. Users are not absolved from any compliance with the directions on the label or the conditions of the permit by reason of any statement made or omitted to be made in this publication.

Editing and compilation

This report has been compiled by Loretta Serafin, Steven Simpfendorfer, Mike Sissons, Andrew Verrell and Guy McMullen, all from NSW DPI, Tamworth, on behalf of the authors.

Front cover photos: (large background photo) Sunflower field on the Liverpool plains;
(smaller photos, left to right) Sorghum trials at Breeza; Sorghum field day; Sunflowers in bloom.
All photos Loretta Serafin, NSW DPI, Tamworth.

Production

Design by Melissa Collins, Campaign Graphic Design.
Production by Barry Jensen, NSW DPI, Orange.

Foreword

NSW Department of Primary Industries (NSW DPI) is a major source of applied Research & Development (R&D) for cropping systems in central and northern NSW especially in collaboration with our major funding partner the GRDC. The NSW DPI R&D teams based across the region; at Trangie, Tamworth and Narrabri, conduct a range of on-farm research trials including plant breeding, agronomy, physiology, nutrition and crop protection.

This is the fifth edition of the Northern Grains Region Trials Book and it has grown significantly since the first edition. The 2014 volume includes over 50 papers reporting on trials from across the northern grains region. These short papers have been written to improve the awareness and accessibility of the results from NSW DPI run research trials in the region. The papers are based on scientifically sound, independent research but need to be taken in the context of the situation and season that the work has been conducted. In many cases the research that is reported will prompt more questions and we encourage you to contact the authors to discuss any of these queries.

The work that is reported is only possible through the cooperation of the many growers, advisors and consultants who our research teams work with throughout the year and these contributions are acknowledged within each paper. We also collaborate with other research organisations including grower groups such as Grains Orana Alliance and Northern Grower Alliance, agribusinesses, universities and other state based research providers.

Finally, we would like to thank the authors and editorial team for all their work compiling and reviewing the diverse range of papers in this year's edition.

We hope that you find the papers informative and of value to your business and we would also welcome any feedback that you might have that would help us to continue to make the Northern Grains Region Trials Book a valuable resource into the future.

The Research & Development Team,
NSW Department of Primary Industries

Contents

Agronomy

Crop protection

Nutrition and soils

Sowing time response of 13 wheat varieties – Trangie 2013

Rohan Brill NSW DPI, Wagga Wagga
Greg Brooke and Leigh Jenkins NSW DPI, Trangie

Key findings

Early sowing into a dry seed-bed on the 8th May was significantly higher yielding than later sowing into a moist seed-bed on the 26th June at Trangie in 2013 (0.91 t/ha averaged across varieties).

EGA_Gregory⚐, LongReach Impala⚐, LongReach Spitfire⚐, and Suntop⚐, were relatively high yielding at the early sowing date.

LongReach Impala⚐ and Suntop⚐ were also relatively high yielding at the later sowing date.

Dry sowing can be a useful tool to limit the amount of crop area planted late.

Introduction

Sowing time is a balance between avoiding frost damage or heat stress at anthesis and during grain-fill and also ensuring that water is available for the critical grain fill period post-flowering. Even where heat and frost are avoided, excessive early vegetative growth from early sowing may reduce the amount of water available for grain fill. Conversely, late sowing of quick varieties may reduce yield potential by not utilising all water and nutrients available.

Past research has generally shown grain yield of wheat declines at approximately 1% per day of delayed sowing beyond the optimum date. Dry sowing can be a useful tool to minimise these delays, especially in seasons where planting rains are delayed.

These results are a continuation of trials since 2009 which have been reported in previous editions of the Northern Grains Region Trial Results Book.

Site details

Location:	**Trangie**
Soil type:	**Brown Chromosol**
2012 crop:	**canola**
2011 crop:	**wheat**
RLN:	**nil**
PAW (sowing):	**30 mm (0–120 cm)**
Rainfall in-crop:	**205 mm**
Nitrogen:	**80 kg/ha (0–120 cm)**
Phosphorus:	**25 mg/kg (Colwell)** **37 mg/kg (BSES)**
pH:	**5.1 $CaCl_2$**
Fertiliser:	**70 kg/ha MAP (sowing)**

Treatments

- Two sowing dates – TOS1, 8 May (dry sown, 10.2 mm recorded 23 May), TOS 2, 26 June, 2013.
- Twelve bread wheat varieties –LongReach Dart⚐, EGA_Eaglehawk⚐, EGA_Gregory⚐, LongReach Gauntlet⚐, LongReach Lancer⚐, LongReach Spitfire⚐, Livingston⚐, Sunguard⚐, Suntop⚐, Sunvale, Sunzell⚐, Wallup⚐
- One soft wheat variety – LongReach Impala⚐.

Results

- Grain yield was 0.91 t/ha higher (averaged across varieties) from the 8 May sowing than the 26 June sowing.
- Within TOS 1, EGA_Gregory⚐, LongReach Impala⚐, LongReach Spitfire⚐ and Suntop⚐ were the highest yielding varieties. EGA_Eaglehawk⚐ and Sunzell⚐ were the lowest yielding varieties within TOS 1.
- Within TOS 2, LongReach Impala⚐, LongReach Dart⚐, LongReach Gauntlet⚐ and Suntop⚐ were the highest yielding varieties. Sunvale, Livingston⚐ and LongReach Spitfire⚐ were the lowest yielding varieties within TOS 2.

- The variety with the greatest yield reduction from TOS 1 to TOS 2 was LongReach Spitfire⁽ᵈ⁾ (43%), while the variety with the least yield reduction from TOS 1 to TOS 2 was Sunzell⁽ᵈ⁾ (10%). LongReach Spitfire⁽ᵈ⁾ was ranked first for grain yield from TOS 1 but dropped to a ranking of eleventh in TOS 2. Sunzell⁽ᵈ⁾ was ranked thirteenth for grain yield from TOS 1 and fifth for grain yield from TOS 2.
- Averaged across varieties, grain protein concentration increased from 12.3% for TOS 1 to 13.4% for TOS 2. Only LongReach Lancer⁽ᵈ⁾, EGA_Eaglehawk⁽ᵈ⁾ and Sunzell⁽ᵈ⁾ achieved 13% grain protein from TOS 1; however these varieties were generally relatively low yielding. LongReach Gauntlet⁽ᵈ⁾, LongReach Impala⁽ᵈ⁾ and Suntop⁽ᵈ⁾ had grain protein concentration less than 13% from TOS 2.

Table 1. *Grain yield and grain protein concentration of 13 wheat varieties sown on two sowing dates at Trangie in 2013.*

Variety	Yield (t/ha)		Protein (%)	
	8 May	26 June	8 May	26 June
EGA_Eaglehawk⁽ᵈ⁾	2.52	2.03	13.5	13.8
EGA_Gregory⁽ᵈ⁾	3.42	2.14	11.1	13.0
Livingston⁽ᵈ⁾	3.08	1.98	12.3	13.2
LongReach Dart⁽ᵈ⁾	2.99	2.22	12.5	13.2
LongReach Gauntlet⁽ᵈ⁾	3.04	2.20	11.5	12.4
LongReach Impala⁽ᵈ⁾	3.30	2.37	10.9	11.8
LongReach Lancer⁽ᵈ⁾	2.93	2.14	13.2	14.1
LongReach Spitfire⁽ᵈ⁾	3.53	2.02	11.9	14.9
Sunguard⁽ᵈ⁾	2.87	2.03	11.7	13.6
Suntop⁽ᵈ⁾	3.27	2.31	12.0	12.3
Sunvale	2.99	1.86	12.5	14.0
Sunzell⁽ᵈ⁾	2.40	2.16	13.8	13.6
Wallup⁽ᵈ⁾	3.01	2.06	12.5	14.9
Mean of sow time	3.03	2.12	12.3	13.4
l.s.d. p = 0.05	0.35		0.6	
c.v. (%)	8.6		3.1	

Summary

This trial highlighted the negative effect of delayed sowing on grain yield in the central-west region. The yield loss from TOS 1 to TOS 2 was 0.91 t/ha, which was effectively a grain yield reduction of 26 kg/ha per day of delayed sowing from when rain fell on the 23rd May until TOS 2 on 26th June. TOS 1 was dry sown in this trial, which is a useful tool to ensure more of the crop is planted on time and to ensure more moisture is available for establishment, because:

- The seed germination process will commence (but not be completed) in soils that are considered too dry to sow.
- Often there are delays of several days or more after rainfall is received and before sowing can actually be carried out.
- The sowing process accelerates moisture loss from the seed bed.

Similar to previous seasons, EGA_Gregory⁽ᵈ⁾, LongReach Impala⁽ᵈ⁾ and Suntop⁽ᵈ⁾ were relatively high yielding in 2013 across both sowing times.

LongReach Spitfire⁽ᵖ⁾ was relatively higher yielding in 2013 (from TOS 1 only) compared to previous seasons, where it has generally yielded similar to the trial mean.

LongReach Impala⁽ᵖ⁾ is a soft wheat variety, so planting decisions should be made with this in mind. LongReach Impala⁽ᵖ⁾ can also be used as a stockfeed variety, so in seasons where feed grain prices are elevated or where growers are close to a feedlot this variety may be an attractive option.

EGA_Eaglehawk⁽ᵖ⁾ and Sunzell⁽ᵖ⁾ had lower grain yield relative to the other varieties, likely because they are long season varieties that would be better suited to an April sowing to maximise yield potential. Similarly, LongReach Lancer⁽ᵖ⁾ which is a longer season variety may also achieve higher yields if planted in late April.

Acknowledgements

This project is funded by NSW DPI and GRDC under the Variety Specific Agronomy Package Project (DAN00129). Thanks to Jayne Jenkins (NSW DPI, Trangie) for technical assistance throughout this trial.

AGRONOMY

Effect of wheat seed source, protein concentration and size on subsequent crop establishment and grain yield – Trangie 2013

Rohan Brill NSW DPI, Wagga Wagga
Greg Brooke and Leigh Jenkins NSW DPI, Trangie

Key findings

Sowing seed with relatively high grain protein gave a small but significant improvement in crop establishment but did not result in increased grain yield compared with sowing low protein seed.

Seed source (2012 growing location) and seed size did not impact on crop establishment but did significantly influence grain yield.

Averaged across seed treatments, EGA_Gregory⊕ was significantly higher yielding than LongReach Spitfire⊕, which is consistent with NVT and VSAP trials in the northern grains region over previous seasons.

Introduction

Seed quality can be an important factor for determining subsequent crop yield. The benefit of sowing large seed, especially for deep sowing, is well documented. However there is little information on the effect of grain protein concentration of sown seed on subsequent crop performance.

To assess the effect of seed protein concentration on subsequent crop establishment and grain yield, EGA_Gregory⊕ and LongReach Spitfire⊕ samples from 2012 nitrogen trials at Coonamble and Trangie Agricultural Research Centre (TARC) (results of trials reported in 2013 Northern Grains Region Trial Results book) with resultant varying levels of grain protein were graded into common size classes. These seed quality treatments were then planted at Trangie Agricultural Research Centre in 2013.

Site details

Location:	**Trangie**
Soil type:	**Brown Chromosol**
2012 crop:	**canola**
PAW (sowing):	**30 mm (0–120 cm)**
Rainfall in-crop:	**205 mm**
Nitrogen:	**80 kg/ha (0–120 cm)**
Phosphorus:	**25 mg/kg (Colwell)**
Fertiliser:	**70 kg/ha Triple Super (sowing)**

Treatments

There were 24 separate treatments included in this trial (Table 1). These treatments represented all combinations of 2012 location (TARC or Coonamble), variety (LongReach Spitfire⊕ or EGA_Gregory⊕), 2012 N rate (0, 50 or 100 kg/ha) and seed size (seed retained above a 2.8 mm sieve or seed between 2.2 and 2.8 mm sieve). Grain protein is not a treatment in its own right but Table 1 shows the difference in seed protein concentration as affected by the N rate applied in 2012.

Results

- There was a significant effect of 2012 N rate on crop establishment. Seed from the 100 kg/ha N rate in 2012 established more plants than seed from the nil N rate in 2012 (Table 2).
- There was no effect of seed size, 2012 location or variety choice on 2013 crop establishment.
- Conversely there was a significant effect of seed size, seed source and variety on 2013 grain yield. Seed sourced from Trangie in 2012 was higher yielding than seed sourced from Coonamble. EGA_Gregory⊕ was higher yielding than LongReach Spitfire⊕ and seed graded above 2.8 mm was higher yielding than seed graded between 2.2 and 2.8 mm (Table 2).
- There was no effect of 2012 N rate (and therefore seed protein concentration) on 2013 grain yield.

Table 1. Seed source, variety, 2012 N rate, protein and seed size of grain used at Trangie in 2013.

2012 Location	Variety	2012 N rate	Grain protein	Seed size
TARC	LongReach Spitfire(b)	0	7.8	2.2–2.8mm
TARC	LongReach Spitfire(b)	50	11.1	2.2–2.8mm
TARC	LongReach Spitfire(b)	100	11.9	2.2–2.8mm
TARC	LongReach Spitfire(b)	0	8.8	> 2.8 mm
TARC	LongReach Spitfire(b)	50	9.7	> 2.8 mm
TARC	LongReach Spitfire(b)	100	11.1	> 2.8 mm
TARC	EGA_Gregory(b)	0	7.6	2.2–2.8mm
TARC	EGA_Gregory(b)	50	8.4	2.2–2.8mm
TARC	EGA_Gregory(b)	100	11.2	2.2–2.8mm
TARC	EGA_Gregory(b)	0	8.1	> 2.8 mm
TARC	EGA_Gregory(b)	50	8.8	> 2.8 mm
TARC	EGA_Gregory(b)	100	10.8	> 2.8 mm
Coonamble	LongReach Spitfire(b)	0	10.2	2.2–2.8mm
Coonamble	LongReach Spitfire(b)	50	11.4	2.2–2.8mm
Coonamble	LongReach Spitfire(b)	100	12.5	2.2–2.8mm
Coonamble	LongReach Spitfire(b)	0	10.4	> 2.8 mm
Coonamble	LongReach Spitfire(b)	50	11.4	> 2.8 mm
Coonamble	LongReach Spitfire(b)	100	12.9	> 2.8 mm
Coonamble	EGA_Gregory(b)	0	9.1	2.2–2.8mm
Coonamble	EGA_Gregory(b)	50	9.9	2.2–2.8mm
Coonamble	EGA_Gregory(b)	100	10.8	2.2–2.8mm
Coonamble	EGA_Gregory(b)	0	9.4	> 2.8 mm
Coonamble	EGA_Gregory(b)	50	10	> 2.8 mm
Coonamble	EGA_Gregory(b)	100	11.2	> 2.8 mm

Table 2. Effect of seed source (2012 trial location), variety, 2012 N rate and size class on subsequent grain yield in a trial at Trangie in 2013.

Treatment	Establishment (plants/m²)	l.s.d. (p=0.05)	Grain yield (t/ha)	l.s.d. (p = 0.05)
2012 Location (seed source)				0.06
TARC	54		3.26	
Coonamble	52	n.s.	3.11	
2012 N applied				n.s.
0 kg/ha	44		3.16	
50 kg/ha	48		3.17	
100 kg/ha	53	6	3.23	
Variety				0.06
LongReach Spitfire(b)	52		3.09	
EGA_Gregory(b)	49	n.s.	3.28	
Seed size				0.06
2.2–2.8 mm	51		3.12	
> 2.8 mm	54	n.s.	3.26	

Summary

This trial showed small but significant effects of seed quality on subsequent crop performance. These small effects when added together may lead to much greater yield benefits. For example in this trial the yield of EGA_Gregory$^{(b)}$, sourced from Trangie and graded with a 2.8 mm sieve was 3.47 t/ha compared with 2.96 t/ha for LongReach Spitfire$^{(b)}$ sourced from Coonamble and graded into a 2.2 to 2.8 mm size range.

It is unclear from this trial the reasons for the difference in grain yield as a result of the different seed sources; however it is likely that the benefit of the larger seed size was due to enhanced early vigour.

The establishment advantage of the higher protein seed requires more research and could be a useful advantage in moisture seeking situations. Although this trial showed no yield response from sowing seed with higher grain protein concentration, there is the potential for a yield response to occur if higher protein seed allows a sowing opportunity to be capitalised on when conditions are marginal or where seed needs to be placed into deep moisture.

Acknowledgements

This trial is funded by NSW DPI and GRDC under the Variety Specific Agronomy Package Project (DAN00129). Thanks to Jayne Jenkins for assistance throughout this trial.

Genotype and environment effects on durum wheat quality – implications for breeding

Mike Sissons, Gururaj Kadkol and Steve Harden NSW DPI, Tamworth

Introduction

To effectively select for the best genotypes in terms of yield and technological quality and make genetic gains in a plant breeding program, we need to understand the contribution of genetics and environmental determinants on the traits we measure. This requires obtaining information on the technological quality and yield of genotypes grown at multiple locations with replication and this necessitates extensive and expensive testing not conducted previously in the durum breeding program.

Key findings

It is important to understand the heritability of yield and quality traits to achieve improvements in these characters through breeding.

Based on our results, there is good potential for continued improvement in milling yield, dough strength and yellow colour as these traits have shown strong genotypic variance.

Further work is needed to fully quantify the genotype, environment and genotype X environment interaction contributions in determining quality of Australian durum grain.

Site details

Season:	**2012**
Genotypes:	**9 DBA breeding lines (240578, 241046, 280012, 280115, 280580, 280913, 290491, 290564, UAD0951096) and 4 released varieties (EGA_Bellaroi(|), Caparoi(|), Hyperno(|), Jandaroi(|)).**
Locations:	**Moree, North Star, Breeza, Tamworth and Edgeroi.**
Trials:	**Conducted by DBA Northern node breeding staff using row column trial designs with 3 replicates.**
Quality:	**Conducted by DBA quality staff: Grain yield, test weight, 1000 grain weight, HVK (limited), grain protein, milling value, semolina colour and dough quality.**
Analysis:	**Partially replicated design for the quality assessment including a mill check sample to measure effects of day of milling.**

Results

The site mean data (Table 1) showed that North Star produced the highest yield and Tamworth a much lower yield due to dry conditions in spring combined with poor water holding capacity of the soil. Grain quality was generally good but with low protein at Moree and no evidence of pinched grain at any site. Dough properties reflected good semolina quality.

Table 1. *Site means for yield, grain quality and semolina and dough properties – 2012.*

Site	Grain						Semolina			Dough				
	Grain Yield (t/ha)	HLW (kg/hl)	TGW (g)	HVK (%)	GP % 11% (mb)	SKHI	SY %	L*	b*	MPT min	MPH AU	RBD	WG %	GI
Breeza	4.2	81	39	87	13.2	82	71.4	82.6	31.1	3.3	51	51	28.8	87
Edgeroi	4.5	84	40	92	12.3	90	72.5	82.2	32.3	3.2	48	71	26.8	76
Moree	4.9	85	45	87	10.9	91	72.6	82.6	33.3	3.7	44	76	22.9	87
North Star	5.1	85	45	92	11.4	90	72.4	82.4	34.0	3.6	46	64	24.3	84
Tamworth	1.5	83	45	91	13.0	96	71.4	82.2	34.2	3.2	51	51	28.1	88
Average LSD		0.36	1.22	5.30	0.42	1.23	0.17	0.25	0.21	0.30		7.56	1.05	2.37

Key: HLW=test weight, TGW=1000 kernel weight, HVK=% of hard vitreous kernels, GP=grain protein, SKHI=grain hardness, SY=semolina milling Yield, L* = brightness, b*=yellowness, MPT=mixograph development time, MPH=mixograph peak height, RBD=resistance breakdown, WG=wet gluten, GI=gluten index.

Table 2. Mean values for DBA Stage 4 lines and quality checks for grain yield and grain, semolina and dough quality parameters from 2012 Stage 4 trials conducted in five Northern NSW sites.

Line	Grain					Semolina				Dough				
	Grain Yield (range) t/ha	HLW kg/hl	TGW g	HVK %	GP% (range) 11% mb	SKHI	SY %	L*	b*	MPT min	MPH AU	RBD	WG %	GI
240578	4.1 (1.2–5.1)	83	46	96	12.5 (10.7–14.2)	91	72.1	82.2	34.2	3.3	49	47	27.2	85
241046	4.1 (1.3–5.3)	84	48	93	12.6 (11.2–13.7)	91	72.7	82.3	33.7	3.1	51	64	28.2	82
280012	4.0 (1.2–5.4)	83	41	94	11.4 (9.3–14.1)	90	72.3	82.4	35.1	3.6	43	69	24.8	82
280115	4.0 (1.3–5.4)	84	41	95	12.1 (10.0–14.5)	91	72.1	82.2	34.5	3.3	45	70	26.9	76
280913	3.9 (1.3–4.7)	84	43	94	12.4 (11.1–13.8)	90	72.0	82.2	34.7	3.2	48	57	25.4	89
290491	4.1 (1.5–5.5)	82	41	86	11.9 (10.3–13.5)	88	72.0	82.3	34.0	3.0	48	76	25.3	79
290564	4.1 (1.2–5.2)	84	42	95	12.3 (11.1–13.8)	90	71.2	82.8	33.5	3.0	52	60	26.8	86
EGA_Bellaroi⌽	3.7 (1.3–4.5)	83	42	91	13.1 (11.9–14.8)	89	71.7	82.1	32.1	2.8	52	81	29.9	73
Caparoi⌽	4.1 (1.3–5.7)	85	43	85	12.0 (10.9–13.3)	90	72.0	82.3	31.6	4.1	45	59	25.3	87
Hyperno⌽	4.3 (1.4–6.0)	84	42	73	11.4 (9.2–13.0)	87	72.0	83.0	32.0	3.9	43	66	23.9	86
Jandaroi⌽	3.8 (1.0–5.1)	83	45	88	12.8 (11.4–14.9)	91	72.4	82.4	29.4	3.3	54	54	26.4	96
UAD0951096	4.3 (1.4–5.7)	84	42	86	11.5 (9.4–13.3)	88	72.4	82.5	31.2	4.0	45	46	23.7	92
Average LSD	0.15	1.3	4.3	18.7	1.48	4.3	0.61	0.89	0.76	1.04		26.7	3.70	8.35

The durum entry mean (across all sites) data (Table 2) shows that most of the genotypes achieved a similar yield except for Jandaroi⌽ and EGA_Bellaroi⌽ which were the lowest yielding with Hyperno⌽ and UAD0951096 achieving the highest yields. Grain size was typical of good quality grain with 241046 (potential new release) achieving a higher grain weight (TGW), typical for this line. Only Hyperno⌽ showed lower vitreousness, which would lower its receival grade while UAD0951096, which is related to Hyperno⌽ had HVK similar to all other genotypes achieving the minimum for DR1 of 80%. These results showed there were no adverse effects on grain quality with the 2012 season in northern NSW.

Grain protein showed a large variation between genotypes, ranging from 11.4 (Hyperno⌽) to 13.10 (EGA_Bellaroi⌽), so EGA_Bellaroi was the only genotype which achieved DR1 protein on average. This generally reflected the low grain protein levels achieved commercially across the region in bread wheat and durum crops in 2012. This variation in protein is a reflection of the site, with Moree showing the lowest protein, hence the wide range in protein achieved for each genotype depending on site conditions. All grain samples were very hard (SKHI) and screenings were <5% at all sites except Breeza (irrigated) with values as high as 10% (UAD0951096) and as low as 2.2% for Jandaroi⌽ at this site (data not shown). Most lines showed similar, good milling yield of semolina with the lowest genotype being 290564 and the highest, 241046 (consistent with data from other seasons). Semolina colour was bright with the range in yellowness (b*) from 29.4–35.1, which is quite large. Jandaroi⌽ has the lowest b* falling behind industry quality benchmark varieties, EGA_Bellaroi⌽ and Caparoi⌽. There were several genotypes with superior b* to these varieties which appears promising for improvement of the yellow colour of pasta from breeding. Dough properties were assessed using the mixograph (measures resistance to mixing dough at a fixed water addition) and the amount of functional wheat protein, viz. gluten and the gluten index (GI, 0–100; with 100 being very strong). EGA_Bellaroi was the weakest genotype indicated by the lowest GI and highest RBD and lowest MPT, all known to be related to gluten strength with 280015 also showing weaker dough. In contrast, Jandaroi⌽ displays very strong gluten followed by Caparoi⌽, UAD0951096 and 280913 close behind. All would be very satisfactory for making strong pasta shapes.

Table 3. *Estimates of the percentage of total variance accounted for by genotypic, environment, genotype X environment interaction and residual effects for important grain quality traits of 13 durum wheats.*

Trait	Variance			
	Genotype	Environment	Genotype x environment	Residual
HLW	12.4	40.7	7.2	39.7
TGW	21.1	29.3	5.5	44.2
GP	9.3	43.2	3.5	43.9
SKHI	1.4	76.9	6.8	14.9
Milling yield	32.4	31.0	5.9	30.7
L*	7.8	6.2	0	86.0
b*	51.7	30.3	1.8	16.2
MPT	21.1	9.0	0	70.0
MPH	24.7	45.5	4.3	25.6
RBD	15.6	36.7	0.4	47.4
WG	15.8	34.3	3.1	46.7
GI	24.7	14.9	7.9	52.5

An analysis of the quality data to determine the contribution to the total variance in the data due to genotype, environment (site) and the GxE and unexplained residual variance is outlined in Table 3. This analysis is limited in terms of only being one season data and desirably, more seasons should be assessed to fully understand the variance contribution. Traits that have high genetic variation and are not affected by the environment are more amenable for achieving higher genetic gain in selection. The analysis results (Table 3) showed a large proportion of unexplained variation for most of the traits which is much higher than published reports from other countries and this will be further investigated. Characters that displayed high G variance were b* and milling yield with lesser G variances for GI, MPH, MPT and TGW. As expected, environment (location) had a major influence on HLW, GP, SKHI. There were generally only small GxE interactions in the data. Trends for GP, HLW, b*, GI were similar to reports from studies overseas.

Summary

To assess improvement in yield and quality in plant breeding programs experimental genotypes need to be evaluated at multiple sites in the targeted region over several seasons to allow for fluctuations in climatic conditions. Success in selection for quality is determined by the heritability of each trait and available genetic variation. This preliminary data suggests good genetic progress should be possible in dough properties, yellow colour (b*) and milling potential. Indeed, Jandaroi⦶ dough strength is much stronger than EGA_Bellaroi⦶ and some new elite lines have even higher b* than EGA_Bellaroi while 241046 has consistently improved semolina yield than registered varieties.

Acknowledgements

This project is funded by NSW DPI and GRDC (DAN00163). Thanks to Adam Perfrement, David Gulliford, Darren O'Brien, Richard Morphett, Max Cloake, Narelle Egan, Sue Balfe, Shaylene Sissons and Debbie Delaney for technical assistance.

Row placement strategies in a break crop – wheat sequence

Andrew Verrell NSW DPI, Tamworth

Key findings

Sowing the following wheat crop *directly* over the row of the previous years break crop provided a 10–16% yield advantage.

This system will only work for zero tillage systems where wheat stubble is kept intact.

Introduction

Inter-row sowing has been shown to reduce the impact of crown rot and increase yield, by up to 9%, in a wheat-wheat sequence (Verrell *et al* 2009). Crop rotation reduces the incidence and severity of crown rot resulting in yield gains of 17–23% over continuous wheat (Verrell *et al* 2005). There was a need to examine whether row placement strategies coupled with a break crop – wheat rotation, would result in differences in grain yield over a five year crop sequence.

Treatments

A five year crop sequence experiment consisting of three winter sequences;

1. wheat-wheat-wheat-wheat-wheat
2. wheat-chickpea-wheat-chickpea-wheat
3. wheat-mustard-wheat-mustard-wheat

was established in 2008 at the Tamworth Agricultural Institute (TAI). The TAI site consisted of a brown vertosol with an average summer and winter rainfall of 400 mm and 280 mm, respectively, and soil plant available water holding capacity of 120mm to a depth of 1.0m. Durum wheat (cv. EGA_Bellaroi⊕) was sown in 2008 (40cm row spacing) and inoculated with a low level of the crown rot (CR) fungus, *Fusarium pseudograminearum* (*Fp*) at a rate of 0.5 g/m row. This resulted in a low incidence of Fp (25%) across the site.

In 2009, wheat, mustard or chickpea was sown either on or between the 2008 wheat rows using GPS guided autosteer. In subsequent seasons crops were sown either on or between the previous year rows resulting in sixteen different row placement combinations by the time the 2012 wheat crop was sown. All crops were sown with Janke coulter-tyne-press wheel parallelograms along with 100 kg N/ha (mustard and wheat) and 10 kg P/ha (all crops).

Results

The results presented here will focus solely on the mustard-wheat and chickpea-wheat systems and the last three years of the sequence trial (2010–2011–2012). Four row placement options are presented for both crop sequences and row placements are relative to the position of the 2010 wheat rows (Table 1).

Table 1. *Row placement options relative to the 2010 wheat rows.*

Row sequence	Row placement		
	2011	2012	Abbreviation
1	Between 2010 rows	Between 2010 rows	BB
2	On rows 2010 rows	Between 2010 rows	OB
3	On rows 2010 rows	On rows 2010 rows	OO
4	Between 2010 rows	On rows 2010 rows	BO

The 2012 wheat yield, in the mustard-wheat sequence, was significantly higher for the BB row option (4.46 t/ha) compared to other placements (Table 2). Both the OB and OO options had similar yields which were lower than the BB treatment. The lowest yielding row placement option was BO (3.84 t/ha).

Table 2. *Row placement by year with grain yield, grain N removal and whiteheads for the 2012 wheat crop in a wheat-mustard-wheat sequence.*

Row placement sequence	Row placement x crop			2012 Wheat crop		
	2010 Wheat	2011 Mustard	2012 Wheat	Yield (t/ha)	Grain-N (kgN/ha)	Whiteheads (heads/m^2)
BB				4.46a	87a	0.70a
OB				4.27b	88a	0.64a
OO				4.24b	86a	0.89ab
BO				3.84c	75b	1.53b

NB. Values within a column with the same letter are not significantly different (P<0.05).

The BO row placement sequence had significantly lower grain nitrogen removal and the highest number of whiteheads compared to the other row placement options in the mustard-wheat sequence (Table 2).

Similar data for the mustard-wheat sequence is presented for the chickpea-wheat sequence (Table 3). In this sequence there was no difference between the BB, OB and OO row placements for the 2012 wheat yield. However, the BO sequence had significantly lower yield (4.03 t/ha) for the 2012 wheat crop compared to other options. The BO sequence also had the lowest grain nitrogen removal rate and the highest number of whiteheads under a chickpea-wheat rotation (Table 3).

Table 3. *Row placement by year with grain yield and grain N removal for the 2012 wheat crop in a wheat-chickpea-wheat sequence.*

Row placement sequence	Row placement x crop			2012 Wheat crop		
	2010 Wheat	2011 Chickpea	2012 Wheat	Yield (t/ha)	Grain-N (kg N/ha)	Whiteheads (heads/m²)
BB				4.46a	91a	0.92a
OB				4.45a	92a	0.92a
OO				4.36a	90a	0.83a
BO				4.03b	82b	1.63b

NB. Values within a column with the same letter are not significantly different ($P<0.05$).

Whiteheads for the wheat-wheat sequence were 2.2, 0.8, 3.5 and 1.2 (heads/m^2) for the BB, OB, OO and BO row placement options, respectively (data not shown).

Summary

After five years, both break crop systems showed grain yield advantages in 2012, over continuous wheat, of 40% and 44%, for the mustard-wheat and chickpea-wheat systems, respectively. The chickpea-wheat system tended to have slightly higher wheat grain yields in 2012 for each of the four row placement strategies compared to the mustard-wheat sequence (Table 2 and Table 3).

The number of whiteheads/m^2 does not reflect the total level of incidence of *Fp* in a crop. Whitehead production is heavily influenced by the amount of water (rainfall + soil stored) available to the crop. Under high water levels, whitehead numbers can be very low or even non-existent even if the crop has a high incidence of *Fp*. The whitehead counts provide a trend and should not be considered as absolute values. In this experiment whitehead numbers are low due to high levels of crop available water, from zero-till fallowing and in-crop rainfall.

This experiment has shown that simply alternating row placement in consecutive years will not result in yield gains but a yield loss and increased CR (BO system). In the BO sequence the break crop was sown between standing cereal stubble which was kept intact. The following wheat crop was then sown between the previous years (break crop) rows but this put it directly over the old 2010 wheat row. The consequence of this sequence was that the wheat crop was sown into old infected wheat stubble hence the higher level of CR infection resulting in higher whitehead counts. The benefit of the break crop in breaking any disease cycle was reduced. This is supported by the wheat-wheat whitehead data which showed higher incidence of whiteheads/m^2 for row placements where wheat was sown directly over the previous row (BB=2.5, OO=3.5) compared to between row sequences (OB=0.8, BO=1.2).

Even the traditional on row system (OO) had a better yield and CR outcome than the BO system because the break crop was sown directly over the old wheat stubble row excavating the residue out of the row (tyne with spear points) and providing a direct break to the CR fungus (Table 2 and 3). This may not be the case however if a low disturbance disc system is used.

Based on these results the best option for row placement sequences in a break crop system is shown in Table 4.

Table 4. *Proposed row placement strategy to optimise crop yield in a wheat-break crop-wheat sequence.*

Year 1 Wheat	Year 2 Chickpea	Year 3 Wheat	Year 4 Canola	Year 5 Wheat

Following a wheat crop, the break crop (pulse or oilseed) should be sown between the standing stubble rows. In the next year, the wheat crop should be sown directly over the previous seasons break crop row. Then in the next year of the rotation the break crop should shift back and be sown between the standing wheat rows. Finally, in the fifth year, the wheat crop again should be sown directly over the previous years break crop row.

There are two simple rules that need to be followed;

- Sow break crops between standing wheat rows which need to be kept intact
- Sow the following wheat crop directly over the row of the previous years break crop

By following these two rules it ensures the following;

- Ensures four years occur between wheat crops being sown in the same row space (Table 4)
- Improved germination of break crops, especially canola, not hindered by stubble
- Chickpeas will benefit from standing stubble reducing the impact of virus
- Standing wheat stubble gives better protection to break crop seedlings

Acknowledgements

Thanks to Michael Nowland and Paul Nash for their assistance in the trial program.

References

Verrell, A.G., Simpfendorfer S., Nash P. and Moore K. (2009) Can inter-row sowing be used in continuous wheat systems to control crown rot and increase yield? 13th Annual Symposium on Precision Agriculture in Australasia (2009), UNE, Armidale.

Verrell, A.G., Simpfendorfer S., Nash P. and Moore K. (2005) Crop rotation and its effect on crown rot, common root rot, soil water extraction and water use efficiency in wheat. Proceedings 2005 GRDC Grains Research Update, Goondiwindi.

Response of eight barley varieties to three seed and nitrogen input systems – Trangie 2013

Rohan Brill NSW DPI, Wagga Wagga
Greg Brooke and Leigh Jenkins NSW DPI, Trangie

Key findings

The newer barley varieties LaTrobe$^{(D)}$ and Compass$^{(D)}$ were the highest yielding in this trial.

Increasing the level of inputs (seed and nitrogen) generally reduced grain yield by exacerbating moisture stress; however this was most pronounced in Commander$^{(D)}$, GrangeR$^{(D)}$ and Gairdner$^{(D)}$ and least pronounced in Compass$^{(D)}$, Hindmarsh$^{(D)}$ and LaTrobe$^{(D)}$.

Introduction

Barley breeding has made significant improvement in recent years, with relatively new and popular varieties such as Hindmarsh$^{(D)}$ and Commander$^{(D)}$ generally yielding significantly more than older varieties such as Schooner and Gairdner$^{(D)}$. LaTrobe$^{(D)}$ is a new variety with similar agronomic characteristics to Hindmarsh$^{(D)}$ but still undergoing malt accreditation. Compass$^{(D)}$ has similar grain quality as Commander$^{(D)}$ but has been bred to be higher yielding and with improved straw strength.

This trial was sown to test the performance of several commercially available barley varieties across three input systems – low seed rate and low nitrogen (N) input; moderate seed rate and moderate N input; and high seed rate and high N input.

Site details

Location:	**Trangie**
Soil type:	**Brown Chromosol**
2012 crop:	**canola**
2011 crop:	**wheat**
PAW (sowing):	**30 mm (0–120 cm)**
Rainfall in-crop:	**205 mm**
Sowing date:	**29th May 2013**

Treatments

- Eight barley varieties – Commander$^{(D)}$, Compass$^{(D)}$, Gairdner$^{(D)}$, GrangeR$^{(D)}$, Hindmarsh$^{(D)}$, LaTrobe$^{(D)}$, Scope$^{(D)}$ and Skipper$^{(D)}$
- Three input systems – Low (0N and 75 plants/m^2), Moderate (30N and 150 plants/m^2) and High (90N and 300 plants/m^2). All nitrogen was applied as Urea at sowing.

Results

- For the 'Low' input system, grain yield of Compass$^{(D)}$, Commander$^{(D)}$ and LaTrobe$^{(D)}$ was significantly higher than all other varieties and the grain yield of Gairdner$^{(D)}$ was significantly less than all other varieties (Table 1).
- Compared with the 'Low' input system, most varieties had lower yields in the 'High' input system. Yield loss was greatest for Commander$^{(D)}$ and Gairdner$^{(D)}$ (0.64 and 0.59 t/ha, respectively). Hindmarsh$^{(D)}$ was the only variety to have increased grain yield in the 'High' or 'Moderate' input systems compared to the 'Low' input system.
- Compass$^{(D)}$, Hindmarsh$^{(D)}$ and LaTrobe$^{(D)}$ had significantly higher yields than all other varieties in the "High' input system and the grain yield of Gairdner$^{(D)}$ was significantly less than all other varieties (Table 1).

Table 1. *Grain yield of eight barley varieties sown with three input (seed and nitrogen) systems, 'Low', 'Moderate' and 'High' – Trangie 2013.*

Variety	Input system		
	Low	Moderate	High
Commander$^{\phi}$	3.45	3.32	2.81
Compass$^{\phi}$	3.52	3.53	3.20
Gairdner$^{\phi}$	2.36	2.20	1.77
GrangeR$^{\phi}$	2.74	2.64	2.32
Hindmarsh$^{\phi}$	3.18	3.43	3.35
LaTrobe$^{\phi}$	3.49	3.53	3.03
Scope$^{\phi}$	3.06	2.96	2.63
Skipper$^{\phi}$	2.88	2.79	2.42
l.s.d. (P=0.05)		0.12	

Summary

In this trial, LaTrobe$^{\phi}$ had similar grain yield as Hindmarsh$^{\phi}$. If LaTrobe$^{\phi}$ achieves malt accreditation it appears a likely replacement for Hindmarsh$^{\phi}$ as there was no yield penalty evident in this trial or in other similar trials across the country. Where the input levels were increased, Compass$^{\phi}$ had higher grain yield than Commander$^{\phi}$. With a similar grain quality package as Commander$^{\phi}$, Compass$^{\phi}$ is a potential replacement for Commander$^{\phi}$ if malt accreditation is achieved.

The increase in level of seed and nitrogen input in this trial essentially increased the level of stress on the varieties, likely by accelerating early water use. Hindmarsh$^{\phi}$, LaTrobe$^{\phi}$ and Compass$^{\phi}$ were better able to deal with this stress and maintained relatively high yield in the 'High' input treatment which indicates good suitability for the region in low-medium rainfall seasons.

The sowing date of 29th May would not have suited either Gairdner$^{\phi}$ or GrangeR$^{\phi}$. These varieties ideally need to be sown in late April to early May.

Acknowledgements

This project is funded by NSW DPI and GRDC under the Variety Specific Agronomy Package Project (DAN00129). Thanks to Jayne Jenkins, Lindsay Hyde, Paddy Steele and Scott Richards (NSW DPI, Trangie) for assistance throughout this trial.

Barley varieties for the north – comparing new releases

Guy McMullen NSW DPI, Tamworth **Matthew Gardner** formerly NSW DPI, Tamworth

Key findings

Commander⁽ᵈ⁾ continues to perform well in northern NSW in terms of both grain yield and quality.

New varieties for consideration include;

– Compass⁽ᵈ⁾ which has performed very strongly and appears to have improved straw strength,

– LaTrobe⁽ᵈ⁾ (IGB1101) and Skipper⁽ᵈ⁾ which are quick maturing varieties which is currently a gap for growers in the region.,

– Navigator⁽ᵈ⁾ has also performed well as a longer season malt option and is the most advanced in the malt accreditation process.

Apart from Commander⁽ᵈ⁾, all these recently released lines are still undergoing malt accreditation.

Responses to varying plant population and nitrogen rate were evident in some varieties, indicating agronomic management may need to be varied to achieve the full potential of new varieties.

Introduction

Barley still plays an important role in northern NSW farming systems and the potential for an increase in the area of plantings across the region is substantial. However, any increases in area are primarily dependant on improved receival prices and varieties that reliably achieve malt classification. Since 2011 there has been 16 new barley entries submitted for malt accreditation, with six being released as commercial varieties in the past two seasons. The release of new higher-yielding malting varieties will provide industry with improved grain quality and likelihood of achieving malt specifications. Other factors that favour barley include performance in tough seasons, tolerance to sub-soil constraints (e.g. salinity), better weed competition and its tolerance to root lesion nematodes (RLN). It should be noted that barley is a host for RLN and crop rotation is needed to reduce RLN populations below critical thresholds. It should also be remembered that barley is a host of crown rot so is not a break crop for this disease. Major issues that currently limit barley production are reliability of achieving malting specifications – especially grain size and protein. Lodging remains a problem although there has been some improvement in several of the new lines.

Site details

National Barley Agronomy Trials

Trials across Australian barley growing regions were established to test the performance of new varieties under varying agronomic practices. This paper reports on four trials from the northern NSW grains region in 2012 and 2013. In 2012 sites were located at Spring Ridge and Gurley and in 2013 sites were at Pine Ridge and Garah (Table 1).

Table 1. *Trial site details in 2012 and 2013.*

	2012		2013	
	Gurley	Spring Ridge	Garah	Pine Ridge
Sowing date	31/5/12	15/6/12	29/4/13	6/6/13
Soil Nitrate-N (kg N to 120 cm)	91	110	80	100

Treatments

In 2012 at Spring Ridge six varieties were trialled being, Bass⁽ᵈ⁾, Buloke⁽ᵈ⁾, Commander⁽ᵈ⁾, GrangeR⁽ᵈ⁾, Navigator⁽ᵈ⁾ and Wimmera⁽ᵈ⁾. In 2012, Skipper⁽ᵈ⁾ and LaTrobe⁽ᵈ⁾ were included at the Gurley site to make eight varieties. In 2013 the varieties included at both sites were Bass⁽ᵈ⁾, Buloke⁽ᵈ⁾, Commander⁽ᵈ⁾, Compass⁽ᵈ⁾ , GrangeR⁽ᵈ⁾, LaTrobe⁽ᵈ⁾ , Navigator⁽ᵈ⁾ and Wimmera⁽ᵈ⁾. In both years all varieties were sown with target populations of 75, 150 or 300 plants/m^2, which was in a factorial trial design with three N rates of 0, 30 and 90 kg N/ha, applied as urea. All N treatments were side banded at planting and no further N applications were made throughout the season.

Results 2012

Commander⁽ᵈ⁾ and GrangeR⁽ᵈ⁾ were the highest yielding varieties in the Spring Ridge trial with the average yields across treatments of 6.3 and 6.2 t/ha, respectively (Figure 1). Bass⁽ᵈ⁾, Navigator⁽ᵈ⁾ and Wimmera⁽ᵈ⁾ all had similar yields that were significantly higher than Buloke⁽ᵈ⁾, which yielded 5.6 t/ha on average. There were only limited N responses observed at Spring Ridge, which is not surprising given the starting soil N being over 100 kg N/ha. Despite this, the 90 kg N/ha treatment significantly increased grain yield for Commander⁽ᵈ⁾ and GrangeR⁽ᵈ⁾ compared to the 0 N rate (data not shown). There were no other significant differences observed as a result of N application at Spring Ridge.

Increasing plant population from 75 to 150 plants/m^2 increased grain yield for Bassᶲ and Navigatorᶲ by 0.42 and 0.34 t/ha, respectively (Figure 1). For all other varieties there was no significant increase in grain yield achieved from higher plant populations. Increasing plant population from 150 to 300 plants/m^2 decreased grain yield in Navigatorᶲ, Commanderᶲ and Bulokeᶲ by 6, 9 and 7%, respectively. For both Commanderᶲ and Bulokeᶲ this increase in plant population also coincided with a significant increase in the severity of lodging, which may explain some of the yield decline. The same lodging was not observed in Navigatorᶲ.

The quick season varieties Skipperᶲ and LaTrobeᶲ had the highest grain yields at Gurley in 2012, with 4.0 and 3.9 t/ha respectively, while Commanderᶲ achieved 3.8 t/ha (Figure 2). Wimmeraᶲ and Navigatorᶲ achieved similar yields that were greater than Bulokeᶲ and Bassᶲ which had grain yields of 3.4 and 3.3 t/ha, respectively. GrangeRᶲ had grain yields 1.0 t/ha less than that achieved by Commanderᶲ and was the lowest yielding variety. This site had moderate levels of both crown rot and *Pratylenchus thornei* in 2012 which may explain the poor performance of GrangeRᶲ.

Despite the target populations the actual populations achieved were 70, 125 and 210 plants/m^2. There was no variety interaction with plant population but 125 and 210 plants/m^2 resulted in grain yield increases of 0.4 and 0.6 t/ha, respectively, compared to the 70 plants/m^2. Skipperᶲ and La Trobeᶲ were the only two varieties to have a significant increase in grain yield between the 0 and 90 kg N/ha treatments (Figure 2). There was no significant response in any other variety to N treatments.

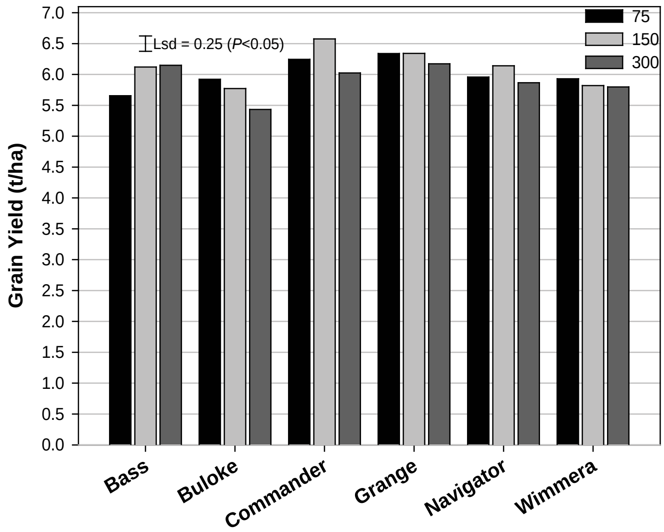


Figure 1. *Grain yield of six barley varieties grown at populations of 75, 150 and 300 plants/m^2 – Spring Ridge 2012.*

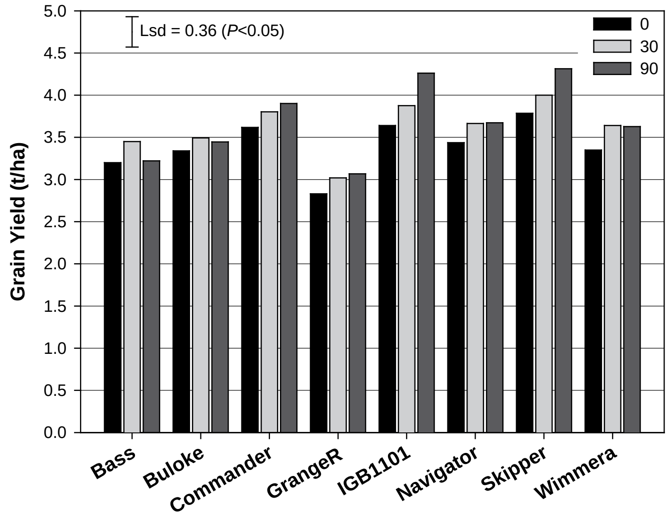


Figure 2. *Grain yield of eight barley varieties grown at three N rates of 0, 30 or 90 kg N/ha – Gurley 2012.*

The high residual N at the Spring Ridge site meant that there were no varieties with protein values under 14%, which is above the malt specification of 12% (Table 2). Bassᶲ and Wimmeraᶲ had the highest protein with 16%, which was 2% greater than the protein achieved by Commanderᶲ. Although the protein values were approximately 3% lower at Gurley there were similar trends with Bassᶲ and Wimmeraᶲ having the highest protein levels. Commanderᶲ and LaTrobeᶲ both achieved proteins under 12% at Gurley (Table 3). Navigatorᶲ, GrangeRᶲ and Skipperᶲ appear to respond similarly in terms of the protein response to N application.

***Table 2.** The average grain quality for six barley varieties grown across three N rates (0, 30 and 90 kg N/ha) and three populations (75, 150 and 300 plants/m^2) at Spring Ridge in 2012. Values followed by the same letter are not significantly different at the 95% confidence level.*

Variety	Protein (%)	Screenings (%)	Retention (%)	Test Weight (kg/hL)
Bass$^{\phi}$	16.1 a	2.2 d	80.6 a	72.4 a
Buloke$^{\phi}$	14.6 c	4.7 c	66.1 d	71.3 b
Commander$^{\phi}$	14.0 d	4.3 c	75.7 b	69.3 c
GrangeR$^{\phi}$	15.2 b	7.5 a	62.5 e	71.1 b
Navigator$^{\phi}$	15.3 b	5.5 b	70.6 c	71.1 b
Wimmera$^{\phi}$	16.0 a	7.7 a	62.1 e	70.8 b
Lsd (P=0.05)	0.3	0.4	1.3	0.5

Screenings were relatively low at both sites. However, the Spring Ridge site had higher screenings than Gurley, with GrangeR$^{\phi}$ and Wimmera$^{\phi}$ actually exceeding the 7% threshold (Table 2 and Table 3). GrangeR$^{\phi}$ also had the highest screenings at Gurley with 4.7%, which was significantly greater than all other varieties. Under the conditions experienced at the Spring Ridge site, high residual N and a hot dry finish to the season, it could be expected that the screenings in a small seeded variety such as Gairdner$^{\phi}$ may have been much higher.

Bass$^{\phi}$ (80.6%) had the highest retention at Spring Ridge (Table 2), whilst Skipper$^{\phi}$ (93.7%) had the greatest retention at Gurley (Table 3). GrangeR$^{\phi}$ and Wimmera$^{\phi}$ had the lowest retention at both sites. At the Spring Ridge site the retentions of GrangeR$^{\phi}$ and Wimmera$^{\phi}$ were both below 70%. There was little difference between the other varieties. Commander$^{\phi}$ and Navigator$^{\phi}$ had the lowest test weights at Spring Ridge and Gurley, respectively but they were above 65 kg/hL in both instances. The test weights were similar between the two sites with the better varieties ranging between 70 and 72 kg/hL, which are above the target test weight of 65 kg/hL (Table 2 and 3).

***Table 3.** Average grain quality for eight barley varieties grown across three N rates (0, 30 and 90 kg N/ha) and three populations (75, 150 and 300 plants/m^2) at Gurley in 2012. Values followed by the same letter are not significantly different at the 95% confidence level.*

Variety	Protein (%)	Screenings (%)	Retention (%)	Test Weight (kg/hL)
Bass$^{\phi}$	13.4 a	2.6 c	89.1 b	71.3 ab
Buloke$^{\phi}$	12.8 b	2.0 d	88.5 b	71.3 ab
Commander$^{\phi}$	11.0 d	2.4 cd	89.1 b	70.3 c
GrangeR$^{\phi}$	12.5b c	4.7 a	82.9 d	70.1 cd
LaTrobe$^{\phi}$	11.7 c	2.2 d	89.3 b	72.3 a
Navigator$^{\phi}$	12.1 c	2.3 d	87.9 b	69.6 d
Skipper$^{\phi}$	12.1 c	1.3 e	93.7 a	72.0 a
Wimmera$^{\phi}$	13.2 ab	2.9 b	85.2 c	71.6 a
Lsd (P=0.05)	0.4	0.3	1.7	0.6

2013 Results

In 2013 the recently released lines Navigator(b) and Compass(b) performed well with respect to yield at both sites (Table 4). The yield of Commander(b) was slightly down at the Pine Ridge site but was competitive with the best lines at Garah. In contrast LaTrobe(b) performed better at the Pine Ridge site compared to Garah. Buloke(b), a southern line, performed poorly in 2013. Bass(b) and GrangeR(b), both longer season lines, performed well at Pine Ridge but were significantly lower yielding at Garah. When averaged across all treatments, the higher yielding lines had significantly lower protein levels at both sites. This meant that on average across all treatments these lines achieved malting protein targets at both sites.

Table 4. *Grain yield and protein for eight barley varieties grown across three N rates (0, 30 and 90 kg N/ha) and three populations (75, 150 and 300 plants/m^2) at Pine Ridge and Garah in 2013. Values followed by the same letter are not significantly different at the 95% confidence.*

	Pine Ridge				Garah			
	Yield (t/ha)		Protein (%)		Yield (t/ha)		Protein (%)	
Bass(b)	5.46	bcd	12.0	a	3.12	c	12.9	a
Buloke(b)	5.05	f	11.0	b	3.10	c	12.6	b
Commander(b)	5.22	ef	10.3	d	3.51	b	11.2	c
Compass(b)	5.64	ab	10.1	d	3.61	ab	11.4	c
GrangeR(b)	5.40	cde	10.9	b	2.92	d	13.0	a
LaTrobe(b)	5.57	abc	10.3	d	3.05	c	12.4	b
Navigator(b)	5.67	a	10.6	c	3.67	a	11.2	c
Skipper(b)	5.28	de	10.9	b	3.06	c	13.1	a
P value	<0.001		<0.001		<0.001		<0.001	
5% LSD	0.20		0.2		0.11		0.3	

Significant yield and protein responses to applied N were measured at both sites in 2013 across all varieties (Table 5). At Pine Ridge yield increased by 0.22 and 0.36 t/ha for the 30 and 90 kg N/ha rates while still achieving acceptable levels of protein for malting. At Garah the yield improvement with increasing N rates was between 0.28 and 0.50 t/ha. With respect to protein levels both the control and the 30 kg N/ha were within malting specifications but the 90 kg N/ha application rate resulted in protein levels above the malting upper limit of 12.0% at Garah.

Table 5. *Grain yield and protein responses to applied N at Pine Ridge and Garah in 2013. Values followed by the same letter are not significantly different at the 95% confidence level.*

N Rate kg N/ha	Pine Ridge				Garah			
	Yield (t/ha)		Protein (%)		Yield (t/ha)		Protein (%)	
0	5.23	c	9.9	c	3.00	c	11.0	c
30	5.41	b	10.5	b	3.28	b	12.0	b
90	5.59	a	11.8	a	3.50	a	13.7	a

Yield responses to varying plant populations in 2013 were strongly dependant on variety. At Pine Ridge significant yield reductions were seen in Buloke(b), Commander(b), Skipper(b) and Compass(b) (Figure 3). All other varieties had no significant response to higher plant populations. At Garah, the longer season variety Navigator(b) had a significant yield increase with high populations while Skipper(b) had a significant yield decrease at the highest targeted population of 300 plants/m^2 (data not shown).

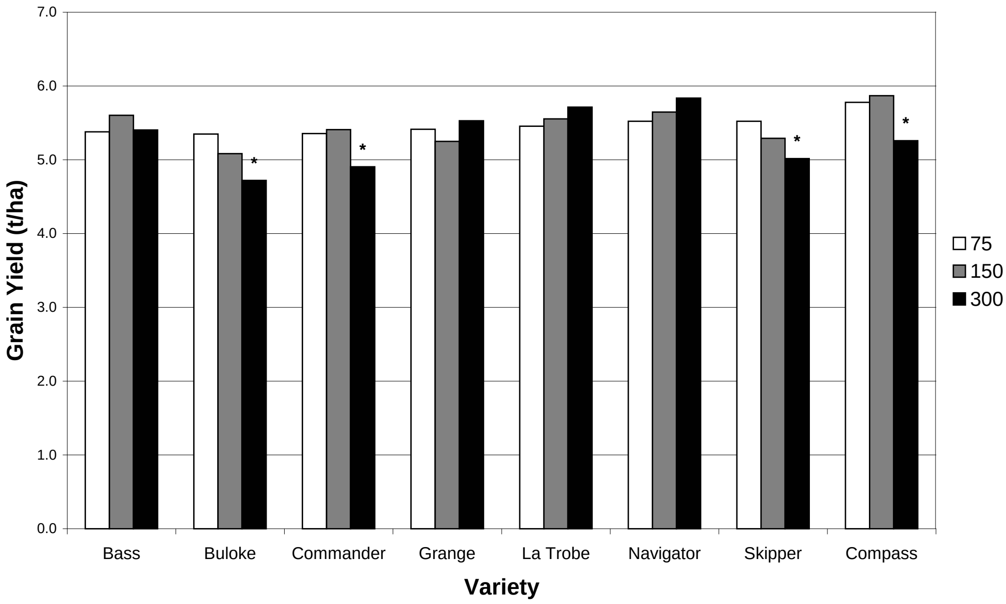


Figure 3. *Grain yield responses of eight barley varieties to plant populations at Pine Ridge in 2013. (significant differences indicated by *)*

Summary

Commander⦹ continues to perform well in the region in terms of both grain yield and quality. Compass⦹ has performed very strongly and appears to have improved straw strength. LaTrobe⦹ (IGB1101) and Skipper⦹ are quick maturing varieties with potential for future production in northern NSW which is currently a gap for growers in the region. Navigator⦹ has also performed well as a longer season malt option and is the most advanced in the malt accreditation process. Apart from Commander⦹, all these recently released lines are still undergoing malt accreditation.

Acknowledgements

The Variety Specific Agronomy Project (DAN00169) is a partnership between NSW DPI and GRDC. The trials would not have been possible without the valuable input of growers and advisors at each location. The trials and data collection were managed by Stephen Morphett, Jim Perfrement, Patrick Mortell, Peter Formann, Jan Hosking and Rod Bambach (all NSW DPI).

National barley varieties– evaluating new varieties for the north

Guy McMullen NSW DPI, Tamworth **Matthew Gardner** formerly NSW DPI, Tamworth

Key findings

A range of new barley varieties have been released in recent years, many of these are still undergoing malt accreditation.

The NVT program has allowed comparison of the performance of these varieties in the northern grains region.

Compass(D), LaTrobe(D) (IGB1101), Skipper(D) and Navigator(D) appear to be worthy of consideration for future production in the region.

Introduction

Barley still has an important role in northern NSW farming systems and the potential area of plantings across the region is substantial. However, any increases in area are primarily dependant on improved receival prices and varieties that reliably achieve malt classification. Since 2011 there has been 16 new barley entries submitted for malt accreditation, with six being released as commercial varieties in the past two seasons. The release of new higher-yielding malting varieties will provide industry with improved grain quality and likelihood of achieving malt specifications. Other factors that favour barley include performance in tough seasons, tolerance to sub-soil constraints (e.g. salinity), better weed competition and its tolerance to root lesion nematodes (RLN). It should be noted that barley is a host for RLN and crop rotation is needed to reduce RLN populations below critical thresholds. Major issues that currently limit barley production are reliability of achieving malt specifications – especially grain size and protein. Lodging remains a problem although there has been some improvement in straw strength in several of the new lines. It should also be remembered that barley is a host of crown rot so is **not** a break crop for this disease.

Results

Variety characteristics and performance

Growers now have access to a number of new varieties which have a range of improvements in yield, disease resistance and grain quality over older varieties (Table 1). When choosing a variety growers and advisers need to consider the current classification of a variety – many new releases do not yet have malt accreditation, receival at local silos needs to be checked, as well as agronomic performance. New lines with improved yield and grain size are also exhibiting lower grain protein levels increasing the likelihood of achieving malt quality in seasons such as 2012 and 2013.

Commander(D) has quickly established itself as the preferred high yielding malt variety for growers in northern NSW, representing >85% of malt barley receival in the northern grains region. Commander(D) is a high yielding variety that tends to have lower protein levels and improved grain size compared to Gairdner(D). In average to high yielding seasons there can be significant lodging issues in Commander(D). There are still significant areas of Gairdner(D) under production and it is still a preferred variety for malting and brewing.

There are also a number of other lines that are recently released and/or undergoing malt evaluation. Compass(D) (WI4593), released from the University of Adelaide, is a high yielding line that performed very well in the 2012 and 2013 NVT trials through northern NSW and Qld. Compass(D) has an early to mid-season maturity with a similar plant type to Commander(D) but with improved straw strength. Compass(D) appears to suit environments with 2–5 t/ha yield potential. Malt accreditation is still pending on Compass(D). LaTrobe(D) (IGB1101), from Intergrain, also performed very well in many sites in the 2013 NVT. La Trobe(D) is an early maturing line suited to the western, low rainfall regions. Similar to Hindmarsh(D), La Trobe(D) performs well under terminal drought – such as in the 2013 winter season.

Table 1. Grain yield (t/ha) and percent of site mean yield (%) data from NVT sites in northern NSW and southern Qld in 2013.

State	NSW		NSW		NSW		NSW		NSW		Qld		Qld		Qld		Qld		Qld	
Nearest Town	North Star		Tamworth		Coonamble		Gilgandra		Tulloona		Biloela		Springsure		Brookstead		Macalister		Lundavra	
Variety Name	t/ha	%	t/ha	%	t/ha	%	t/ha	%	t/ha	%	t/ha	%	t/ha	%	t/ha	%	t/ha	%	t/ha	%
Bass[ⓓ]	3.16	114	2.80	90	4.15	127	2.72	102	2.45	92	2.74	95	2.42	93	3.20	95	3.66	94	2.16	87
Commander[ⓓ]	3.11	112	3.45	111	3.22	99	3.17	119	3.00	112	2.84	99	2.65	102	3.74	111	4.16	107	2.84	115
Compass[ⓓ]	3.34	121	3.61	116	3.10	95	3.42	128	3.38	127	3.34	116	2.86	110	3.82	113	4.44	115	3.23	130
Fathom[ⓓ]	3.21	116	3.70	119	3.53	108	3.13	117	3.43	128	2.69	93	2.56	99	3.66	108	4.32	111	3.12	126
Flinders	2.69	97	3.16	102	4.08	125	2.45	92	2.22	83	2.87	100	2.52	97	3.28	97	3.64	94	2.40	97
Gairdner[ⓓ]	2.08	75	2.92	94	2.19	67	2.28	86	2.21	83	2.75	95	2.57	99	3.03	90	3.48	90	1.91	77
GrangeR[ⓓ]	2.92	106	3.25	105	3.33	102	2.42	91	2.59	97	3.06	106	2.88	111	3.44	102	4.16	107	2.40	97
Henley[ⓓ]	2.85	103	3.21	103	3.25	100	2.64	99	2.59	97	2.86	99	2.70	104	3.08	91	3.93	101	2.41	97
Hindmarsh[ⓓ]	3.26	118	3.39	109	3.18	98	3.03	114	3.32	124	3.18	111	2.76	106	3.36	100	4.14	107	2.89	116
LaTrobe[ⓓ]	3.33	120	3.23	104	3.08	94	2.93	110	3.00	112	3.25	113	3.07	118	3.53	105	4.24	109	2.83	114
Navigator[ⓓ]	2.50	90	2.89	93	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Oxford[ⓓ]	2.76	100	2.85	92	4.01	123	2.31	86	2.39	90	2.34	81	2.44	94	3.15	93	3.81	98	1.82	74
Skipper[ⓓ]	2.81	101	3.39	109	2.49	76	3.31	124	2.99	112	3.01	105	3.04	117	3.83	114	4.25	110	3.14	127
SY Rattler[ⓓ]	2.80	101	3.12	100	–	–	–	–	–	–	2.80	97	2.75	106	3.42	102	3.93	101	–	–
Wimmera[ⓓ]	2.68	97	2.74	88	3.30	101	2.33	87	2.79	104	2.79	97	2.47	95	3.32	98	3.75	97	2.44	99
Site Mean (t/ha)	2.77	–	3.11	–	3.26	–	2.67	–	2.67	100	2.88	–	2.60	–	3.37	–	3.88	–	2.48	–
CV (%)	5.87	–	7.87	–	7.28	–	4.81	–	5.75	–	6.60	–	6.16	–	3.80	–	3.92	–	5.89	–
Probability	<0.001	–	<0.001	–	<0.001	–	<0.001	–	<0.001	–	<0.001	–	<0.001	–	<0.001	–	<0.001	–	<0.001	–
LSD (t/ha)	0.27	10	0.41	13	0.38	12	0.23	8	0.27	–	0.30	10	0.26	10	0.20	6	0.24	6	0.24	10
Sowing Date	20-May-2013		21-Jun-2013		15-May-2013		30-May-2013		05-Jun-2013		06-May-2013		30-May-2013		20-Jun-2013		05-Jun-2013		27-May-2013	

* These results are from one season. When selecting varieties consider the across season results available on the NVT website and in the 2014 NSW DPI Winter Crop Variety Sowing Guide.

Summary

Commander continues to perform well in the region in terms of both grain yield and quality. Compass has performed very strongly and appears to have improved straw strength. LaTrobe (IGB1101) and Skipper appear to be quick maturing varieties for future consideration. Quicker maturity is currently a gap for growers in the northern region. Navigator has also performed well as a longer season malt option and is the most advanced in the malt accreditation process. Apart from Commander, all these recently released lines are still undergoing malt accreditation.

Acknowledgements

The Variety Specific Agronomy Project (DAN00169) and National Variety Trials are a partnership between NSW DPI and GRDC. Thanks to the co-operating growers and advisors at each location. The trials and data collection were managed by NSW DPI technical staff.

Effect of plant population on yield and oil content of four canola varieties at Trangie and Nyngan 2013

Leigh Jenkins NSW DPI, Trangie
Rohan Brill NSW DPI, Wagga Wagga

Key findings

Increasing plant population up to 20 plants/m^2 (established) showed significant grain yield response; but there was no significant effect on yield when plant population was increased further.

Increasing plant population up to 80 plants/m^2 showed an overall effect of increasing oil content; however the differences between incremental increases in plant population were not significant.

Based on the response to plant population trials at Nyngan and Trangie in 2012 and 2013, canola growers should aim to establish 20–25 plants/m^2 in central-western NSW.

Introduction

Successful canola production begins with achieving a uniform crop density at establishment. As the canola area expands into the Western Plains region of NSW, growers have asked whether previous NSW DPI recommendations for optimum plant densities (generally 30–50 plants/m^2 in northern NSW) are suited to lower rainfall western zones. The increasing popularity of hybrid canola varieties has also raised issues as growers seek to offset higher seed costs by planting at lower sowing rates.

These trials aim to provide more regionally specific target plant densities for canola, by assessing the impact of seed size and sowing rates on plant establishment and subsequent grain yield and oil content. Canola varieties were selected to compare hybrid vs. open-pollinated (OP) varieties, as well as triazine tolerant (TT) vs. non-TT varieties. Note that a similar trial was conducted at Nyngan in 2012 and reported via the Autumn 2013 edition of this publication.

Site details

Location:	**Trangie**	Location:	**Nyngan**
Soil type:	**Red Chromosol**	Soil type:	**Red Chromosol**
PAW (sowing):	**30 mm**	PAW (sowing):	**150 mm**
Rainfall in-crop:	**205 mm**	Rainfall in-crop:	**185 mm**
Sowing date:	**28th May 2013**	Sowing date:	**19th April 2013**
Colwell P:	**28 mg/kg (0–10 cm)**	Colwell P:	**24 mg/kg (0–10 cm)**
Nitrogen:	**86 kg/ha (0–90 cm)**	Nitrogen:	**180 kg/ha (0–90 cm)**
pH ($CaCl_2$):	**5.4 (0–10 cm)**	pH ($CaCl_2$):	**6.0 (0–10 cm)**

Treatments

- Four canola varieties: two hybrid varieties – 44Y84 (CL)⦶ and Hyola 559TT⦶; two open pollinated varieties – 43C80 (CL)⦶ and ATR-Stingray(TT)⦶
- Five target plant populations: 5, 10, 20, 40, 80 plants/m^2 (actual sowing rate based on 50% field establishment)

Results

- At the Nyngan site (sown mid-April), achieved establishment rates were similar to the targeted plant population, ranging from 67% for 5 plants/m^2 up to 92% for 80 plants/m^2 (Figure 1).
- At the Trangie site (sown late May), achieved establishment was approximately only 30 to 50% of the targeted plant population, with lower target densities achieving higher establishment percentages (Figure 2).

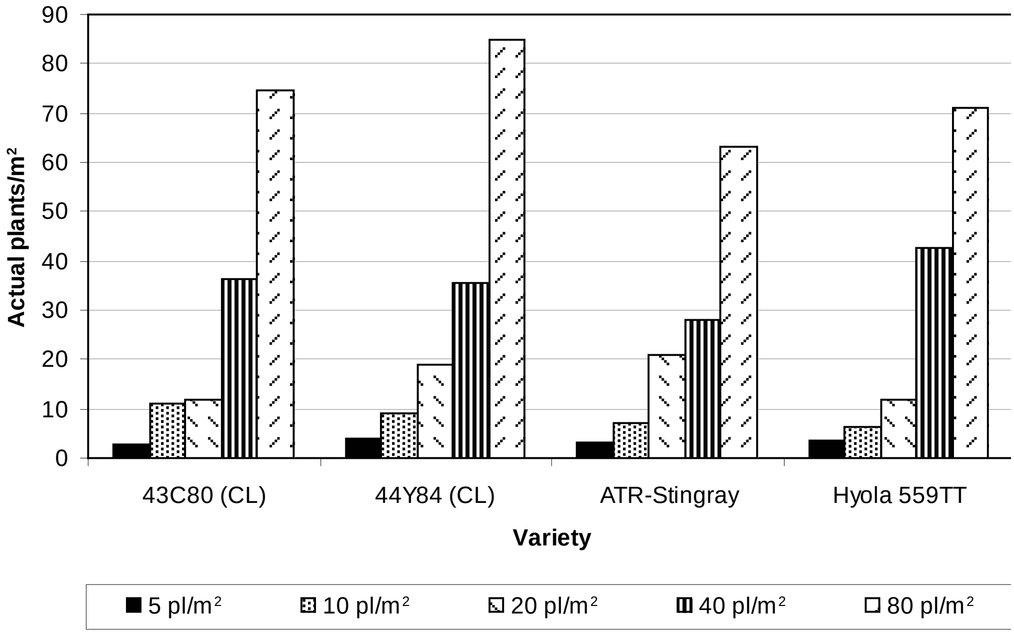


Figure 1. *Establishment of four canola varieties sown at five plant populations, Nyngan 2013.*

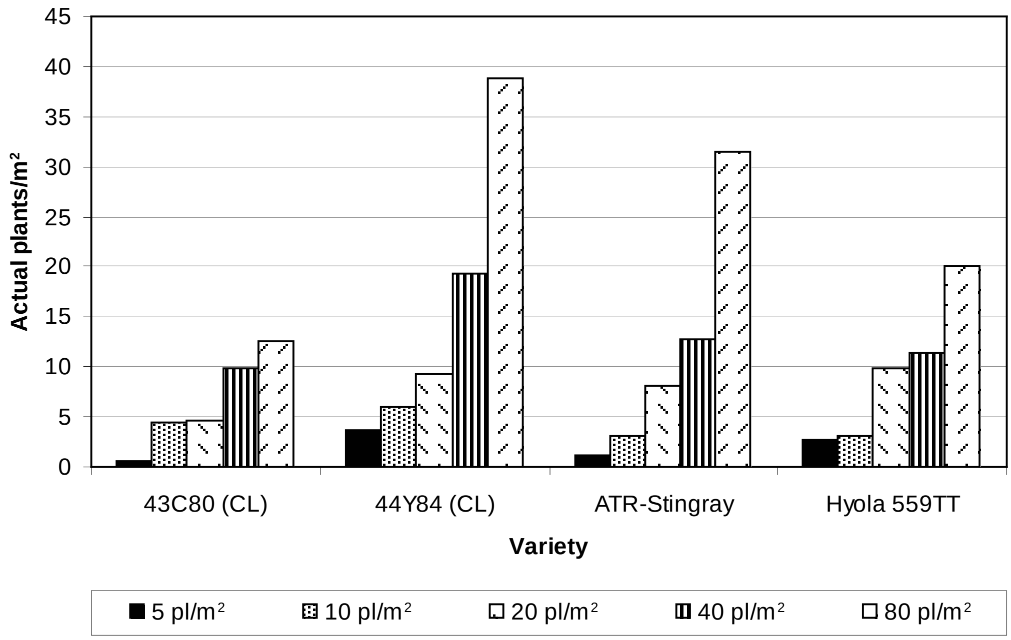


Figure 2. *Establishment of four canola varieties sown at five plant populations, Trangie 2013.*

- At Nyngan, there was a significant yield increase of 0.42 t/ha (averaged across all varieties) as targeted plant population increased from 5 to 10 plants/m^2. Further increases in targeted plant population from 10 to 80 plants/m^2 had no significant effect on grain yield at Nyngan (Figure 3).

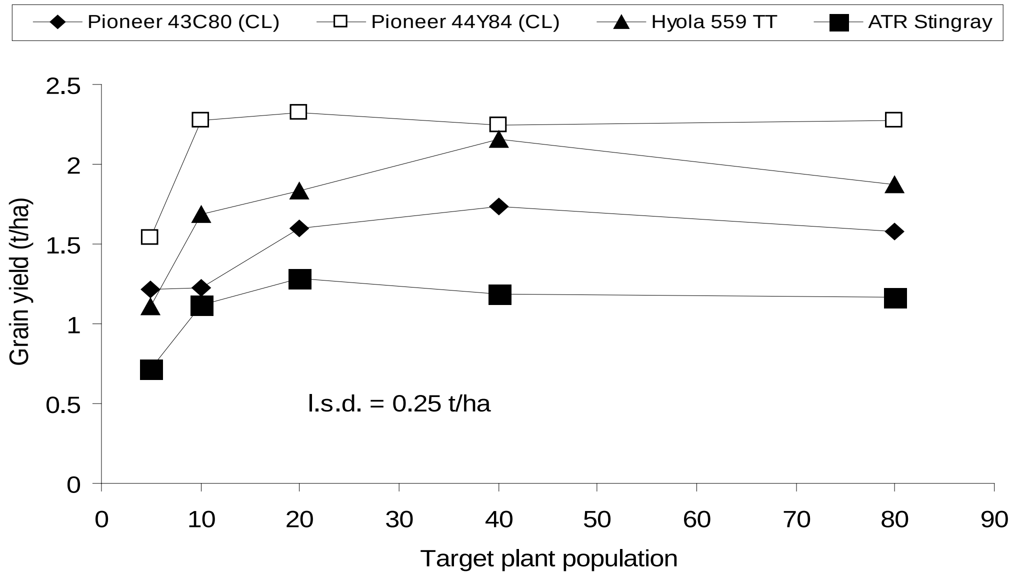


***Figure 3:** Grain yield of four canola varieties sown at five plant populations, Nyngan 2013*

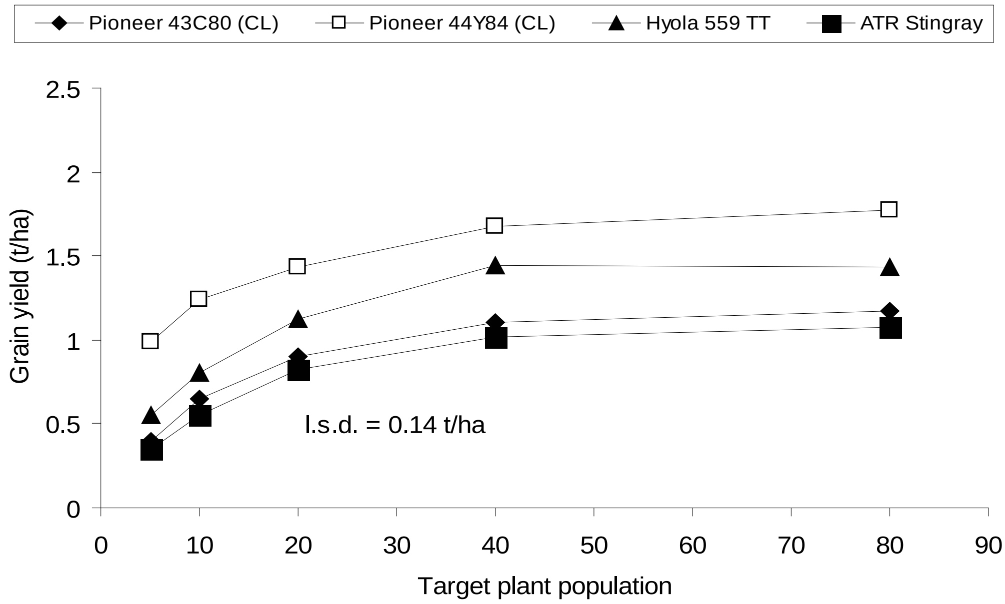


***Figure 4:** Grain yield of four canola varieties sown at five plant populations, Trangie 2013*

- At Trangie, there was a significant grain yield increase of 0.74 t/ha (averaged across all varieties) as targeted plant population increased from 5 to 40 plants/m^2. In effect maximum yield was achieved at 20 plants/m^2 given actual establishment was only 50% or less of targeted establishment (Figure 4).
- Varietal response was similar for both Nyngan and Trangie sites in 2013, and replicated the previous trial at Nyngan in 2012. The hybrid Clearfield variety was significantly higher yielding than the open-pollinated (OP) Clearfield variety; and the hybrid TT variety was significantly higher yielding than the OP TT variety.
- Oil content response of varieties was also similar for both Nyngan and Trangie sites in 2013 (data not shown). TT varieties were significantly higher in oil content than Clearfield varieties (43.7% cf. 42.5% respectively at Nyngan and 43.4% cf. 42.2% respectively at Trangie). Hybrid varieties were significantly higher in oil content than open-pollinated varieties; although the margin was less than the Clearfield-TT comparison (43.3% cf. 42.8% respectively at Nyngan and 43.1% cf. 42.5% respectively at Trangie).

- Increasing the plant population overall from 5 to 80 plants/m^2 had a significant effect on increasing oil content at both Nyngan (from 42.7% to 43.4%, averaged for all varieties) and Trangie (from 42.2% to 43.2%, averaged for all varieties), but in most cases the difference between incremental plant population increases (e.g. 10 to 20 plants/m^2) was not significant.

Summary

The initial trial conducted at Nyngan in 2012 found a significant grain yield response when target plant population was increased from 10 to 25 plants/m^2, but no further response when increased from 25 to 40 and 60 plants/m^2. Oil content was also increased as plant population increased up to 40 plants/m^2.

The 2013 trials conducted at Nyngan and Trangie showed a very similar response in maximising grain yield when approximately 20 plants/m^2 were established. At Nyngan, this was achieved at the target rate of 20 plants/m^2, whereas at Trangie it was achieved when only 50% of the targeted 40 plants/m^2 were established. Further increases in plant population up to 80 plants/m^2 had no significant effect in increasing grain yield at either site.

Oil contents were significantly different when grouped between types of varieties, with an increasing trend of higher oil content overall as plant population was increased.

The 2013 canola plant population trials at Nyngan and Trangie confirmed the advantage of hybrid varieties over open-pollinated lines in both previous years (2012) and other VSAP canola trials conducted in 2013. In the majority of these trials, hybrid Clearfield and TT varieties have been significantly higher yielding than their respective open pollinated Clearfield and TT varieties.

Acknowledgements

This project is funded by NSW DPI and GRDC under the Variety Specific Agronomy Package Project (DAN00129). Thanks to Jayne Jenkins and Scott Richards (NSW DPI) for technical assistance with this trial.

AGRONOMY

Response of six canola varieties to three seeding depths – Trangie and Nyngan 2013

Leigh Jenkins NSW DPI, Trangie
Rohan Brill NSW DPI, Wagga Wagga

Key findings

Increasing sowing depth of canola from 25 mm to 75 mm significantly reduced canola establishment; however grain yield was reduced by a smaller magnitude.

Where seed was sown progressively deeper, the hybrid varieties generally had better establishment than open-pollinated (OP) varieties and suffered a smaller yield penalty.

Introduction

It is widely accepted that canola, being a small seeded crop, should be sown relatively shallow (25 mm). There are situations though where moisture may be slightly deeper than 25 mm at the optimum planting time for canola. This trial work examines the response of several commercially available canola varieties to progressively deeper sowing in order to assess their suitability for moisture seeking situations at sowing.

Site details

Location:	**Trangie**	Location:	**Nyngan**
Soil type:	**Brown Chromosol**	Soil type:	**Red Chromosol**
PAW (sowing):	**30 mm (0–90 cm)**	PAW (sowing):	**150 mm (0–90 cm)**
Rainfall in-crop:	**205 mm**	Rainfall in-crop:	**185 mm**
Sowing date:	**29th May**	Sowing date:	**19th April**

Treatments

- Six canola varieties:
  – Three hybrid – 43Y85 (CL)$^{\phi}$, 44Y84 (CL)$^{\phi}$, Hyola 555TT$^{\phi}$
  – Three open pollinated (OP)_ – 43C80 (CL)$^{\phi}$, ATR-Stingray$^{\phi}$, AV-Garnet$^{\phi}$
- Three sowing depths – 25, 50 and 75 mm

Seed size and herbicide tolerance group

Variety	Herbicide tolerance group	Seed weight (g/1000 seeds)	Seeds sown/m^2
AV-Garnet$^{\phi}$	Conventional	3.27	60
ATR-Stingray$^{\phi}$	Triazine Tolerant (TT)	2.97	60
43C80 (CL)$^{\phi}$	Clearfield® (CL)	4.11	60
43Y85 (CL)$^{\phi}$	Clearfield® (CL)	4.77	60
44Y84 (CL)$^{\phi}$	Clearfield® (CL)	5.20	60
Hyola 555TT$^{\phi}$	Triazine Tolerant (TT)	4.00	60

Results

- There was a significant reduction in establishment at both sites as seed was sown progressively deeper (Table 1).
- The hybrid varieties generally had better establishment than the OP varieties when sown relatively deep (Table 1).
- Deep sowing of canola generally (but not always) reduced grain yield, but the effect on grain yield was of a smaller magnitude than the effect of deep sowing on establishment (Table 2).
- There were varietal differences in the extent of grain yield loss as a result of deep sowing. For example at Nyngan, there was no significant grain yield reduction from deep sowing of the hybrid variety 44Y84 (CL) compared with a 1.4 t/ha grain yield reduction for the OP variety AV-Garnet$^{\phi}$ (Table 2).

Table 1. *Establishment (plant/m^2) of six canola varieties from three sowing depths at Nyngan and Trangie in 2013.*

Type	Variety	Nyngan			Trangie		
		25 mm	50 mm	75 mm	25 mm	50 mm	75 mm
Hybrid	43Y85 (CL)$^{\phi}$	43	19	6	22	5	2
	44Y84 (CL)$^{\phi}$	36	19	11	17	6	4
	Hyola555TT$^{\phi}$	39	23	8	24	8	4
Open pollinated	43C80 (CL)$^{\phi}$	37	13	2	14	1	2
	ATR-Stingray$^{\phi}$	39	10	2	12	2	1
	AV-Garnet$^{\phi}$	28	10	3	12	1	1
l.s.d. variety		3			3		
l.s.d. depth		2			4		
l.s.d. variety.depth		n.s.			n.s.		

Table 2. *Grain yield (t/ha) of six canola varieties from three sowing depths at Nyngan and Trangie in 2013.*

Type	Variety	Nyngan			Trangie		
		25 mm	50 mm	75 mm	25 mm	50 mm	75 mm
Hybrid	43Y85 (CL)$^{\phi}$	1.3	1.5	0.9	1.3	0.9	0.5
	44Y84 (CL)$^{\phi}$	2.2	2.0	2.0	1.6	1.4	0.7
	Hyola555TT$^{\phi}$	2.3	1.8	1.5	1.5	1.1	0.6
Open pollinated	43C80 (CL)$^{\phi}$	1.6	1.5	1.1	1.2	0.6	0.3
	ATR-Stingray$^{\phi}$	1.2	1.0	0.4	1.2	0.5	0.2
	AV-Garnet$^{\phi}$	2.5	2.0	1.1	1.0	0.4	0.2
l.s.d. variety		0.3			0.1		
l.s.d. depth		0.2			0.2		
l.s.d. variety.depth		0.5			0.2		

Summary

These trials clearly demonstrate the negative effects of deep sowing on canola establishment and to a lesser extent grain yield; however timely establishment of canola is important in western environments and deep sowing (moisture seeking) of canola may be a useful tool to ensure timely establishment, as sowing date of canola affects grain yield more than plant population. For moisture seeking situations, these trials (and similar trials in 2012) showed a clear advantage of sowing large seeded (>5g/1000 seeds) hybrid varieties as deep sowing will generally have a reduced impact on establishment and grain yield compared to smaller seeded OP varieties.

Acknowledgements

This project is funded by NSW DPI and GRDC under the Variety Specific Agronomy Package Project (DAN00129). Thanks to Jayne Jenkins (NSW DPI, Trangie) for assistance throughout this trial.

PBA Chickpea program – Evaluation in 2013

Kristy Hobson, Andrew Verrell, Andrew George, Mike Nowland and Judy Duncan NSW DPI, Tamworth
Gabriela Borgognone DAFFQ, Toowoomba Pulse Breeding Australia

Key findings

Growers should base variety selection on long term yield results, disease resistance and grain marketing opportunities.

The adaptation and yield potential of desi breeding lines derived from wild relatives (e.g. CICA1309) is improving whilst maintaining superior levels of disease resistance.

Introduction

The PBA Chickpea program is a national program which delivers superior chickpea varieties faster. The program breeds both desi and kabuli types and is lead by NSW DPI with all core breeding activities occurring at the Tamworth Agricultural Institute. The medium and low rainfall temperate region of northern NSW and southern Qld is a major target area for the program.

The major desi breeding objectives for this region are:

- increased ascochyta blight (AB) and phytophthora root rot (PRR) resistance
- improved adaptation through phenology, particularly chilling tolerance at podset
- increased root lesion nematode resistance (especially Pratylenchus thornei)
- increased salt tolerance

The major kabuli breeding objectives for this region are:

- increased ascochyta blight resistance with 9 mm seed size
- increased PRR resistance
- improved adaptation through phenology

The breeding program conducts evaluation across this region in close collaboration with project partners from DAFF Qld who are also responsible for PRR screening nurseries. Within NSW DPI, the program conducts screening for AB, PRR, virus and seed quality. The program also has key collaborators at SARDI (herbicide screening), DAFWA (AB screening) and VIC DEPI (AB, Botrytis grey mould, and salt screening). A strong interaction also exists with numerous pulse germplasm enhancement projects both nationally and internationally.

Site and treatments 2013

Site	Entries
North Star – sown 16/05/2013	36 desi entries; varieties and advanced PBA Breeding lines
Moree – sown 29/05/2013	36 desi entries; varieties and advanced PBA Breeding lines
Burren Junction – sown 28/05/2013	36 desi entries; varieties and advanced PBA Breeding lines
Edgeroi – sown 21/05/2013	36 desi entries; varieties and advanced PBA Breeding lines
Edgeroi – sown 21/05/2013	60 kabuli entries; varieties and advanced PBA Breeding lines
Pine Ridge – sown 08/07/2013	36 desi entries; varieties and advanced PBA Breeding lines
Pine Ridge – sown 09/07/2013	60 kabuli entries; varieties and advanced PBA Breeding lines

The Burren Junction site failed to achieve uniform establishment due to a lack of soil moisture and was abandoned in August.

Desi Results 2013

- The mild August temperatures induced an earlier than normal flowering in most chickpea lines which were then adversely affected by a significant frost event in late August. The subsequent rise in temperatures and dry finish resulted in terminal moisture stress and an early harvest in most locations.
- Kyabra⟃ was the best performing of current commercial varieties whilst the elite breeding lines, CICA1007 and CICA1311 were high yielding at all PBA sites (Table 1).
- Good yields were also observed in a backcross line CICA1309 which is derived from a wild chickpea relative.
- Long term analysis identifies clusters of environments which improves selection decisions. Cluster 2 clearly demonstrates the yield benefit from the improved disease resistance of CICA0912 over older varieties such as Kyabra⟃ and Jimbour.

Kabuli Results 2013

- The small seeded (7–8 mm) Genesis™ 090 was the highest yielding commercial variety (Table 2) and higher yielding than PBA HatTrick⟃ in the co-located desi trial. Of the medium and large seeded varieties the best performing were PBA Monarch⟃ and Genesis™ Kalkee.
- Of the breeding lines, the medium seeded CICA1156 was one of the better yielding lines tested.

Table 1. *Yield of selected entries in Stage 3 PBA desi trials across northern NSW in 2013 and long term (2009 – 2013) results from southern Qld and northern NSW (% PBA HatTrick⟃).*

Name	North Star	Moree	Edgeroi	Pine Ridge	Long term (2009–2013[A])		
					Cluster 1	Cluster 2	Cluster 3
PBA HatTrick⟃ (t/ha)	100 (1.88)	100 (1.23)	100 (1.13)	100 (1.83)	100 (2.18)	100 (2.56)	100 (1.40)
Jimbour	99	105	112	100	101	83	104
Kyabra⟃	103	112	120	107	108	80	108
PBA Boundary⟃	105	98	112	108	104	105	107
CICA0912	99	101	100	96	102	114	104
CICA1007	103	119	117	103	112	106	109
CICA1309	109	110	119	108	110	–	112
CICA1311	116	108	121	107	114	–	114
LSD (P<0.05)	8	6	11	11			

[A] Long term results from Multi-Environment Trial (MET) analysis identified three major clusters of environments. Cluster 1 – 2009 Qld sites and most 2012 and 2013 sites, Cluster 2 – 2010 NSW sites and 2011 Liverpool Plains, Cluster 3 – remaining 2012 and 2013 sites.

__Table 2.__ Yield of selected entries in Stage 3 PBA kabuli trials across northern NSW in 2013 and long term (2009 – 2013) results from eastern Australia (% Genesis 090).

Name	Edgeroi	Pine Ridge	Cluster 1	Cluster 2	Long term (2010–2013[B])		
					Cluster 1	Cluster 2	Cluster 3
Genesis 090 (t/ha)	100 (1.38)	100 (1.86)	100 (1.77)	100 (2.48)	100 (2.20)	100 (2.45)	100 (1.63)
Almaz(b)	87	94	93	94	92	98	87
Genesis™ Kalkee	88	103	91	85	95	97	94
PBA Monarch(b)	92	94	103	98	94	96	105
CICA1156	91	99	97	104	97	100	84
LSD (P<0.05)	9	11					

[B] Long term results from Multi-Environment Trial (MET) analysis identified five major clusters; Cluster 1 – NSW 2012, Cluster 2 – Edgeroi 2013, Cluster 3 – NSW 2011, Cluster 4 – 2013 Qld, Cluster 5 – Pine Ridge 2013.

Summary

Kyabra(b) performed very well in most desi trials in 2013 along with the breeding line CICA1007 and CICA1311. CICA1007 has an erect plant type and larger seed size than PBA HatTrick(b). The superior disease resistance of CICA0912 (both PRR and AB) was observed again in PBA disease nurseries and its yield was similar to PBA HatTrick(b).

In kabuli evaluation trials, the excellent adaptation of the small seeded Genesis™ 090 resulted in higher yields than PBA HatTrick(b) at sites where desi trials were co-located. The breeding program is developing medium and large seeded lines using the superior yield potential of Genesis™ 090.

Acknowledgements

This project is funded by NSW DPI and GRDC under the Pulse Breeding Australia Chickpea Program (DAN00151). Thanks to our co-operators the Doolin Family (North Star), Stevenson Family (Moree), Gourley Family (Edgeroi), Harris Family (Burren Junction) and Bailey Family (Pine Ridge).

The effect of plant density on yield in chickpea across central and northern NSW

Andrew Verrell NSW DPI, Tamworth **Rohan Brill** NSW DPI, Wagga Wagga **Leigh Jenkins** NSW DPI Trangie

Introduction

Research in Queensland by Beech and Leach (1989), recommended plant populations of 40 plants/m^2 for chickpea production and later work by Brinsmead et al. (1996) suggested an optimum sowing density of 20–40 plants/m^2.

Whish et al. (2007) monitored 52 commercial chickpea crops over three seasons (2002–04) which showed the median plant density on farm fluctuated between 14 and 22 plants/m^2. Modelling by Whish et al. (2007) suggested that increasing plant density independent of sowing date would improve yields 55% of the time for chickpea crops sown in early June and 60% of the time for crops sown in mid May.

Current agronomic advice suggests that chickpea yields are relatively stable over plant densities of 20–30 plants/m^2, with an optimum target population of 25 plants/m^2 for the northern regions (Cumming and Jenkins, 2011).

Key findings

When sowing within the optimum sowing window for chickpeas, mid May–mid June;

- if yield potential ≥ 1.5 t/ha, sow chickpeas at ≥ 30 plants/m^2.
- if yield potential ≤ 1.5 t/ha; sow chickpeas at ≥ 20 plants/m^2.

When planting very late (after mid June) sow at a higher plant density (≥ 35 plants/m^2).

To reduce losses to virus, DO NOT sow below 20 plants/m^2.

Site details

2011 and 2012

Locations:	**Coonamble and Tamworth 2013**
Locations:	**Coonamble, Tamworth, Trangie, North Star, Edgeroi, Moree and Pine Ridge**

Treatments

- A series of variety x plant density factorial experiments were conducted across a number of central and northern NSW locations from 2011 to 2013.
- Varieties examined were PBA HatTrick$^{\text{⌽}}$, PBA Boundary$^{\text{⌽}}$, Kyabra$^{\text{⌽}}$, CICA912 and Genesis 090™ (small seeded kabuli) at plant densities of 5, 10, 15, 20, 30 and 45 plants/m^2.
- Row spacing varied across sites; Trangie 33 cm, Tamworth 40 cm, North Star, Moree, Edgeroi, and Pine Ridge all at 50 cm and Coonamble at 66 cm.
- Across all sites and years variety and plant density were significant as main effects but there were no significant interactions between variety and plant density. In this paper only yield responses to plant density are reported.

Results

Effect of plant density on yield in Coonamble and Tamworth

- Experiments were conducted at Coonamble and Tamworth from 2011–2013. The differences between these locations is best characterised in terms of crop season (May – November) rainfall and evapotranspiration.
- In 2011, the wettest of the three crop seasons, Tamworth received 499 mm compared to Coonamble with 381 mm. Both 2012 and 2013 were drier years in both environments with Tamworth (262 and 268 mm) receiving, on average, 130 mm more in-crop rainfall in each year than Coonamble (132 and 139 mm).
- Crop season evapotranspiration totals in Coonamble were 846, 918 and 1043 mm, compared to Tamworth with 725, 818 and 872 mm, for 2011, 2012 and 2013, respectively.

- At Coonamble, in the two drier seasons, yield was ≤ 1.5 t/ha and was not significantly different at densities ranging from 15 to 45 plants/m^2 (Figure 1).
- In the wetter year, 2011, grain yield reached over 3.5 t/ha and there was a marginal but significant increase in yield between 15 (3.53 t/ha) and 45 plants/m^2 (3.89 t/ha).
- At Tamworth, the wetter of the two locations, yields were more responsive across the range of plant densities over all years (Figure 2).
- At Tamworth, the optimum plant density was 30 plants/m^2 with yields of 2.97, 2.18 and 2.15 t/ha in 2011, 2012 and 2013, respectively.
- The linear response of yield to plant density, from 15 to 45 plants/m^2, was derived for each year at both locations.
- Coonamble had a flatter response across all years with slopes of 5.35, 0.18 and –7.35 kg/ha/plant/m^2, compared to Tamworth with, 23.51, 19.26, and 9.08 kg/ha/plant/m^2 for 2011, 2012 and 2013, respectively (Figures 1 and 2).

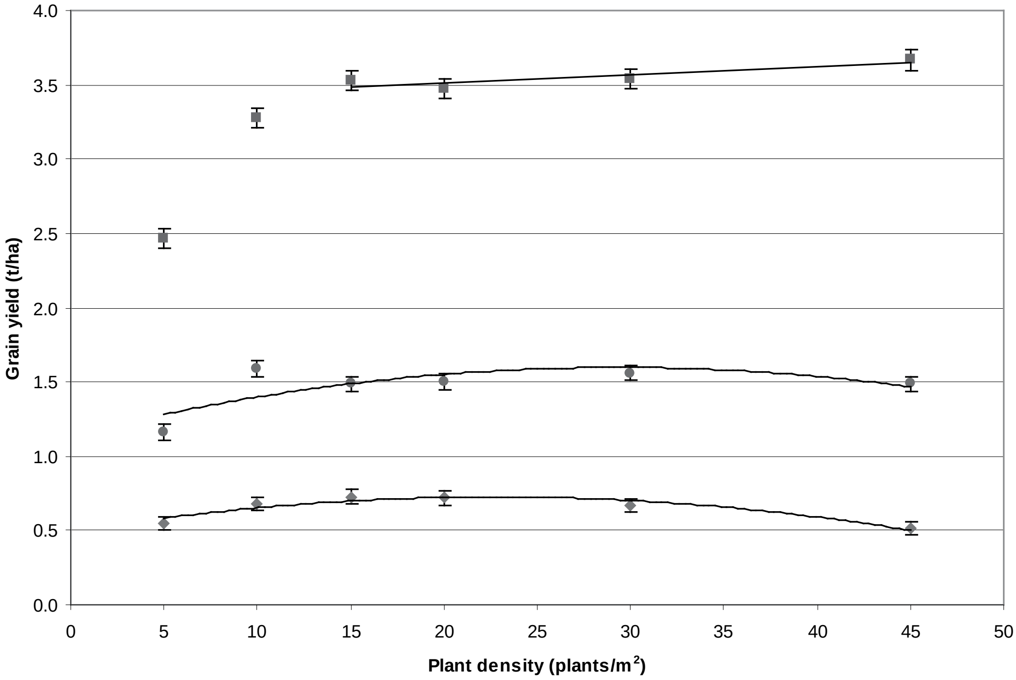


Figure 1. *Effect of plant density on grain yield at Coonamble in 2011 (■), 2012 (●) and 2013 (◆).*

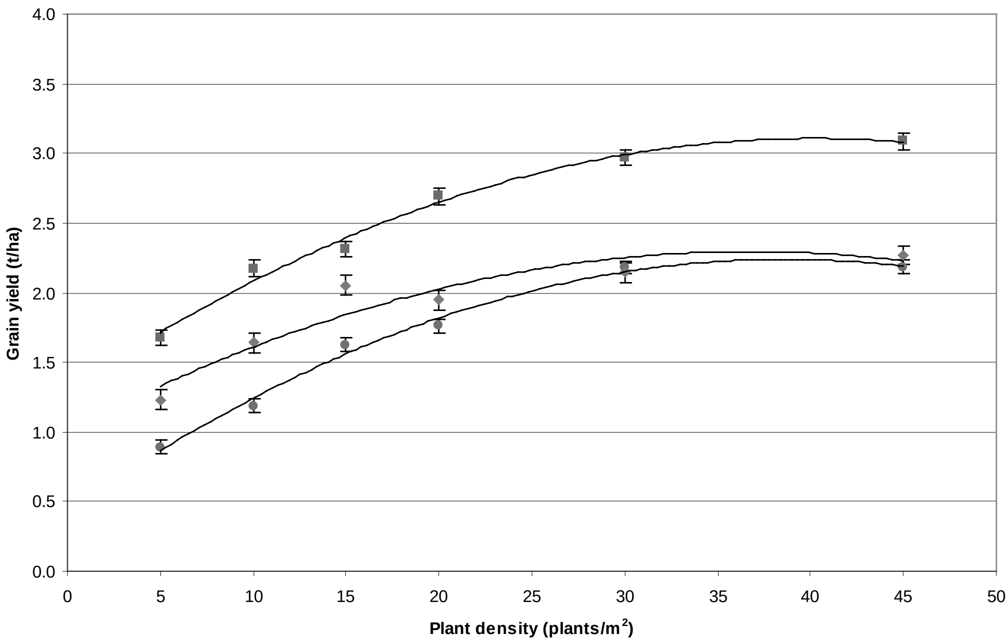


Figure 2. *Effect of plant density on grain yield at Tamworth in 2011 (■), 2012 (●) and 2013 (◆).*

Effect of plant density on yield across sites – 2013

- In 2013 the number of locations was expanded and sites have been grouped into northern (North Star, Moree, Edgeroi, Coonamble) and southern locations (Tamworth, Pine Ridge, Trangie).
- The May to November rainfall (mm) for the northern sites was; Coonamble = 139, Moree = 173, North Star = 205 and Edgeroi = 226 mm, while for the southern sites it was; Trangie = 214, Tamworth = 266 and Pine Ridge = 306 mm.
- The plot of grain yield versus plant density for the northern sites is in Figure 3 while the same relationship for the southern sites is shown in Figure 4.
- For the northern sites the response of yield to plant density was flat from 15 to 45 plants/m² with slopes of; Coonamble = –7.35, Edgeroi = –1.27, North Star = 1.6 and Moree = 3.93 kg/ha/plant/m² (Figure 3).

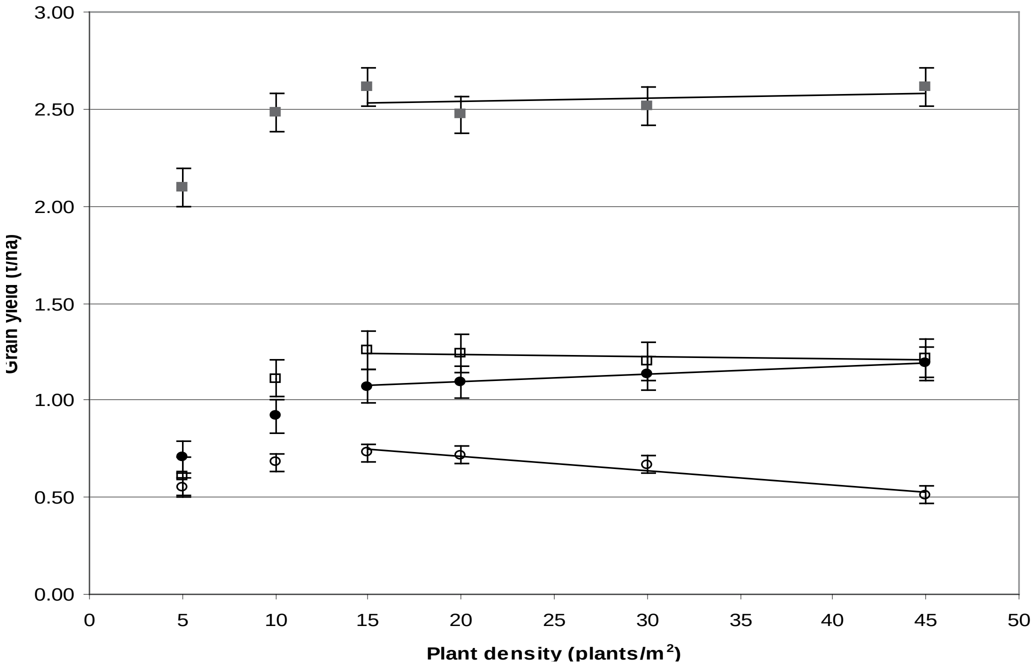


Figure 3. *Effect of plant density (plants/m²) on grain yield (t/ha) for the 2013 northern sites; North Star (■), Edgeroi (□), Moree (●) and Coonamble (○).*

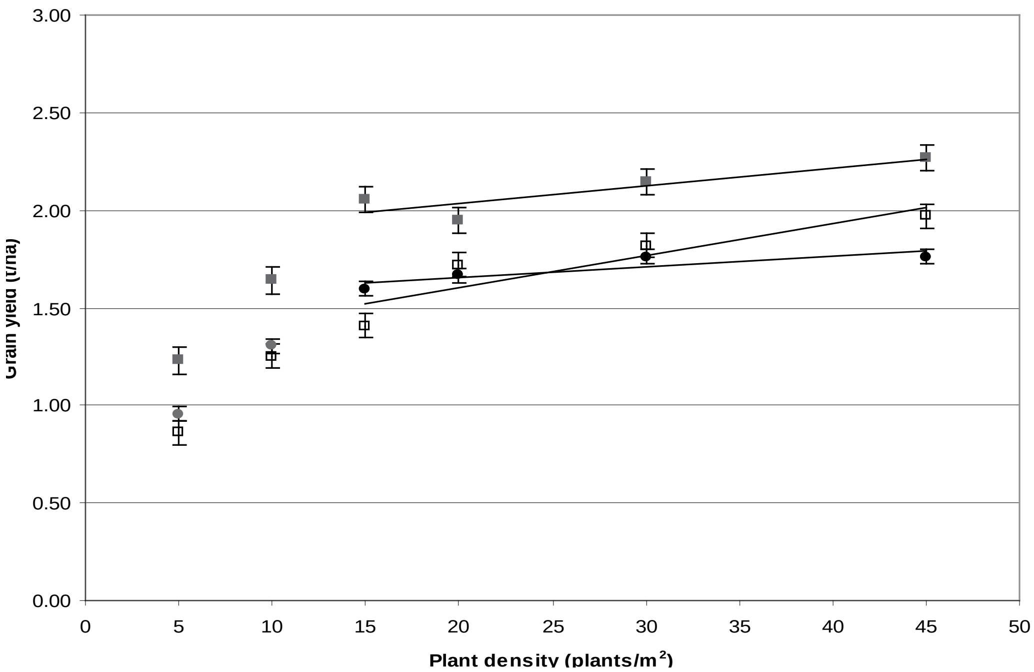


Figure 4. *Effect of plant density (plants/m²) on grain yield (t/ha) for the 2013 southern sites; Tamworth (■), Edgeroi (□) and Trangie (●).*

- For the southern sites, the slope of yield to plant densities, from 15 to 45 plants/m^2 were; Trangie = 5.31, Tamworth = 9.09 and Pine Ridge = 16.31 kg/ha/ plant/m^2 (Figure 4).
- The southern sites, which on average received more in-crop rainfall, gave greater yield responses as plant density increased from 15 to 45 plants/m^2 and optimum yield was achieved around 30 plants/m^2 (Figure 4).
- With the exception of North Star, the northern sites yielded less than 1.5 t/ha at optimum densities of about 20 plants/m^2 (Figure 3). Even North Star had a flat yield response to plant densities above 15 plants/m^2.

Summary

When sowing chickpeas within the optimum sowing window in northern NSW, mid May – mid June, where yield potential is ≥ 1.5 t/ha (generally southern sites); sow at ≥ 30 plants/m^2 and where yield potential is ≤ 1.5 t/ha (generally northern sites); sow at ≥ 20 plants/$m^{2.}$ When sowing very late, sow at a higher plant density (≥ 35 plants/m^2) and to reduce losses due to virus, DO NOT sow below 20 plants/m^2.

Acknowledgements

This project is funded by NSW DPI and GRDC under the Northern Pulse Agronomy Project (DAN00171). Thanks to Michael Nowland and Paul Nash for technical assistance.

References

1. Beech DF, Leach GJ (1989). Comparative growth, water use and yield of chickpea, safflower and wheat in south-eastern Queensland. *Australian Journal of Experimental Agriculture* **29**, 655–662.
2. Brinsmead RB, Thompson PR, Martin WD (1996) Chickpea cultivar x population x row space stude in southern Queensland. Australian Agronomy Conference, Poster.
3. Whish JPM, Castor P, Carberry PS (2007). Managing production constraints to the reliability of chickpea (*Cicer arietinum* L.) within marginal areas of the northern grains region of Australia. *Australian Journal of Agricultural Research* **58**, 396–405.
4. Cumming G, Jenkins L (2011). Chickpea: Effective Crop Establishment Sowing Window, Row Spacing, Seeding Depth & Rate. Australian Pulse Bulletin PA 2011 #07.

Sorghum in the western zone – Row Configuration x Population x Hybrid – trial overview 2010–2013

Loretta Serafin, Guy McMullen and Nicole Carrigan NSW DPI, Tamworth
Ben Frazer formerly NSW DPI, Tamworth **Fiona Scott** NSW Trade & Investment, Tamworth

Introduction

Sorghum is a reliable summer crop in eastern areas of northern NSW. However there is a need to improve the reliability of sorghum in western cropping areas and to assess strategies that will allow growers to adapt to increasingly variable seasonal conditions. The introduction of hybrids with increasing levels of Staygreen (SG) or reduced tillering in combination with plant population and row configuration may help improve the reliability of sorghum yields in the western zone of northern NSW.

In the eastern zone there has been a reasonable amount of work evaluating population and row spacing in sorghum. Modelling work has suggested that sorghum can be a reliable component of western cropping systems but applied research to verify the modelling and give growers confidence to incorporate sorghum into their rotations is needed.

In northern NSW crown rot, a stubble-borne fungal pathogen continues to be the most prevalent and damaging disease affecting winter cereals. Sorghum is recommended as a break crop but the success is dictated by the extent of decomposition of the winter cereal stubble which harbours the crown rot fungus. Although altering row configuration and population may improve the reliability of sorghum it may also reduce the rate of decomposition of cereal stubble and hence break crop benefits while also impacting on water accumulation during the fallow period.

Over the past three summer crop season's data has been collected from 8 sorghum trials in north-west NSW. Five sites had a spring planting, while the remaining three sites had a late plant (January). An additional two sites were sown but then abandoned in the 2011/12 season, due to flooding shortly following crop establishment.

Key findings

In higher than average yielding seasons, the best sorghum yields were achieved from the narrowest row spacing (solid plant on 1.0 m). As the effective row spacing widened, final grain yields were reduced.

Establishing plant populations of 50–70,000 plants/ha helped maximise yields, Lower plant populations were not able to produce the highest yields.

The hybrids with a moderate to high level of tillering produced the highest yields in all three seasons. Under these above average conditions, the low tillering hybrid produced lower yields.

As the most common practice in this environment is the double skip configuration, growers have in some cases sacrificed up to 40% of their potential yield through maintaining this 'safe and low' risk planting configuration in the 2010–2013 summer crop seasons.

Site details

2010–2013

Locations:	**2010/11 – Rowena, Gurley and Mungindi** **2011/12 – Rowena (early and late plant), Garah and Morialta** **2012/13 – Garah, Gurley and Bullarah**
Planter:	**Monosem double disc precision planter**
Fertiliser:	**42kg/ha Supreme Z at sowing**
Paddock History:	**All sites were long fallow from wheat in the previous season.**

Treatments

Hybrids

- 2436 (or LT10 – low tillering and high SG)
- MR43 (moderate SG and tillering)
- MR Bazley (previously PAC2437) (high tillering and low SG)

Row Configuration

- Solid on 1 m spacings
- Single skip
- Double Skip
- Superwide (1.5 m spacings or 2.0 m at Garah in the 2012–13 season)

Plant Populations

Populations were targeted using germination for each hybrid and an estimated establishment of 80%. Three populations were targeted in each of the row configurations.

- 15,000 plants/ha (2012/13 season only)
- 30,000 plants/ha
- 50,000 plants/ha
- 70,000 plants/ha (2010/11 and 2011/12 seasons)

Results

Row Configuration

Four row configurations have been used over the life of the project; these have been 1.0 m solid plant, super wide (1.5 m solid plant or 2.0 m at Garah in the 2012/13 season), single skip and double skip.

Over the last 3 years the trend across the 8 sites has been consistent with regards to reducing grain yields as effective row spacing's widened. In the last three seasons, growers have been losing significant yields from planting on the skip configurations. As the most common practice in this environment is for double skip, growers have in some cases sacrificed up to 40% of their potential yield through maintaining this "safe and low" risk planting configuration (Figure 1).

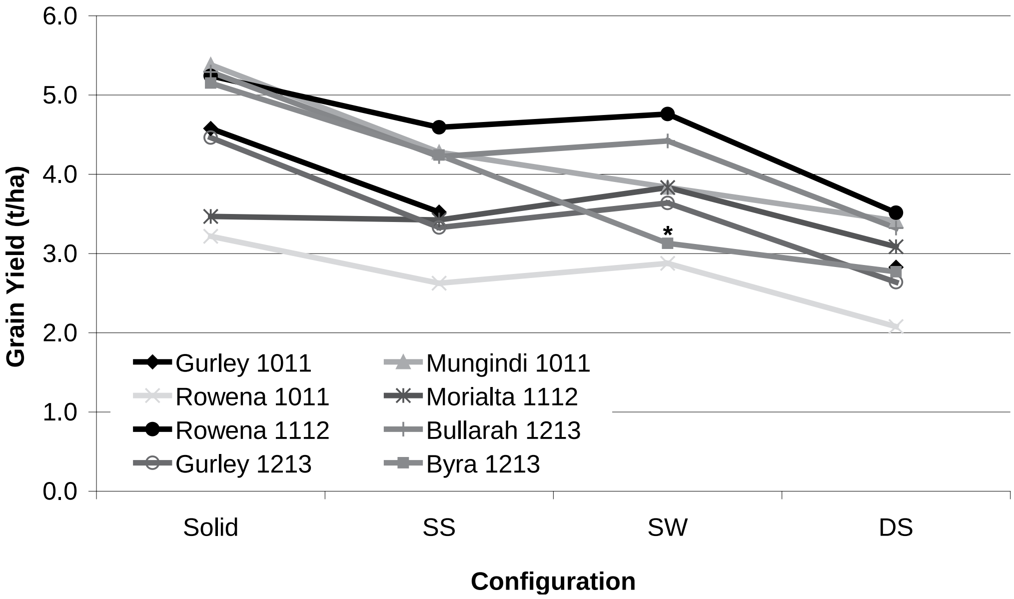


Figure 1. *Effect of row configuration on the grain yield of sorghum across 8 sites in north-west NSW (2010–2012).*

The solid (1.0 m) treatment was the highest yielding row spacing at all sites with the exception of Morialta in 2011/12. Widening the row spacing to 1.5 m (single skip/ super wide) reduced yield by between 20–30%, while the double skip or 2.0m effective row spacing reduced yields by 35% on average. (Figure 2).

Plant Population

During the 2010–2012 season, three target plant populations were used, 30, 50 and 70,000 plants/ha. In the 2012–13 season, it was decided to remove the 70,000 plants/ha population as it had proved to not be significantly different from the 50,000 population and was unlikely to be adopted by growers due to the increased seed costs required to establish the higher population and the higher risk associated with more plants. Growers in the western area often ask about lowering plant populations in sorghum and hence a target plant population of 15,000 plants/ha was substituted in the 2012/13 season.

Based on the data from the 2010–2012 seasons (Figure 3) it appears that a plant population above 50,000 plants/ha is not required to achieve high yields as they are seldom significantly better than the 50,000 plants/ha treatment. In contrast targeting 15,000 plants/ha was too low as yields were higher from the other increased plant populations. Additional difficulties from this low population included "patchy" stands as achieving accurate plant spacing is more difficult at this low sowing rate.

Hybrid Selection

The three hybrid types were selected based on their contrasting tillering and staygreen characteristics, 2436 (low tillering and staygreen) MR 43 (moderate tillering and moderate staygreen) and MR Bazley (high tillering and low staygreen).

Over the three seasons, it has been noted that the low tillering, high staygreen hybrid has been "yield capped" under these high yielding conditions. In contrast there has been little difference between the moderate and high tillering hybrids.

What is driving grain yield?

Analysis of the relationship between plants, tillers, heads, grain number and final yield has shown an increasing role is played by each of these plant structures. However, grain number was by far the strongest driver of yield with correlations of between 0.90–0.94 for each site compared (Figure 4).

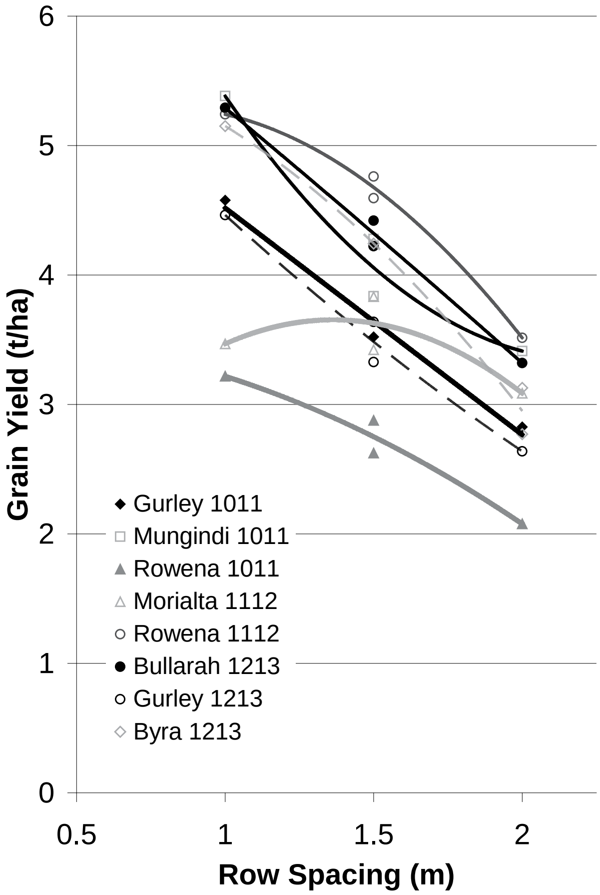


Figure 2. *Yield reduction from widening the effective row spacing in sorghum.*

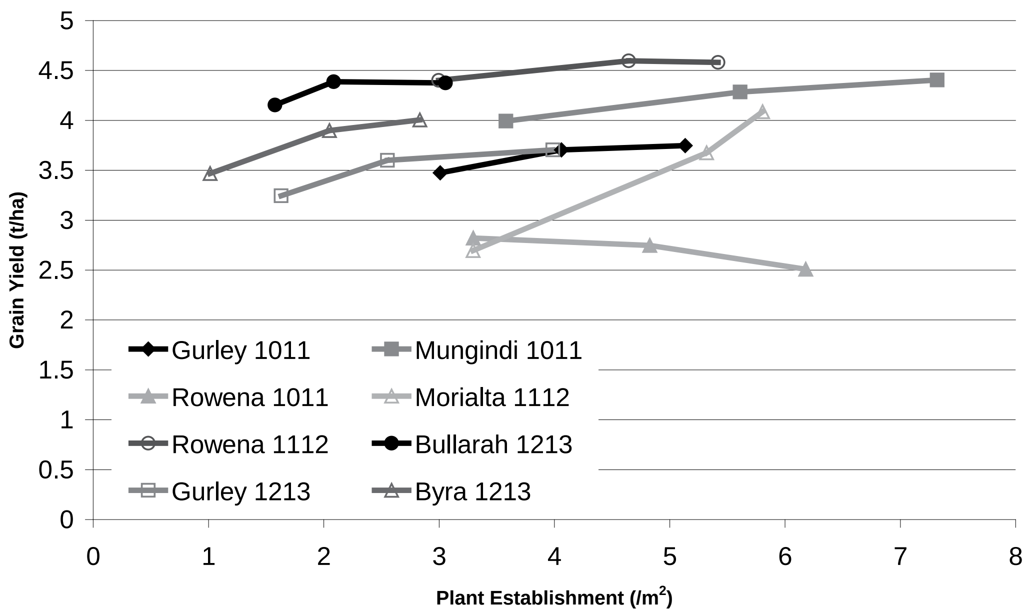


Figure 3. *Effect of varying plant population on sorghum yield at 8 sites.*

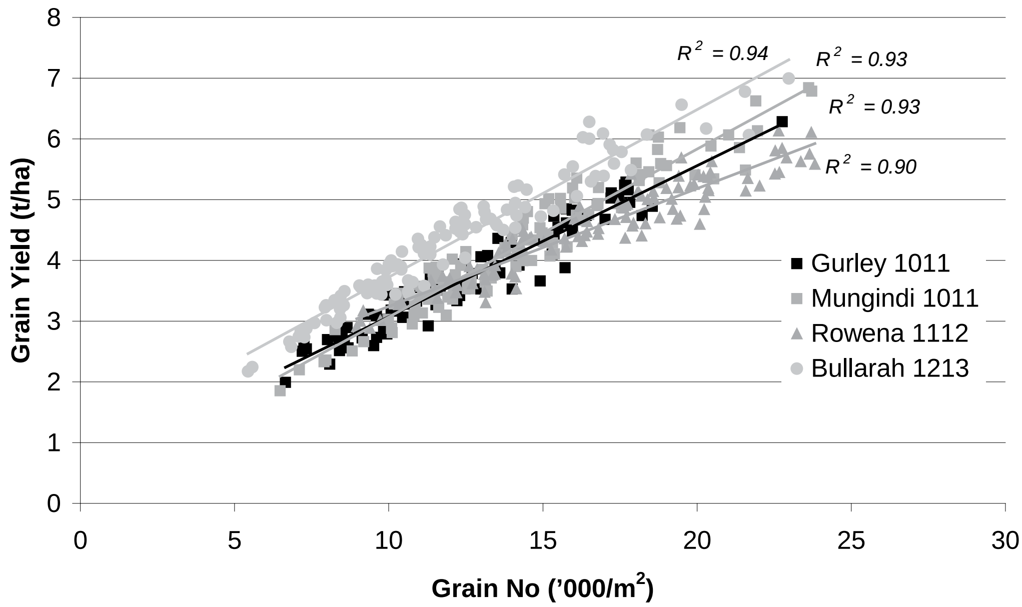


***Figure 4.** Relationship between grain yield and grain number 2010–2013.*

Summary

The 2010–2013 summer crop seasons have all been reasonably high yielding (~3 to 5 t/ha) for the western zone of northern NSW. This has allowed a robust data set to be developed outlining the typical results growers could expect from varying row configuration, plant population and hybrid type in seasons where the average yield is greater than 3 t/ha.

In these higher than average seasons, the narrower row spacing produced the greater final yield. The typical trend was for grain yield to reduce as the effective row spacing increased. Typically the relationship established was solid plant yielded highest then single skip and super wide configurations resulted in between a 20–30% yield penalty and double skip around a 35% yield penalty compared to the solid plant.

Lower tillering hybrids struggle to compete with hybrids which have a moderate or high tillering ability in these conditions. The lower tillering hybrid 2436, produced the lowest yields, however there was very little difference between the mid and high tillering hybrids, MR43 and MR Bazley.

Acknowledgements

This research was funded by the GRDC under project DAN00150 with support from Pacific Seeds. Thanks to Jan Hosking, Peter Formann, Peter Perfrement, Stephen Morphett, Matthew Gardner and Jim Perfrement (all NSW DPI) for technical assistance. Thanks to all of our co-operators and their agronomists for provision of trial sites and assistance with the trials.

Sorghum in the western zone – Row Configuration x Population x Hybrid – Bullarah 2013

Loretta Serafin, Guy McMullen and Nicole Carrigan NSW DPI, Tamworth
Ben Frazer formerly NSW DPI, Tamworth **Fiona Scott** NSW Trade & Investment, Tamworth

Key findings

In moderately high yielding seasons (~5 t/ha) the narrowest solid plant row configuration achieved the highest sorghum yield. At this site, the super wide (1.5 m solid) configuration was the next highest yielding followed by single skip and then double skip configuration.

The mid and high tillering hybrids, MR 43 and MR Bazley yielded significantly better than the low tillering hybrid 2436.

In the 2013 season at this site there was very little impact of varying plant population on plant structures, yield or grain quality.

Introduction

Sorghum is a reliable summer crop in eastern areas of northern NSW. However, there is a need to improve the reliability of sorghum in western cropping areas as both a break for winter crop diseases and weed management. Strategies also need to be assessed in this environment which may allow growers to adapt to increasingly variable seasonal conditions. The introduction of hybrids with increasing levels of Staygreen (SG), or using a combination of reduced tillering, plant population and row configuration may help improve the reliability of sorghum yields.

In the eastern zone there has been a reasonable amount of work evaluating population and row spacing in sorghum. Modelling work has suggested that sorghum can be a reliable component of western cropping systems but this work needs applied research to verify the modelling and give growers confidence to incorporate sorghum into their rotations.

In northern NSW crown rot, a stubble-borne fungal pathogen continues to be the most prevalent and damaging disease affecting winter cereals. Sorghum is recommended as a break crop but the success is dictated by the extent of decomposition of winter cereal stubble which harbours the crown rot fungus. Although altering row configuration and population may improve the reliability of sorghum yield it may also reduce the rate of decomposition of cereal stubble and hence the break crop benefits while also potentially decreasing water accumulation during the subsequent fallow period.

The trial outlined below aimed to answer some of these questions and provide data for use in modelling the trial outcomes over longer term climatic data sets. This was one of three sites planted across northern NSW in the 2012/13 season, the other two sites being at Garah and Gurley.

Site details

2012/13

Location:	**“Kirribilli”, Bullarah**
Co-operator:	**Charles & Fiona Brett**
Sowing Date:	**4th January, 2013**
Planter:	**Monosem double disc precision planter**
Fertiliser:	**42 kg/ha Supreme Z at sowing**
Paddock History:	**Long fallow from wheat in 2011.**
Starting soil water:	**199 mm (0–120 cm)**
Starting pathogens:	**Root lesion nematodes and crown rot below detection limit based on PreDicta B. Based on plating 0% *Fusarium* crown and 16% 1st node.**

In crop rainfall

Table 1. *In-crop rainfall 2013 season*

January	February	March	April	May	Total (mm)
33	68	21.5	0	32	154.5

Starting soil nutrition

Table 2. *Soil Test results for "Kirribilli", Bullarah.*

Soil depth (cm)	Total N (mg/kg)	Sulphur (mg/kg)	Organic Carbon %	pH Level ($CaCl_2$)	Phosphorus (Colwell) mg/kg	Phosphorus (BSES) mg/kg	Zinc (DTPA) mg/kg
0–10	27	5.7	0.69	7.2	18	55.50	1.54
10–30	26	4.0	0.36	7.6	7	47.12	5.13
30–60	30	6.3	0.31	8.0	6	–	–
60–90	26	13.5	0.32	7.9	10	–	–
90–120	41	37.5	0.26	8.0	14	–	–

Treatments

Hybrids

- 2436 (low tillering and high SG)
- MR43 (moderate SG and tillering)
- MR Bazley (PAC2437) (high tillering and low SG)

Row Configuration

- Solid on 1m spacings
- Single skip
- Double Skip
- Superwide (1.5m spacings)

Plant Populations

Populations were targeted using germination for each hybrid and an estimated establishment of 80%. Three populations were targeted in each of the row configurations.

- 15,000 plants/ha
- 30,000 plants/ha
- 50,000 plants/ha

Results

Plant Establishment

There was no impact of row configuration on plant establishment at this site (Table 3). Established plant populations were lower than targeted for the 30 and 50,000 plants/ha treatments, most likely due to the hot and dry conditions which followed planting, however there was good separation between the established populations (Table 4).

Table 3. *Plant structures data across configurations.*

Configuration	Plants/m²	Tillers/m²	Tillers/plant	Heads/m²	Heads/plant
Solid	2.37	5.56 a	2.59 a	5.48 a	2.55 a
SS	2.37	4.80 b	2.36 ab	4.33 b	2.25 ab
SW (1.5m)	2.12	4.46 bc	2.31 b	4.25 b	2.29 ab
DS	2.09	4.22 c	2.18 b	3.91 b	2.05 b
l.s.d	n.s.d	0.57	0.26	0.88	0.41

Table 4. Plant structures data across plant populations.

Population (0'000/ha)	Plants/m²	Tillers/m²	Tillers/ plant	Heads/m²	Heads/plant
15	1.58 b	4.03	2.79	3.70	2.58
30	2.08 b	4.62	2.34	4.54	2.36
50	3.06 a	5.63	1.95	5.26	1.91
l.s.d	0.54	n.s.d	n.s.d	n.s.d	n.s.d

Tillers

Tiller production reduced as row spacing widened for both the number of tillers per metre square and the number of tillers per plant. Solid plant > Single skip = Super wide= Double skip (Table 3). There was no significant impact of plant population on tiller production (Table 4). In terms of hybrids, they performed as expected with 2436 being the low tillering hybrid, MR43 the mid and MR Bazley the higher tillering hybrid. There was very little difference in the tillering of MR 43 and MR Bazley overall. 2436 had quite a flat response to varying row configuration (Figure 1).

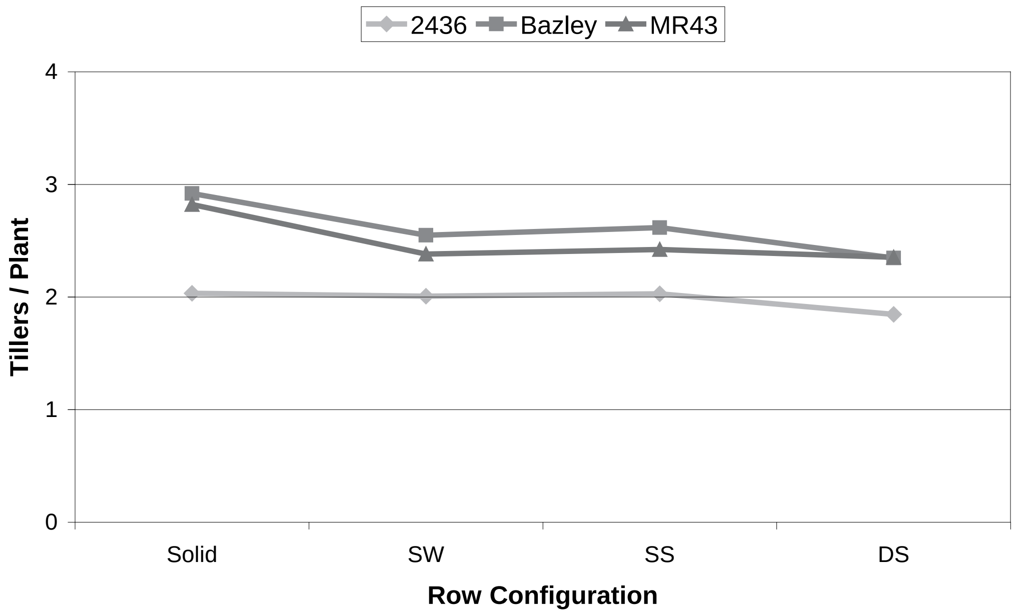


***Figure 1.** Impact of varying row configuration on tiller production per plant.*

Head Numbers

The number of heads produced followed a similar trend to the tillers, with less heads produced as row spacing widened, however only the solid plant produced significantly more heads per metre squared (Table 3). In terms of hybrids, they performed as expected with 2436 producing less heads than MR43 and MR Bazley the higher tillering hybrid.

Dry Matter Production

Dry matter cuts were taken at anthesis and showed that there was a decline in the amount of dry matter produced as the row configuration increased. Solid plant produced slightly over 7 t/ha DM, which was significantly more than any of the other row configurations. There was no impact of varying hybrid or plant population on dry matter production.

Yield

There were significant differences in yield across row configurations; solid plant yielded the highest at 5.29 t/ha, followed by the superwide configuration at 4.42 t/ha, the single skip at 4.22 t/ha and double skip at 3.32 t/ha when averaged across the three hybrids (Figure 2). There was no significant difference in yield across the three plant populations. In terms of hybrid 2436 was the lowest yielding, while there was no significant difference in the yield of MR43 and MR Bazley.

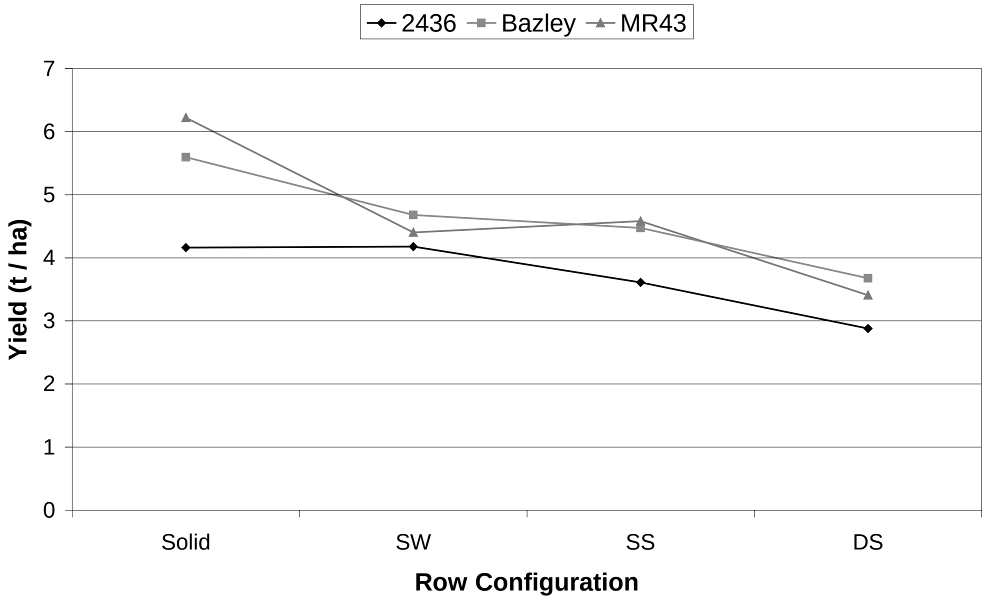


Figure 2. *Grain yield across row configuration.*

Grain protein

There was no significant impact of configuration (Table 5), hybrid variety or plant population on the protein results.

1000 Grain weight

Varying row configuration had a significant impact on 1000 grain weight with all configurations having a higher 1000 grain weight than the solid configuration (Table 5). There was no impact of hybrid or plant population.

Screenings

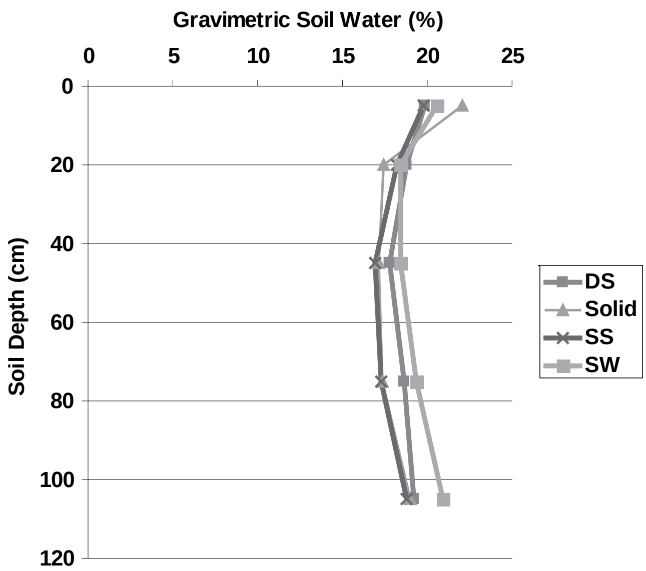
Screening levels were very low, and not to a point where they would impact on receival standards. However, there were still statistical differences with screenings being lower from the skip row configurations when compared to the solid plant (Table 5).

Table 5. *Grain quality across row configurations.*

Configuration	Protein (%)	1000 Grain wgt (g)	Screenings (%)
Solid	10.2	35.12 b	1.89 a
SS	10.0	36.35 a	1.40 b
SW	10.0	36.72 a	1.60 ab
DS	10.0	36.43 a	1.39 b
l.s.d (5% level)	n.s.d	1.01	0.34

Finishing Soil Water

Finishing soil water cores from the Bullarah site were taken post harvest (Figure 3). Results at the site showed there were very minor differences in the amount of water remaining, both on the row and mid row.



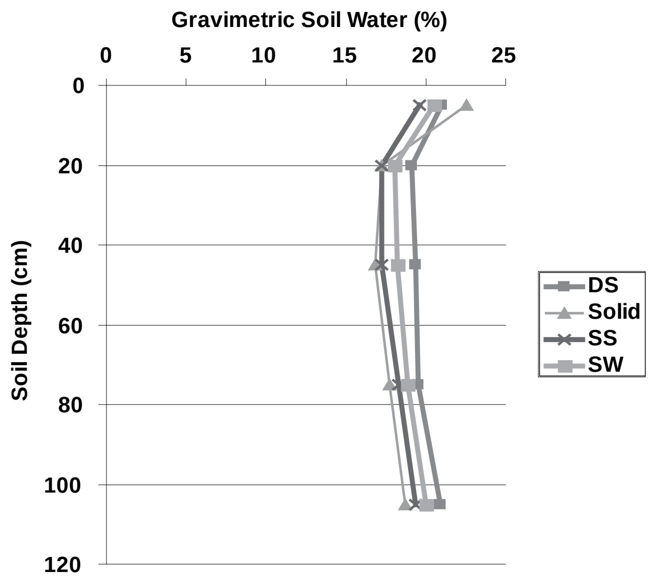


Figure 3. *Finishing soil water at Bullarah (LH – on row, RH – mid row).*

Summary

In a reasonably high yielding season, even on a late plant the narrower row spacing yielded the best. Varying row configuration had the biggest impact on all plant structures and yield components. While the impact of varying plant population and hybrid selection was less significant. The lower tillering hybrid 2436, produced the lowest yields, however there was very little difference between the mid and high tillering hybrids, MR43 and MR Bazley.

There was very little difference in the finishing soil water under the sorghum rows, however small differences started to appear in the mid row measurements at depth with the solid plant being the driest and the double skip the wettest.

Acknowledgements

This research was funded by the GRDC under project DAN00150 with support from Pacific Seeds. Thanks to Jan Hosking, Peter Formann, Peter Perfrement, Matthew Gardner and Jim Perfrement (all NSW DPI) for technical assistance. Thanks to Charles and Fiona Brett “Kirribilli”, Bullarah for hosting the trial site. The assistance of Brad Coleman, Coleman Ag is also gratefully acknowledged.

AGRONOMY

Sorghum in the western zone – Row Configuration x Population x Hybrid – Gurley 2013

Loretta Serafin, Guy McMullen and Nicole Carrigan NSW DPI, Tamworth
Ben Frazer formerly NSW DPI, Tamworth **Fiona Scott** NSW Trade & Investment, Tamworth

Key findings

Grain yield declined as row spacing widened with the double skip configuration yielding 60% of the solid configuration. There was no significant impact of varying plant population or hybrid on grain yield at this site in this season.

Grain quality met the receival standards, so while there were significant impacts of varying some of the agronomic treatments, none were at a level to be commercially significant.

Dry matter production reduced as row configuration increased. Solid plant produced more than double the dry matter of the double skip configuration. There was no effect of varying plant population or hybrid on biomass production.

Introduction

Sorghum is a reliable summer crop in eastern areas of northern NSW. However there is a need to improve the reliability of sorghum in western cropping areas and to assess strategies that will allow growers to adapt to increasingly variable seasonal conditions. The introduction of hybrids with increasing levels of Staygreen (SG) or reduced tillering in combination with plant population and row configuration may help improve the reliability of sorghum yields.

In the eastern zone there has been a reasonable amount of work evaluating population and row spacing. Modelling work has suggested that sorghum can be a reliable component of western cropping systems but research is required to verify the modelling and give growers confidence to incorporate sorghum into their rotations.

In northern NSW crown rot, a stubble-borne fungal pathogen continues to be the most prevalent and damaging disease affecting winter cereals. Sorghum is recommended as a break crop but the success is dictated by the extent of decomposition of the winter cereal stubble that harbours the crown rot fungus. Although altering row configuration and population may improve the reliability of sorghum it may also reduce the rate of decomposition of cereal stubble and hence break crop benefits while also affecting soil water accumulation during the fallow period.

The trial outlined below aims to answer some of these questions and provide data for use in modelling the trial outcomes over a long term climatic data sets. This was one of three sites planted across northern NSW in the 2012/13 summer crop season, the other two sites being Bullarah and Garah.

Site details

2012/13

Location:	**"Forestvale", Gurley**
Co-operator:	**Max, Maree and David Onus**
Sowing Date:	**9th and 10th January, 2013**
Starting soil water:	**120 mm PAW (0–120 cm)**
Starting soil pathogen levels:	**Nil Pratylenchus neglectus, 1.0 P. thornei/g soil and nil crown rot based on PreDicta B (0–30 cm). Nil crown rot confirmed by plating of wheat stubble from paddock at sowing.**
Planter:	**Monosem double disc precision planter**
Fertiliser:	**42 kg/ha Supreme Z at sowing**
Paddock History:	**Long fallow from wheat in 2011**

In crop rainfall

Table 1. *In-crop rainfall 2013 season.*

January	February	March	April	May	Total (mm)
10.5	154	78	5.5	0	257

Starting soil nutrition

Table 2. *Soil test results for "Forestvale", Gurley.*

Soil depth (cm)	Total N (mg/kg)	Sulphur (mg/kg)	Organic carbon %	pH level ($CaCl_2$)	Phosphorus (Colwell) mg/kg	Phosphorus (BSES) g/kg	Zinc (DTPA) mg/kg
0–10	16	5.2	0.77	7.7	6	19.36	0.81
10–30	17	2.4	0.54	8.0	3	15.15	1.47
30–60	18	33.8	0.50	8.2	2	–	–
60–90	15	33.8	0.32	8.2	3	–	–
90–120	11	208.1	0.22	8.3	2	–	–

Treatments

Hybrids

- 2436 (low tillering and high SG)
- MR43 (moderate SG and tillering)
- MR Bazley (PAC2437) (high tillering and low SG)

Row Configuration

- Solid on 1 m spacings
- Single skip
- Double Skip
- Super wide (1.5 m spacings)

Plant Populations

Populations were targeted using germination for each hybrid and an estimated establishment of 80%. Three populations were targeted in each of the row configurations.

- 15,000 plants/ha
- 30,000 plants/ha
- 50,000 plants/ha

Results

Plant Establishment

Plant establishment was reduced as the row configuration increased (Table 3). This is most likely due to the additional inter-row competition. There was no significant difference in plant establishment between hybrids or across plant populations.

Table 3. *Plant structure data averaged across three sorghum hybrids with various row configurations. Values followed by the same letter are not significantly different at the 95% confidence level.*

Configuration	Plants/m²	Tillers/m²	Tillers/ plant	Heads/m²	Heads/plant
Solid	3.06 a	6.04	2.23	6.26	2.32
SS	2.81 ab	4.98	1.92	5.09	1.99
SW (1.5m)	2.51 b	5.14	2.27	5.26	2.35
DS	2.52 b	4.05	1.86	4.13	1.93
l.s.d (P=0.05)	0.38	n.s.d	n.s.d	n.s.d.	n.s.d

Tillers

Tiller production reduced as row spacing widened for both the number of tillers per metre square and per plant but the differences were not statistically significant (Table 3). There was no significant impact of plant population or hybrid on tiller production.

Head Numbers

While there were no significant differences at this site, the trend was for less heads per square metre and per plant as row configuration widened and as plant population increased.

Dry Matter production

Dry matter cuts were taken at anthesis and showed that dry matter production reduced as the row configuration widened. The solid configuration produced more than double the amount of dry matter than the double skip (DS) configuration (Table 4). There was no effect of varying plant population or hybrid on dry matter production.

Table 4. *Impact of varying row configuration on dry matter production and yield averaged across three sorghum hybrids.*

Configuration	Dry Matter (t/ha)	Yield (t/ha)
Solid	10.47 a	4.46 a
SS	7.28 b	3.33 bc
SW (1.5m)	7.06 b	3.64 ab
DS	5.18 c	2.64 c
l.s.d (P=0.05)	1.88	0.96

Yield

Grain yield declined as row spacing widened (Table 4), with the double skip configuration yielding 60% of the solid configuration. The solid plant yielded 4.46t/ha which was not significantly different to the super wide configuration. There was no significant impact of varying plant population or hybrid on grain yield. However, there was a trend towards the same result as from the Bullarah site where MR43 and MR Bazley performed similarly and the low tillering hybrid 2436 yielded less (Figure 1).

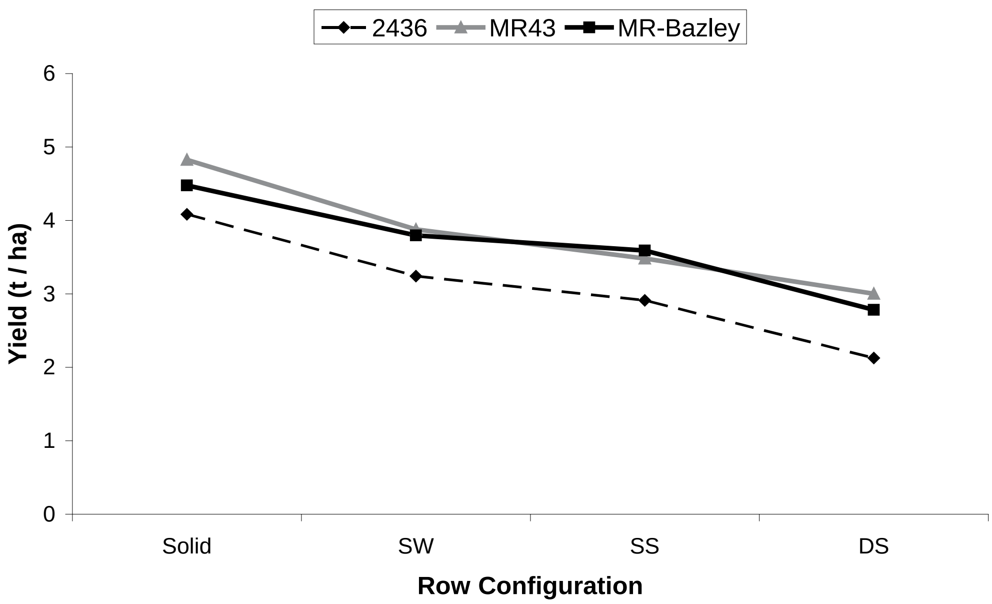


Figure 1. *Grain yield across row configuration.*

Grain quality

Grain quality was assessed through testing screenings (%), 1000 grain weight, hectolitre weight and protein.

Protein

Grain protein levels were not significantly impacted on by varying any of the treatments (row configuration, plant population or hybrid).

1000 Grain weight

All three treatments had a significant impact on 1000 grain weight. Configuration had a significant impact but there was no trend with increasing or decreasing effective row width (Table 5). The 1000 grain weight decreased with increasing plant population (data not shown). Hybrid also had an impact on 1000 grain weight, with the low tillering hybrid 2436 producing the highest grain weight, followed by MR Bazley and then MR43 (data not shown).

Screenings

Screening levels were very low at this site, with a site mean of 0.86% which is below receival standards. There was no significant impact of row configuration (Table 5) or plant population (data not shown) on screenings. There was a significant difference between the hybrids with 2436 producing a higher level of screenings than the other two hybrids (data not shown).

Hectolitre weight

Hectolitre weights at the site averaged 78.61 kg/hl, which is well above the receival standards for all grain sorghum grades. There was no impact of row configuration or plant population on hectolitre weight. Hybrid had an impact on hectolitre weight but only to note that 2436 and MR Bazley were statistically different, with MR Bazley being lower (data not shown).

***Table 5**. Grain quality averaged across three sorghum hybrids with different row configurations.*

Configuration	Protein %	1000 Grain Wgt	Screenings (%)	Hectolitre wgt
Solid	9.88	34.38 b	0.91	78.52
SS	10.03	34.16 b	0.93	78.56
SW	10.11	35.24 a	0.80	78.62
DS	10.10	34.83 ab	0.82	78.76
l.s.d (5% level)	n.s.d	0.73	n.s.d	n.s.d

Finishing Soil Water

Finishing soil water was measured with very small differences in the amount of water remaining in the super wide configuration from the on-row coring position evident. The mid row coring position also showed little difference in the finishing soil water between sowing configurations (Figure 2).

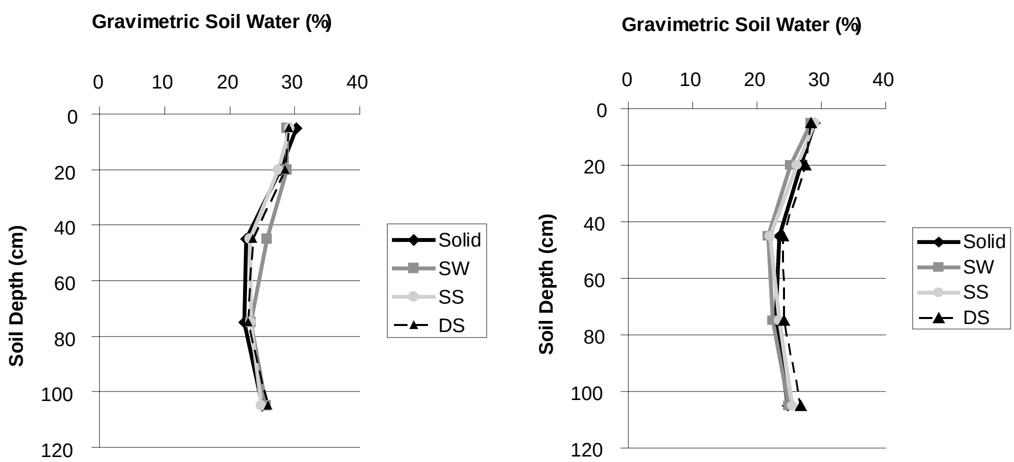


***Figure 2.** Finishing soil water at Gurley (LH – on row, RH – mid row).*

Summary

In a reasonably high yielding season, even on a late plant the solid plant row spacing yielded the best, the super wide configuration was not significantly different though. The double skip yields were disappointing, at 60% of the solid plant yields. Varying row configuration had the biggest impact on all plant structures and yield components. While the impact of varying plant population and hybrid was not significant at this site. The lower tillering hybrid 2436, produced the lowest yields, however there was very little difference between the mid and high tillering hybrids, MR43 and MR Bazley.

There was very little difference in the finishing soil water under the sorghum rows, however small differences started to appear in the mid row measurements at depth with the solid plant being the driest and the double skip the wettest.

Acknowledgements

This project is funded by the GRDC under project DAN00150 with support from Pacific Seeds. Thanks to Jan Hosking, Peter Formann, Peter Perfrement, Matthew Gardner and Jim Perfrement (all NSW DPI) for technical assistance. Thanks to the Onus Family "Forestvale", Gurley for hosting the trial site. The assistance of Gary Onus, Landmark, Moree is also gratefully acknowledged.

Sorghum in the western zone – Row Configuration x Population x Hybrid – Garah 2013

Loretta Serafin, Guy McMullen and Nicole Carrigan NSW DPI, Tamworth
Ben Frazer formerly NSW DPI, Tamworth **Fiona Scott** NSW Trade & Investment, Tamworth

Introduction

Sorghum is a reliable summer crop in eastern areas of northern NSW. However there is a need to improve the reliability of sorghum in western cropping areas and to assess strategies that will allow growers to adapt to increasingly variable seasonal conditions. The introduction of hybrids with increasing levels of Staygreen (SG) or reduced tillering in combination with plant population and row configuration may help improve the reliability of sorghum yields in the western zone of northern NSW.

In the eastern zone there has been a reasonable amount of work evaluating population and row spacing. Modelling work has suggested that sorghum can be a reliable component of western cropping systems but applied research is needed to verify the modelling and give growers confidence to incorporate sorghum into their rotations.

In northern NSW crown rot, a stubble-borne fungal pathogen continues to be the most prevalent and damaging disease affecting winter cereals. Sorghum is recommended as a break crop but the success is dictated by the amount of decomposition of the winter cereal stubble which harbour the crown rot fungus. Although altering row configuration and population may improve the reliability of sorghum it may also reduce the rate of decomposition of cereal stubble and break crop benefits while also affecting soil water accumulation during the fallow period.

Key findings

Sorghum grain yield decreased as row spacing increased at this site under 2012–13 seasonal conditions. The double skip treatment yielded close to half that of the solid plant treatment. The 2.0 m super wide treatment was also significantly lower yielding than the solid and single skip treatments.

There was no significant difference in hybrid sorghum performance at this site.

The 15,000 plants/ha plant population yielded significantly less than the 30 or 50,000 plants/ha treatments.

Finishing soil water data showed there was more water remaining in the wider row configurations (double skip and super wide) in the mid row area when compared to the solid and single skip treatments.

Site details

Location:	**"Byra", Garah**
Co-operator:	**Justin & Justine Malone**
Sowing Date:	**7th and 8th January, 2013**
Planter:	**Monosem double disc precision planter**
Paddock History:	**Short fallow from irrigated wheat in 2012. The paddock was then worked and beds reformed. The paddock was pre-watered and then remained dryland for the rest of the season.**

Starting soil nutrition

The trial site had been pre-fertilised by the grower with 300 kg/ha of Urea (138 kg N) and 50 kg /ha Starter fertiliser which was worked in prior to the pre-watering.

Table 1. *Soil Test results for "Byra", Garah 2013*

Soil Depth (cm)	Total N (mg/kg)	Sulphur (mg/kg)	Organic Carbon %	pH Level ($CaCl_2$)	Phosphorus (Colwell) mg/kg	Phosphorus (BSES) mg/kg	Zinc (DTPA) mg/kg
0–10	15	11.8	0.66	7.0	30	66.40	3.49
10–30	5	3.5	0.34	7.6	7	57.26	1.70
30–60	4	3.7	0.38	7.9	6	–	–
60–90	4	9.3	0.38	7.8	20	–	–
90–120	4	22.5	0.37	7.9	23	–	–

Treatments

Hybrid

- 2436 (low tillering and high SG)
- MR 43 (moderate SG and tillering)
- MR Bazley (PAC2437) (high tillering and low SG)

Row Configuration

- Solid on 1 m spacings
- Single skip
- Double Skip
- Super wide (2.0 m spacings)

Plant Populations

Populations were targeted using germination for each hybrid and an estimated establishment of 80%. Three populations were targeted in each of the row configurations.

- 15,000 plants/ha
- 30,000 plants/ha
- 50,000 plants/ha

Results

Plant Establishment

The row configurations varied slightly at this site due to it being on 2.0 m wide raised beds, a 1.5 m super wide treatment was not possible, so a 2.0 m super wide was utilised instead. There was no significant impact of configuration on plant establishment at this site (Table 2).

Table 2. *Plant structures data across row configurations averaged across three sorghum hybrids. Values followed by the same letter are not significantly different at the 95% confidence level.*

Configuration	Plants/m^2	Tillers/m^2	Tillers/ plant	Heads/m^2	Heads/ plant
Solid	2.22	8.39 a	4.33	7.76 a	3.65
SS	2.04	6.68 b	3.96	5.95 b	4.18
SW (2.0 m)	1.80	5.19 c	3.51	4.93 bc	3.30
DS	1.81	5.21 c	3.52	4.56 c	3.16
l.s.d (P=0.05)	n.s.d	1.40	n.s.d	1.25	n.s.d

Plant population data (Table 3) showed that target establishment populations were not achieved for any of the treatments. However, significant differences were achieved between all plant populations. There was no impact of hybrid on plant establishment.

Table 3. *Plant structures data across sorghum populations. Values followed by the same letter are not significantly different at the 95% confidence level.*

Population ('000/ha)	Plants/m^2	Tillers/m^2	Tillers/ plant	Heads/m^2	Heads/ plant
15	1.01 c	5.22 b	5.49 a	5.00 b	5.27 a
30	2.05 b	6.66 a	3.40 b	6.12 a	3.16 b
50	2.83 a	7.22 a	2.60 c	5.89 a	2.27 c
l.s.d (P=0.05)	0.25	0.70	0.44	0.63	0.55

Tillers

The wider the row configuration, the less tillers per square metre were produced (Table 2). The solid configuration produced significantly more tillers/m^2 than the single skip. The super wide and double skip were comparable to each other.

The number of tillers per square metre increased as plant population increased, however the difference between 30 and 50,000 plants/ha was not significant (Table 3). The tiller production per plant decreased as the plant population increased.

There were significant differences only in the number of tillers/m^2. As expected 2436 was lower tillering, while MR 43 was in the middle and MR Bazley was the higher tillering sorghum hybrid.

Head Numbers

Head production declined as row spacing widened (Table 2). Varying plant population also impacted on head production with less heads per metre square from the lowest population but more heads per plant (Table 3). There was no significant effect of varying hybrid choice on head numbers.

Dry Matter Production

Dry matter cuts were taken at anthesis and showed that dry matter production declined as effective row spacing increased (Table 4). Less dry matter was produced from the 15,000 plants/ha treatment as well. There was no impact of hybrid on dry matter production.

Table 4. *Impact of varying row configuration on dry matter production and yield averaged across three sorghum varieties. Values followed by the same letter are not significantly different at the 95% confidence level.*

Configuration	Dry Matter (t/ha)	Yield (t/ha)
Solid	9.46 a	5.29 a
SS	7.88 b	4.26 b
SW (2.0 m)	6.41 bc	3.13 c
DS	5.56 c	2.75 c
l.s.d (P=0.05)	1.58	0.55

Yield

Grain yield decreased as row spacing increased (Table 4). At this site the double skip (DS) treatment yielded close to half that of the solid plant treatment. The 2.0 m super wide (SW) treatment was also significantly lower yielding than the solid and single skip (SS) treatments. There was no significant difference between the 30 and 50,000 plants/ha treatments but both were higher yielding than the 15,000 plants/ha (data not shown). Differences in yield between hybrids were not significant at this site.

Grain Quality

Grain quality was assessed through testing protein, 1000 grain weight, screenings (%) and hectolitre weights.

Protein

Grain protein levels were significantly impacted on by varying configuration and hybrid variety only. There was no obvious reasoning behind the trend exhibited by varying configuration (Table 5). In terms of hybrids, 2436 produced the highest protein levels followed by MR Bazley and then MR 43 (Table 7).

1000 Grain weight

There was no significant difference in the 1000 grain weight produced by the solid, super wide and double skip treatments (Table 5). 1000 grain weight reduced as the plant population increased (Table 6). There were significant differences in hybrids with 2436 exhibiting the highest 1000 grain weight (Table 7).

Screenings

Screenings reduced as the effective row width increased, however the overall screenings level was below the receival standard of 11% (Table 5). There was no impact of plant population on screenings (Table 6). The lower tillering hybrid 2436 had significantly higher screenings than MR 43 or MR Bazley (Table 7).

Hectolitre weight

All hectolitre weights were well above the receival standards for all grades of sorghum. The solid plant had significantly higher hectolitre weights than the other configurations (Table 5). As plant populations increased, the hectolitre weights also increased (Table 6). There was no impact of hybrid on hectolitre weight (Table 7).

Table 5. *Grain quality for different row configurations averaged across sorghum varieties. Values followed by the same letter are not significantly different at the 95% confidence level.*

Configuration	Protein (%)	1000 gwt (g)	Screenings (%)	Hectolitre wgt
Solid	9.56 ab	36.92 a	3.59 a	81.91 a
SS	9.26 c	35.98 b	3.02 b	80.3 b
SW (2.0m)	9.5 b	37.31 a	3.41 ab	79.66 b
DS	9.79 a	37.61 a	3.02 b	80.48 b
l.s.d (P=0.05)	0.24	0.88	0.40	0.92

Table 6. *Grain quality for different plant populations averaged across sorghum varieties. Values followed by the same letter are not significantly different at the 95% confidence level.*

Population ('000/ha)	Protein (%)	1000 gwt (g)	Screenings (%)	Hectolitre wgt
15	9.56	39.64 a	3.15	78.49 c
30	9.45	36.01 b	3.25	80.85 b
50	9.53	35.23 c	3.38	82.43 a
l.s.d (P=0.05)	n.s.d	0.76	n.s.d	0.79

Table 7. *Grain quality of three sorghum hybrids – Garah 2013.*

Hybrid	Protein (%)	1000 gwt (g)	Screenings (%)	Hectolitre wgt
2436	10.05 a	39.11 a	4.24 a	80.87
MR Bazley	9.47 b	36.51 b	2.67 b	80.59
MR43	9.06 c	35.26 c	2.87 b	80.30
l.s.d (P=0.05)	0.21	0.76	0.35	n.s.d.

Finishing Soil Water

Finishing soil water measurements from under the sorghum rows showed there was no difference across the configurations. However, soil coring in the mid row area showed there was more water remaining under the double skip treatments at nearly all depths and also under the super wide treatment below 30 cm (Figure 1).

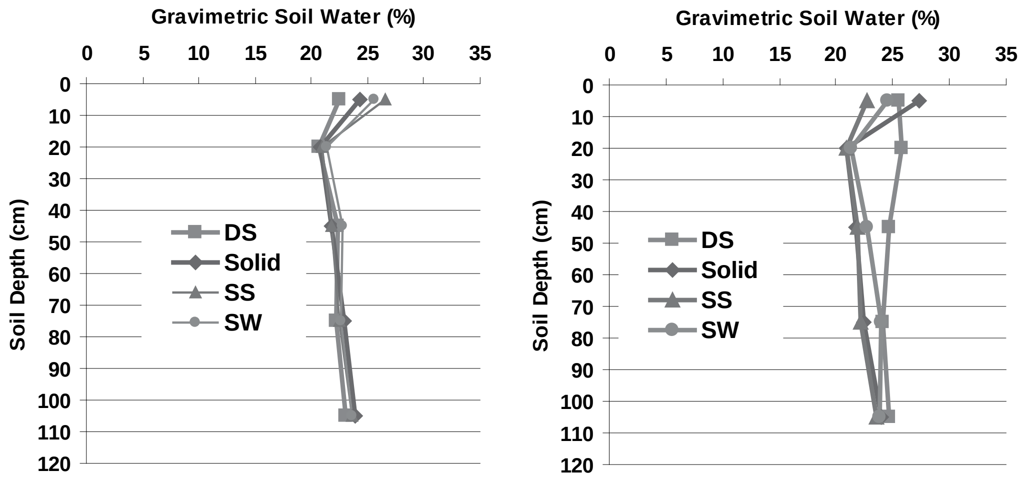


Figure 1. *Finishing soil water at Garah (LH – on row, RH – mid row)*

Summary

In this season with above average yields, grain yield of sorghum decreased as row spacing increased. At this site the double skip treatment yielded close to half that of the solid plant treatment. The 2.0 m super wide treatment was also significantly lower yielding than the solid and single skip treatments.

While there were significant impacts on grain quality from varying row configuration, plant population and hybrid, the overall grain quality was very high so would not have impacted on the returns to a grower.

Finishing soil water data showed that there was no variation in the amount of water left in the soil profile under the sorghum rows but there was more water remaining down the profile in the wider row configurations in the mid row area.

Acknowledgements

This project is funded by the GRDC under project DAN00150 with support from Pacific Seeds. Thanks to Jan Hosking, Peter Formann, Peter Perfrement, Stephen Morphett and Jim Perfrement (all NSW DPI) for technical assistance. Thanks to Justin and Justine Malone and family "Byra", Garah for hosting the trial site. The assistance of Rob Holmes, HMAg, Moree is also gratefully acknowledged.

Grain sorghum – managing irrigation, nitrogen, hybrid selection and plant population – Breeza 2012–13

Loretta Serafin, Guy McMullen, Nicole Carrigan and Peter Perfrement NSW DPI, Tamworth

Key findings

The use of one in crop irrigation increased grain yields by 0.86 t/ha, reduced grain protein by 0.5% and increased 1000 grain weight.

Increasing plant populations from 50 to 100 or 150,000 plants/ha increased grains yields by 0.5 and 0.7 t/ha, respectively. MR 43 and MR Bazley were more responsive to increasing plant population than Enforcer.

Varying nitrogen (N) rate had little impact on grain yield or quality at Breeza in 2012–13. The primary impact of N application was on increasing grain protein levels with each additional rate of N.

Individual hybrids had varying impacts from altering the management practices. MR 43 and MR Bazley performed similarly under most variations. Enforcer was lower yielding regardless of agronomic management.

Introduction

Grain sorghum grown under irrigation is a small but important part of irrigated farming systems in the northern grains region. Research on irrigated grain sorghum aimed at maximising grain yield, particularly in seasons where limited irrigation water is available is minimal. This trial aimed to investigate the impact of varying four of the most important agronomic management practices in sorghum production (hybrid selection, plant population, irrigation management and nitrogen rate).

Site details

2012–2013

Location:	**Liverpool Plains Field Station, Breeza**
Planter:	**Monosem double disc precision planter on a 90 cm row spacing.**
Sowing date:	**2nd November, 2012**
Insecticides:	**4th January – Karate® applied by plane**
Harvest date:	**21st May, 2013**

In–crop rainfall (mm)

Nov 12	Dec 12	Jan 13	Feb 13	Mar 13	Apr 13	May 13	Total
12.5	27	138	127	76	5	17	402.5

Treatments

- Two irrigation treatments:
  – I–0 = dryland
  – I–1 = 1 irrigation – applied 9th January, 2013

Bare beds were left between irrigation treatments to minimise lateral movement of water. Additional buffers were also sown alongside the experimental beds to reduce any edge effects.

- Three sorghum hybrids: **Enforcer, MR Bazley and MR 43**
- Three target plant populations: **50, 100 and 150,000 plants/ha**
- Four nitrogen rates: **0, 50, 100 and 200 kg /ha Nitrogen applied as Urea at sowing**

Starting soil nutrition

Starting soil tests showed there was 114 kg N/ha to a depth of 120 cm. Hence there was sufficient nitrogen in the profile to produce around 3.5 t/ha at 10% protein prior to the application of any additional nitrogen.

Table 1. Soil test results

Soil Depth (cm)	Total N (mg/kg)	Sulphur (mg/kg)	Organic Carbon %	pH Level (CaCl2)	Phosphorus (Colwell) mg/kg	Phosphorus (BSES) mg/kg	Potassium (Colwell) mg/kg	Zinc (DTPA) mg/kg
0–10	15.3	4.7	0.86	7.9	31	462.88	469	2.84
10–30	28.08	6.2	0.65	7.9	20	465.61	310	1.10
30–60	23.73	5.3	0.54	8.0	13	–	222	–
60–90	35.1	10.0	0.50	8.1	21	–	270	–
90–120	11.79	16.7	0.38	8.3	25	–	270	–

Results

Grain Yield

Significant yield responses were recorded for population, irrigation and hybrid treatments; however there was no effect of varying nitrogen application rate. The addition of one in crop irrigation increased yields from 5.64 t/ha in the dryland treatments to 6.50 t/ha, averaged across the three sorghum varieties.

Averaged across hybrid, the 100 and 150,000 plants/ha treatments yielded significantly more than the 50,000 plants/ha treatment by 0.71 and 0.54 t/ha, respectively.

Both MR 43 and MR Bazley performed similarly, yielding more than Enforcer. However there were some interactions between hybrid, plant population and irrigation. All three hybrids had increased yield with the the addition of an irrigation.

MR 43 and MR Bazley were more responsive to increasing plant population than Enforcer (Table 2). Both MR Bazley and MR 43 showed an increase in yield when plant population increased from 50 to 100, 000 or 150,000 plants/ha.

Table 2. Effect of varying hybrid and plant population on grain yield (t/ha)

Population (‘000/ha)	Hybrid		
	Enforcer	MR Bazley	MR43
50	5.44	6.12	5.85
100	5.75	6.91	6.90
150	5.67	6.65	6.72

Grain Quality

Grain quality was assessed through measuring protein, screenings, 1000 grain weight and hectolitre weight.

Protein

Varying irrigation, hybrid, plant population and nitrogen rate also had significant impacts on grain protein. The average protein from the site was 11.2%. Increasing the nitrogen rate significantly increased grain protein by 1% at the 200 kg N /ha application rate.

As would be expected the addition of irrigation reduced the grain protein content, as the protein was diluted by the extra yield obtained from the additional water which was available (data not shown).

Increasing plant population showed small but significant impacts on grain protein. In MR 43 grain protein declined as plant population increased, whereas with MR Bazley and Enforcer there was a slight increase in grain protein when the plant population increased from 50 to 100,000 plants/ha and then a decline at 150,000 plants/ha (Figure 1).

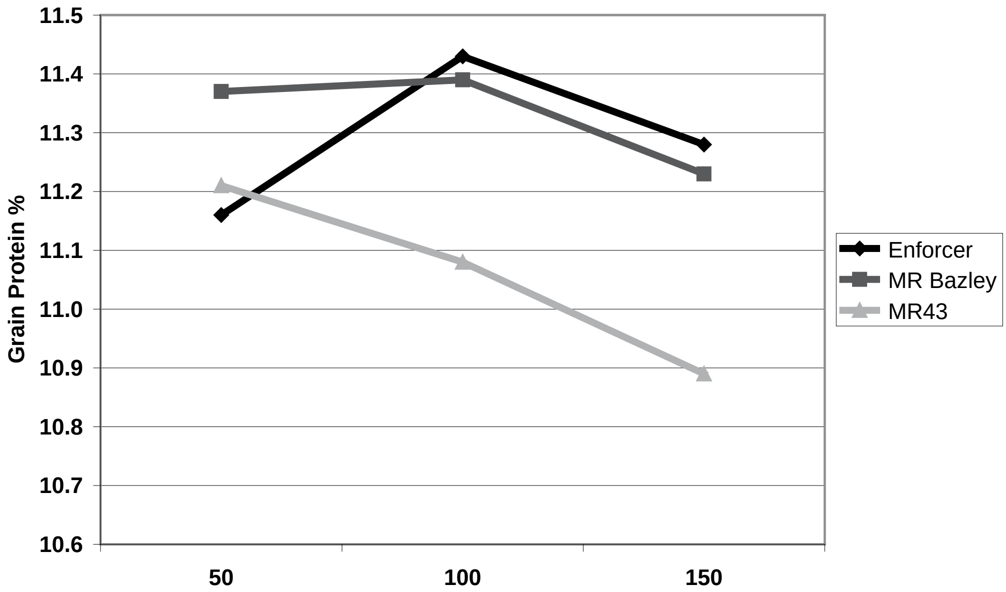


Figure 1. *Impact of varying plant population on grain protein of three sorghum hybrids – Breeza 2012/13.*

Screenings

There were significant differences in screenings as a result of both hybrid and irrigation treatments, however varying hybrid had the largest impact on screenings. There was no significant difference in screenings for both MR 43 and MR Bazley regardless of irrigation treatment which were also both below the 11% receival standard for sorghum 1 classification (Table 3). However, Enforcer had significantly higher screenings with the addition of one irrigation. Both of the screenings levels for Enforcer were sufficiently high to result in a downgrade to sorghum 2.

Table 3. *Effect of irrigation on screenings (%) across hybrid (Values followed by the same letter are not significantly different at the 95% confidence level).*

Irrigation	Screenings (%)		
	Enforcer	MR Bazley	MR43
I–O	13.7 b	10.7 c	10.1 c
I–1	16.3 a	10.3 c	10.2 c
l.s.d (P=0.05)	1.8		

1000 grain weight

There was a significant impact of irrigation and hybrid, both alone and in combination on 1000 grain weight. The addition of one irrigation increased 1000 grain weight in all hybrids, and there was no statistical difference between the hybrids under this treatment. However under the dryland treatment, Enforcer had a significantly lower 1000 grain weight than the other two hybrids (Figure 2).

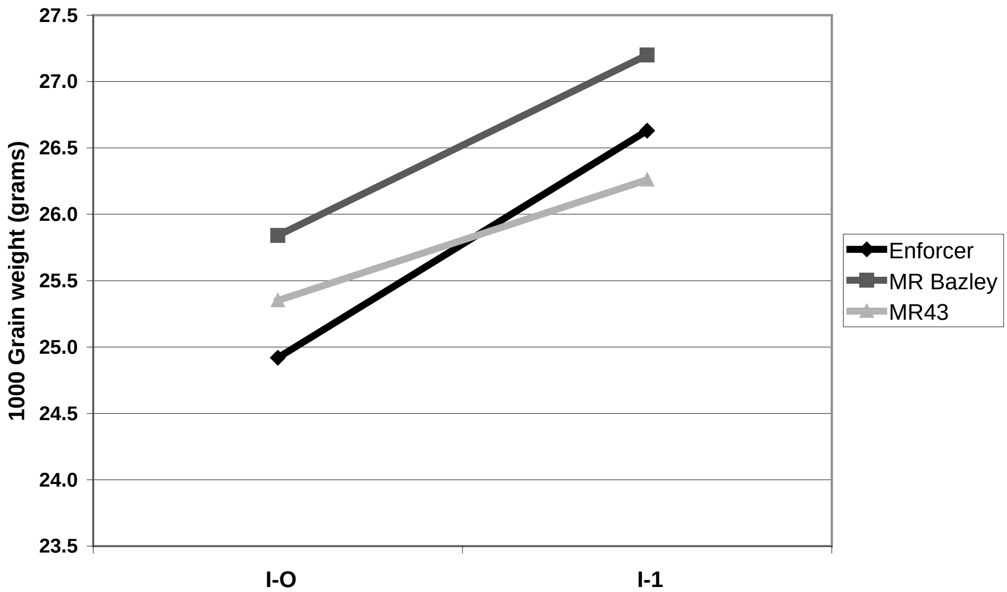


Figure 2. *Effect of irrigation on 1000 grain weight of hybrids.*

Varying plant population also had a significant impact on 1000 grain weight, as plant population increased, the 1000 grain weight decreased (Figure 3). Increasing plant population had the greatest impact on 1000 grain weight in Enforcer.

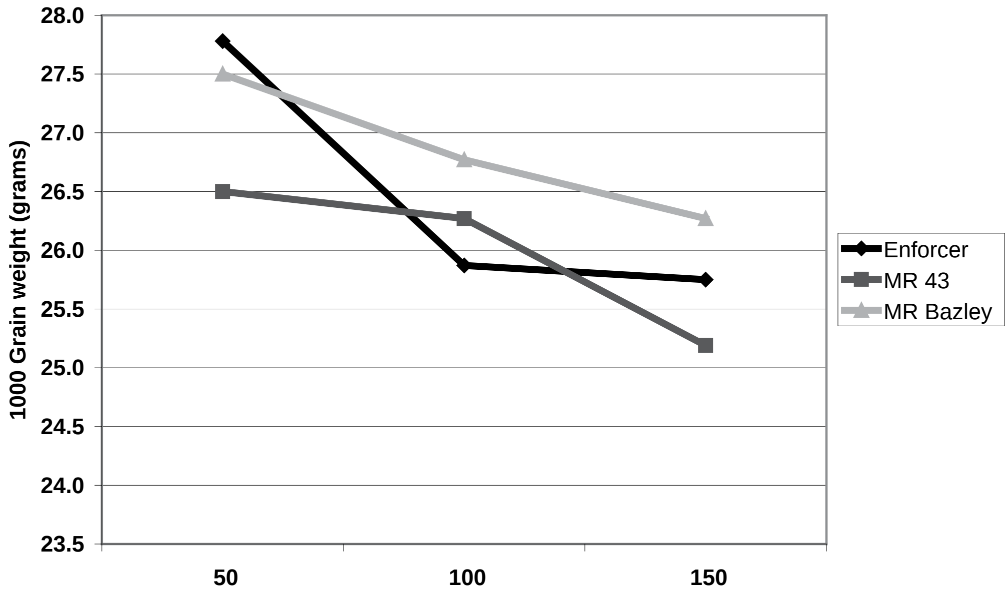


Figure 3. *Effect of varying plant population on 1000 grain weight across hybrids.*

Hectolitre weight

Hybrid was the only factor which had a significant impact on hectolitre weight. Enforcer had the highest hectolitre weight at 91.69 kg/hl, significantly higher than MR 43 and MR Bazley at 87.56 and 86.19 kg/hl, respectively. All of the hectolitre weights were very high (data not shown).

Summary

The use of one in-crop irrigation increased grain yields by 0.86 t/ha, reduced grain protein by 0.5% and increased 1000 grain weight.

Increasing plant populations from 50 to 100 or 150,000 plants/ha increased grain yields by 0.5 and 0.7 t/ha respectively. MR 43 and MR Bazley also showed increases in yield from increasing plant populations from 50 to 100,000 plants/ha, there was no significant difference between the 100 and 150,000 plants/ha treatments. Enforcer was less responsive to changes in plant population.

Varying nitrogen rate had very little impact on grain yield or quality at this site in this season. The primary impact was on increasing grain protein levels with each additional rate of nitrogen.

Individual hybrids showed varying reactions to altering the agronomic management practices. MR 43 and MR Bazley performed similarly under most treatments with Enforcer being lower yielding across all treatments.

Acknowledgements

Thanks to Peter Formann, Jim Perfrement, Sarah Kampe, Jan Hosking and Patrick Mortell for technical assistance. Thanks also to Scott Goodworth and Steve Jengos, Liverpool Plains Field Station, for site management.

Sunflower – impact of varying irrigation, nitrogen application rate and plant population on yield and oil content – Breeza 2012–13

Loretta Serafin, Guy McMullen, Nicole Carrigan and Peter Perfrement NSW DPI, Tamworth

Introduction

Sunflowers are a relatively small summer oilseed industry in the northern grains region which currently attracts very little research under either dryland or irrigated systems. This trial was targeted at continuing to build on previous research relating to the management of sunflower yield and oil content through manipulating plant populations, nitrogen application and water scheduling with irrigation. In this season, only one in crop irrigation was applied due to the high rainfall received at the critical growth stages of budding through to grain fill.

Key findings

Under high rainfall and water logging conditions there was no significant impact of additional irrigation water, varying nitrogen application rate or plant population on sunflower yield.

There was a significant impact of adding any nitrogen at sowing on the final oil contents. Oil contents declined with the addition of nitrogen under these conditions.

Varying irrigation and plant population did not impact on oil contents at this site under the seasonal conditions experienced in 2012–13.

Site details

2012–2013

Location:	**Liverpool Plains Field Station, Breeza**
Planter:	**Monosem double disc precision planter on a 90 cm row spacing.**
Sowing date:	**5th November, 2012**
Fertiliser:	**42 kg/ha Supreme Z**
Herbicides:	**17th December, 2012 – Verdict® applied at 150 mL/ha.**
Insecticides:	**4th January – Karate® applied by plane for Rutherglen Bug.**
Harvest date:	**22nd March, 2013**

In-crop rainfall (mm)

Nov 12	Dec 12	Jan 13	Feb 13	Mar 13	Apr 13	May 13	Total
12.5	27	138	127	76	5	17	402.5

Treatments

- **Two Irrigation treatments:**
  – I–0 = dryland
  – I–1 = 1 irrigation – applied 9th January, 2013
- Bare beds were left between irrigation treatments to minimise lateral movement of water. Additional buffers were also sown alongside the experimental beds to reduce any edge effects.
- **One Hybrid:** Ausigold 62
- **Three plant populations:** 30, 40 and 50,000 plants/ha
- **Four nitrogen rates:** 0, 50, 100 and 200 kg N/ha applied as Urea at sowing

Starting soil nutrition

Starting soil tests showed there was 114 kg N/ha to a depth of 120 cm. Hence there was sufficient nitrogen in the profile to produce around 2.6 t/ha prior to the application of any additional nitrogen.

Table 1. *Soil test results.*

Soil Depth (cm)	Total N (mg/kg)	Sulphur (mg/kg)	Organic Carbon %	pH Level ($CaCl_2$)	Phosphorus (Colwell) mg/kg	Phosphorus (BSES) mg/kg	Potassium (Colwell) mg/kg	Zinc (DTPA) mg/kg
0–10	15.3	4.7	0.86	7.9	31	463	469	2.84
10–30	28.08	6.2	0.65	7.9	20	466	310	1.10
30–60	23.73	5.3	0.54	8.0	13	–	222	–
60–90	35.1	10.0	0.50	8.1	21	–	270	–
90–120	11.79	16.7	0.38	8.3	25	–	270	–

Results

Plant Establishment

Plant establishment was above the targeted plant populations at this site but significant differences in the established populations were still achieved (Table 2).

Table 2. *Target versus established plant populations. Values followed by the same letter are not significantly different.*

Target Plant Population /ha)	Established Plant Population (/ha)
30,000	39,220 a
40,000	47,850 b
50,000	56,170 c
L.s.d (P=0.05)	3,720

Grain Yield

Overall yields were lower than desirable due to water logging during the critical grain fill stage of sunflower development. The site mean was 1.19 t/ha. Under these conditions there was no significant difference in grain yield regardless of treatment (irrigation, nitrogen application rate or plant population).

Oil Content

There was no significant impact of plant population or irrigation on oil content. The average site mean for oil content was 37.04%, which is below the 40% receival standard for sunflowers.

The application of nitrogen at sowing at all three rates (50, 100 and 200 kg N/ha) significantly reduced oil content by between 0.88 to 1.10% compared to applying no nitrogen (0 kg N/ha, Table 3). However, the difference between oil contents with the three nitrogen application rates were not significantly different (Table 3).

Table 3. *Impact of nitrogen application rate on oil content in sunflowers – Breeza 2012–13.*

Nitrogen Rate (kg/ha)	0	50	100	200
Oil content %	37.71 a	36.83 b	36.99 b	36.61 b
L.s.d (P=0.05)	0.53			

Summary

In this season, under high rainfall and water logged conditions during grain fill there was no significant impact of additional irrigation, varying nitrogen rate or plant population on the yield of sunflowers.

However there was a significant impact of nitrogen application on final oil contents. Oil contents declined with the application of any additional nitrogen (50, 100 or 200 kg N/ha) at sowing under these conditions. Considering there was sufficient starting soil nitrogen to have supplied a crop yield of around 2.6 t/ha it is not surprising that supplying additional nitrogen reduced oil contents when the sunflower crop only achieved a mean yield of 1.19 t/ha.

Varying irrigation and plant population did not impact on sunflower oil contents at this site under the seasonal conditions experienced in 2012–13.

These findings highlight the importance of testing nitrogen levels available in the soil profile prior to sowing to match inputs to a targeted yield potential for a sunflower crop.

Acknowledgements

Thanks to Ben Frazer, Peter Formann, Jim Perfrement, Sarah Kampe, Jan Hosking and Patrick Mortell (all NSW DPI, Tamworth) for technical assistance. Thanks also to Scott Goodworth and Steve Jengos, Liverpool Plains Field Station (NSW DPI) for site management. Thanks to Neil Weier and Nuseed for their generous supply of trial seed.

Response of 18 bread wheat and 6 durum varieties to three planting times at Breeza in 2013

Guy McMullen NSW DPI, Tamworth **Matthew Gardner** formerly NSW DPI, Tamworth

Key findings

In 2013 the optimum flowering window appeared to shift forward 10 days compared to the traditional flowering window between 20th of September to October 5th. This shift in date resulted in the better performance of shorter season varieties from earlier planting times.

Suntop⫫ and Sunguard⫫ behaved similar to EGA_Gregory⫫ in terms of maturity, while Suntop⫫ had comparable yields across all planting times.

LongReach Dart⫫ provides a quick option that is faster than anything else on the market from a main season planting time. Despite reduced time to anthesis, LongReach Dart⫫ does not reach physical maturity any quicker than LongReach Spitfire⫫, which suggests that it has a longer grain filling period.

Late season rainfall meant that longer season varieties were able to gain a yield advantage over quick maturing varieties from a late planting time.

Introduction

The autumn break in NSW occurs anywhere between March and June, with the reliability of the break being more inconsistent in northern NSW compared to the south. There are an increasingly large number of wheat and durum varieties available to growers across a wider range of maturities which provides the opportunity to sow crops from late March until late June and still have the crop flowering when the risks of frost and heat stress are acceptable. Optimum flowering windows for cereal crops need to balance the risk of avoiding excessive frost losses (>10%) and limiting exposure to heat stress later in the season. Flowering time in plants is controlled by accumulated thermal time, vernalisation, photoperiod and earliness *per se*. In spite of years of research the genetic control of maturity is still not completely understood.

Varieties differ in their ability to achieve yield from different sowing times. A replicated trial was conducted at Breeza on the Liverpool Plains region of northern NSW in 2013 to determine the yield and quality of a range of wheat and durum varieties across three different sowing times. In addition, phenology information was collected throughout the season to aid sowing time recommendations.

Site details

Liverpool Plains Field Station (Breeza)

Previous Crop:	**Sorghum**
Starting N:	**102 kg N/ha (0–120 cm)**
Applied N:	**220 kg N/ha (as Urea at sowing)**
Starter fertiliser:	**70 kg/ha Starter Z applied at sowing**

Treatments

There were 18 bread wheat and 6 durum varieties with varying maturities and agronomic characteristics included in the trial. This included both commercially available lines and advanced breeder lines. These varieties were sown on three separate occasions 8th May, 6th June and the 9th July 2013 in a randomised block design with three replicates.

Results

As has been clearly demonstrated in previous years there was also a general relationship between flowering date and grain yield in 2013 (Figure 1). There was a greater degree of variability in the earliest sowing time due to the influence of frost on quicker lines especially Jandaroi⫫ durum. LongReach Dart⫫ was the quickest to flowering at each of the sowing dates while EGA_Eaglehawk⫫ was the longest. LongReach Lancer⫫ is a newly released line which appears to have slightly longer maturity than EGA_Gregory⫫ (Table 1). In this trial Suntop⫫ was six days quicker to flower than EGA_Gregory⫫ on the first sowing time but this difference declined with the last two sowing dates.

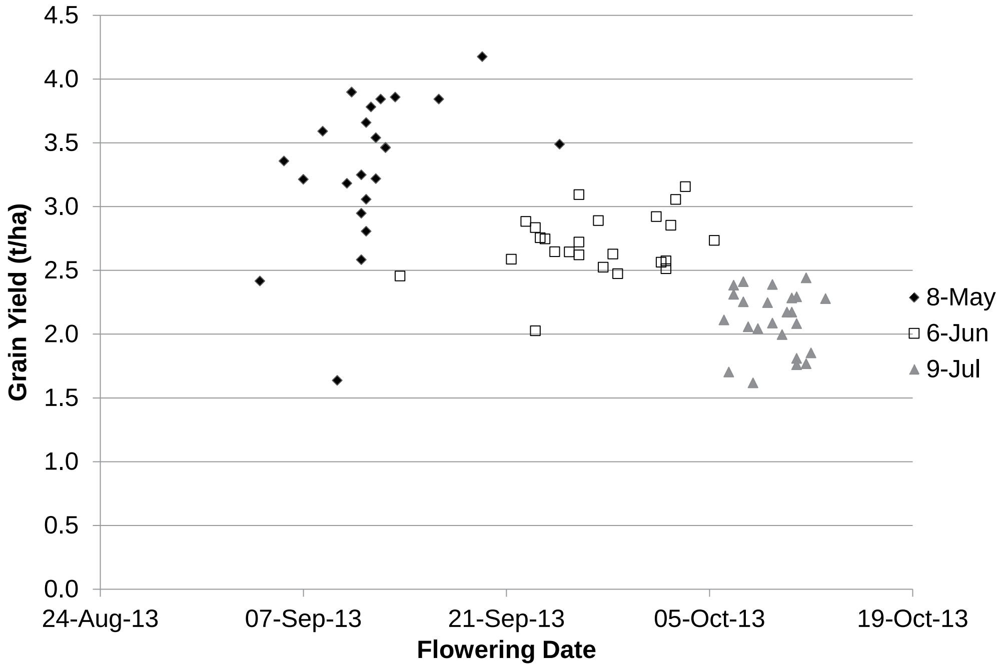


Figure 1. *Relationship between grain yield and flowering date for three sowing dates at Breeza in 2013*

Yields in 2013 were significantly lower than 2012 reflecting the reduced starting soil water and the very low in-crop rainfall that was received. There was a significant decline in grain yield for each delay in planting time for most varieties in 2013 (Table 1). There were several frost events in 2013 and results from this experiment suggest that Jandaroi⟑ durum and LongReach Dart⟑ suffered frost losses at the earliest sowing date. Commercial varieties that performed best on the earliest sowing time included LongReach Lancer⟑, Suntop⟑ and EGA_Gregory⟑. Of the durums Caparoi⟑ had the highest yield with the first sowing time. At the second sowing time LongReach Lancer⟑ and Suntop⟑ performed well again while the best durum was Jandaroi⟑ which also performed well on the last sowing date. A very surprising result was the low relative yield of LongReach Dart⟑ across all sowing times. It would have been expected that this very quick maturing line would have performed better at the later sowing times. Three experimental lines performed well at the later sowing times including one durum line.

Table 1. *Grain yield, yield rank and days to anthesis for 20 wheat varieties at 3 sowing times at Breeza in 2013.*

		Grain Yield (t/ha)			Days to Flowering		
		8-May	6-Jun	9-Jul	8-May	6-Jun	9-Jul
Bread wheats	LongReach Crusader$^{(b)}$	3.18	2.84	2.31	125	109	90
	EGA_Bounty$^{(b)}$	3.46	2.92	2.29	128	117	94
	EGA_Eaglehawk$^{(b)}$	3.49	2.73	2.28	140	121	96
	EGA_Gregory$^{(b)}$	3.84	2.51	1.77	131	118	95
	Elmore_CL$^{(b)}$	3.78	2.64	1.81	127	111	94
	Impala$^{(b)}$	3.59	2.59	2.09	123	107	92
	Livingston$^{(b)}$	3.36	2.75	2.04	121	110	91
	LongReach Dart$^{(b)}$	2.42	2.46	1.70	119	100	89
	LongReach Lancer$^{(b)}$	4.18	3.06	2.28	134	119	94
	LPB08-0079	3.86	2.85	2.17	128	118	94
	QT14381	3.84	3.16	2.44	127	119	95
	LongReach Spitfire$^{(b)}$	3.21	2.03	1.62	122	109	91
	Sun663A	3.46	2.47	2.39	128	115	92
	Sunguard$^{(b)}$	2.95	2.72	2.08	126	112	94
	Suntop$^{(b)}$	3.90	3.09	2.17	125	112	93
	Sunvale	3.90	2.57	1.85	125	118	95
	Sunvex$^{(b)}$	3.22	2.56	1.76	127	118	94
	Sunzell$^{(b)}$	2.81	2.63	2.00	126	114	93
Durums	Caparoi$^{(b)}$	3.54	2.62	2.25	127	112	92
	Jandaroi$^{(b)}$	1.64	2.76	2.38	124	109	90
	TD201046	2.58	2.88	2.41	126	108	90
	TD290491	3.06	2.52	2.06	126	114	91
	TD290564	3.25	2.89	2.11	126	113	89
	UAD0951096	3.66	2.65	2.25	126	110	90

5% LSD within TOS = 0.51 t/ha, 5% LSD between TOS = 0.56 t/ha.

When comparing the performance of a long season (EGA_Eaglehawk$^{(b)}$), a main season (EGA_Gregory$^{(b)}$) and a short season (LongReach Dart$^{(b)}$) variety, the longer season variety had the better yields from an early season planting (Figure 2a). However, for the late plant EGA_Gregory$^{(b)}$ and EGA_Eaglehawk$^{(b)}$ had similar yields to LongReach Dart$^{(b)}$ as was seen in 2012 in a similar trial at Tamworth. LongReach Dart$^{(b)}$ had very low yield at the first sowing date suggesting some frost damage but the yield differences were not significant at the second sowing date for any of these varieties. Differences in the flowering dates in 2013 between EGA_Eaglehawk$^{(b)}$ and LongReach Dart$^{(b)}$ (Figure 2b) were much smaller than was observed at the Tamworth trial in 2012. This highlights the highly seasonal dependant nature of crop development which needs to be considered.

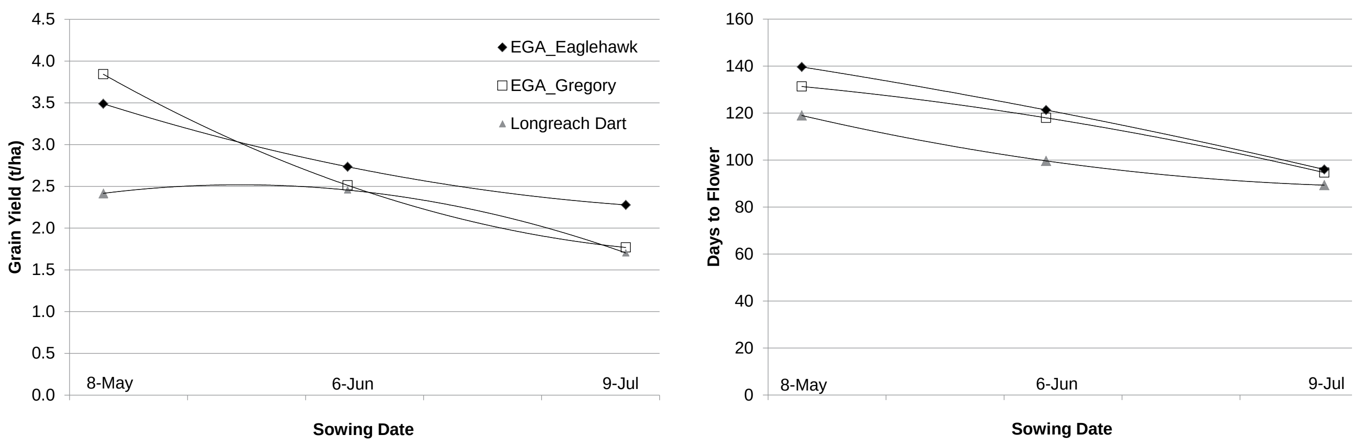


Figure 2. *Grain yield (a) and days from sowing to flowering (b) at 3 sowings dates for EGA_Eaglehawk$^{(b)}$, EGA_Gregory$^{(b)}$ and LongReach Dart$^{(b)}$ at Breeza in 2013.*

Summary

Sowing time trials allow new varieties entering the market to be compared for their maturity and performance against existing variety benchmarks. Over time they also provide greater confidence across seasons in varietal performance and flowering behaviour.

LongReach Lancer$^{\phi}$ appears to provides another early and main season sowing option for growers with low lodging risk. Suntop$^{\phi}$ continues to perform very well for yield across the region as does EGA_Gregory$^{\phi}$. Caparoi$^{\phi}$ durum remains the highest yielding durum for earlier sowing windows while Jandaroi$^{\phi}$ has performed best at the later times with outstanding grain quality. There also appears to be a number of promising experimental lines emerging in both bread and durum wheats. LongReach Dart$^{\phi}$ performed poorly in this experiment in 2013 but has shown better yields in NVT trials and other agronomy experiments.

Targeting early sowing windows with the correct variety gave the greatest grain yields, with a yield penalty incurred for every delay in sowing. Ranking of varieties changes across sowing times and variety choice needs to be considered in each sowing window. Jandaroi$^{\phi}$ provided a very strong example of sowing the wrong variety early and the risk of frost losses that eventuated. Sowing Caparoi$^{\phi}$ in the early window resulted in a 2 t/ha yield advantage over Jandaroi$^{\phi}$ at this site in 2013.

Sowing decisions, both timing and variety, should be driven by risk management. Whenever considering varieties growers and advisors need to consider a wide range of data including long term NVT trial analysis, target markets, disease resistance and tolerance when deciding what variety to sow when and in which paddock.

Acknowledgements

This trial was run under the Variety Specific Agronomy Package Project (DAN00169), which is jointly funded by NSW DPI and GRDC. Technical assistance provided by Rod Bambach, Jan Hosking, Patrick Mortell, Stephen Morphett, Jim Perfrement and Peter Formann are also gratefully acknowledged.

Impact of cereal varieties on the build-up of *Pratylenchus thornei* with varying starting populations: 2012

Steven Simpfendorfer NSW DPI, Tamworth

Key findings

Cereal variety choice can have a large impact on the build-up of *Pt* populations within paddocks.

Even with different starting populations there was a 7 to 7.5 fold difference between the lowest and highest *Pt* population developed by individual varieties at each site.

Some varieties appear to perform differently to their published resistance ratings under field conditions.

Field based evaluations need to be given greater consideration in resistance ratings.

Introduction

NSW DPI conducted a series of 13 pathology trials across central and northern NSW in 2012 on the fungicide management of stripe rust. Each site was cored at sowing to determine background levels of soil-borne pathogens using the DNA based test PreDicta B. The sites varied in their levels of the root lesion nematode (RLN) *Pratylenchus thornei* (*Pt*). Previous survey work conducted by NSW DPI has established that *Pt* is widespread across the region.

Varieties differ in their tolerance (yield in presence of *Pt*) and resistance (build-up of *Pt* populations in the soil) to this nematode. Varieties with lower resistance ratings (e.g. VS, very susceptible) should build-up higher *Pt* populations within their root systems over a season than varieties with higher resistance ratings (e.g. MR, moderately resistant). The populations built-up within the root systems of a variety remain within the soil to affect subsequent crops within the rotation. Higher *Pt* populations within the soil increase the risk of yield loss in following intolerant crops or wheat varieties. However, if *Pt* build-up to high enough levels then significant yield loss can even occur in moderately tolerant cereal varieties. It is therefore desirable that wheat varieties with higher levels of resistance to *Pt* are grown in the northern region to minimise the build-up of this damaging nematode. Although *Pt* resistance ratings are published for wheat varieties (see state department sowing guides) there is limited information available to illustrate what these ratings actual relate to in the build-up of *Pt* populations within grower paddocks.

The opportunity was therefore taken to re-core plots of 11 cereal varieties not treated with fungicide after harvest at three sites with varying background populations of *Pt* to examine their relative resistance under field conditions.

Details 2012

- Three field sites – starting levels were established at Coolah (2.0 *Pt*/g), North Star (3.7 *Pt*/g) and Bullarah (18.6 *Pt*/g) with varying background starting levels of *Pt* based on 30 cores (0–30 cm) bulked from across the site targeting previous cereal crop rows (May 2012).
- Ten bread wheat and one durum variety with a range of current resistance ratings to *Pt* (Table 1) grown in replicated plots at each site (3 reps Bullarah; 4 reps North Star and Coolah).
- Untreated plots of each variety re-cored (10 cores/plot at 0–30 cm on previous crop row) after harvest (March 2013).
- *Pt* populations determined in all soil samples based on PreDicta B, a DNA based test provided by the South Australian Research and Development Institute (SARDI).
- Natural log of all *Pt* data used in analysis and back-transformed values presented in graphs.

Results

North Star

- *Pt* populations remaining after the 11 cereal varieties ranged from 0.7 *Pt*/g (Suntop⟠) up to 4.9 *Pt*/g soil (Ellison⟠; Figure 1). This represents a 7 fold difference in *Pt* populations remaining after the different varieties.

- The starting *Pt* population, based on a single composite sample across the site, was 3.7 *Pt*/g soil. Only LRPB Crusader⁽ᵈ⁾ and Ellison⁽ᵈ⁾ increased *Pt* populations above this level while the remaining varieties appear to have maintained or reduced numbers.
- Populations between 2–15 *Pt*/g soil represent a medium risk of damage where 10–60% yield loss could be expected if an intolerant variety was sown as the next crop. All varieties to the right of Baxter⁽ᵈ⁾ left behind medium populations of *Pt* (Figure 1).
- *Pt* populations after each variety were roughly in line with published resistance ratings with the obvious exception of LRPB Spitfire⁽ᵈ⁾ which left one of the lowest populations but is rated very susceptible (VS). Ellison⁽ᵈ⁾ and Ventura⁽ᵈ⁾ also built-up higher *Pt* populations than their current resistance ratings would indicate.

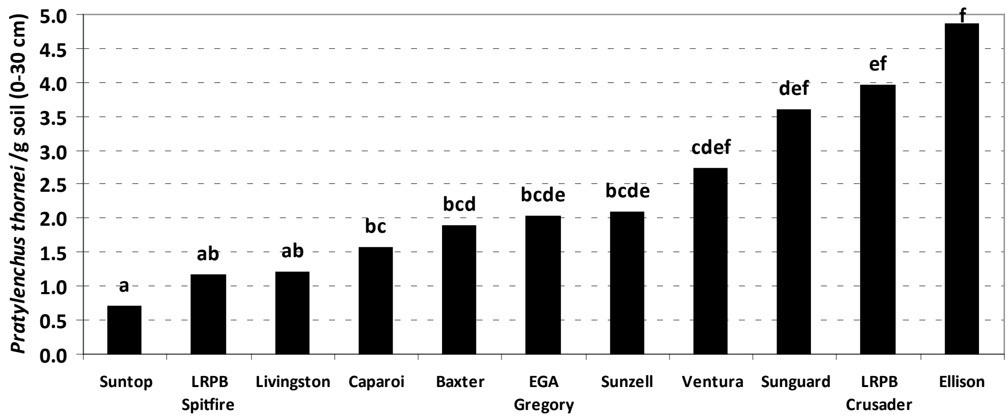


Figure 1. *Post harvest Pt soil populations (0–30 cm) after 11 cereal varieties grown in 2012 – North Star Bars with the same letter not significantly different at 95% confidence level.*

Coolah

- *Pt* populations remaining after the 11 cereal varieties ranged from 2.9 *Pt*/g (Caparoi⁽ᵈ⁾) up to 20.9 *Pt*/g soil (LRPB Crusader⁽ᵈ⁾; Figure 2). This represents around a 7 fold difference in *Pt* populations left behind by the different varieties.
- The starting *Pt* population, based on a single composite sample across the site, was 2.0 *Pt*/g soil. All varieties increased *Pt* populations above this level with a replication factor (initial/final *Pt* population) of between 1.5 (Caparoi⁽ᵈ⁾) up to 10.5 (LRPB Crusader⁽ᵈ⁾).
- Populations between 2 – 15 *Pt*/g soil represent a medium risk of damage where 10–60% yield loss could be expected if an intolerant variety was sown as the next crop. All varieties left behind medium populations of *Pt* with the exception of LRPB Crusader⁽ᵈ⁾ which built-up a high risk level where 40–80% yield loss could be expected if an intolerant variety was sown as the next crop (Figure 2).
- *Pt* populations after many varieties varied from what was expected based on their current resistance ratings. LRPB Spitfire⁽ᵈ⁾ and Sunguard⁽ᵈ⁾ left much lower *Pt* populations than expected with their current very susceptible (VS) rating. Baxter⁽ᵈ⁾ and Caparoi⁽ᵈ⁾ were a bit better performing than their current ratings while Ventura⁽ᵈ⁾ was poorer than its current rating leaving higher *Pt* populations than the two other MS rated varieties in the trial (Caparoi⁽ᵈ⁾ and Suntop⁽ᵈ⁾).

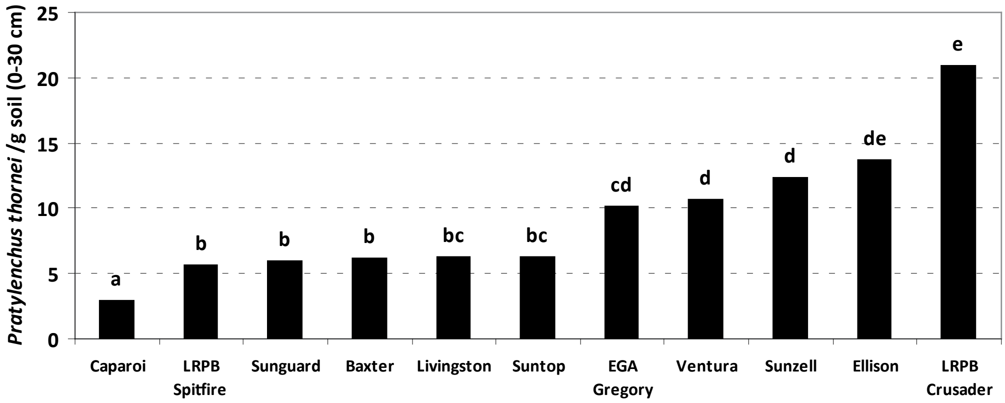


Figure 2. *Post harvest Pt soil populations (0–30 cm) after 11 cereal varieties grown in 2012 – Coolah*
Bars with the same letter not significantly different at 95% confidence level

Bullarah

- *Pt* populations remaining after the 11 cereal varieties ranged from 14.4 *Pt*/g (Caparoi$^{(\phi)}$) up to 107.3 *Pt*/g soil (Ellison$^{(\phi)}$; Figure 3). This represents around a 7.5 fold difference in *Pt* populations left behind by the different varieties.
- The starting *Pt* population, based on a single composite sample across the site, was high at 18.6 *Pt*/g soil. Caparoi$^{(\phi)}$ and Suntop$^{(\phi)}$ were the only varieties that did not increase *Pt* populations above this level having maintained or very slightly reduced the population. At this high starting *Pt* level the varieties had a replication factor (initial/final *Pt* population) of between 0.8 (Caparoi$^{(\phi)}$) up to 5.8 (Ellison$^{(\phi)}$).
- Populations between 2 – 15 *Pt*/g soil represent a medium risk of damage where 10–60% yield loss could be expected if an intolerant variety was sown as the next crop while populations >15 *Pt*/g represent a high risk where 40–80% yield loss is possible in intolerant varieties. All varieties, except Caparoi$^{(\phi)}$ which was just below, developed a high risk *Pt* population for the following crop (Figure 3). Some of these levels were so high that yield loss up to 30% in moderately tolerant varieties is likely.
- *Pt* populations after many varieties differed from what was expected based on their current resistance ratings. LRPB Spitfire left much lower *Pt* populations than expected with its current very susceptible (VS) rating. Baxter$^{(\phi)}$ and Caparoi$^{(\phi)}$ were a bit better performing than their current ratings while Ventura$^{(\phi)}$ was poorer than its current rating leaving higher *Pt* populations than the two other MS rated varieties in the trial (Caparoi$^{(\phi)}$ and Suntop$^{(\phi)}$).

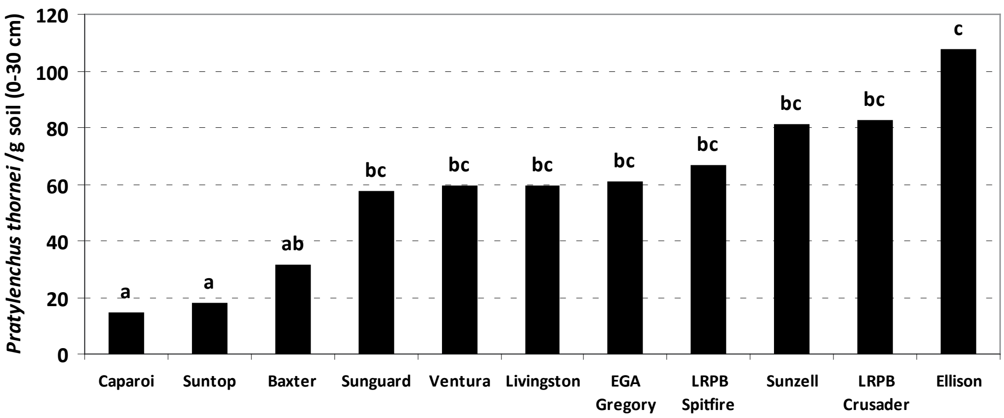


Figure 3. *Post harvest Pt soil populations (0–30 cm) after 11 cereal varieties grown in 2012 – Bullarah*
Bars with the same letter not significantly different at 95% confidence level

Comparing across sites

The *Pt* populations that developed with each variety in these field situations can be expressed relative to a check variety such as EGA_Gregory$^{(\phi)}$ (Table 1). There was considerable variation in populations relative to EGA_Gregory(b) across the sites and three sites in one year ***is not*** sufficient to draw robust conclusions. However, field evaluation at three sites in 2012 indicates that some of these varieties appear to perform a bit differently under field conditions.

Table 1. *Ten bread wheat and one durum variety evaluated across sites (ranked worse to best under current ratings), Pt populations relative to EGA_Gregory(b) at three sites and mean across sites, current resistance ratings (based on 2013 Qld and NSW variety guides) and reaction based on field sites in 2012*

Variety	*Pt* population % EGA_Gregory(b)				*Pt* resistance rating	
	North Star	Coolah	Bullarah	Mean	Current	Sites 2012
LRPB Spitfire(b)	58	56	110	74	VS	MS
Sunguard(b)	180	59	95	111	VS	MS
LRPB Crusader(b)	198	207	136	180	S–VS	VS
Baxter(b)	94	61	52	69	S	MS
Ellison(b)	243	135	177	185	S	VS
EGA_Gregory(b)	100	100	100	100	MS–S	MS–S
Sunzell(b)	104	123	134	120	MS–S	S
Caparoi(b)	78	29	24	44	MS	MR
Suntop(b)	35	62	29	42	MS	MR
Ventura(b)	137	105	98	114	MS	MS–S
Livingston(b)	60	62	98	73	MR–MS	MS

Conclusions

Cereal variety choice can have a large impact on the build-up of *Pt* populations within paddocks. Interestingly, across the three field sites in 2012, which ranged in starting *Pt* populations from 2.0 *Pt*/g soil up to 18.6 *Pt*/g soil, there was a consistent 7–7.5 fold difference in populations between the highest and lowest variety at each site.

Resistance ratings are currently based primarily on relative replication rates (initial population/final population) in pot experiments conducted under glasshouse conditions.

If it is accepted that EGA_Gregory(b) is rated MS–S to *Pt* then based on this field testing LRPB Spitfire(b) is performing considerably better than its current VS rating. LRPB Spitfire(b) populations ranged from 56 to 110% of EGA_Gregory(b) across the three sites and were significantly lower than Ellison(b) (S) and LRPB Crusader(b) (S–VS) at both North Star and Coolah. The different performance of LRPB Spitfire(b) at Bullarah indicates that this variety may behave differently at higher *Pt* starting populations.

We ***are not*** proposing that current resistance ratings should be changed on the basis of findings from these three field sites. Rather, some varieties clearly appear to perform differently to their published resistance ratings under field conditions and hence field based evaluations need to be given greater consideration in determining resistance ratings. Ratings should be based on multiple (a lot more than three) field trials over a number of seasons and starting *Pt* populations to fully understand the variability in responses. This will ensure that ratings accurately reflect populations which growers can expect to develop with different crop and variety choices in their paddocks.

Acknowledgments

This project was co-funded by NSW DPI and GRDC under the northern integrated disease management project (DAN00143). Assistance provided by Robyn Shapland, Jayne Jenkins, Greg Brooke and Rod Bambach (NSW DPI) in coring plots is greatly appreciated. Soil samples were assessed for RLN populations using PreDicta B analysis by Dr Alan McKay and his team at SARDI in Adelaide. Thanks to Richard Daniel (NGA) for comments and edits on paper.

Pre-sow assessment of crown rot risk in the northern region

Steven Simpfendorfer NSW DPI, Tamworth **Alan McKay** SARDI, Adelaide

Key findings

PreDicta B is a good technique for identifying the level of risk for crown rot (and other soil-borne pathogens) prior to sowing within paddocks. However, this requires a dedicated sampling strategy and IS NOT a simple add on to a soil nutrition test.

Soil cores should be targeted at the previous winter cereal row if evident and DO NOT remove any stubble fragments.

Short pieces of stubble (up to 15) from previous winter cereal crops and/or grass weed residues can be added to the soil sample to enhance detection of the *Fusarium* spp. that cause crown rot.

If you are not willing to follow the recommended PreDicta B sampling strategies then DO NOT assess disease risk levels prior to sowing.

Introduction

PreDicta B is a DNA based soil test which detects levels of a range of cereal pathogens that is commercially available to growers and advisors through the South Australian Research and Development Institute (SARDI). The main pathogens of interest in the northern grains region detected by PreDicta B are *Fusarium* spp. (crown rot), *Bipolaris sorokiniana* (common root rot), *Pythium* (damping off) and both *Pratylenchus thornei* and *P. neglectus* (root lesion nematodes, RLN's). Over recent years PreDicta B has been shown to be a reliable method for assessing RLN populations but is perceived by industry to be less reliable in assessing levels of crown rot risk in the northern region. This is potentially due to the crown rot fungus being stubble-borne while PreDicta B is a soil based test. Consequently, there may be sampling issues which need to be resolved to improve the reliability of detecting crown rot inoculum levels prior to sowing.

The following paper reports on collaborative research conducted by NSW DPI and SARDI across central/northern NSW from 2010–2013 to determine the accuracy of PreDicta B in predicting the risk of crown rot infection prior to sowing and progress in improving the reliability of this technique within the region.

Survey 2010–2012

NSW DPI conducted a winter cereal pathogen survey of 248 paddocks annually across 12 agronomy districts in central and northern NSW from 2010–2012. A one hectare area was established in each focus paddock and 20 small cores were collected in a grid across the trial area targeting the previous winter cereal crop rows to a depth of 0–30 cm prior to sowing in each year. The soil samples were sent to SARDI for PreDicta B analysis. Winter cereal stubble if evident was collected from each focus paddock when taking soil samples then trimmed, surface sterilised and plated on laboratory media for the recovery of *Fusarium* spp. Fifty crowns, collected from different plants, were plated from each paddock to provide an incidence of crown rot (*Fusarium*) infection. Over the three survey years this allowed 307 comparisons of *Fusarium* DNA levels assessed at sowing using PreDicta B with the actual incidence of infection that developed by harvest as determined from laboratory plating (Table 1).

Table 1. *Relationship between levels of Fusarium detected using PreDicta B at sowing and incidence of crown rot infection based on laboratory plating after harvest from 307 paddocks (2010–2012)*

PreDicta B		Plating			
		25%> High	11–24% Medium	3–10% Low	0–2% Nil
>2.0	High	28	8	8	1
1.4–2.0	Medium	17	13	6	1
0.6–1.4	Low	12	15	9	10
<0.6	BDL	30	27	65	57

BDL = Below detectable limit.

PreDicta B risk categories have been established for crown rot based on log DNA levels at sowing (Table 1). Similarly, previous NSW DPI research has established an infection scale, using a low (3–10%), medium (11–24%) and high (>25%) level of crown rot infection based on laboratory plating (Table 1).

In 107 paddocks (35%) PreDicta B at sowing predicted the exact level of infection that developed in the crop when measured after harvest (darker grey shading Table 1). For example, soil DNA levels indicated a high risk of crown rot development in 28 paddocks and over 25% of plants were infected with *Fusarium* at harvest in these paddocks.

However, these categories are fairly narrow. The predicted risk of crown rot development at sowing using PreDicta B was within one category of the actual level of infection measured after harvest in 121 paddocks (39%, light grey shading). For example, soil DNA levels indicated a medium risk of crown rot development in 17 paddocks (i.e. should have been between 11–24% infection by plating) but greater than 25% infection actually occurred making this a high level of crown rot infection. In many of these situations the actual levels of infection that developed were only just outside the predicted levels at sowing. Hence, taking this approach PreDicta B correctly predicted the risk of crown rot development at sowing within one category of what developed in 74% (228) of the paddocks over the three years.

In 10 paddocks (3%) PreDicta B overestimated the risk of infection compared to that which actually developed. For example, soil DNA levels indicated a high risk of crown rot development in 8 paddocks but only low levels of infection (3–10%) were measured at harvest. This could potentially relate to inter-row sowing of the wheat crop between the previous cereal stubble rows which has been shown in previous research to significantly reduce the incidence of crown rot infection.

The bigger concern was that in 69 paddocks (22%) PreDicta B underestimated the risk of crown rot compared to the levels which actually developed. For example, soil DNA levels indicated crown rot levels were below the detection limit (BDL) in 30 paddocks but greater than 25% of plants were infected with *Fusarium* at harvest. This is considered a 'failure to warn' with the question being **why?**

Detection issue?

A potential cause of the failure to warn in 22% of paddocks could be the inability of the current PreDicta B tests to actually detect the species of *Fusarium* causing crown rot across the region. Currently there are three separate tests within PreDicta B that detect common species causing crown rot across Australia. There are two tests which detect variations in *F. pseudograminearum* (*Fp*) populations and a third test which detects both *F. culmorum* (*Fc*) and *F. graminearum* (*Fg*) but cannot differentiate between these two species.

A total of 180 *Fusarium* isolates (1 or 2 isolates per paddock) were collected from crown rot infected winter cereal crops throughout central and northern NSW in late 2012 and early 2013. The isolates were sent to SARDI who extracted DNA and tested them against the three current PreDicta B *Fusarium* tests. The DNA was also sent to CSIRO laboratories in Canberra where each isolate was sequenced to confirm the species identification. A total of 84.5% of the isolates were identified by PreDicta B to be *Fp* which were all confirmed by sequencing to also be *Fp*. That is, there were no variants of *Fp* identified by sequencing which are not being detected by the current PreDicta B tests. A further 9.5% of isolates were identified by PreDicta B to be *Fc* or *Fg*. Sequencing determined that these isolates actually consisted of 5.6% *Fc* and 3.9% *Fg*. However, there were no variants of *Fc* or *Fg* which were not detected by the current PreDicta B test, it simply cannot differentiate between these two species. The remaining 6.0% of isolates were identified by sequencing to be a *Fusarium* sp. chlamydosporum complex which is not detected in the current PreDicta B tests. Further work is required to confirm the distribution and importance of these isolates and incorporate their detection into the PreDicta B tests if warranted.

Sampling issues?

Fifty crowns and 50 first above ground nodes were cut from primary tillers and plated separately from stubble collected out of each paddock. This allowed the relative survival of *Fusarium* below ground (crowns) and above ground (1st nodes) to be determined at each site. In 5–10% of paddocks where PreDicta B underestimated the crown rot risk there was much lower survival of *Fusarium* in the crown tissue relative to the 1st node. For example at site WE9A in the Wellington district in 2011 there was 8% *Fusarium* recovery from the crowns but 54% from the 1st node above ground.

PreDicta B is a soil based test so with the collection of cores targeted at the previous winter cereal rows it can provide a good measure of *Fusarium* levels in the crowns below ground but is restricted in its ability to detect levels in above ground stubble. This could potentially be an issue with sampling especially following wet summers which would reduce survival in the crowns relative to above ground residues.

In the remaining 5–10% of sites where PreDicta B underestimated the crown rot risk more traditional plating of winter cereal stubble from the site would also have failed to warn of the risk as generally there was no stubble evident to plate. This may be related to hosting of *Fusarium* inoculum on grass weeds that were not adequately sampled or cultivation/harrowing/mulching of the paddock after collecting soil cores which more evenly distributed inoculum across the paddock and into the main infection zones for the crown rot fungus. The impact of these practices on distributing crown rot inoculum requires further research.

Can we improve PreDicta B assessment of crown rot risk?

One of the big advantages of PreDicta B is its ability to assess the relative risk of a range of soil-borne cereal pathogens within the one sample. In the northern region PreDicta B has been primarily used to assess RLN populations. Consequently, a composite sample taken from the top 30 cm of soil has usually been used in the northern region based on this being the recommended sampling depth with traditional manual nematode counts within the region. In other regions a shallower sampling depth (0–10 cm or 0–15 cm) is recommended with PreDicta B. In 2013 we aimed to determine if this deeper sampling depth in the northern region, to account for RLN populations deeper in the soil profile, is potentially compromising the accuracy of PreDicta B in measuring levels of other soil-borne pathogens including *Fusarium*.

In 2013 each of the six ranges in 11 NSW DPI pathology trials, 11 cereal NVT sites and 2 grain and graze trial sites were cored using PreDicta B. A separate 0–15 cm (40 cores) and 0–30 cm (20 cores) bulked soil sample was collected from each range at each of the 24 field sites spread from central NSW into southern Qld. All cores were targeted at the previous winter cereal rows if evident. Previous winter cereal crop stubble was also collected across each separate range at coring if present and used to spike set soil samples. Twenty-five lowest nodes (1 cm segments around node) were cut from the corresponding stubble sample and added to half of samples collected at each depth. All samples were then sent to SARDI for PreDicta B analysis. After harvest stubble will be pulled from three check wheat varieties at each site and these plots will be re-cored for RLN numbers using PreDicta B. This information will be used to validate and calibrate if required the sampling strategy and resulting risk categories across the northern region. Unfortunately this information is not currently available and will also need to be repeated over a few seasons to fully refine risk categories and sampling strategies.

What have we found so far?

Pratylenchus thornei (*Pt*) populations did vary with sampling depth across the 24 sites (Figure 1a). Points above the 1:1 diagonal line indicate higher *Pt* populations in the 0–30 cm sampling than in the 0–15 cm sampling. Conversely, points below the diagonal line represent sites with higher *Pt* populations in the 0–15 cm than in the 0–30 cm sampling. Interestingly, there were five sites above the line and four sites below the line which varied from the 1:1 line by 0.3 *Pt*/g or greater. However, this relatively minor variation in *Pt* numbers with sampling depth only resulted in a slight shift in risk category at one site. At the Coolah NVT site the 0–30 cm samples indicated a low risk of *Pt* with 1.8 *Pt*/g soil but the 0–15 cm sampling averaged 2.1 *Pt*/g soil which just pushed the site into a medium risk category (2.1 to 15.0 *Pt*/g soil). Even though the Bullarah NVT site averaged 1.3 *Pt*/g soil in the 0–15 cm sampling and only 0.2 *Pt*/g soil in the 0–30 cm sampling, both depths would still have resulted in this site being classified in the low risk category (0.1 to 2.0 *Pt*/g soil).

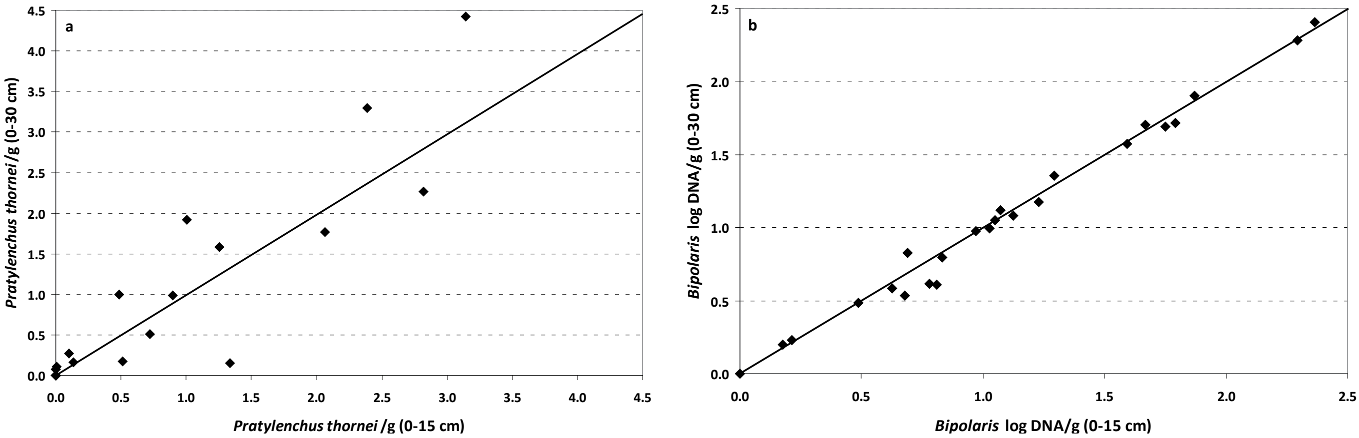


Figure 1. *Populations of Pratylenchus thornei (a) and Bipolaris sorokiniana (b) detected using PreDicta B at 24 sites in 2013 at two samplings depths (0–15 cm vs 0–30 cm). Diagonal lines represent a 1:1 relationship.*

Bipolaris levels are expressed on a log scale which flattens out variation in numbers with sampling depth (Figure 1b). However, levels do not appear to vary greatly between a 0–15 cm versus a 0–30 cm sampling depth. Generally there were more sites with higher levels in the 0–15 cm compared to the 0–30 cm indicating that *Bipolaris* is more concentrated in the surface which is being diluted with a deeper sampling.

Similarly, *Fusarium* DNA is expressed on a log scale. There was only one site (Bullarah NVT) where a higher level in the 0–30 cm sample would have classified the crown rot risk as medium while the 0-15 cm sampling indicated a low risk (Figure 2). However, there were four sites (Tulloona, Gilgandra, Westmar and Narrabri) where greater values in the 0–15 cm samples indicate a higher crown rot risk level than in the 0–30 cm samples. As with *Bipolaris*, this indicates that *Fusarium* is more concentrated in the surface which is being diluted with a deeper 0–30 cm sampling depth.

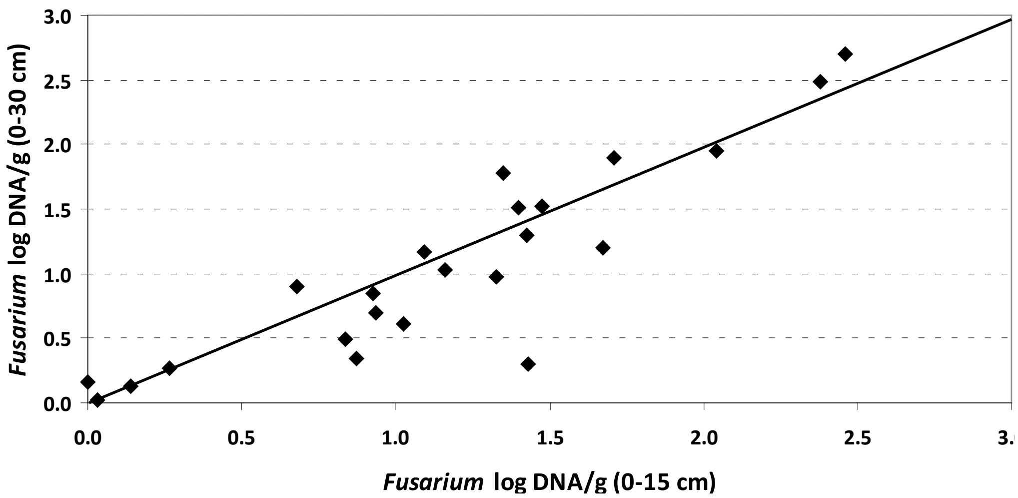


Figure 2. *Populations of Fusarium detected using PreDicta B at 24 sites in 2013 at two samplings depths (0–15 cm vs 0–30 cm). Samples spiked with stubble fragments excluded from comparison.*

Addition of stubble to soil samples

Previous cereal stubble was only present at 7 of the 24 sites in 2013 to allow addition of stubble fragments to soil samples. Bithramere was the only site where the addition of stubble did not increase the predicted crown rot risk level. Even though the log *Fusarium* DNA/g increased from 2.5 to 4.3 with the addition of stubble, both values represented a high risk of crown rot development at the Bithramere site in 2013. The addition of stubble at the remaining six sites increased the crown rot risk level from low to high at two sites (Coonamble and Westmar), low to medium at two sites (Gilgandra and North Star) and medium to high at two sites (Bullarah and Tamworth).

Laboratory plating of harvest samples will determine if the addition of stubble to soil samples improves the accuracy of PreDicta B to determine crown rot risk prior to sowing. Adding stubble is likely to increase the overestimation of crown rot risk while reducing the likelihood of underestimation or 'failure to warn'. This is probably a preferred situation for growers and advisors. The addition of stubble will also reduce sampling issues following wetter summers which can result in greater survival of *Fusarium* in above ground residues than in the crowns as occurred in some of the previous survey paddocks between 2010–2012. Research to refine the sampling strategy is continuing.

Conclusions

RLNs being soil-borne appear to be more flexible with sampling technique to obtain an accurate risk level prior to sowing. However, the crown rot fungus is stubble-borne so detection is more sensitive to the sampling technique used to collect the soil samples. Taking 3–6 cores between the previous crop rows in a paddock, as with a soil nutrition test, may give a reasonable estimate of RLN levels but is likely to provide a poor indication of the crown rot risk. Recent collaborative research in the northern region between SARDI and NSW DPI has demonstrated that use of a smaller diameter soil core (e.g. Accucore) to collect 15–30 cores (depending on sampling depth) targeted at the previous cereal row if evident provides a good measure of both RLN and crown rot risk along with a range of other pathogens. This number of cores collected spatially across the paddock is required to account for the potential variability in the distribution of crown rot inoculum.

Important change to sampling; it is now recommended that up to 15 short pieces of cereal stubble from previous cereal crops and/or grass weeds be added to PreDicta B soil samples to enhance detection of the *Fusarium* spp. that cause crown rot. Where stubble is present, add one piece per sampling location. Each piece should be selected from the base of separate crowns; discard stubble above the first node.

Soil cores – collect up to three cores from 15 different locations within the target area; take cores from the previous cereal rows and retain any stubble collected by the core. The number of cores per location will vary depending on core diameter and sampling depth. Maximum sample weight should not exceed 500g. Sampling depth (0–15 cm or 0–30 cm) does not appear to greatly impact on detection of the various pathogen levels in the northern region ***when the collection of cores is targeted at the previous cereal rows.*** However, the actual sampling depth needs to be recorded on the sample bag when collected as it is used to refine reporting of results to adjust for pathogens which are more concentrated at the soil surface. Significant stubble disturbance (harrowing, cultivation, mulching etc.) increases the risk of crown rot development if the stubble is infected with *Fusarium*. Collection of soil samples prior to stubble disturbance is likely to underestimate the crown rot risk.

If you are not willing to follow the recommended PreDicta B sampling strategies then DO NOT assess disease risk levels prior to sowing using this method.

Acknowledgments

This project was co-funded by NSW DPI, SARDI and GRDC under the national improved molecular diagnostics for disease management project (DAS00137) and a previous project DAN00143. Assistance provided by Robyn Shapland, Finn Fensbo, Amy Alston, Liz Farrell, Kay Warren and Karen Cassin (NSW DPI); Herdina Herdina, Russell Burns, Aidan Thomson, Ina Dumitrescu, Danuta Pounsett, Irena Dadej, Daniele Giblot-Ducray (SARDI); and Diane Hartley (CSIRO) is greatly appreciated.

Regional crown rot management trials: summary 2013

Steven Simpfendorfer NSW DPI Tamworth **Matthew Gardner** formerly NSW DPI, Tamworth
Greg Brooke and Leigh Jenkins NSW DPI, Trangie

Introduction

Crown rot, caused predominantly by the fungus *Fusarium pseudograminearum* (*Fp*) is a significant disease of winter cereals in the northern region. Root lesion nematodes (RLN's) are also a wide spread constraint to wheat production across the region. Two important species of RLN exist throughout the northern region, namely *Pratylenchus thornei* (*Pt*) and *P. neglectus* (*Pn*). Previous surveys of northern NSW have found that *Pt* is more widespread and generally at higher populations than *Pn*. Recent collaborative research between Northern Grower Alliance and NSW DPI has also established that the presence of RLN feeding within root systems increases the severity of crown rot.

Cereal varieties differ in their tolerance to crown rot and either species of RLN. This can have a significant impact on the relative yield of varieties in the presence of these various disease constraints. In 2013, NSW DPI conducted a series of 11 trials across central/northern NSW extending into southern Qld to examine the impact of crown rot and RLN on the yield of two durum and ten bread wheat varieties.

What did we do?

Eleven trials were sown between the 15th May and the 4th July in 2013. The six ranges at each site were soil cored separately at sowing to establish background levels of crown rot and RLN using PreDicta B (Table 1). Two durum and 10 bread wheat varieties (Table 2) were established at each site with the sowing rate adjusted to target 100 plants/m^2 based on seed weight and germination. LRPB Crusader(b and SUN663A were not included in the Garah and Rowena trials. Each variety had either added or no added crown rot (CR) inoculum as durum grain colonised by *Fp* in the seed furrow at sowing. The only site where frost damage was noted in 2013 was with the quicker maturing varieties LRPB Dart(b and Jandaroi(b at Coonamble.

What did we find?

The average yield of the 12 cereal varieties at each of the 11 trial sites in the presence of no added CR or added CR varied across the sites (Table 1). Tamworth was the only site where the addition of CR inoculum at sowing did not result in a significant reduction in yield. This was a function of moderate levels of CR inoculum already present across the site and comparatively low yields. Data is therefore presented as an average of the added CR and no added CR treatments for this site.

The impact of added CR on yield was highest at Rowena and Macalister with 53% and 57% yield loss, respectively and considerably lower at Spring Ridge (15%) and Trangie (14%) (Table 1). However, determining yield loss by comparing inoculated and uninoculated plots across sites potentially underestimates the full impact of crown rot on yield at some sites. PreDicta B coring at sowing indicated that 6 of the 11 sites had medium to high levels of CR inoculum already present across the trial area (Table 1). Comparisons would underestimate losses at these sites as there is no way to account for yield loss that is attributed to the background infection levels in the no added CR plots. Yield outcomes are also a function of the interaction of each variety with CR, RLN populations which varied across the sites (Table 1), starting soil water, in-crop rainfall and maturity relative to moisture/temperature stress during the flowering and grain-fill period.

Key findings

Two durum and ten bread wheat varieties were evaluated in the presence of added or no added crown rot inoculum across 11 field sites in 2013.

Under high crown rot pressure (added CR inoculum) Suntop(b was 0.42 t/ha, LRPB Lancer(b 0.51 t/ha, Sunguard(b 0.61 t/ha and LRPB Spitfire(b 0.63 t/ha higher yielding than EGA_Gregory(b on average across sites.

Where no additional CR was added EGA_Gregory(b had similar yield to other varieties at sites with low background levels of crown rot but was between 0.52 t/ha (Suntop(b) to 0.37 t/ha (Sunguard(b) lower yielding at sites with medium–high background levels of crown rot.

EGA_Gregory(b production should be specifically targeted to paddocks with lower levels of crown rot risk based on testing such as PreDicta B.

Some newer wheat varieties have a measurable improvement in their tolerance to crown rot but these current levels are not a complete solution to crown rot. The best varieties still suffered up to 34% and 41% yield loss at the two sites with the highest impact from crown rot infection.

Table 1. Field sites, sowing dates, background risk levels of RLN and crown rot at sowing and average site yield without and with added crown rot inoculum in 2013. Note difference between no added and added CR at Tamworth was not significant so average of both treatments provided.

Site	Sowing date	Background levels		Average site mean yield (t/ha)	
		RLN	Crown rot	No added CR	Added CR
Bithramere	7 June	Medium *Pn*	High	2.25	1.88
Tamworth	4 July	Nil	Medium	1.39	
Spring Ridge	23 June	Nil	Medium	5.03	4.29
Terry Hie Hie	29 May	Nil	Low	3.69	2.95
Narrabri	17 May	Medium *Pt*	Medium	3.21	2.68
Coonamble	15 May	Nil	Medium	4.59	3.54
Trangie	28 May	Low *Pn*	Nil	3.62	3.12
Rowena	30 May	Low *Pt*	Nil	3.29	1.55
Garah	31 May	Low *Pt*	Low	2.62	2.03
Macalister	5 June	Low *Pt*	Low	3.35	1.43
Westmar	31 May	Nil	Medium	2.26	1.89

The average yield loss (difference between no added CR and added CR treatments) across the 11 sites was roughly in line with the reported crown rot resistance ratings (Table 2). The very susceptible (VS) and susceptible (S) varieties averaged between 30–39% yield loss while the moderately resistant-moderately susceptible (MR–MS) variety Sunguard⸸ had roughly half the level of yield loss (17%).

LRPB Spitfire⸸ and QT14381, which are both moderately susceptible (MS), averaged the same level of yield loss as Sunguard⸸ even though they have a lower resistance rating. Suntop⸸ which is also rated MS to crown rot averaged a higher level of yield loss (25%) than the other MS rated varieties. As outlined earlier these numbers are likely to be an underestimate of the impact of crown rot due to background inoculum levels at over half of the sites. Comparing varieties in terms of percentage yield loss can also be potentially misleading for growers and advisers as it masks the actual yields obtained in the presence of crown rot.

Table 2. Crown rot resistance, Pratylenchus thornei *(Pt) and* P. neglectus *(Pn) tolerance rating of 12 cereal varieties across 11 sites in 2013 and relative yield loss from the addition of CR inoculum.*
** Indicates provisional rating.*

Variety	Crown rot	*Pt* tolerance	*Pn* tolerance	Average % yield loss
Caparoi⸸	VS	MI	MI–I	39
Jandaroi⸸	VS	MI–I	MI	30
EGA_Gregory⸸	S	MT	MI	30
Strzelecki⸸	S	I–VI	MI	30
Suntop⸸	MS	MT	MT–MI	25
LRPB Dart⸸	MS–S	MI	MI–I	23
SUN663A	MS–S*	MT*	–	23
LRPB Lancer⸸	MS–S	T–MT	MI*	21
LRPB Crusader⸸	S	I	MI–I	19
LRPB Spitfire⸸	MS	MT–MI	MI	17
QT14381	MS*	MT*	–	17
Sunguard⸸	MR–MS	MT	MI	17

Under high crown rot pressure (added CR) only the two durum varieties (Caparoi and Jandaroi) and the bread wheat variety Strzelecki were lower yielding than EGA_Gregory when averaged across sites (Table 3). The remaining bread wheat varieties all appear to have improved tolerance to crown rot compared to EGA_Gregory with yield benefits in added CR treatments of between 0.26 t/ha (LRPB Dart) up to 0.63 t/ha (LRPB Spitfire).

Table 3. *Average yield (t/ha) of varieties with no added CR and added CR at sowing, protein level obtained and yield difference (%) compared with EGA_Gregory in no added CR plots at sites with either nil to low or medium to high background levels of crown rot.*

Variety	Average site yield (t/ha)		Protein	Yield (% EGA_Gregory)	
	No added CR	Added CR		Nil/Low CR	Med/High CR
Caparoi	2.72	1.66	13.4	85	86
Jandaroi	2.63	1.83	14.2	82	84
EGA_Gregory	3.18	2.21	12.2	100	100
Strzelecki	2.97	2.08	12.7	92	95
Suntop	3.49	2.63	12.5	102	117
LRPB Dart	3.19	2.47	12.9	94	106
SUN663A	3.41	2.64	12.9	103	113
LRPB Lancer	3.43	2.72	13.5	101	115
LRPB Crusader	3.41	2.78	13.1	108	110
LRPB Spitfire	3.42	2.84	13.9	100	115
QT14381	3.42	2.83	12.3	103	112
Sunguard	3.40	2.82	12.7	102	112

Under lower crown rot levels (no added CR) the two durum varieties and Strzelecki were again lower yielding than EGA_Gregory, while LRPB Dart had an equivalent average yield across sites (Table 3). The remaining bread wheat varieties were between 0.22 t/ha (Sunguard) to 0.31 t/ha (Suntop) higher yielding than EGA_Gregory. This probably reflects the medium to high background crown rot levels in just over half of the sites and supports the improved crown rot tolerance of these newer varieties as evident in the added CR treatments.

Protein levels were fairly high across sites in 2013 ranging from a variety average of 11.9% (Spring Ridge) to 14.3% (Bithramere). Jandaroi had the highest protein concentration at 14.2% while EGA_Gregory averaged the lowest protein concentration at 12.2%. LRPB Spitfire was the highest bread wheat variety at 13.9% which was 1.7% higher than that achieved by EGA_Gregory when averaged across sites (Table 3).

Further examining the relative yield of varieties compared to EGA_Gregory across the no added CR treatments highlights the value of determining the background levels of crown rot in trial sites (e.g. using PreDicta B). This treatment is essentially equivalent to GRDC funded National Variety Trial (NVT) sites with plots located in grower paddocks where both background crown rot and/or RLN levels may be present at varying levels. The Coonamble, Macalister and Westmar trials were actually co-located with cereal NVT sites in 2013. There were five sites with nil to low background levels of crown rot and six sites with medium to high starting levels (Table 1). Suntop, LRPB Lancer, LRPB Spitfire and Sunguard had similar yields to EGA_Gregory at sites with nil/low background levels of crown rot but were between 17% (Suntop) to 12% (Sunguard) higher yielding than EGA_Gregory at sites with medium/high background levels of crown rot (Table 3). This highlights the potential impact that targeting the production of EGA_Gregory specifically to paddocks with lower levels of crown rot risk based on PreDicta B testing could have on the profitability of growing this popular variety. Growers and advisors should also take into account the background levels at trial sites, if known, before interpreting their local NVT results.

Determining the relative impact of crown rot versus RLN on yield from these current trials is difficult as the varieties with reduced tolerance to *Pt* (CaparoiΦ, JandaroiΦ, StrzeleckiΦ, LRPB DartΦ and LRPB CrusaderΦ) also have lower resistance to crown rot. The varieties also do not vary greatly in their tolerance to *Pn*. Furthermore, only two sites had medium levels of RLN with Bithramere having *Pn* and Narrabri having *Pt*. The remaining sites had low or no RLN populations which limits the ability to infer nematode impacts. However, Narrabri in 2013 which had medium risk of both *Pt* and crown rot highlights the benefit of growing varieties with improved tolerance to *Pt* (e.g. EGA_GregoryΦ 3.09 t/ha) or combined tolerance to *Pt* and resistance to crown rot (e.g. SuntopΦ 3.87 t/ha) compared to varieties with poor levels of resistance/tolerance to both pathogens (e.g. StrzeleckiΦ 2.45 t/ha).

Conclusions

Determining the relative tolerance of varieties to crown rot is complex as it can be significantly influenced by background inoculum levels, RLN populations, differential variety tolerance to *Pn* versus *Pt* and varietal interaction with the expression of crown rot. Other soil-borne pathogens such as *Bipolaris sorokiniana*, which causes common root rot, also need to be accounted for in the interaction between crown rot and varieties. Starting soil water, in-crop rainfall, relative biomass production, sowing date and resulting variety phenology in respect to moisture and/or temperature stress during grain-fill can all differentially influence the expression of crown rot in different varieties. The research reported above needs to be conducted over a number of seasons and locations with full measurement of these influencing factors to fully understand the relative tolerance of varieties to crown rot under varying conditions.

A more detailed interpretation of individual site results will be available in the autumn 2014 Northern Grains Region Trial Results book, published annually by NSW DPI.

Summary

The 2013 season was very conducive to the expression of crown rot in the northern region with little rainfall in spring and hot grain-fill temperatures. EGA_GregoryΦ remains the dominant wheat variety across the region due to its high yield potential and flexibility in sowing time. However, under high crown rot pressure (i.e. added CR treatments) SuntopΦ was 0.42 t/ha, LRPB LancerΦ 0.51 t/ha, SunguardΦ 0.61 t/ha and LRPB SpitfireΦ 0.63 t/ha higher yielding than EGA_GregoryΦ when averaged across the 11 sites in 2013. This reflects the improved levels of tolerance to crown rot and *Pt* in recently released varieties in the region, which can significantly impact on profitability in the presence of these disease constraints.

Due to its increased susceptibility to crown rot growers should consider targeting EGA_GregoryΦ production to paddocks with low risk of crown rot development based on disease testing services such as PreDicta B. Otherwise growers should consider switching to one of these newer varieties, which have a measurable yield improvement in the presence of crown rot. Growers still need to be aware that significant yield loss can occur in these more tolerant varieties under high infection levels, particularly when plants suffer serious moisture/temperature stress during grain-fill. Macalister and Rowena were sites that experienced the greatest yield loss from crown rot in 2013. Under high infection levels the best variety at Macalister was LRPB SpitfireΦ which still suffered 34% yield loss while SunguardΦ was the best at Rowena but still suffered 41% yield loss from crown rot compared to the nil crown rot treatment. That is, some of these newer varieties have a measurable improvement in their tolerance to crown rot but these current levels are still not a complete solution to crown rot.

Acknowledgments

This project was co-funded by NSW DPI and GRDC under the national crown rot epidemiology and management project (DAN00175). Technical assistance provided by Robyn Shapland, Finn Fensbo, Karen Cassin, Kay Warren, Jim Keir, Rod Bambach, Peter Formann, Stephen Morphett and Jim Perfrement all based with NSW DPI at Tamworth are gratefully acknowledged. The technical assistance of Jayne Jenkins with NSW DPI based at Trangie is also appreciated. The two southern Qld sites (Westmar and Macalister) were kindly managed by Douglas Lush (QDAFF).

Regional crown rot management – Westmar Qld 2013

Steven Simpfendorfer, Finn Fensbo and Robyn Shapland NSW DPI, Tamworth

Key findings

QT14381, Suntop$^{\phi}$, LRPB Spitfire$^{\phi}$ and Sunguard$^{\phi}$ were between 0.52 t/ha to 0.30 t/ha higher yielding than EGA_Gregory$^{\phi}$ under high crown rot pressure.

Targeting fungicide application at the base of plants increased yield under high crown rot pressure by 0.36 t/ha with droppers and 0.20 t/ha with the on crop application. However, they **do not** provide complete control. Application 50 cm above crop height provided no benefit.

Slashing reduced yield by 0.42 t/ha with no added CR but had no yield penalty with added CR.

CROP PROTECTION

Introduction

Crown rot (CR) caused predominantly by the fungus *Fusarium pseudograminearum* (*Fp*), remains a major constraint to the production of winter cereals in the northern grains region. Root lesion nematodes (RLN's) are also a wide spread constraint to wheat production across the region. Two important species of RLN exist throughout the northern region, namely *Pratylenchus thornei* (*Pt*) and *P. neglectus* (*Pn*). Previous surveys have found that *Pt* is more widespread and generally at higher populations than *Pn*. Recent collaborative research between Northern Grower Alliance and NSW DPI has also established that the presence of RLN feeding within root systems increases the severity of crown rot.

Cereal varieties differ in their tolerance to crown rot and either species of RLN. This can have a significant impact on the relative yield of varieties in the presence of these various disease constraints. This trial is one of nine conducted by NSW DPI in 2013 across central/northern NSW extending into southern Qld to examine the impact of crown rot and RLN on the yield of two durum and ten bread wheat varieties.

Control of crown rot using fungicides has been studied extensively with limited success and quite variable outcomes. No fungicides are currently registered for the control of crown rot in winter cereals either as seed or in-furrow treatments or in-crop sprays. As the name implies, crown rot primarily infects the base of plants through the sub-crown internode, crown and/or outer leaf sheaths at the base of tillers at the soil surface.

The second trial aimed to take a step back in the approach of using foliar fungicides to determine if targeting application at the base of tillers might improve the level of control and provide more consistent effects. The reduction of crop canopy through slashing at around GS30 was also examined for its potential to impact on crown rot expression and yield.

Site details

Location:	**"Enarra", Westmar, Qld**
Co-operator:	**Phil Coggan**
Sowing date:	**31st May 2013**
Fertiliser:	**100 kg/ha Urea and 40 kg/ha Granulock Z extra at sowing**
Starting N:	**85 kg/ha nitrate N to 1.0 m**
In-crop rainfall:	**~60 mm**
PreDicta B:	**Nil RLN, 1.7 log *Fusarium* DNA/g (medium risk), 0.8 log *Bipolaris* DNA/g**
Treatment date:	**All 2nd August at GS31**
Harvest date:	**14th October 2013**

Treatments

Variety evaluation

- Two durum varieties (Caparoi$^{\phi}$ and Jandaroi$^{\phi}$)
- Eight commercial bread wheat varieties (EGA_Gregory$^{\phi}$, Strzelecki$^{\phi}$, LRPB Dart$^{\phi}$, LRPB Lancer$^{\phi}$, LRPB Crusader$^{\phi}$, LRPB Spitfire$^{\phi}$, Suntop$^{\phi}$ and Sunguard$^{\phi}$; listed in order of increasing resistance to crown rot).
- Two numbered bread wheat lines (SUN663A and QT14381)

- Added or no added crown rot at sowing using sterilised durum grain colonised by at least five different isolates of *Fp*.

Fungicide application evaluation

- EGA_Gregory⦶ with added or no added crown rot at sowing using infected durum grain.
- One fungicide (Prosaro® at 300 mL/ha + 0.25% chemwet 1000).
- Three in-crop application strategies at GS30-31 using Turbo Teejet (110015) nozzles at ~300 L/ha.
  - Above crop – foliar spray 50 cm above crop height (i.e. normal rust spray with most of product deposited on upper leaf surfaces).
  - On crop – boom dropped to crop height and nozzles moved between wheat rows (i.e. product hitting base of plant and soil).
  - Droppers – solid rod from boom down to below canopy height then two nozzles angled at ~45 degrees towards base of tillers on opposite crop rows (i.e. all of product targeted at base of plants).
- One slashing treatment using a cutter bar at GS30-31 with cut leaf material left on soil surface.

Results – Variety evaluation

Yield

- Only four varieties (QT14381, Suntop⦶, LRPB Spitfire⦶ and Sunguard⦶) did not suffer significant yield loss in the presence of added CR compared to the no added CR treatment (Figure 1).
- In the presence of high crown rot infection (added CR) these four varieties were between 0.30 t/ha (Sunguard⦶) up to 0.52 t/ha (QT14381) higher yielding than EGA_Gregory⦶.
- Yield loss from crown rot infection was highest in the durum variety Caparoi⦶ at 44% (0.84 t/ha). Even though the other durum variety Jandaroi⦶ lost 27% yield from crown rot it was 0.56 t/ha higher yielding than Caparoi⦶ under high crown rot infection (added CR).
- LRPB Crusader⦶ was the highest yielding variety with no added CR being 0.30 t/ha higher than the nearest variety Suntop⦶.
- LRPB Crusader⦶ had 19% yield loss (0.53 t/ha) in added CR plots but its higher yield at this site meant it still remained amongst the top four varieties under high crown rot infection (added CR) along with QT14381, Suntop⦶ and Sunguard⦶.

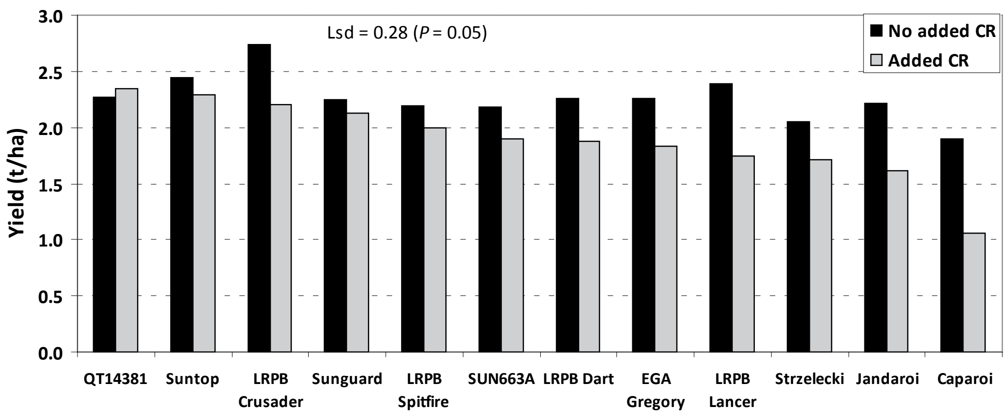


Figure 1. *Yield (t/ha @ 11% moisture) of varieties with no added and added crown rot – Westmar 2013.*

Protein

- There was a slight (0.3%) decrease in protein with added CR when averaged across varieties but the effect was not significant in any individual entry.
- Protein levels ranged between 12.7% (LRPB Dart⁽ᵈ⁾) up to 14.5% (LRPB Lancer⁽ᵈ⁾; Figure 2).
- The higher protein content in LRPB Dart⁽ᵈ⁾ is largely a function of its lower yield at this site. Conversely, Suntop⁽ᵈ⁾ and QT14381 were amongst the lower protein achievers but were amongst the highest yield achievers across the added and no added CR treatments.
- Consequently, grain N removal was not different between LRPB Crusader⁽ᵈ⁾, Suntop⁽ᵈ⁾, LRPB Lancer⁽ᵈ⁾, QT14381, Sunguard⁽ᵈ⁾ and LRPB Spitfire⁽ᵈ⁾ at this site.

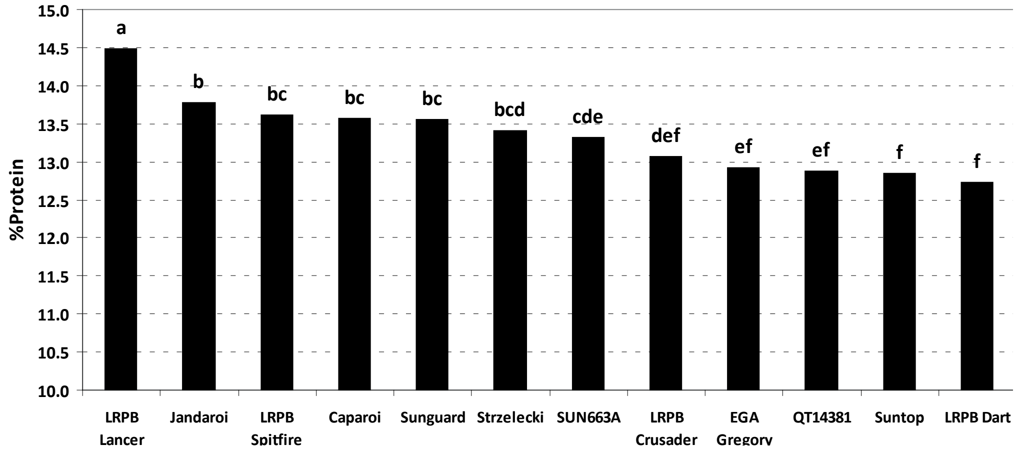


Figure 2. *Average protein concentration achieved by varieties – Westmar 2013. Bars with the same letter are not significantly different (P=0.05).*

Results – Fungicide application evaluation

Yield

- With background levels of infection (no added CR) none of the fungicide applications provided a significant yield benefit over the nil treatment at the 95% confidence level (Figure 3). The 0.18 and 0.19 t/ha yield benefit provided by the on crop and dropper applications, respectively was only significant at the trend level (90% confidence).
- Under high crown rot pressure (added CR) the on crop application increased yield by 0.20 t/ha and the dropper application by 0.36 t/ha compared to no fungicide application (Figure 3).
- Fungicide application 50 cm above crop height did not provide a yield benefit with either no added CR or added CR.
- Slashing at GS31 significantly reduced yield by 0.42 t/ha compared to the nil control with no added CR. However, there was no yield penalty from slashing under higher crown rot levels in the added CR treatment.

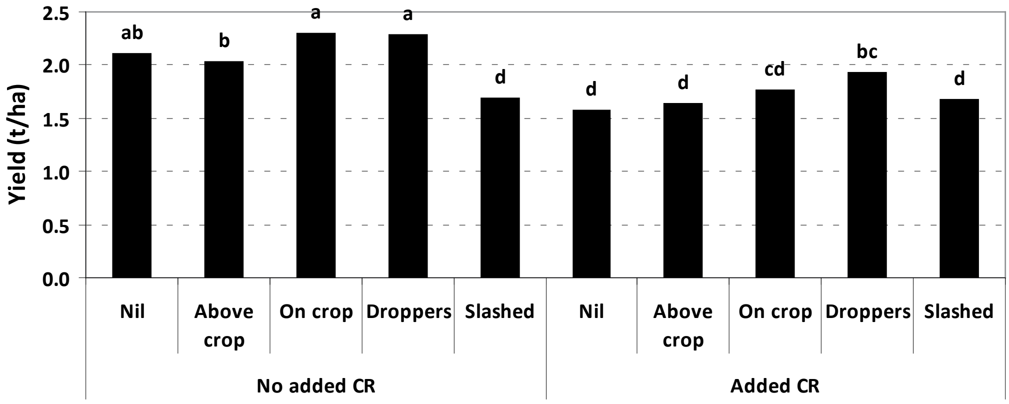


Figure 3. *Effect of fungicide application technique on grain yield of EGA_Gregory[(l)] with no added or added crown rot inoculum – Westmar 2013. Bars with the same letter are not significantly different (P=0.05)*

Protein

- Fungicide application did not significantly change protein levels compared to nil treatments.
- There was a trend (90% confidence) for reduced (0.7%) protein levels in the slashing treatments.

Acknowledgements

This project was co-funded by NSW DPI and GRDC under the National Crown Rot Management and Epidemiology Project (DAN00175). Thanks to Phil Coggan for providing the trial site and to Douglas Lush (QDAFF) who kindly sowed, managed and harvested the trial.

Regional crown rot management – Macalister Qld 2013

Steven Simpfendorfer, Finn Fensbo and Robyn Shapland NSW DPI, Tamworth

Introduction

Crown rot (CR) caused predominantly by the fungus *Fusarium pseudograminearum* (*Fp*), remains a major constraint to the production of winter cereals in the northern grains region. Root lesion nematodes (RLNs) are also a wide spread constraint to wheat production across the region. Two important species of RLN exist throughout the northern region, namely *Pratylenchus thornei* (*Pt*) and *P. neglectus* (*Pn*). Previous surveys have found that *Pt* is more widespread and generally at higher populations than *Pn*. Recent collaborative research between Northern Grower Alliance and NSW DPI has also established that the presence of RLN feeding within root systems increases the severity of crown rot.

Cereal varieties differ in their tolerance to crown rot and either species of RLN. This can have a significant impact on the relative yield of varieties in the presence of these various disease constraints. This trial is one of nine conducted by NSW DPI in 2013 across central/northern NSW extending into southern Qld to examine the impact of crown rot and RLN on the yield of two durum and ten bread wheat varieties.

Control of crown rot using fungicides has been studied extensively with limited success and quite variable outcomes. No fungicides are currently registered for the control of crown rot in winter cereals either as seed or in-furrow treatments or in-crop sprays. As the name implies, crown rot primarily infects the base of plants through the sub-crown internode, crown and/or outer leaf sheaths at the base of tillers at the soil surface.

The second trial aimed to take a step back in the approach of using foliar fungicides to determine if targeting application at the base of tillers might improve the level of control and provide more consistent effects. The reduction of crop canopy through slashing around GS30 was also examined for its potential to impact on crown rot expression and yield.

Key findings

LRPB Spitfire⁽ᴾ⁾, QT14381, Sunguard⁽ᴾ⁾, LRPB Crusader⁽ᴾ⁾ and LRPB Lancer⁽ᴾ⁾ were between 1.19 t/ha to 0.68 t/ha higher yielding than EGA_Gregory⁽ᴾ⁾ under high crown rot pressure.

Targeting fungicide application at the base of plants increased yield under high crown rot pressure by 0.34 t/ha with droppers and 0.28 t/ha with the on-crop application. However, neither treatment provided complete control, with them still being 2.41 t/ha lower yielding than no fungicide application under lower crown rot levels. Application 50 cm above crop height provided no benefit.

Slashing did not affect yield with no added CR but provided a 0.21 t/ha benefit with added CR.

Site details

Location:	**"Curraweena", Macalister, Qld**
Co-operator:	**Rob Taylor**
Sowing date:	**5th June 2013**
Fertiliser:	**40 kg/ha Granulock Z extra at sowing**
Starting N:	**118 kg/ha nitrate N to 1.0 m**
In-crop rainfall:	**~66 mm**
PreDicta B:	**0.7 *Pratylenchus thornei*/g soil (low risk), 0.8 log *Fusarium* DNA/g (low)**
Treatment date:	**All 3rd July at GS30**
Harvest date:	**28th October 2013**

Treatments

Variety evaluation

- Two durum varieties (Caparoi⁽ᴾ⁾ and Jandaroi⁽ᴾ⁾)
- Eight commercial bread wheat varieties (EGA_Gregory⁽ᴾ⁾, Strzelecki⁽ᴾ⁾, LRPB Dart⁽ᴾ⁾, LRPB Lancer⁽ᴾ⁾, LRPB Crusader⁽ᴾ⁾, LRPB Spitfire⁽ᴾ⁾, Suntop⁽ᴾ⁾ and Sunguard⁽ᴾ⁾; listed in order of increasing resistance to crown rot).
- Two numbered bread wheat lines (SUN663A and QT14381)

- Added or no added crown rot at sowing using sterilised durum grain colonised by at least five different isolates of *Fp*.

Fungicide application evaluation

- EGA_Gregory⁽ᵈ⁾ with added or no added crown rot at sowing using infected durum grain.
- One fungicide (Prosaro® at 300 mL/ha + 0.25% chemwet 1000).
- Three in-crop application strategies at GS 30 using Turbo Teejet (110015) nozzles at ~300 L/ha.
  - Above crop – foliar spray 50 cm above crop height (i.e. normal rust spray with most of product deposited on upper leaf surfaces).
  - On crop – boom dropped to crop height and nozzles moved between wheat rows (i.e. product hitting base of plant and soil).
  - Droppers – solid rod from boom down to below canopy height then two nozzles angled at ~45 degrees towards base of tillers on opposite crop rows (i.e. all of product targeted at base of plants).
- One slashing treatment using a cutter bar at GS30-31 with cut leaf material left on soil surface.

Results – Variety evaluation

Yield

- PreDicta B coring at sowing indicated a low level of crown rot was already present across this site with low levels of whiteheads (up to ~20% in EGA_Gregory⁽ᵈ⁾) in no added CR plots when scored on the 10th September.
- Added CR resulted in significant expression of crown rot with around 40% (Sunguard⁽ᵈ⁾) to 80% (Caparoi⁽ᵈ⁾) whiteheads present in inoculated plots of all varieties in early September. Whiteheads scores were a good reflection of final grain yield in added CR treatments of each variety.
- Yield loss from added CR ranged from 34% in LRPB Spitfire⁽ᵈ⁾ (1.22 t/ha) up to 86% in the durum variety Caparoi⁽ᵈ⁾ (2.47 t/ha) compared to uninoculated plots of that variety.
- Yield under high crown rot pressure (added CR) was in line with reported resistance ratings with the exception of Suntop⁽ᵈ⁾ which performed poorer than expected at this site.
- LRPB Spitfire⁽ᵈ⁾, QT14381, Sunguard⁽ᵈ⁾, LRPB Crusader⁽ᵈ⁾ and LRPB Lancer⁽ᵈ⁾ were between 1.19 t/ha to 0.68 t/ha higher yielding than EGA_Gregory⁽ᵈ⁾ under high crown rot pressure (Figure 1).

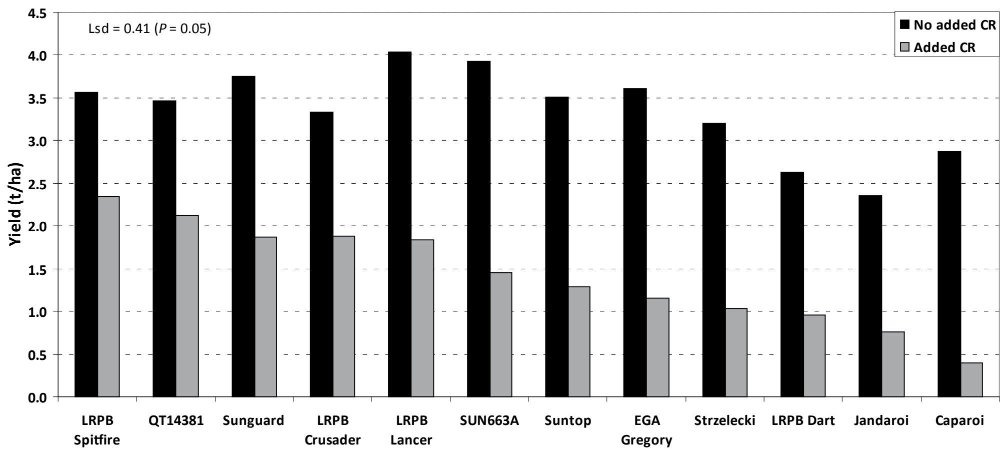


Figure 1. *Yield (t/ha @ 11% moisture) of varieties with no added and added crown rot – Macalister 2013.*

Protein

- Crown rot infection did not impact on protein levels in any variety.
- Protein levels ranged between 12.1% (EGA_Gregory⊕) up to 14.7% (Jandaroi⊕; Figure 2).
- Even though EGA_Gregory⊕ was the lowest protein achiever at this site its grain N removal in no added CR treatments was only significantly lower than LRPB Lancer⊕ and was actually significantly higher than Caparoi⊕, LRPB Dart⊕ and Jandaroi. Protein levels are influenced by dilution or concentration within grain with increasing or decreasing yield, respectively.

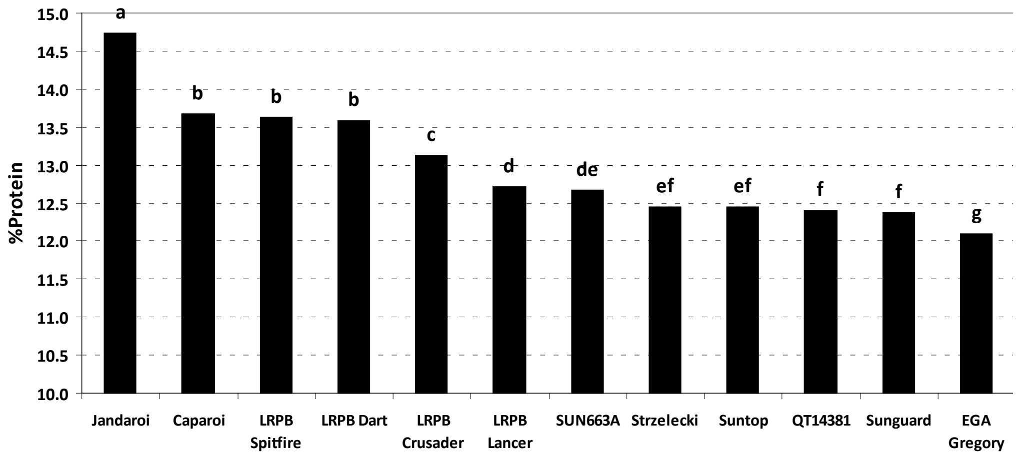


Figure 2. *Average protein concentration achieved by varieties – Macalister 2013. Bars with the same letter are not significantly different (P=0.05).*

Results – Fungicide application evaluation

Yield

- Under background levels of infection (no added CR) only the dropper application provided a significant (0.25 t/ha) benefit over the nil treatment (Figure 3).
- Under high crown rot pressure (added CR) the on crop application increased yield by 0.28 t/ha and the dropper application by 0.34 t/ha compared to no fungicide application (Figure 3).
- Fungicide application provided only a minor reduction in disease impact under high crown rot pressure. The dropper application yielded 2.41 t/ha less than no fungicide application with a much lower level of crown rot infection (no added CR).
- Fungicide application 50 cm above crop height did not provide a yield benefit with either no added CR or added CR.
- Slashing at GS30 caused a slight (0.14 t/ha) but not significant yield reduction compared to the nil control with no added CR but significantly increased yield by 0.21 t/ha in the added CR treatment.

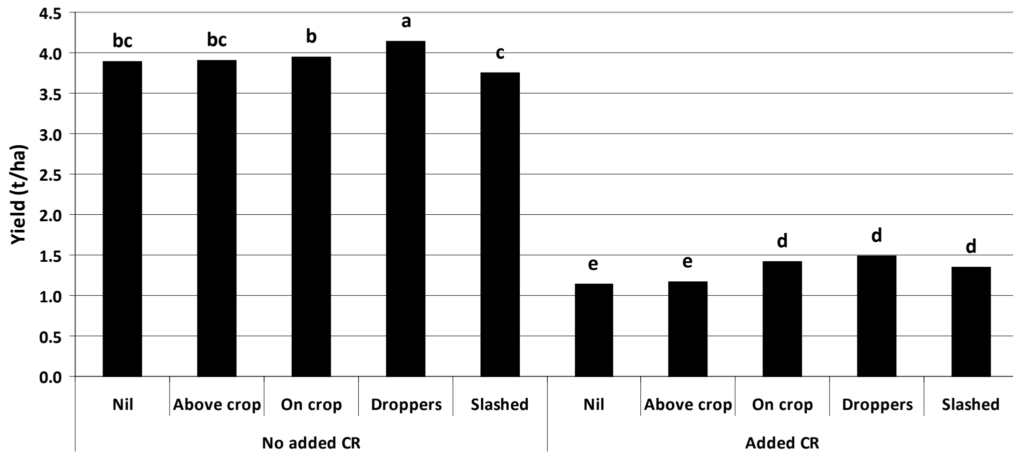


Figure 3. *Effect of fungicide application technique on grain yield of EGA_Gregory*⑩ *with no added or added crown rot inoculum – Macalister 2013. Bars with the same letter are not significantly different (P=0.14).*

Protein

- Protein was reduced by 0.6% in added CR plots when averaged across treatments.
- Fungicide application did not significantly change protein levels compared to nil treatments.
- Slashing at GS30 slightly reduced protein levels by 0.3%.

Acknowledgements

This project was co-funded by NSW DPI and GRDC under the National Crown Rot Management and Epidemiology Project (DAN00175). Thanks to Rob Taylor for providing the trial site and to Douglas Lush (QDAFF) who kindly sowed, managed and harvested the trial.

Regional crown rot management – Narrabri 2013

Steven Simpfendorfer, Finn Fensbo and Robyn Shapland NSW DPI, Tamworth

Introduction

Crown rot (CR) caused predominantly by the fungus *Fusarium pseudograminearum* (*Fp*), remains a major constraint to the production of winter cereals in the northern grains region. Root lesion nematodes (RLN's) are also a wide spread constraint to wheat production across the region. Two important species of RLN exist throughout the northern region, namely *Pratylenchus thornei* (*Pt*) and *P. neglectus* (*Pn*). Previous surveys have found that *Pt* is more widespread and generally at higher populations than *Pn*. Recent collaborative research between Northern Grower Alliance and NSW DPI has also established that the presence of RLN feeding within root systems increases the severity of crown rot.

Cereal varieties differ in their tolerance to crown rot and either species of RLN. This can have a significant impact on the relative yield of varieties in the presence of these various disease constraints. This trial is one of nine conducted by NSW DPI in 2013 across central/northern NSW extending into southern Qld to examine the impact of crown rot and RLN on the yield of two durum and ten bread wheat varieties.

Control of crown rot using fungicides has been studied extensively with limited success and quite variable outcomes. No fungicides are currently registered for the control of crown rot in winter cereals either as seed or in-furrow treatments or in-crop sprays. As the name implies, crown rot primarily infects the base of plants through the sub-crown internode, crown and/or outer leaf sheaths at the base of tillers at the soil surface.

The second trial aimed to take a step back in the approach of using foliar fungicides to determine if targeting application at the base of tillers might improve the level of control and provide more consistent effects. The reduction of crop canopy through slashing around GS30 was also examined for its potential to impact on crown rot expression and yield.

Key findings

This site had a medium background level of both *Pratylenchus thornei* and crown rot.

All bread wheat varieties (except Strzelecki⒫) were between 0.41 t/ha to 0.81 t/ha higher yielding than EGA_ Gregory⒫ under high levels of crown rot infection.

Fungicide application increased yield by 0.37 t/ha (on crop) to 0.51 t/ha (droppers). Fungicide application 50 cm above crop height provided no yield benefit.

Slashing at GS30 reduced yield by 0.23 t/ha compared to the nil control.

CROP PROTECTION

Site details

Location:	**"Myall Vale", Narrabri**
Co-operator:	**Peter and Sarah Leitch**
Sowing date:	**17th May 2013**
Fertiliser:	**180 kg/ha urea and 70 kg/ha Granulock Supreme Z at sowing**
Starting N:	**175 kg/ha nitrate N to 1.2 m**
Starting water:	**~170 mm (0–180 cm)**
In-crop rainfall:	**~120 mm**
PreDicta B:	**2.5 *Pt*/g soil (medium risk), 1.7 log *Fusarium* DNA/g (medium) and 2.3 log *Bipolaris* DNA/g (high)**
Treatment date:	**All 26th July at GS31**
Harvest date:	**24th October 2013**

Treatments

Variety evaluation

- Two durum varieties (Caparoi⒫ and Jandaroi⒫).
- Eight commercial bread wheat varieties (EGA_Gregory⒫, Strzelecki⒫, LRPB Dart⒫, LRPB Lancer⒫, LRPB Crusader⒫, LRPB Spitfire⒫, Suntop⒫ and Sunguard⒫; listed in order of increasing resistance to crown rot).

- Two numbered bread wheat lines (SUN663A and QT14381).
- Added or no added crown rot at sowing using sterilised durum grain colonised by at least five different isolates of *Fp*.
- Fungicide application evaluation.
- EGA_Gregory⁽ᵖ⁾ with added or no added crown rot at sowing using infected durum grain.
- One fungicide (Prosaro® at 300 mL/ha + 0.25% chemwet 1000).
- Three in-crop application strategies at GS 30 using Turbo Teejet (110015) nozzles at ~300 L/ha.
  – Above crop – foliar spray 50 cm above crop height (i.e. normal rust spray with most of product deposited on upper leaf surfaces).
  – On crop – boom dropped to crop height and nozzles moved between wheat rows (i.e. product hitting base of plant and soil).
  – Droppers – solid rod from boom down to below canopy height then two nozzles angled at ~45 degrees towards base of tillers on opposite crop rows (i.e. all of product targeted at base of plants).
- One slashing treatment using a cutter bar at GS30-31 with cut leaf material left on soil surface.

Results – Variety evaluation

Yield

- This site had a moderate level of background infection with crown rot across the site as predicted by PreDicta B analysis at sowing. The site also had a medium risk level of *Pt*. Determining the impact of *Pt* is difficult as varieties with reduced tolerance to *Pt* (Caparoi⁽ᵖ⁾, Jandaroi⁽ᵖ⁾, Strzelecki⁽ᵖ⁾, LRPB Dart⁽ᵖ⁾ and LRPB Crusader⁽ᵖ⁾) also have lower resistance to crown rot.
- However, the benefit of growing varieties with improved tolerance to *Pt* (e.g. EGA_Gregory⁽ᵖ⁾ which is MT to *Pt* but S to crown rot, 3.09 t/ha) or combined tolerance to *Pt* and resistance to crown rot (e.g. Suntop⁽ᵖ⁾ which is MT to *Pt* and MS to crown rot, 3.87 t/ha) compared to varieties with poor levels of resistance/tolerance to both pathogens (e.g. Strzelecki⁽ᵖ⁾ which is I–VI to *Pt* and S to crown rot, 2.45 t/ha) was apparent at this site in un-inoculated plots.
- The impact of crown rot on yield (tolerance) is determined by comparing no added CR plots and added CR plots. This would underestimate the yield impacts from crown rot as medium inoculum levels already existed across this site. There is no way to determine what the yield of each variety would have been at this site in the absence of crown rot infection. Hence, the no added CR plots represent a medium infection level and the added CR plots represent a high infection level.
- Under high crown rot infection (added CR) all bread wheat varieties (except Strzelecki⁽ᵖ⁾) were between 0.41 t/ha (LRPB Dart⁽ᵖ⁾) to 0.81 t/ha (QT14381) higher yielding than EGA_Gregory⁽ᵖ⁾.
- Jandaroi⁽ᵖ⁾ was 0.51 t/ha higher yielding than Caparoi⁽ᵖ⁾ under high infection levels (added CR) but both durum varieties are very susceptible to crown rot and lower yielding than all bread wheat varieties including Strzelecki⁽ᵖ⁾ and EGA_Gregory⁽ᵖ⁾ which are both rated susceptible to crown rot.
- Varieties with improved resistance to crown rot also have increased yield (tolerance) in the presence of this disease. Selecting varieties with improved tolerance to crown rot can have a large impact on profit in the presence of this disease constraint.

- PreDicta B assessment prior to sowing can identify high risk paddocks to allow growers to implement appropriate management strategies and/or avoid sowing more susceptible varieties.

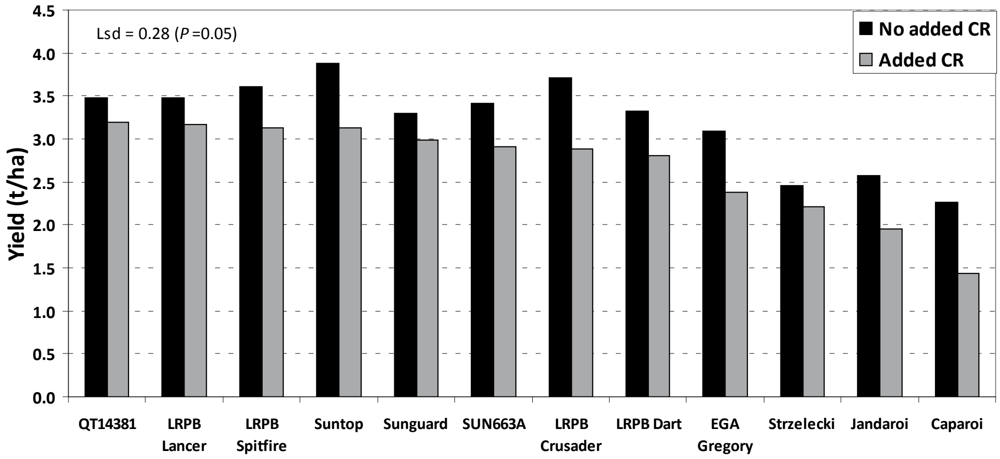


Figure 1. *Yield (t/ha @ 11% moisture) of varieties with no added and added crown rot – Narrabri 2013.*

Protein

- The addition of crown rot inoculum slightly reduced protein by 0.3% when averaged across varieties but was not significant in any individual variety.
- Protein levels were relatively high at this site ranging between 13.2% (EGA_Gregory⦶) up to 15.9% (Jandaroi⦶; Figure 2).
- Even though Suntop⦶ was amongst the lowest protein achievers at this site its grain N removal in the no added CR treatments was only lower than LRPB Spitfire⦶ and higher than all other varieties except LRPB Lancer⦶ which had equivalent grain N removal. In contrast, EGA_Gregory⦶ had lower protein and lower yield so had significantly lower grain N removal than Suntop⦶ and QT14381 even though they had equivalent protein concentrations. Protein levels are influenced by dilution or concentration within grain with increasing or decreasing yield, respectively.

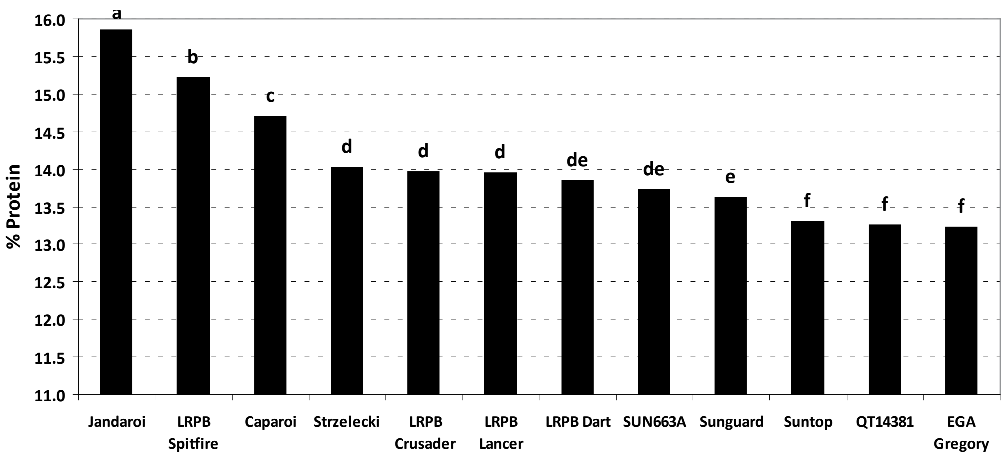


Figure 2. *Average protein concentration achieved by varieties – Narrabri 2013. Bars with the same letter are not significantly different (P=0.05).*

CROP PROTECTION

Results – Fungicide application evaluation

Yield

- The effect of treatments was not significant at the added CR versus no added CR level due to medium levels of background crown rot across the trial site as predicted at sowing using PreDicta B.
- Fungicide application on crop increased yield by 0.37 t/ha while application with droppers had a further benefit increasing yield by 0.51 t/ha (Figure 3). Fungicide application 50 cm above crop height provided no yield benefit.
- Slashing at GS31 reduced yield by 0.23 t/ha compared to the nil control.

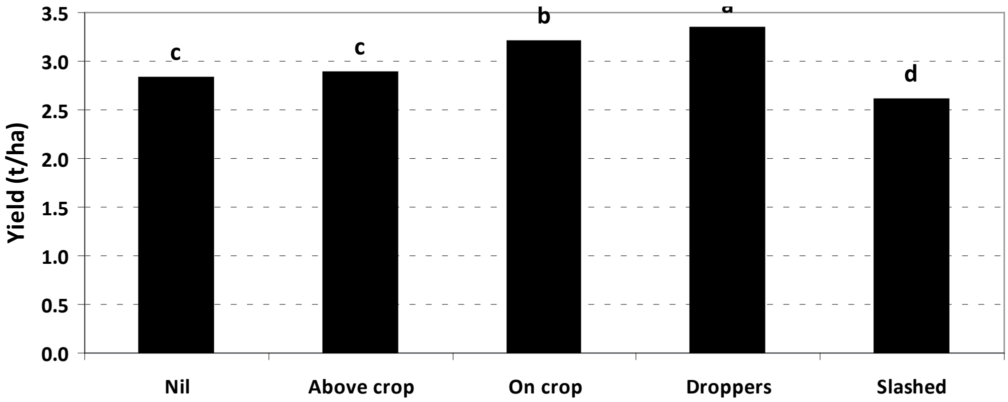


Figure 3. *Effect of fungicide application technique on grain yield in EGA_Gregory⫙ (average of no added or added CR plots) – Narrabri 2013. Bars with the same letter are not significantly different (P=0.05).*

Protein

- Protein levels were slightly lower (0.3%) in the added CR treatment.
- Slashing at GS31 reduced grain protein by 0.3 compared to the nil treatment.

Acknowledgements

This project was co-funded by NSW DPI and GRDC under the National Crown Rot Management and Epidemiology Project (DAN00175). Thanks to Sarah and Peter Leitch for providing the trial site and to Matt Gardner, Stephen Morphett, Jim Perfrement, Patrick Mortell, Peter Formann and Rod Bambach (all NSW DPI) for sowing, maintaining and harvesting the trial.

Regional crown rot management – Tamworth 2013

Steven Simpfendorfer, Finn Fensbo and Robyn Shapland NSW DPI, Tamworth

CROP PROTECTION

Introduction

Crown rot (CR) caused predominantly by the fungus *Fusarium pseudograminearum* (*Fp*), remains a major constraint to the production of winter cereals in the northern grains region. Root lesion nematodes (RLN's) are also a wide spread constraint to wheat production across the region. Two important species of RLN exist throughout the northern region, namely *Pratylenchus thornei* (*Pt*) and *P. neglectus* (*Pn*). Previous surveys have found that *Pt* is more widespread and generally at higher populations than *Pn*. Recent collaborative research between Northern Grower Alliance and NSW DPI has also established that the presence of RLN feeding within root systems increases the severity of crown rot.

Cereal varieties differ in their tolerance to crown rot and either species of RLN. This can have a significant impact on the relative yield of varieties in the presence of these various disease constraints. This site is one of nine conducted by NSW DPI in 2013 across central/northern NSW extending into southern Qld to examine the impact of crown rot and RLN on the yield of two durum and ten bread wheat varieties.

Control of crown rot using fungicides has been studied extensively with limited success and quite variable outcomes. No fungicides are currently registered for the control of crown rot in winter cereals either as seed or in-furrow treatments or in-crop sprays. As the name implies, crown rot primarily infects the base of plants through the sub-crown internode, crown and/or outer leaf sheathes at the base of tillers at the soil surface.

The second trial aimed to take a step back in the approach of using foliar fungicides to determine if targeting application at the base of tillers might improve the level of control and provide more consistent effects. The reduction of crop canopy through slashing around GS30 was also examined for its potential to impact on crown rot expression and yield.

Key findings

LRPB Lancer⁽ᵈ⁾ was 0.30 t/ha and LRPB Spitfire⁽ᵈ⁾ 0.19 t/ha higher yielding than EGA_Gregory⁽ᵈ⁾ under high crown rot pressure in this low yielding red soil site.

Under higher crown rot levels (added CR) all fungicide application techniques significantly increased yield by between 0.16 t/ha (above crop) to 0.24 t/ha (droppers).

Slashing at GS30 did not significantly impact on yield under either moderate (no added CR) or high (added CR) crown rot levels.

Site details

Location:	**Pd25, Tamworth Agricultural Institute**
Sowing date:	**4th July 2013**
Fertiliser:	**50 kg/ha Urea and 50 kg/ha Granulock Supreme Z at sowing**
Starting N:	**~80 kg/ha nitrate N to 1.2 m**
Starting water:	**<100 mm PAW to 1.2 m**
In-crop rainfall:	**~110 mm**
PreDicta B:	**Nil RLN, 1.9 log *Fusarium* DNA/g (medium risk), 1.4 log *Bipolaris* DNA/g**
Treatment date:	**All 9th September at GS30**
Harvest date:	**22nd November 2013**

Treatments

Variety evaluation

- Two durum varieties (Caparoi⁽ᵈ⁾ and Jandaroi⁽ᵈ⁾).
- Eight commercial bread wheat varieties (EGA_Gregory⁽ᵈ⁾, Strzelecki⁽ᵈ⁾, LRPB Dart⁽ᵈ⁾, LRPB Lancer⁽ᵈ⁾, LRPB Crusader⁽ᵈ⁾, LRPB Spitfire⁽ᵈ⁾, Suntop⁽ᵈ⁾ and Sunguard⁽ᵈ⁾; listed in order of increasing resistance to crown rot).
- Two numbered bread wheat lines (SUN663A and QT14381).

- Added or no added crown rot at sowing using sterilised durum grain colonised by at least five different isolates of *Fp*.

Fungicide application evaluation

- EGA_Gregory⁽ᵈ⁾ with added or no added crown rot at sowing using infected durum grain.
- One fungicide (Prosaro® at 300 mL/ha + 0.25% chemwet 1000).
- Three in-crop application strategies all at GS 30-31 using Turbo Teejet (110015) nozzles at ~300 L/ha.
  - Above crop – foliar spray 50 cm above crop height (i.e. normal rust spray with most of product deposited on upper leaf surfaces).
  - On crop – boom dropped to crop height and nozzles moved between wheat rows (i.e. product hitting base of plant and soil).
  - Droppers – solid rod from boom down to below canopy height then two nozzles angled at ~45 degrees towards base of tillers on opposite crop rows (i.e. all of product targeted at base of plants).
- One slashing treatment using a cutter bar at GS30-31 with cut leaf material left on soil surface.

Results – Variety evaluation

Yield

- This trial was conducted on a tough red soil type at the Tamworth Agricultural Institute. This is a long term paddock where we conduct crown rot trials as it has a low water holding capacity which facilitates yield loss assessment even in wetter years such as 2010. Rainfall in June unfortunately delayed sowing until July with dry conditions after sowing limiting the development of crown rot until late in the season. The varieties therefore produced relatively low biomass and background crown rot levels, as indicated by PreDicta B at sowing, resulted in moderate levels of infection also in no added CR plots. Even though the addition of CR inoculum caused a 24% reduction in yield averaged across varieties the interaction was not significant at the individual variety level. Yield data is therefore presented as an average of added CR and no added CR treatments for each variety (Figure 1).
- LRPB Lancer⁽ᵈ⁾ was 0.30 t/ha and LRPB Spitfire⁽ᵈ⁾ 0.19 t/ha higher yielding than EGA_Gregory⁽ᵈ⁾ under high crown rot pressure (Figure 1).

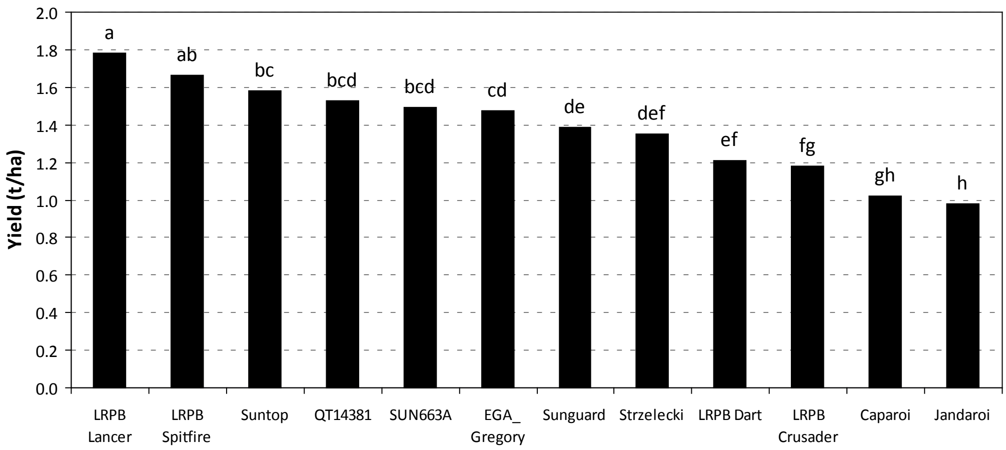


Figure 1. *Yield (t/ha @ 11% moisture) of varieties (average no added and added crown rot treatments) – Tamworth 2013.*

Protein

- Crown rot infection did not impact on protein levels in any variety.
- Protein levels ranged between 11.0% (QT14381) up to 14.9% (Jandaroi⁽ᵈ⁾; Figure 2).

- Even though QT14381 and EGA_Gregory⁽ᵈ⁾ were the lowest protein achievers at this site their grain N removal was only significantly lower than LRPB Lancer⁽ᵈ⁾ and LRPB Spitfire⁽ᵈ⁾ but were actually significantly higher than Caparoi⁽ᵈ⁾. Protein levels are influenced by dilution or concentration within grain with increasing or decreasing yield, respectively.

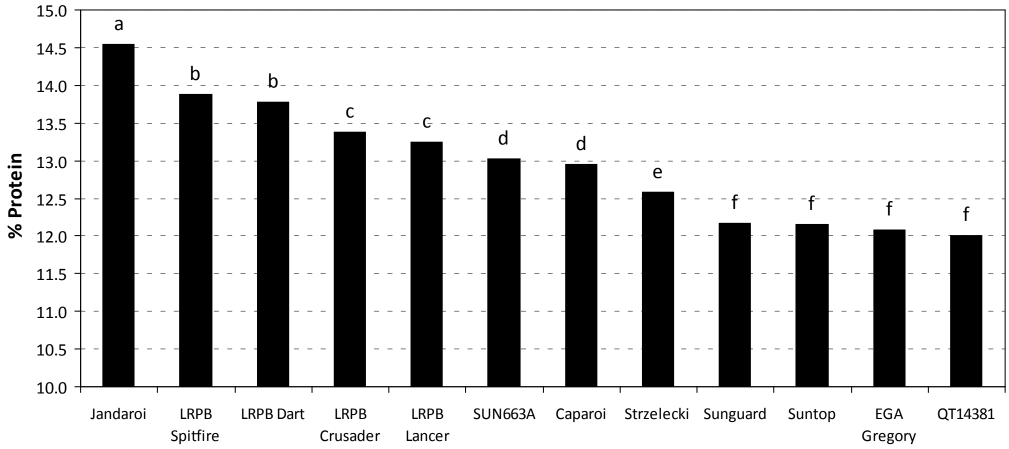


Figure 2. *Average protein concentration achieved by varieties – Tamworth 2013. Bars with the same letter are not significantly different (P=0.05).*

Results – Fungicide application evaluation

Yield

- None of the fungicide application techniques significantly affected yield under moderate background crown rot levels in the no added CR treatment (Figure 3).
- Under higher crown rot levels (added CR) all fungicide application techniques significantly increased yield by between 0.16 t/ha (above crop) to 0.24 t/ha (droppers).
- Slashing at GS30 did not significantly impact on yield under either moderate (no added CR) or high (added CR) crown rot levels.

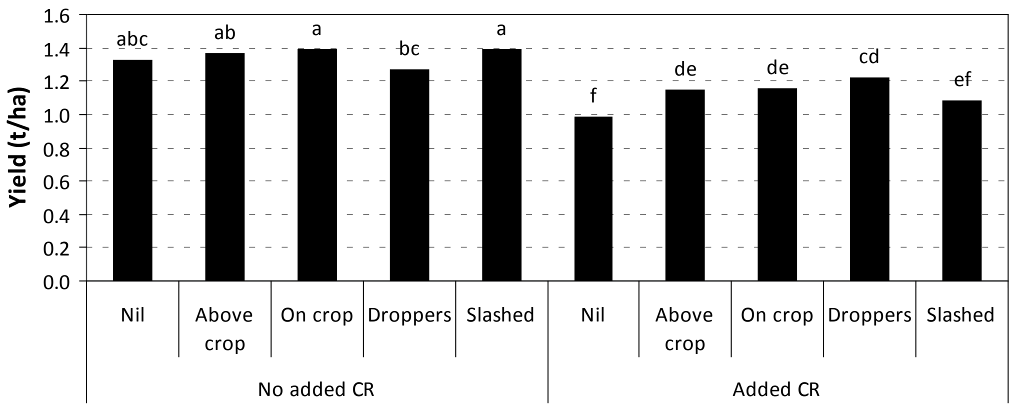


Figure 3. *Effect of fungicide application technique on grain yield of EGA_Gregory⁽ᵈ⁾ with no added or added crown rot inoculum – Tamworth. Bars with the same letter are not significantly different (P=0.05).*

Protein

- Protein was reduced by 0.5% in added CR treatments when averaged across treatments.
- Fungicide application or slashing did not significantly affect protein levels compared to nil treatments.

Acknowledgements

This project was co-funded by NSW DPI and GRDC under the National Crown Rot Management and Epidemiology Project (DAN00175). Thanks to NSW DPI for providing the trial site and to Paul Nash for assistance with sowing and harvest of the trial.

Regional crown rot management – Terry Hie Hie 2013

Steven Simpfendorfer, Finn Fensbo and Robyn Shapland NSW DPI, Tamworth

Key findings

All bread wheat varieties (except Strzelecki⁽ᵈ⁾) were between 0.64 t/ha to 1.59 t/ha higher yielding than EGA_Gregory⁽ᵈ⁾ under high levels of crown rot infection.

Under high crown rot levels all fungicide application techniques significantly increased yield by between 0.38 t/ha (above crop) to 0.54 t/ha (droppers). However, fungicide application **does not** provide complete control being 0.77 to 0.93 t/ha lower yielding than no fungicide application in the no added CR treatment.

Slashing at GS30 reduced yield by 0.30 t/ha at low infection levels but significantly increased yield by 0.29 t/ha in the presence of high crown rot infection.

Introduction

Crown rot (CR) caused predominantly by the fungus *Fusarium pseudograminearum* (*Fp*), remains a major constraint to the production of winter cereals in the northern grains region. Root lesion nematodes (RLN's) are also a wide spread constraint to wheat production across the region. Two important species of RLN exist throughout the northern region, namely *Pratylenchus thornei* (*Pt*) and *P. neglectus* (*Pn*). Previous surveys have found that *Pt* is more widespread and generally at higher populations than *Pn*. Recent collaborative research between Northern Grower Alliance and NSW DPI has also established that the presence of RLN feeding within root systems increases the severity of crown rot.

Cereal varieties differ in their tolerance to crown rot and either species of RLN. This can have a significant impact on the relative yield of varieties in the presence of these various disease constraints. This trial is one of nine conducted by NSW DPI in 2013 across central/northern NSW extending into southern Qld to examine the impact of crown rot and RLN on the yield of two durum and ten bread wheat varieties.

Control of crown rot using fungicides has been studied extensively with limited success and quite variable outcomes. No fungicides are currently registered for the control of crown rot in winter cereals either as seed or in-furrow treatments or in-crop sprays. As the name implies, crown rot primarily infects the base of plants through the sub-crown internode, crown and/or outer leaf sheaths at the base of tillers at the soil surface.

The second trial aimed to take a step back in the approach of using foliar fungicides to determine if targeting application at the base of tillers might improve the level of control and provide more consistent effects. The reduction of crop canopy through slashing around GS30 was also examined for its potential to impact on crown rot expression and yield.

Site details

Location:	**"Maneroo", Terry Hie Hie**
Co-operator:	**David Anderson**
Sowing date:	**29th May 2013**
Fertiliser:	**180 kg/ha Urea and 70 kg/ha Granulock Supreme Z at sowing**
Starting N:	**93 kg/ha nitrate N to 1.2 m**
Starting water:	**~175 mm (0–180 cm)**
In-crop rainfall:	**123 mm**
PreDicta B:	**Nil RLN, 1.1 log *Fusarium* DNA/g (low risk), 1.7 log *Bipolaris* DNA/g**
Treatment date:	**All 1st August at GS31**
Harvest date:	**28th October 2013**

Treatments

Variety evaluation

- Two durum varieties (Caparoi⁽ᵈ⁾ and Jandaroi⁽ᵈ⁾)
- Eight commercial bread wheat varieties (EGA_Gregory⁽ᵈ⁾, Strzelecki⁽ᵈ⁾, LRPB Dart⁽ᵈ⁾, LRPB Lancer⁽ᵈ⁾, LRPB Crusader⁽ᵈ⁾, LRPB Spitfire⁽ᵈ⁾, Suntop⁽ᵈ⁾ and Sunguard⁽ᵈ⁾; listed in order of increasing resistance to crown rot).

- Two numbered bread wheat lines (SUN663A and QT14381)
- Added or no added crown rot at sowing using sterilised durum grain colonised by at least five different isolates of *Fp*.

Fungicide application evaluation

- EGA_Gregory⊕ with added or no added crown rot at sowing using infected durum grain.
- One fungicide (Prosaro® at 300 mL/ha + 0.25% chemwet 1000).
- Three in-crop application strategies at GS31 using Turbo Teejet (110015) nozzles at ~300 L/ha.
  - Above crop – foliar spray 50 cm above crop height (i.e. normal rust spray with most of product deposited on upper leaf surfaces).
  - On crop – boom dropped to crop height and nozzles moved between wheat rows (i.e. product hitting base of plant and soil).
  - Droppers – solid rod from boom down to below canopy height then two nozzles angled at ~45 degrees towards base of tillers on opposite crop rows (i.e. all of product targeted at base of plants).
- One slashing treatment using a cutter bar at GS30-31 with cut leaf material left on soil surface.

Results – Variety evaluation

Yield

- Sunguard⊕ was the only variety to not suffer significant yield loss from crown rot infection. The remaining varieties suffered yield losses between 14% (0.59 t/ha) in QT14381 up to 40% (1.31 t/ha) in Caparoi⊕ (Figure 1).
- With the exception of Strzelecki⊕, all bread wheat varieties were between 0.64 t/ha (SUN663A) to 1.59 t/ha (Sunguard⊕) higher yielding than EGA_Gregory⊕ in the added CR treatment (Figure 1).

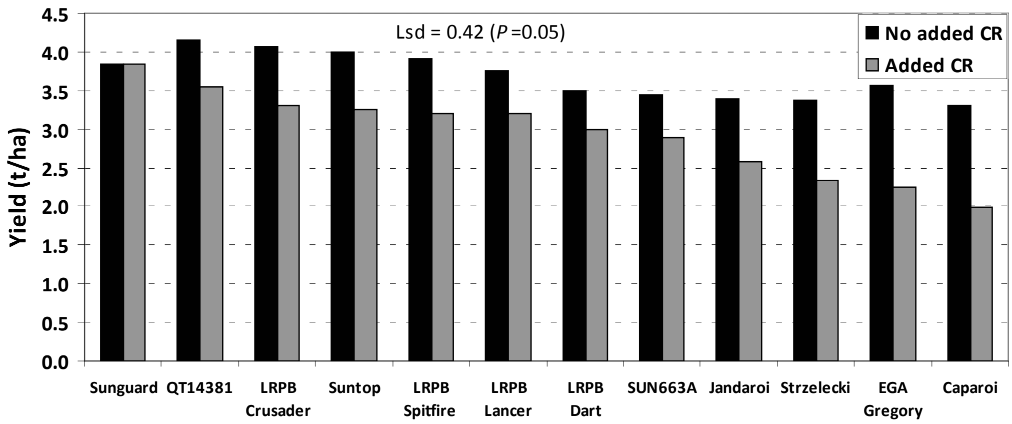


Figure 1. *Yield (t/ha @ 11% moisture) of varieties with no added and added crown rot – Terry Hie Hie 2013.*

Protein

- The addition of crown rot inoculum at sowing significantly changed protein levels in two varieties. The addition of CR inoculum increased protein levels in Jandaroi⊕ by 0.5% but reduced protein in Sunguard⊕ by 0.7%.
- Protein levels ranged between 11.6% (QT14381) up to 13.4% (Jandaroi⊕; Figure 2).
- Even though Suntop⊕ and QT14381 were amongst the lowest protein achievers at this site their grain N removal in no added CR treatments was not significantly different from varieties which achieved higher protein. Their grain N removal was actually higher than Jandaroi⊕ which was the highest protein achiever at this site. Protein levels are influenced by dilution or concentration within grain with increasing or decreasing yield, respectively.

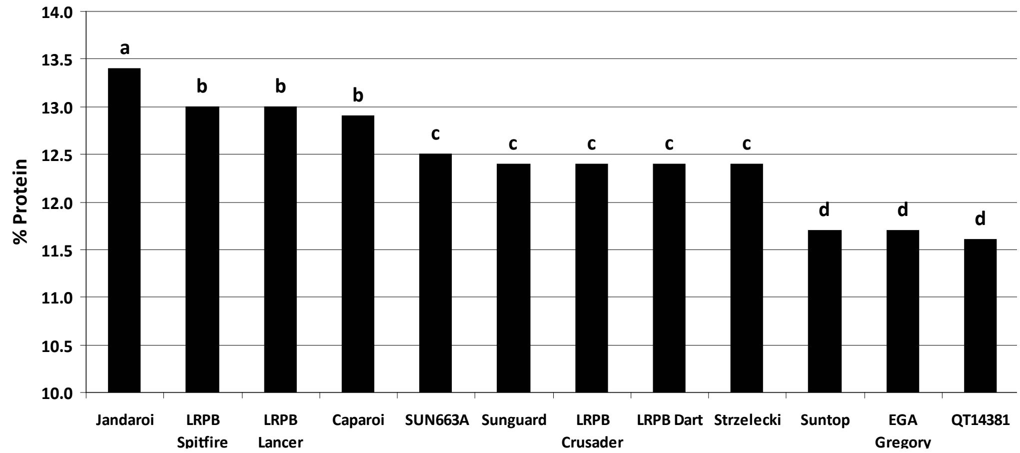


Figure 2. *Average protein concentration achieved by varieties – Terry Hie Hie 2013. Bars with the same letter are not significantly different (P=0.05).*

Results – Fungicide application evaluation

Yield

- Under background levels of infection (no added CR) the above crop and dropper applications increased yield by 0.42 t/ha over the nil treatment (Figure 3).
- Under high crown rot pressure (added CR) all fungicide application techniques increased yield by 0.38 t/ha (above crop) to 0.54 t/ha (droppers) compared to no fungicide application (Figure 3).
- However, fungicide application **did not** provide complete control of crown rot still being 0.77 t/ha (droppers) to 0.93 t/ha (above crop) lower yielding than no fungicide application under lower infection levels (no added CR).
- Slashing at GS31 reduced yield by 0.30 t/ha with no added CR but significantly increased yield by 0.29 t/ha in the added CR treatment.

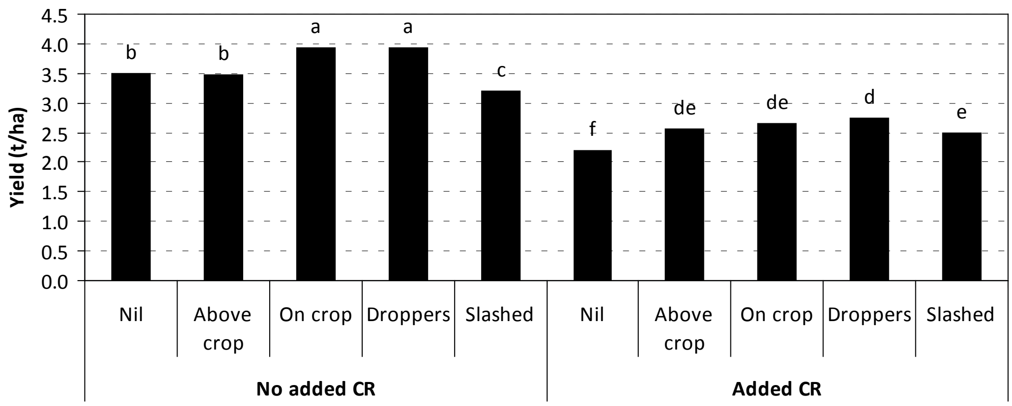


Figure 3. *Effect of fungicide application technique on grain yield of EGA_Gregory⊕ with no added or added crown rot inoculum – Terry Hie Hie 2013. Bars with the same letter are not significantly different (P=0.05).*

Protein

- Protein levels were slightly lower (0.2%) in the added CR treatment.
- Slashing at GS31 reduced grain protein by 0.7 to 0.8% compared to other treatments.

Acknowledgements

This project was co-funded by NSW DPI and GRDC under the National Crown Rot Management and Epidemiology Project (DAN00175). Thanks to David Anderson for providing the trial site and to Matt Gardner, Stephen Morphett, Jim Perfrement, Patrick Mortell, Peter Formann and Rod Bambach (all NSW DPI) for sowing, maintaining and harvesting the trial.

Regional crown rot management – Bithramere 2013

Steven Simpfendorfer, Finn Fensbo and Robyn Shapland NSW DPI, Tamworth

Introduction

Crown rot (CR) caused predominantly by the fungus *Fusarium pseudograminearum* (*Fp*), remains a major constraint to the production of winter cereals in the northern grains region. Root lesion nematodes (RLN's) are also a wide spread constraint to wheat production across the region. Two important species of RLN exist throughout the northern region, namely *Pratylenchus thornei* (*Pt*) and *P. neglectus* (*Pn*). Previous surveys have found that *Pt* is more widespread and generally at higher populations than *Pn*. Recent collaborative research between Northern Grower Alliance and NSW DPI has also established that the presence of RLN feeding within root systems increases the severity of crown rot.

Cereal varieties differ in their tolerance to crown rot and either species of RLN. This can have a significant impact on the relative yield of varieties in the presence of these various disease constraints. This site is one of nine trials conducted by NSW DPI in 2013 across central/northern NSW extending into southern Qld to examine the impact of crown rot and RLN on the yield of two durum and ten bread wheat varieties.

Control of crown rot using fungicides has been studied extensively with limited success and quite variable outcomes. No fungicides are currently registered for the control of crown rot in winter cereals either as seed or in-furrow treatments or in-crop sprays. As the name implies, crown rot primarily infects the base of plants through the sub-crown internode, crown and/or outer leaf sheaths at the base of tillers at the soil surface.

The second trial at these sites aimed to take a step back in the approach of using foliar fungicides to determine if targeting application at the base of tillers might improve the level of control and provide more consistent effects. The reduction of crop canopy through slashing at GS30 was also examined for its potential to impact on crown rot expression and yield.

Key findings

This site had a high background level of crown rot as indicated by PreDicta B at sowing.

All bread wheat varieties (except Strzelecki⁽ᐩ⁾) were between 0.58 t/ha to 1.26 t/ha higher yielding than EGA_Gregory⁽ᐩ⁾ under ***high*** levels of crown rot infection.

All bread wheat varieties (except Strzelecki⁽ᐩ⁾) were between 0.78 t/ha to 1.68 t/ha higher yielding than EGA_Gregory⁽ᐩ⁾ under ***extreme*** levels of crown rot infection.

All fungicide application techniques provided a modest increase in yield of between 0.19 t/ha to 0.25 t/ha and slashing at GS30 did not significantly affect yield.

Site details

Location:	**"Wheatacres", Bithramere**
Co-operator:	**Richard & Michael Bowler**
Sowing date:	**7th June 2013**
Fertiliser:	**50 kg/ha Granulock Supreme Z at sowing**
Starting N:	**180 kg/ha nitrate N to 120 cm**
Starting water:	**~194 mm PAW (0–120 cm)**
In-crop rainfall:	**119 mm**
PreDicta B:	**2.0 *Pn*/g soil (medium risk), 3.4 log *Fusarium* DNA/g (high risk)**
Treatment date:	**All 6th August at GS30**
Harvest date:	**21st November 2013**

Treatments

Variety evaluation

- Two durum varieties (Caparoi⁽ᐩ⁾ and Jandaroi⁽ᐩ⁾).
- Eight commercial bread wheat varieties (EGA_Gregory⁽ᐩ⁾, Strzelecki⁽ᐩ⁾, LRPB Dart⁽ᐩ⁾, LRPB Lancer⁽ᐩ⁾, LRPB Crusader⁽ᐩ⁾, LRPB Spitfire⁽ᐩ⁾, Suntop⁽ᐩ⁾ and Sunguard⁽ᐩ⁾; listed in order of increasing resistance to crown rot).

- Two numbered bread wheat lines (SUN663A and QT14381)
- Added or no added crown rot at sowing using sterilised durum grain colonised by at least five different isolates of *Fp*.

Fungicide application evaluation

- EGA_Gregory⍉ with added or no added crown rot at sowing using infected durum grain.
- One fungicide (Prosaro® at 300 mL/ha + 0.25% chemwet 1000).
- Three in-crop application strategies all at GS 30-31 using Turbo Teejet (110015) nozzles at ~300 L/ha.
  - Above crop – foliar spray 50 cm above crop height (i.e. normal rust spray with most of product deposited on upper leaf surfaces).
  - On crop – boom dropped to crop height and nozzles moved between wheat rows (i.e. product hitting base of plant and soil).
  - Droppers – solid rod from boom down to below canopy height then two nozzles angled at ~45 degrees towards base of tillers on opposite crop rows (i.e. all of product targeted at base of plants).
- One slashing treatment using a cutter bar at GS30-31 with cut leaf material left on soil surface.

Results – Variety evaluation

Yield

- This site had a high level of background infection with crown rot across the site as predicted by PreDicta B analysis at sowing. The site also has a medium risk level of *Pn*. Determining the impact of *Pn* is difficult as all varieties in the trial are rated moderately intolerant to *Pn*.
- The impact of crown rot on yield (tolerance) is determined by comparing no added CR plots and added CR plots. This would underestimate the yield impacts from crown rot as high inoculum levels already existed across this site. There is no way to determine what the yield of each variety would have been at this site in the absence of crown rot infection. Hence, the no added CR plots represent a high infection level and the added CR plots represent an extreme infection level.
- Under high crown rot infection (no added CR) all bread wheat varieties (except Strzelecki⍉) were between 0.58 t/ha (LRPB Crusader⍉) to 1.26 t/ha (LRPB Spitfire⍉) higher yielding than EGA_Gregory⍉.
- Under extreme crown rot infection (added CR) all bread wheat varieties (except Strzelecki⍉) were between 0.78 t/ha (SUN663A) to 1.68 t/ha (LRPB Spitfire⍉) higher yielding than EGA_Gregory⍉.
- Jandaroi⍉ was higher yielding than Caparoi⍉ under both high and extreme infection levels but both durum varieties are very susceptible to crown rot and lower yielding than all bread wheat varieties except Strzelecki⍉ and EGA_Gregory⍉ which are both rated as susceptible to crown rot.
- Varieties with improved resistance to crown rot also have increased yield (tolerance) in the presence of this disease. Selecting varieties with improved tolerance to crown rot can have a large impact on profit in the presence of this disease constraint.
- PreDicta B assessment prior to sowing can identify high risk paddocks to allow growers to implement appropriate management strategies and/or avoid sowing more susceptible varieties.

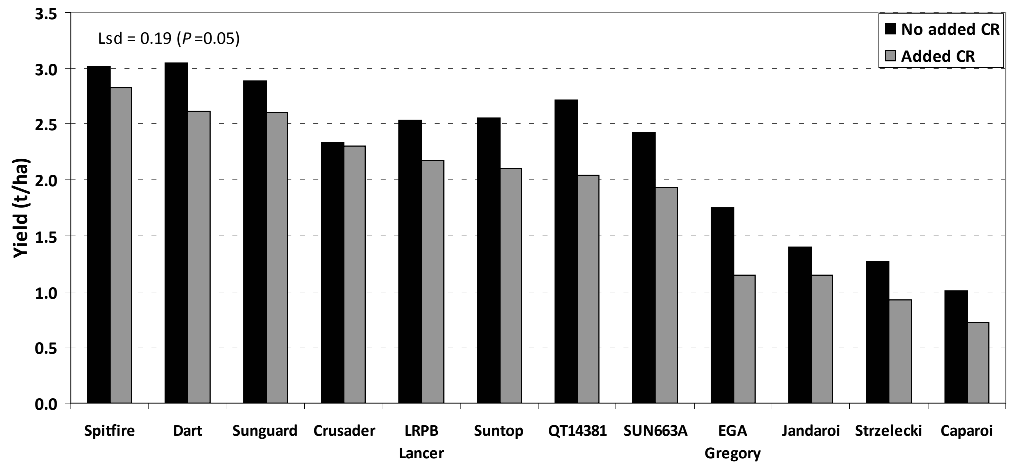


Figure 1. *Yield (t/ha @ 11% moisture) of varieties with no added and added crown rot – Bithramere 2013.*

Protein

- The addition of crown rot inoculum at sowing did not significantly change protein levels in any variety.
- Protein levels were quite high at this site ranging between 13.1% (EGA_Gregory⁽ᵗ⁾) up to 15.6% (LRPB Spitfire⁽ᵗ⁾; Figure 2).

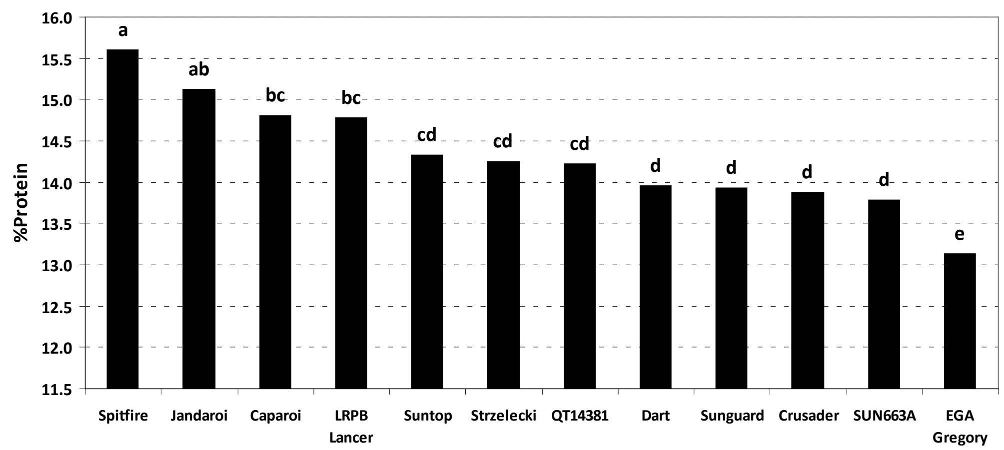


Figure 2. *Average protein concentration achieved by varieties – Bithramere 2013. Bars with the same letter are not significantly different (P=0.05).*

Results – Fungicide application evaluation

Yield

- The effect of treatments was not significant at the added CR versus no added CR level due to high levels of background crown rot infection across the trial site as predicted at sowing using PreDicta B.
- All fungicide application techniques provided a modest increase in yield of between 0.19 t/ha (above crop) to 0.25 t/ha (on crop and droppers; Figure 3).
- Slashing at GS30 did not significantly affect yield compared to the nil treatment but was significantly lower than the fungicide treatments.

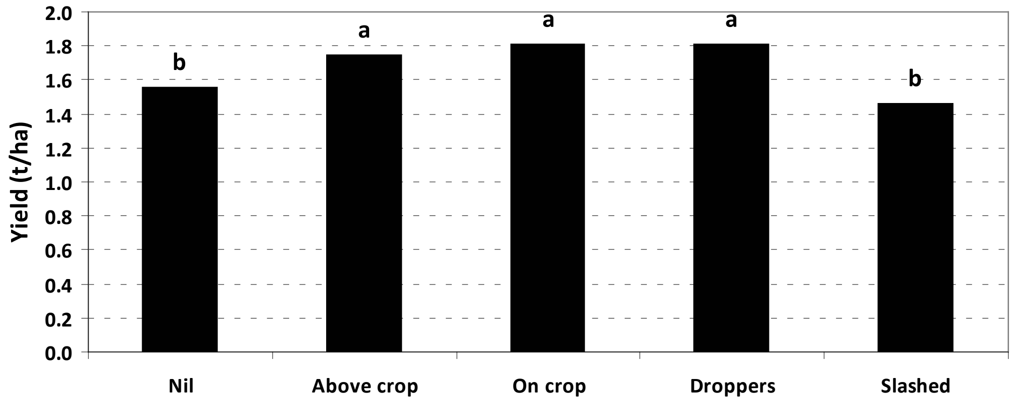


Figure 3. *Effect of fungicide application technique on grain yield in EGA_Gregory⁽ᴰ⁾ (average of no added or added CR plots) – Bithramere 2013. Bars with the same letter are not significantly different (P=0.05).*

Protein

- Protein levels were slightly lower (0.3%) in the added CR treatment.
- The on crop fungicide application increased protein by 0.3% while application with droppers provided a 0.5% increase in grain protein levels. The remaining treatments did not significantly affect protein.

Acknowledgements

This project was co-funded by NSW DPI and GRDC under the National Crown Rot Management and Epidemiology Project (DAN00175). Thanks to the Bowler Family for providing the trial site and to Matt Gardner, Stephen Morphett, Jim Perfrement, Patrick Mortell, Peter Formann and Rod Bambach (all NSW DPI) for sowing, maintaining and harvesting trial.

Regional crown rot management – Spring Ridge 2013

Steven Simpfendorfer, Finn Fensbo and Robyn Shapland NSW DPI, Tamworth

Introduction

Crown rot (CR) caused predominantly by the fungus *Fusarium pseudograminearum* (*Fp*), remains a major constraint to the production of winter cereals in the northern grains region. Root lesion nematodes (RLNs) are also a wide spread constraint to wheat production across the region. Two important species of RLN exist throughout the northern region, namely *Pratylenchus thornei* (*Pt*) and *P. neglectus* (*Pn*). Previous surveys have found that *Pt* is more widespread and generally at higher populations than *Pn*. Recent collaborative research between Northern Grower Alliance and NSW DPI has also established that the presence of RLN feeding within root systems increases the severity of crown rot.

Cereal varieties differ in their tolerance to crown rot and either species of RLN. This can have a significant impact on the relative yield of varieties in the presence of these various disease constraints. This trial is one of nine conducted by NSW DPI in 2013 across central/northern NSW extending into southern Qld to examine the impact of crown rot and RLN on the yield of two durum and ten bread wheat varieties.

Control of crown rot using fungicides has been studied extensively with limited success and quite variable outcomes. No fungicides are currently registered for the control of crown rot in winter cereals either as seed or in-furrow treatments or in-crop sprays. As the name implies, crown rot primarily infects the base of plants through the sub-crown internode, crown and/or outer leaf sheaths at the base of tillers at the soil surface.

The second trial aimed to take a step back in the approach of using foliar fungicides to determine if targeting application at the base of tillers might improve the level of control and provide more consistent effects. The reduction of crop canopy through slashing around GS30 was also examined for its potential to impact on crown rot expression and yield.

Key findings

All bread wheat varieties (except Strzelecki(ᶲ)) were between 0.42 t/ha to 1.11 t/ha higher yielding than EGA_Gregory(ᶲ) under high levels of crown rot infection.

Under high crown rot levels all fungicide application techniques significantly increased yield by between 0.35 t/ha (above crop) to 0.53 t/ha (droppers). However, fungicide application **does not** provide complete control being 0.52 to 0.70 t/ha lower yielding than no fungicide application at a lower level of crown rot infection.

Slashing did not affect yield with no added CR but provided a 0.53 t/ha benefit with added CR.

CROP PROTECTION

Site details

Location:	**"Yoorooga", Spring Ridge**
Co-operator:	**Angus Murchison**
Sowing date:	**23rd June 2013**
Fertiliser:	**50 kg/ha Granulock Supreme Z at sowing**
Starting N:	**200 kg/ha nitrate N to 1.2 m**
In-crop rainfall:	**105 mm**
PreDicta B:	**Nil RLN, 2.0 log *Fusarium* DNA/g (medium risk)**
Treatment date:	**All 27th August at GS30**
Harvest date:	**27th November 2013**

Treatments

Variety evaluation

- Two durum varieties (Caparoi⁽ᴾ⁾ and Jandaroi⁽ᴾ⁾).
- Eight commercial bread wheat varieties (EGA_Gregory⁽ᴾ⁾, Strzelecki⁽ᴾ⁾, LRPB Dart⁽ᴾ⁾, LRPB Lancer⁽ᴾ⁾, LRPB Crusader⁽ᴾ⁾, LRPB Spitfire⁽ᴾ⁾, Suntop⁽ᴾ⁾ and Sunguard⁽ᴾ⁾; listed in order of increasing resistance to crown rot).
- Two numbered bread wheat lines (SUN663A and QT14381).
- Added or no added crown rot at sowing using sterilised durum grain colonised by at least five different isolates of *Fp*.

Fungicide application evaluation

- EGA_Gregory⁽ᴾ⁾ with added or no added crown rot at sowing using infected durum grain.
- One fungicide (Prosaro® at 300 mL/ha + 0.25% chemwet 1000).
- Three in-crop application strategies all at GS 30-31 using Turbo Teejet (110015) nozzles at ~300 L/ha.
  - Above crop – foliar spray 50 cm above crop height (i.e. normal rust spray with most of product deposited on upper leaf surfaces).
  - On crop – boom dropped to crop height and nozzles moved between wheat rows (i.e. product hitting base of plant and soil).
  - Droppers – solid rod from boom down to below canopy height then two nozzles angled at ~45 degrees towards base of tillers on opposite crop rows (i.e. all of product targeted at base of plants).
- One slashing treatment using a cutter bar at GS30-31 with cut leaf material left on soil surface.

Whitehead assessment

- Each plot was scored for the extent of whitehead development on a 0 to 10 scale (0 = no whiteheads, 10 = 100% whiteheads) on the 5th of November.

Results – Variety evaluation

Yield

- Yield loss from added CR ranged from 9% in EGA_Gregory⁽ᴾ⁾ (0.38 t/ha) up to 26% in Strzelecki⁽ᴾ⁾ (1.28 t/ha).
- Yield loss in the two durum varieties with added CR was 0.71 t/ha with Caparoi⁽ᴾ⁾ and 0.93 t/ha with Jandaroi⁽ᴾ⁾.
- Yield loss in added CR plots was not significant in LRPB Spitfire⁽ᴾ⁾ and LRPB Lancer⁽ᴾ⁾. Background levels of crown rot across this site are likely to have resulted in an underestimation of the full extent of yield loss from crown rot infection.
- With the exception of Strzelecki⁽ᴾ⁾, all bread wheat varieties were between 0.42 t/ha (Sunguard⁽ᴾ⁾) to 1.11 t/ha (LRPB Crusader⁽ᴾ⁾) higher yielding than EGA_Gregory⁽ᴾ⁾ in the added CR treatment (Figure 1).

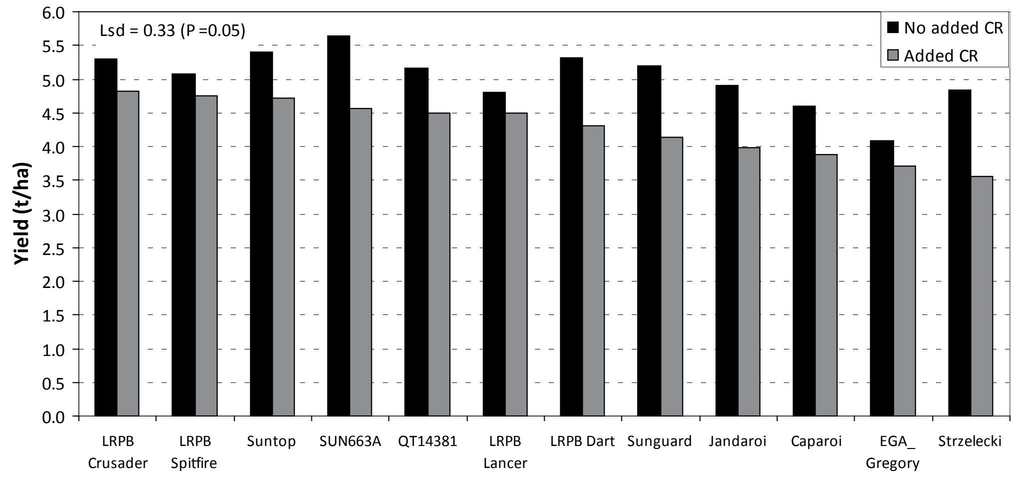


Figure 1. *Yield (t/ha @ 11% moisture) of varieties with no added and added crown rot – Spring Ridge 2013.*

Protein

- Crown rot infection did not impact on protein levels in any variety.
- Protein levels ranged between 11.4% (SUN663A) up to 13.0% (Jandaroi⊕; Figure 2).
- Even though Suntop⊕ was amongst the lower protein achievers at this site its grain N removal in no added CR treatments was only significantly lower than Jandaroi⊕ and LRPB Spitfire⊕ and was actually significantly higher than Strzelecki⊕, LRPB Lancer⊕ and EGA_Gregory⊕. Protein levels are influenced by dilution or concentration within grain with increasing or decreasing yield, respectively.

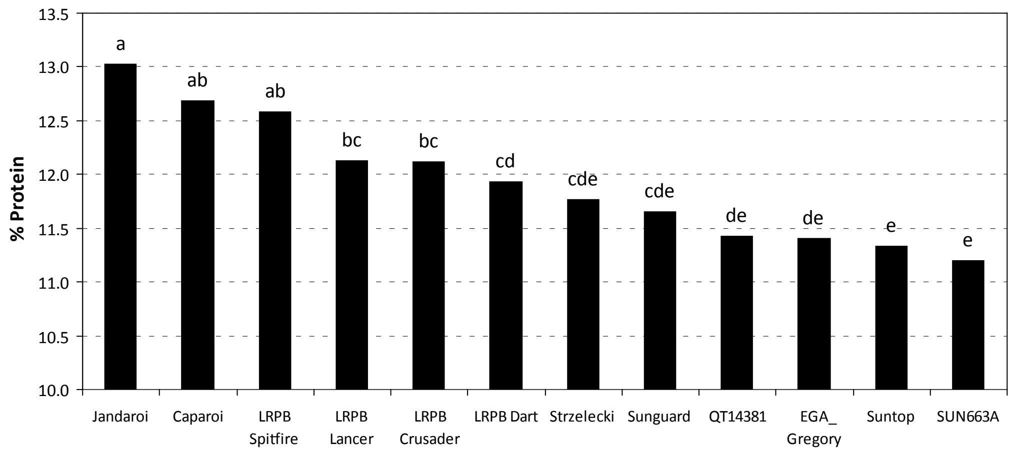


Figure 2. *Average protein concentration achieved by varieties – Spring Ridge 2013. Bars with the same letter are not significantly different (P=0.05).*

Results – Fungicide application evaluation

Yield

- Fungicide application using on crop or dropper techniques provided a modest (0.20 t/ha) yield benefit in the no added CR treatment.
- Under high crown rot levels (added CR) all fungicide application techniques significantly increased yield by between 0.35 t/ha (above crop) to 0.53 t/ha (droppers). However, fungicide application **did not** provide complete control being 0.52 to 0.70 t/ha lower yielding than no fungicide application at lower levels of crown rot infection (no added CR).
- The on crop and dropper techniques reduced the number of whiteheads by around 10% compared to the nil treatment averaged across added and no added CR infection levels.
- Slashing did not affect yield with no added CR but provided a 0.53 t/ha benefit with added CR.

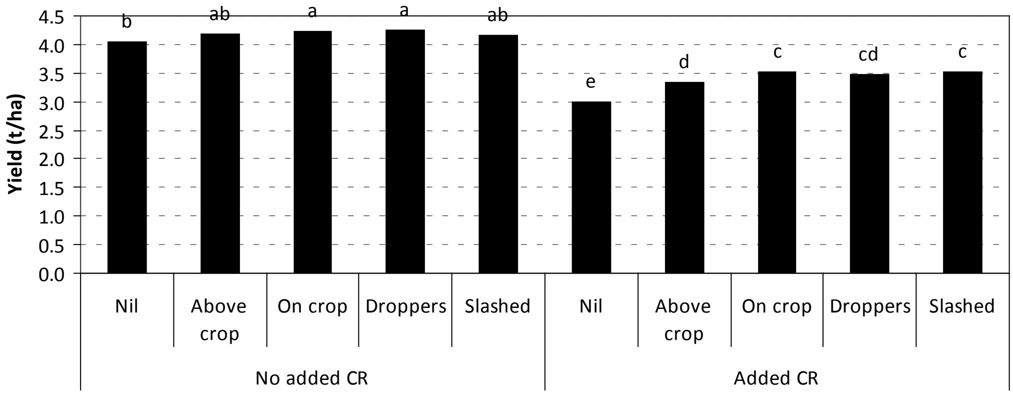


Figure 3. *Effect of fungicide application technique on grain yield of EGA_Gregory⁽ᵇ⁾ with no added or added crown rot inoculum – Spring Ridge 2013. Bars with the same letter are not significantly different (P=0.05).*

Protein

- Protein levels were slightly lower (0.4%) in the added CR treatment.
- None of the fungicide treatments or slashing significantly influenced protein levels.

Acknowledgements

This project was co-funded by NSW DPI and GRDC under the National Crown Rot Management and Epidemiology Project (DAN00175). Thanks to Angus Murchison for providing the trial site and to Matt Gardner, Stephen Morphett, Jim Perfrement, Patrick Mortell, Peter Formann and Rod Bambach (all NSW DPI) for sowing, maintaining and harvesting the trial.

Regional crown rot management – Coonamble 2013

Steven Simpfendorfer, Finn Fensbo, Robyn Shapland NSW DPI, Tamworth
Greg Brooke, Jayne Jenkins, Leigh Jenkins NSW DPI, Trangie **Rohan Brill** NSW DPI, Wagga Wagga

Key findings

QT14381, LRPB Lancer⊕, LRPB Spitfire⊕ and Sunguard⊕ were between 0.93 t/ha to 0.54 t/ha higher yielding than EGA_Gregory⊕ under high crown rot pressure.

Targeting fungicide application at the base of plants increased yield under high crown rot pressure by 0.57 t/ha with droppers and 0.44 t/ha with the on crop application. However, these strategies **do not** provide complete control still being 1.21–1.34 t/ha lower yielding than no fungicide application under lower crown rot levels. Application 50 cm above crop height provided no benefit.

Slashing reduced yield by 0.57 t/ha with no added CR but had no yield penalty with added CR.

CROP PROTECTION

Introduction

Crown rot (CR) caused predominantly by the fungus *Fusarium pseudograminearum* (*Fp*), remains a major constraint to the production of winter cereals in the northern grains region. Root lesion nematodes (RLN's) are also a wide spread constraint to wheat production across the region. Two important species of RLN exist throughout the northern region, namely *Pratylenchus thornei* (*Pt*) and *P. neglectus* (*Pn*). Previous surveys have found that *Pt* is more widespread and generally at higher populations than *Pn*. Recent collaborative research between Northern Grower Alliance and NSW DPI has also established that the presence of RLN feeding within root systems increases the severity of crown rot.

Cereal varieties differ in their tolerance to crown rot and either species of RLN. This can have a significant impact on the relative yield of varieties in the presence of these various disease constraints. This site is one of nine conducted by NSW DPI in 2013 across central/northern NSW extending into southern Qld to examine the impact of crown rot and RLN on the yield of two durum and ten bread wheat varieties.

Control of crown rot using fungicides has been studied extensively with limited success and quite variable outcomes. No fungicides are currently registered for the control of crown rot in winter cereals either as seed or in-furrow treatments or in-crop sprays. As the name implies, crown rot primarily infects the base of plants through the sub-crown internode, crown and/or outer leaf sheathes at the base of tillers at the soil surface.

The second trial aimed to take a step back in the approach of using foliar fungicides to determine if targeting application at the base of tillers might improve the level of control and provide more consistent effects. The reduction of crop canopy through slashing around GS30 was also examined for its potential to impact on crown rot expression and yield.

Site details

Location:	**"Narratigah", Coonamble**
Co-operator:	**John, Mary and Tony Single**
Sowing date:	**15th May 2013**
In-crop rainfall:	**~140 mm**
PreDicta B:	**Nil RLN, 1.7 log *Fusarium* DNA/g (medium risk) and 1.1 log *Bipolaris* DNA/g**
Treatment date:	**All 31st July at GS31**
Harvest date:	**14th November 2013**

Treatments

Variety evaluation

- Two durum varieties (Caparoi⊕ and Jandaroi⊕).
- Eight commercial bread wheat varieties (EGA_Gregory⊕, Strzelecki⊕, LRPB Dart⊕, LRPB Lancer⊕, LRPB Crusader⊕, LRPB Spitfire⊕, Suntop⊕ and Sunguard⊕; listed in order of increasing resistance to crown rot).
- Two numbered bread wheat lines (SUN663A and QT14381).
- Added or no added crown rot at sowing using sterilised durum grain colonised by at least five different isolates of *Fp*.

Fungicide application evaluation

- EGA_Gregory⁽ᵈ⁾ with added or no added crown rot at sowing using infected durum grain.
- One fungicide (Prosaro® at 300 mL/ha + 0.25% chemwet 1000).
- Three in-crop application strategies all at GS 30-31 using Turbo Teejet (110015) nozzles at ~300 L/ha.
  - Above crop – foliar spray 50 cm above crop height (i.e. normal rust spray with most of product deposited on upper leaf surfaces).
  - On crop – boom dropped to crop height and nozzles moved between wheat rows (i.e. product hitting base of plant and soil).
  - Droppers – solid rod from boom down to below canopy height then two nozzles angled at ~45 degrees towards base of tillers on opposite crop rows (i.e. all of product targeted at base of plants).
- One slashing treatment using a cutter bar at GS30-31 with cut leaf material left on soil surface.

Results – Variety evaluation

Yield

- A frost was noted at this site during flowering which appears to have impacted on the yield of the quicker maturing varieties LRPB Dart⁽ᵈ⁾ and Jandaroi⁽ᵈ⁾ and to a lesser extent LRPB Crusader⁽ᵈ⁾. Caution should be taken when interpreting results of these varieties at this site. LRPB Spitfire⁽ᵈ⁾ is also a relatively quick variety but does not appear to have had as big a yield drop off in the no added CR treatment (Figure 1).
- Of the nine sites with this trial design in 2013, this was the only site where a negative effect of crown rot inoculation on crop establishment was noted. We suspect this was a result of a deeper sowing depth and wet soil conditions around sowing. The coleoptiles of all varieties are susceptible to crown rot infection. Deeper sowing has been shown in previous studies to exacerbate seedling death resulting from infection by *Fusarium* species.
- With the exclusion of frost affected varieties, QT14381 was the only variety to not suffer significant yield loss from crown rot infection. The remaining varieties suffered between 16% (–0.77 t/ha) yield loss in LRPB Spitfire⁽ᵈ⁾ up to 34% (–1.73 t/ha) in EGA_Gregory⁽ᵈ⁾ (Figure 1).
- QT14381, LRPB Lancer⁽ᵈ⁾, LRPB Spitfire⁽ᵈ⁾ and Sunguard were between 0.93 t/ha to 0.54 t/ha higher yielding than EGA_Gregory⁽ᵈ⁾ under high crown rot pressure (Figure 1).

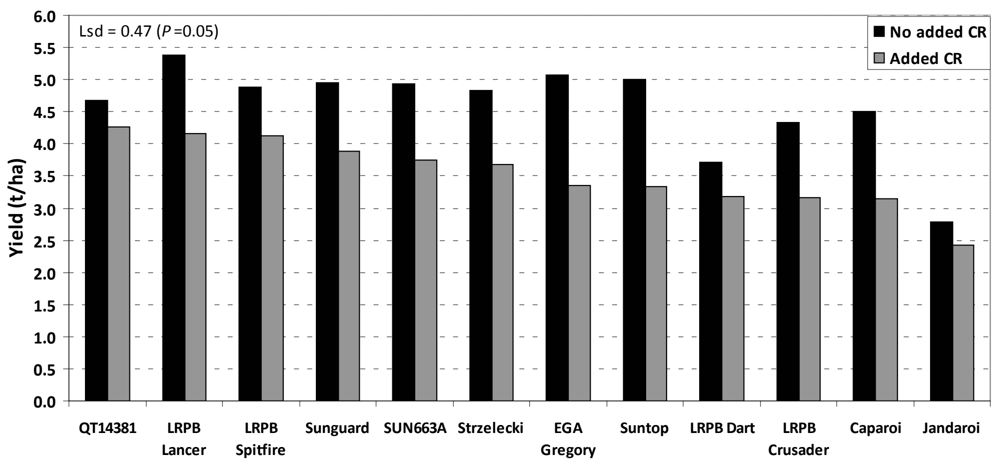


Figure 1. *Yield (t/ha @ 11% moisture) of varieties with no added and added crown rot – Coonamble 2013.*

Protein

- Protein levels ranged between 12.0% (QT14381) up to 14.6% (Jandaroi⁽ᵖ⁾; Figure 2).
- Even though EGA_Gregory⁽ᵖ⁾, Suntop⁽ᵖ⁾ and Sunguard⁽ᵖ⁾ were amongst the lowest protein achievers at this site their grain N removal in absence of crown rot (no added CR) was only significantly lower than LRPB Lancer⁽ᵖ⁾ and LRPB Spitfire⁽ᵖ⁾. Protein levels are influenced by dilution or concentration within grain with increasing or decreasing yield, respectively.

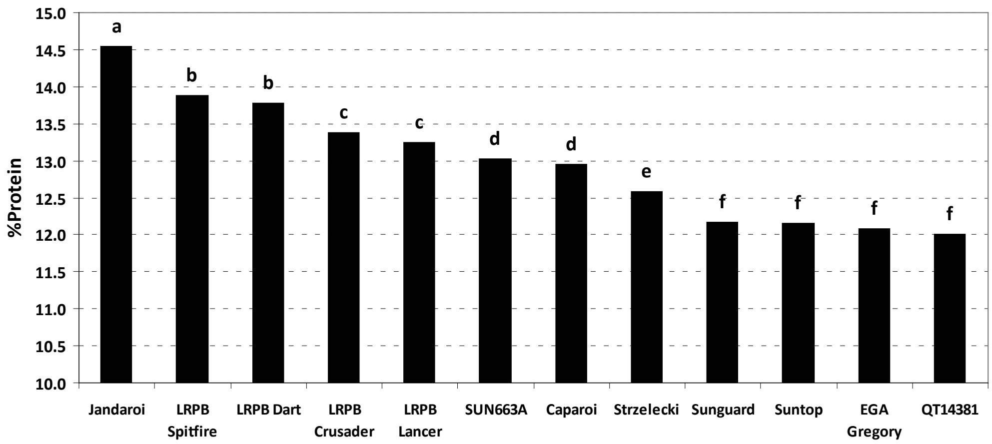


Figure 2. *Average protein concentration achieved by varieties – Coonamble 2013. Bars with the same letter are not significantly different (P=0.05).*

Results – Fungicide application evaluation

Yield

- None of the fungicide application techniques significantly affected yield in the no added CR treatment.
- Under high crown rot pressure (added CR) the on crop application increased yield by 0.44 t/ha and the dropper application by 0.57 t/ha compared to no fungicide application (Figure 3).
- However, fungicide application **did not** provide complete control of crown rot still being 1.34 t/ha (on crop) to 1.21 t/ha (droppers) lower yielding than no fungicide application in the absence of high infection levels (no added CR).
- Fungicide application 50 cm above crop height did not provide a yield benefit with either no added CR or added CR.
- Slashing at GS31 reduced yield by 0.57 t/ha in the no added CR treatment but there was no yield penalty from slashing in the presence of high levels of crown rot infection (added CR).

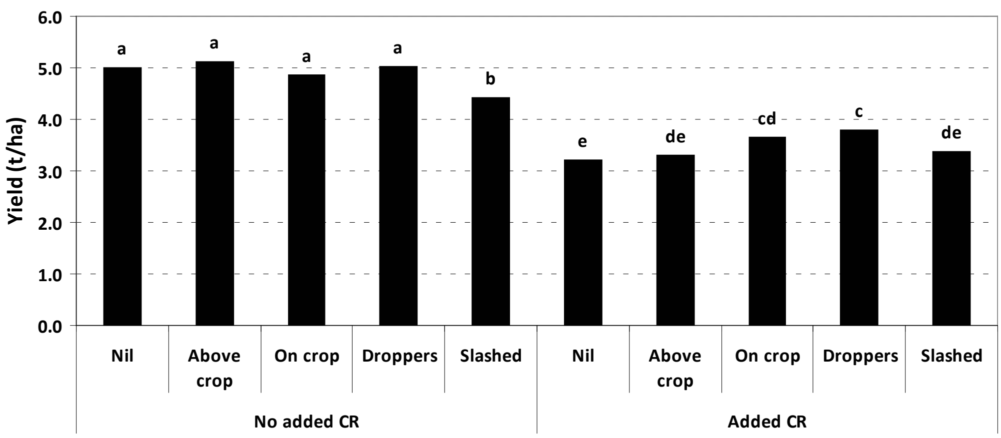


Figure 3. *Effect of fungicide application technique on grain yield of EGA_Gregory⁽ᵖ⁾ with no added or added crown rot inoculum – Coonamble 2013. Bars with the same letter are not significantly different (P=0.05).*

Protein

- Fungicide application and the addition of CR inoculum had no effect while slashing resulted in a small (0.2%) reduction in protein levels.

Acknowledgements

This project was co-funded by NSW DPI and GRDC under the National Crown Rot Management and Epidemiology Project (DAN00175). Thanks to John, Mary and Tony Single for providing the trial site and to Gerard Lonergan (NSW DPI) for assistance in sowing, maintaining and harvesting the trial.

Regional crown rot management – Trangie 2013

Steven Simpfendorfer, Finn Fensbo and Robyn Shapland NSW DPI, Tamworth
Greg Brooke, Jayne Jenkins and Leigh Jenkins NSW DPI, Trangie **Rohan Brill** NSW DPI, Wagga Wagga

Introduction

Crown rot (CR) caused predominantly by the fungus *Fusarium pseudograminearum* (*Fp*), remains a major constraint to the production of winter cereals in the northern grains region. Root lesion nematodes (RLNs) are also a wide spread constraint to wheat production across the region. Two important species of RLN exist throughout the northern region, namely *Pratylenchus thornei* (*Pt*) and *P. neglectus* (*Pn*). Previous surveys have found that *Pt* is more widespread and generally at higher populations than *Pn*. Recent collaborative research between Northern Grower Alliance and NSW DPI has also established that the presence of RLN feeding within root systems increases the severity of crown rot.

Cereal varieties differ in their tolerance to crown rot and either species of RLN. This can have a significant impact on the relative yield of varieties in the presence of these various disease constraints. This trial is one of nine conducted by NSW DPI in 2013 across central/northern NSW extending into southern Qld to examine the impact of crown rot and RLN on the yield of two durum and ten bread wheat varieties.

Control of crown rot using fungicides has been studied extensively with limited success and quite variable outcomes. No fungicides are currently registered for the control of crown rot in winter cereals either as seed or in-furrow treatments or in-crop sprays. As the name implies, crown rot primarily infects the base of plants through the sub-crown internode, crown and/or outer leaf sheaths at the base of tillers at the soil surface.

The second trial aimed to take a step back in the approach of using foliar fungicides to determine if targeting application at the base of tillers might improve the level of control and provide more consistent effects. The reduction of crop canopy through slashing around GS30 was also examined for its potential to impact on crown rot expression and yield.

Key findings

The impact of crown rot on yield at this site was only moderate in 2013.

LRPB Dart⦸ was the only variety higher yielding than EGA_Gregory⦸ in the presence of crown rot.

Fungicide application provided no benefit in the absence of crown rot infection but all application techniques provided a 0.30 t/ha benefit in the presence of crown rot infection. However, they **do not** provide complete control.

Slashing at GS30 reduced yield by 0.30 t/ha in the absence of crown rot but had no yield penalty in the presence of crown rot infection.

Site details

Location:	**Trangie Agricultural Research Centre, Trangie**
Sowing date:	**28th May 2013**
Fertiliser:	**80 kg/ha MAP at sowing; 80 L/ha Easy N post-sow pre-emergent**
Starting N:	**26.5 kg/ha nitrate N to 60 cm (below detection limit to 1.2 m)**
Starting water:	**30.4 mm (0–120 cm, April)**
In-crop rainfall:	**197 mm**
PreDicta B:	**1.2 *Pratylenchus neglectus*/g soil (low risk), nil crown rot or common root rot.**
Treatment date:	**All 31st July at GS30**
Harvest date:	**5th Nov 2013**

Treatments

Variety evaluation

- Two durum varieties (Caparoi⦸ and Jandaroi⦸).
- Eight commercial bread wheat varieties (EGA_Gregory⦸, Strzelecki⦸, LRPB Dart⦸, LRPB Lancer⦸, LRPB Crusader⦸, LRPB Spitfire⦸, Suntop⦸ and Sunguard⦸; listed in order of increasing resistance to crown rot).
- Two numbered bread wheat lines (SUN663A and QT14381).

- Added or no added crown rot at sowing using sterilised durum grain colonised by at least five different isolates of *Fp*.

Fungicide application evaluation

- EGA_Gregory(ᶲ) with added or no added crown rot at sowing using infected durum grain.
- One fungicide (Prosaro® at 300 mL/ha + 0.25% chemwet 1000).
- Three in-crop application strategies all at GS 30-31 using Turbo Teejet (110015) nozzles at ~300 L/ha.
  - Above crop – foliar spray 50 cm above crop height (i.e. normal rust spray with most of product deposited on upper leaf surfaces).
  - On crop – boom dropped to crop height and nozzles moved between wheat rows (i.e. product hitting base of plant and soil).
  - Droppers – solid rod from boom down to below canopy height then two nozzles angled at ~45 degrees towards base of tillers on opposite crop rows (i.e. all of product targeted at base of plants).
- One slashing treatment using a cutter bar at GS30-31 with cut leaf material left on soil surface.

Results – Variety evaluation

Yield

- The levels of yield loss from crown rot infection were moderate at this site in 2013 ranging from around 10% up to 20% (Strzelecki(ᶲ)) in the bread wheats. The extent of yield loss was not significant in both Sunguard(ᶲ) and LRPB Lancer(ᶲ). Yield loss was higher in the two durum varieties being between 26% in Jandaroi(ᶲ) and 32% in Caparoi(ᶲ) (Figure 1).
- Only LRPB Dart(ᶲ) was significantly higher yielding than EGA_Gregory(ᶲ) in the presence of crown rot (added CR) at this site in 2013 while Strzelecki(ᶲ), SUN663A, Caparoi(ᶲ) and Jandaroi(ᶲ) were all lower yielding.

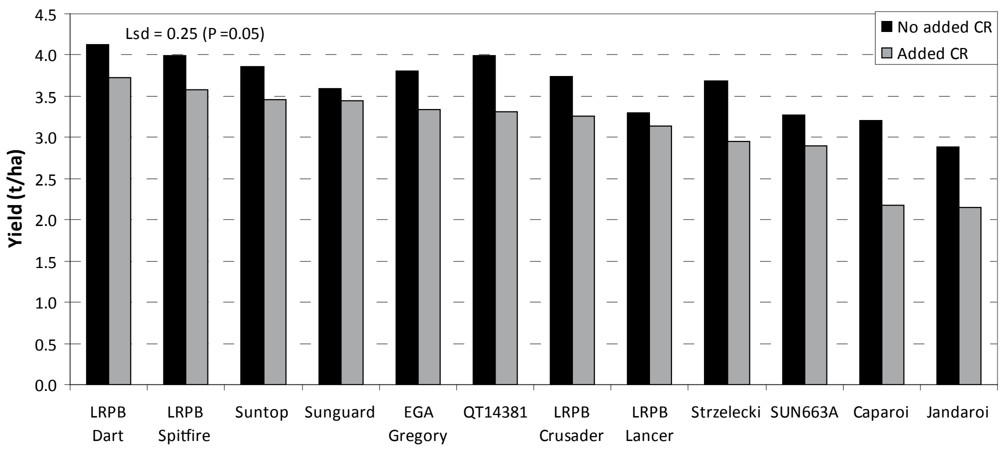


***Figure 1.** Yield (t/ha @ 11% moisture) of varieties with no added and added crown rot – Trangie 2013.*

Protein

- There was a slight (0.2%) decrease in protein with added CR when averaged across varieties but the effect was not significant in any individual entry.
- Protein levels ranged between 11.7% (EGA_Gregory(ᶲ)) up to 13.6% (Jandaroi(ᶲ); Figure 2).
- Even though EGA_Gregory(ᶲ) was the lowest protein achiever at this site its grain N removal in no added CR treatments was only significantly lower than LRPB Spitfire(ᶲ) and LRPB Dart(ᶲ) and was actually significantly higher than Caparoi(ᶲ). Protein levels are influenced by dilution or concentration within grain with increasing or decreasing yield, respectively.

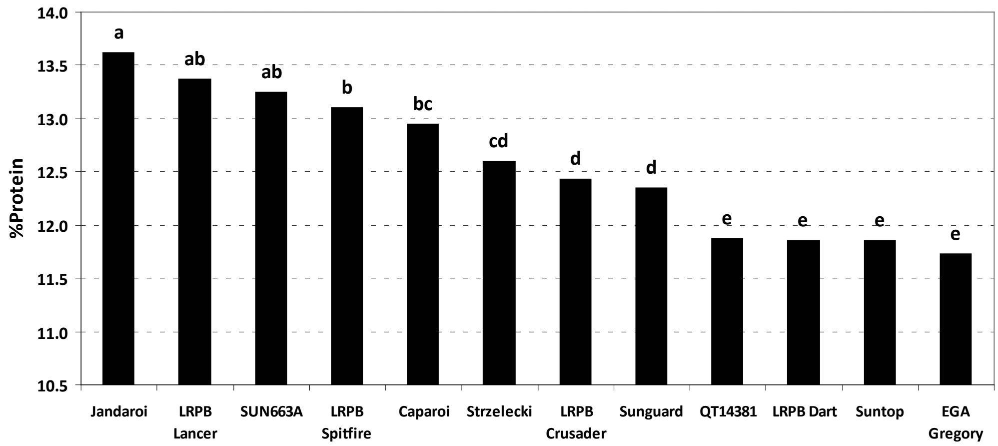


Figure 2. *Average protein concentration achieved by varieties – Trangie 2013. Bars with the same letter are not significantly different (P=0.05).*

Results – Fungicide application evaluation

Yield

- None of the fungicide application techniques significantly affected yield in the no added CR treatment.
- In the presence of crown rot infection (added CR) all fungicide application techniques provided a small 0.30 t/ha yield increase which was significant only at the 87% confidence level (Figure 3). However, fungicide application **did not** provide complete control of crown rot still being 0.46 t/ha lower yielding than no fungicide application in the absence of crown rot (no added CR).
- Slashing at GS30 reduced yield by 0.30 t/ha in the absence of crown rot (no added CR) but there was no yield penalty from slashing in the presence of crown rot infection (added CR).

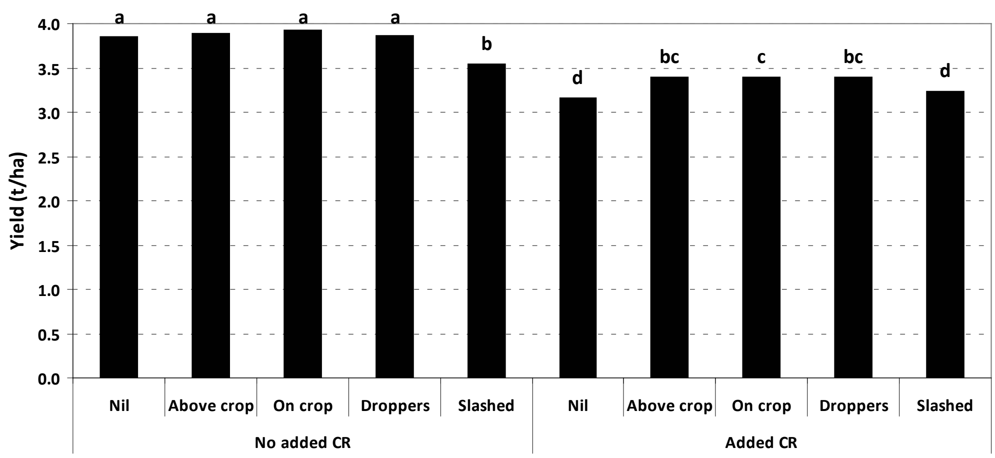


Figure 3. *Effect of fungicide application technique on grain yield of EGA_Gregory⁽ᵇ⁾ with no added or added crown rot inoculum – Trangie 2013. Bars with the same letter are not significantly different (P=0.13).*

Protein

- The addition of crown rot inoculum and none of the fungicide application or slashing treatments impacted on protein levels in EGA_Gregory⁽ᵇ⁾.

Acknowledgements

This project was co-funded by NSW DPI and GRDC under the National Crown Rot Management and Epidemiology Project (DAN00175). Thanks to Kelvin Appleyard (NSW DPI) for providing and preparing the trial site at Trangie ARC.

Impact of fungicide application or slashing on crown rot – Garah 2013

Steven Simpfendorfer, Finn Fensbo and Robyn Shapland NSW DPI, Tamworth

Key findings

Normal foliar fungicide application ~50 cm above the crop canopy did not provide any yield benefit.

Targeting the in-crop application of fungicides at the base of plants provided a minor (5–10%) yield improvement but is **NOT** a complete control measure under high crown rot levels.

Slashing at GS30 had a negative impact on yield with no added CR but no impact on yield in the presence of added CR. However, slashing also reduced grain protein levels by nearly 1% compared to other treatments.

Introduction

Crown rot (CR) caused predominantly by the fungus *Fusarium pseudograminearum* (*Fp*), remains a major constraint to the production of winter cereals in the northern grains region. Control of crown rot using fungicides has been studied extensively with limited success and quite variable outcomes. No fungicides are currently registered for the control of crown rot in winter cereals either as seed or in-furrow treatments or in-crop sprays. As the name implies, crown rot primarily infects the base of plants through the sub-crown internode, crown and/or outer leaf sheaths at the base of tillers at the soil surface.

This trial aimed to take a step back in the approach of using foliar fungicides to determine if targeting application at the base of tillers might improve the level of control and provide more consistent effects. The reduction of crop canopy through slashing at GS30 was also examined for its potential to impact on crown rot expression and yield.

Site details

Location:	**"Miroobil", Garah**
Co-operator:	**Andrew and Bill Yates**
Sowing date:	**31st May 2013**
Fertiliser:	**180 kg/ha Urea and 70 kg/ha Granulock Supreme Z at sowing**
Starting N:	**80 kg/ha nitrate N to 120 cm**
Starting water:	**~160 mm PAW (0–180 cm)**
In-crop rainfall:	**140 mm**
PreDicta B:	**1.46 *Pratylenchus thornei*/g soil (low), 0.8 log *Fusarium* DNA/g (low)**
Treatment date:	**All 1st August at GS30-31**
Harvest date:	**27th October 2013**

Treatments

- Two wheat varieties (EGA_Gregory⊕ and Suntop⊕).
- Plus or minus added crown rot at sowing using sterilised durum grain colonised by at least five different isolates of *Fp*.
- One fungicide (Prosaro® at 300 mL/ha + 0.25% chemwet 1000).
- Three in-crop application strategies all at GS 30-31 using Turbo Teejet (110015) nozzles at ~300 L/ha.
  - Above crop – foliar spray 50 cm above crop height (i.e. normal rust spray with most of product deposited on upper leaf surfaces).
  - On crop – boom dropped to crop height and nozzles moved between wheat rows (i.e. product hitting base of plant and soil).
  - Droppers – solid rod from boom down to below canopy height then two nozzles angled at ~45 degrees towards base of tillers on opposite crop rows (i.e. all of product targeted at base of plants).
- Two slashing treatments using a cutter bar at GS30-31
  - Leave – plot slashed and cut leaf material left on soil surface
  - Remove – plot slashed and cut leaf material raked off plot

Results

Yield

- Averaged across treatments the addition of crown rot inoculum at sowing (added CR) resulted in 34% yield loss in EGA_Gregory⊕ (3.15 t/ha down to 2.09 t/ha) and 28% yield loss in Suntop⊕ (3.09 t/ha down to 2.22 t/ha) compared to the uninoculated treatment (no added CR).
- The dropper treatment was the only fungicide application technique to significantly increase yield compared to the nil treatment under both low background levels of crown rot (minus CR) and high infection levels (added CR; Figure 1). However, the yield advantages were relatively small being 5% (+0.17 t/ha) in the no added CR treatment and 10% (+0.21 t/ha) in the added CR treatment averaged across the two wheat varieties (Figure 1).
- Slashing at GS30 significantly reduced grain yield by around 16% (–0.52 t/ha) in no added CR treatments but did not significantly impact on yield compared to the nil control under high crown rot pressure (added CR)(Figure 1). However, leaving the cut material on the soil surface compared to removing (e.g. simulated grazing) resulted in a significant 11% (+0.21 t/ha) yield benefit in the added CR treatment only.

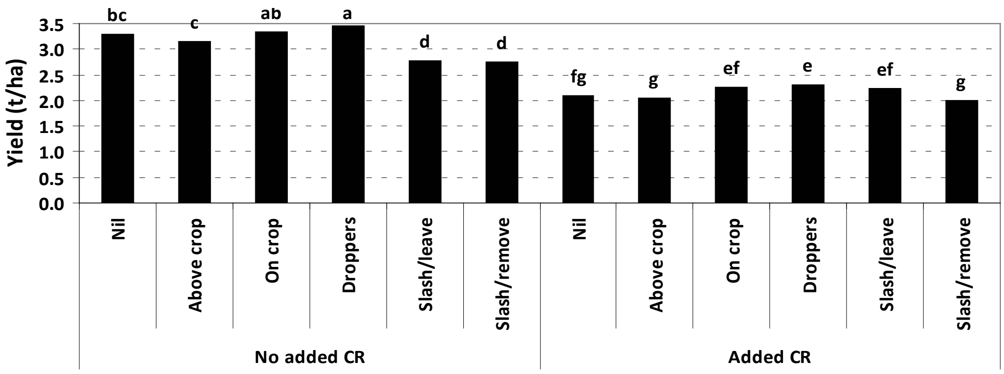


Figure 1. *Effect of fungicide application or slashing at GS30 on grain yield minus or plus added crown rot inoculum – Garah 2013.*

- Wheat variety appeared to impact on the yield response to fungicide application with EGA_Gregory⊕ being more responsive than Suntop⊕. The three fungicide application techniques did not significantly increase yield over the nil control in Suntop⊕ (Figure 2). However, application both on crop and using droppers provided an 8% (0.20 t/ha) and 12% (+0.30 t/ha) yield benefit respectively in EGA_Gregory⊕.
- Fungicide application 50 cm above crop height, as would be normal when controlling a foliar pathogen, did not significantly increase yield in either variety (Figure 2), in the presence or absence of added CR inoculum (Figure 1). Note that both varieties have moderate resistance to stripe rust but are both susceptible to yellow spot. However, no leaf diseases were evident in the unsprayed nil plots of either variety throughout the year.
- The impact of slashing on grain yield also appeared to be variety related with no significant impact over the nil control in EGA_Gregory⊕ but a 15% to 21% yield decline over the nil control in Suntop⊕ when left or removed, respectively (Figure 2).

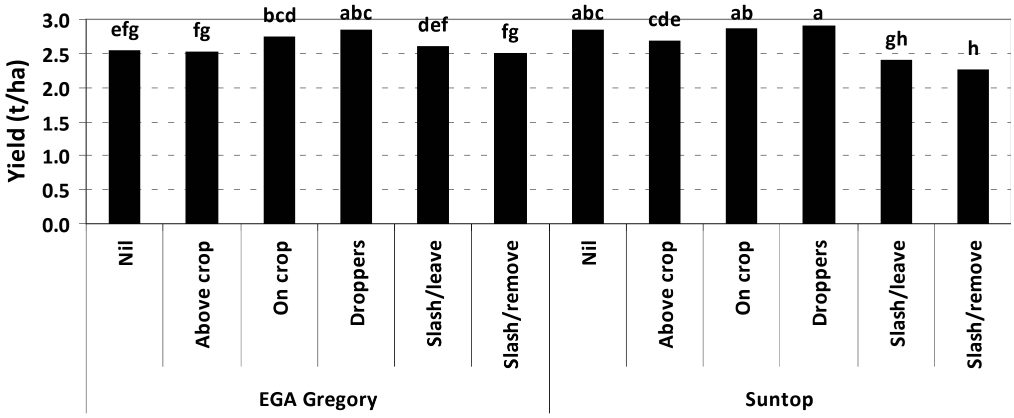


Figure 2. *Effect of fungicide application or slashing at GS30 on grain yield in two wheat varieties – Garah 2013.*

Protein

- None of the three fungicide application techniques significantly affected grain protein levels compared to the nil treatment (range 12.5 to 12.6%).
- Slashing significantly reduced grain protein levels to 11.8 and 11.7% with leaving and removal of the cut biomass, respectively.
- Crown rot significantly increased protein levels by 0.5% (12.2% no added CR and 12.7% added CR) in Suntop⁽ᵈ⁾ but had no effect on grain protein in EGA_Gregory⁽ᵈ⁾ (12.2% both added and no added CR).

Summary

Prosaro® (prothioconazole + tebuconazole) was used in this study as it is known to have improved efficacy in the control of *Fusarium* head blight (FHB) compared to other fungicides. However, the control of crown rot infection is quite a different prospect compared to FHB which has a defined infection area (anthers) and much narrower window of infection (flowering to soft dough). In contrast, crown rot infection occurs through the coleoptile, sub-crown internode, crown and outer leaf sheaths at the soil surface. Infection can also occur throughout crop growth. This trial was not designed as a product evaluation rather it was primarily a proof of concept as to whether targeting fungicide application at the base of plants could potentially improve the control of crown rot.

The use of droppers with nozzles angled at the base of tillers provided a 5% yield benefit (+0.17 t/ha) in the no added crown rot treatment and a 10% (+0.21 t/ha) yield benefit in the added CR treatment. However, the level of benefit provided even with this best fungicide treatment in the presence of high crown rot levels (added CR) was 0.98 t/ha lower yielding than no fungicide application in the absence of added crown rot (no added CR). At best, the impact of fungicides targeted at the base of plants in still relatively minor but an improvement over a normal foliar application above the crop canopy which did not provide any yield benefit.

Slashing at GS30 to reduce canopy size and hence soil water usage for a short period had a negative impact on yield in the absence of added CR but no impact on yield in the presence of added CR. There was a slight but significant yield advantage to leaving the cut biomass on the soil surface rather than removing (e.g. through grazing) in the presence of added CR only. Slashing also reduced grain protein levels by nearly 1% compared to other treatments. The negative impact of slashing on yield was more pronounced in Suntop⁽ᵈ⁾ than EGA_Gregory⁽ᵈ⁾ while the fungicide benefit on yield was greater in EGA_Gregory⁽ᵈ⁾ than Suntop⁽ᵈ⁾.

Targeting the in-crop application of fungicides at the base of plants provided a minor (5–10%) yield improvement but is far from a complete control measure under high crown rot levels. However, it may be a useful addition to an integrated control strategy for managing crown rot.

Acknowledgements

This project was co-funded by NSW DPI and GRDC under the National Crown Rot Management and Epidemiology Project (DAN00175). Thanks to Andrew and Bill Yates for providing the trial site and to Matt Gardner, Stephen Morphett, Jim Perfrement, Patrick Mortell, Peter Formann and Rod Bambach (all NSW DPI) for sowing, maintaining and harvesting the trial.

Impact of crown rot on durum and bread wheat varieties – Winton 2012

Steven Simpfendorfer and Loretta Serafin NSW DPI, Tamworth

Key findings

Durum and bread wheat varieties differ in their ***tolerance*** to crown rot.

In a high crown rot background, the following differences were noted;

- Durum variety choice resulted in a 78% increase in yield between the worst (EGA_Bellaroiⓓ) and best entry (Jandaroiⓓ).
- Bread wheat variety choice resulted in a 94% increase in yield between the worst (Lincolnⓓ) and best entry (Venturaⓓ).

Venturaⓓ, Suntopⓓ and LRPB Spitfireⓓ were 18–20% higher yielding than EGA_Gregoryⓓ.

Variety choice is **not** the sole solution to crown rot and root lesion nematodes but it can significantly impact on final yield and profit in the presence of these disease constraints.

Introduction

Crown rot (CR) caused predominantly by the fungus *Fusarium pseudograminearum* (*Fp*), remains a major constraint to the production of winter cereals in the northern grains region. Cereal varieties differ in their tolerance and resistance to crown rot which can have a significant impact on the relative yield of varieties in the presence of this disease. This site was established in a growers paddock which had high background levels of crown rot inoculum to examine the impact of crown rot on the yield of six durum and fourteen bread wheat entries.

Site details

Location:	**"Lara Downs", Winton**
Co-operator:	**Rob and Kylie Lamph**
Sowing date:	**29th May 2012**
Fertiliser:	**300 kg Sulfate of Ammonia pre-sowing and 85 kg/ha Granulock Supreme Z Extra at sowing**
Starting water:	**~ 190 mm (0–120 cm)**
In-crop rainfall:	**226 mm**
Pathogen:	**1.0 *Pt*/g soil (low risk) with PreDicta B, 70% recovery *Fusarium* from stubble based on plating. Site then cultivated twice prior to sowing.**
Harvest date:	**16th November 2012**

Treatment details

- Four durum varieties (EGA_Bellaroiⓓ, Caparoiⓓ, Hypernoⓓ and Jandaroiⓓ) and two experimental durum lines (TD241046 and UAD0951096).
- Twelve bread wheat varieties (Lincolnⓓ, Ellisonⓓ, EGA_Gregoryⓓ, LRPB Crusaderⓓ, Sunzellⓓ, Baxterⓓ, Livingstonⓓ, Venturaⓓ, LRPB Spitfireⓓ, Suntopⓓ, EGA_Wylieⓓ and Sunguardⓓ; listed in order of increasing resistance to crown rot) and two experimental bread wheat lines (SUN643A and QT16026).
- Sowing rates were adjusted to target 100 plants/m^2 for each entry based on grain weight and germination.
- Each plot was scored for the presence of whitehead development using a 0 to 10 scale (0 = no whiteheads, 10 = 100% whiteheads) on the 17th of October.

Results

Yield

- The six durum entries varied in their yield in the presence of crown rot infection (***tolerance***) from 2.67 t/ha (Jandaroiⓓ) down to 1.50 t/ha (EGA_Bellaroiⓓ; Figure 1). That is, durum variety choice (Jandaroiⓓ over EGA_Bellaroiⓓ) resulted in a 78% increase in yield in this paddock in 2012.
- EGA_Bellaroiⓓ has been shown in previous NSW DPI trials to suffer greater yield loss from crown rot than other durum varieties. EGA_Bellaroiⓓ was the lowest yielding entry in the trial along with another durum variety Caparoiⓓ and the bread wheat variety Lincolnⓓ.

- TD241046 appears to have better ***tolerance*** to crown rot than the other numbered durum entry UAD0951096.
- The 14 bread wheat entries also varied in their ***tolerance*** to crown rot infection with yield ranging from 3.39 t/ha (Ventura$^{\phi}$) down to 1.75 t/ha (Lincoln$^{\phi}$). That is, bread wheat variety choice (Ventura$^{\phi}$ over Lincoln$^{\phi}$) resulted in a 94% increase in yield in this paddock in 2012.
- SUN643A appears to have better ***tolerance*** to crown rot than the other numbered bread wheat entry QT160126.

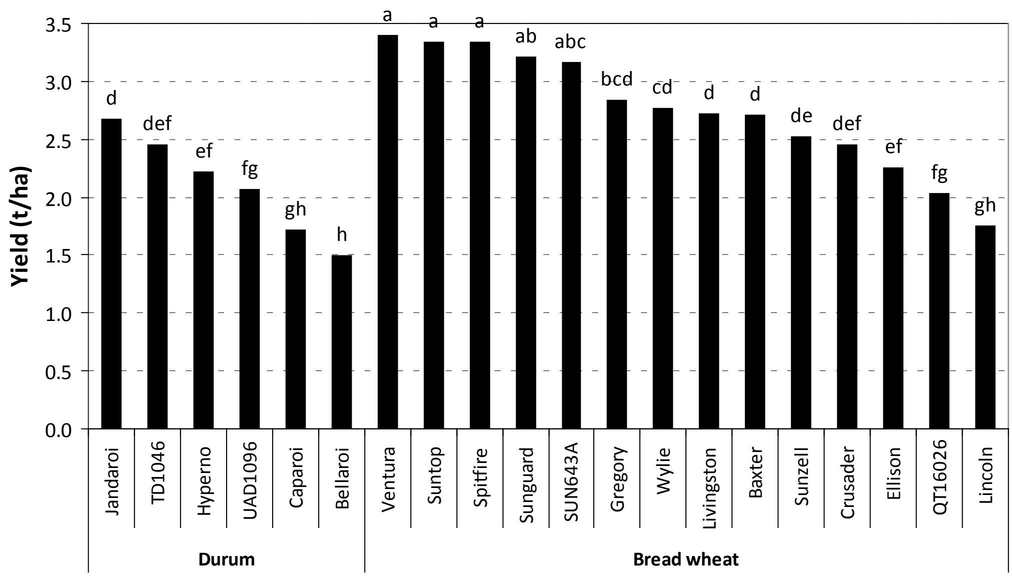


Figure 1. *Yield (t/ha @ 11% moisture) of varieties under high crown rot pressure – Winton 2012*

- Only Ventura$^{\phi}$ (20%), Suntop$^{\phi}$ (18%) and LRPB Spitfire$^{\phi}$ (18%) were significantly higher yielding than EGA_Gregory$^{\phi}$ under high crown rot infection at this site in 2012 (Figure 1).
- Even though only a low level of *Pratylenchus thornei* (*Pt*)(1.0 *Pt*/g 0–30 cm) was present at this site, the bread wheat varieties LRPB Crusader$^{\phi}$ (moderately intolerant–intolerant), Ellison$^{\phi}$ (intolerant–very intolerant) and Lincoln$^{\phi}$ (very intolerant) had lower yield than other varieties which all have better levels of tolerance. That is, Ventura$^{\phi}$, LRPB Spitfire$^{\phi}$, Livingston$^{\phi}$, Baxter$^{\phi}$ and Sunzell$^{\phi}$ are moderately tolerant–intolerant while Suntop$^{\phi}$, Sunguard$^{\phi}$ and EGA_Wylie$^{\phi}$ are moderately tolerant to *Pt*. Recent collaborative research between the Northern Grower Alliance and NSW DPI has also established that the presence of RLN feeding within root systems increases the severity of crown rot.

Grain quality and disease assessments

- Protein levels were relatively low at this site in 2012 ranging from 12.2% (EGA_Bellaroi$^{\phi}$) down to 9.5% (Suntop$^{\phi}$) (Table 1).
- Even though Suntop$^{\phi}$ was amongst the lower protein achievers at this site its grain N removal was equivalent to all other bread wheat entries and higher than Sunzell$^{\phi}$, LRPB Crusader$^{\phi}$, Ellison$^{\phi}$ and Lincoln$^{\phi}$ even though they all had higher protein levels. Protein levels are influenced by dilution or concentration within grain with increasing or decreasing yield, respectively.
- Plants were pulled from each plot at harvest and plated to determine the incidence of crown rot infection based on the percentage recovery of *Fusarium* from the crown of primary tillers. Infection levels averaged between 79% in Baxter$^{\phi}$ and up to 96% in Lincoln$^{\phi}$ but the difference between varieties was not significant (data not shown). Plating confirmed that all plots had a very high level of crown rot infection and that varieties do not significantly differ in their actual resistance to infection by the crown rot fungus.

- Screenings ranged from 2.3% (SUN643A) up to 18.8% (Lincoln$^{\phi}$) (Table 1). Only Baxter$^{\phi}$ and SUN643A were below the 5% screenings receival standard. Varieties with lower crown rot resistance ratings and reduced yield in the presence of crown rot at this site tended to also have higher screenings. Increased screenings is characteristic of crown rot expression with moisture stress during grain-fill triggering proliferation of the crown rot fungus in the base of infected tillers which then restricts water movement up the stem at this point. This limits the plants ability to fill grain in tillers with a basal infection from crown rot.
- The severity of crown rot infection was determined from stubble pulled over a set area in each plot at harvest. Severity is visually based on the number of tillers with characteristic basal browning and the extent that the discolouration extends up the stem expressed on a 0–100 scale. Severity was lowest in the MR–MS variety EGA_Wylie$^{\phi}$ (16.0) and highest in the VS durum variety Caparoi$^{\phi}$ (57.1) (Table 1).
- Jandaroi$^{\phi}$ and Hyperno$^{\phi}$ had lower crown rot severity (and screenings) than the other four durum entries (Table 1).
- The bread wheat varieties did not differ greatly in their visual crown rot severity scores with significance only at the two extremes. That is, EGA_Wylie$^{\phi}$ was significantly lower than five entries (EGA_Gregory$^{\phi}$, Baxter$^{\phi}$, Ellison$^{\phi}$, Lincoln$^{\phi}$ and LRPB Crusader$^{\phi}$) and LRPB Crusader$^{\phi}$ was significantly higher than nine entries (EGA_Wylie$^{\phi}$, Sunguard$^{\phi}$, Suntop$^{\phi}$, Ventura$^{\phi}$, Sunzell$^{\phi}$, SUN643A, Livingston$^{\phi}$, LRPB Spitfire$^{\phi}$ and QT16026). Ellison$^{\phi}$, Lincoln$^{\phi}$ and LRPB Crusader$^{\phi}$ which have reduced tolerance to *Pt* tended to have the higher crown rot severity scores amongst bread wheat entries with the same crown rot resistance rating.
- Whitehead scores ranged from 1.0 (Baxter$^{\phi}$ and SUN643A) up to 9.0 (Lincoln$^{\phi}$) on a 0–10 scale where 0 = no whiteheads and 10 = 100% whiteheads in a plot (Table 1). Varieties rated S–VS or VS tended to have greater expression of whiteheads than other varieties with better resistance ratings. However, the relative maturity of varieties can interact with the expression of whiteheads depending on the timing of temperature/moisture stress during grain-fill. With stress occurring later in a season the quicker varieties are more advanced making it harder to visually pick whiteheads from maturing heads. For example, LRPB Crusader$^{\phi}$ is amongst the quicker maturing bread wheat varieties in this trial but had a visual whitehead score of 2.3 even though it had the highest severity score.

__Table 1.__ Crown rot resistance rating, protein level, screenings, grain N removal, crown rot severity at harvest and whitehead plot score for 20 cereal entries – Winton 2012

Crop	Variety	Resistance rating	Protein (%)	Screenings (%)	Grain N removal (kg/ha)	CR Severity (0–100)	Whiteheads (0–10)
Durum	Jandaroi$^{\phi}$	VS	10.9	5.0	50.7	32.1	6.0
	Hyperno$^{\phi}$	VS	11.4	5.9	44.0	28.9	5.3
	Caparoi$^{\phi}$	VS	11.1	10.1	33.4	57.1	7.0
	EGA_Bellaroi$^{\phi}$	VS	12.2	12.4	32.1	52.0	7.3
	TD1046	–	10.8	7.9	46.3	52.4	6.0
	UAD1096	–	11.0	13.1	39.6	55.9	7.7
Bread wheat	Sunguard$^{\phi}$	MR–MS	9.9	6.7	55.6	20.0	1.3
	EGA_Wylie$^{\phi}$	MR–MS	10.6	5.9	51.1	16.0	2.7
	Suntop$^{\phi}$	MS	9.5	7.7	55.5	20.9	1.3
	LRPB Spitfire$^{\phi}$	MS	10.4	6.3	60.9	22.8	1.3
	Baxter$^{\phi}$	MS	10.7	4.4	50.6	27.8	1.0
	Ventura$^{\phi}$	MS–S	10.0	6.5	59.4	21.3	2.3
	EGA_Gregory$^{\phi}$	S	9.6	10.6	47.4	26.9	4.3
	Sunzell$^{\phi}$	S	11.1	7.6	48.6	21.7	2.0
	LRPB Crusader$^{\phi}$	S	10.7	7.8	45.8	36.7	2.3
	Livingston$^{\phi}$	S–VS	10.5	11.2	49.8	22.4	4.0
	Ellison$^{\phi}$	S–VS	11.2	13.1	44.1	28.9	6.0
	Lincoln$^{\phi}$	VS	11.0	18.8	33.6	29.1	9.0
	SUN643A	–	10.6	2.3	58.6	22.4	1.0
	QT16026	–	10.9	14.9	38.8	24.2	5.3
	Lsd (P=0.05)		0.5	3.3	8.4	10.8	2.0

Summary

This site had a high background level of crown rot inoculum in 2012 which produced infection levels greater than 80%. The site was therefore useful for determining the relative ***tolerance*** of cereal varieties to crown rot. However, a low level of the root lesion nematode *Pratylenchus thornei* was also present at the site which appears to have further reduced the yield of the more *Pt* intolerant varieties.

Durum and bread wheat varieties clearly differ in their ***tolerance*** to crown rot. Amongst the durum entries in this trial variety choice could have resulted in a 78% increase in yield between the worst and best entry. Similarly, bread wheat variety choice could have resulted in a 94% increase in yield between the worst and best entry. Variety choice does not eliminate crown rot with all entries still being heavily infected but differences in ***tolerance*** can significantly impact on grower returns in the presence of crown rot and *Pt*. However, variety selection is **not** the sole solution to crown rot as there is no resistance to infection, so all varieties will build-up inoculum within paddocks and significant yield loss can still occur under tough seasonal finishes.

Acknowledgements

This project was co-funded by NSW DPI and GRDC under the Northern Integrated Disease Management Project (DAN00143). Thanks to Rob and Kylie Lamph for providing the trial site and to Dougal Pottie, Peter Formann and Paul Nash (NSW DPI) for sowing, maintaining and harvesting the trial. Thanks to Robyn Shapland, Karen Cassin and Kay Warren for assistance with laboratory disease assessments.

CROP PROTECTION

Chickpea yields with and without *Pratylenchus thornei* – Coonamble & Trangie 2013

Kevin Moore, Kristy Hobson and Steve Harden NSW DPI, Tamworth
Leigh Jenkins NSW DPI, Trangie **Rohan Brill** NSW DPI, Wagga Wagga

Key findings

Yield varied significantly with chickpea genotype at two sites, one with high starting numbers of *Pt*, the other with no detectable *Pt*.

The new kabuli, PBA Monarch⁽ᶲ⁾, yielded as well as the industry standards Jimbour and PBA HatTrick⁽ᶲ⁾.

Three interspecific hybrids also performed well.

There was no evidence that an experimental product had any beneficial effect on yield in the presence or absence of *Pt*.

Introduction

Current strategies to minimise the impact of Root Lesion Nematodes (RLN) on northern region farming systems are based on: (i) growing resistant crops and varieties to reduce the reproduction of nematodes, (ii) growing tolerant varieties to reduce the impact of nematodes on growth and yield and (iii) hygiene to limit spread.

As a crop, chickpea is considered susceptible (and intolerant) to both *Pratylenchus thornei* (*Pt*) and *P. neglectus* (*Pn*) which are the main RLN species in the region. However, varieties differ in their influence on nematode reproduction (level of resistance) and the impact of nematode on yield (level of tolerance)

This paper reports on the tolerance of two chickpea genotypes at a field site (Coonamble) with natural populations of *Pt*. The potential of an experimental agent to limit yield loss from *Pt* was also included. A second site (Trangie) was found to have undetectable levels of both species and thus presented an opportunity to compare yields of 16 chickpea genotypes in the absence of RLN; the experimental agent was also included at this site on two genotypes.

Site details

Location:	**Trangie Agricultural Research Centre**	**"Woolingar", Coonamble**
Co-operator:	**NSW DPI**	**Lindsay Meers, Manager Jason Peters**

Treatments – Trangie

- Ten desi varieties: PBA Boundary⁽ᶲ⁾, PBA HatTrick⁽ᶲ⁾, Kyabra⁽ᶲ⁾, Yorker⁽ᶲ⁾, Jimbour, Genesis™ 090, Genesis™ 090, CICA0709, CICA1007, CICA0912.
- Three kabulis: Genesis™ 425, PBA Monarch⁽ᶲ⁾, Almaz⁽ᶲ⁾.
- Three interspecific hybrids with a wild relative of chickpea purported to have improved resistance to *Pt*, CICA0313, CICA0314 and one designated D5253.
- The trial also included a coded chemical product (BAY) claimed to have activity against *Pratylenchus* spp. This was applied to the seed of Kyabra⁽ᶲ⁾ (the least *Pt* resistant entry in the trial) and CICA0912 (most resistant entry).
- There were 4 replicates.

Treatments – Coonamble

- Kyabra⁽ᶲ⁾ and CICA0912 with and without the experimental agent; 6 replicates.

Results

- At Trangie, *Pt* and *Pn* were not detected in post sow PreDicta B testing of a composite sample from each rep.
- At Coonamble, post sow PreDicta B *Pt* numbers of a composite sample from each rep varied from 6,709 to 17,788, mean 11,579 *Pt*/kg soil (*Pn* undetected).
- At both sites, genotype had a highly significant (P<0.001) effect on yield (Figure 1, Figure 2).
- At both sites, Kyabra⁽ᶲ⁾ was the highest yielding entry, possibly reflecting its high root to shoot ratio (FitzGerald 2010).

- Kyabra's performance at Coonamble under high *Pt* pressure confirms other research that has shown no relationship between resistance and tolerance to *Pt* (Moore et al, 2013).
- The overall low yields at Coonamble are thought to have resulted from severe frosts in August and a dry quick finish.
- At Trangie, the kabulis as a group were the lowest yielders except for the recently released PBA Monarch⊕, which yielded as well as the industry standards Jimbour and PBA HatTrick⊕ (Figure 1).
- At Trangie, the interspecific hybrids also yielded well, particularly CICA0313, demonstrating their inherent yield potential.
- There was no significant effect of the experimental agent on yield of Kyabra⊕ or CICA0912 at either site.

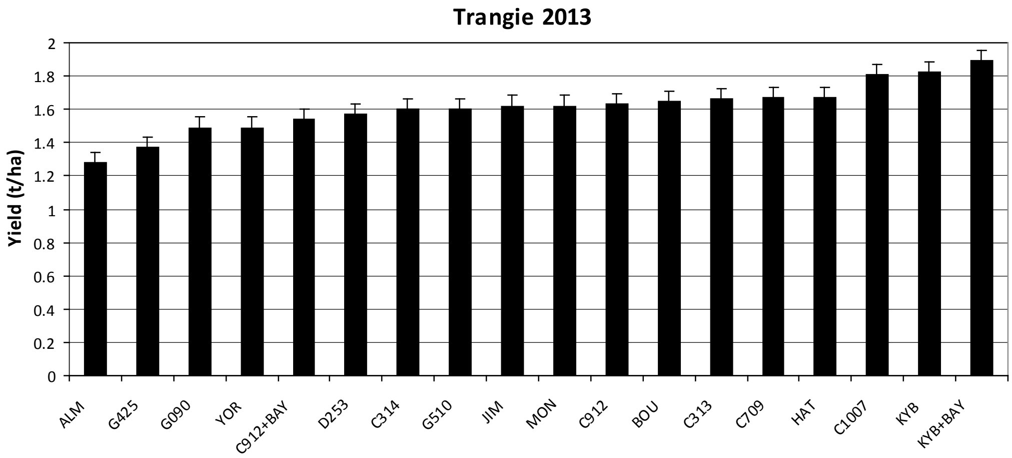


Figure 1. *Yield of 16 chickpea genotypes in the absence of RLN and effect of an experimental agent (BAY) on yield of two genotypes, Trangie 2013.*

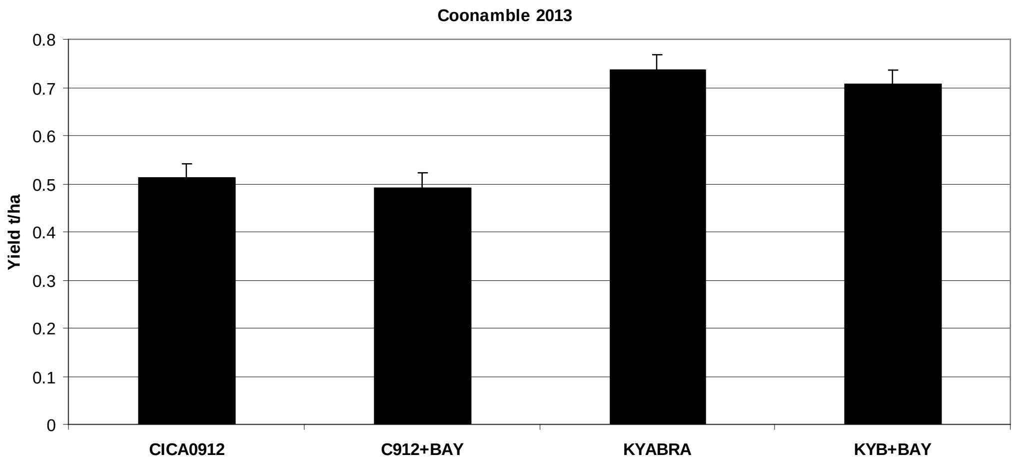


Figure 2. *Yield of Kyabra⊕ and CICA0912 chickpeas in the presence of RLN, with and without an experimental agent (BAY), Coonamble 2013.*

Summary

Chickpea yield varied with genotype at the two sites, one with high starting numbers of *Pt*, the other with no detectable *Pt*. The new kabuli, PBA Monarch⊕ and one interspecific hybrid yielded as well as the industry standards Jimbour and PBA HatTrick⊕. The Coonamble trial confirmed that resistance to *Pt* is a poor predictor of tolerance. There was no evidence that an experimental product had any beneficial effect on yield in the presence or absence of *Pt.*

Acknowledgements

This project is funded by NSW DPI and GRDC under the Northern NSW Integrated disease management project (DAN00176). Thanks to Lindsay Meers and Jason Peters for providing the Woolingar trial site and to Jayne Jenkins, Paul Nash and Gail Chiplin for technical support.

References

1. FitzGerald JC (2010). Tolerance of Chickpea (*Cicer arietinum*) genotypes to pre-emergent application of isoxaflutole. Fourth Year Thesis. Faculty of Agriculture, Food and Natural Resources, University of Sydney.
2. Moore K, Brill R, Harden S and Coombes N (2013). Increasing numbers of the root lesion nematode Pratylenchus thornei did not affect yield of six chickpea varieties – Coonamble 2012. *Northern Grains Region Trial Results Autumn 2013*: 123–125.

Reducing risk of viral infection in chickpea through management of plant density, row spacing and stubble – 2013

Andrew Verrell, Kevin Moore NSW DPI, Tamworth
Mohammed Aftab Vic DEPI, Horsham

CROP PROTECTION

Key findings

Aim to establish at least 20 plants/m^2.

Plant on time to encourage even growth and early canopy closure.

Retain standing winter cereal stubble – this is thought to deter aphids from landing on the chickpea crop.

Use precision agriculture techniques to sow between the stubble rows. This helps generate a uniform crop canopy which makes the chickpea crop less attractive to aphids.

Introduction

Controlling viral diseases in chickpeas is difficult and plants that become infected usually die. All current chickpea varieties grown in the GRDC Northern Region are susceptible to the main viruses in that region. Field trials conducted by NSW DPI at Breeza from 2000–2003 showed no benefit of seed or foliar insecticides or a combination of both against chickpea viruses. The best and at this stage only, control strategies to reduce risk of viruses in chickpeas are agronomic (Schwinghamer *et al.* 2009, Verrell 2013, Sharman *et al.* 2014).

Observations during the 2012 chickpea virus epidemic in northern NSW (Moore *et al.* 2013, van Leur *et al.* 2013), suggested a link between plant density and incidence of symptomatic plants. In addition, growers and agronomists reported a higher incidence of viral symptoms in chickpea crops with thin stands. A 2012 trial designed to examine the effect of plant population on chickpea viruses found the highest incidence of symptomatic plants occurred at the lowest plant density of 5 plants/m^2 (Verrell 2013). Incidence declined in a curvilinear fashion as plant densities increased. However, there was no significant difference in the incidence of symptomatic plants at chickpea populations of 20, 30 and 45 plants/m^2. The 2012 trial was repeated in 2013 trials at two locations, one (Pine Ridge) in the virus prone region of the Liverpool Plains (van Leur *et al.* 2013) and the other at the Tamworth Agricultural Institute (TAI).

Planting into standing cereal stubble is known to help reduce risk of virus in lupin crops (Jones 2001) and is believed to be useful in reducing virus in chickpea crops (Schwinghamer *et al* 2009). van Leur *et al* (2013) found no relationship between stubble loading and incidence of viral infection in a quantitative survey of chickpea crops on the Liverpool Plains in 2012. We are not aware of any experimental data from trials designed specifically to examine the effect of stubble management on incidence of virus in chickpeas in the GRDC Northern region.

In 2013, field trials were conducted to evaluate a range of agronomic practices on the incidence of natural infection of chickpeas by viruses.

Site details

Location:	**"Gunnadilly", Pine Ridge**	Location:	**Tamworth Agricultural Institute, NSW DPI**
Co-operator:	**Tom Bailey**		

Treatments

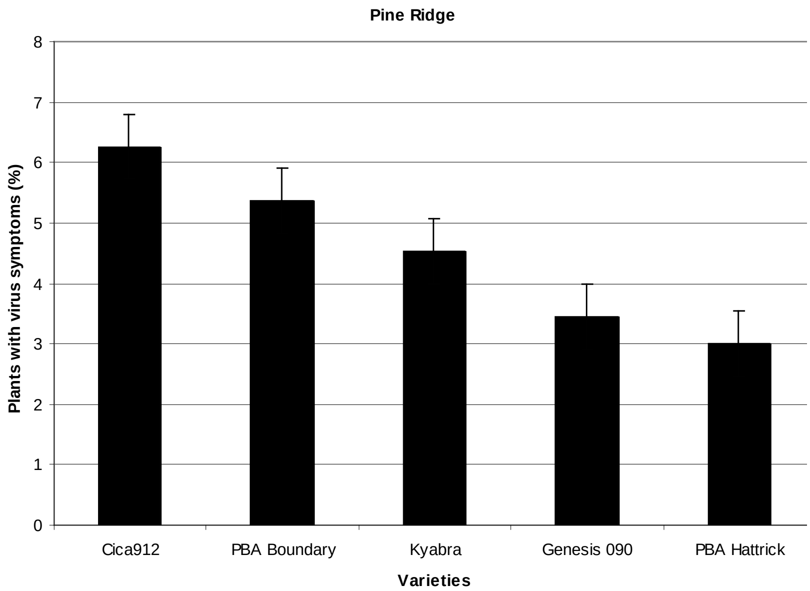
- Plant density: targeting 5, 10, 15, 20, 30, 45 plants/m^2.
- Variety:
  Desi: PBA HatTrick⁽ᵈ⁾, PBA Boundary⁽ᵈ⁾, Kyabra⁽ᵈ⁾ and an advanced breeding line CICA0912.
  Kabuli: Genesis™ 090.
- Row spacing: 40 cm and 80 cm.

- Stubble management: Flat (slashed) and standing. Two trials were conducted at Tamworth in 2013 to compare standing versus flat wheat stubble on incidence of plants with virus symptoms. One trial was sown at 80 cm row spacing; the other at 40 cm spacing; both with PBA HatTrick⁽ᴰ at 30 plants/m^2.

Results

Effect of chickpea genotype on incidence of plants with virus-like symptoms at Pine Ridge and Tamworth

- Incidence of plants with virus-like symptoms (symptomatic) was visually assessed on 11th October at Pine Ridge and the 9th and 16th of October at Tamworth.
- Although the incidences of symptomatic plants throughout the trial sites and, at Pine Ridge in the surrounding commercial chickpea crop, were relatively low (<10%), variety had a significant effect on incidence at both sites (Figure 1).
- PBA HatTrick⁽ᴰ had the lowest incidence at both sites followed by Genesis™ 090. The ranking of Kyabra⁽ᴰ, PBA Boundary⁽ᴰ and CICA0912 varied with site (Figure 1).
- In a similar trial conducted in 2012, there was no effect of variety (the same ones as in these trials) on the incidence of symptomatic plants. Accordingly, there is insufficient data to recommend using chickpea variety as a management tool for reducing risk of viral infection.



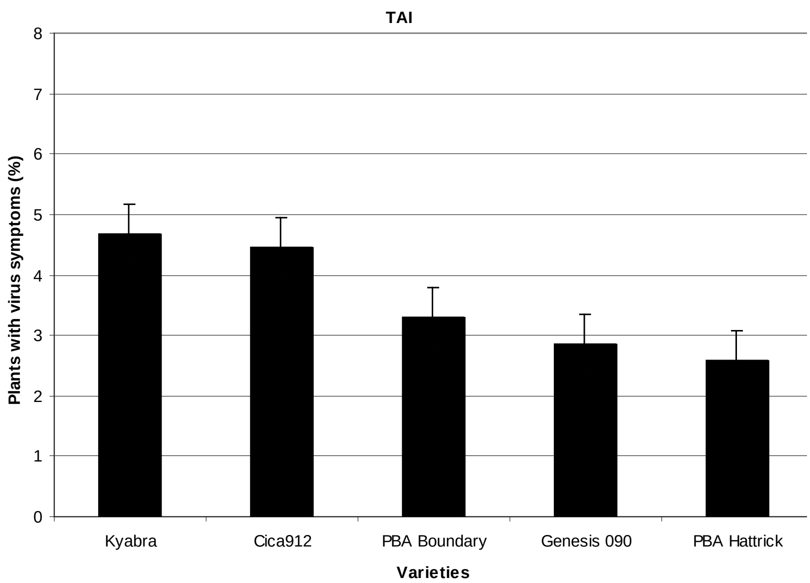


Figure 1. *Incidence (%) of plants with virus symptoms for four desis and one kabuli (Genesis 090) chickpea variety at Pine Ridge (top) and Tamworth (bottom) on 11 October 2013.*

Plant density and incidence of plants with virus symptoms

- The incidence of symptomatic plants was greatest at the lowest sowing rate (5 plants/m^2) at both 2013 sites and declined as plant densities increased. Similar to 2012 results, there was no significant difference in the proportion of plants with virus symptoms at 20, 30 and 45 plants/m^2.

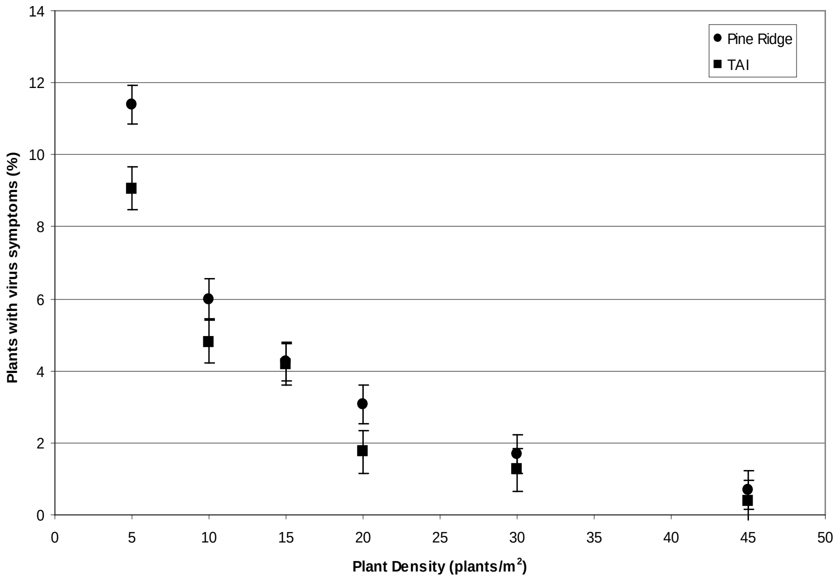


Figure 2. *Effect of plant density on incidence of chickpea plants with virus symptoms at Pine Ridge and Tamworth, 2013.*

Row spacing and incidence of plants with virus symptoms

- Row spacing had a significant effect on incidence of plants with virus symptoms in a 2013 trial at Tamworth.
- On 11 October 2013, there were more than twice as many symptomatic plants/m^2 in plots with 40 cm rows compared to those with 80 cm rows (Figure 3).
- Both row configurations were sown at 30 plants/m^2 so plant density per unit area cannot account for the difference. Rather, plant density within each row appears to be responsible (12 plants/m row @ 40 cm and 24 plants/m row @ 80 cm).

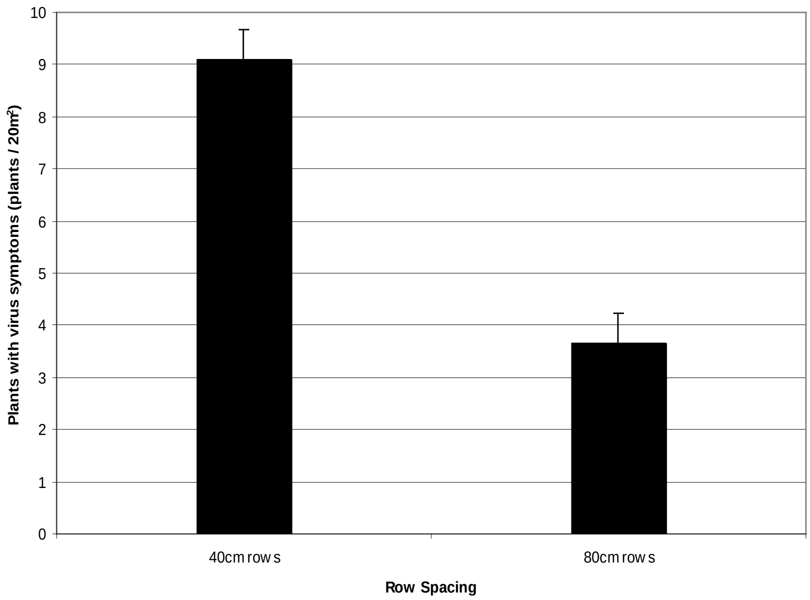


Figure 3. *Effect of row spacing on the incidence of chickpea plants with virus symptoms at Tamworth, 2013.*

CROP PROTECTION

Stubble management and incidence of plants with virus symptoms

- In both trials, the incidence of plants with virus symptoms was lower where the chickpeas had been sown into standing stubble (Figures 4 and 5).
- Individual plots in these trials were small, 2 m x 10 m for the 80 cm trial and 4 m x 10 m in the 40 cm trial. This raises the question: "If the vectors (aphids) have no choice i.e. the entire paddock has standing stubble (or not), is stubble management still a useful tool for reducing virus risk?"
- Based on our own and other's observations in commercial crops, we believe the answer is Yes; but further research is needed.

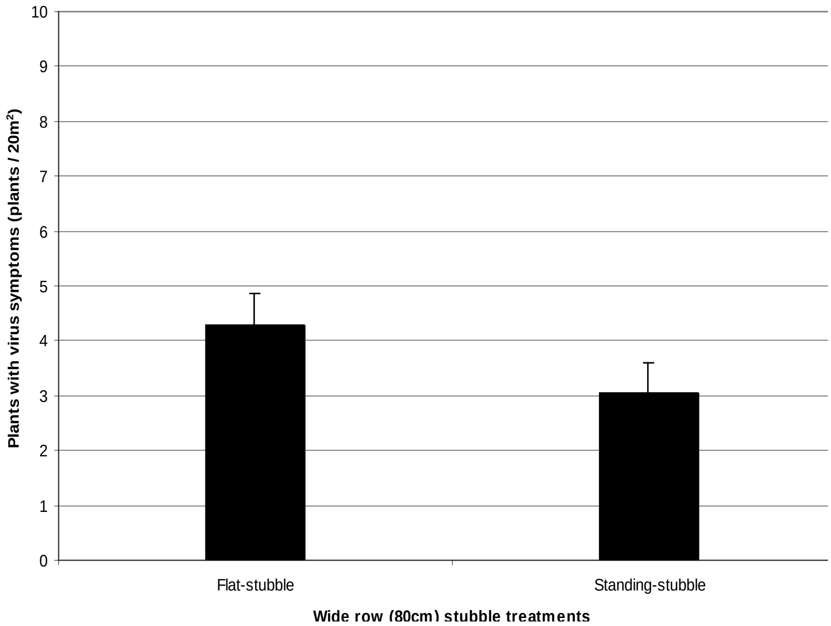


Figure 4. *Effect of stubble management (flat vs standing) on incidence of chickpea plants with virus symptoms, Tamworth 2013.*

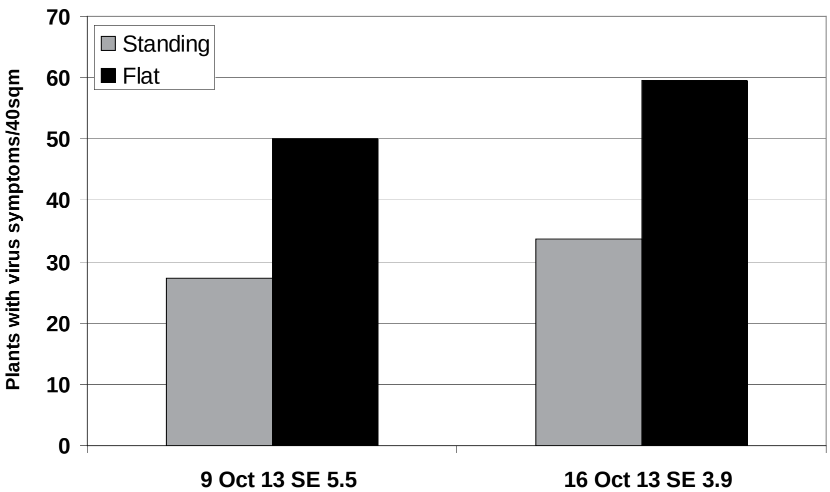


Figure 5. *Effect of stubble management (flat vs standing) on incidence of chickpea plants with virus symptoms assessed on two dates, Tamworth 2013.*

Virus species in 2013 Pine Ridge and Tamworth trials

- Chickpea plants with symptoms of virus infection were sampled for virus testing by Tissue Blot Immuno Assay (TBIA).
- At each sampling time, 15 symptomatic plants were collected and tested for Alfalfa mosaic virus (AMV), Cucumber mosaic virus (CMV) and Beet western yellows virus (BWYV). At Pine Ridge, 15 symptomatic plants were also tested from the surrounding crop of Almaz⁽ᵈ⁾ chickpeas.
- In addition 15 asymptomatic (healthy, turgid, vigorous, green plants) were also tested from each trial and the Almaz⁽ᵈ⁾ crop.
- By far the most common virus was BWYV, accounting for 65 – 94% (mean 83%) of symptomatic plants; 12% of symptomatic plants were positive for AMV; CMV was not detected in any symptomatic plants; only one (out of 105) plant was co-infected with BWYV and AMV.
- None of the 45 asymptomatic plants tested positive to any of the three viruses.

Summary

This research and observations in commercial crops indicate growers can minimise the risk of virus problems in 2014 chickpea crops by planting on time; sowing at the optimal seeding rate – irrespective of sowing date; aiming to establish at least 25 plants/m^2, retaining standing cereal stubble and using precision agriculture techniques to sow between the stubble rows.

Other factors known or thought to reduce virus risk in chickpeas include: adequate plant nutrition; control of in-crop, fence-line and fallow weeds (which are sources of vectors and virus); avoid planting next to lucerne stands – lucerne is a perennial host on which legume aphids and viruses survive and increase; and, consider growing chickpeas away from canola, as canola can have a high incidence of BWYV.

Acknowledgements

This work is funded by NSWDPI and GRDC under DAN00143, DAN00171, DAN00176, DAV00134. Thanks to Tom Bailey, 'Gunnadilly', Pine Ridge for providing land and other resources for the Pine Ridge trial, and to Michael Nowland, Paul Nash and Gail Chiplin (all NSW DPI) for technical support.

References

1. Jones RAC (2001) Developing integrated disease management strategies against non-persistently aphid-borne viruses: a model program. Integr Pest Manag Rev 6:15–46.
2. Moore K, Ryley M, Sharman M, van Leur J (2013). Proceedings 2013 GRDC Grains Research Update, Goondiwindi.
3. Sharman M, Moore K, van Leur J, Aftab M and Verrell A (2014). Viral diseases in chickpeas – impact and management. Proceedings 2014 GRDC Grains Research Update, Goondiwindi.
4. Schwinghamer M, Knights T, Moore K (2009). Virus control in chickpea – special considerations. Australian Pulse Bulletin PA 2009 #10.
5. van Leur J, Aftab M, Manning W, Bowring A and Riley M (2013). A severe outbreak of chickpea viruses in northern New South Wales, Australia, during 2012. Australasian Plant Dis. Notes (2013) 8:49–53.
6. van Leur JAG, Makkouk K, Freeman A, Schilg M (2003) Occurrence of viruses in faba bean on the Liverpool Plains, northern New South Wales. In: Martin B (ed) Update of research in progress at the Tamworth Agricultural Institute 2002. NSW Agriculture, Tamworth, pp 58–59.
7. Verrell A (2013). Virus in chickpea in northern NSW 2012 – the effects of sowing date, plant density and nutrition on virus symptoms in chickpea. Proceedings 2013 GRDC Grains Research Update, Goondiwindi.

CROP PROTECTION

Response of chickpea genotype to Phytophthora root rot (*Phytophthora medicaginis*) – Warwick Qld 2013

Kevin Moore, Ted Knights, Steve Harden, Paul Nash, Gail Chiplin and Kristy Hobson NSW DPI, Tamworth
Mal Ryley DAFFQ, Toowoomba **Willy Martin and Kris King** DAFFQ, Warwick

Key findings

Chickpea Phytophthora root rot (PRR) caused yield losses from 33% to 82%.

Under high disease pressure the current best variety Yorker⁽ᴾ⁾, sustained serious yield loss.

Hybrid breeding lines have significantly improved levels of resistance to PRR than the moderately resistant variety Yorker⁽ᴾ⁾, which has the highest resistance available in current commercial varieties.

Introduction

Phytophthora root rot (PRR) of chickpea is endemic and widespread in northern NSW and southern Qld and can cause total yield loss as it did in 2012 in a crop of PBA Boundary⁽ᴾ⁾ near Moree. In 2013, PRR was common in crops of PBA Boundary⁽ᴾ⁾ in the Darling Downs district when saturated soil conditions in the early part of the season favoured infection.

As there are no in-crop control measures for PRR, avoidance of high risk paddocks and varietal selection are the only cost effective management tools available to growers.

Current commercial varieties differ in their resistance to *P. medicaginis*, with Yorker⁽ᴾ⁾ and PBA HatTrick⁽ᴾ⁾ having the best resistance and are rated MR (Yorker⁽ᴾ⁾ slightly better than PBA HatTrick⁽ᴾ⁾), Jimbour MS–MR, Flipper⁽ᴾ⁾ and Kyabra⁽ᴾ⁾ MS and PBA Boundary⁽ᴾ⁾ having the least resistance (S).

Since 2007, trials have been conducted to quantify losses caused by PRR in current and advanced breeding lines. In 2013 we also included elite germplasm incorporating very high levels of resistance from a wild relative of chickpea, *Cicer echinospermum*.

2013 Site details

Location: **Hermitage Research Station, Warwick, Qld**

Treatments

- Three released varieties, two advanced breeding lines and two hybrid crosses with *C. echinospermum* (Table 1).
- All plots inoculated with oospores of *P. medicaginis* at sowing on 8 July 2013 (mean rate 2,818 oospores per plant).
- Half the plots were treated with metalaxyl to stop PRR infection; metalaxyl was applied to seed plus regular soil drenches (9 Aug, 11 Sep and 18 Oct 2013). Yield loss from PRR is the difference between metalaxyl treated plots and untreated plots.

Results

- Seed and soil treatment with metalaxyl controlled PRR.
- PRR caused yield losses from 33% to 82% (Table 1).
- Of the commercial varieties, Yorker⁽ᴾ⁾ lost the least yield whilst PBA Boundary⁽ᴾ⁾ lost the most.
- Of the advanced breeding lines, CICA0912 was as resistant as Yorker⁽ᴾ⁾.
- The elite hybrid lines, generated by crossing chickpea (Jimbour or Howzat) with *Cicer echinospermum*, have significantly (P<0.0001) higher levels of resistance to *P. medicaginis* than the most resistant variety, Yorker⁽ᴾ⁾ (Table 1).

- PRR was more severe than in a similar 2012 trial and differences among the varieties were not as great. It is thought the milder winter conditions of the 2013 chickpea season kept soil temperatures above average and this favoured the disease. Nevertheless, the improved resistance of hybrids over varieties was obvious and the ranking of the varieties remained similar to that of the 2012 trial. Indeed, since we started these PRR yield loss trials in 2007, the ranking of varieties has been consistent with the cumulative survival data showing: Yorker⟠>HatTrick⟠>Jimbour >Kyabra⟠>Boundary⟠.
- The 2013 trial clearly demonstrated that even the current best varieties e.g. Yorker⟠, can sustain serious yield loss under high Phytophthora pressure. The trial also highlights the importance of assessing the PRR risk for a given paddock/season.

CROP PROTECTION

Table 1. *Yield of commercial chickpea varieties and breeding lines in the absence of PRR and % yield losses due to PRR from a 2013 trial at Warwick Qld (P Yield<0.001; lsd Yield = 0.25; P % yield loss <0.001, lsd Yield loss = 23)*

Variety / LineA	Yield (t/ha) without PRR	% yield loss due to PRR
D06318	1.8	33
D06344	1.9	37
CICA0912	1.9	63
Yorker⟠	2.2	66
CICA1007	2.0	73
PBA HatTrick⟠	1.8	79
PBA Boundary⟠	1.8	82

[A] D lines are hybrid crosses between chickpea and a wild *Cicer* species.

Summary

- Phytophthora root rot (PRR) caused yield losses from 33% to 82%.
- Yorker⟠ is still the most resistant commercial variety.
- Some advanced breeding lines are just as resistant to PRR as Yorker⟠ or even appear to have improved levels of resistance.
- Under high disease pressure PBA HatTrick⟠ did not perform better than the more susceptible PBA Boundary⟠.

Acknowledgements

This project is funded by NSW DPI, DAFFQ and GRDC under the Northern NSW Integrated disease management project (DAN00176) and the Northern Integrated disease management project (DAQ00154).

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

Chickpea varietal purity and implications for disease management

Kevin Moore, Kristy Hobson NSW DPI, Tamworth **Ata-ur Rehman** CSU, Wagga Wagga

Key findings

Unusually aggressive levels of Ascochyta blight in a moderately resistant commercial chickpea variety in 2011 raised questions about varietal purity.

DNA testing of 36 seed lots from 2011 chickpea crops identified a high incidence of genetic contamination.

Introduction

Australian chickpea varieties differ in their reaction to Ascochyta blight caused by the fungus *Phoma rabiei* (syn *Ascochyta rabiei*). Varieties released before 2005 e.g. Jimbour, are susceptible to Ascochyta and, in seasons conducive to disease, require intensive management with foliar fungicides. Most cultivars released in 2005 and later e.g. PBA HatTrick⦗, have improved Ascochyta resistance and require fewer fungicide sprays. Accurate identification of chickpea varieties is thus critical to appropriate Ascochyta management in commercial crops.

Since 2011, several chickpea crops in the GRDC northern region have shown inconsistencies in their reactions to Ascochyta blight. In all cases the variety was believed to be PBA HatTrick⦗ and the seed was grower retained. PBA HatTrick⦗, released in 2009, is rated Moderately Resistant (MR) to Ascochyta but the level of disease in these crops was more typical of varieties rated Susceptible (S). Possible explanations for these unexpected higher levels of disease include (i) a change in the pathogenicity of *P. rabiei* i.e. breakdown of varietal resistance, and (ii) authenticity and/or purity of the variety i.e. mix up in seed source or contamination. Leo *et al.* (2014) found that genetic diversity in the Australian population of *P. rabiei*, was low and there was little evidence for widespread changes in pathogenicity. Simpfendorfer *et al.* (2013) showed varietal contamination caused the higher than expected levels of stripe rust in the MR bread wheat variety Sunvale. This posed the question: could contamination or a mix-up in source of planting seed account for the observed differences in Ascochyta levels in 'HatTrick" crops grown from grower retained seed. It also raised the larger issue of maintaining genetic purity in Australian chickpea varieties after their release.

2011 Seed Lot details

- Thirty six seed-lots from commercial chickpea crops grown in the GRDC northern region in the 2011 season were assessed for seed purity using four simple sequence repeats (SSR, also called microsatellite) markers. These four were a subset of 15 SSR markers that were shown to differentiate 24 Australian commercially released chickpea varieties and breeding lines which are outlined along with their year of release in Table 1.
- For each seed lot, DNA was extracted from eight seedlings and assayed separately using the four SSR markers. **Note:** this work has not yet been peer reviewed.
- The seed weight for each seed lot was determined by weighing three random subsamples, each of 100 seeds, per lot.

Table 1. *Australian chickpea varieties and breeding lines used to identify SSR markers that could discriminate among individual varieties*

Variety/Genotype	Year of Release	Variety/Genotype	Year of Release
Jimbour	2001	PBA HatTrick⁽ᵖ⁾	2009
Moti	2003	PBA Slasher⁽ᵖ⁾	2009
Sonali	2004	Genesis™ 079	2009
Flipper ⁽ᵖ⁾	2005	Genesis™ 114	2010
Kyabra⁽ᵖ⁾	2005	Genesis™ Kalkee	2011
Yorker⁽ᵖ⁾	2005	PBA Pistol	2011
Almaz⁽ᵖ⁾	2005	PBA Boundary ⁽ᵖ⁾	2011
Genesis™ 090	2005	PBA Striker⁽ᵖ⁾ (CICA0603)	2012
Genesis™ 425	2007	PBA Maiden (CICA0717)	2013
CICA0709	not released	PBA Monarch⁽ᵖ⁾ (CICA0857)	2013
CICA0912	not released	CICA1007	not released
CICA1016	not released	04067-81-2-1-1	not released

Results

- In only 15 of the 36 seed lots, were all eight seedlings deemed to be the same.
- The remaining 21 lots showed varying degrees of contamination by known and unknown genotypes.
- Results for eight of the 36 seed lots are outlined in Table 2.
- The DNA assays for the 36 seed lots suggest that unintentional contamination, or mix up in planting seed, is the most plausible explanation for any differences among the eight seedlings.
- The seed weight data support the findings of the DNA assays.
- The 100 seed weights for Amethyst, Flipper⁽ᵖ⁾, PBA HatTrick⁽ᵖ⁾, Howzat, Jimbour, and Kyabra⁽ᵖ⁾ in field trials conducted in Southern Qld from 2005–2008, were 14, 18, 20, 21, 20 and 24 grams respectively.
- Thus it is not surprising that the seed lot declared to be Amethyst in Table 2 was determined to be a variety with a 100 sdw greater than 14 g.
- Similarly, the lot declared to be Howzat had seeds that were too small to be Howzat (100 sdw 21 g) but that were similar to those of Flipper⁽ᵖ⁾ (100 sdw 18 g).

Table 2. *Selected results from 36 chickpea seed lots ex 2011 harvest showing the variety declared at receival, 100 seed dry weight (sdw) and identity of each of 8 seedlings as determined by four SSR markers based on DNA profiles.*

Declared	100 sdw (g)	DNA Identity (maximum 8)
Jimbour	21.8	Jimbour (1), Kyabra⁽ᵖ⁾ (6), Undetermined (1)
Jimbour	20.0	HatTrick⁽ᵖ⁾ (8)
Kyabra⁽ᵖ⁾	21.8	Moti (7), Kyabra⁽ᵖ⁾ (1)
Kyabra⁽ᵖ⁾	20.9	HatTrick⁽ᵖ⁾ (4), Kyabra⁽ᵖ⁾ (1), Undetermined (3)
Kyabra⁽ᵖ⁾	18.3	Kyabra⁽ᵖ⁾ (1), Jimbour (2), Moti (4), Undetermined (1)
Howzat	17.2	Flipper⁽ᵖ⁾ (6), Undetermined (2)
HatTrick⁽ᵖ⁾	21.2	HatTrick⁽ᵖ⁾ (8)
Amethyst	18.2	Jimbour (7), Undetermined (1)

How widespread is the chickpea varietal purity issue?

- The results of the 36 seed lots suggest varietal purity is a far bigger problem than the chickpea industry currently believes. However, it is not difficult to see how this can happen. If the multiplication rate of a single chickpea plant is roughly 50, a single seed of say Jimbour in one hectare of otherwise pure PBA HatTrick⁽ᴰ⁾ yields 50 Jimbour seeds at the end of season one. Season two gives 2,500 Jimbour contaminants; season three 125,000 etc. And that is just one hectare.
- Whilst the problem first surfaced in 2011, the issue of varietal purity appears to be getting worse. In 2013, on a property near Moree, three paddocks had been planted with seed from three different sources, all grower retained and all believed to be PBA HatTrick⁽ᴰ⁾. When inspected on 8 and 9 August 2013, it was obvious that one of the paddocks was different from the other two and was clearly not PBA HatTrick⁽ᴰ⁾ (possibly Howzat). A similar situation was observed, again in 2013, on another north western NSW property where the grower had sown one half of a paddock with grower retained seed and the other half with a different source of grower retained seed. The seed from the two sources was believed to be PBA HatTrick⁽ᴰ⁾ but it was obvious when inspected that they were not the same variety and again one was not PBA HatTrick⁽ᴰ⁾ (possibly Yorker⁽ᴰ⁾).

Does it really matter if a chickpea crop is a mixture of varieties?

Why is it important for growers to know what they are growing and the level of contamination, if any? Accurate identification of chickpea variety is essential for:

- Implementing appropriate disease management strategies.
- Minimising the risk to resistance genes in MR varieties from increased inoculum generated on contaminant plants or 'mix up' crops, of susceptible varieties.
- Maximising marketing opportunities by producing pure seed of one variety.
- Supporting grower's legal rights e.g. if seed you purchased is not what you paid for.
- Assessing compliance with plant breeder's rights legislation thus ensuring breeding programs receive the appropriate royalties.
- Prolonging the commercial life of new varieties.
- Providing confidence in the chickpea seed industry.
- Providing technical support to research programs e.g. knowing the genotype of a plant from which an Ascochyta isolate is obtained is critical to the current GRDC project on the variability of the Australian population of the chickpea Ascochyta pathogen.

Cost of Ascochyta management – an example of a consequence of varietal impurity

- In an Ascochyta favourable season, Tamworth research has shown that a crop of pure PBA HatTrick⁽ᴰ⁾ will require two foliar fungicide sprays totalling $30/ha.
- An Ascochyta susceptible variety e.g. Jimbour would need six sprays costing $90/ha.
- This equates to a difference of $30,000 for a 500 ha planting.
- If unsure of the variety's identity or it is a mixture, the crop must be treated as a susceptible variety.

Where to from here?

- The molecular work has not been peer reviewed and, due to staff changes, is currently on hold.
- Continuation of the variety identification work is being discussed with the University of Adelaide and there is an opportunity to tap into existing genomic resources that have been funded by the Australian Federal Government through the Australia India Strategic Research Fund.

Summary

- DNA evidence has identified genetic contamination in commercial chickpea crops going back to at least 2011.
- Crop inspections have revealed obvious differences among plantings believed by growers to be the one variety.
- Growers have been advised to minimise the risk of contamination of their 2014 planting seed by obtaining seed from a registered seed merchant.
- If retaining their own seed, growers have been advised to implement a Quality Management System to avoid accidental contamination.

Acknowledgements

This work was funded by NSW DPI and GRDC under the Northern NSW Integrated disease management project (DAN00176). Thanks to agronomists and growers for identifying paddocks and giving permission to inspect and sample crops. Thanks to Paul Nash and Gail Chiplin for technical support.

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

References

1. Leo A E, Ford R and Linde CC (2014). Evolution and dispersal of a recently introduced pathogen of chickpea, *Ascochyta rabiei*, to Australia. Biological Invasions *In Press.*
2. Simpfendorfer S, Martin A and Sutherland MW (2013). Use of SSR markers to determine the genetic purity of a popular Australian wheat variety and consequences for stripe rust reactions. Seed Sci. & Technol., 41, 98–106.
3. http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/chickpeas/varieties.

Rust management strategies for modern Faba bean varieties

Bill Manning North West LLS, Gunnedah
Joop van Leur and Merv Riley NSW DPI, Tamworth

Key findings

The new variety PBA Warda⚅ is showing good levels of rust resistance.

Faba bean varieties with good levels of rust resistance still respond to fungicide application under high rust pressure.

This trial supports the present recommendation of an early fungicide spray followed by monitoring to determine if a second spray is required in spring to avoid late rust development.

Introduction

Faba bean is a rotation crop used in northern NSW to break cereal diseases cycles and to maintain soil fertility. The Pulse Breeding Australia (PBA) faba bean breeding program aims to breed locally adapted varieties with improved disease resistance. Faba bean rust (*Uromyces viciae-fabae*) is a significant production constraint in northern NSW and growers are advised to apply one preventative early fungicide spray, and to then monitor disease development in the crop during spring. The variety Doza⚅ was released in 2008 and is classified as rust resistant. The variety PBA Warda⚅ was released in 2012 and is classed as moderately resistant to rust. This trial used a split plot design to measure the benefits of different fungicide strategies on these two newer, rust resistant varieties. The trial was located next to a rust nursery producing sufficient inoculum to ensure disease development.

Site details

2013

Location: **Liverpool Plains Field Research Station**

Co-operator: **Scott Goodworth, NSW DPI**

Sowing date: **17th May 2013**

Treatments

The trial used two varieties, Doza⚅ and PBA Warda⚅ and four fungicide treatments;

- Control – no fungicide applied.
- Early – one spray of Mancozeb @ 2.5 kg/ha (750 g/kg) on the 18th July 2013.
- Late – one spray of Mancozeb @ 2.5 kg/ha (750 g/kg) on the 2nd September 2013.
- Early and Late – one spray of Mancozeb 2.5 kg/ha on both the 18th July and 2nd September 2013.

The trial was assessed visually for rust on 10th October 2013 by estimating the percentage leaf area with rust pustules. The trial was harvested on the 1st of November to determine yield and seed weight.

Results

Rainfall (mm) Breeza 2013

Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
138	127	76	5	17	77	45	3	26	19	91	28	652

Results

Table 1. *Impact of treatments on rust development, grain yield and seed size.*

Treatment	Rust symptoms (% leaf coverage)	Significance	Yield (t/ha)	Yield significance	Seed size (g/100)	Seed size significance
Control	23.7	a	2.2	b	41.5	a
Early & Late (two spray)	0.5	c	2.5	a	44.2	a
Early	9.8	b	2.3	b	43.0	a
Late	1.7	c	2.4	ab	44.3	a
L.s.d	4.7		0.18		n.s.d	n.s.d

- All spray treatments significantly reduced development of rust pustules on leaves (Table 1). The single late spray and the two spray treatment had significantly fewer rust pustules compared to the single early spray indicating that rust developed later in the season in 2013. There was no significant difference between the late only and the early & late spray strategy, indicating that the late spray was very important in this season.
- Across all treatments there was a trend to lower leaf rust in PBA Warda⁽ᵈ⁾ (7.3%) compared to Doza⁽ᵈ⁾ (11.1%) (data not shown). This may indicate outcrossing in this Doza⁽ᵈ⁾ seed source which reduced the rust resistance of this seed lot; however it also indicates that PBA Warda⁽ᵈ⁾ has good rust resistance.
- In a season not highly favourable for rust development there was a trend to higher yield with fungicide spray and significant improvement in yield with the two spray strategy compared to the nil spray treatment.
- There was a non significant trend to higher seed weight with fungicide spray, it is likely that the yield increase associated with fungicide application was due to larger seed size.
- Across all treatments PBA Warda⁽ᵈ⁾ produced significantly larger (45.8 g/100 seeds) seed than Doza (40.8 g/100 seeds).

Glasshouse experiment testing two sowthistle populations for glyphosate resistance – 2013

Tony Cook, Bill Davidson and Bec Miller NSW DPI, Tamworth

Key findings

Fallows, glyphosate tolerant crops and non-cropping areas are under threat from another glyphosate resistant species.

Group B resistance is present in sowthistle populations within the Qld/NSW border region. It is likely that plants will develop multiple resistance to Groups B and M over time.

With the partial loss of effectiveness of glyphosate and Group B resistance in other parts of the northern grain region, there will be more selection pressure on Group I chemistry. Further to this point, herbicide Groups C, G, H and L could be used more to take selection pressure off Groups B, I and M.

Due to its wind borne seed, glyphosate resistant sowthistle populations will spread rapidly, similar to fleabane. Surveys are presently underway to gauge the spread of resistance in the northern grain region. In time, southern regions should be surveyed to determine the extent of resistance to glyphosate in sowthistle populations.

Aims

- To confirm possible glyphosate resistance in two sowthistle populations; one growing in a round-up ready (RR) cotton crop near Boggabri and the other in a winter fallow at Bundella. The first population was highlighted by Graham Charles from ACRI, after showing photographic evidence of the population; it became a high research priority. The second population was detected by members of the AGSWG (Australian Glyphosate Sustainability Working Group) on a recent field trip.
- First population in RR cotton: Most plants surviving were common sowthistle (*Sonchus oleraceus*) and an occasional prickly sowthistle (*S. asper*) was present (please note taxonomy of these species is somewhat nebulous). Although all glyphosate labels only have claims for common sowthistle there is a claim for Prickly sowthistle on the Touchdown Hi-Tech label. Both formulations will be checked on both species to determine resistance or tolerance levels. Second population in fallow: All surviving plants were most likely prickly sowthistle.
- To investigate the effect of four glyphosate rates on these species and another population (*Sonchus oleraceus*) with a low glyphosate control history – likely to be susceptible (collected from Tamworth).

Methods

Site details

Tamworth Agricultural Institute glasshouse

Treatments

- Five sowthistle biotypes
  - Possible glyphosate resistant common sowthistle from Boggabri (as 'white' biotype). These were collected on first visit to the site.
  - Possible glyphosate resistant prickly sowthistle from Boggabri (as 'yellow' biotype). These were collected on the second visit to the site; hence more likely to be resistant.
  - Possible glyphosate resistant prickly sowthistle from Bundella ('*Sonchus asper*' and labelled 'CRK' biotype).
  - 'Susceptible' common sowthistle from Tamworth – with little history of glyphosate use.
  - Potentially 'Susceptible' prickly sowthistle from Tamworth – with unknown history of glyphosate use.
- Two sowthistle growth stages for each spraying rate
  - Large rosettes (at least 15 cm diameter)
  - Bolting and early flowering

- Four herbicide rates
  - Untreated
  - ½ Standard fallow rate: 0.8 L/ha glyphosate (450 g/L) + non-ionic wetter at 0.2% v/v = 360 g a.i. glyphosate/ha. Used this rate in case suspect population isn't resistant but has a marginal low level of resistance.
  - Standard fallow label rate: 1.6 L/ha glyphosate (450 g/L) + non-ionic wetter at 0.2% v/v = 720 g a.i. glyphosate/ha.
  - Touchdown Hi-Tech label rate: 2.0 L/ha glyphosate (500 g/L) + non-ionic wetter at 0.2% v/v = 1000 g a.i. glyphosate/ha.
- Pot size and design
  - 200 (8 cm square) pots were used
  - Randomised Complete Block of 5 sowthistle types x 2 ages x 4 herbicide rates x 5 replicates
  - 1 plant per pot (initially grew two plants per pot but thin down to one plant if required after emergence)
  - Potting mix: Scotts Osmocote Premium Potting Mix
- Herbicide application
  - DG 110-015 nozzles with pressure of 2 bars with speed of application designed to deliver 100 L/ha.

Special notes

- Plants grown in glasshouse most of the time, however 1 week prior to spraying they were grown outside to 'toughen-up'.
- After herbicide application the plants were taken back to the glasshouse for the rest of the life of the experiment.

Measurements

- Biomass rating (% of untreated) of whole pot using visual assessment at 14, 28, and 42 days after each treatment (DAT).
- Plant counts of survivors at 42 DAT
- Destructive biomass sampling of green material 42 DAT.
- Photographic comparison between rates and biotypes is essential.

Treatments

Herbicide	Rate (ha)	(gly ai/ha)	Wetter	Rate (in 5 L)
Untreated	Nil	(0)		Nil
Glyphosate CT 450	0.8 L	(360)	Non-ionic 0.2%	40 mL
Glyphosate CT 450	1.6 L	(720)	Non-ionic 0.2%	80 mL
Touchdown Hi-Tech	2.0 L	(1000)	Non-ionic 0.2%	100 mL

Site where the 'white' and 'yellow' biotypes were collected. The 'white' biotype was collected just after this photo was taken whereas the 'yellow' was collected at least another month later following a further application of glyphosate. Note the variable control of sowthistle; plants foreground right are dead while others appear healthy.

Results – Large rosette/early stem elongating sowthistle

Table 1. *Final assessments on sowthistle for plant survival, biomass control / production and reproductive capacity, made 42 days after treatment. Note: growth stage at treatment was large rosette to early elongating stage.*

Glyphosate rate a.i./ha rate	Live plants (max = 1 plant per pot)	Estimate of biomass control (%)	Green biomass as g/plant (% control)	Viable flower buds per plant
Common sowthistle 'potentially susceptible'				
0	1	0	32.56 (0)	26.6
360	0.8	84	3.46 (89)	0
720	0.4	94	1.12 (97)	0
1000	0.4	98	0.56 (98)	0
'CRK' biotype				
0	1	0	49.94 (0)	21.8
360	1	54	18.36 (63)	0.4
720	1	67	10.38 (79)	0
1000	1	56	19.06 (62)	0
Prickly sowthistle 'potentially susceptible'				
0	1	0	70.22 (0)	22.4
360	1	62	12.74 (82)	0
720	1	88	5.44 (92)	0
1000	0.8	95	2.10 (97)	0
'White' biotype				
0	1	0	61.56 (0)	12.2
360	1	85	5.82 (91)	0
720	0.2	98	0.24 (99)	0
1000	0.2	99	0.64 (99)	0
'Yellow' biotype				
0	1	0	59.26 (0)	16.8
360	1	44	32.84 (45)	6
720	1	53	18.92 (68)	0.2
1000	0.8	79	19.08 (68)	0

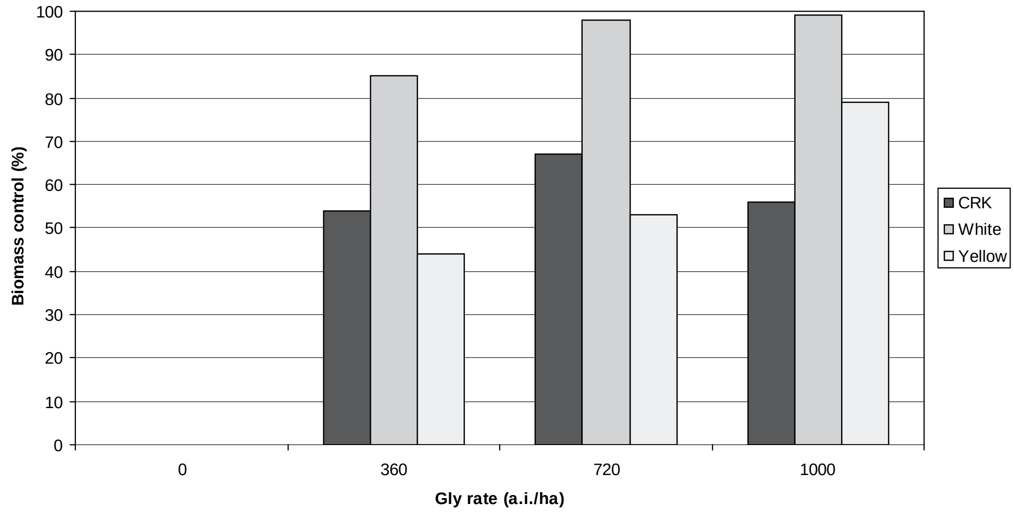


Figure 1. *Effect of glyphosate rate on estimated sowthistle biomass control 42 DAT. The 'white' population is considered susceptible.*

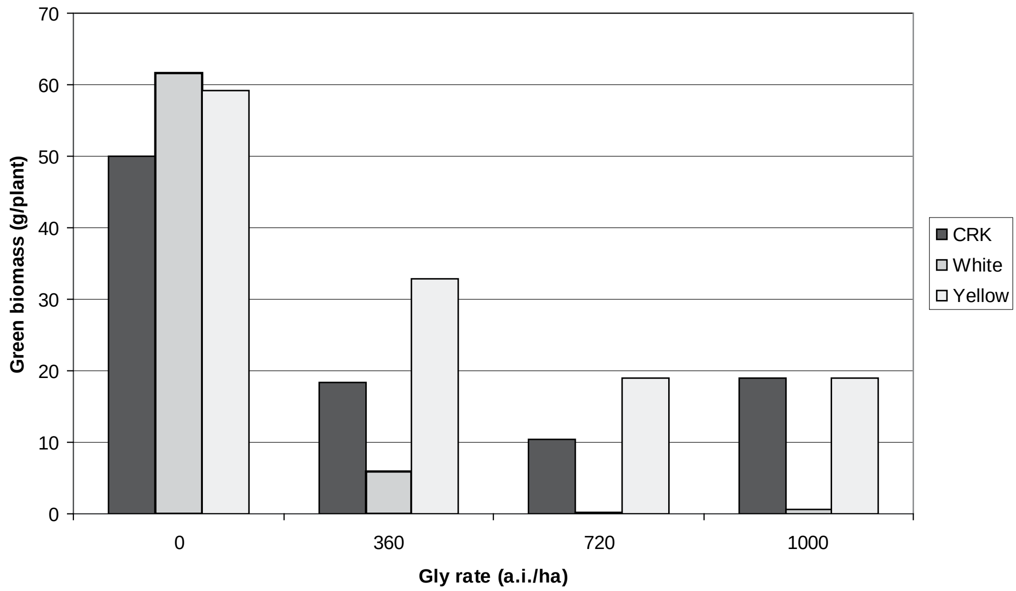


Figure 2. *Effect of glyphosate rate on sowthistle green biomass production 42 DAT. The 'white' population is considered susceptible.*

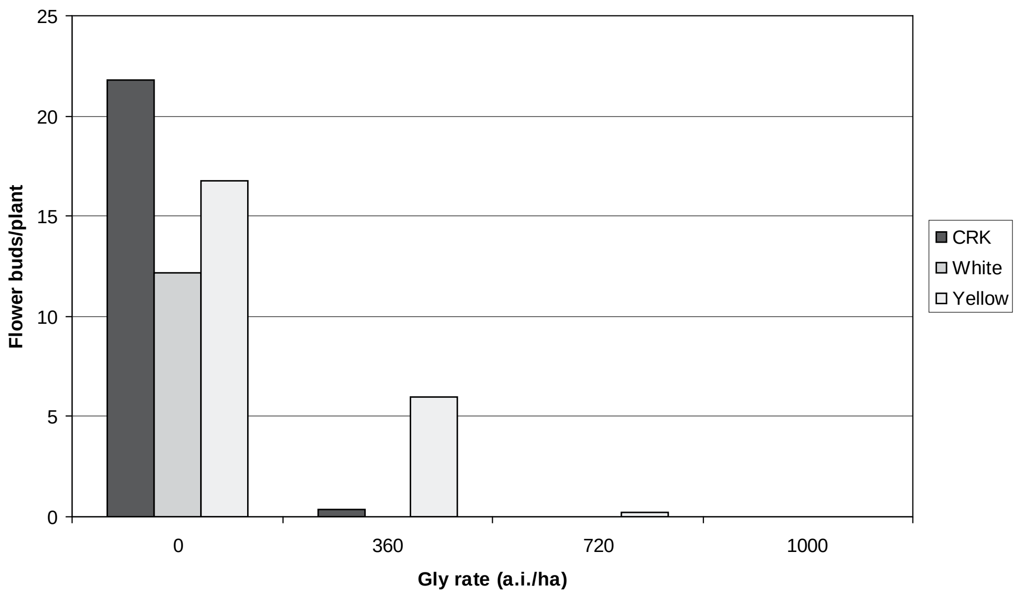


Figure 3. *Effect of glyphosate rate on sowthistle flower production 42 DAT. The 'white' population is considered susceptible.*

Results – Stem elongating/early flowering sowthistle

Table 2. *Final assessments on sowthistle for plant survival, biomass control / production and reproductive capacity, made 56 days after treatment. Note: growth stage at treatment was stem elongating/early flowering stage.*

Glyphosate rate g a.i./ha rate	Live plants (max = 1 plant per pot)	Estimate of biomass control (%)	Green biomass as g/plant (% control)	Viable flower buds per plant
Common sowthistle 'potentially susceptible'				
0	1	0	52.96 (0)	30
360	1	17	25.30 (52)	6
720	0.8	79	6.62 (88)	22
1000	1	43	14.04 (73)	41
'CRK' biotype				
0	1	0	59.78 (0)	31
360	1	42	31.76 (47)	10
720	1	22	21.42 (64)	23
1000	1	25	26.34 (56)	22
Prickly sowthistle 'potentially susceptible'				
0	1	0	73.70 (0)	41
360	1	26	24.52 (67)	19
720	0.8	46	20.14 (73)	17
1000	1	32	23.90 (68)	14
'White' biotype				
0	1	0	56.76 (0)	33
360	0.8	52	20.8 (63)	13
720	0.6	88	5.2 (91)	0
1000	0.8	76	10.4 (82)	0
'Yellow' biotype				
0	1	0	72.56 (0)	51
360	1	15	43.22 (40)	29
720	1	8	55.56 (23)	33
1000	1	14	51.50 (29)	31

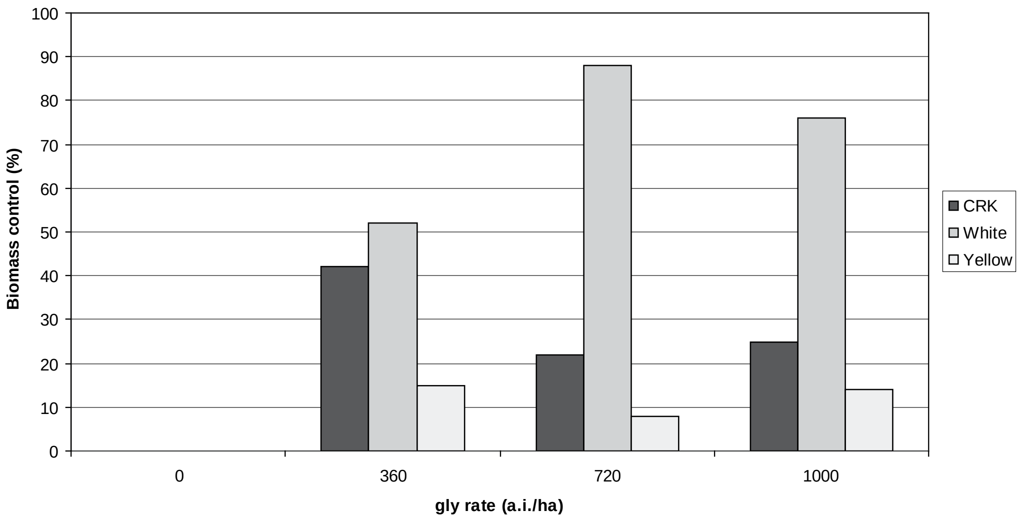


Figure 4. *Effect of glyphosate rate on estimated sowthistle biomass control 56 DAT. The 'white' population is considered susceptible.*

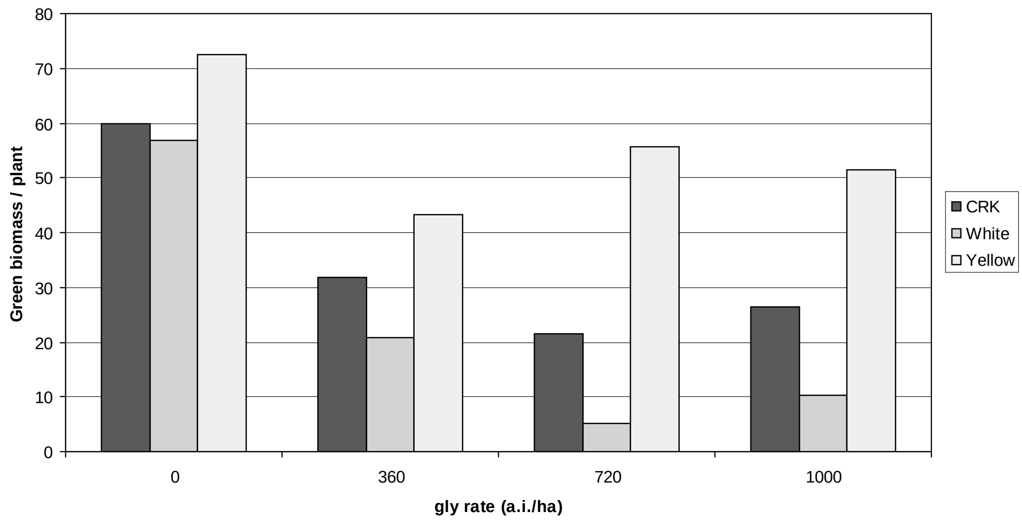


Figure 5. *Effect of glyphosate rate on sowthistle green biomass production 56 DAT. The 'white' population is considered susceptible.*

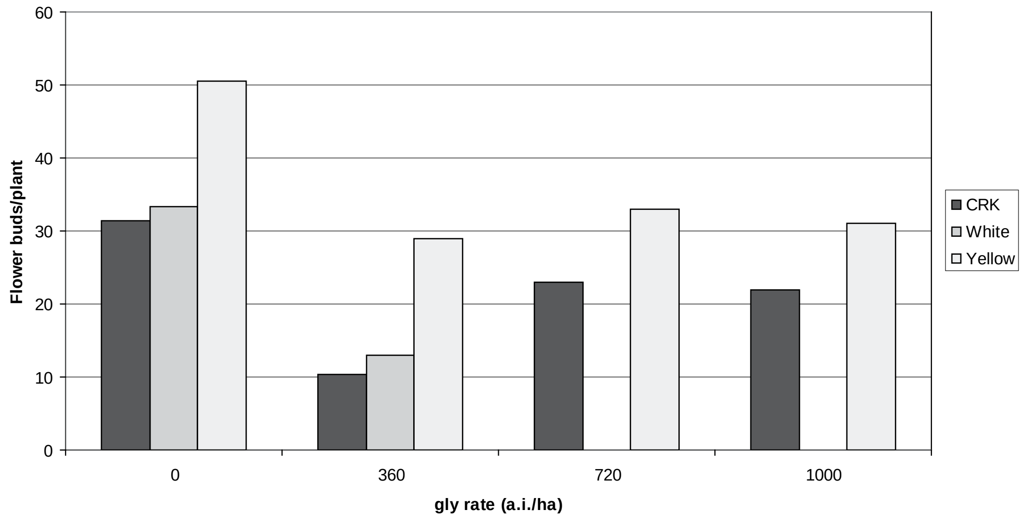


Figure 6. *Effect of glyphosate rate on sowthistle flower production 56 DAT. The 'white' population is considered susceptible.*

Results

The discovery of two potential populations of sowthistle resistant to glyphosate is of concern to farmers in the northern grain region. These populations are located in northern NSW in the Liverpool Plains district. They are identified as the 'yellow' and 'CRK' biotypes. In 1990, a population in Queensland was confirmed resistant to ALS inhibitors (Group B mode of action).

Treating large rosette sowthistle

The standard label rates of 1.6 L/ha of 450 g/L and 2 L/ha of the 500 g/L formulations are the treatments of interest (720 and 1000 g active per hectare). The 'white' and the two 'potentially susceptible' biotypes harvested green biomass was reduced from 92 and 99% at these registered label rates. However the 'CRK' and the 'yellow' populations green biomass were lowered from 62 and 79%. Evidence indicates that the 'yellow' population was producing some reproductive structures (flower buds) at the 720 g a.i./ha rate. Both confirmed resistant biotypes were developing flower buds at the 360 g a.i./ha rate whereas the other populations had no evidence of recovery/ reproduction. Refer to Table 1 and Figures 1, 2 and 3.

Treating stem elongating to early flowering sowthistle

Comments in this section are with reference to the label rates of glyphosate of 720 and 1000 g active per hectare (refer to Table 4 and Figures 4, 5 and 6). The differences between the nominated susceptible 'white' biotype and the potentially glyphosate resistant 'CRK' and 'yellow' biotypes was much more pronounced when treating sowthistle at a more advance stage. For example, the estimated biomass reduction on the 'white' biotypes was 76 and 88% for the top two rates of glyphosate; however it ranged from 8 to 25% for the potentially resistant plants. Other measured variables such as flower buds per plant and green biomass per plant exhibited a similar trend (Figures 5 and 6).

This growth stage by resistance interaction is an important consideration when undertaking herbicide resistance testing. Herbicide application should be completed when plants are at the early stem elongating to early flowering stage, as this timing extracts greater differences between the biotypes in terms of glyphosate responses and still complies with the growth stage specified on the herbicide label.

The nominated susceptible 'white' biotype was used as the standard, however another population of sowthistle was discovered that has greater susceptibility to glyphosate and will be used as the standard susceptible in future work.

Summary

Rates of glyphosate used in this experiment cover all the registered label claims. The highest rate permitted in Australia is 1800 g a.i./ha or 4 L/ha of the 450 g/L formulation via a WeedSeeker® permit (number 11163). This rate will be tested later in a growth stage and herbicide rate factorial experiment.

Sowthistle requires more time to complete the glyphosate resistance testing compared to other species such as awnless barnyard grass and annual ryegrass due to the slow brownout of the weed. Brownout may take much longer if applied to more advanced sowthistle plants.

Some of the 'susceptible' standards, collected around Tamworth, did not completely die, however the percentage control of biomass was very high. The history of these plants is hard to determine as they could have blown in from an area that had a reasonable glyphosate history. The search for a more appropriate 'susceptible' standard is in progress. Plants may need to be sourced from the tablelands or coastal districts where glyphosate history is likely to be very low.

Implications to grains and cotton industries

- Fallows, glyphosate tolerant crops and non-cropping areas are under threat from sowthistle being another glyphosate resistant species.
- Group B resistance in sowthistle is present within the Qld/NSW border region. It is likely that plants will develop multiple resistance to Groups B and M over tiime.
- With the partial loss of effectiveness of glyphosate and Group B resistance in other parts of the northern grain region, there will be more selection pressure on Group I chemistry. Further to this point, herbicide Groups C, G, H and L could be used more to take selection pressure off Groups B, I and M.
- Due to its wind borne seed, glyphosate resistant sowthistle populations will spread rapidly, similar to fleabane. Surveys are presently underway to gauge the spread of resistance in the northern grain region. In time, southern regions should be surveyed to determine the extent of resistance to glyphosate in sowthistle populations.

Acknowledgements

Funding for this work was courtesy of GRDC under the project codes UA00124 and UQ00062. Other valuable assistance from Graham Charles (NSW DPI) is appreciated. A final thankyou for support from members of the Australian Glyphosate Sustainability Working Group, who verified this report to determine that these two populations satisfied the criteria of glyphosate resistance.

Group I resistant Wild Radish Herbicide Trial 2013

Greg Brooke NSW DPI, Trangie **Tony Cook** NSW DPI, Tamworth

Introduction

A site at Nyngan with known Group I (2,4-D) resistance was selected to field screen a range of alternative herbicides. This wild radish site has also had sub-optimal control from triasulfuron but group B resistance has not yet been checked.

Wild radish is a competitive broadleaf weed and is a problem in all crop and pasture types. Wild radish sets large amounts of seed which have a long seed bank life. The woody seed coat segments dry to around the same size as wheat and so make grading out difficult. Seed pod segments are a grain contaminant in cereals.

Wild radish's opportunistic emergence allows it to germinate at almost any time of year. Consequently it is often sprayed in summer fallows, pre-sowing of winter crops, in crop – sometimes more than once and weed escapes in winter cereals often require late salvage sprays. (Weed escapes in winter pulses can generally not be treated effectively). These multiple germinations mean wild radish populations in any paddock are frequently targeted several times with group I chemistry in any one year. When it is considered that a group I product is mostly used in almost all of these applications it is easy to see how resistance builds.

Wild radish is mostly ignored by grazing stock.

Herbicide tolerant canola groups B (Clearfield), C (Triazine tolerant) and M (Glyphosate) are also at risk as these chemical groups are used in other crops and/or fallow sprays as well.

Key findings

Pyrasulfotole 37.5 g/L + Bromoxynil 210 g/L herbicide (groups H+C) gave notably quicker and better results than Group I or B products and a much better result than Pyrasulfotole 50 g/L + MCPA 250 g/L in this trial.

Metsulfuron methyl alone was inadequate and in conjunction with MCPA did little to improve control.

Further testing for possible group B resistance of this weed population will be undertaken.

Site details

2013

Location:	**Nyngan**
Soil Type:	**Red loam, box/pine**
Crop sown:	**Wheat Strzelecki**$^{\text{(b}}$
Crop stage:	**Z25**
Weed size:	**4 to 6 leaf (10 to 15 cm rosettes – some larger)**
Spraying date:	**7th August 2013**
Assessment dates:	**(1) 28 Aug 2013 21 Days after treatment (D.A.T)** **(2) 28 Oct (Terminal drought conditions)**

Assessment rankings conducted by the 2 authors. 1 = nil control, 10 = full control.

Both crop and weeds were fresh and actively growing at the time of spraying. Several frosts had occurred in the week leading up to spraying. The surrounding crop had already been sprayed with an MCPA LVE product (750 g.a.i) @ 1 L/ha. The weeds were showing symptomatic phenoxy effects e.g. leaf curling and twisting.

Table 1. *List of herbicide treatments applied.*

Treatment No.	Herbicide groups	Treatment	Rate	Efficacy score 1 to 10 (21 D.A.T)
1	H + C	Pyrasulfotole+Bromoxynil+ oil	1 L/ha	9
2	H + C+ I	Pyrasulfotole +Bromoxynil + MCPA L.V.E (750 g.a.i) + oil	500 ml + 500 ml	7
3	H+C+I+B	Pyrasulfotole + Bromoxynil + MCPA LVE + Triasulfuron + Oil	250 ml + 250 ml + 15 grams	5
4	H+I	Pyrasulfotole + MCPA + Oil	1 L/ha + 500 ml Wetter	4
5	I	2,4-D Ester (Low vol) (680 g.a.i)	500 ml	5
6	I + H+C	2,4-D Ester + Pyrasulfotole + bromoxynil + oil	250 ml + 250 ml	6.5
7	B	Triasulfuron + wetter	15 g + 1% wetter	4
8	B+I	Flumetsulam + 2,4-D amine (625 g.a.i)	7.5 g + 500 ml	3
9	B	Flumetsulam + wetter	25 g/ha + 1% Wetter TX	1.5
10	B + I	Flumetsulam + MCPA LVE® (750 g.a.i) + wetter	25 g/ha + 1 L/ha + 1% wetter	3

NB. Most of these tank mixtures are not on label and no recommendation should be made or inferred.

Results 2013

#1

#2

#3

#4

#5

#6

#7

#8

#9

#10

Summary

Treatments with bromoxynil and pyrasulfotole clearly gave the quickest results. Due to terminal drought conditions all treatments received enough of a set back to eventually die after around 8 weeks. This may well have NOT been the case if more favourable growing conditions returned post spraying.

Acknowledgements

Thanks to Jayne Jenkins for technical assistance. Name of co-operating farmer withheld. Thanks to Farmoz Chemicals for supplying all needed products.

Nitrogen response of 6 wheat varieties – Trangie and Wongarbon 2013

Rohan Brill NSW DPI, Wagga Wagga
Greg Brooke and Leigh Jenkins NSW DPI, Trangie

NUTRITION & SOILS

Key findings

At Trangie, only EGA_Gregory⊕ had grain yield significantly higher than the trial mean. There was a small but significant grain yield reduction as a result of increasing N rate from nil to 160 kg/ha.

LongReach Spitfire⊕ required a lower rate of nitrogen than EGA_Gregory⊕ and Suntop⊕ to achieve 13% grain protein concentration.

At Wongarbon, only LongReach Dart⊕ had grain yield significantly higher than the trial mean. There was no effect of nitrogen rate on grain yield, which was not surprising based on the starting soil nitrogen levels.

LongReach Spitfire⊕ and Sunvale had (averaged across N rates), grain protein at least 1% higher than all other varieties.

Introduction

Soil nitrogen (N) levels have generally declined in the northern grains region in recent seasons; however the response to applied N in VSAP trials in previous seasons has generally only been low to moderate. These trials aim to identify varieties that most efficiently use N fertiliser to increase grain yield and protein concentration.

Site details

Location:	**Trangie**	Location:	**Wongarbon**
2012 crop:	**canola**	2012 crop:	**canola**
PAW (sowing):	**30 mm**	PAW (sowing):	**50 mm**
Rainfall in-crop:	**205 mm**	Rainfall in-crop:	**265 mm**
Nitrogen:	**80 kg/ha (0–120 cm)**	Nitrogen:	**290 kg/ha (0–90 cm)**

Treatments

- 4 N rates – 0, 40, 80 and 160 kg/ha applied at sowing.
- 6 bread wheat varieties –LongReach Dart⊕, EGA_Gregory⊕, LongReach Spitfire⊕, Sunguard⊕, Suntop⊕, Sunvale.

Results

- At Trangie, EGA_Gregory⊕ was significantly higher yielding than all other varieties, averaged across all N rates (Table 1).
- There was a small but significant grain yield reduction (0.18 t/ha) as a result of increasing N rate from nil to 160 kg/ha, which was observed across all varieties.
- At Wongarbon, only LongReach Dart⊕ had grain yield significantly higher than the trial mean (Table 1).
- There was no effect of N rate on grain yield at Wongarbon on any variety.

Table 1. *Grain yield of six wheat varieties sown with four rates of nitrogen at Trangie and Wongarbon – 2013.*

Grain Yield (t/ha)	Trangie	Wongarbon
LongReach Dart⊕	2.97	4.09
EGA_Gregory⊕	3.42	3.96
LongReach Spitfire⊕	3.22	3.91
Sunguard⊕	3.07	4.04
Suntop⊕	3.12	3.79
Sunvale	2.81	3.70
	l.s.d. (p=0.05)	
	0.12	0.17

- Grain protein concentration increased as N rate increased at Trangie (Table 2). At Wongarbon (data not shown) there was only a 0.3% grain protein concentration increase as N rate increased from nil to 160 kg/ha.
- At Trangie, the amount of nitrogen required to achieve 13% protein was 40 and 80 kg/ha for LongReach Spitfire$^{\phi}$ and EGA_Gregory$^{\phi}$ respectively. Suntop$^{\phi}$ did not achieve 13% protein at any N application rate.
- At Wongarbon, the grain protein concentration of LongReach Spitfire$^{\phi}$ and Sunvale was significantly higher than all other varieties (averaged across N rates).

Table 2. *Grain protein concentration of six wheat varieties sown with four rates of nitrogen at Trangie and averaged across four rates of nitrogen at Wongarbon – 2013.*

Site	**Trangie**				**Wongarbon**
N Rate (kg/ha)	**0**	**40**	**80**	**160**	**Average of N rates**
LongReach Dart$^{\phi}$	12.6	13.0	13.4	13.4	12.6
EGA_Gregory$^{\phi}$	11.5	12.4	13.0	13.2	13.2
LongReach Spitfire$^{\phi}$	12.9	14.2	14.3	14.8	14.6
Sunguard$^{\phi}$	11.8	12.5	12.8	13.3	13.9
Suntop$^{\phi}$	11.7	12.2	12.4	12.9	12.9
Sunvale	12.4	13.3	13.8	13.9	14.6
	l.s.d. (p=0.05)				l.s.d. (p=0.05)
Variety	0.2				0.2
N rate	0.1				0.2
Variety by N rate	0.3				n.s.

Summary

Similar trials to this were conducted at Trangie and Wongarbon in 2012, with similar varietal rankings where EGA_Gregory$^{\phi}$ was significantly higher yielding than Suntop$^{\phi}$ in both trials. Also, despite the high rates of N applied in these trials as well as the high background N level at Wongarbon, Suntop$^{\phi}$ did not achieve 13% grain protein concentration at any N rate at Trangie or averaged across N rates at Wongarbon. In VSAP trials in northern NSW over the previous three seasons, Suntop$^{\phi}$ has generally been relatively high yielding on heavy clay soils especially where crown rot is an issue; however in the central-west trials conducted on coarser soils the yield of Suntop$^{\phi}$ has generally been closer to average.

LongReach Spitfire$^{\phi}$ achieved at least average grain yield in both trials; however it had the highest grain protein in both trials. This supports findings from previous seasons in northern NSW, that LongReach Spitfire$^{\phi}$ achieves a high grain protein concentration for a given yield level, especially in these higher protein situations.

Since there was no positive grain yield response to nitrogen in these trials, it is unlikely that the grain protein concentration response alone would have made the N applications profitable.

Acknowledgements

These trials are funded by NSW DPI and GRDC under the Variety Specific Agronomy Package Project (DAN00129). Thanks to Jayne Jenkins, Paddy Steele, Scott Richards and Lindsay Hyde (all NSW DPI Trangie) for assistance throughout this trial.

Nitrogen response of 6 wheat varieties – Merriwa 2013

Greg Brooke NSW DPI, Trangie **Rohan Brill** NSW DPI, Wagga Wagga
Guy McMullen NSW DPI, Tamworth **Matthew Gardner** formerly NSW DPI, Tamworth

NUTRITION & SOILS

Key findings

There was no effect of nitrogen on grain yield in this trial.

There were significant differences in grain yield between varieties. The varieties that were the quickest to reach flowering; LongReach Spitfire⁽ᴰ⁾ and LongReach Dart⁽ᴰ⁾, were the highest yielding varieties in this trial.

The application of nitrogen increased grain protein concentration from 10.9% with nil N to 14.8% with 160 kg/ha N.

LongReach Spitfire⁽ᴰ⁾ had significantly higher grain nitrogen yield than all other varieties.

Introduction

Soil nitrogen (N) levels have generally declined in the northern grains region in recent seasons; however the response to applied N in previous seasons VSAP trials has generally only been low to moderate. These trials aim to identify varieties that most efficiently use N fertiliser to increase grain yield and protein concentration.

Site details

Location:	**Merriwa**
2012 crop:	**canola**
Sowing date:	**16th May 2013**
PAW (sowing):	**100 mm**
Rainfall in-crop:	**150 mm**
Nitrogen:	**215 kg/ha (0–120 cm)**

Treatments

- 4 N rates – 0, 40, 80 and 160 kg/ha applied as urea, pre-drilled prior to sowing.
- 6 bread wheat varieties –LongReach Dart⁽ᴰ⁾, EGA_Gregory⁽ᴰ⁾, LongReach Spitfire⁽ᴰ⁾, Sunguard⁽ᴰ⁾, Suntop⁽ᴰ⁾, Sunvale.

Results

- Due to the high starting soil N, there was no effect of N application on grain yield for any of the varieties in this trial.
- There were significant differences in the grain yield of varieties in this trial. LongReach Spitfire⁽ᴰ⁾ and LongReach Dart⁽ᴰ⁾ were significantly higher yielding than all other varieties and Sunvale was significantly lower yielding than all other varieties (Table 1).

Table 1. *Grain yield of six wheat varieties averaged across four rates of nitrogen at Merriwa – 2013*

Variety	Grain yield (t/ha)
LongReach Dart⁽ᴰ⁾	2.73
EGA_Gregory⁽ᴰ⁾	2.14
LongReach Spitfire⁽ᴰ⁾	2.81
Sunguard⁽ᴰ⁾	2.17
Suntop⁽ᴰ⁾	2.14
Sunvale	1.64
l.s.d. (p=0.05)	0.31

- As well as being the highest yielding variety in this trial, LongReach Spitfire⁽ᴰ⁾ had significantly higher grain protein concentration (averaged across N rates) than EGA_Gregory⁽ᴰ⁾, Suntop⁽ᴰ⁾ and LongReach Dart⁽ᴰ⁾ (Table 2).
- Grain protein concentration (averaged across varieties) increased from 10.9% with nil N to 14.8% with 160 kg/ha N (data not shown).

Table 2. *Grain protein concentration of six wheat varieties averaged across four rates of nitrogen at Merriwa – 2013*

Variety	Grain protein concentration (%)
LongReach Dart$^{\phi}$	12.2
EGA_Gregory$^{\phi}$	12.8
LongReach Spitfire$^{\phi}$	13.5
Sunguard$^{\phi}$	13.2
Suntop$^{\phi}$	12.4
Sunvale	14.5
l.s.d. (p=0.05)	0.6

- The grain nitrogen yield of LongReach Spitfire$^{\phi}$ was significantly higher than all other varieties (Table 3).

Table 3. *Grain nitrogen yield of six wheat varieties averaged across four rates of nitrogen at Merriwa – 2013*

Variety	Grain nitrogen yield (kg/ha)
LongReach Dart$^{\phi}$	58.1
EGA_Gregory$^{\phi}$	47.8
LongReach Spitfire$^{\phi}$	65.9
Sunguard$^{\phi}$	50.3
Suntop$^{\phi}$	45.9
Sunvale	41.4
l.s.d. (p=0.05)	6.7

Summary

This trial suffered from a dry finish which was exacerbated by crown rot, which has resulted in higher yields being achieved by varieties that were faster to reach anthesis (LongReach Spitfire$^{\phi}$ and LongReach Dart$^{\phi}$) relative to other varieties that were slower to reach anthesis. The quicker varieties essentially flowered in a slightly cooler period and would have used less soil water prior to flowering.

Generally, grain yield and grain protein concentration are negatively correlated; however LongReach Spitfire$^{\phi}$ followed a trend of similar trials in Northern NSW where it maintained a relatively high grain protein concentration even at a relatively high grain yield. This meant that LongReach Spitfire$^{\phi}$ had the highest grain nitrogen yield in this trial. Effectively LongReach Spitfire$^{\phi}$ was the most efficient at converting soil and applied N into grain N.

The efficiency of use of applied N in this trial was generally low. The increase in grain protein concentration would not be enough to have justified the application of N in this season alone; however some N may be carried over for use in the subsequent crop.

Acknowledgements

This project is funded by NSW DPI and GRDC under the Variety Specific Agronomy Package Project (DAN00129). Thanks to Jayne Jenkins, Dougal Pottie and Gerard Lonergan for assistance throughout this trial.

Effect of macro and micro nutrients on wheat yield and grain protein – Nyngan 2013

Greg Brooke and Leigh Jenkins NSW DPI, Trangie **Andrew Verrell** NSW DPI, Tamworth
Rohan Brill NSW DPI, Wagga Wagga

NUTRITION & SOILS

Key findings

There was a significant yield response (+ 0.48 t/ha) from applying the 'All' nutrient treatment above the nil fertiliser control, even in a dry year.

Excluding MAP produced the second lowest yield (– 0.31 t/ha compared to 'All' treatment).

Excluding Nitrogen significantly reduced grain protein compared with the 'All' nutrients applied treatment.

Introduction

For the majority of farms in the Nyngan district the two major elements Phosphorus (P) and Nitrogen (N) have been the only nutrients routinely applied to crops with some sulphur (S) used in canola. Regular P application has been low to moderate. Typical N application rates are generally very low e.g. 10 kg/ha per annum. Crop rotation practices are generally continuous and winter cereals dominate.

Growers have repeatedly sought information on the use of trace elements and whether there are responses to any on these nutrients on red soils which predominate in the Nyngan district. The methodology for this trial was to give a one-timing (Z30-32) application of 8 foliar trace elements as chelates at a maximum of 1 kg/ha and take one away. For example, all nutrients minus boron or all nutrients minus copper etc.

Site details

Location:	**Nyngan**
Co-operator:	**Kent Johnston, "Komoora"**
Soil type:	**Red-brown earth**
Wheat Variety:	**LongReach Dart⟨PBR⟩ @ 33 kg/ha**
Sowing date:	**24th May 2013.**
Herbicide:	**Pre-sow spray Logran®, Boxer Gold®, Glyphosate.**
Sowing details:	**Tyne and presswheel direct into stubble. 33cm row spacing. 15 mm pressed soil cover. Good establishment. Low stubble cover.**
Urea Topdressing:	**29th May**
Foliar nutrient application date:	**16 August (Z32). Foliar fungicide Opus® applied Z32.**
Paddock history:	**Canola 2012; Wheat 2011; Paddock is a long-term continuous crop, zero-till paddock.**
Comments:	**Sown one day after 15mm rainfall. A low rainfall year with a very tight finish.**

Table 1. Soil Test Results

Depth	0–10cm	10–30 cm
Colour	BR	Or
Gravel %	0	0
Texture	2.0	2.0
Ammonium Nitrogen mg/kg	6	4
Nitrate Nitrogen mg/kg	8	12
Phosphorus (P) Colwell mg/kg	50	11
Potassium (K) Colwell mg/kg	590	399
Sulphur (S) mg/kg	14.0	8.6
Organic Carbon %	0.74	0.35
Conductivity dS/m	0.067	0.054
pH Level ($CaCl_2$) pH	5.5	5.8
pH Level (H_2O) pH	6.5	6.6
DTPA Copper (Cu) mg/kg	1.09	1.00
DTPA Iron (Fe) mg/kg	21.87	10.02
DTPA Manganese (Mn) mg/kg	24.99	14.80
DTPA Zinc (Zn) mg/kg	1.03	0.20
Exc. Aluminium meq/100g	0.089	0.118
Exc. Calcium (Ca) meq/100g	4.54	5.31
Exc. Magnesium (Mg) meq/100g	1.06	1.16
Exc. Potassium (K) meq/100g	1.51	1.02
Exc. Sodium (Na) meq/100g	0.02	0.02
Boron (Bo) Hot $CaCl_2$ mg/kg	0.45	0.42

Treatments

As this was a nutrient *exclusion* trial the treatments listed are for example Boron (Bo) means all nutrients were applied *except* for Boron and so on.

The major element P was applied as MAP at 90 kg/ha (i.e. 22 kg/ha P) in all treatments except for 'Nil Fert' and 'Nil MAP' (this also supplies 9.9 kg/ha N and 1.8 S).

The trace elements Boron (Bo), Calcium (Ca), Copper (Cu), Iron (Fe), Potassium (K), Magnesium (Mg), Manganese (Mn), and Zinc (Zn) were all applied in the chelated form as foliar sprays at growth stage Z32 as individual nutrients in multiple passes. This was on 16th August following a light rainfall of 1.5 mm

All treatments had N applied as topdressed urea with the exception of the 'Nil N' and 'Nil Fert' treatments. Rate was 110 kg/ha Urea = 50 kg/ha N).

Table 2. Yield (t/ha) and grain protein (%) of LRPB Dart grown with varying nutrition – Nyngan 2013

Nutrient treatment	Yield (t/ha)	Protein (%)
Minus Bo	2.15	12.8
Minus Fe	2.10	12.9
All (applied)	2.08	12.9
Minus Mn	2.07	13.0
Minus Ca	2.06	12.7
Minus Zn	2.03	12.7
Minus Mg	2.03	12.6
Minus Cu	1.95	12.0
Minus N	1.93	11.2
Minus K	1.87	12.4
Nil MAP	1.77	12.3
Nil Fert	1.60	11.4
CV %	9.4	7.2
LSD	0.27	0.8
Site Mean	1.97	12.4

Summary

Nil MAP gave the greatest yield reduction in this trial besides Nil Fertiliser being 0.31 t/ha lower yielding than the ALL nutrients treatment (Table 2). The site has a background P level of 50 mg/kg Colwell P which is very high for this district and soil type (12 to 25 mg/kg Colwell P more typical). This shows again that these soils are very P responsive even on above average fertility sites and in a poor season. It is generally considered that wheat on canola stubble has a higher critical Colwell P than wheat on wheat (Jim Laycock, Incitec Pivot, pers comm.)

The Nil fertiliser treatment yielded 0.48t/ha lower than with ALL nutrients applied treatment highlighting the importance of adequate crop nutrition to maximise yield. Phosphorus (MAP) appears to be the major nutrient (macro) which limited yield at this site in 2013. The exclusion of Potassium (K) gave the next lowest yield (0.21 t/ha lower than 'All') but the difference was not significant. These soils are high in K so it is an unusual response.

The exclusion of nitrogen (N) as expected resulted in a significant reduction (–1.7%) in grain protein levels compared to the ALL nutrient treatment (Table 1). The only other element that significantly impacted on protein levels was the exclusion of Copper (Cu) which reduced levels by 0.9% compared to the ALL nutrient treatment.

The design of this trial meant all nutrients needed to be applied at the one timing (i.e. growth stage Z32). Further work could examine the interaction between the timing of nutrient addition and growth stage in wheat.

Acknowledgements

This project was funded by NSW DPI and GRDC under the Variety Specific Agronomy Package Project (DAN00129). Thanks to Peter Formann (NSW DPI Tamworth), Jayne Jenkins, Paddy Steele and Scott Richards (NSW DPI Trangie) for technical assistance with the trial. Thanks to Jim Laycock (Incitec Pivot) for assistance with interpreting soil test and trial data. Thanks to Gavin Melville (Biometrician, NSW DPI Trangie) for data analysis.

Phosphorus nutrition in canola at Caroona, Mullaley and Garah in 2013

Guy McMullen, Rod Bambach, Stephen Morphett and Jan Hosking NSW DPI, Tamworth
Matthew Gardner formerly NSW DPI, Tamworth

Introduction

Phosphorus (P) supply to canola is usually considered important for two critical crop stages, firstly at establishment to help support early root growth and development and secondly during the biomass accumulation stage. Typically phosphorus is supplied in the form of a starter fertiliser which is applied with the seed at sowing, with the remainder of the crops phosphorus supply being extracted from the deeper soil layers.

Significant research has been conducted in winter cereals, which has demonstrated that current starter fertiliser programs are only supplying around 5–10% of the crops actual phosphorus requirements. It has also been established that soil tests to a depth of 0–10 cm and 10–30 cm using both Colwell –P and BSES-P are important components in developing a fertiliser program to ensure mining of the soil P supply is not occurring. There is significantly less data available on P responses in other crops including canola.

The trials were established to determine the effect of varying phosphorus rate on a canola crop's establishment, growth, final yield and oil content. Canola has a relatively high phosphorus requirement compared to many other crops, with nutrient guidelines suggesting that 7 kg of P is removed in one tonne of grain. This is much higher than winter cereals which are in the range of 2–4.5 kg of P per tonne of grain.

Site details

In 2013 three sites were established in northern NSW. Table 1 summarises the sowing dates and soil fertility at each site. Caroona and Mullaley had relatively low starting soil N levels while Garah had an additional 40 kg N/ha. Sulphur levels were relatively low in the surface at Caroona and Mullaley but Caroona had large stores available below 30 cm. Garah also had very high levels of S in the subsoil.

Garah was established very early in the season and suffered some apparent frost damage. Establishment at the Garah and Mullaley was very good as a result of adequate sowing moisture. The establishment at Caroona was a lot poorer as a result of dry, cloddy sowing conditions and heavy stubble from the previous crop.

Phosphorus levels were varied at the three trial sites. The critical value of Colwell P concentration in the 0–10 cm depth for canola is 16 mg/kg with a range of 14–19 mg/kg based on the Better Fertiliser Decisions Database. Using this information, the Garah and Mullaley sites had quite similar phosphorus levels with between 20–27 mg/kg in the top 10cm, which was more than adequate, and the Caroona site had very high phosphorus levels. The Caroona site had high phosphorus levels in the 10–30cm depth, while in contrast both the Garah and Mullaley sites had quite low phosphorus levels in the 10–30cm depth.

Key findings

There was no impact of varying phosphorus rate on plant establishment at any of the three trial sites.

There was only a significant difference in dry matter production at the Mullaley site, but this was not consistent with increasing phosphorus application rate.

There was no effect of varying phosphorus rate on final grain yield or oil content at all three trials sites, across a range of quite low final yields, from 0.5 – 1.4 t/ha.

Pioneer®44Y84 had better establishment than Hyola®559TT, however, the grain yield was only significantly better at the Caroona trial site.

Table 1. Site Details.

	Garah	Caroona	Mullaley
Co-operator	Andrew Yates	Angus Duddy	Ross Durham
Sowing Date	10th April	10th May	16th May
Nitrate N (kg N to 120 cm)	123	84	83
Phosphorus – Colwell 0–10 cm	20	76	27
Phosphorus – Colwell 10–30 cm	3	42	6
BSES 0–10 cm	38	595	42
BSES 10–30 cm	23	574	44
Sulphur 0–10 cm	7.7	4.7	3.2
Sulphur 10–30	5.3	4.4	3.3
Sulphur 30–90 cm (ave)	1046	117	6

Treatments

At all three sites two varieties were grown, Pioneer® 44Y84 and Hyola®559TT as these two varieties are known to have varying oil achievement. The focus of both trials was solely on Phosphorus responses with both sites receiving 120 kg N/ha applied as Urea at planting to eliminate N effects. Each site also had 25 kg/ha of sulphur applied in the form of Gypsum at sowing to eliminate any S effects, with the exception of the single super treatment which has sulphur included in the product.

The urea and gypsum were side banded approximately 2.5 cm below the seed and 2.5 cm away from the planting row to avoid any impact on establishment. All fertiliser rates were applied at planting.

Phosphorus rates: 0, 5, 10, 20 and 40 kg P/ha all sites in the form of triple superphosphate. An additional treatment of 20 kg /ha P was applied as Single Superphosphate (8.8 P, 11.0S).

Trials were fully factorial with six P rates × two varieties and three replicates.

Results

Caroona

Plant establishments were quite low at the Caroona site, considering the target population was 40 plants/m^2; however the establishment was even across all of the phosphorus treatments (Table 2). There was a significant difference in the establishment between the two hybrids with Pioneer®44Y84 establishing nearly three times the number of plants compared to Hyola®559TT.

There was no significant difference in the dry matter, grain yield or oil contents across all phosphorus treatments at this site. Oil contents at this site were quite low at 37–38% and grain yields were also low, in the range of 1.27–1.42 t/ha.

Table 2. *Plant establishment, dry matter production, grain yield and oil content across phosphorus treatments at Caroona in 2013.*

Phosphorus (kg P/ha)	Plants/m^2	Dry Matter (kg/ha)	Grain Yield (t/ha @ 8% moisture)	Oil Content %
0	11	5933	1.27	37.6
5	15	5893	1.30	37.3
10	11	5442	1.32	37.8
20	15	5743	1.42	38.2
40	19	5626	1.40	37.6
20 as SSP	15	6130	1.35	37.8
Significance	nsd	nsd	nsd	nsd

There were significant differences in the performance of canola varieties with Pioneer® 44Y84 producing more than double the grain yield and having a higher oil content than Hyola® 559TT (Table 3).

Table 3. *Plant establishment, dry matter production, grain yield and oil content of two canola varieties at Caroona in 2013.*

Variety	Plants/m²	Dry Matter (kg/ha)	Grain Yield (t/ha @ 8% moisture)	Oil Content %
44Y84	21	7719	1.79	38.2
Hyola559TT	8	3870	0.87	37.2
Significance	<0.001	<0.001	<0.001	<0.001

Mullaley

Crop establishment was much better at Mullaley compared to the Caroona site, with all treatments achieving close to the 40 plants/m² target. There was no impact of phosphorus treatment on plant establishment.

There was no significant difference in grain yield or oil content based on the phosphorus treatments.

There were significant differences in the dry matter production across treatments but the trend did not support increases in dry matter with increasing phosphorus application rate (Table 4).

Table 4. *Plant establishment, dry matter production, grain yield and oil content of phosphorus treatments at Mullaley in 2013.*

Phosphorus (kg P/ha)	Plants/m²	Dry Matter (kg/ha)		Grain Yield (t/ha @ 8% moisture)	Oil Content %
0	32	6861	cd	1.08	44.1
5	37	7617	abc	1.14	44.5
10	36	7260	bcd	0.97	44.4
20	38	8386	a	1.12	45.1
40	41	7827	ab	1.28	45.4
20 as SSP	35	6617	d	1.13	44.9
Significance	nsd	0.008	–	nsd	nsd

Garah

Plant establishment was excellent at the Garah site, but again there was no interaction between phosphorus rate and plant establishment.

Grain yields and oil contents were both low at this site as a result of frost damage, but there was also no significant difference in dry matter production, grain yield or oil content across phosphorus treatments (Table 5).

Table 5. *Plant establishment, dry matter production, grain yield and oil content of Phosphorus treatments at Garah in 2013.*

Phosphorus (kg P/ha)	Plants/m^2	Dry Matter (kg/ha)	Grain Yield (t/ha @ 8% moisture)	Oil Content %
0	55	3821	0.46	35.5
5	45	4632	0.40	35.2
10	45	4245	0.53	35.5
20	46	3774	0.53	34.5
40	46	5187	0.49	34.7
20 as SSP	45	5122	0.49	35.0
Significance		nsd	nsd	

There were significant differences in the performance of the two canola varieties for plant establishment, dry matter and oil content but not grain yield.

At the Garah site, Pioneer® 44Y84 had a significantly better plant establishment with almost double the number of plants establishing (Table 6). Pioneer® 44Y84 also produced a significantly larger crop biomass and higher oil content by 0.7% compared to Hyola®559TT. However oil contents were still low.

Table 6. *Plant establishment, dry matter production, grain yield and oil content of 2 canola varieties at Garah in 2013.*

Phosphorus (kg P/ha)	Plants/m^2	Dry Matter (kg/ha)	Grain Yield (t/ha @ 8% moisture)	Oil Content %
44Y84	61	5482	0.47	35.4
Hyola559TT	34	3445	0.49	34.7
Significance	<0.001	<0.001	nsd	0.01

Summary

There was no impact of varying phosphorus rate on plant establishment at any of the three trial sites. Plant establishment did vary across the three sites, but this was mainly due to the moisture conditions at sowing. There was only a significant difference in dry matter production at the Mullaley site, but this was not consistent with increasing phosphorus application rate.

There was no effect of varying phosphorus rate on final grain yield or oil content at all three trials sites, across a range of quite low final yields, from 0.5–1.4 t/ha. Oil contents were also well below the receival standard of 42% at all sites except Mullaley where they were 44–45%.

Canola variety performance was consistent at the Garah and Caroona trial sites, with Pioneer® 44Y84 establishing two to three times the number of plants, higher dry matter production and higher oil contents than Hyola®559TT. However, the grain yield of Pioneer® 44Y84 was only significantly better than Hyola®559TT at the Caroona trial site.

Acknowledgements

This trial was run under the Variety Specific Agronomy Package Project (DAN00169) and More Profit from Crop Nutrition Projects (UQ00063), which are jointly funded by NSW DPI and GRDC. Andrew Yates "The Wilderness", Garah, Ross Durham, "Araluen", Mullaley and Angus Duddy, "Rossmar Park", Caroona and their families are gratefully acknowledged for the provision of the trial sites. Technical assistance provided by Patrick Mortell, Jim Perfrement and Peter Formann are also gratefully acknowledged.

Effect of nitrogen rate and application timing on yield and oil content of four canola varieties at Trangie and Nyngan 2013

Leigh Jenkins NSW DPI, Trangie
Rohan Brill NSW DPI, Wagga Wagga

Introduction

Canola production in southern NSW has relied on the addition of significant amounts of nitrogen fertiliser to maximise yields, albeit as a major input cost. In western areas of NSW the application of high rates of nitrogen can be risky, given an overall trend for lower yield potential, and seasonal fluctuations in reliable winter rainfall determining crop response to nitrogen or crop failure regardless.

These trials chiefly aim to provide more regionally specific recommendations for nitrogen requirements in canola, by assessing the impact of both nitrogen rate and application timing on grain yield and oil quality. A second aim was to determine if there are varietal differences between canola varieties and types. Canola varieties were selected to compare hybrid vs. open-pollinated varieties, as well as triazine tolerant (TT) vs. non-TT varieties. Note that similar trials were conducted at Coonamble, Nyngan, Trangie, Gilgandra and Wellington in 2012 which were all reported on in the Autumn 2013 edition of this publication.

Site details

Location:	**Trangie**	Location:	**Nyngan**
Soil type:	**Red Chromosol**	Soil type:	**Red Chromosol**
PAW (sowing):	**30 mm (0–90 cm)**	PAW (sowing):	**150 mm (0–90 cm)**
Rainfall in-crop:	**205 mm**	Rainfall in-crop:	**185 mm**
Sowing date:	**28th May**	Sowing date:	**19th April**
Colwell P:	**28 mg/kg (0–10 cm)**	Colwell P:	**24 mg/kg (0–10 cm)**
Nitrogen:	**86 kg/ha (0–90 cm)**	Nitrogen:	**180 kg/ha (0–90 cm)**
pH ($CaCl_2$):	**5.4 (0–10 cm)**	pH ($CaCl_2$):	**6.0 (0–10 cm)**

Treatments

- Four canola varieties: two hybrid varieties – 44Y84 (CL)⟑ and Hyola 559TT⟑; two open pollinated (OP) varieties – 43C80 (CL)⟑ and ATR-Stingray (TT)⟑.
- Four nitrogen rates at sowing: 0, 30, 60, 120 kg N/ha applied as Urea.
- Three application timings for the 60 kg N rate: 60:0 (all up-front), 30:30 (split), 0:60 (all in-crop) applied as Urea at the late bud to early stem elongation stage.

Key findings

The application of nitrogen fertiliser resulted in increased grain yield of all four canola varieties at both sites in 2013, even with moderate to high soil nitrogen levels at sowing.

Based on the response to nitrogen trials at Nyngan and Trangie in 2012 and 2013, canola growers should aim to apply at least 30 kg N/ha to achieve a grain yield response in central-western NSW. Current trial results suggest no difference between applying nitrogen at sowing or in-crop.

Although nitrogen application can increase grain yield, it may reduce oil concentration at high rates of nitrogen when applied to soils with relatively high starting soil nitrogen levels.

NUTRITION & SOILS

Results

- At the Nyngan site (sown mid-April), there was a significant grain yield response (by 0.27 t/ha) to applied nitrogen as rate increased from 0 to 30 kg N/ha. However there was no further significant increase in grain yield as rates increased above 30 kg N/ha, although all rates applied were significantly higher than nil N applied (Figure 1).
- Oil content at Nyngan declined as N application rate increased. There was little difference between increasing rates progressively, with the largest significant difference in oil content occurring when N rate was increased from 0 kg N/ha (oil content 42.7%) to 120 kg N/ha (oil content 41.6%). TT varieties (42.6%) had significantly higher oil content than non-TT varieties (41.9%), but there was no significant difference between hybrid (42.3%) and open-pollinated varieties (42.2%).
- There was no significant difference between application timing treatments (at sow / split / in-crop) at the Nyngan site in 2013.
- Varietal differences followed the trend of other 2013 VSAP canola trials. Hybrid varieties had significantly higher yield than open pollinated varieties; and non-TT varieties had significantly higher yield than TT varieties. However there was no significant interaction between any one variety and N application rate, with all varieties responding positively to the 30 kg N/ha rate, and only Hyola 559TT showing a positive response to the 120 kg N/ha rate.

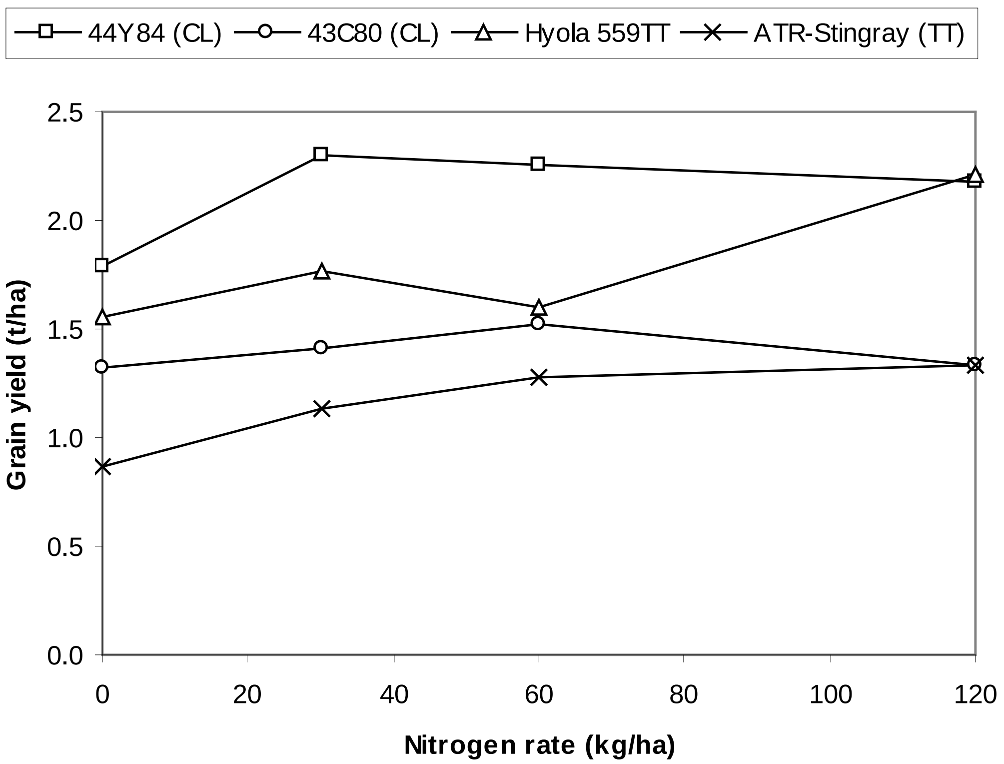


Figure 1. *Grain yield of four canola varieties across four nitrogen application rates, Nyngan 2013 (l.s.d. = 0.2 t/ha at p = 0.05).*

- At the Trangie site (sown late May), there was also a significant grain yield response (by 0.09 t/ha) to applied nitrogen as rate increased from 0 to 30 kg N/ha. However there was no further significant increase in grain yield as rates increased above 30 kg N/ha, although all rates applied were significantly higher than nil N applied (Figure 2).

- Oil content at Trangie also declined as N rate was increased. Overall there was a total decline of 1.7% in oil content as N rate increased from 0 kg N/ha (43.4%) to 120 kg N/ha (41.7%). At Trangie there were also significant differences between the 0 and 30 kg N/ha rates; and the 60 and 120 kg N/ha rates. TT varieties (43.1%) had significantly higher oil content than non-TT varieties (41.9%), but there was no significant difference between hybrid (42.7%) and open-pollinated varieties (42.3%).
- There was no significant difference between application timing treatments (at sow / split / in-crop) at the Trangie site in 2013.
- Varietal differences followed the trend of other 2013 VSAP canola trials. Hybrid varieties had significantly higher yield than open pollinated varieties; and non-TT varieties had significantly higher yield than TT varieties. However there was no significant interaction between any one variety and N application rate, with all varieties responding positively to the 30 kg N/ha rate, and only 44Y84 (CL) showing a positive response to the 120 kg N/ha rate.

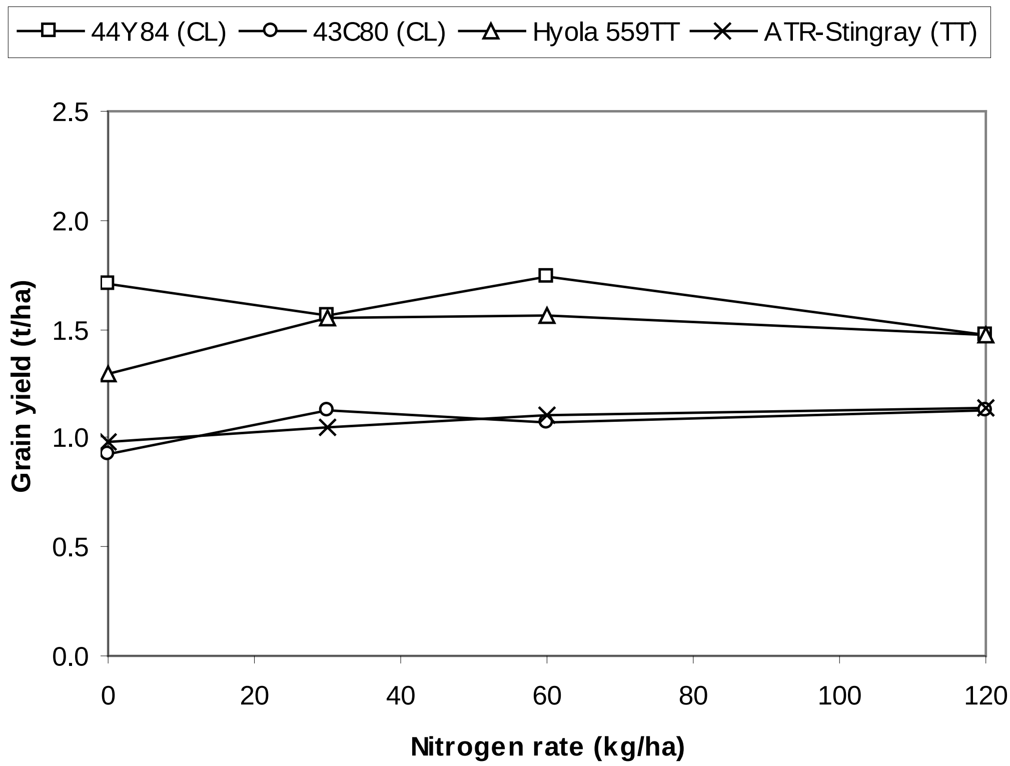


Figure 2. *Grain yield of four canola varieties across four nitrogen application rates, Trangie 2013 (l.s.d. = 0.09 t/ha at p = 0.05).*

Summary

Previous VSAP canola nitrogen trials conducted by NSW DPI in 2012 resulted in four of five trial sites showing some level of positive yield response to the application of nitrogen. This ranged from only one canola variety being responsive at the low N rate at Gilgandra, to all varieties having increased grain yield at all N application rates at Wellington and Nyngan. One of the five trial sites (Gilgandra) showed a reduction in oil content as nitrogen application rate increased.

The 2013 nitrogen trials conducted at Nyngan and Trangie showed almost identical responses to each other, as well as confirming the initial results from 2012. Both sites in 2013 had relatively high soil nitrogen levels at sowing. At both sites there was a significant yield response to the addition of nitrogen up to 30 kg N/ha, but no significant yield increases (averaged for all varieties) at higher nitrogen rates.

Oil content at both sites was reduced by a significant level as nitrogen rate increased, particularly when comparing the highest rate of N (120 kg/ha) to the nil treatment. This supports the trial result from Gilgandra in 2012, which also had a reasonably high level of soil nitrogen at sowing (62 kg/ha N). TT varieties had consistently higher oil content at both sites than non-TT varieties.

Comparisons of nitrogen application timing have been constrained in both 2012 and 2013 by a lack of adequate follow-up rainfall post treatment. 2012 trials (Gilgandra and Wellington) showed a slight reduction in yield from delaying all nitrogen until in-crop timings; the 2013 trials at Nyngan and Trangie showed no significant difference between timing of nitrogen applications.

The 2013 canola nitrogen trials at Nyngan and Trangie confirmed the advantage of hybrid varieties over open-pollinated lines similar to findings in 2012 and other VSAP canola trials conducted in 2013. In the majority of these trials, hybrid Clearfield and TT varieties have been significantly higher yielding than their respective open pollinated Clearfield and TT varieties.

Acknowledgements

This project is funded by NSW DPI and GRDC under the Variety Specific Agronomy Package Project (DAN00129). Thanks to Jayne Jenkins and Scott Richards (NSW DPI) for technical assistance with this trial.

Nitrogen and sulphur nutrition in canola at Caroona, Mullaley and Garah in 2013

Guy McMullen, Rod Bambach and Jan Hosking NSW DPI, Tamworth
Matthew Gardner formerly NSW DPI, Tamworth

Key findings

There was no significant impact of varying sulphur rates at any of the three sites in 2013 on grain yield or oil content.

There were significant effects of nitrogen on grain yield at the Mullaley and Caroona sites only, however the responses were opposite, with improved yield with increasing N at Mullaley and a reduction at the Caroona site.

Increasing nitrogen rates reduced oil contents at all three trial sites, however the extent of the reduction varied.

Differences in the performance of the two canola varieties was not consistent across the three sites.

Introduction

Canola, as an oilseed crop attracts returns based on grain yield as well as a premium/discount system based on the final oil content (above or below a 42% receival standard). Nitrogen (N) and sulphur (S) have traditionally been thought to play important roles in grain yield and oil content as well as being significant components of the total crop expenditure, and ultimately influencing the final gross margin.

The literature indicates that N and S relationships are very important in canola production. The quantity of nutrients required to optimize production depends on the yield potential of the crop, the method and form of application of the fertilizer, and the levels of available nutrients in the soil. Canola has a relatively high nutrient requirement, and most soils on which the crop is grown are deficient in one or more nutrients for optimum grain yield, oil content and protein concentration based on recent studies.

The N and S requirements of crops are closely related because both nutrients are required for protein synthesis. Sulphur has been described as being especially critical in canola production as S deficiencies have the potential to restrict yield. Nitrogen applications consistently decrease oil and increase protein content; however, large quantities of N are required to maximise grain yield in canola. The nutrient requirement guidelines for canola suggest that crops need 15 kg of S and 60 kg of N per tonne of grain produced. Typically S nutrition has been considered as equally important as N nutrition. These trials were established to add to the current data set on the impact of N and S nutrition on grain yield, protein and oil concentration in canola.

Site details

In 2013 three sites were established in northern NSW. Table 1 summarises the sowing dates and soil fertility at each site. Caroona and Mullaley had relatively low starting soil N levels while Garah had an additional 40 kg N/ha. Sulphur levels were relatively low in the surface at Caroona and Mullaley but Caroona had large stores available below 30 cm. Garah also had very high levels of S in the subsoil.

Garah was established very early in the season and suffered some frost damage. Caroona and Mullaley were sown on the 10th and 16th of May respectively with good establishment at both sites and were not impacted on by frost.

Table 1. *Site Details.*

	Garah	Caroona	Mullaley
Co-operator	Andrew Yates	Angus Duddy	Ross Durham
Sowing Date	10th April	10th May	16th May
Nitrate N (kg N to 120 cm)	123	84	83
Phosphorus – Colwell 0–10 cm	20	76	27
Phosphorus – Colwell 10–30 cm	3	42	6
BSES 0–10 cm	38	595	42
BSES 10–30 cm	23	574	44
Sulphur 0–10 cm	7.7	4.7	3.2
Sulphur 10–30 cm	5.3	4.4	3.3

Treatments

At all sites two varieties were grown, Pioneer® 44Y84 and Hyola® 559TT as these two varieties are known to have varying oil achievement. The focus of both trials was solely on N and S responses with both sites receiving 20 kg P/ha applied as triple superphosphate (TSP) at planting with the seed to eliminate P effects. This application of TSP provided a baseline level of 1 kg S/ha. Nitrogen was applied as Urea while S was applied as granulated gypsum. Both Urea and gypsum were side banded approximately 7.5 cm below the seed and 7.5 cm away from the planting row to avoid any impact on establishment. All fertiliser rates were applied at planting.

Nitrogen rates: 0, 40, 80, 160 and 240 kg N/ha all sites.

Sulphur rates: 0, 20 and 40 kg S/ha at all sites.

The S rates were not adjusted for the baseline S received from the TSP. Trials were fully factorial with five N rates × three S rates × two varieties and four replicates.

Results

Garah

There was no significant effect of N or S on grain yield at Garah (Figure 1). There was a slight decrease, from already low levels, in oil content with increasing N rates. Yields and oil contents were both low at this site as a result of frost damage.

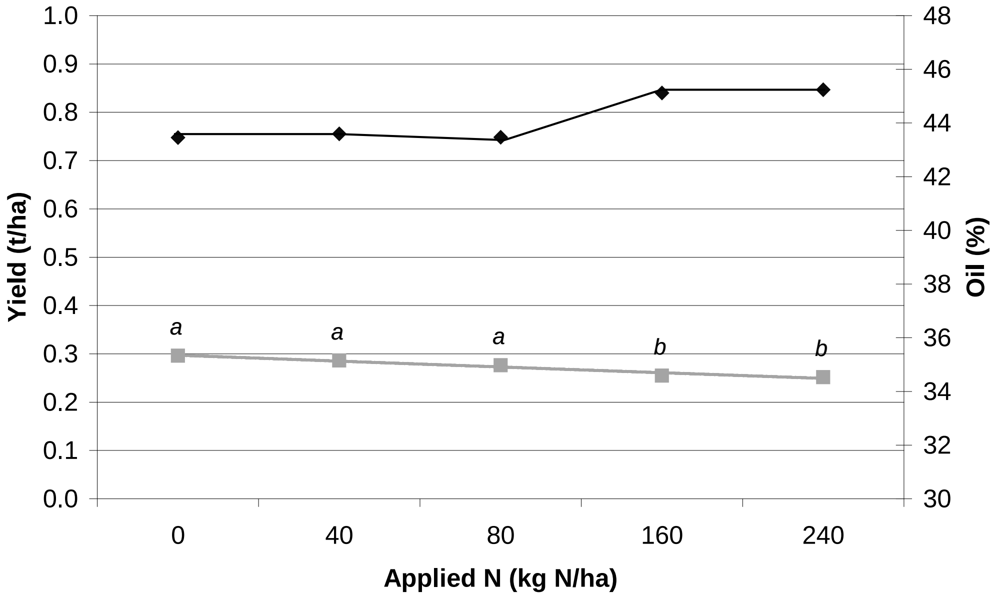


Figure 1. *Effect of applied N on grain yield (dark points, NSD) and oil content (lighter line) at Garah in 2013 (data points with the same letter are not significantly different).*

Mullaley

There was no significant difference between the yields of the two varieties although Hyola 559TT had marginally higher oil content (Table 2). Generally the grain yields were quite low, as a result of the dry spring and finish to the season. The oil contents were quite high at this site, with both varieties achieving well above the 42% standard.

Table 2. *Grain yield and oil content of two canola varieties at Mullaley in 2013.*

Variety	Grain Yield (t/ha)	Oil %
44Y84	1.04	43.2
Hyola559TT	1.12	44.0
5% LSD	n.s.d	0.6

NUTRITION & SOILS

There was a significant increase in grain yield with increasing N at Mullaley but there was no significant response to applied sulphur despite it having the lowest starting S levels of the three sites (Figure 2). Yield increased from 0.9 t/ha with no applied N to 1.2 t/ha at 240 kg N/ha however there was no significant difference between 160 and 240 kg N/ha.

While applied N increased grain yield, oil content was significantly reduced from 46% with no applied N to 41% with 160 and 240 kg N/ha (Figure 2). Again, there was no significant response to applied S at this site.

There were no significant interactions between any of the main treatments at the Mullaley site.

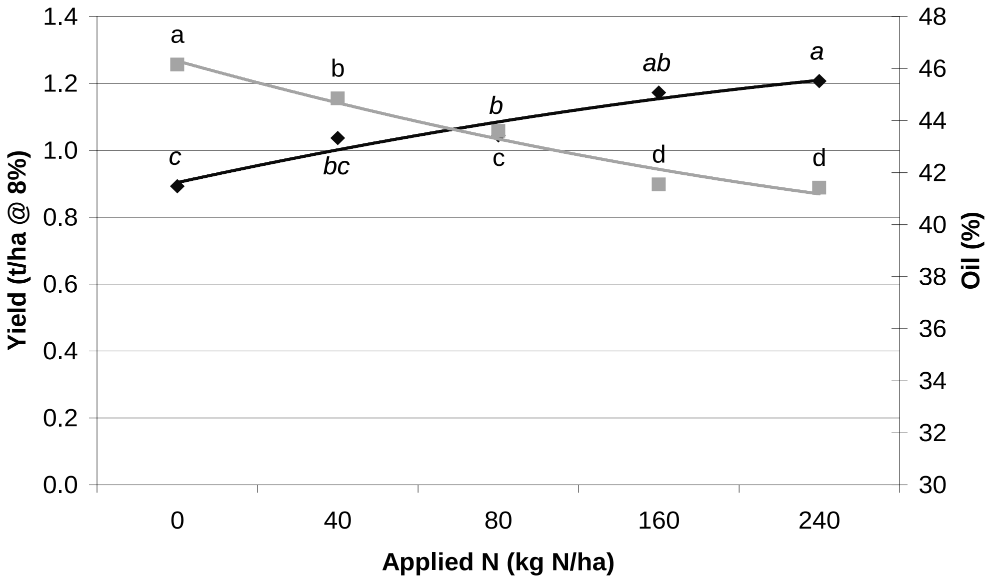


Figure 2. *Effect of applied N on grain yield (darker line) and oil content (lighter line) at Mullaley in 2013 (data points with the same letter are not significantly different at 95% confidence level).*

Caroona

There was a significant difference in the grain yield between the two varieties at the Caroona site with 44Y84 yielding 0.7 t/ha higher and also having marginally improved oil content compared to Hyola559TT. Yields were higher at this site compared to the Mullaley site, however oil contents were much lower.

Table 3. *Grain yield and oil content of two canola varieties at Caroona in 2013.*

Variety	Grain Yield (t/ha)	Oil %
44Y84	1.90	38.6
Hyola 559TT	1.21	38.3
5% LSD	0.08	0.3

In contrast to the Mullaley site there was a significant reduction in both grain yield and oil content with increasing N (Figure 3). Yield was reduced by 0.3 t/ha at the highest N rate while oil fell from 40% to 37.5% at the highest N rates.

There was no significant impact of applied S on either yield or oil content at this site. Similar to the Mullaley site there were no significant interactions between any of the main treatments at Caroona.

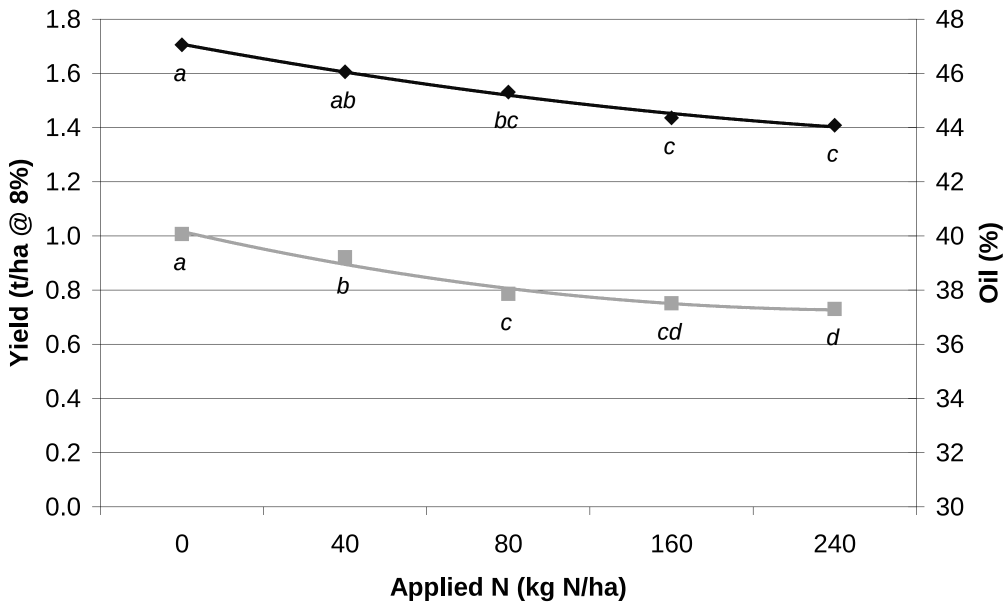


Figure 3. *Effect of applied N on grain yield (darker line) and oil content (lighter line) at Caroona in 2013 (data points with the same letter are not significantly different at 95% confidence level).*

Summary

There was no significant response to the varying sulphur treatments at any of the three sites in 2013, even with varying starting soil levels. While the Mullaley site had low sulphur levels even to depth in the soil profile, no response was evident in yield or oil content with the addition of sulphur at sowing.

There were significant effects of nitrogen on grain yield at the Mullaley and Caroona sites only, however the responses were opposite, with a higher grain yield with increasing N at Mullaley and a reduction at the Caroona site.

In contrast, there was a significant reduction in oil content at all three trial sites, however the extent of the reduction varied. At Garah, oil contents reduced with increasing N rates, but started at a low oil content. At Mullaley and Caroona which both had high oil contents, the reduction was from 46–47% with no applied N to 41 and 44% with 160 and 240 kg N/ha, respectively.

Differences in the performance of the two varieties were not consistent across the three trial sites. At Caroona 44Y84 yielded significantly more than Hyola 559TT, while there was no significant difference at the Mullaley and Garah sites between the two canola varieties.

Acknowledgements

These trials were run under the Variety Specific Agronomy Package Project (DAN00169) and the More Profit from Crop Nutrition Project (UQ00066), which is jointly funded by NSW DPI and GRDC. Andrew Yates, "The Wilderness", Garah, Ross Durham, "Araluen", Mullaley and Angus Duddy, "Rossmar Park", Caroona and their families are gratefully acknowledged for the provision of the trial sites. Technical assistance provided by Patrick Mortell, Stephen Morphett, Jim Perfrement and Peter Formann are also gratefully acknowledged.

Effect of starter fertiliser and phosphorus rate on establishment and grain yield of canola – Trangie and Nyngan 2013

Rohan Brill NSW DPI, Wagga Wagga
Leigh Jenkins NSW DPI, Trangie

Introduction

Starter fertiliser is commonly applied with canola at sowing to provide adequate nutrition for crop establishment and early development. Phosphorus (P) is an essential nutrient for canola growth and development; however the application of phosphate fertilisers with the seed may have negative effects on germination and reduce overall crop establishment. These trials aim to determine the effect that P rate, source and variety choice can have on canola establishment and grain yield.

A range of common products were selected for use in this trial, with a range of P concentrations and other nutrients, including nitrogen and sulphur. Triple superphosphate which is not commonly used commercially was also used as it supplies phosphorus in isolation. In this trial two key comparisons are possible – the affect of increasing P rate in TSP on the establishment of two canola hybrids and a comparison of the relative effects of a range of sources of P.

Key findings

Increasing phosphorus (P) rate (applied directly with canola seed) applied as triple super phosphate (TSP) and mono-ammonium phosphate (MAP) significantly reduced canola establishment. The only difference between these two products was at the highest application rate of MAP, with an additional increase in N rate, having the lowest plant establishment.

A comparison across a wider range of starter fertilisers showed significant reductions in plant establishment compared to the controls. This reduction in the compound products may also be related to increasing rates of sulphur and nitrogen.

Despite the negative effect of P on canola establishment, there was a positive effect of P on grain yield at Nyngan and no effect at Trangie.

Site details

Location:	**Trangie**
Soil type:	**Brown Chromosol**
PAW (sowing):	**30 mm**
Rainfall in-crop:	**205 mm**
Sowing date:	**29th May**
Row spacing:	**33 cm**
Phosphorus:	**25 mg/kg (Colwell)**
Seeding unit:	**Janke parallelogram (seed and fertiliser placed together)**
Location:	**Nyngan**
Soil type:	**Red Chromosol**
PAW (sowing):	**150 mm**
Rainfall in-crop:	**185 mm**
Sowing date:	**19th April**
Row spacing:	**33 cm**
Phosphorus:	**24 mg/kg (Colwell)**
Seeding unit:	**Janke parallelogram (seed and fertiliser placed together)**

Treatments

Triple superphosphate (TSP – 0N:20.7P:1S) was applied at four rates of P (0, 5, 10 and 20 kg P/ha) across two Clearfield® canola varieties (Pioneer 44Y84 CL⟠ hybrid and the open pollinated Pioneer 43C80 CL⟠. Monoammonium phosphate (MAP – 10N:21.5P:1.5S) was applied at equivalent phosphorus rates to Pioneer 44Y84 CL⟠ with concomitant increases in applied N. Two additional commercially used starter fertilisers – di-ammonium phosphate (DAP – 18N:20P:1.6S) and single superphosphate (SSP – 0N:8.8P:11S) – were applied at an equivalent of 20 kg P/ha to Pioneer 44Y84 CL⟠ with concomitant increases in N and S respectively.

All treatments were applied in a fully randomised block design with three replicates at each site.

NUTRITION & SOILS

Results

At the Nyngan site, there was a consistent reduction in establishment at all TSP rates across both varieties. At Trangie the application of 5 kg P/ha as TSP did not reduce establishment in Pioneer 43C80 CL⊕ but the establishment in the untreated control was low compared to Pioneer 44Y84 CL⊕. All other rates of TSP at Trangie resulted in increasing reductions in establishment (Tables 1 and 2). Compared with TSP (at equivalent P rates), the application of MAP (applied to Pioneer 44Y84 CL⊕ only) resulted in the same established populations at Nyngan while at Trangie establishment at the highest equivalent P rate was significantly lower with MAP compared to TSP.

In the comparison of differing starter fertilisers at an equivalent rate of 20 kg P/ha (applied to Pioneer 44Y84 CL⊕ only), all products resulted in a reduction in canola establishment compared to the untreated controls. The only significant difference between products was reduced establishment with MAP compared to TSP and SSP at Trangie.

Table 1. *Effect of P rate, source and variety choice on establishment of canola – Trangie 2013.*

P rate (kg/ha)	Triple Super		MAP	DAP	Single Super
	43C80 (CL)	44Y84 (CL)	44Y84 (CL)	44Y84 (CL)	44Y84 (CL)
0	16	27	27	27	27
5	19	20	17	–	–
10	13	16	13	–	–
20	5	10	5	7	10
l.s.d. (p=0.05)	5 plants/m^2				

Table 2. *Effect of P rate, source and variety choice on establishment of canola – Nyngan 2013.*

P rate (kg/ha)	Triple Super		MAP	DAP	Single Super
	43C80 (CL)	44Y84 (CL)	44Y84 (CL)	44Y84 (CL)	44Y84 (CL)
0	32	35	35	35	35
5	22	24	23	–	–
10	11	13	12	–	–
20	5	8	10	9	8
l.s.d. (p=0.05)	4 plants/m^2				

Despite the strong negative effect of phosphorus and starter fertilisers on canola establishment, grain yield was not affected by P rate at Trangie (Table 3) and responded positively to increasing P rate with TSP at Nyngan (Table 4). The comparison of yield responses to increasing rates of P as MAP and TSP at the four equivalent P rates was inconsistent at Nyngan with higher yields with MAP at the highest application rate but higher yields with TSP at 10 kg P/ha. At Nyngan, the grain yield where Single Super was sown with the seed was significantly less than where all other products were sown with the seed. Comparison of yields between the products in this trial is compromised by differences in rates of other nutrients; however Sulphate of Ammonia was applied to limit this effect.

Pioneer 44Y84 CL⊕ was generally higher yielding than Pioneer 43C80⊕ CL at both sites across all rates of P applied as TSP.

Table 3. *Effect of P rate, source and variety choice on grain yield of canola – Trangie 2013.*

P rate (kg/ha)	Triple Super		MAP	DAP	Single Super
	43C80 (CL)	44Y84 (CL)	44Y84 (CL)	44Y84 (CL)	44Y84 (CL)
0	0.91	1.14	1.14	1.14	1.14
5	0.81	1.15	1.27		
10	0.88	1.20	1.23		
20	0.75	1.19	1.19	1.24	1.07
l.s.d. (p=0.05)	0.17 t/ha				

Table 4. *Effect of P rate, source and variety choice on grain yield of canola – Nyngan 2013.*

P rate (kg/ha)	Triple Super		MAP	DAP	Single Super
	43C80 (CL)	44Y84 (CL)	44Y84 (CL)	44Y84 (CL)	44Y84 (CL)
0	1.00	1.49	1.49	1.49	1.49
5	1.19	1.82	1.69		
10	1.22	1.99	1.75		
20	1.18	1.73	1.98	1.77	1.51
l.s.d. (p=0.05)	0.21 t/ha				

Summary

These trials showed that all starter fertilisers containing phosphorus (and other nutrients) can have a negative effect on canola establishment when placed with the seed. This effect was observed with four different products, at increasing rates of P applied as TSP and with a hybrid and an open-pollinated canola variety. Despite this, there was still a significant grain yield response to the application of P at Nyngan with the use of triple super, MAP and DAP but not with single super. This highlights that there is generally only a weak correlation between canola establishment and grain yield.

Growers looking to limit the negative effect of starter fertiliser on canola establishment should ideally separate the seed and fertiliser at sowing. Narrower row spacings will also reduce the linear concentration of P in the furrow as well as providing other potential benefits such as increased grain yield and improved competition with weeds.

Acknowledgements

This project is funded by NSW DPI and GRDC under the Variety Specific Agronomy Package Project (DAN00129) and More Profit from Crop Nutrition II (UQ00063). Thanks to Jayne Jenkins, Lindsay Hyde, Scott Richards and Paddy Steele for assistance throughout this trial.

Response of three pulse species (chickpea, field pea, lentil) to phosphorus and nitrogen rate at Trangie 2013

Leigh Jenkins NSW DPI, Trangie **Rohan Brill** NSW DPI, Wagga Wagga **Andrew Verrell** NSW DPI, Tamworth

NUTRITION & SOILS

Key findings

Grain yield was significantly increased for all three pulse species as applied phosphorus was increased up to 20 kg P/ha, on a red chromosol soil with moderate soil P level at Trangie in 2013.

Chickpea and field pea significantly out yielded the lentil species, which may have been disadvantaged due to being sown later than optimum in comparison to the other pulse species.

Grain yield response to applied nitrogen was not significant in this trial.

Introduction

All plants require phosphorus (P) for root development, which then drives the plant's capacity to utilise available moisture and nutrients and achieve yield potential when cultivated as a grain-producing crop. In recent years growers have questioned whether currently grown pulse crops (e.g. chickpeas, field peas and lupins) require additional applied phosphorus in the form of fertiliser, or whether soil P reserves and pulse root exudates are adequate means to provide sufficient P to the crop. However many red (chromosol) soils in central west NSW are either inherently low, or declining, in P levels due to original soil type source and length of cropping rotations.

This trial was conducted as part of the new Northern Pulse Agronomy Initiative Project which commenced in 2012. The primary aim was to examine the effect of applied phosphorus on establishment and yield of three different pulse species (chickpea, field pea and lentil). A secondary aim was to examine the effect of using starter nitrogen (N) fertiliser on establishment and yield of the same three pulse species. Note that a similar trial was conducted by Andrew Verrell at Tamworth in 2012 (chickpea x phosphorus only) and reported via the Autumn 2013 edition of this publication.

Site details

Location:	**Trangie ARC**
Soil type:	**Red Chromosol**
PAW (sowing):	**30 mm**
Rainfall in-crop:	**205 mm**
Sowing date:	**31st May 2013 (all species)**
Colwell P:	**28 mg/kg (0–10 cm)**
Nitrogen:	**86 kg/ha (0–90 cm)**
pH ($CaCl_2$):	**5.4 (0–10 cm)**

Treatments

- 3 pulse species: Chickpea (PBA HatTrick⁽ᴾ⁾); Field pea (PBA Twilight⁽ᴾ⁾); Red Lentil (PBA Blitz⁽ᴾ⁾).
- 4 phosphorus rates at sowing: 0, 5, 10, 20 kg P/ha, applied as Trifos.
- 2 nitrogen rates at sowing: 0, 10 kg N/ha, applied to the 0 and 20 kg P/ha treatments only as Urea.

Results

- All three pulse species were sown on the one date (31st May, post rain) which may have disadvantaged the lentil species due to later than recommended sowing. Establishment targets were set at 40 plants/m^2 for the chickpea and field pea species, and 100 plants/m^2 for the lentil species. Achieved establishments were chickpea – 30 plants/m^2 (76% of target); field pea – 32 plants/m^2 (81%); and lentil – 57 plants/m^2 (57%).

- The P and N treatments had no significant effect on the established plant densities of the lentil and chickpea species (Figure 1 (a) and (c)). The addition of P had a significant and positive impact on the established plant density of field pea while adding 10 units of N to the 20 kg P rate led to a reduction in the plant stand, relative to the 20 kg P/ha treatment (Figure 1 (b)).

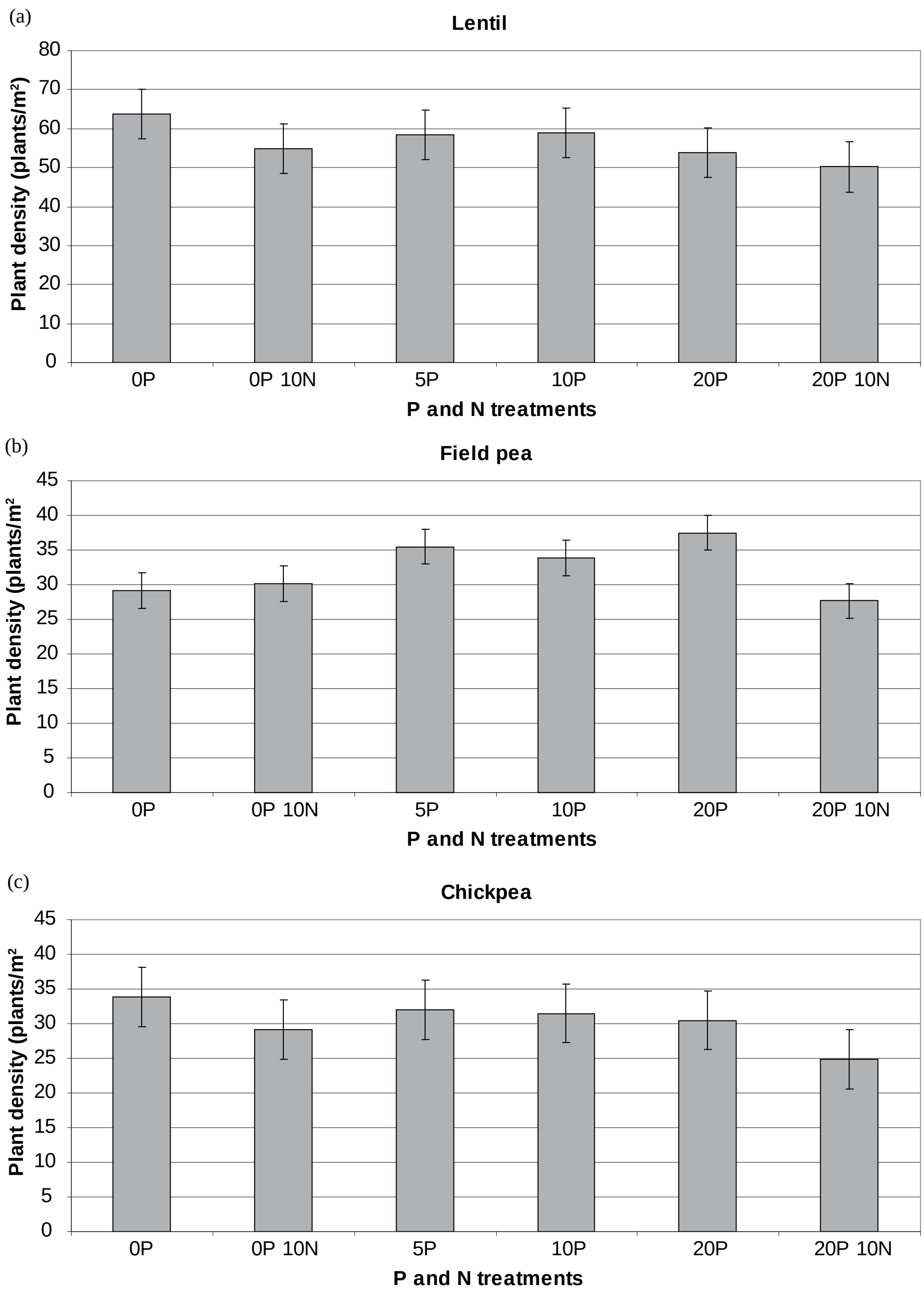


Figure 1. *The effect of phosphorus and nitrogen treatments on established plant densities (plants/m^2) for Lentils (a), Field pea (b) and Chickpea (c).*

- Biomass cuts to measure the difference in dry matter production between species and in response to phosphorus and nitrogen were done at early flowering stage (all species, 9th Sept) and pre-harvest maturity (chickpea and lentil only, 11th Nov). Only the early flowering biomass data is presented (Figure 2).
- Field pea produced much greater biomass at early flowering, with 2971 kg/ha averaged across all P rate treatments. Chickpea and lentil species produced much lower biomass than field pea at early flowering, with an average of 1160 and 954 kg/ha, respectively, across all P rate treatments.

- Lentils showed no significant response in biomass to P on its own, however, when 10 units of N was added to the 20 kgP/ha rate this increased total biomass substantially compared to all P rates and the zero treatment (Figure 2a).
- Field pea biomass responded to a small addition of N (10 kgN/ha) at sowing, while the addition of 5 kgP/ha on its own was sufficient to provide a significant increase in biomass compared to the zero treatment .There was no significant increase in biomass in applying P rates above 5 kgP/ha (see Figure 2b).
- In this experiment chickpea needed the addition of 10 kgP/ha to significantly increase biomass above the zero treatment. The addition of 10 kgN/ha at sowing had no impact on increasing biomass compared to the zero treatment or in the comparative treatments of 20 kgP/ha and the 20 kgP/ha + 10 kgN/ha treatments (Figure 2c).

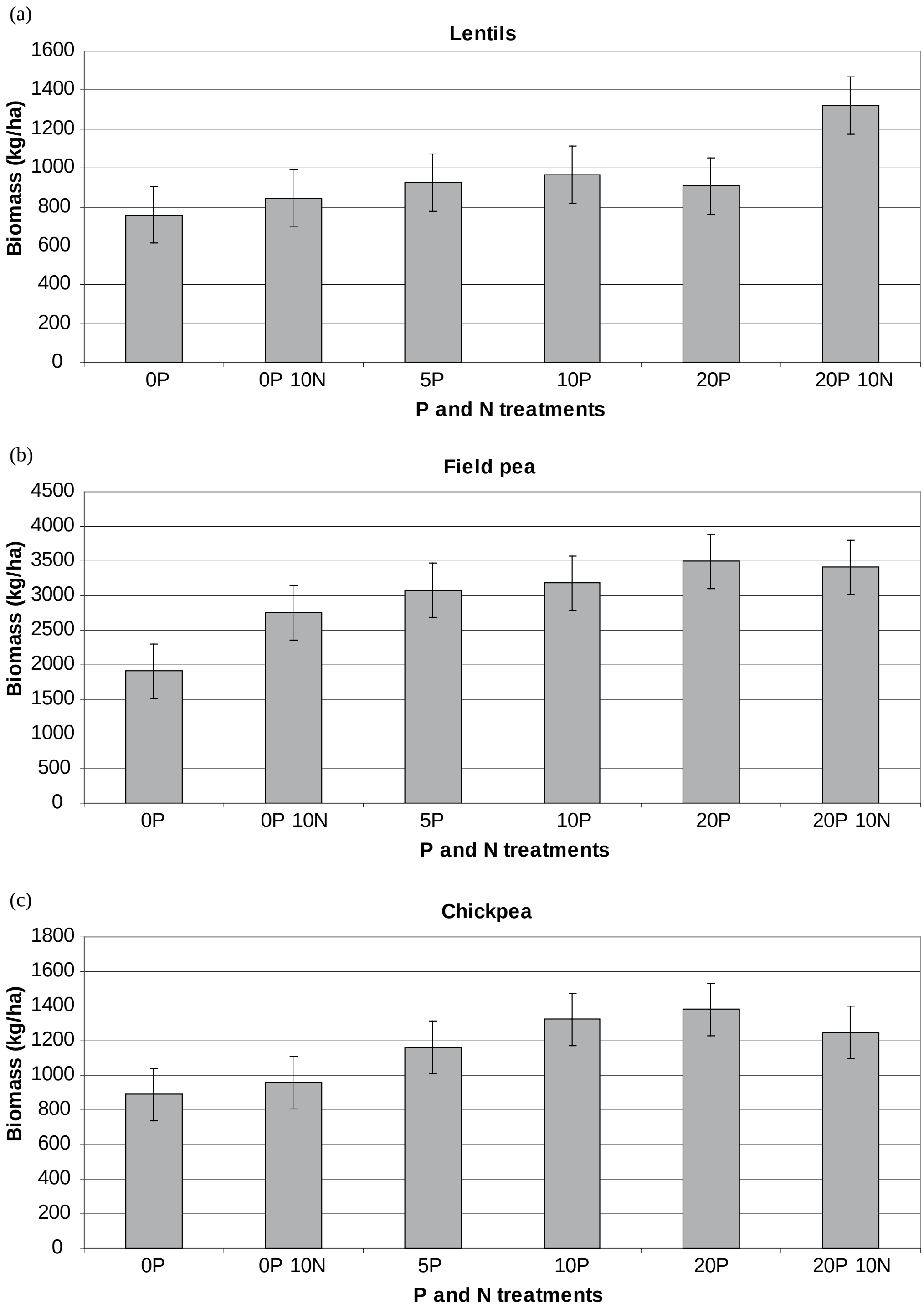


Figure 2. *The effect of phosphorus and nitrogen treatments on plant biomass (kg/ha) for Lentils (a), Field pea (b) and Chickpea (c).*

- The three pulse species were harvested as they matured on separate dates. In terms of grain yield (Figure 3), there was a significant difference in grain yield between the three species (averaged across all P rate treatments). Chickpea (1.62 t/ha) were significantly higher yielding than both field pea (1.49 t/ha) and lentil (0.59 t/ha) species (l.s.d. p = 0.05 = 0.09 t/ha).
- Grain yield (averaged across all species) was significantly increased as P rate was increased from 0 to 5, 10 and 20 kg P/ha (l.s.d. p = 0.05 = 0.08 t/ha). There was a positive response to all rates of P, i.e. 0 to 5 kg P/ha increased yield by 0.14 t/ha; 0 to 10 kg P/ha increased yield by 0.19 t/ha; and 0 to 20 kg P/ha increased yield by 0.29 t/ha.
- In Lentil, grain yield had a significant response to P at the 10 kgP/ha rate, while the field pea maintained a significant yield increase at the 5 kgP/ha rate, above the zero treatment (see Figure 3a and 3b).

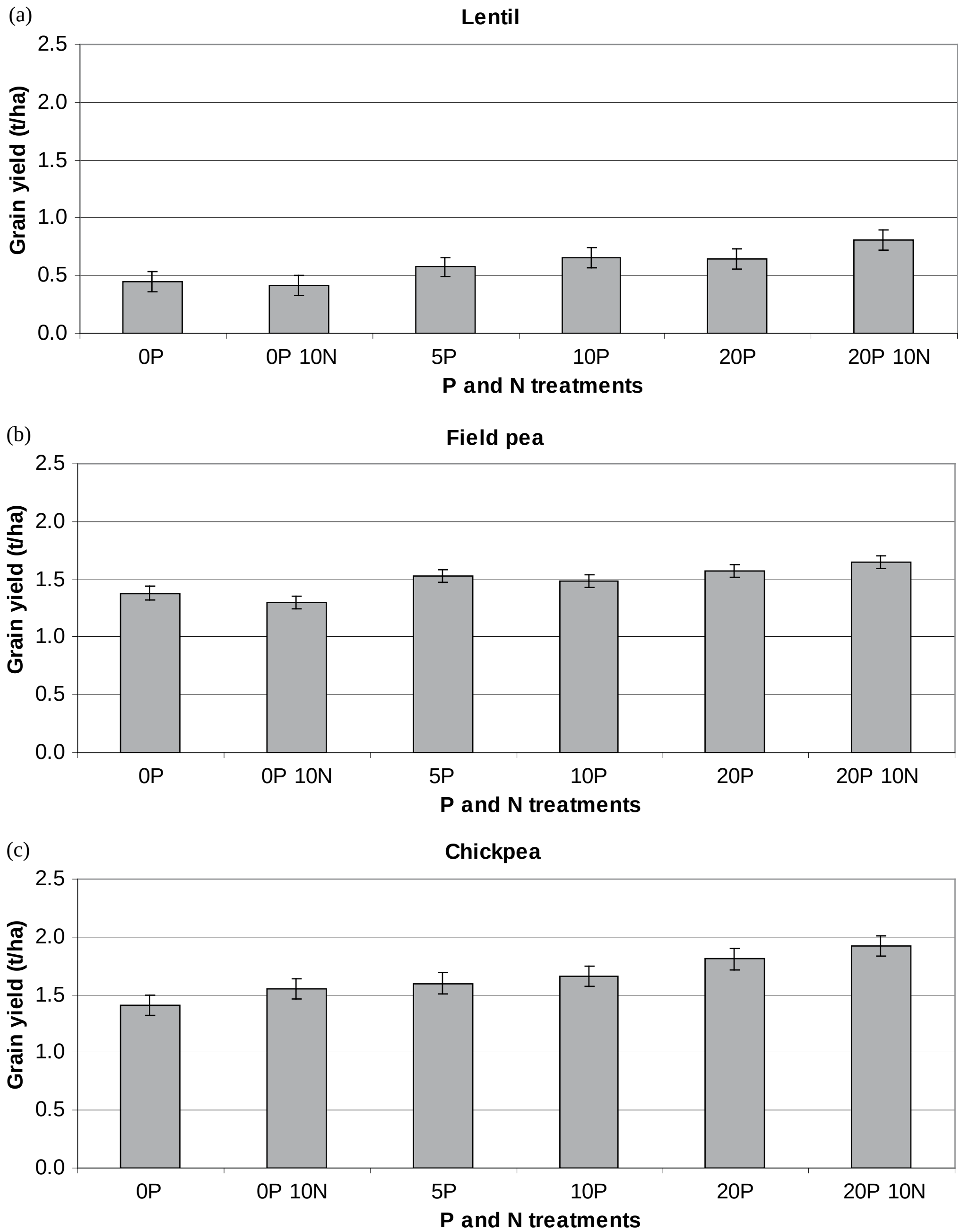


Figure 3. *The effect of phosphorus and nitrogen treatments on grain yield (t/ha), for Lentils (a), Field pea (b) and Chickpea (c).*

NUTRITION & SOILS

- As in the biomass response, chickpea required the addition of 10 kgP/ha to significantly raise yield above the zero treatment (see Figure 3c).
- Previous trial results showing a suppression the yield of chickpea at the highest rate of 20 kg P/ha (e.g. Verrell, NGRTR 2013) were not evident in this trial for any pulse species.
- There was no significant effect of applied nitrogen on grain yield for any of the three species in this trial.

Summary

All three pulse species (chickpea, field pea and lentil) showed a positive response to applied phosphorus, on a red chromosol soil with a moderate level of available P (28 mg/kg Colwell P). This response was significant at all rates of applied P. For the applied rates of 5, 10 and 20 kg P/ha, there was a 13%, 17.5% and 27% yield advantage (respectively) over not applying phosphorus (averaged for all species in this trial).

Chickpea and field pea crops will continue to play an important role in central west cropping rotations. Chickpea out-yielded field pea in this trial, despite current NSW DPI recommendations that field pea would be the preferable option on red soil. However the higher biomass of the field pea species as measured at early flowering would have significant intangible benefits in maintaining or increasing nitrogen and organic matter levels in the soil. The lentil species was lower in both biomass and grain yield than chickpea or field pea. Late sowing (relative to other species) may have unfairly disadvantaged the lentil species in this trial.

Acknowledgements

This project is funded by NSW DPI and GRDC under the Northern Pulse Agronomy Initiative Project (DAN00171). Thanks to Greg Brooke, Jayne Jenkins, Scott Richards, and Gerard Lonergan (all NSW DPI) for assistance in sowing, maintaining and harvesting this trial.

Effect of macro and micro nutrients on yield and protein in wheat – Coonamble 2013

Greg Brooke and Leigh Jenkins NSW DPI, Trangie **Andrew Verrell** NSW DPI, Tamworth
Rohan Brill NSW DPI, Wagga Wagga

Key findings

There was a significant response from applying all nutrients above Nil (0.39 t/ha).

The greatest yield and protein losses were incurred where no Nitrogen (N) was applied (–0.73 t/ha).

Yield losses occurred also where any other nutrient was excluded with some being statistically significant – Calcium, Iron, Potassium, Magnesium, Phosphorus.

Introduction

Growers have repeatedly sought information on the use of trace elements and whether there are responses to any on the vertosol soils.

The methodology for this trial was to give a one-off application of 8 foliar trace elements as chelates and take one away e.g. All nutrients *minus* boron or all nutrients *minus* copper.

Site details

2013

Location:	**Coonamble Black vertosol**
Co-operator:	**"Narratigah"**
Wheat Variety:	**EGA_Gregory⟆ @ 100 seeds/m²**
Sowing date:	**6th May**
Nitrogen application:	**21st May topdress 100 kg/ha Urea**
Phosphorous application:	**100 kg/ha triple super at sowing**
Foliar application date:	**15 August 2013 GS Z31**
Paddock history:	**Long fallowed from sorghum.**
Comments:	**A dry year with a tight finish. Yield losses from excluding some treatments occurred even in a water limited year. The crop was fresh at time of foliar application. Neither root nor foliar diseases were visibly present throughout the growing season in this trial.**

Treatments

As this was a nutrient exclusion trial the treatments listed are for example Calcium (Ca) means all nutrients were applied *except* for Calcium and so on.

The major element Phosphorous (P) was applied as triple super at 20 kg/haP i.e. 90 kg/ha at sowing.

The major element Nitrogen (N) was applied as top-dressed urea two weeks after sowing at 100 kg/ha urea (46 kg/ha N).

The trace elements Boron (Bo), Calcium (Ca), Copper (Cu), Iron (Fe), Potassium (K), Magnesium (Mg), Manganese (Mn), and Zinc (Zn) were all applied in the chelated form as foliar sprays at growth stage Z32 as individual nutrients in multiple passes.

NUTRITION & SOILS

Results

Table 1. *Results for yield and protein at Coonamble in 2013*

Nutrient	Yield (t/ha)	Protein %
All Applied	2.96	11.97
Minus Ca	2.63	11.97
Minus Cu	2.76	11.77
Minus Fe	2.61	11.92
Minus K	2.59	11.93
Minus Mg	2.50	11.7
Minus Mn	2.72	11.76
Minus N	2.23	10.83
Nil fert	2.57	10.89
Minus P	2.63	11.86
Minus Bo	2.81	11.9
Minus Zn	2.85	11.99
LSD	0.29	0.36
CV %	9.8	2.7
Site Mean	2.65	11.7

Summary

Nil nitrogen produced the greatest effect on yield with a reduction of 0.73 t/ha. It is likely that N was the major limiting nutrient; however the removal of several other trace elements also caused reductions in yield which were statistically significant.

Excluding every other trace element saw a reduction in yield below the 'All treatment. Those nutrients which caused statistically significant yield losses when excluded are:- Ca; Fe, K; Mg; N; Nil fert; P.

Yields and proteins were average for this season.

Acknowledgements

This project is funded by NSW DPI and GRDC under the Variety Specific Agronomy Package Project (DAN00129). Thanks to Gerard Lonergan, Jayne Jenkins and Paddy Steele for technical assistance.

Thanks to Gavin Melville Biometrician Trangie for data analysis.

The effect of increasing nitrogen fertiliser on emission of nitrous oxide when growing sorghum on Vertosols

Graeme Schwenke and Bruce Haigh NSW DPI, Tamworth
Matthew Gardner formerly NSW DPI, Tamworth

Introduction

Nitrous oxide (N_2O) is a greenhouse warming gas that is accumulating in the atmosphere. N_2O is produced naturally in the soil by the biological processes of nitrification and denitrification, but adding nitrogen (N) as fertiliser, manure or legume crop residues increases N_2O emissions above natural levels. Nitrification is where ammonium (from urea, ammonium sulfate, anhydrous ammonia) is converted to nitrate in aerobic soils, with a little N_2O lost as well. Denitrification occurs in anaerobic (oxygen depleted) soils, as occurs when soils are waterlogged, and converts nitrate into the gases nitric oxide (NO), nitrous oxide (N_2O) and di-nitrogen (N_2). Most of the N lost during denitrification is N_2 which does not affect global warming but does constitute a significant loss of applied N from the paddock.

Previous research at Tamworth has shown that N_2O emissions can be relatively high from N fertiliser applied to summer sorghum, so strategies are needed for mitigation in this sector. One such strategy is to better match the crop's N demand with N supplied by fertiliser, as excess N may lead to disproportionately high losses as N_2O. In the 2012–13 summer, we had two field trials comparing N_2O emissions emanating from cracking clay soils (Vertosols) fertilised at various N rates for grain sorghum production.

Site details

Main trial (auto chambers)

Location: **Tamworth Agricultural Institute**

Co-operator: **NSW DPI**

On-farm trial (manual chambers)

Location: **Quirindi**

Co-operator: **Ian Carter**

Treatments

Tamworth trial	Quirindi trial
N rates – 0, 20, 40, 80, 120, 160, 200 kg N/ha (side-banded as urea at planting)	N rates – 0, 40, 80, 120, 160, 200, 240 kg N/ha (side-banded as urea at planting)
Variety – MR Bazley Row spacing – 75 cm Sown – 23rd October 2012 Harvested – 22nd March 2013	Variety – MR Bazley Row spacing – 75 cm Sown – 8th December 2012 Harvested – 3rd May 2013
Auto gas emissions chambers on 0, 40, 120 and 200 kg N/ha treatments. Sampled 8 times/day for whole year from planting.	Manual gas emissions chambers on all N rate treatments. Sampled every 1–14 days, depending on rain, from sowing till harvest.

Key findings

Sorghum grain yield increased with nitrogen (N) fertiliser rate up to 120 kg N/ha at two trials on N-deficient Vertosols (cracking clay soils). Higher N rates only increased grain protein not yield.

Intense rainfall on the heavy clay soil type at the Quirindi site led to prolonged waterlogging and denitrification (N loss from the soil as N gases, including nitrous oxide (N_2O)). The loss of N led to reduced grain yield and protein.

At both sites more N_2O was emitted from the soil as N fertiliser rate increased. At the Tamworth site, 0.79% of the N applied as fertiliser was emitted as N_2O. At the Quirindi site, the proportion of N emitted as N_2O also increased with N rate, from 1.43% up to 3.3% at the highest N rate.

N supply for sorghum (soil N + fertiliser N) should be matched to potential grain yield to minimise N_2O production.

Results

- There was a strong plant growth response to N fertiliser at both trial sites as shown by biomass cuts taken at flowering (Figure 1). At Tamworth there was very little initial soil mineral N so the sorghum in the nil N rate plots was visibly N deficient and yielded poorly, around 2.3 t/ha (Fig 1b). Top yields were achieved at N rates of 120 kg N/ha and above (around 6.6 t/ha). N rates greater than 120 kg/ha produced no further increase in grain yield, but did continue to increase grain protein (from around 7.5% to 10%) (Figure 1c).
- The Quirindi site was not as low in initial soil mineral N as the Tamworth site and produced a similar amount of biomass by the flowering stage of crop development (Figure 1a). However, grain yields and proteins at the Quirindi site were much lower than at the Tamworth site. This was because much of the N applied in fertiliser was lost from the soil through denitrification in January–February 2013. Earlier dry conditions in the trial meant that the growing crop had used very little of the fertiliser N by the end of January when heavy rains waterlogged the soil resulting in denitrification.
- N_2O emissions were greater from the higher N treatments throughout the early growing season in response to rainfall (Figure 2). The highest N_2O concentrations were associated with the manual chamber measurements made in late January 2013, when 145 mm of rain had fallen over the previous 5 days (95 mm on the last day). The highest N_2O emissions came from the treatments with the highest N fertiliser applied.
- Total N_2O losses at the Quirindi site were three times higher than those measured at the Tamworth site as the rainfall at the former was much greater in total, fell with a greater intensity, and fell at an early crop growth stage (before it had used much of the supplied N). The soil at Quirindi was also heavier texture (80% clay) compared to that at the Tamworth trial site (44% clay). Heavier clay soils are more slowly drained and therefore remain oxygen depleted for longer.
- The N fertiliser emission factor (% of applied N lost as N_2O) increased with increasing fertiliser N rate at Quirindi (from 1.45–3.3%), but remained around 0.79% at Tamworth for the three N rates tested.

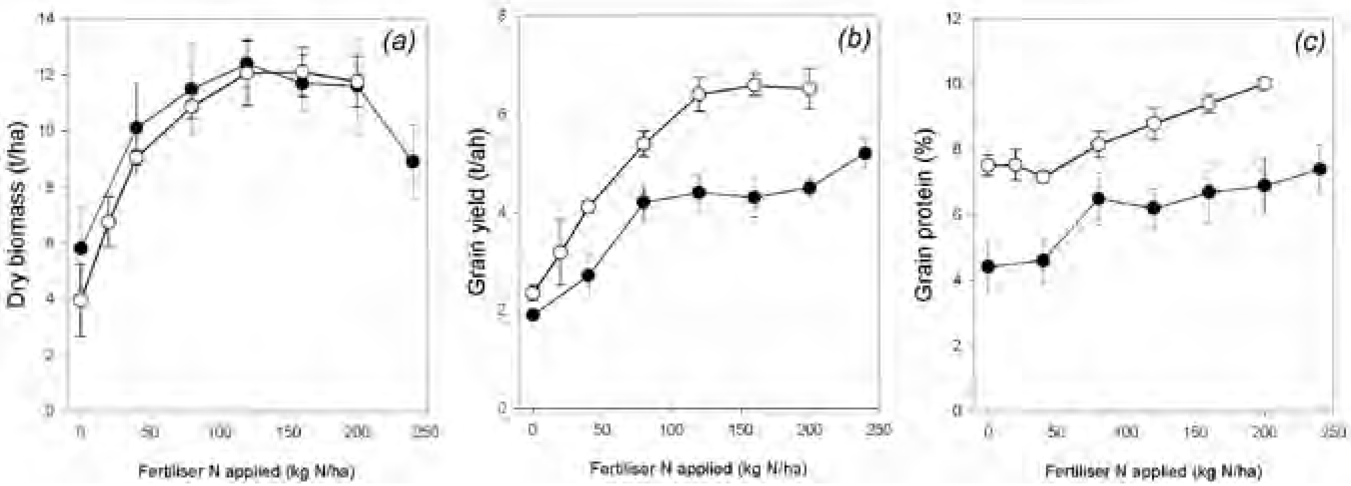


***Figure 1.** Effect of nitrogen fertiliser rate on (a) plant biomass at flowering, (b) grain yield, and (c) grain protein at Tamworth (white circles) and Quirindi (black circles). Yield and protein are corrected to 12% moisture.*

NUTRITION & SOILS

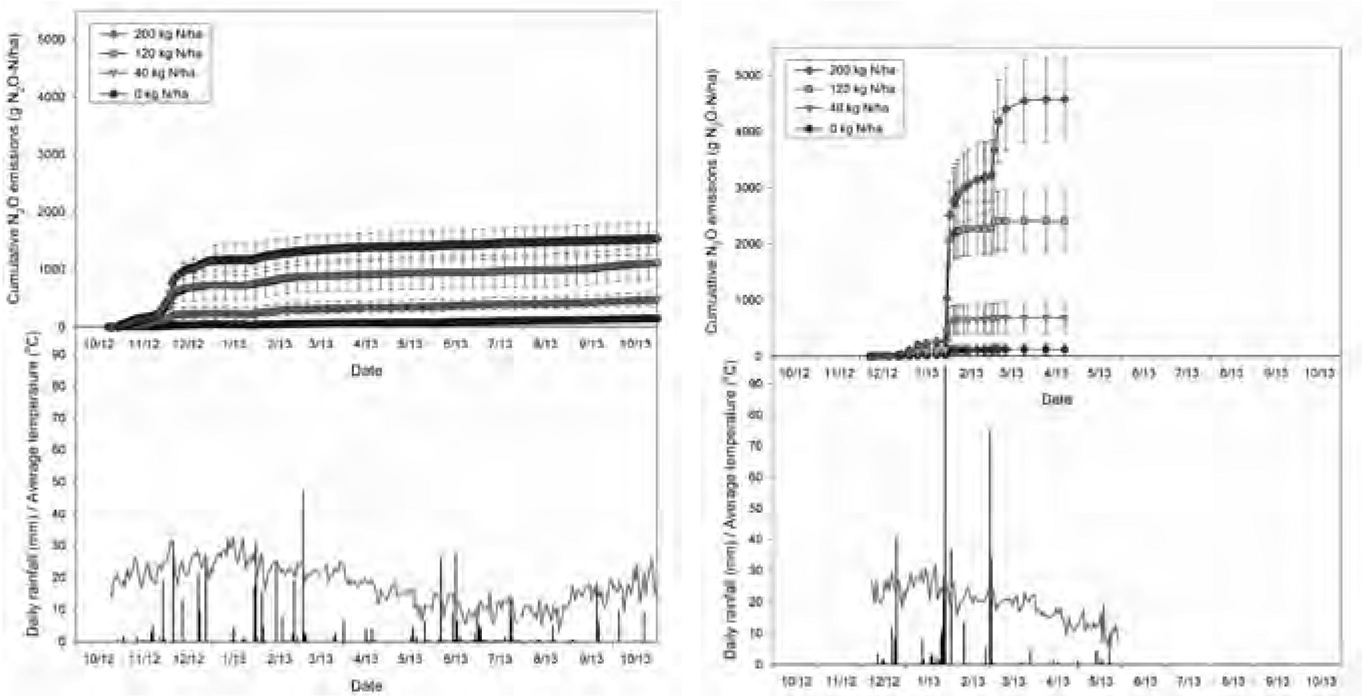


Figure 2. *Cumulative N_2O emissions from different N fertiliser rate treatments at Tamworth (left) and Quirindi (right) trial sites, along with the daily rainfall and daily average temperature at each site (below). Measurements at Tamworth were for 12 months, while those at Quirindi covered from sowing until harvest.*

Summary

Applications of N fertiliser above 120 kg N/ha to two sorghum crops grown on Vertosols produced no additional grain yield. While some of the extra N was accumulated into additional grain protein, much of the unused nitrate N in the Quirindi soil was lost by denitrification when the soil became waterlogged which reduced grain yield and protein at that site. Some of the denitrified N was lost as N_2O which has important environmental consequences. At both the Tamworth and Quirindi sorghum trials, total soil N_2O emissions increased with increasing N fertiliser application rate. At Tamworth, the losses as a proportion of N applied were much the same regardless of N rate, whereas increasing N fertiliser rate at Quirindi led to a higher proportional loss of N_2O in much more waterlogged conditions. N supply for sorghum (soil N + fertiliser N) should be matched to potential grain yield to minimise N_2O emissions.

Acknowledgements

This research was funded by NSW DPI and DAFF under the National Agricultural Nitrous Oxide Research Program. Thanks to Kamal Hossain, Bill Keene and Annabelle McPherson for technical assistance.

Ammonia volatilisation losses from nitrogen fertilisers surface-applied to Vertosols

Graeme Schwenke and Bruce Haigh NSW DPI, Tamworth
Bill Manning North West LLS, Gunnedah

NUTRITION & SOILS

Key findings

Between April and July 2013, nitrogen volatilised from fertilisers applied to four fallow paddocks ranged from 3.5–16% of the N applied.

In medium to heavy clay soils of northwest NSW, measured N losses from urea were less than 20% of the applied N in bare-fallows, and less than 10% when applied to mid-tillering wheat.

Less N was volatilised from ammonium sulphate, unless the soil contained calcium carbonate.

Reduction in urea N loss with a urease inhibitor was inconsistent, possibly due to temperature.

Introduction

When nitrogen (N) fertilisers are broadcast, sprayed or dribbled onto the surface, significant losses may occur via ammonia volatilisation. Global estimates of fertiliser volatilised are 7% from N applied to crops in temperate industrialised countries, 18% from crops in tropical developing countries, and 6% from N applied to grasslands (Bouwman et al. 2002). However, these averages do not take into account the many factors known to influence N volatilisation, including fertiliser type, fertiliser form (solid, liquid, gas), soil properties (pH, CEC), application method (broadcast, sprayed, incorporated, injected), environmental conditions (weather, soil moisture), and paddock condition (fallow, crop, pasture, ash-bed).

Vertosols (cracking clay soils) are the dominant soil type used for cropping in the northern grains region. Soil properties characteristic of many Vertisols may either enhance ammonia volatilisation (e.g. alkaline pH, high water-holding capacity, high pH buffering capacity, high calcium carbonate content), or hinder it (e.g. high clay content, high cation exchange capacity). Only measurements under field conditions can tell us the actual magnitude of loss that occurs. Few field studies on Vertosols (cracking clay soils) have been reported, and none in the northern grains region.

During 2013 we conducted field measurements in 2 pairs of pre-crop fallow paddocks, bringing the project total to 19 paddocks (10 fallow, 9 in-crop and 2 perennial grass-based pastures).

Site details (2013 trials)

Locations:	**Edgeroi (2), Pine Ridge (2).**
Co-operators:	**Ian Gourley, Mick Cudmore, Ian Carter**
Soil type:	**Grey, Brown and Black Vertosols (medium-heavy cracking clays)**

Treatments – fertiliser products

- Urea (granular solid)
- Green Urea (GU) (urea + urease inhibitor)
- Urea ammonium nitrate (UAN) (aq. solution)
- Ammonium sulphate (AS) (crystalline)

Results

2013 results

Despite differences in soil pH, EC, clay content, CEC and initial moisture content, there were no significant differences between paddocks 16 and 17 at Edgeroi in ammonia volatilisation for any fertiliser treatment (Figure 1). Over the month-long measurement period, there was no difference between fertiliser treatments within paddock 16, while at paddock 17 there was more ammonia volatilised from AS than from urea or GU, but not UAN. For most of the measurement period both paddocks were very dry. For several weeks after application we observed the spread urea (and GU) laying undissolved on the soil surface. Soil moisture was low at spreading and relative humidity remained below that needed to dissolve urea until rain came on the 14th May, 2013. The critical relative humidity needed to dissolve urea varies with the ambient temperature.

At Pine Ridge, the soil in paddock 18 had more calcium carbonate (1.9% *vs* 0.3%), and a higher pH (8.7 *vs* 8.0) than Paddock 19. Volatilisation was greater for all fertiliser treatments in paddock 18, but was 2–5 times greater from AS compared to the other fertiliser products. Volatilisation is increased by high pH, but when AS comes into contact with calcium carbonate in the soil, a chemical reaction further enhances the loss as ammonia. Within paddock 18, the N loss from AS was still less than that from urea. At paddock 19, with very little calcium carbonate in the soil surface, N loss from AS was only a third of that from urea. Green urea, where normal urea is treated with a urease inhibitor compound before use, reduced N loss by an average of 61% at paddocks 18 and 19, compared to untreated urea. Losses from UAN were less than urea at paddock 18, but no different at paddock 19.

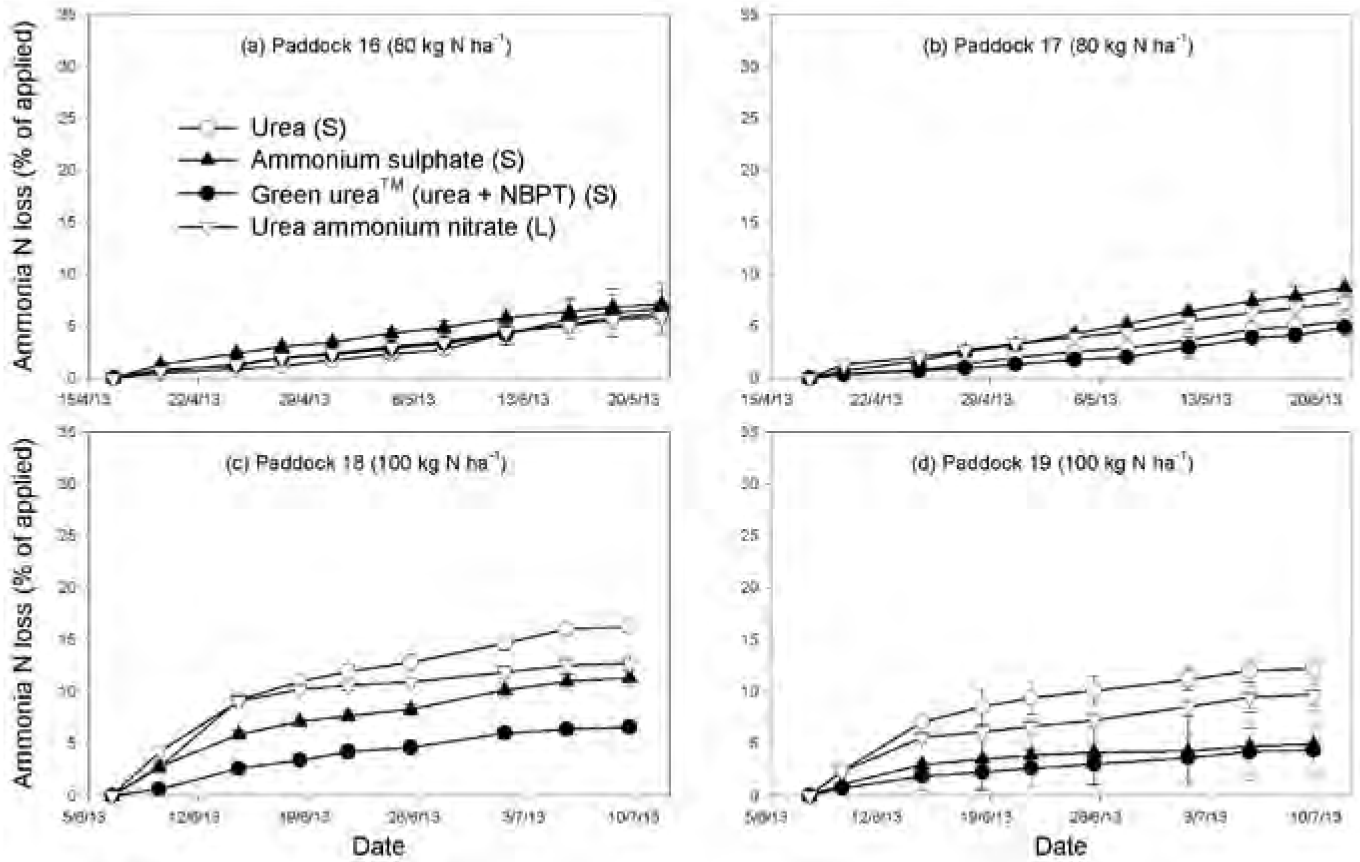


Figure 1. *Cumulative ammonia-N loss (% of N applied) at the four fallow paddock experiments in 2013 (means ± standard error).*

Whole project (2011–13) results summary

Cumulative ammonia volatilisation results for all fertiliser treatments in all fallow, wheat crop, and pasture experiments are summarised in Figure 2. Ammonia volatilised from surface-applied urea averaged 11% from fallowed cropping soils (range: 5.4–19%), 4.8% from in-crop applications (range: 3.1–7.6%), and 27% from grass-based pasture (range: 22–31%). Provided the surface soil does not contain calcium carbonate, AS is preferred to urea for minimising ammonia volatilisation on fallowed or pastured Vertosols. At five of the eight low calcium carbonate (<2%) fallow paddocks, ammonia loss from AS was an average of 52% less than that from urea. At the two pasture paddocks volatilisation averaged 74% less from AS than urea. The reduced N loss from AS needs to be balanced against its higher product cost (36% more expensive in 2013), and lower N content (21%N vs 46%N for urea), meaning higher spreading costs. Broadcasting AS onto fallowed Vertosols with >10% calcium carbonate is not recommended as N losses from AS averaged 26% in these paddocks. Soil calcium carbonate did not affect volatilisation from the other fertilisers trialled.

Ammonia volatilised from GU was less than from urea at several fallow and cropped paddocks, but the responses were not consistent enough to justify its additional cost (25% more than urea in 2013). Paddocks 18 and 19 were the only two fallow paddocks (out of eight) where GU significantly reduced N volatilisation compared to urea. Studies elsewhere have found that the urease inhibitor in GU is less effective at temperatures greater than 15ºC. Daily average temperatures at paddocks 18 and 19 were <11ºC throughout the measurement period, whereas most of the other fallow paddocks were higher (daily average range: 11–22ºC).

Urea ammonium nitrate (UAN) should be a lower risk than urea in terms of ammonia volatilisation, because part of the compound is already in the nitrate form. However, ammonia losses from UAN in our study ranged from 4.0–15% and were similar overall to N losses from urea in both fallow and in-crop experiments. Volatilisation from UAN was only significantly less than urea (31% less on average) at two out of eight fallow paddocks and one out of six in-crop paddocks.

The magnitude of ammonia losses we measured from Vertosols was generally lower than expected from results of previous studies on other soil types. The reason for low N losses may be the moderate to high cation exchange capacity (CEC) of most Vertosols in this study. Most soils in our study had CEC's greater than 25 cmol kg^{-1} (average 44.6 cmol kg^{-1}, range: 16–68 cmol kg^{-1}), a critical level above which ammonium adsorption in the soil substantially reduces volatilisation. The neutral to alkaline pH of the studied soils (average pH of 8.0, range: 6.8–9.3) influenced volatilisation in some paired-paddock comparisons, but not overall, probably due to the range of soil moisture and weather conditions experienced at the different paddocks.

Conditions of low soil moisture at fertiliser spreading, low average daily temperatures, little rainfall in the first week after spreading, low humidity, and canopy protection from wind, all contributed to minimal volatilisation of ammonia from in-crop topdressing. Losses from fertilisers applied to fallow soils were generally greater due to moister soil, higher daily average temperatures, light rain after spreading, and, sometimes, greater humidity.

Soil mineral N measured at the end of the month-long trials indicated that, after accounting for volatilisation, most of the applied N was still present in the surface soil. So, even if crop uptake was limited by low rainfall, most of the N applied was not wasted. In the pasture paddocks, almost all of the applied N not volatilised was found in the plant biomass by the end of the measurement period, very little remained in the soil.

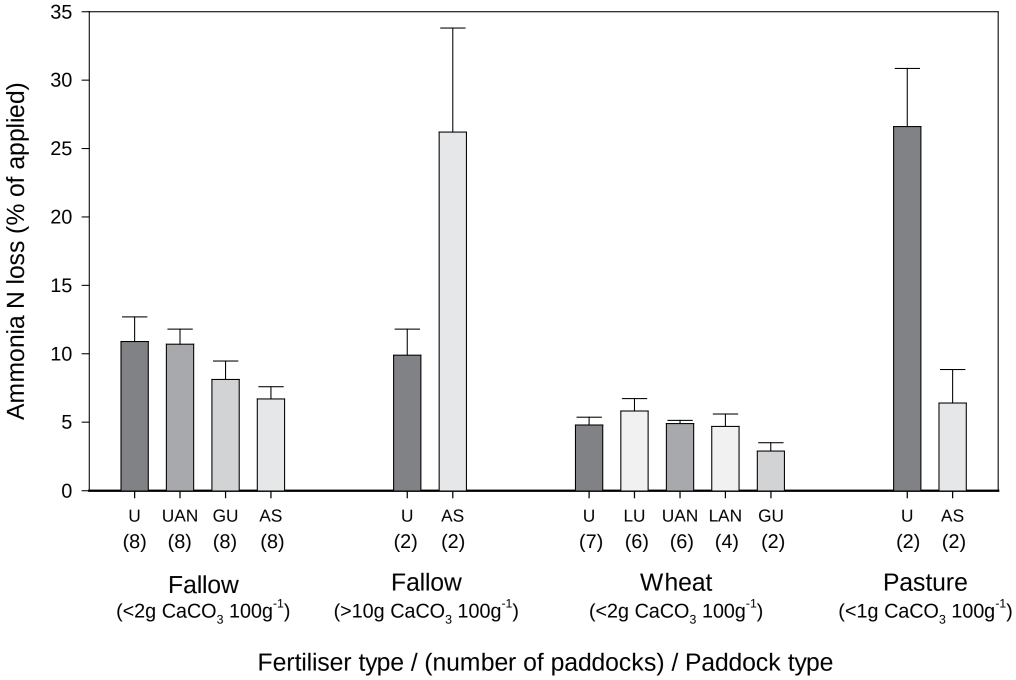


Figure 2. *A summary of the cumulative N loss via volatilisation in this study, grouped by paddock type and fertiliser treatment. Bars are means (+ standard error) of results from 2–8 paddock experiments (number of paddocks in each group is given under bar).*

Summary

When surface-applying N fertilisers, there is the potential for some of the N to be lost by ammonia volatilisation. Trials on medium to heavy clay soils in northwest NSW found that these losses were less than 20% of the N applied to bare fallow soils and less than 10% when applied to a wheat crop at late tillering stage.

N losses from ammonium sulfate applications were less than normal urea in both bare fallows and grass-based perennial pastures. However, ammonium sulfate should be avoided where there is calcium carbonate in the soil surface.

Coating urea with a urease inhibitor reduced volatilisation loss at several paddocks but its effectiveness may have been affected by temperature at other sites where it had no effect on N loss.

Acknowledgements

This project was funded by NSW DPI and GRDC (Project DAN 00144: How much ammonia is lost from surface-applied nitrogen fertiliser in northwest NSW?). Many thanks to Adam Perfrement, Kelly Leedham, Bill Keene, Zara Temple-Smith, Dougal Pottie, Rebecca Byrne, Russell Carty, George Truman, Peter Formann, Annabelle McPherson, Wayne McPherson, and Kamal Hossain for technical assistance.

Reference

Bouwman AF, Boumans LJM, Batjes NH (2002) Estimation of global NH3 volatilization loss from synthetic fertilizers and animal manure applied to arable lands and grasslands. Global Biogeochemical Cycles 16 (2):8-1-8-14.

Carbon footprint of long fallow wheat production in north-east NSW using Life Cycle Assessment of greenhouse gas emissions

Sally Muir and Graeme Schwenke NSW DPI, Tamworth **Pip Brock** NSW DPI, Port Stephens
Fiona Scott NSW Trade & Investment, Tamworth **David Herridge** PIIC University of New England

NUTRITION & SOILS

Key findings

Life Cycle Assessment (LCA) of no-till wheat production after long fallow in the north east NSW (NE NSW) region, based around Gunnedah, using averaged district data has demonstrated that major sources of greenhouse gas (GHG) emissions are the manufacture and use of nitrogen fertiliser. Machinery modifications may give small reductions in GHGs.

There is a need to extend LCA to examine the effects of replacing N fertiliser with legumes in cropping systems and provide other economically viable options to reduce GHG emissions.

Introduction

Wheat production inevitably generates greenhouse gas (GHG) emissions. The relative contribution of each emission and total emissions from wheat production can be determined using Life Cycle Assessment (LCA). LCA is an internationally agreed approach that is used to assess environmental impacts from production systems, using methodology described by International Standards ISO14040 series.

NSW DPI has chosen to conduct LCA calculations using SimaPro 7.3.3 (Pré International 2011), an internationally recognised and validated modelling tool. Specific data used in the calculation of emissions from wheat production, such as yields, fertiliser rates and machinery types are mainly obtained from Australian commercial and research sources. Other data are embedded in inventory databases used by SimaPro to provide environmental outputs from each of the activities in a process flow, such as carbon dioxide emissions from diesel combustion by farm machinery. These data are modified to be specific to the study in question. Emission factors are applied from Australian field research, such as into nitrous oxide emissions from N fertiliser applied in particular regions.

A Carbon Footprint is calculated from GHG emissions, determined as CO_2-equivalents (CO_2-e), which arise from all on-farm emissions and fossil fuel inputs used to grow a crop of wheat and are presented as a profile to demonstrate their origins. These emissions are considered to be major contributors to the warming of the global atmosphere resulting in climate variability and change. Energy from fossil fuels used to manufacture fertiliser, fuel, chemicals and machinery contributes to crop emissions during the 'pre-farm' stage of a 'cradle-to-farm-gate' LCA for a tonne of grain, in addition to transport of these inputs from manufacturer to farm.

Fuel use by field machinery during crop production adds to overall emissions of GHGs during the 'on-farm' stage. Burning and rotting of crop residues contribute methane and carbon dioxide. Nitrogen fertiliser may also release nitrous oxide, which can be calculated as CO_2-e for inclusion in total emissions. Nitrous oxide and methane have 298 and 25 times more global warming potential than CO_2 per molecule, respectively.

Expected outcomes of modelling GHG emissions during LCAs for cropping operations in northern NSW are that the grains industry will be able to:

- demonstrate environmental stewardship
- identify practice change to reduce GHG emission in cropping operations
- translate nitrous oxide emissions and carbon sequestration data into accurate information for carbon footprint labelling
- understand the influence of carbon price and input costs on emissions.

There are a number of studies currently examining the emissions from various crop, livestock and forestry production systems in NSW. A recent study of long fallow wheat production in NW NSW showed greenhouse gas emissions were 139 kg CO_2-e per tonne of wheat based on a grain yield of 2.4 t/ha and 334 kg CO_2-e emitted per hectare. The main sources of emissions were pre-farm production and transport of urea (13%) and from the nitrous oxide and carbon dioxide emitted directly on-farm (24.7%) from the urea when applied to the crop (Northern Grains Region Trial Results 2014). An earlier study of wheat production in Central NSW showed greenhouse gas emissions were 200 kg CO_2-e per tonne of wheat based on a grain yield of 3.5 t/ha.

The main sources of emissions were pre-farm production and transport of fertilisers (30%) and from the nitrous oxide (26%) emitted directly on-farm from the N fertiliser applied to the crop.

The following information is from a LCA for a GRDC-funded project that is focussed on GHG emissions from wheat production in various cropping systems in northern and southern NSW. This specific study is for a no-till, long fallow wheat crop grown at Gunnedah and the Liverpool Plains in NE NSW.

Crop production details

Dryland wheat under no-till with long fallow

District:	**Gunnedah–Liverpool Plains**
Source:	**NSW DPI Farm Enterprise Budget Series – North East NSW, Winter 2012 with gross margins.**
Yield base:	**3.5 t/ha after prior sorghum crop.**

Average overhead costs for 2012 were taken from Holmes and Sackett Aginsights Vol 15 (2013).

LCA data and inventories

The LCA is based on median values taken from regional-level production data collected annually over many years by NSW DPI and from recent field trials measuring nitrous oxide emissions during a range of crop sequences at Tamworth.

The quantities of chemicals and fertiliser applied were taken from the calendar in NSW DPI Farm Enterprise Budget Series – North East NSW, Winter 2012 (Table 1). Machinery options were selected from this budget as described below.

The emission outputs from each input were calculated mostly from the Australasian Life Cycle Inventory v3 database to which SimaPro is linked. It was necessary to use accredited European inventories however for some chemical inputs which are imported from global markets but their emissions are not yet available in the Australasian inventory.

Data sources for transport of inputs to farm and farm machinery

Trucks used to transport the fertiliser, chemicals and fuel were selected to represent average cartage from city to farm. Most of the journey from point of manufacture or import into Australia (Brisbane or Sydney) to a regional centre (Gunnedah) is assumed to occur by articulated truck of >20 tonne and by smaller rigid trucks from the regional centre to farm. Fuel usage by these trucks and emissions from the energy used in their manufacture contributes to pre-farm emissions.

Fuel consumption by a tractor with implements was estimated from 'Guide to Tractor and Implement Costs' for a tractor with 130 kW PTO/146 kW engine (NSW Trade & Investment 2012). Spraying was based on a self-propelled sprayer with a 24 m boom, with data collected from commercial sources. Harvesting was based on use of a Class 8 combine harvester with data from Kondinin publications plus collection of grain to an on-farm silo with tractor and chaser bin. Farm machinery data were used to also calculate contributions to emissions as pre-farm 'embodied energy' used for production of all machinery, based on a 10 year life.

Chemicals used for production

Fertilisers: Anhydrous ammonia was applied by contract truck during fallow. Supreme Z Extra was applied at sowing as indicated in Table 1.

Herbicides: In fallow, glyphosate, dicamba, 2,4-D amine and triclopyr with ethoxylated alcohol surfactant were used for general and broadleaf weed control. In-crop, metsulfuron-methyl with MCPA were used for broadleaf weed control.

Fungicides: Propiconazole is included as a yearly application for stripe rust control.

Table 1. *Calendar of on-farm operations.*

Time	Farm operation
Mar Yr 1	Previous sorghum crop harvest
Jun Yr 1	Weed control – herbicide spray
Aug Yr 1	Weed control – herbicide spray
Nov Yr 1	Weed control – herbicide spray
Feb Yr 2	Fertiliser application – anhydrous ammonia (122 kg/ha) to supply 100 kg/ha of N.
May Yr 2	Weed control – herbicide spray
May Yr 2	Sowing: Seed (50 kg/ha) with Supreme Z (60 kg/ha) to supply 6.5 kg/ha of N.
Jun Yr 2	Broadleaf weed control – herbicide spray
Aug Yr 2	Fungicide aerial spray for stripe rust control
Nov Yr 2	Harvest

Results

- Emissions from the production of 1 tonne of wheat grown in this long fallow system were calculated as 143.4 kg CO_2-e, of which 43.2 kg CO_2-e, or 30% of emissions were from on-farm use of anhydrous ammonia and direct soil emissions of nitrous oxide (N_2O direct) (Table 2). Emissions from the pre-farm production and transport of anhydrous ammonia added 42.7 kg CO_2-e or 29.8% of the emissions profile per tonne of wheat to a total 85.9 kg CO_2-e, or 59.9%.
- Fallow management contributes 91.3 kg CO_2-e per tonne of wheat or 63.7%, consisting wholly of manufacture and transport of herbicides and fertilisers, with diesel combustion for on-farm application.
- Emissions of 18.3 kg CO_2-e per tonne of wheat or 12.8% were associated with manufacture of Supreme Z Extra fertiliser and its direct soil emissions of nitrous oxide.
- Decomposition of crop residues for 6 months after harvest are estimated at 12.7 kg CO_2-e or 8.9%.

Table 2. *GHG emissions for fallow and in-crop during wheat production.*

Inputs for production of 2.4 tonne wheat /ha	kg CO_2-e emitted per tonne wheat	
	Fallow	Crop
Manufacture of herbicides, surfactant, fungicide	7.7	1.0
Manufacture of Supreme Z Extra	–	15.6
Manufacture of Anhydrous ammonia	24.8	–
Transport of chemicals	0.08	0.02
Transport of fertilisers	1.5	0.8
Production & transport of diesel	0.4	2.0
Production of seed	–	2.1
Embodied energy of machinery	0.4	3.0
Total 'Pre-farm' emissions:	34.88	24.52
Diesel combustion by farm operations	2.4	11.3
Supreme Z Extra direct N_2O	–	2.7
Supreme Z Extra indirect N_2O	–	0.9
Anhydrous ammonia direct N_2O	40.5	–
Anhydrous ammonia indirect N_2O	13.5	–
Decomposition of residues	–	12.7
Total 'On-farm' emissions:	56.4	27.6
Fallow management emissions	–	91.3
Total emissions per tonne wheat:	91.3	143.4
Total emissions per ha	319.5	503

- Minor emissions occurred from transport of diesel, embodied energy of machinery, seed used for sowing and in-crop on-farm operations. Low levels of indirect **N_2O** emissions occur during ammonia volatilisation from soil and re-deposition. Leaching and runoff of emissions were deemed not to occur.
- Long fallow wheat priced at an average of $265 per tonne (AH on farm) with a gross margin of $142 per tonne and overheads of $44 per tonne returns a profitability of $686 per tonne of CO_2-e.

Discussion

- Total emissions of 143 kg CO_2-e per tonne of long fallow wheat in NE NSW were similar to those calculated for long fallow wheat in north west NSW at 139 kg CO_2-e per tonne. Emissions from both long fallow wheat systems were less than 200 kg CO_2-e per tonne wheat grown in Central NSW with similar yield and N inputs. Emissions from soil-applied lime were included in the total for wheat grown in Central NSW, but lime is not used for wheat in northern NSW.
- Manufacture and use of N fertiliser contributed more GHG emissions per tonne of wheat in the NE NSW system than in the north west NSW long fallow system. Anhydrous ammonia and Supreme Z Extra (30.5 kg N per tonne of wheat) emitted 83.6 kg CO_2-e per tonne of wheat from manufacture and direct soil emissions in north east system. This was greater than emissions from urea and Starter Z combined in long fallow wheat for NW NSW at 68 kg CO_2-e per tonne of wheat using 13.3 kg N per tonne wheat. Anhydrous ammonia has lower manufacturing and direct soil emissions at 2.3 kg CO_2-e per kg N than urea at 4.2 kg CO_2-e per kg N.

NUTRITION & SOILS

- Replacement of N fertiliser applications with leguminous crops in rotation systems and Precision Ag application are options to further reduce emissions. Research trials currently being undertaken at Tamworth will provide data for further LCA studies to examine how N_2-fixing chickpeas and other pulses may reduce emissions.
- Diesel combustion during spraying is reduced by using a self-propelled sprayer rather than tractor and spray rig. The emissions for an average self-propelled sprayer were calculated at 9.8 kg CO_2-e per ha compared with 23.4 kg CO_2-e per ha for a tractor and rig.
- Profitability per tonne of CO_2-e provides an indication of the cost of emissions. Profitability of $686 per tonne of CO_2-e for NE NSW long fallow wheat is greater than $617 per tonne of CO_2-e for north west NSW long fallow wheat, which demonstrates benefits to be gained from fertiliser and machinery modifications where rainfall allows increased yields.
- Further LCA studies on farming system combinations of wheat with canola, sorghum and chickpeas across NSW during this year will incorporate data from growers about their practices and from other commercial sources, as well as research trials. These data will supplement the general averaged sources being currently used for LCA reported here. Further economic analysis of the farming systems within the LCAs will indicate potential changes to profitability.

Summary

- Life Cycle Assessment of no-till wheat production after long fallow in NE NSW using averaged district data has demonstrated that major sources of emissions are the manufacture and use of nitrogen fertiliser.
- LCA can be used to study cropping systems with a view to identifying major opportunities for reducing GHG emissions and linking them to economic outcomes.
- There are opportunities to advise on alternative farm operation efficiencies to reduce on-farm emissions, such as use of self-propelled sprayers and anhydrous ammonia.

Acknowledgements

This trial was funded by GRDC and NSW Department of Primary Industries under the 'Life Cycle Assessment (LCA) for farming systems in NSW'. Project (GRDC DAN 00160). Thanks to Bill Manning, Senior Land Officer, North West Local Land Services Gunnedah, NSW for technical advice. Some fuel usage data for self-propelled sprayers were kindly provided by Paul Slack and Mike Smith, Gurley, NSW, and Rod Murchison and Sean Seymour, Caroona, NSW.

Carbon footprint of long fallow wheat production in north-west NSW using Life Cycle Assessment of greenhouse gas emissions

Sally Muir and Graeme Schwenke NSW DPI, Tamworth **Pip Brock** NSW DPI, Port Stephens
Fiona Scott NSW Trade & Investment, Tamworth **David Herridge** PIIC University of New England

Introduction

Wheat production inevitably generates greenhouse gas (GHG) emissions. The relative contribution of each emission and total emissions from wheat production can be determined using Life Cycle Assessment (LCA). LCA is an internationally agreed approach that is used to assess environmental impacts from production systems, using methodology described by International Standards ISO14040 series.

NSW DPI has chosen to conduct LCA calculations using SimaPro 7.3.3 (Pré International 2011), an internationally recognised and validated modelling tool. Specific data used in the calculation of emissions from wheat production, such as yields, fertiliser rates and machinery types are mainly obtained from Australian commercial and research sources. Other data are embedded in inventory databases used by SimaPro to provide environmental outputs from each of the activities in a process flow, such as carbon dioxide emissions from diesel combustion by farm machinery. These data are modified to be specific to the study in question. Emission factors are applied from Australian field research, such as into nitrous oxide emissions from N fertiliser applied in particular regions.

A Carbon Footprint is calculated from GHG emissions, determined as CO_2-equivalents (CO_2-e), which arise from all on-farm emissions and fossil fuel inputs used to grow a crop of wheat and are presented as a profile to demonstrate their origins. These emissions are considered to be major contributors to the warming of the global atmosphere resulting in climate variability and change. Energy from fossil fuels used to manufacture fertiliser, fuel, chemicals and machinery contributes to crop emissions during the 'pre-farm' stage of a 'cradle-to-farm-gate' LCA for a tonne of grain, in addition to transport of these inputs from manufacturer to farm.

Fuel use by field machinery during crop production adds to overall emissions of GHGs during the 'on-farm' stage. Burning and rotting of crop residues contribute methane and carbon dioxide. Nitrogen fertiliser may also release nitrous oxide, which can be calculated as CO_2-e for inclusion in total emissions. Nitrous oxide and methane have 298 and 25 times more global warming potential than CO_2 per molecule, respectively.

Expected outcomes of modelling GHG emissions during LCAs for cropping operations in northern NSW are that the grains industry will be able to:

- demonstrate environmental stewardship,
- identify practice change to reduce GHG emission in cropping operations,
- translate nitrous oxide emissions and carbon sequestration data into accurate information for Carbon Footprint labelling,
- understand the influence of carbon price and input costs on emissions.

There are a number of studies currently examining emissions from various crop, livestock and forestry production systems in NSW. A recent study of short fallow wheat production in NW NSW showed greenhouse gas emissions were 193 kg CO_2-e per tonne of wheat based on a grain yield of 1.7 t/ha and 329 kg CO_2-e emitted per hectare. The main sources of emissions were pre-farm production and transport of urea (17.5%) and from the nitrous oxide and carbon dioxide emitted directly on-farm (46%) from the urea when applied to the crop (Northern Grains Region Trial Results 2013).

Key findings

Life Cycle Assessment (LCA) of no-till wheat production after long fallow in the north-west NSW (NW NSW) region, based around Walgett, using averaged district data has demonstrated that major sources of greenhouse gas (GHG) emissions are the manufacture and use of urea fertiliser.

There is a need to extend LCA to examine the effects of replacing N fertiliser with legumes in cropping systems and provide other economically viable options to reduce GHG emissions.

The following information is from a LCA for a GRDC-funded project that is focussed on determination of GHG emissions from wheat production in various cropping systems in northern and southern NSW. This specific study is for a no-till, long fallow wheat crop grown west of the Newell Highway in NW NSW.

Crop production details

Dryland wheat under no-till with long fallow

District:	**Moree-Walgett**
Source:	**NSW DPI Farm Enterprise Budget Series – North West NSW, Winter 2012 with gross margins.**
Yield base:	**2.4 t/ha after prior sorghum crop.**

Average overhead costs for 2012 were taken from Holmes and Sackett Aginsights Vol 15 (2013).

LCA data and inventories

The LCA is based on median values taken from regional-level production data collected annually over many years by NSW DPI and from recent field trials measuring nitrous oxide emissions from various crop sequences at Tamworth.

The quantities of chemicals and fertiliser applied were taken from the calendar in NSW DPI Farm Enterprise Budget Series – North West NSW, Winter 2012 (Table 1). Machinery options were selected from this budget as described below.

The emission outputs from each input were calculated mostly from the Australasian Life Cycle Inventory v3 database to which SimaPro is linked. It was necessary to use accredited European inventories however for some chemical inputs which are imported from global markets but their emissions are not yet available in the Australasian inventory.

Data sources for transport of inputs to farm and farm machinery

Trucks used to transport the fertiliser, chemicals and fuel were selected to represent average cartage from city to farm. Most of the journey from point of manufacture or import into Australia (Brisbane or Sydney) to a regional centre (Walgett) is assumed to occur by articulated truck of >20 tonne and by smaller rigid trucks from the regional centre to farm. Fuel usage by these trucks and emissions from the energy used in their manufacture contributes to pre-farm emissions.

Fuel consumption by a tractor with implements was estimated from 'Guide to Tractor and Implement Costs' for a tractor with 180 kW PTO/217 kW engine (NSW Trade & Investment 2012). Harvesting was based on use of a Class 8 combine harvester with data from Kondinin publications plus collection of grain to an on-farm silo with tractor and chaser bin. Farm machinery data were used to also calculate contributions to emissions as pre-farm 'embodied energy' used for production of all machinery, based on a 10 year life.

Chemicals used for production

Fertilisers: Urea with Starter Z at sowing as indicated in Table 1.

Herbicides: In fallow, glyphosate, 2,4-D amine and triclopyr with surfactant and chlorsulfuron with paraquat/diquat were used for general and broadleaf weed control. In-crop, MCPA was used for broadleaf weed control. Fenoxaprop-p-ethyl was included as a 1 in 4 year option for wild oats.

Results

- Emissions from the production of 1 tonne of wheat grown in this long fallow system were calculated as 139.1 kg CO_2-e, of which 34.4 kg CO_2-e, or 24.7% of emissions were from on-farm use of urea and direct soil emissions of carbon dioxide and nitrous oxide (N_2O direct) (Table 2). Emissions from the pre-farm production and transport of urea added 18.1 kg CO_2-e or 13% of the emissions profile per tonne of wheat to a total 52.5 kg CO_2-e, or 37.7%.
- Fallow management contributes 30.7 kg CO_2-e per tonne of wheat or 22.1%, consisting wholly of manufacture and transport of herbicides and fertilisers, with diesel combustion for on-farm application.
- Emissions of 17.1 kg CO_2-e per tonne of wheat or 12.3% were associated with manufacture of Starter Z fertiliser and its direct soil emissions of nitrous oxide.

Table 1. *Calendar of on-farm operations.*

Time	Farm operation
Mar Yr 1	Previous sorghum crop harvest; Weed control – herbicide spray
Aug Yr 1	Weed control – herbicide spray
Dec Yr 1	Weed control – herbicide spray
Jan Yr 2	Weed control – herbicide spray
Feb Yr 2	Weed control – herbicide spray
Apr Yr 2	Weed control – herbicide spray
May Yr 2	Sowing: Seed (40 kg/ha) with urea (60 kg/ha) and Starter Z (40 kg/ha) to supply 32 kg/ha of N.
Jun Yr 2	Wild oat control (1 in 4 years) – herbicide spray
Jul Yr 2	Broadleaf weed control – herbicide spray
Dec Yr 2	Harvest

- Decomposition of crop residues for 6 months after harvest was estimated at 12.7 kg CO_2-e or 9.1%.
- Minor emissions occurred from transport of diesel, embodied energy of machinery, seed used for sowing and in-crop on-farm operations. Low levels of indirect **N_2O** emissions occur during ammonia volatilisation from soil and re-deposition. Leaching and runoff of emissions were deemed not to occur.
- Wheat priced at an average of $275 per tonne (PH13 on farm) with a gross margin of $150 per tonne and overheads of $64.20 per tonne returns a profitability of $617 per tonne of CO_2-e.

Table 2. GHG emissions for fallow and in-crop during wheat production

Inputs for production of 2.4 tonne wheat /ha	kg CO_2-e emitted per tonne wheat	
	Fallow	Crop
Manufacture of herbicides	18.2	0.7
Manufacture of Starter Z	–	14.5
Manufacture of Urea	–	16.5
Transport of chemicals	1.1	0.02
Transport of fertilisers	–	2.7
Production and transport of diesel	1.6	1.7
Production of seed	–	2.4
Embodied energy of machinery	0.8	3.8
Total 'Pre-farm' emissions:	21.7	42.3
Diesel combustion by farm operations	9.0	10.1
Starter Z direct N_2O	–	2.6
Starter Z indirect N_2O	–	0.9
Urea direct N_2O	–	15.9
Urea indirect N_2O	–	5.3
CO_2 emissions from urea	–	18.5
Decomposition of residues after crop	–	12.7
Total 'On-farm' emissions:	9.0	66.0
Fallow management emissions	–	30.7
Total emissions per tonne wheat:	30.7	139
Total emissions per ha	73.7	333.6

Discussion

- Total emissions of 139 kg CO_2-e per tonne of long fallow wheat in NW NSW were less than those calculated for short fallow wheat in NW NSW at 193 kg CO_2-e per tonne. The emissions per ha were similar for the two cropping systems but the higher yield of 2.4 tonne/ha from the long fallow crop compared with 1.7 tonne/ha for the short fallow crop reduces the per tonne emissions.
- Manufacture and use of N fertiliser contributed less GHG emissions per tonne of wheat after long fallow than in the short fallow system. Urea and Starter Z combined (13.3 kg N per tonne wheat) emitted 68 kg CO_2-e per tonne of wheat from manufacture and direct soil emissions in long fallow wheat., This was lower than the emissions from fertiliser in short fallow wheat for NW NSW at 122.7 kg CO_2-e emitted per tonne wheat using 23.5 kg N, as reported in 2013. An emissions benefit gained from a longer period of nitrification in long fallow reduces N requirements compared with short fallow. All manufacturing and direct soil emissions from Starter Z (9.5 kg CO_2-e per kg N) are greater than from urea (4.2 kg CO_2-e per kg N).
- Replacement of N fertiliser applications with leguminous crops in rotation systems, use of N fertilisers other than urea and precision agriculture based application e.g. to reduce overlap, are options to further reduce emissions. Anhydrous ammonia has been calculated to produce less emissions than urea for long fallow wheat grown in north-east NSW as reported elsewhere in this publication (2014). Research trials currently being undertaken at Tamworth will provide data for further LCA studies to examine how N_2-fixing chickpeas and other pulses may reduce emissions.

- Diesel combustion during spraying is expected to be larger than other operations because it is repeated several times during fallow period. The single sowing operation (4.8 CO_2-e per run) produces more emissions than harvesting (3.4 CO_2-e per run) or a single spraying run (~2 kg CO_2-e per run). Ongoing improvements in machinery efficiencies may contribute to some future reduction in emissions. Other LCA studies into alternative implements e.g. self-propelled sprayers, may also show reductions in diesel use and related GHG emissions.
- Profitability per tonne of CO_2-e provides an indication of the cost of emissions. Profitability of $617 per tonne of CO_2-e for long fallow wheat is greater than $248 per tonne of CO_2-e for short fallow wheat, which demonstrates benefits and efficiencies gained from the long fallow in the short term.
- Further LCA studies on farming system combinations of wheat in rotation with canola, sorghum and chickpeas across NSW during this year will incorporate data from growers about their practices and from other commercial sources, as well as research trials. These data will supplement the general averaged sources being currently used for LCA reported here. Further economic analysis of the farming systems within the LCAs will indicate potential changes to profitability.

Summary

- Life Cycle Assessment of no-till wheat production after long fallow in NW NSW using averaged district data has demonstrated that major sources of emissions are the manufacture and use of urea fertiliser.
- Total crop emissions are less for the north-west long fallow than the north-west short fallow, but similar to those for long fallow in north-east NSW.
- LCA can be used to study cropping systems with a view to identifying major opportunities for reducing GHG emissions and linking them to economic outcomes.
- There are opportunities to advise on alternative farm operation efficiencies to reduce on-farm emissions, such as use of legumes to replace N fertiliser use.

Acknowledgements

This trial was funded by GRDC and NSW Department of Primary Industries under the 'Life Cycle Assessment (LCA) for farming systems in NSW' project (DAN 00160). Thanks to Tim Weaver, previously District Agronomist Walgett, and Loretta Serafin, Leader Northern Dryland Cropping Systems, Tamworth, for technical advice.

Northern Grains Region Trial Results Autumn 2014
Research & Extension – Independent Research for Industry

Editors: Loretta Serafin, Steven Simpfendorfer, Mike Sissons, Andrew Verrell and Guy McMullen

www.dpi.nsw.gov.au

12623